

Auckland Regional Council
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On-site Wastewater Systems: Design and Management Manual

Third Edition ARC Technical Publication 2004
Prepared by: A W Ormiston (ARC Consultant) & R E Floyd



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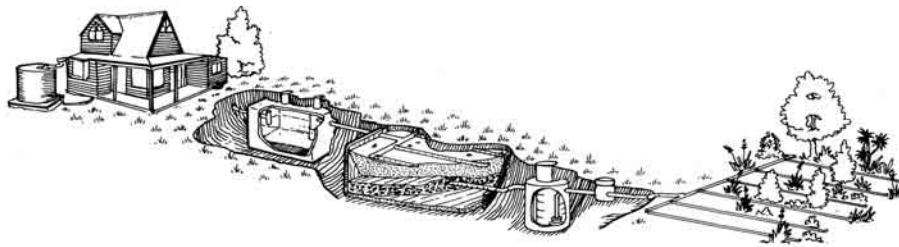
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On-site Wastewater Systems: Design and Management Manual

*Treatment and Land Disposal Systems for Domestic Wastewater from Households,
Commercial Premises and Similar Facilities*

Third Edition, August 2004

Prepared by:
A W (Sandy) Ormiston
Robyn E Floyd



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PREFACE

This manual addresses the management of on-site treatment and land disposal of sewage wastewater from domestic sources. The effective and environmentally sustainable disposal of domestic wastewater in non-sewered areas is critical for the protection of receiving environments and of public health and to provide for the long-term sustainable use of our environmental resources.

The Auckland Regional Council (ARC) encourages continued improvements in wastewater treatment and disposal methodologies, to protect the environment for current and future generations in the Auckland region. To facilitate achieving this objective, ARC has updated these guidelines, the Third Edition of ARC Technical Publication No. 58 (TP 58), to assist with the design of on-site wastewater management systems and to assist with the regulatory assessment of such systems.

TP 58 is intended to serve as a guideline design manual, rather than a set of regulations in its own right. It also does not provide comprehensive or complete design details for all of the types of on-site wastewater treatment and disposal systems available. The design guidelines in this manual have been produced to primarily apply to on-site systems for the treatment and disposal of domestic wastewater from households and from larger types of accommodation, community and public facilities in the Auckland region. They may also apply equally to domestic wastewater management systems outside this region, as determined by the relevant regulatory authority, with due consideration of the specific environmental circumstances particular to that region.

ARC has developed these guidelines with major assistance from its key consultants and is grateful to them for the comprehensive technical advice received. This edition of TP58 is issued with the acknowledgement that scope remains for further technical details and expansion of detail on some matters. To address these anticipated needs, TP58 will require revision again in due course and/or new addenda and/or technical sheets will be produced where gaps are identified.

Finally, while the engineering design guidelines in this edition are not subject to direct formal consultation, ARC would be pleased to receive specific technical comments for consideration in the preparation of future editions or addenda to this edition as appropriate. Please do not hesitate to forward any comments in writing to The Manager, Land and Water Quality at the address below.

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ACKNOWLEDGEMENTS

In response to needs identified in the on-site wastewater industry in the late 1990's, ARC initiated the preparation of the revised third edition of TP58. The material throughout the document is based on extensive searches of local and international literature and is also based on our comprehensive experience with on-site disposal systems in the Auckland region and beyond. ARC gratefully acknowledges the extensive technical assistance provided by Mr Ormiston throughout the preparation of this document, and is most appreciative that a major proportion of his time that was provided at no cost to the Auckland region.

ARC also acknowledges the strong leadership and technical guidance provided by Mr Ian Gunn with respect to his preparation of the earlier editions of TP58 and in the on-site wastewater industry over the years. This provided the foundation on which these revised guidelines could be based. Mr Gunn's technical advice was much appreciated in the early stages of the preparation of this edition, and then again towards the final stages of the draft edition.

The quality diagrams and schematics throughout the document were prepared by Mr Don Abbott of Handline Illustrations and the document was formatted by PDF Communications Ltd. ARC is appreciative of both parties creativity, attention to detail and rapid responses to requests.

A consultative draft of this document was circulated to key consultants, equipment supply companies and other interested parties for comment. Comments on technical details have been gratefully received from the following parties:

- Design Consultants: Mr Colin Ashby (Ashby Consulting Ltd), Mr Peter Riddell (Ecogent Ltd), Mr Brett Black & Grant Fleming (Riley Consultants Ltd), Mr Peter Gearing (URS New Zealand Ltd), Mr Hugh Fendall (Hugh Fendall Consultants Ltd.), Mr Tim Rimmer.
- System Suppliers: Mr Rick Soar & Mr Paul Riethmaier (Reflections Treatment Systems Ltd), Mr Jeff Buchan & Mr Brent Hawthorn (Innoflow Technologies Ltd), Ms Jane High (Hynds Environmental), Mr Lewis Austin (Oasis Clearwater Systems Ltd), Mr Allan Hanson (Irrigation Technologies Ltd), Mr Wayne Ingham (Netafim New Zealand) and Mr Rodney Ruskin (Geoflow Inc.).
- Regulatory Advisors: Mr Bruce Fulford (Rodney District Council), Dr David Sinclair (Medical Officer of Health, Auckland Region Public Health Service), Dr Margaret Leonard (Institute of Environmental and Science and Research Ltd), Mr Brent Fletcher (Environment Waikato), Mr Terry Long (Franklin District Council), Mr Glen Moser and Mr Graham Leonard (Waitakere City Council), Mr Graham Boyle & Mr John Waetford (Auckland City Council), George Little & Alan McColl (Manukau City Council) and further contributions from other local Council and ARC staff.

All comments were carefully considered and incorporated into the document where appropriate, with some in particular providing a most substantial contribution to the quality and depth of the final guidelines.

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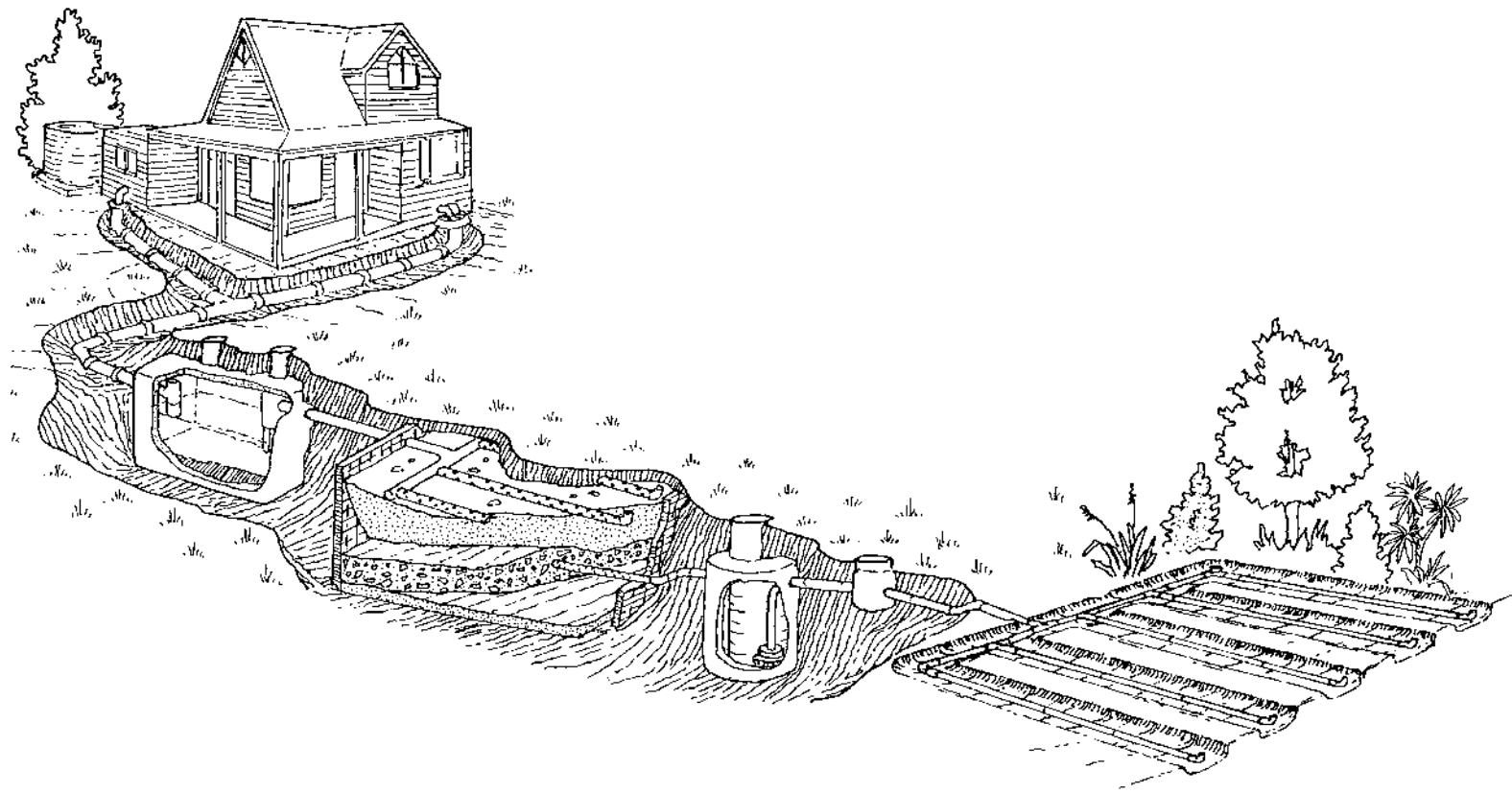
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1 > Introduction



1. INTRODUCTION

1.1 GENERAL

The purpose of TP58 is to provide guidance for the design and maintenance of on-site treatment and disposal systems for domestic wastewater from households and institutions. In this context, the term “institutions” refers to non-dwelling type facilities such as schools, residential accommodation facilities and commercial and public facilities.

The approach taken in the setting of design recommendations for on-site wastewater systems has been based on extensive experience in the region supported by comprehensive literature searches. Wherever practicable, these design guidelines attempt to use a pragmatic approach. However, where any uncertainty exists, ARC is obliged to take a conservative approach and to ensure some safety factor is maintained in final system designs to address uncertainties inherent in the design and operation of on-site systems. This is also to provide confidence that meeting the design recommendations as set out in TP58 gives surety that potential for adverse effects from system design alone will be minor. Maintenance is also recognised as an equally important factor, along with correct system design, installation and operation to ensure optimum performance of the system. These factors are all critical for mitigating potential adverse effects throughout the life of a system.

This document is aimed at providing guidelines applicable to existing sites in situations where there is no existing reticulation system such that on-site disposal is the only option. In the case of new developments, it applies where subdivision is of a scattered nature for example large rural lots, lifestyle blocks or developments on remote sites where reticulation for combined decentralised or centralised treatment systems is not practicable.

In the case of proposed new developments or subdivisions, that could lead to a concentration of settlement, ARC policies promote the need for consideration of all reasonable means of treating and disposing of wastewater, in addition to the immediate option of on-site disposal. There is a requirement for assessments of alternative infrastructure options to be undertaken at the early planning stage. This matter is addressed in the relevant policies in the Auckland Regional Policy Statement, which are outlined in Chapter 2. The need for alternatives to on-site disposal to be considered at the planning stages of a development is specifically discussed in Chapter 4. This outlines matters to be considered in the early *Design Planning* stages of a development, before any decision can be made towards on-site, off-site or a combination of on and off site treatment and disposal options.

1.2 THE CONTEXT OF THIS AND EARLIER EDITIONS/BACKGROUND

The First Edition of this manual titled "On-site Wastewater Disposal from Households and Institutions", commonly referred to as “TP58”, was produced by the ARC in 1989. The design standards of that time, NZS 4610:1982 “Household Septic Tank Systems”, recommended that in difficult subsoil conditions and/or where institutional facilities were to be served, a manual of engineering practice should be used for specific design purposes. TP58 was developed to fill an information gap identified in the Auckland region.

In 1994, the Second Edition was produced, which incorporated revisions and additions to the previous guidelines, in response to feedback from a user survey. It was noted in the Second Edition that the range of on-site systems outlined in TP58 was by no means conclusive and many local variations on traditional and special types of systems were available and in use. It encouraged designers to apply the design principles and procedures as outlined in the manual, to the technology current at the time, to achieve innovative solutions and effective environmental outcomes for

unsewered wastewater servicing. Industry initiatives in the absence of clear design standards have, in some cases, resulted in a wide range of performance standards in the treatment and disposal systems available.

This, the Third Edition, now addresses the significant advances in on-site wastewater system technology, practices and standards over the past nine years. It has attempted to clarify design standards in areas where clear standards have been lacking. Its preparation has included a complete review of design guidelines in the previous editions, in response to changes in industry practices and to advances in international guidelines and practices. This has also included a consultation process with other regulatory authorities and TP58 user groups and as a result, it attempts to provide increased confidence to areas requiring clarification and detail where it was lacking in the earlier editions.

1.3 The Source of Technical Material and Their Relationship to TP58

Major sources of technical information for the revisions to these guidelines have included the updated version of the USEPA Wastewater Treatment Systems Manual (2002) and recent key research from the USA. New joint Australian and New Zealand Standards have now also been issued in parallel to the drafting of these revised guidelines, specifically:

- AS/NZS 1546.1:1998 On-site domestic wastewater treatment units
Part 1: Septic tanks
- AS/NZS 1547:2000 On-site domestic wastewater management
- AS/NZS 1546.3:2001 On-site domestic wastewater treatment units
Part 3: Aerated wastewater treatment systems

Further joint Standards in the AS/NZS 1546 series are being issued for “waterless composting toilets” and other systems. AS/NZS 1547 forms an umbrella Standard under which the various treatment unit Standards fit. Material in AS/NZS:1547 has been considered in the preparation of these revised TP58 guidelines and has been included where appropriate.

However, it is important to note that these guidelines are not based on the AS/NZS standards, and in the Auckland region at least, TP58 remains the guidelines against which wastewater system design specifications will be assessed. This requirement is enshrined within legislation through the rules in ARC’s Transitional Regional Plan and the Proposed Auckland Regional Plan: Air, Land and Water. (Appendix B includes technical reasons concerning on why TP58 is considered more appropriate and relevant to the Auckland region than the AS/NZS standards. Further details of the relevant objectives and rules for the Auckland region are provided in Section 2.1.2 to 2.1.3 and in 2.6, and also further in Appendix C.)

Where information is lacking in these guidelines, reference should be made to the relevant literature. In particular, where further information is required, consideration should be given to relevant design criteria as specified in AS/NZS standards [Ref 1] and/or USEPA Manual [Ref 5] standards and/or Crites & Tchobanoglou, “Small and Decentralised Wastewater Management Systems” (1998) [Ref 2].

This edition is issued with the recognition that scope remains for further technical details and expansion of some chapters. To address anticipated gaps and changes in the on-site wastewater industry over time and corresponding needs for more detailed guidelines, TP58 will require revision again in forthcoming years and/or new addenda and/or technical sheets will be produced overtime as gaps are identified.

In the interim, where a design detail is outside the recommended specifications in TP58 the appropriate mechanism for approval is via the resource consent process. Once the particular new

design specifications have been proven to meet the objectives of TP58 for effective and sustainable on-site treatment and disposal to the reasonable satisfaction of ARC, then the intent is that it will be incorporated into TP58 via addendum as appropriate, following a notified variation to the Proposed Regional Plan: Air, Land and Water.

ARC is pleased to receive specific comments on the guidelines in this edition for consideration in the preparation of future editions or addenda to this edition, as appropriate.

1.4 USE OF THESE GUIDELINES

These guidelines will assist designers and installers to overcome the complexities that can be involved in selecting and designing the most appropriate wastewater system for a site.

A summary of the structure of the further chapters in these guidelines is as follows:

CHAPTER 2 “Statutory Context and Requirements” outlines the regulatory framework within which application of these guidelines must fall, both within the national context (the Resource Management Act 1991 and other legislation) and more specifically within the Auckland Region (Regional Rules for on-site disposal). Other relevant legislation, such as the Health Act, Building Act and Local Government Act, and how these Acts address sewage disposal, is also introduced. This chapter then further discusses the status of discharges under in terms of the relevant transitional and proposed regional plans, and the relevant status in terms of permitted, controlled and discretionary of a discharge activity.

CHAPTER 3 “Introduction to On-site Wastewater Management” introduces and defines the concept of On-Site Wastewater Management. It provides an overview of some types of wastewater treatment processes systems available, potential effects to be considered from the on-site land disposal of domestic wastewater and introduces key principles associated with achieving effective design, implementation and performance of on-site wastewater systems.

CHAPTER 4 “Design Planning” introduces concerns with respect to a potential for effects from single or a clusters of on-site disposal systems. It outlines key on-site wastewater management issues to be considered early in the subdivision/development planning process, and leads into the need for an assessment to be undertaken of potential cumulative adverse effects on the environment in the case of proposed land use intensification. It covers the need for consideration of decentralised (combined community) wastewater systems at the early planning stage.

CHAPTER 5 “Site Assessment” specifies the key criteria that must be considered when assessing a site for on-site wastewater disposal. This is the first step towards determining the capacity of the site for wastewater disposal. The site constraints must be evaluated before the appropriate maximum design flow, appropriate treatment system and wastewater land disposal methodologies can be determined.

CHAPTER 6 “Design Flow Volumes” provides guidance for determining an appropriate system design flow for the proposed development. It is critical that all wastewater systems are designed to cope well in extreme situations and to achieve this, the design flow must be based on maximum flows. This chapter also provides appropriate conservative flow allowances that must be used for determining the peak flows for design purposes.

CHAPTER 7 “Treatment Systems” is the most comprehensive section and provides design guidelines for primary, secondary and tertiary types of treatment systems. It specifies design criteria for a variety of key systems, many of which need to be used in series to ensure the required final treated wastewater discharge quality is achieved. Additional issues that need to be considered in the selection of appropriate treatment processes are also outlined, such as nutrient removal, disinfection

processes and treated wastewater reuse considerations, in addition to details of alternative treatment options.

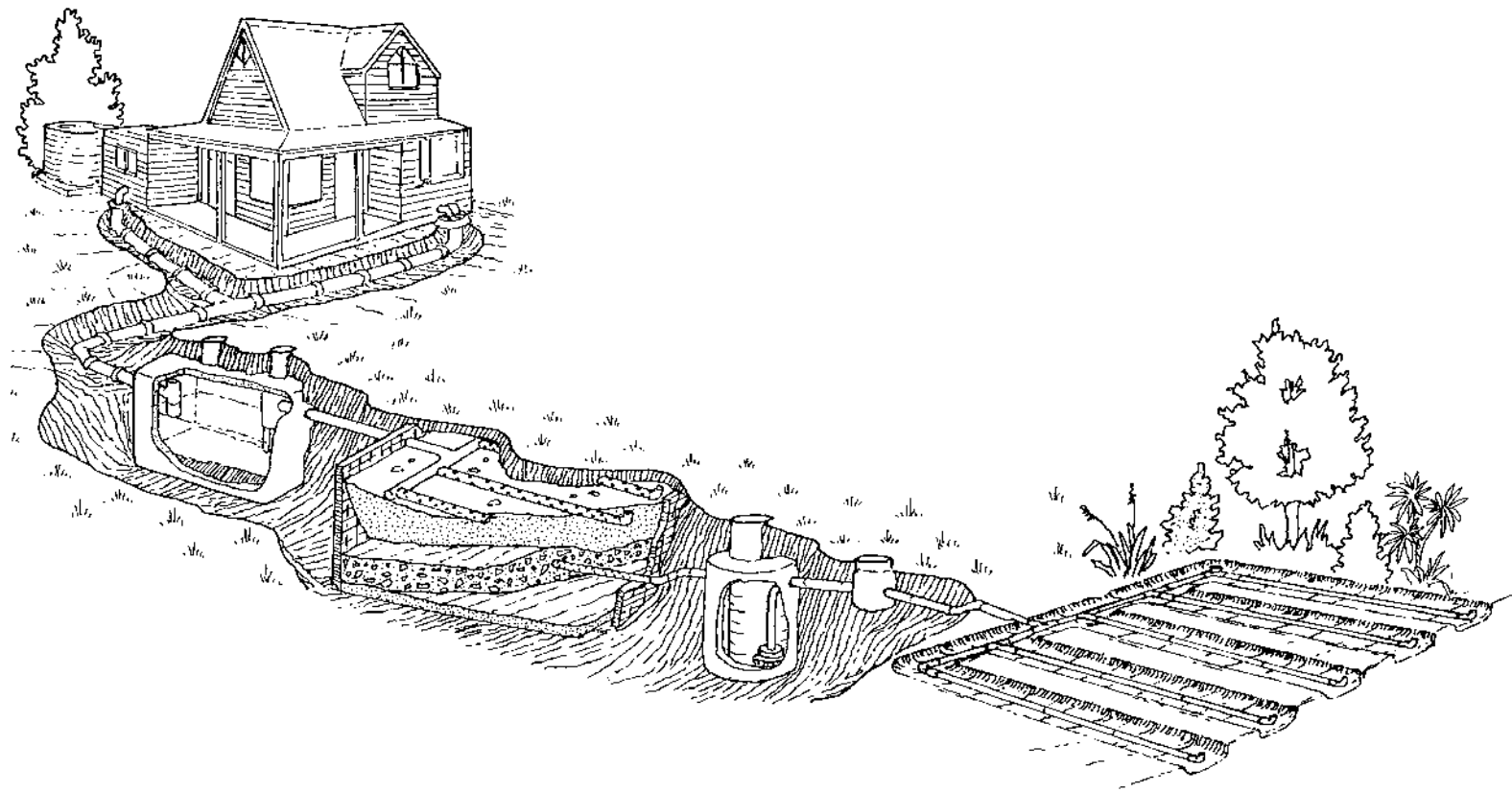
CHAPTER 8 “Dosing and Distribution Methods and Fixtures” discusses effective dosing and distribution methods for surface and subsurface land disposal systems.

CHAPTERS 9 and 10 “Land Disposal Systems” outline design criteria for the selection and design of an appropriate system. These chapters include critical design detail for the wide range of land disposal options to provide further land treatment to ensure that any potential impacts on surface and groundwater and any potential health risks are minimised. CHAPTER 9 provides information on surface and shallow irrigation systems, predominantly pressure compensated drip irrigation and low pressure effluent distribution irrigation systems. While CHAPTER 10 focuses on more conventional generally older technology systems, predominantly subsurface trenches and bed disposal systems, as well as other less common forms of disposal systems.

CHAPTER 11 “Environmental Effects From On-Site Wastewater Disposal” discusses the subsurface movement and fate of contaminants in wastewater applied to land and the need to consider options for minimising and assessing the impacts on the receiving environment. It recognises the limited capacity of soils to absorb nutrients and raises the need to not only design systems based on the hydraulic and organic capacity of the soils, but to also consider the potential chemical loadings, cationic salt balance and the nutrient immobilisation and buffering capacity of the receiving soils.

CHAPTER 12 “Installation, Operation and Maintenance Requirements” covers the importance of good system installation practices, including site preparation, building certification and records. It is then followed by the importance of on-going system maintenance. This section outlines the issues to be covered in management plans and those to be considered in relation to maintenance contracts. It also raises options for remedying failed or malfunctioning wastewater treatment or disposal systems. It refers to a number of detailed fact sheets appended, which further specify core system maintenance and operation requirements for optimum long term performance.

2> Regulatory Context and Requirements



2. REGULATORY CONTEXT AND REQUIREMENTS

2.1 THE STATUTORY FRAMEWORK

2.1.1 The Resource Management Act

The Resource Management Act 1991 (RMA) is the primary environmental legislation in New Zealand, under which regional and district plans are developed and administered. It does not specify direct requirements for on-site wastewater disposal, but Section 5(1) does state that the purpose of the Act *"is to promote the sustainable management of natural and physical resources"*. Section 5(2) defines *"sustainable management"* as:

- "..managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while -*
- (a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
 - (b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
 - (c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment."*

Sections 6 to 8 of the RMA, 'the principles', set out a hierarchy of considerations, which the Council must consider in determining any applications for resource consent. Section 6 outlines the Matters of National Importance in relation to managing the use, development and protection of natural and physical resources that must be recognised and provided for under the Act. Section 7 outlines Other Matters of environmental and cultural significance including among others the maintenance and enhancement of the quality of the environment and any finite characteristics of natural and physical resource. Section 8 outlines the need to take into account the principles of the Treaty of Waitangi under the Act.

The primary clause that requires authorisation of discharges of contaminants, such as on-site wastewater disposal, is in Section 15. This states the following:

- "Section 15 – Discharge of contaminants into environment*
No person may discharge any –
- (a) Contaminant or water into water; or*
 - (b) Contaminant onto or into land in circumstances which may result in that contaminant ... entering water or...*
- unless the discharge is expressly allowed by a rule [in a regional plan, and in any relevant proposed regional plan], a resource consent or regulations .."*

Section 104(1) requires that the consent authority, when considering an application and any submissions received, have regard to any actual or potential environmental effects and any relevant objectives, policies, rules or other provisions of a plan or proposed plan.

Section 107 specifies minimum restrictions on granting a discharge permit to do something that would otherwise contravene Section 15, including that *"a discharge of a contaminant cannot [directly or indirectly] enter water if, after reasonable mixing, [it] is likely to give rise to any of the following effects in the receiving waters:*

- (c) The production of any conspicuous oil or grease films, scums or foam, or floatable or suspended materials;*
- (d) Any conspicuous change in colour or visual clarity;*
- (e) Any emission of objectionable odour;*
- (f) The rendering of fresh water unsuitable for consumption by farm animals;*
- (g) Any significant adverse effects on aquatic life"*

Section 105 specifies matters relevant to discharge applications, providing provisions that must be met in order for a consent authority to grant or refuse a resource consent. For a discharge consent to allow “*something that would contravene section 15, the consent authority must have regard to:*

- (a) *the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and*
- (b) *the applicant’s reasons for the proposed choice; and*
- (c) *any possible alternative methods of discharge, including discharge into any other receiving environment.”*

Section 108 specifies that a resource consent may include conditions requiring the holder to adopt the most efficient and effective means of preventing or minimising any actual or likely adverse effects on the environment. It may also require measurements, sampling, inspections, surveys etc. to be carried out.

Section 338 defines offences under the RMA, which includes contravention of Section 15, discharges of contaminants, and Section 339 refers to maximum penalties. Sections 314 to 325 specify enforcement provisions, including enforcement orders issued by the Environment Court and abatement notices issued by local authorities. Sections 343_a, 343_b, 343_c and 343_d specify infringement offences and provisions for infringement notices.

2.1.2 The Auckland Regional Policy Statement

In accordance with Sections 59 to 62 and Sections 63 to 70 of the RMA, ARC has produced a Regional Policy Statement (July 1999) (ARPS). The ARPS is a statement of how the natural and physical resources of the region are to be used, developed and protected, and states objectives, policies and methods for achieving the sustainable management of the region’s resources. It also provides the framework in the form of objectives, policies and other methods for the control of on-site disposal of domestic wastewater in the Auckland Region.

Section 104(c) of the RMA requires ARC to have regard to the relevant provisions of the ARPS, when regulating discharges in the region.

Chapter 8 of the ARPS, ‘Water Quality’, addresses the management of the region’s water quality. The policies in this chapter require an assessment of potential cumulative adverse effects on the environment from wastewater discharges, in order to provide for the long term protection of water quality. Section 8.2.1 identifies that “*many activities have adverse effects on water quality*” and Section 8.2.2 identifies that “*some parts of the Region are more susceptible to water quality degradation than other areas and/or have significant values that warrant special protection*”.

Section 8.3.1 contains an overall objective that seeks “*To maintain water quality in water bodies and coastal waters which have good water quality ..(for the) protection of aquatic ecosystems, recreation, food-gathering, water supply, cultural and aesthetic purposes.*” (Extract from Objective 8.3.1(iv)).

In pursuit of this objective, Policy 8.4.4.1 provides a framework for the assessment of wastewater disposal options. It requires that land use intensification only occurs where adequate provision has been made for control of sediment and storm water discharges, the collection, transport, treatment and disposal of sewage and the protection of ground water and water quality. Policy 8.4.4.2 provides an additional framework that addresses the effects of land use intensification in rural areas.

An assessment of various options of wastewater disposal systems, including combined and separate treatment and land application systems, should be undertaken in accordance with Policies 8.4.4.1 and 8.4.4.2.

The Other Methods detailed in Section 8.4.5 seek to ensure that as development proceeds, adverse effects on water quality are avoided or mitigated. It outlines Other Methods to achieve the policy, with the purpose being *"to ensure that the potential adverse effects, including cumulative effects, of new development and redevelopment, are considered prior to committing an area to further intensification and that adequate controls are implemented as development proceeds to avoid or mitigate adverse effects."*

The Other Methods include giving consideration to the preparation of a catchment management plan and/or a structure plan (refer Other Method 8.4.5.2). The need for a plan will be determined by assessing the proposal in terms of the following criteria:

- i. The scale of the proposal;
- ii. The sensitivity of the receiving environment to effects of the proposed land use; and
- iii. The potential for adverse effects, particularly cumulative adverse effects on water quality.

A catchment management plan or structure plan should include measures necessary to address matters set out in Policies 8.4.4.1 and 8.4.4.2. ("Catchment management planning" is further described in Appendix A-5 of the ARPS).

2.1.3 The Auckland Regional Plan: Air, Land and Water

The ARC has produced the Proposed Regional Plan: Air, Land and Water¹ (PARP:ALW), which amongst other matters, provides the proposed objectives, policies and rules for the disposal of sewage in the region. Following notification, submissions relevant to sewage discharges were heard by ARC Councillors in Hearings in August 2003. The decisions on the proposed plan, the "PARP:ALW - Decision Version 2004" are due to be released in August 2004 and may then be subject to appeals. Any provisions not subject to appeal will become effective from the date the appeal period closes.

The Objectives of the PARP:ALW plan, with respect to sewage discharges, are covered in Section 5.3 of the Plan, with specific objectives specified in Parts 5.3.1, 5.3.2, 5.3.8 to 5.3.10 in the notified version. A key objective states it is an objective *"to encourage land application disposal of sewage where appropriate."* In the case of onsite disposal, this must be balanced against the following objective which aims *"To avoid significant adverse cumulative effects on water quality arising from single lots or multiple on-site systems."*

A key policy (Policy 5.4.16 in the notified version) *"Promote[s] the reuse of treated sewage and sewage solids where it can be demonstrated that:*

- a) *The extent and nature of the wastewater and solids will not pose a threat to the environment or to human health;*
- b) *The current and proposed future use of the land will not be adversely affected; and*
- c) *Ground and surface water resources are not at risk of contamination."*

The next section states, *"When considering the use of on-site sewage treatment and disposal systems for new subdivision and/or land use intensification, regard shall be had to the potential for cumulative adverse effects."*

¹ At the time of printing, the current version of this plan was titled *"Proposed Regional Plan: Air, Land and Water, (Notified October 2001)"*

This is followed by a policy, which states, *“When considering on-site sewage treatment and disposal, regard shall be had to:*

- a) *Adverse public health and environmental impacts on water quality and amenity values;*
- b) *The location and proximity of the discharge to other discharges, and cumulative effects on the receiving environment;*
- c) *The feasibility of connecting the discharge to a sanitary sewer or decentralised system and whether that connection is the 'best practicable option';*
- d) *The system design and whether the volume of the discharge, level of contaminants and rate of discharge has been minimised to the greatest extent practicable;*
- e) *Whether the type of wastewater treatment system is suitable for the site and conditions; and*
- f) *Whether the method of land application is appropriate for the site and conditions.”*

Rules in Part 5.5 of the PARP:ALW², apply to the discharge of domestic wastewater and specify the criteria for permitted activities, controlled activities³ and discretionary activities. In particular, the Plan specifies permitted activity (PA) criteria for the On-site Disposal of Domestic Wastewater. These are activities that must be permitted as of right, providing certain criteria are met. Details of the PA criteria are provided in Section 2.6.2 and further in Appendix C⁴, attached. Activities that do not meet the PA criteria require an ARC resource consent for the discharge of contaminants.

The Rule for On-site Domestic Wastewater Disposal up to the printing of this manual has been the Transitional Regional Plan. This remains the operative Rule until the new Regional Plan becomes operative. Once the "Proposed Auckland Regional Plan: Air, Land and Water Decision Version 2004" is released, any rules that are under appeal, will be given effect to wherever they are more stringent than the rules already in existence, in the ARC Transitional Regional Plan.

The criteria for a PA for On-site Domestic Wastewater Disposal in both the Transitional and the Proposed Regional Plans require that wastewater treatment and disposal systems designs comply fully with the design criteria specified in TP58. TP58 is not a statutory document in itself, under the Resource Management Act 1991, but it is a technical guideline manual, developed by ARC to provide suitable design standards for on-site wastewater treatment and land application systems in the Auckland region.

2.2 PUBLIC HEALTH

Protecting public health has been the prime reason for the treatment of wastewater and other aspects of sanitation. There is a major overlap between public health and environmental protection, although one or the other may be more prominent in a given situation.

2.2.1 The Health Act

The Health Act 1956 gives territorial authorities a duty to “improve, promote and protect” public health (Section 23), primarily through the detection and abatement of “nuisances”, i.e. conditions likely to be injurious to health or offensive.

Statutory nuisances injurious to health are defined in Section 29. Nuisances are defined as including any pool, ditch, gutter, watercourse, sanitary convenience, cesspool, drain or vent pipe, any accumulation or deposit, and any premises, which are in such a state as to be offensive or likely to be

² *At the time of printing, the current version of this plan was titled “ARC Proposed Regional Plan: Air, Land and Water, (Notified October 2001)”*

³ *There is no “controlled activity” criteria specified in the Transitional Regional Plan*

⁴ *It is proposed to continue to update material in Appendix C as the appeals are resolved and the relevant rules come into force.*

injurious to health, or to harbour or to be likely to harbour rats or other vermin. Penalties for permitting or causing nuisances are provided for in Section 30 [Ref 42].

Councils may apply to the District Court for an abatement order or issue abatement notices if needed urgently (under Section 33 and 34 of the Health Act). Costs are recoverable from the property owner. The nuisance provisions are useful for responding to situations where public health could be at risk, although fines are small. While there are no provisions for preventing nuisances from arising through the Health Act, it would be unwise of a consenting authority to grant a resource consent or building consent under the Resource Management Act where a nuisance would be likely to result [Ref 42].

Section 39 prohibits any building or part of a building used for dwelling from being built, sold, let, or occupied unless it has adequate water supplies and waste water disposal facilities, in accordance with the Building Act. Section 25 allows the Minister of Health to direct local authorities to provide sanitary works, but this is rarely used [Ref 42].

Sections 41 and 42 allow territorial authorities to issue cleansing orders, closure orders or require repairs if residential facilities are insanitary, including associated structures such as waste water treatment systems. Section 44 allows Medical Officers of Health (with approval of the Director General of Health) to issue such an order where a local authority doesn't [Ref 42]. Section 54 relates to septic tank desludging and sludge disposal and specifies that they are "offensive trades, which require authorisation by the local authority and Medical Officer of Health.

Section 60 covers the offence of polluting watercourses, including those used for municipal water supply. Penalties in the RMA are far greater.

2.2.2 The Environmental Health and Public Health Services

Each territorial authority has Environmental Health Officers who administer most of the provisions in the Health Act related to nuisances and sanitation, and the Building Act.

Public Health Services, which are part of District Health Boards, provide advice to councils, members of the public and government departments on strategic and operational sanitation issues, and have some role in administering the parts of the Health Act related to nuisances and sanitation.

In Auckland, the Auckland Regional Public Health Service (ARPHS) is part of the Auckland District Health Board, but also provides a range of regulatory public health and health promotion services for the Counties-Manukau and Waitemata District Health Board areas. The section in this edition of TP58 on Reuse of Treated Wastewater (Section 7.7) uses material from guidelines produced by ARPHS.

The ARPHS should be consulted in the case of the design of any wastewater system in the Auckland region that requires an ARC discharge consent, which is outside the scope of relevant ARPHS guidelines and that has the potential to involve significant health risk and/or any potential for human contact with untreated/treated wastewater. The Auckland ARPHS office can be contacted on phone (09) 2621855.

2.3 THE LOCAL GOVERNMENT ACT 2002

The Local Government Act 2002 is the main legislation defining the power and responsibility of local authorities. One of the responsibilities of local authorities in New Zealand is the provision of appropriate facilities and services on behalf of central government, including but not limited to the provision and maintenance of infrastructure and other services for the collection treatment and disposal of sewage. Sections 127 and 128 require territorial authorities to make an assessment of

water and wastewater sanitary services, including the use of on-site wastewater systems, in their district. Section 127 requires that assessments relating to sanitary services include:

- (a) *a description of the sanitary services provided within the district for each community in it; and*
- (b) *a forecast of future demands for sanitary services within the district...*
- (c) *a statement of the options available to meet the forecast demands....*
- (d) *a statement of the territorial authority's intended role in meeting the forecast demands...*
- (e) *a statement of the territorial authority's proposals for meeting the forecast demands...*
- (f) *a statement about the extent to which the proposals will ensure that public health is adequately protected.*

The Water and Sanitary Services assessment is used to formulate forward strategies for these activities. The reports set out the proposed policies for sustainably managing the water and sanitary services for consideration. The first versions of these assessments are to be reported to the Minister of Local Government by 30th June 2005. This will follow consultation concerning the assessments with the community other and interested stakeholders, and the adoption of resulting policies being incorporated into the local authority's Long Term Council Community Plan.

2.4 IWI VALUES AND RELEVANCE IN THE STATUTORY CONTEXT

The effects of sewage and storm water discharges into waterways and degradation of water quality is of concern to tangata whenua. Many activities involving the handling of wastewater have the potential to adversely affect the relationship of tangata whenua and their culture and traditions with their ancestral lands, water, sites, waahi tapu and other taonga. Issues of particular concern to tangata whenua include the discharge of any liquid wastes directly to waterbodies and the mixing of different types of liquid waste e.g. sewage and storm water.

All persons exercising functions and duties under the Act are required to specifically have regard to the effects of the activities on the relationship of the tangata whenua of the catchment and its environs. (*Sections 6(e), 7(a) and 8 of the Resource Management Act 1991, are further outlined in Section 2.1.1 above.*)

Section 6(e) of the RMA requires that "*all persons exercising functions and powers under the Act shall recognise and provide for the relationship of Maori and their culture and traditions with the their ancestral lands, water, sites, waahi tapu, and other taonga*".

Section 7(a) of the RMA requires the ARC to have particular regard to "*Kaitiakitanga*"; being "*the exercise of guardianship by the tangata whenua of an area in accordance with tikanga Maori in relation to natural and physical resources; and includes the ethic of stewardship*" (as defined in the Resource Management Amendment Act 1997) [Ref 22].

Section 8 of the RMA requires that "*In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).*" No formal codification of these principles exists but a useful guide is "Taking into account the principles of the Treaty of Waitangi: Ideas for the implementation of Section 8 Resource Management Act 1991, Ministry for the Environment, 1993".

Furthermore, Chapter 3 of the Auckland Regional Policy Statement (1999) (ARPS) states the objectives and policies to address matters of significance to iwi in resource management in the Auckland Region. These include Policies 3.4.10 and 3.4.13, which requires the customary rights of tangata

whenua and enabling the practical expression of kaitiakitanga, to be considered in assessing resource consents.

Policy 3.4.10

"The management of natural and physical resources shall take into account the effects on relevant Treaty claims and/or customary rights of Tangata whenua."

Policy 3.4.13

"In the exercise of their responsibilities under the RM Act, the ARC and TAs will enable the practical expression of Kaitiakitanga by Tangata Whenua."

Policy 8.4.24 further requires that:

"Maori cultural and traditional values shall be recognised and provided for in the management of water quality"

It is the view of tangata whenua that by passing water through or over land, its mauri (life force) is restored and as it mixes with natural waters the mauri of the receiving waters is not impaired. Interpretation by Auckland Regional Health Services of an analysis by Durie [Ref 22] of the Maori view of health and the need for balance and harmony with the environment, suggests that for Maori, the environmental aspects of wastewater treatment and reuse are not distinguishable from the public health aspects [Ref 42].

The requirements of the RMA and the ARPS that tangata whenua values are to be recognised through the sustainable use of air land and water, promotes the application of wastewater to land and where appropriate, its reuse, rather than its discharge and disposal to water. Consequently, ARC encourages through the Regional Plan and thus through its regulation of permitted, controlled and discretionary activities, that all domestic wastewater in the Auckland region is discharged to land for further treatment and rejuvenation in the soil in the first instance wherever this is practicable. Furthermore, it promotes the separation of different types of liquid waste and to facilitate appropriate treatment and disposal.

The ARC holds a number of iwi and hapū planning documents. Many of these documents contain specific reference to storm water, wastewater and water quality issues. The documents are valuable for obtaining a broad understanding of these issues and can be obtained from the ARC.

ARC requires that consultation is undertaken with relevant iwi representatives as part of applications for Resource Consent, where the activity does not comply with the criteria of a permitted or controlled activity and/or has the potential to result in an adverse effect on land or water quality. Chapter 2 of the Regional Plan provides policies that specify that iwi have input and involvement when ARC is considering consent applications. Consultation should be undertaken with the tangata whenua⁵ that are identified as having mana whenua (customary authority exercised by an iwi or hapu group in an identified area). Consultation may also be required with Maori who have ancestral interests in an area. Information concerning advice on appropriate tangata whenua representatives for particular iwi or hapu (areas), in addition to information concerning iwi planning documents, can be obtained by contacting ARC Enviroline, phone (09)3662000.

Where tangata whenua express interest in an application, and/or there is indication that they could be considered a potentially affected party, ARC will also require their written approval before non-notification of an application is likely to be considered.

⁵ The relevant tangata whenua contact details for a catchment in the Auckland region can be obtained from ARC Enviroline on phone 09 3662000.

2.5 THE BUILDING ACT

The installation of an on-site wastewater system requires authorisation via a Building Consent under the Building Act 1991 (administered by territorial local authorities). Section 32 of the Building Act provides that *"building work" subject to certain exceptions shall not be commenced without a building consent*. Building work is defined in Section 2 as *".work for or in connection with the constructionof a building; and includes site work"*. Building is also defined in Section 3(1) as *"..including any utility system attached to and forming part of the structure..., excluding systems owned or operated by a network utility operator for the purpose of reticulation of other property ..."*.

Through building consents, the local authorities can ensure that on-site wastewater systems are appropriately installed and can operate so as to not pose a threat to public health. The performance requirements of systems that store and treat wastewater are given in the New Zealand Building Code 1992, which is contained in the First Schedule of the Building Regulations 1992.

On-site wastewater treatment systems and associated land application areas, are classified as a building in Section 3 of the Building Act 1991.

Treatment systems must meet the requirements of the Building Code in respect to:

- Clause B1 - Structure
- Clause B2 - Durability
- Clause G1 - Personal Hygiene
- Clause G13 - Foul Water (sanitary drainage, sanitary plumbing)
- Clause G14 - Industrial Liquid Waste (includes on-site foul water)

The NZ Building Code also requires compliance with public health and environmental standards. The most relevant provisions of the Building Code are as follows:

G13.1 The objective of this provision is to:

(a) Safeguard people from illness due to infection or contamination resulting from personal hygiene activities; and

(b) Safeguard people from loss of amenity due to the presence of unpleasant odours or the accumulation of offensive matter resulting from foul water disposal.

G13.3.2 *The drainage system [for foul water] shall:*

(a) Convey foul water to an appropriate outfall;

G13.3.4 *Where no sewer is available, an adequate on-site disposal system shall be provided for foul water in the same manner as detailed in clause G14.*

G14.3.2 *Facilities for the storage treatment and disposal of industrial liquid waste shall be constructed:*

(a) To avoid the likelihood of contamination of soils, ground water and waterways except as permitted under the Resource Management Act 1991.

It is important to be aware that while the Building Act allows for the construction of on-site wastewater systems in accordance with the provisions of the Building Code, the discharges from such systems are covered under Section 15 of the RMA. The provisions in Section 15 refer to the need for discharges to comply with “*the rules in a Regional Plan or a consent*”. Relevant Rules of a Regional Plan, as imposed by a regional council, or of a discharge consent specify the design criteria the system design must meet, before any discharge from the system is authorised under the RMA. This means it is regional council rules and/or a consent under the RMA and not the Building Act that ultimately specify design criteria for an on-site wastewater system.

2.6 STATUTORY PROCESS FOR THE DISCHARGE WASTEWATER (IN THE AUCKLAND REGION)

2.6.1 Categories of Activities

In the Auckland Region, the rules in the Proposed Regional Plan: Air, Land and Water (PARP:ALW) determine the category of an activity for on-site wastewater discharge activity and the type of consent required. The types of activities specified in the PARP:ALW are:

- *Permitted Activity* - No consent is required for activities specified as permitted activity, providing all the specified permitted activity criteria are complied with. Subject to compliance with these criteria, the activity can be carried out as of right providing relevant building consents are obtained from the local authority.
- *Controlled Activity* - A resource consent is required and the ARC exercises control over the specified matters. Consent cannot be refused for a controlled activity that meets the standards and terms set out in the plan. However conditions may be imposed in respect of the matters over which the ARC exercises control.
- *Discretionary Activity* - A resource consent is required for any other activity, that complies with the criteria for a discretionary activity, and the ARC may grant or refuse such an application. An application for a discretionary activity is assessed for its compliance with the design guidelines in TP58 and/or with any other relevant literature and design guidelines and in terms of the potential environmental effects of the activity and subject to RMA provisions. All such applications are assessed on a case by case basis.
- *Prohibited Activity* - No consent can be granted for an activity that is listed as a prohibited activity.

2.6.2 Permitted Activities in the Auckland Region

In the Auckland region, as part of any on-site wastewater treatment and disposal system assessment, the designer must determine whether the proposed discharge it is likely to comply with the criteria for a permitted activity, a controlled activity or a discretionary activity, as specified in the Proposed Regional Plan: Air, Land and Water⁶ (the Regional Plan).

While ARC has overarching responsibilities for wastewater discharges within the Auckland region, responsibilities for approvals of permitted activities has been designated to local authorities, occasionally in conjunction with ARC. ARC can require a discharge consent for any activity that may appear to comply with permitted activity (PA) criteria where doubt remains or where there is any uncertainty with respect to potential adverse effects.

In order for a discharge to be a PA it must comply with key specified criteria or a discharge consent will be required. The Regional Plan includes a rule to authorise existing systems that were lawfully permitted at the time the new rules came into force, providing certain criteria continue to be met. Concerning the proposed new rules for new or modified on-site domestic wastewater systems, there

⁶ It is proposed to continue to update material in Appendix C as the appeals are resolved and the relevant new rules come into force.

are two preliminary requirements and then a number of key system design criteria, all of which must be complied with.

For the proposed new PA rules, two initial tests are involved. Firstly, the maximum daily discharge volume, which must be less than 2000litres. Secondly, the gross lot area to discharge volume must be either greater than 1.5 under the First PA rule (Rule No. 5.5.20). This rule also requires secondary treatment and disposal by drip irrigation in accordance with TP58, along with other design criteria. The gross lot area to discharge must be greater than 3 under the Fourth PA rule (Rule No. 5.5.23) for larger sites (which provides more flexibility in the type of treatment and disposal system but does still require that the design is in accordance with design criteria in TP58).

Other criteria in all PA rules involves specifications for the level of treatment and type of disposal system required, with all design specifications needing to be in accordance with design criteria in TP58. Two other PA rules (Rule No. 5.5.21 and 5.5.22) exist for systems lawfully in place when the rules came into force in September 2004 and for systems where there is no permanent power supply.

Further details of tests required to determine compliance with ARC PA criteria are provided in ARC Technical Sheets in Appendix C. Table1 in this Technical Sheet sets out a comparison of lot sizes versus design flows that can be accepted within the PRP:ALW PA rules. Note that the upper limit for design flow beyond which a discharge permit is required in all cases remains at 2,000litre/day.

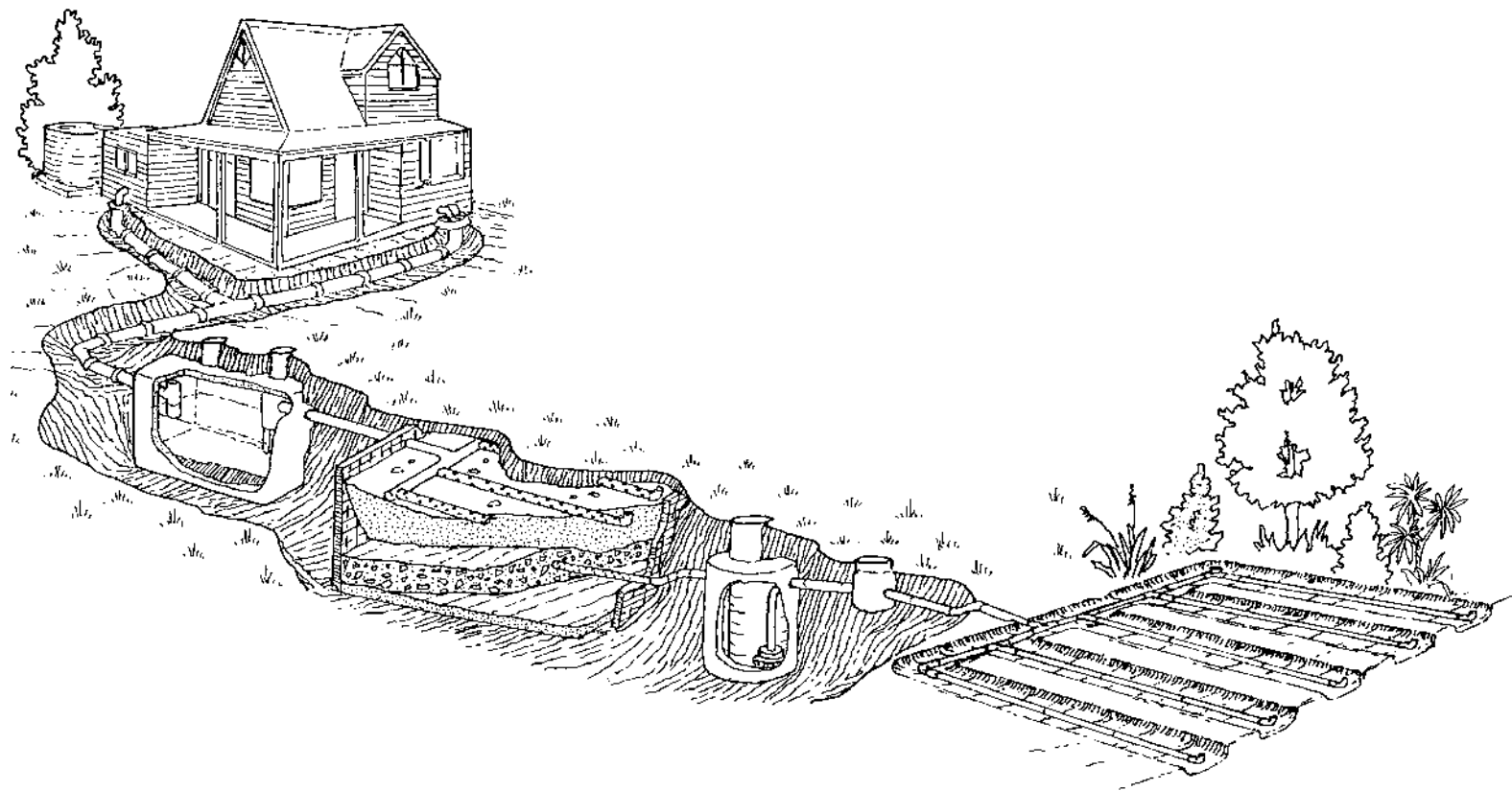
2.6.3 Notification/Non-notification of Resource Consent Applications

Authorisation for controlled or discretionary activities involves obtaining a discharge consent from the ARC. Pursuant to Section 93 of the Resource Management Act, a resource consent application must be publicly notified, unless it is for a controlled activity or the consent authority is satisfied that the effects of on the environment will be minor

The criteria of a PA have been developed so as to ensure that providing all the criteria are met, then the effects of the proposed activity will be minor. For a PA, it is also deemed that no person will be adversely affected by the activity. On this basis, consultation and affected party approvals are not required for PA's. This also applies to applications for controlled activities. However, Section 94(c) of the RMA allows a consent authority to publicly notify an application for a controlled activity, in certain circumstances.

Applications for discretionary activities are required to be publicly notified in accordance with Section 93 of the RMA, unless the authority is satisfied that the effects of the proposed activity will be minor **and** written approval is obtained from affected persons in accordance with the provisions of Section 94. If such approval is not obtained, Section 94(1) requires the consent authority to serve notice on all affected parties. This includes those parties who may have already provided written approval.

3> Introduction To On-site Wastewater Management



3. INTRODUCTION TO ON-SITE WASTEWATER MANAGEMENT

3.1 AN OUTLINE OF ON-SITE WASTEWATER MANAGEMENT

The application of wastewater to land can provide significant benefit to the receiving environment over time if appropriately designed, installed and managed. The sustainability and corresponding benefits of a land application system are dependent upon a number of key factors. These include:

- A comprehensive assessment of site constraints prior to the design stage (refer to Sections 4 and 5);
- An appropriate treatment system design involving the determination of the appropriate quantity and quality of wastewater to be applied (refer to Sections 6 and 7);
- The methodology of application of the wastewater to land and system design (refer to Sections 8, 9 and 10);
- The installation methodologies (refer Section 12.1); and
- Lastly, on going system maintenance is critical to ensure a system's long term effectiveness (refer to Section 12.2).

New technologies have enabled the production of high quality treated wastewater, and its recognition as a resource for beneficial reuse. Recent trends towards sustainable development and environmental protection, have led to increased community views that wastewater should be kept away from natural water to reduce pollution of surface water and groundwater. Both these factors have resulted in a trend towards increased need for wastewater reuse, particularly in situations where there is a need to address difficulties in disposal. However, any system involving the reuse of wastewater must consider both the protection of public health and of the environment.

3.2 DEFINITION OF ON-SITE DOMESTIC WASTEWATER MANAGEMENT

Domestic wastewater is the liquid waste or sewage discharged from residential households or human wastes of a similar character discharged from other facilities. Domestic wastewater includes wastewater discharged from toilets, bathrooms, sinks, showers, baths, laundries and kitchens, dishwashers, sinks and garbage grinders. The types of facilities that typically generate such wastewater include dwellings and other residential institutions such as motels, rest homes and equivalent accommodation units, as well as facilities servicing schools, cafes, restaurants, offices, commercial premises, and other public facilities. Non-domestic wastewater flows require special site specific system designs and are outside the scope of this manual. Commercial wastewater flows (other than domestic flows from lunch bars and staff toilet facilities) are excluded from this manual, as are any "trade" wastes, such as processing wastewater from vegetable, meat and dairy products facilities, wineries, car wash facilities, breweries and the like, located in unsewered areas in rural localities.

The term "*On-site Domestic Wastewater Management*" was introduced by AS/NZS 1547:2000 [Ref 1] to replace the term "*on-site wastewater disposal*". This change was intended to reflect a focus on achieving sustainable public health and environmental performance from on-site wastewater systems by ensuring that site assessment, the assessment of environmental effects, and system selection and implementation, are supported by a management and control process that acknowledges ongoing monitoring and maintenance.

An "*on-site wastewater management*" system is a system that provides the treatment and return to the environment of domestic wastewater residuals within the boundaries of its property of origin. Such a treatment system includes a *primary* treatment stage (such as a septic tank) and in many systems installed since the 1980s, also includes *secondary* treatment, such as an aerated wastewater

treatment system or filter treatment unit. The treatment system is then followed by an effluent land application system, such as soakage trenches, or drip irrigation lines. For the purpose of this manual, ARC has continued to use the older terminology of "*wastewater/effluent treatment*" and "*wastewater/effluent disposal*", when referring to specific aspects of on-site wastewater management systems. The more recent terminology of "*land application*" is also used at times in these guidelines with the more conventional term of "*land disposal*". Land application recognises the important further treatment provided in the soils rather than regarding the soils as solely a means of effluent disposal. The receiving soil system plays an important role in the further treatment and renovation of both primary and secondary effluent before that effluent is finally assimilated into the natural environment. However, despite the appropriate meaning of the term land application within the subject of this manual, it is recommended that it is used with caution in the New Zealand context where it is easily and frequently confused with common abbreviated terms for "*land use consent applications*" and others.

3.3 TYPES OF ON-SITE DOMESTIC WASTEWATER SYSTEMS

In conventional systems, on-site wastewater management involves a combination of both conventional septic tank and soakage trench system, which was in the past the most common type of on-site system for domestic wastewater. However, the advent of a whole range of technology and design approaches in the late 1980's and 1990's expanded the options for wastewater servicing of unsewered areas.

3.3.1 Types of Treatment Systems

Primary treatment involves separation of bulk solids, grease and grit from the main liquid stream. Solids are removed by the physical process of gravity settling, and greases and oils are removed by cooling and floatation in quiescent conditions. Due to the low oxygen levels, the accumulated sludge solids are subjected to anaerobic biodegradation and the primary treated wastewater discharged is usually also anaerobic. Septic tanks, as primary treatment units, should now always include "*effluent outlet filters*". These are very effective low cost devices that are installed at the outlet of a septic tank to control solids discharge to the land application area. They can be installed in new septic tanks or easily retrofitted into existing tanks. The design of conventional septic tank primary treatment systems are now also frequently supplemented by siphon and pump dosed systems discharging to the disposal system or followed by a secondary treatment system.

Pretreatment options can also be included, involving grease traps, gross solids collection screens, macerating pumps and waterless toilet units (such as chemical toilets) or composting toilets which discharge only the liquid component of the waste flow to the septic tank and/or disposal system.

Secondary treatment involves biological processes to biodegrade the organic contaminants in the wastewater. The biodegradation process is enhanced by aerobic conditions, so therefore secondary treatment processes usually involve aeration, such as aerated wastewater treatment systems (AWTS), or controlled dosing to maintain aerobic conditions, in the case of sand or textile filters. Removal of the biomass generated in the biological process from the treated wastewater prior to its discharge is critical to ensure a high final effluent quality. Biomass is removed either via clarification/sedimentation processes in AWTS systems and filtration and biodegradation in filter systems. There are many types of treatment systems for domestic use within the range of AWTS systems, intermittent, recirculating and intermittent bottomless filter units. There is also the more recent treatment option is the recirculating textile filter unit, which are only available as recirculating systems. Sand and textile filtration systems are also known as packed bed reactors (PBR).

Tertiary treatment involves further *polishing* of the secondary treated wastewater to further remove remaining organic and physical contaminants. This can be achieved by reducing nutrient levels by complex modifications to the flow regimes and aeration within the system, further filtration to

remove remaining suspended material and pathogens (e.g. further sand filtration, membrane filtration) and/or, disinfection to destroy or reduce pathogen levels by practices such as chemical treatment (e.g. chlorination) or radiation (ultraviolet light), and other less common methods. The solids and biomass generated by the treatment process is also referred to as sludge. This can be collected and returned to the head of the treatment process (usually the primary tank). However, eventually some may need to be removed from the treatment system for off-site disposal, to ensure sufficient treatment capacity remains within the system and effective treatment. The frequency of removal required depends on the system loading and design and the wastewater characteristics.

Further variations on standard treatment options include vermicomposting, recycling or reuse of disinfected treated wastewater for toilet flushing and reuse of treated wastewater or grey water either for toilet flushing or irrigation.

Design details for all the above treatment options are provided in Chapter 7. Final treatment of the applied wastewater is provided by the soils in the land disposal system. Therefore appropriate design of the land disposal system is necessary to achieve optimum distribution into the soils and to maximise this further treatment potential.

3.3.2 Types of Land Disposal Systems

With the need for environmental protection becoming an increasingly important consideration in system design, there has been a significant trend, over the past 10 to 15 years, away from the concept of "disposal" of wastewater to ground at depth by conventional soakage trench or bore type systems. This has been replaced by increased consideration of land application of the wastewater via shallow "irrigation" systems, to assist with vegetation growth. Supporting this evolution in thinking is the availability of improved electrically powered on-site treatment systems, which can produce higher quality wastewater with low solids content, and by the use of siphon and pump dosing systems to distribute treated wastewater throughout an irrigation field. The use of drip irrigation systems using pressure compensating drip emitters now enables uniform wastewater distribution throughout a land disposal area and better control on the placement of irrigated wastewater within the soil profile. The availability of drip irrigation systems for secondary effluent enables land application disposal to be combined with the use of treated effluent for landscape development and enhancement of vegetation within the property being serviced by the on-site system.

Conventional land application systems, involving gravity fed trenches, conventional soakage beds, advanced bed systems such as evapotranspiration beds, and a variety of mounded systems and spray irrigation, are still in use but have generally been superseded in most instances by drip irrigation systems. Drip irrigation systems are an effective land disposal option relative to conventional disposal systems providing improved wastewater distribution but do require a more advanced and therefore costly prior treatment process. The benefit is that this additional cost is somewhat off set by the significant cost savings with installation of a drip irrigation disposal system compared to conventional subsurface soakage system. Deep bores are no longer permitted to be installed in the Auckland region, due to their proven lack of potential on most sites for adequate rejuvenation of contaminants in the wastewater in the soils prior to contact with groundwater.

Design details of the above treated wastewater disposal options is provided in Chapters 9 and 10. A schematic diagram showing the layout of the typical components of a modern on-site wastewater treatment and disposal is shown in Figure 3.1.

3.3.3 Alternatives to On-site Systems

Decentralised or cluster systems are community systems serving two or more dwellings with wastewater disposal on a different site from where it is generated. They are generally much smaller in scale than centralised systems, with the design concepts similar to those of on-site disposal systems.

The wastewater from each cluster or group of dwellings or facilities may or may not be discharged into a combined off-site treatment system or systems. Partial on-site pretreatment prior to a combined secondary treatment is commonly seen as the most cost effective option for a decentralised treatment and disposal system. The advantages of this are that the bulk solids are retained on the site of origin and can remain the responsibility of the site owner and the cost of reticulation pipe work is dramatically reduced by the ability to then use of small rather than large bore pipes, which also have the additional advantage if properly installed of being significantly less susceptible to storm water or groundwater infiltration. The combined wastewater flows from all sites/facilities usually then involve the discharge to a combined off-site land disposal system.

The need to consider the on-site or off-site wastewater management at the early subdivision design stage and the comparison of the different options and other necessary considerations is discussed in Section 4.3.

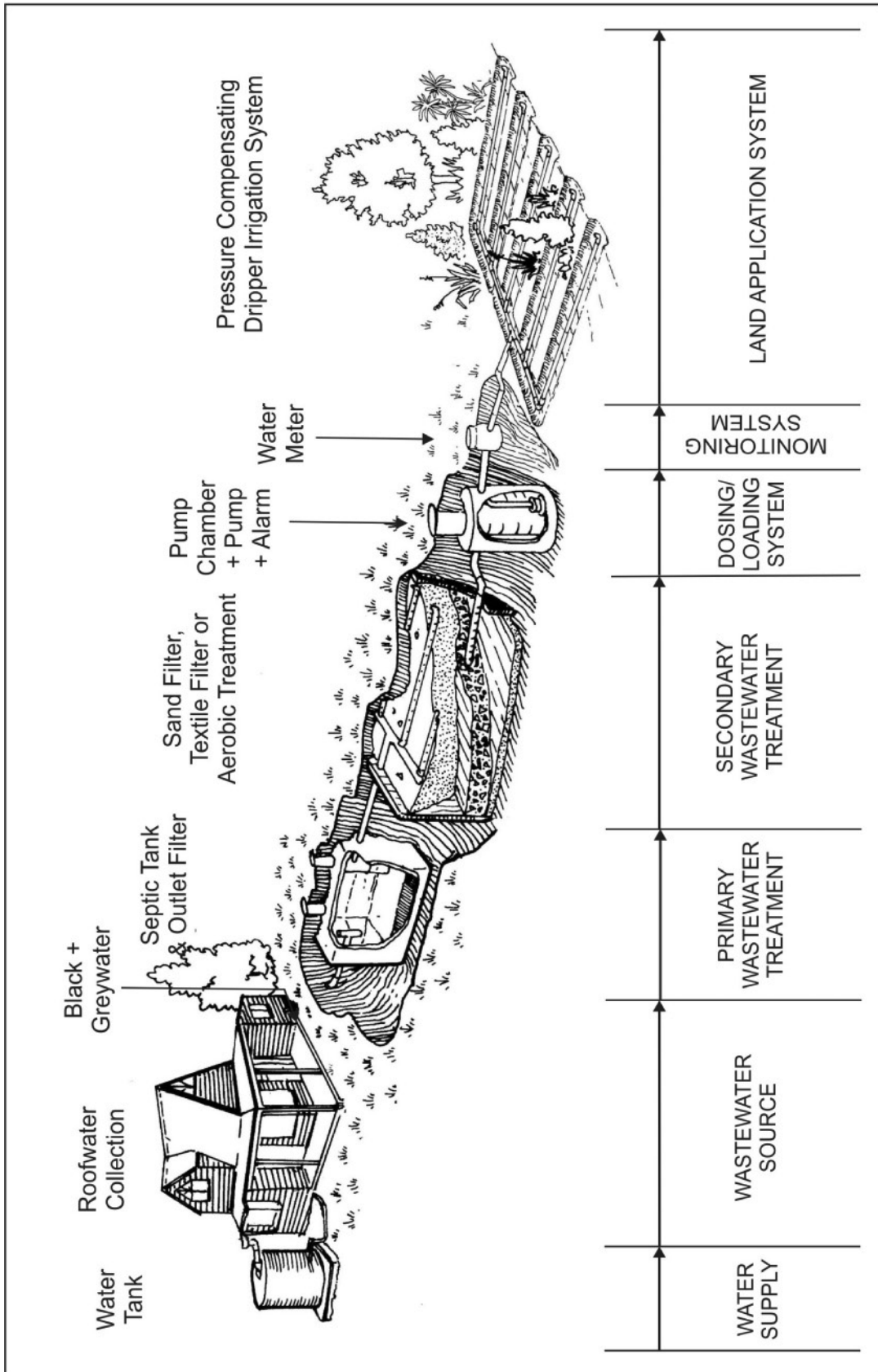
Centralised systems involve the collection and transport of untreated wastewater to a central municipal treatment site, normally managed by a local authority. The treatment plants usually involve advanced technology components and up to daily inspections, monitoring and management by a specialised system operator. The maintenance costs for such systems can be substantial compared to smaller systems. The size and complexity of the treatment system is dependent on the size of the community served and on the types of waste flows received. Due to the volume of wastewater involved, relative to limited land availability, these systems often discharge into natural water and individual systems are outside the scope of this manual.

3.4 ENVIRONMENTAL EFFECTS OF ON-SITE LAND DISPOSAL SYSTEMS

The application of treated wastewater to land can result in impacts on groundwater and surface water quality, soil structure and vegetation, and in the event of failure or other problems, has the potential to affect public health and the amenity value of land.

On-site wastewater land disposal systems add organic matter, nutrients, and microorganisms to the subsoil and groundwater. If sufficient free draining soil is provided between the land application area and the highest seasonal groundwater table, then the natural biological processes within the soil "treat" the applied wastewater residuals discharged. This results from the soils ability to degrade and stabilise organic matter, as well as filtering and providing for the die off of wastewater microorganisms (including pathogenic intestinal bacteria and viruses). These processes minimise potential effects on groundwater quality. Aerobic soils, achieved by unsaturated conditions from timer/demand dosed systems using low application rates, rather than gravity fed land disposal systems, are most effective in accomplishing such in soil treatment.

Figure 3.1: Schematic of On-site Wastewater Treatment and Disposal System



Significant treatment levels by soil microorganisms are obtained by the travel of wastewater through a few centimetres of soil, with the most significant reduction occurring in the surface topsoil horizon. Nutrients, such as phosphates, are often absorbed well by finer soils such as clay-loams and clays, but nitrogen derivatives, such as ammonia and nitrates, may only be partially absorbed and removed via plant uptake. Where nutrients such as nitrogen compounds are of environmental significance, (for example nitrate effects on groundwater used for potable purposes), they may have to be managed by the provision of additional pretreatment of the wastewater prior to discharge to land. The removal of nutrients in soil is addressed in Section 11.

Where the land disposal system becomes “water logged” with effluent lying against the base and sidewalls of a soakage system, such as in a conventional trench, the soil treatment mechanism becomes anaerobic. Although anaerobic processes work at a slower rate than aerobic processes, they are, nevertheless, an effective treatment mechanism of waste residuals given time. An anaerobic slime layer build up on the infiltrative surfaces will accomplish significant treatment, although it also seals the soil infiltration surfaces and reduces the capacity of the system to transmit effluent into the soil.

Where a land disposal system is under designed, overloading may result in effluent breakout onto the surface. Breakout is indicative of system “failure” and has the potential to lead to environmental and public health effects. Methods of improving the potential for on-site system performance include reducing the wastewater flow, increasing the land disposal system size by using more conservative design loading factors, increasing the level of pretreatment or installing a more appropriate land disposal system that is tailored for the site constraints.

In areas dependant on on-site land application systems, it is important that the density of development is controlled to ensure that cumulative effects from the addition of wastewater to the soil and groundwater system are provided for in system design considerations. Providing wastewater treatment and land application systems are selected and sized appropriately to the soil and site conditions, and that the density of development and the level of treatment are such as to avoid individual or cumulative adverse effects, then sustainable public health and environmental performance requirements can be met. Ongoing system maintenance is critical to ensuring these design performance requirements continue to be met to achieve minimal cumulative effects in the long term (refer Section 12.2).

3.5 EFFECTIVE ON-SITE WASTEWATER MANAGEMENT PRACTICE

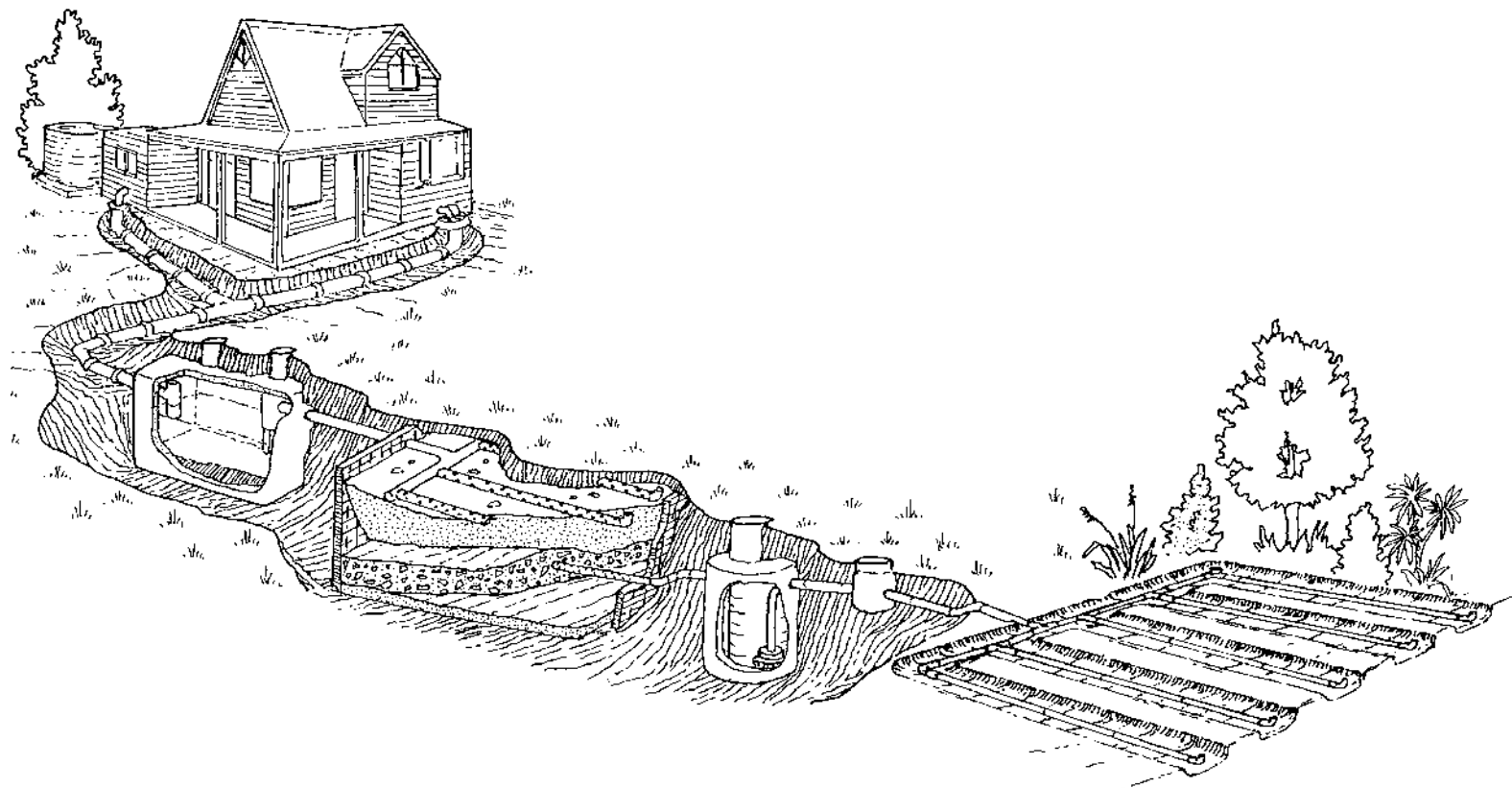
The key principles associated with achieving effective implementation and performance of on-site wastewater systems are:

- Ensuring a comprehensive predesign **site and soil evaluation** is undertaken;
- Ensuring a realistic and **conservative design flow volume** based on a ‘worst case’ peak flow;
- Selecting a **treatment system** suited to both the facility to be served and the site conditions determined by the evaluation;
- Selecting a **land disposal system** loading rate appropriate to soil conditions and environmental constraints;
- Ensuring a comprehensive **assessment of potential environmental effects** on the environment from the land disposal of wastewater is completed;
- Ensuring that the system is **installed** in accordance with the design and the manufacturers’ and/or suppliers’ specifications; and
- Ensuring that the whole process of on-site wastewater system management incorporates **informed operation and preventative maintenance** procedures to ensure the system’s satisfactory long term performance.

Both designers and the approving agencies officers must ensure design and approval processes meet these principles. There is a wider expectation by many stakeholders that to optimise the on-site wastewater management system performance, training and educational programmes developed by the on-site industry, in conjunction with regulatory responsibilities, should bring about a better integration of theory with practice. In the longer term, this will provide higher levels of certainty in the effective performance of on-site wastewater systems.

The success of any on-site wastewater treatment and disposal system can be significantly improved through the use of conservative design parameters such as design wastewater production rates, soil loading rates and contingency measures such as emergency storage in pump chambers, high water level alarms and reserve wastewater disposal areas. A further critical factor in achieving this objective will be ongoing operation and maintenance programmes that achieve a consistent management approach.

4 > Design Planning



4. DESIGN PLANNING

4.1 INTRODUCTION

Within the Auckland region there are approximately 45,000 households and businesses in unsewered areas relying on on-site sewage treatment and disposal systems. Provided they are properly designed, installed and maintained, individually they should be an environmentally sound method of effluent disposal. However, localised problems do occur and significant cumulative effects can develop. Problems are commonly from a combination of:

- Poor soil types such as clay soils unable to cope with conventional septic tank and soakage trench systems, especially where high wastewater volumes are generated; and/or
- Shallow groundwater tables; and/or
- Wastewater production exceeding the design flow; and/or
- High densities of septic tank use; and/or
- Insufficient land for ground disposal; and/or
- The land disposal rate exceeding the soil capacity; and/or
- Poor maintenance practices.

Ineffective land disposal can lead to adverse effects on the water quality and amenity values of the region's waterbodies. Adverse effects include eutrophication of waterbodies, public health threats and odour. The recognition of industry advances in the design of treatment and land disposal systems is critical to ensure a sustainable use of resources or best practicable option. As raised in Section 1.3, amendments to TP58 over the longer term will be necessary to ensure that it covers proven technology.

Sites where there are actual adverse environmental effects and/or potential for such effects from on-site disposal of domestic wastewater in the Auckland region, may require discharge consents from the ARC. These include older subdivisions within the Auckland Region having small lot areas and/or sites with modern dwellings with upmarket wastewater producing fixtures and/or a significant number of bedrooms. In such circumstances, the wastewater flow volumes can exceed the capacity of the site, increasing the potential for direct and/or cumulative adverse effects. The requirement for a discharge consent will be assessed against the Regional Council rules for on-site wastewater systems, as outlined in Chapter 2.

4.2 CUMULATIVE EFFECTS

4.2.1 Auckland Regional Policy Statement & Proposed Auckland Regional Plan: Air, Land and Water

The cumulative effects of wastewater discharges are an important factor in water quality and require evaluation. Both the Auckland Regional Policy Statement (ARPS) and the Proposed Auckland Regional Plan: Air, Land and Water (PARP:ALW) outline potential cumulative effects and the assessment required. A summary is outlined below and further detail is provided in TP58 Chapter 2, Sections 2.1.2 and 2.1.3.

The policies and methods in Chapter 8 – ‘Water Quality’, of the ARPS, require an assessment of various options of wastewater disposal systems, including combined and separate treatment and land application systems and the corresponding potential cumulative adverse effects on the environment, in order to provide for the long term protection of water quality. Of particular importance are Policies 8.4.4.1, 8.4.4.2 and the methods contained in 8.4.5.

Method 8.4.5 outlines methods to achieve the policy, with the purpose being *"to ensure that the potential adverse effects, including cumulative effects, of new development and redevelopment, are considered prior to committing an area to further intensification and that adequate controls are implemented as development proceeds to avoid or mitigate adverse effects."*

Chapter 5 ‘Discharges to Land and Water’ of the PARP:ALW Decision Version 2004, contains objectives and policies specifically directed to the potential for adverse cumulative effects from on site sewage treatment and disposal. Of particular importance are the considerations outlined in Objective 5.3.10 to 5.3.12 and Policy 5.4.20.

4.2.2 Cumulative Effects from Individual On-site Wastewater Management Systems

Cumulative effects need to be considered where a number of separate on-site systems are located in close proximity (e.g. more than one dwelling per 3,000m² of total site area). In such situations, the cumulative (combined) effects from a number of separate on-site systems can become significant. Where on-site wastewater systems are determined to be the best longterm solution for wastewater disposal in a proposed development area, appropriate development standards need to be assessed. These should include appropriate locations for combined or individual on-site land disposal systems and lot sizes, before land is approved for subdivision.

While District Plans may contemplate residential development and on-site waste disposal may be technically feasible, there are many situations involving intensification and development with decreasing lot sizes where on-site disposal may not be the most appropriate option. In all cases it is critical that consideration is given to alternative wastewater disposal options at the early planning stages. Reasons for this are provided further below.

In many instances where it is predetermined that wastewater will be managed with on-site disposal systems, it is not known in advance how large the dwellings may be or whether they will be occupied permanently or on an intermittent basis. Therefore, until the dwelling is occupied it remains uncertain how much wastewater will be generated and whether the site will be able to accommodate the peak flows and contain all the effects of the discharge within the site boundaries. Furthermore, even though the dwelling size and/or lot size and characteristics may be large enough to allow for an individual on-site treatment system, the lot size may significantly restrict the size of dwelling and/or wastewater system that can be developed.

A related problem from on-site disposal systems occurs as a consequence of clustering of properties, without adequate provision of open space. The intensification of individual on-site wastewater treatment and land disposal systems within a limited area has the potential for cumulative adverse effects on the environment. Effects can result from the reluctance of an individual site owner to purchase the potentially more costly advanced treatment system technologies and from the need for the land disposal systems to be located on the only undeveloped land on each site. This is often the lowest lying land on each site (to enable discharge by gravity rather than by pump), which means it is often also the wettest land on a site.

The resulting potential cumulative effects can include:

- Potential increased odour;
- Breakout, ponding or channelling of treated wastewater;
- Contamination of storm water drains and corresponding health risks;
- Adverse soil quality and decreasing infiltrative capacity effects over time;
- Increased contaminant loads on groundwater from seepage from a number of systems;
- Decreased (separate from proximity to) watercourses and increased risk of seepage effects downstream off the site of origin;
- Cumulative adverse effects on surface water quality, potentially leading to eutrophication of watercourses;
- Potential increased health risks;
- Aesthetic effects; and/or
- Increased health risk impacts on bathing beaches and shellfish gathering.

To address the above problems with individual on-site wastewater management systems, alternative methods of disposal may be more appropriate while still achieving the objectives of good design.

4.3 ALTERNATIVES TO ON-SITE SYSTEMS: DECENTRALISED WASTEWATER SYSTEMS

A *Decentralised Wastewater Management System* (DWTS) refers to a single combined treatment system serving a group or cluster of sites, compared to the centralised systems, which refer to the reticulation and treatment system serving all properties within a whole town or city. They may or may not involve partial treatment on individual lots, but do involve reticulation of the wastewater from all the lots to a combined treatment system and then land disposal system.

A typical DWTS would comprise septic tanks at individual homes, a package treatment plant serving a cluster of homes within a local drainage catchment, and disposal of treated effluent to public land either within the catchment or close to it. Disposal of the treated effluent would typically be by subsurface trickle irrigation to local soils. However, other options include subsurface irrigation to modified or imported soils or raised beds; surface irrigation of fields and crops; recycling for non-potable use at the homes; or a combination of these design options.

DWTS are well suited to small communities or clusters of homes where land is available for disposal/reuse of the treated effluent. Furthermore, they can provide better certainty of reduced public health risks, odour and environmental impacts on ground and surface water quality. Decentralised systems have considerable advantages in operation and maintenance surety compared to separate individual on-site disposal systems.

They should be operated and managed by external parties such as a Body Corporate or similar private owner, or by the local Council. The local Council would enforce design, construction, and operation and maintenance standards. Consideration at the early planning stage of design alternatives and industry advances in of treatment and land disposal systems, ensures that on-site disposal is a sustainable use of resources or the best practicable option, in accordance with the general purpose of the Resource Management Act 1991.

ARC expects prior consideration be given to combined decentralised or centralised wastewater collection treatment and disposal systems for large scale subdivision proposals at both the structure planning stage by the local authority and then again later by the developer at the predevelopment stage. Key advantages and disadvantages of options of centralised and decentralised systems also need to be closely examined on a case by case basis, and are introduced below in Table 4.1.

Table 4.1: Comparison of Decentralised (DWTS), Centralised (CWTS) and On-site (OWTS) Wastewater Treatment Systems.

Advantages of a DWTS over a CWTS	Advantages of a DWTS over an OWTS
➤ Simplified reticulation system: small diameter pipes, shallow buried, and relatively short lengths.	➤ Ability to select land most suitable for a combined wastewater land disposal system at the early planning stage, reducing potential for adverse effects over time.
➤ Water tight septic tanks and pipes (no manholes, sealed joints) reduce storm water inflow and infiltration.	➤ A communal disposal field could be an attractive feature of the subdivision.
➤ Systems can be designed on an “as required” basis rather than for a predicted future population. Therefore, no large, upfront capital costs.	➤ Homeowners would have a greater sense of security and freedom from responsibility (the flush and forget mentality).
➤ Greater potential for recycling (e.g. for toilet flushing), and reuse of effluent.	➤ Greater ability to design a system suitable for the site constraints providing greater protection of ground and surface waters
➤ No overflows from manholes and pump stations during storms.	➤ Decreased risks of human contact with wastewater and decreased health risks.
➤ Reduced potential for illegal storm water connections and for contaminants to enter the reticulation system.	➤ Improved technology options for a combined system than that likely to be considered for each individual system
➤ No odours from manholes.	➤ Easier to manage (monitor and maintain) by the responsible body.
➤ System failures are isolated and small scale events. They are also easily identified with simple monitoring systems (e.g. telemetric systems to monitor water level in the septic tanks and operation of pumps).	➤ Economies of scale would significantly reduce the final cost per lot, although the initial capital outlay could be higher for the developer.
➤ No single, large volume effluent discharge point.	
➤ Greater options for land disposal to parks, reserves, sports grounds, etc. with corresponding increased public amenity values.	
➤ Greater potential for reuse of treated effluent for wet industries such as greenhouses.	

The reticulation of wastewater enabling combined off-site land disposal also enables the use higher technology advanced combined wastewater treatment systems. This can decrease the risk of human contact and potential health risks, whilst maximising the potential environmental advantages. Options for reuse close to source are potentially more viable, which can then decrease the extent of land required for disposal. This in turn can provide more open space for storm water control and other uses. The economic advantages can include shared costs for a combined system, with capital and operational costs per lot being more representative of actual costs incurred.

Combined decentralised or centralised wastewater systems require resources for viable wastewater management system to be allocated in the early design stage. This includes the allocation of appropriate land for the land disposal system, the allocation of land for and the installation of appropriate reticulation infrastructure, and the provision of adequate funding for treatment systems that provide the best technologies. Guidelines encouraging such consideration are often available at district and Regional Council levels. In the Auckland region, it is therefore crucial to consider decentralised wastewater management systems at the development design stage.

4.3.1 Consideration of Decentralised Wastewater Systems at the Early Planning Stage

Preliminary investigations into options for providing wastewater services to some existing townships, concluded that the cluster approach was the preferred option. Consideration of decentralised wastewater systems at the early planning stage needs to be undertaken against standard robust criteria.

Following is a typical evaluation by a local Council, involving the comparison of individual on-site and decentralised wastewater management options for new developments:

On-site treatment and disposal systems in new subdivisions could be acceptable providing that:

- i. The combination of section size, soil type, ground slope, and final effluent quality is suited to on-site disposal for each and every site in the development.*
- ii. The effluent is treated to at least a secondary standard, and preferably to a tertiary standard (e.g. UV disinfection).*
- iii. The effluent will not run off any disposal areas in wet conditions, where it could lead to health and/or environmental risks.*
- iv. Any effluent reuse meets Department of Health, Public Health Protection requirements.*
- v. The maintenance requirements for each system should be covered by a maintenance contract between each site owner and a professional system maintenance contractor.*
- vi. Adequate monitoring is provided to ensure on going good performance at each and every site in the development, and that proper records are kept of all monitoring results.*

Decentralised systems - A cluster and decentralised wastewater management system approach also has to meet the above objectives but has several significant advantages over the individual on-site approach:

- vii. The above objectives could be more easily achieved and monitored.*
- viii. Economies of scale should significantly reduce the final installation and maintenance cost per lot. While it could result in a higher initial capital outlay, predominantly due to reticulation costs and consequent financial risk to the developer, property buyers could prefer a community system to an on-site system. This is on the basis that this is consistent with the "flush and forget" approach and gives them more choice on how they use all the land they purchase.*
- ix. The maintenance and monitoring requirements for the whole system should be covered by a maintenance contract between the body corporate or equivalent legal entity and an appropriately qualified and skilled service provider/maintenance contractor, to monitor and maintain the systems throughout the life of the subdivision.*
- x. Site owners would have the sense of security and freedom from regular responsibility in accordance with that which is associated with public sewage reticulation systems.*

- xi. Most importantly, a communal disposal field could be located on land that would be most suitable for a sustainable system rather than at the lowest/least accessed area of each individual lot. It could be well planted and developed as an attractive and thriving feature of the subdivision.*

Additional related matters to be considered by the developer could include:

- xii. The requirement for a permanent maintenance contract to be applied in perpetuity on each lot.*
- xiii. Relevant easement rights are obtained.*
- xiv. There is shared responsibility between each lot owner e.g. by a body corporate arrangement and/or with the local Council, for control of the system and to ensure the performance standards continue to be met.*

In summary, a well designed decentralised community system can be considered to provide benefits for both developers and the community that are greater than those available from use of individual on-site systems. In addition to the advantages listed above, an additional potential benefit for the developers would be their resulting reputation for producing a quality, sustainable, and environmentally friendly subdivision. In comparison, individual on-site systems are acceptable provided:

- xv. The treat to an equivalent or higher standard.*
- xvi. There is justification in a particular case that cluster system would not be a viable option, e.g. due to distances between dwellings.*
- xvii. Individual permanent maintenance contracts are entered into between the owner of each lot and the respective system suppliers."*

In cases where combined decentralised systems are not an option, appropriate management of on-site wastewater systems by the system owner(s) is required. In the Auckland region and as stated in the above example, on-site systems in new subdivisions need to meet the objectives stated in points *i.* to *vi.* above.

4.3.2 Case Study

Following are supporting arguments for a decentralised wastewater treatment system in a case study of a proposed development in the Auckland region. In this example a developer wished to pursue on-site wastewater disposal after a decentralised system had been specified as a requirement under the local Council's land use consent for the subdivision. ARC addressed technical concerns raised by the developer concerning a the DWTS system as follows:

- a. Reticulation pipe work difficult to install as most works, including roading and driveways essentially complete and cost savings already spent on aesthetic features: ARC's view was that the development to date would not prohibit reticulation; thrust bore drilling can enable piping under roading without disturbing surfaces. We appreciate additional reticulation costs could be in the order of two to three fold but apparently the total reticulation cost will still be less than \$2,000 per lot. In any event, this is a consequence of your decision to undertake works that were outside the requirements of the land use consent and the corresponding lack of consultation with regulators.*
- b. Properties have been sold without inclusion of cost of a decentralised system: ARC's view was that the while it appreciated the additional financial difficulties possibly imposed on the developer, this is not a strong argument on its own and did not, in ARC's view, outweigh the benefits of off-site disposal, which had yet to be presented to new purchasers.*

- c. *Off-site Disposal by way of a DWTS would be more Expensive:* ARC's understanding was that the quotes received were in the order of \$10,000 to \$16,000 per on-site disposal systems versus approximately \$12,000 per site for a decentralised system. The latter quote was based on the need for a very conservatively designed system to be installed due to the large dwelling sizes and in some cases, luxury facilities anticipated. The lower price quoted for on-site systems were not considered relevant as they applied more to small dwellings with full water saving devices (the latter of which are also expensive and inconvenient and tend only to be used on lots half the size of these). Therefore, costs per lot for on-site systems are likely to be closer to the higher end of the range, which is still greater than the estimated cost per lot of a decentralised system.
- d. *Timing - To achieve effective treatment system start, the developer had been advised that several sites may need to be connected simultaneously, prohibiting staged connections and delaying occupation:* ARC's view from system suppliers was that the argument about stage startup difficulties do not apply to advanced secondary treatment provided by sand or textile filter systems.
- e. *On-site wastewater irrigation could provide benefits to individual property owners:* ARC's view was that while wastewater irrigation could provide some benefit to plant growth on individual sites, it could provide the same benefit to a collective woodlot or vegetation on the allocated shared disposal irrigation land. The option was also acknowledged that should a property owner wish to reuse treated wastewater for irrigation purposes on their site they could have the option of tapping into the treated wastewater supply provided this was covered in the discharge consent.
- f. *Local Council's Position:* The territorial local authority (TLA) were in favour of the use of decentralised systems wherever practicable and were satisfied with the certainty provided by the consent process.
- g. *In this example, some on-site disposal was allowed on higher more remote low density lots. It was considered that these lots had a lower potential for cumulative effects from the clustered sites on lower lying land closer to water. The developer raised arguments concerning inconsistent Joint Venture responsibilities:* It was ARC's view that while there could be an extra complication in cost allocation to land owners by the Joint Venture, it did not consider it would be difficult to address.

Other advantages of a decentralised system discussed with the developer included the ability for the plant to be installed in a modular form, which enables easy extensions if required in future. Decentralised treatment would also enable an easy connection should the wider area need to be reticulated in the future. A well planted irrigated bush area could be an additional positive aesthetic feature on the farm land. In conclusion, ARC did not consider there was sufficient argument to support a change to the TLA land use consent to allow on-site disposal in this case. An effective DWTS was subsequently approved for the subdivision by an ARC discharge consent.

4.4 SITE LAYOUT

4.4.1 Planning and Design of New Subdivisions

Land under consideration for rural residential subdivision should be thoroughly evaluated for wastewater servicing, at the subdivision scheme plan stage. The advantages of both on-site and decentralised wastewater treatment and disposal options need to be considered in detail at this time (refer Section 4.3). It is only once a decision is made concerning the need for on-site or off-site wastewater treatment disposal, that the selection and design of individual lot sizes should proceed.

A detailed soil survey is required in association with identifying topography and drainage features, the potential for individual water supplies from bores, and an assessment of the movement of

remaining contaminant levels in the effluent into groundwater together with any other likely environmental impacts. This process will then lead to the identification of appropriate area(s) on the sites for wastewater land disposal systems and the selection of the most suitable type of on-site system(s) required to match soil types and evapotranspiration potential.

This will then involve making allowance, within the constraints identified above, for the following facilities on the lot area:

- Wastewater land disposal area;
- Reserve area (33% to 100% allowance depending on the land disposal method and land application rate);
- Buffer distances between the primary and reserve disposal areas to boundaries and other facilities including habitable dwellings on the lot;
- Surface water drainage channels;
- Potential flood levels (one in 20 year flood plain, one in 100 year flood plain);
- Gardens, lawn areas;
- Decks, swimming pool, barbecue and other outdoor areas;
- Dwelling, garage, outhouse, workshop; and
- Driveway, front yard.

The specific facilities should be of secondary priority to the locating of suitable land application disposal and reserve areas. These are priority items in terms of longterm maintenance of public health and environmental values. The actual size of each lot will also be dependent on the market for which the subdivision is aimed. Designs for high value housing developments will incorporate larger unit allowances and a greater variety of facilities (particularly in terms of the last four items on the above list).

As detailed in Section 4.3 above, an alternative to subdivision servicing utilising individual on-site wastewater systems is to construct a decentralised community wastewater treatment and land application system. Community based systems have the potential to result in better utilisation of the available land, but need facilities and space provided for at the beginning of the subdivision design process. In some cases, these may include recycling of secondary treated and disinfected wastewater. Reuse of wastewater is discussed further in Section 7.8. In all cases, reuse is only recommended where existing development restricts land availability for land disposal and where all other options of restricting water usage have been applied. This is *not* the case in the early design stages of new subdivisions, where it is more appropriate that sufficient primary and reserve disposal land is allocated early in the design planning stage to ensure land disposal remains an effective long term option.

In conclusion, decentralised or community based systems have the potential to result in better utilisation of the available land. They may comprise a mix of on-site pretreatment (via septic tanks including outlet filters) with combined off-site secondary treatment before combined recycle and land irrigation management of final effluent. Alternatively, all treatment may take place at the centralised location. The end result of the planning and design process will be a subdivision of either a range of lot sizes to match varying soil and topography conditions along with varying market requirements, or a single uniform lot size. If there is a possibility of sewerage servicing by way of municipal reticulation feeding into a centralised wastewater system in future, the planning and design may also give consideration to the potential for resubdivision and cross leasing.

4.4.2 Factors of Safety

The implementation of on-site systems is as much of an “art” as it is a “science”, and hence highly conservative factors of safety against future malfunction and failure must be provided for within design. Those specific design and layout elements, which individually or in total can contribute to the factor of safety, include:

- Establish the design flow based on high water use fixtures.
- Install water conservation fixtures.
- Use secondary or higher level wastewater treatment.
- Install a disinfection system to improve final effluent quality if there is potential for human contact.
- Provide additional treatment to achieve nutrient reduction to protect the receiving environment.
- Ensure all access risers are proud of ground level and watertight.
- Ensure the sewers, tanks and all connection points are water tight to prevent groundwater and storm water intrusion.
- Storm water diversion around the treatment plant.
- Provide 24 hours emergency storage in all pump chambers.
- Install high water level alarms on all pump chambers.
- Pump dose loading of the land disposal system, using timer rather than demand dosing system.
- Use pressure compensating dripper irrigation land disposal system to optimise evapotranspiration.
- Use a conservative areal loading rate (3mm/day or less for moderate to slowly draining soils).
- Install storm water diversion measures upslope of the land disposal system.
- Maximise reserve land disposal area of 50% to 100%.
- Ensure the site owner enters into a maintenance contract for the treatment and land disposal system with the system provider.

Inclusion of conservative design components minimises the risk of premature system failure from higher than anticipated wastewater flows and reduces the load on the land disposal area. The above list provides an indication of the factors contributing to a conservative design approach and should as far as possible be included in any on-site wastewater system. The most conservative system design approach should be used as far as practicable including a generous wastewater flow allowance for design purposes (refer Table 6.2), secondary or higher level wastewater treatment and a conservative areal loading rate applicable to the soil type and environmental constraints.

The least conservative designs include the use of water conservation measures and/or recycling, septic tank treatment and trench land disposal. Although the least conservative designed systems are an acceptable solution in terms of these guidelines, their use in combination is not always appropriate, particularly not for new developments where there extent of uncertainties can be significant, such that a conservative approach is necessary. Designs may include a combination of most and least conservative factors, based on environmental constraints, environmental risks and other safety factors already incorporated within the system design.

Where these design features are omitted from conventional design approaches, the factor of safety is reduced considerably. The prudent designer should always maximise the contingency in a design by

incorporating as full a range of backup measures as is deemed appropriate in their and the regulator's professional opinion for the particular site or subdivision.

4.4.3 Storm water and Groundwater Management

Storm water and groundwater control measures are a critical component of any on-site wastewater treatment and land disposal system. Measures must be taken to prevent ingress of any storm water or groundwater into the reticulation pipe network, the treatment system or the land application disposal system itself. Where ingress occurs, it will result in overloading of the treatment and land disposal systems. Where elevated land application rates exceed the capacity of the soil, wastewater breakout and system failure will occur.

Following are some contingency measures for minimising water infiltration into a wastewater system:

- All lids and risers must be watertight.
- All pipe connections must be watertight .
- Storm water cutoff drains must be installed immediately upslope of a land application system, if there is potential for runoff from upslope.
- Where there is inadequate separation distance between the base of the wastewater distribution network and groundwater, subsurface cutoff drains may also be necessary. (It may also be necessary to investigate alternative land disposal areas or consider raising the ground level in conjunction with tertiary wastewater treatment.)

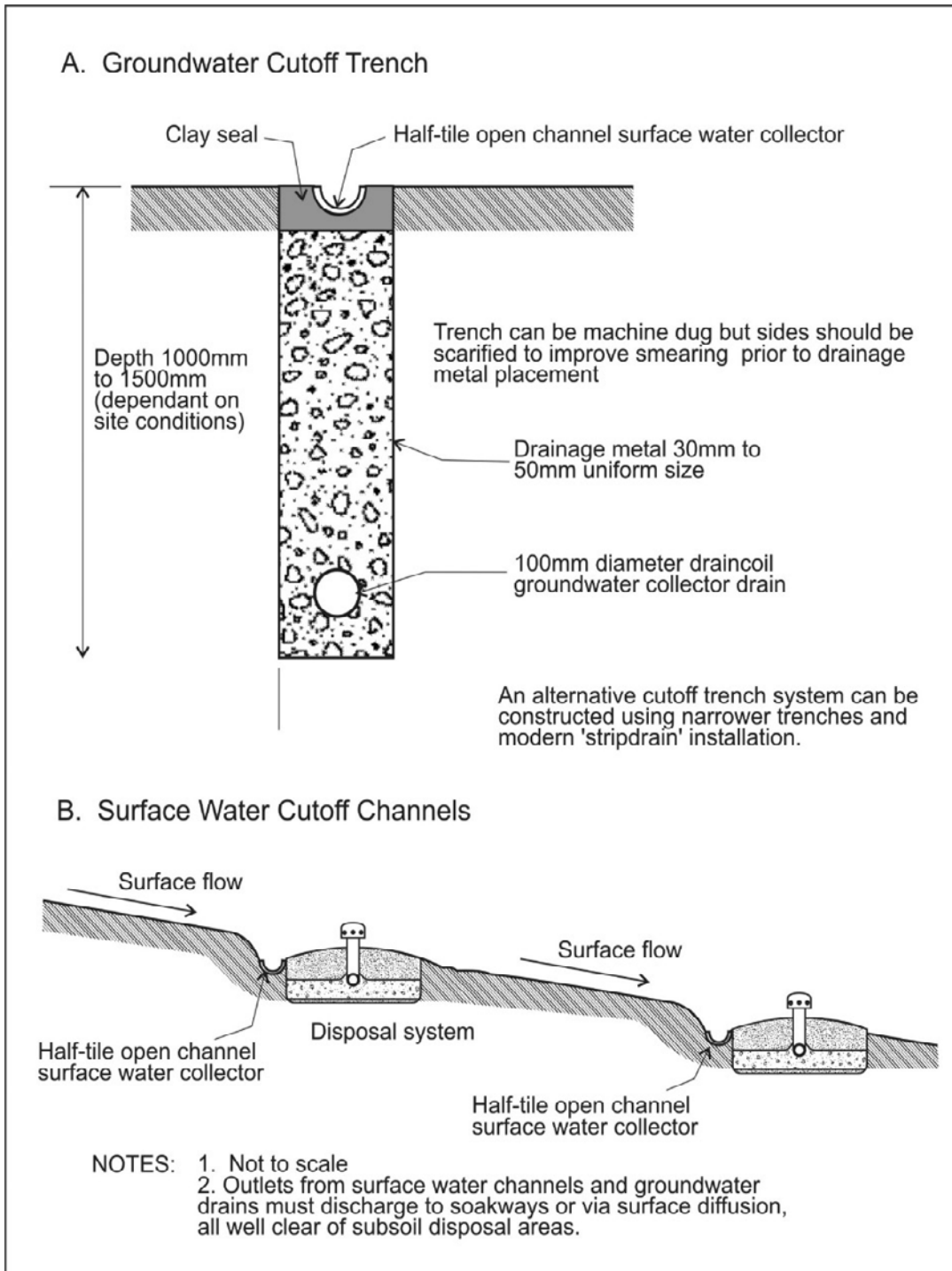
Figure 4.1 is a diagrammatic diagram showing details of water cutoff drains. Groundwater infiltration into older ceramic and clay pipe systems can be most significant and difficult to rectify without construction of a new watertight sewer network, e.g. comprising glued joints. The designer must take into account the risk of seepage/short circuiting from the land disposal system into the groundwater diversion drains and therefore water contamination.

4.4.4 Summary of Minimum Wastewater System Requirements at Subdivision Stage

In summary, the following minimum requirements apply to any subdivision to assist provide adequate protection against cumulative adverse effects:

- Consideration and appropriate use of technical guidelines at the early design stage for the site evaluation, design, consent application, construction and operation stages;
- System ownership and responsibilities specified to ensure ongoing system management requirements will be undertaken to maintain optimum performance in accordance with design specifications;
- System maintenance contracts maintained between individual property owners or the body corporate entity and the system supplier or another professional experienced wastewater system maintenance contractor;
- Education and training for site owners and practitioners concerning minimum household responsibilities for maintenance requirements and care of discharges into the system; and
- Compliance monitoring and enforcement from the relevant local authority of mitigation measures to remedy failing systems.

Figure 4.1: Surface Water and Subsurface Groundwater Cutoff Trenches



4.4.5 Subdivided but Unoccupied Areas

Proposals for subdivisions involving large dwellings with upmarket, high water producing fixtures, on small sites, may require an ARC discharge consent for the on-site discharge of wastewater. The requirement for a discharge consent is assessed on a case by case basis, against the ARC rules for on-site wastewater systems (discussed further in Section 2.5 and in Appendix C).

Many older subdivisions in the Auckland region with lots of up to 800m² to 1000m² were designed (some 15 to 20 years or more ago), at a time when conventional septic tank and soakage trench systems were considered adequate for on-site wastewater servicing. New owners now have the expectation that they will be able to install modern fixtures that are the norm in dwellings in reticulated urban areas. When they come to build, they often expect that the low technology aged conventional wastewater treatment and disposal system, will be adequate to serve the new modern dwellings on the potentially undersized lot. However, use of the site evaluation techniques outlined in Section 5 will lead to the identification of constraints that could require use of an alternative treatment and land disposal systems. This could involve greater expenditure and the use of a larger portion of the site than anticipated compared to that which was considered acceptable in the past. The need for allocation of reserve and buffer areas can mean that all undeveloped land on the site is required for wastewater disposal.

On extremely difficult sites, (e.g. tight clays, steep slopes, small lot area, vulnerable environments) it may well be necessary to either restrict the size of the dwelling (e.g. to a two bedroom dwelling instead of three) in order to reduce wastewater design flows to a quantity appropriate to area and soil constraints, or alternatively to manage and monitor wastewater flow volumes in accordance with consent procedures administered by the Regional Council. This latter mechanism would not necessarily restrict the size of dwelling, but would require careful selection of water flow control devices (perhaps incorporating recycling systems) and flow monitoring and reporting to ensure the maximum design flow volume, and thus the assimilation capacity of the land are not exceeded.

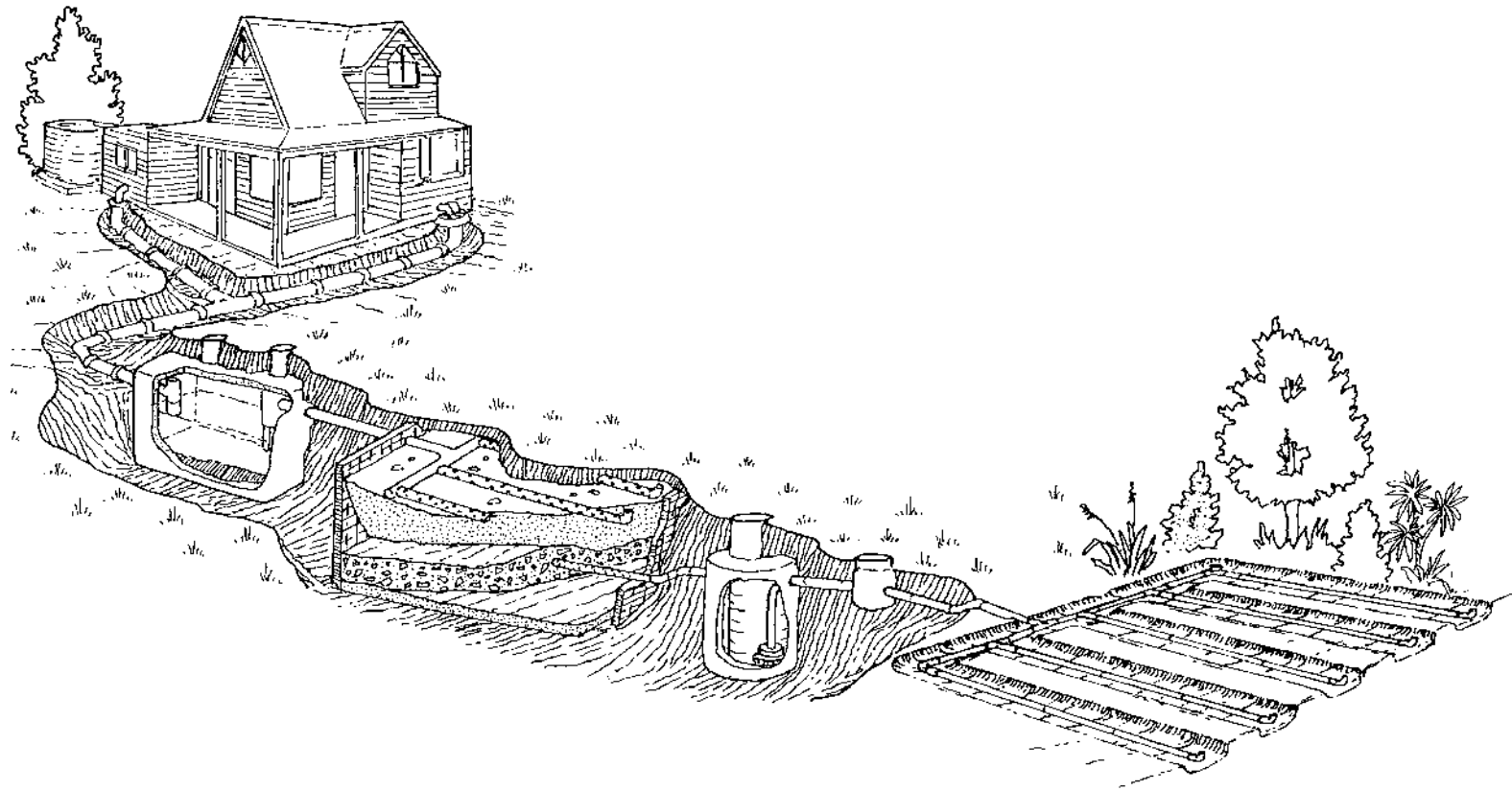
4.4.6 Failed/Malfunctioning Systems

Prior to replacing a failed land disposal system, it is essential that the cause(s) of failure be used to determine the most appropriate system design changes in any replacement.

Failure may have resulted from a number of factors, described in more detail throughout this document, such as overloading (exceeding the long term acceptance rate of the soil) due to the wastewater discharge volume exceeding design flow or storm water/groundwater infiltration into the collection and treatment systems. In the case of modern package treatment systems and drip irrigation land disposal systems, failure is often associated with poor system installation or maintenance and/or an under estimate of actual flow volumes at the design stage.

Where signs of failure occur (refer Section 4.1, 4.2.2 above and Section 12.2), advice should be sought from the system supplier before significant works are undertaken to remedy a faulty system. In many cases, the installation of a flow meter to monitor actual daily water usage can assist determine the actual treatment and disposal system capacity required. (It is important; meters are read at the same time of each day.) Sometimes, only simple actions to reduced excess water usage can significantly lessen the scale of a problem.

In the case of older technology systems, trenches, beds and mounds, a "failed" system may recover after a period of extended resting combined with other measures to reduce the wastewater flow volume. However, subsurface systems do have a limited life, in the order of 10 to 25 years) so it is more likely that the beds or trenches will have to be abandoned (if clearly incapable of recovery to the design soakage capacity following resting) followed by full replacement at an alternative location on the site or installation of a shallow irrigation system. For further options and discussion related to correcting failed/malfunctioning systems, refer Section 12.2.



5 > Site Evaluation Procedures

5. SITE EVALUATION PROCEDURES

5.1 PRINCIPLES FOR SELECTION OF LAND DISPOSAL SYSTEMS

Current practice requires attention to two principal aspects of site evaluation:

- Comprehensive site surface assessment; and
- Comprehensive site subsurface investigation.

Best practice now relies on an assessment of soil morphology to assign a Soil Category for design purposes in order to determine the appropriate wastewater treatment level, land disposal system and the separation distance requirements. The determination of the most appropriate land disposal system is based on the following.

Following consideration of environmental constraints identified in the surface and subsurface assessments:

- Select the appropriate wastewater treatment system and wastewater discharge quality;
- Select the appropriate land disposal system (Figure 5.1).

Only suitably qualified and experienced designers/site evaluators familiar with soils investigation and description techniques should undertake both these aspects. The information obtained from the site evaluation should then be applied to answering the following questions:

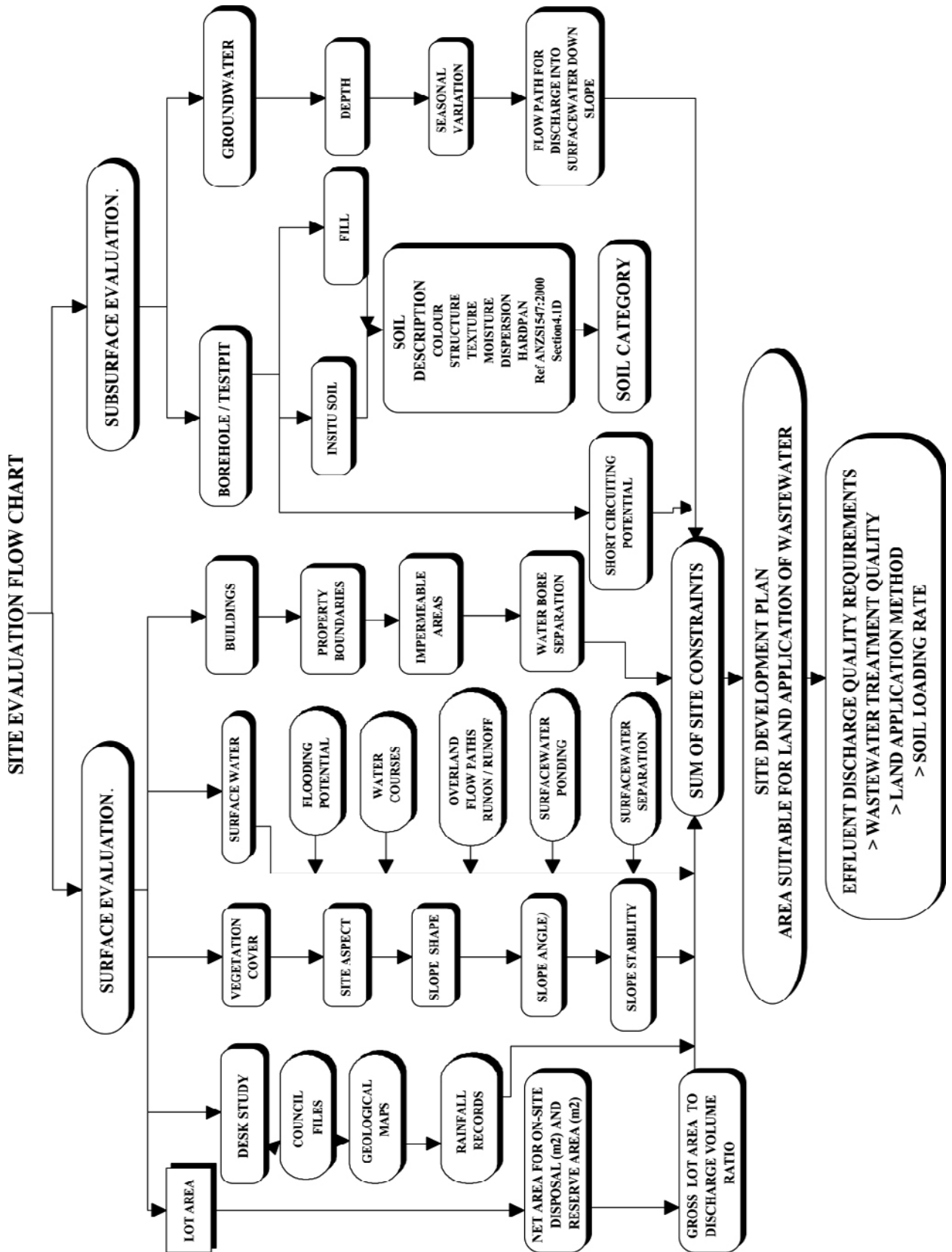
- What is the daily wastewater volume to be discharged?
- What level of wastewater treatment is required to address environmental constraints?
- What are the soils underlying the land disposal area?
- What type of land disposal system is suitable?
- Is the disposal system likely to be sustainable?
- What hydraulic loading rate is appropriate for the soils?
- What size should that land disposal system be?
- Is the site area sufficient for the daily wastewater flow?
- Is the site environmentally suitable for an on-site wastewater land disposal system?

The site evaluation process will tend to be concurrent with the preliminary design assessment. The matching of site assessment information (sum of environmental constraints) with subsoil investigation (Soil Category and groundwater constraints) can assist in identifying the most appropriate land disposal system (Figure 5.1).

Site constraints (soils and environmental) and the design land disposal method will determine the minimum level of wastewater treatment and therefore the wastewater treatment system required. The next step in the design process is to determine the area(s) available for a suitable land disposal system. This can be restricted by required separation distances to buildings, boundaries, waterways, discussed in Section 5.5. Once the available area is known, the third step is to determine the design loading rate appropriate for the site and for the proposed land disposal system. In this manual, the range of recommended design land application rates for each type of land disposal system and Soil Category is detailed in Figure 5.1, Table 10.3 and in Chapters 9 & 10.

A concurrent step is to size the selected land disposal system and determine its configuration relative to the general site layout, at all times keeping in mind the objective of achieving a high factor of safety for long term performance. It may be that the initially selected land disposal system (with the necessary reserve area) will not fit within the site constraints requiring a review of options and a redesign of the land disposal system proposal, and possibly the whole land use development.

Figure 5.1: Site Evaluation Flow Cart



5.2 SITE EVALUATION

5.2.1 General

This section outlines the key factors to be considered in a site assessment and subsurface evaluation to ensure that all appropriate site constraints are quantified and taken into account prior to completion of the final design.

Figure 5.1 outlines the key steps involved in completing a comprehensive site evaluation procedure. Each of these steps is discussed further below. The chart is divided into surface and subsurface requirements and these are combined to provide the sum of all the site constraints. The combination of site constraints should be taken into account by the system designer to determine whether the site is suitable for on-site wastewater disposal and whether additional design considerations to ensure that the proposal will have a minimum environmental impact. However, again it is noted that the assessment should not necessarily be limited to the factors indicated. This is intended as a guideline for designers to identify the critical factors required for any site assessment.

5.2.2 Site Assessment

The site assessment should identify and evaluate both positive and limiting factors relating to surface and subsurface characteristics influencing on-site wastewater land disposal. Factors that are to be addressed in any site assessment are as follows:

a. SURFACE EVALUATION

- GROSS LOT AREA - total site area (m²) is necessary for determining whether the peak design discharge volume can be accommodated within Auckland Regional Council permitted activity criteria or discharge consent requirements.
- NET LOT AREA - area available for primary and reserve land disposal areas after excluding land area taken up by right of ways, impermeable areas, setback requirements from surface water etc.
- DESK STUDY - review of any existing site specific information available from council property files.
- PERFORMANCE OF OTHER SYSTEMS - no on-site systems should be proposed in any locality without consideration of matters affecting the performance of adjacent existing systems, and the reason for any failures occurring. Failures can be linked to soil type, loading rates, poor system construction or changes in the type of development and increased per capita water consumption. Any doubts about the viability of land disposal, may be overcome by using the best available wastewater treatment and land application technology.
- GEOLOGY - review of geological maps for preliminary soils/constraints evaluation.
- RAINFALL - precipitation intensities and duration will influence the choice and siting of disposal systems relative to subsoil saturation effects.
- VEGETATION COVER - natural vegetation, trees and bush cover can be retained and incorporated into land disposal, reserve and buffer areas or garden and lawn areas can be subsurface irrigated.

- **SLOPE ASPECT** – consider the direction the slope faces to maximise evapotranspiration potential through exposure to sun and wind.
- **SLOPE SHAPE** - identify slope shape and location of depressions/zones with potential for surface water ponding. Depressions in which water could pond must be avoided.
- **SLOPE ANGLE** – in the past, slope limits have been set to accommodate machine digging of conventional trenches; however, slopes steeper than 15° and up to 30° can be utilised in good soils by employing either narrow trenching machines, by hand digging or pinning dripper irrigation lines to the ground surface (refer Chapters 9 & 10).
- **SLOPE STABILITY** - identify any areas of previous or existing slope instability, these areas require specific geotechnical investigation to assess the potential impact of land application of wastewater. In some cases, the land may be unsuitable for wastewater irrigation, as frequently wetted areas may exacerbate problems in areas prone to slope failure.
- **SURFACE WATER DRAINAGE** - identify surface water flow paths onto and off the site including concentrated flow channels or sheet flow and areas of potential surface water ponding.
- **FLOODING POTENTIAL** - where there is a risk of flooding, the one in 100 year, one in 20 year and one in 5 year flood levels will need to be determined. Areas below the one in 100 year flood plain should be avoided wherever practicable.
- **SURFACE WATER SEPARATION** - identify any surface water in the vicinity, such as permanent and ephemeral streams, lakes, dams, ponds and wetlands, and specify the separation distances from the site.
- **SITE CLEARANCES** - identify separation distances from proposed and existing buildings, site boundaries, paved areas, water bores and topographical discontinuities e.g. embankments either supported or unsupported. Table 5.2 offers some recommended minimum separation distances as a guide to determining suitable clearances based on the wastewater treatment quality.
- **SPECIAL SOIL CHARACTERISTICS** – take account of characteristics of surface soil such as cracking, evidence for seasonal soil saturation, seepage areas, exposure of rock.
- **WATER SUPPLY SOURCE** – specify whether the supply is via rainwater roof collection, groundwater bore or reticulated public supply.

b. SUBSURFACE EVALUATION

- **BOREHOLE/TESTPIT** - all site assessments are to include a detailed assessment of soils underlying the proposed land disposal area. The assessment shall be by test pit or where this is impractical by hand auger borehole. The subsurface assessment should be to a depth of at least 1.0 to 2.0m or the minimum recommended groundwater separation distance between the base of the land disposal system and any groundwater table (refer Table 5.2). The actual depth of investigation required will be dependent upon the environmental sensitivity of the site, the soil type(s) encountered and groundwater conditions. A detailed description of soils encountered, depth to groundwater and relevant soil structure and soil textural features shall be recorded and the depth to each horizon and soil description within the soil profile submitted with the site assessment report.
- **IN-SITU SOIL** - determine if the soils are natural and determine soil suitability for land disposal of wastewater.

- **FILL MATERIAL** - fill may be poorly suited for land disposal of wastewater, depending on the composition and level of compaction. If this is the case, the proposed land disposal area should be relocated, the fill removed or the land disposal system specifically designed to accommodate the soil constraints. In the case of filled sloping sites the designer should take into account the potential for short circuiting along the interface between the fill and natural ground interface.
- **SOILS** - determine soil type, (e.g. clay, silt, sand or gravel) and provide a detailed description of the soil structure and texture. A summary of recommended soil description procedures is provided in TP58 in Appendix D. The USEPA On-site Wastewater Treatment Systems Manual 2002 Sections 4.4.5 and 5.5.7 [Ref 5] and in AS/NZS 1547:2000 Section 4.1D, all provide soil description procedures [Ref 1].
- **SOIL CATEGORY** - the soils description above allows determination of the Soil Category.
- **SHORT CIRCUITING PATHS** - assess potential for wastewater to short circuit through clay or highly permeable soil such as sand or gravel into surface or groundwater. The soil type, permeability and level of wastewater renovation/further treatment required within the soil also influence the clearance distance required from the groundwater table and separation from surface water. Extreme care is required in soils prone to summer desiccation in which development of shrinkage cracks can provide short circuiting paths directly to groundwater or surface water.
- **GROUNDWATER DEPTH VARIATION** - it is important to determine the capacity of the site to accept treated wastewater and an appropriate disposal method. The disposal method should enable further in soil renovation of the wastewater and minimises groundwater impacts; a minimum "clearance" will be required between the base of the disposal area and the critical groundwater level to satisfy one of two situations (refer Table 5.2):
 1. Where no public health or environmental constraints exist, then the clearance must be adequate to ensure that hydraulic conductivity requirements are met (and no adverse groundwater mounding occurs).
 2. Where such constraints are present (e.g. due to the use of groundwater for individual or community water supply) then the clearance must be such that when combined with quality control provided by the on-site treatment and disposal system, the further renovation of effluent during its percolation through the unsaturated soil layer between the land disposal area and groundwater surface is adequate to meet environmental and public health criteria.
- **GROUNDWATER FLOW** - groundwater flow direction must be identified in more permeable soils (such as sand & gravel) when in close proximity to lakes, rivers or beaches and the location of identified groundwater abstraction bores. The travel time for applied wastewater to reach the groundwater table and to travel with groundwater to the zone of emergence or extraction should be assessed and pathogen die off predicted to determine if environmental and public health requirements are met.

A proforma checklist that requires the on-site system designer's/site assessor to consider each and every aspect of a site's characteristics as part of the site assessment and the subsoil investigation can provide such a mechanism for standardised reporting. The form in Appendix E, titled "On-site Wastewater Disposal Site Assessment and Subsoil Investigation Checklist", is an example of such a checklist. A site assessment checklist should be completed without any shortcuts as a full and comprehensive site evaluation record is essential for justifying the integrity of the final system design, and for assisting the approving agency to verify the adequacy of the final design. However, except for straightforward on-site systems conforming with the permitted activity (refer Appendix E), the checklist alone should not substitute for a full design report, but instead should be used as a tool to ensure all factors are addressed.

5.3 SUBSURFACE INVESTIGATIONS

5.3.1 General

A soil profile determination should be undertaken to the depth of the limiting horizon (hardpan, clay surface, bedrock, seasonal water table) or at least until adequate clearance is confirmed from the base of the disposal field to the groundwater table. Details of the soil type, texture and structure should be determined and documented. The free draining capacity of the soil should be assessed from an examination of soil colour (red-browns indicate oxidised free draining conditions, mottled and grey colours indicate lack of internal drainage). Appendix D provides guidance on assessment of subsoil characteristics.

The preferred method of undertaking the soil profile determination is via an inspection pit dug with an excavator to a depth sufficient to identify the limiting horizon (e.g. rock or hardpan or seasonally high water table), or alternatively sufficient to confirm adequate depth to meet vertical clearance requirements through free draining soil. Such pits are likely to be 1.2 to 2m, and should be large enough to enable access for detailed visual inspection of the soil profile. If investigation pits are excavated access must only be undertaken following OSH regulations.

It is not always practical to excavate inspection pits in which case a machine or hand auger borehole study may be undertaken to assess soil types and the depth to limiting horizons. The depth of the investigation borehole is dependent on the soil type and proposed ground disposal method but should be at least 1m below the base of the proposed disposal system or to the groundwater table. Determination of the depth to the groundwater table is particularly critical in high permeability soils where groundwater protection is important.

The soil to a depth of between 600mm and 900mm within the land disposal system provides significant additional treatment via entrapment of residuals, biological stabilisation of organic matter, and inactivation of bacteria and viruses. The subsoil below the land disposal area, into which the treated wastewater will infiltrate, will provide a third stage of treatment. This is as a result of the gradual soakage of treated wastewater via an unsaturated flow path within the subsoil, and the soils absorbing and modifying waste residuals and bacteria in the treated wastewater, thus renovating the final discharge before it reaches groundwater. The level of further treatment depends upon soil type, depth to groundwater, and effluent loading rate into the soil. Nutrients are only partially modified during this renovation process in the natural soil, with little if any renovation being provided by free draining sands and gravels and with ammonia concentration in some cases increasing as a result of anaerobic soils conditions.

5.3.2 Determination of Seasonal Groundwater Level

Where subsoil investigations are carried out in summer some estimate of the winter high water table is necessary. Subsurface soils investigation will assist in determining the boundary between fully oxidised coloured soils (above high water table) and partly oxidised speckled (mottled) soils subject to periodic saturation from high water table (refer Appendix C).

5.3.3 Soil Permeability Testing

Traditional percolation testing, as outlined in the withdrawn NZS 4610:1982 and in previous editions of TP58 (refer "Table 5.2: Soil Texture and Percolation Rates - USEPA Design Manual 10980", in the Second Edition of TP58), is not provided in this edition as a test method for assisting in determining soil infiltration capacity. Any percolation test results may only be used to support or check an individual designer's conclusions regarding Soil Category, and **must not be used** (as has been done in the past) as the sole criteria on which decisions on site suitability and design of land disposal

systems are made. Soil percolation testing has been superseded by the Soil Type method (soil categorisation) detailed below in Section 5.4. Design loading rates must be selected according to soil type and site constraints. *Percolation testing thus has a limited role in the design process covered in this manual.*

Note:

Soil permeability testing is a useful tool to help confirm the Soil Category for design purposes, particularly if there is any element of doubt, or if the design is not to be conservative, but permeability test results are not used as the sole determinant of Soil Category. The designer must be aware that soil permeability testing results can be highly misleading and can indicate high soakage capacity in Category 5 or 6 soils for example through short circuiting via shrinkage cracks. Many designers have in the past too readily accepted permeability test results in preference to categorisation of the soil types following investigation of actual soil properties, which has resulted in a land disposal systems being designed to fail.

5.4 SUBSOIL TYPE AND LAND DISPOSAL SYSTEM SELECTION

5.4.1 Soil Category Descriptions

Soil Category classes have been based on soil texture (grain size) along with an indication of clean water percolation capacity for each texture class. The assignment of Soil Categories for design purposes based on site and soil information becomes a somewhat subjective process where the investigator/designer has to bring judgement into the determination. However, by using soil morphology information supported as appropriate by soil textural analysis and possibly permeability testing, there are ample tools available to the investigator/designer to enable an appropriate determination of Soil Category.

The Soil Category descriptions used in TP58 have been in place since the First Edition in 1989. These are retained in this Third Edition, but are compared in Table 5.1 below alongside those categories adopted in AS/NZS 1547:2000.

Within AS/NZS 1547:2000, design loading rate (DLR) values within each Soil Category are subdivided according to structural classification. Similarly, in this edition of TP58, it is intended that designers make allowance for soil structural influence on soil infiltration capacity by adjusting the Soil Category selected for design purposes in an appropriate manner, or interpolating loading rate values between Soil Categories (refer Section 5.4.2 below).

5.4.2 Soil Category and Design Loading Rate Selection

The design process detailed in this manual is a nonprescriptive one. It relates loading rate range to soil type in a manner that then requires conservative selection of a design loading rate suitable for the site once Soil Category and other site constraints have been taken into account. The steps for determining an appropriate loading rate for a site include:

- a. Undertake site and soil assessment in accordance with Section 5.2 & 5.3.
- b. Complete a soils description in accordance with the method presented in Appendix D, ARC Technical Sheet D1, TP58*.
- c. Complete a technical report setting out the assessment process, site constraints identified, include results from test pits or boreholes and specify the design conclusions reached.

* This is also outlined in AS/NZS1547:2000 Appendix 4.1D [Ref 1]. However, the AS/NZS 1547 Soil Category descriptions are different from those used in TP58 and therefore, the Soil Categories from AS/NZS should not be used, when using TP58.

- d. Complete item 5.3 of the Appendix E checklist (this provides the estimated Soil Category from the site information). Take this Soil Category and decrease the design loading rate as necessary in order to allow for specific site conditions. Site constraints may impose design or construction/installation constraints, or may require the incorporation of an additional factor of safety.
- e. Select a land disposal system appropriate to the site.

Figure 5.1 sets out the general range of on-site land disposal systems, which can be applied within the soil categories of Table 5.1. The subjective judgement required to determine which of the seven soil categories of Table 5.1 applies in any case, must be based upon the designer's experience, and utilise those assessment procedures discussed above that are appropriate to the specific design. Consideration should also be given to other assessments undertaken on nearby similar sites in the area (this information may be available at the local council). Where there is doubt, a conservative approach should be used and the higher category used to prevent loading rates being adopted that could prove to be too high and inappropriate for the soil type. Appendix D provides information to assist in assessing soil characteristics.

Table 5.1: TP58 Soil Category Description (comparison with AS/NZS:1547 2000)

Soil Category	Soil Description TP 58 3 rd Edition	Soil Category	Soil Description AS/NZS 1547:2000.
1	Gravel, coarse sand - rapid draining	1	<i>Gravels and sands - rapidly drained</i>
2	Coarse to medium sand - free Draining	2	<i>Sandy loams - well drained</i>
3	Medium-fine and loamy sand - good drainage	3	<i>Loams - moderately well drained</i>
4	Sandy loam, loam and silt loam - moderate drainage	4	<i>Clay loams - imperfectly drained</i>
5	Sandy clay-loam, clay-loam and silty clay-loam – moderate to slow drainage	5	<i>Light clays - poorly drained</i>
6	Sandy clay, non-swelling clay and silty clay - slowly draining	6	<i>Medium to heavy clays - very poorly drained</i>
7	Swelling clay, grey clay, hardpan - poorly or non-draining		

5.5 RECOMMENDED SEPARATION DISTANCES FOR ON-SITE MANAGEMENT SYSTEMS

There are a number of minimum separation distances that must be taken into account when siting an on-site land disposal system. These include required distances from buildings, site boundaries, surface water, water supply bores, groundwater and embankment walls. The minimum distances are also dependant upon potential for adverse effects, specifically impacts on surface or ground water quality, and therefore vary depending on the type of treatment and the final treated wastewater quality.

Recommended minimum separation distances are specified in Table 5.2 below:

Figure 5.2: On-Site Land Disposal Systems According to Soil Categories

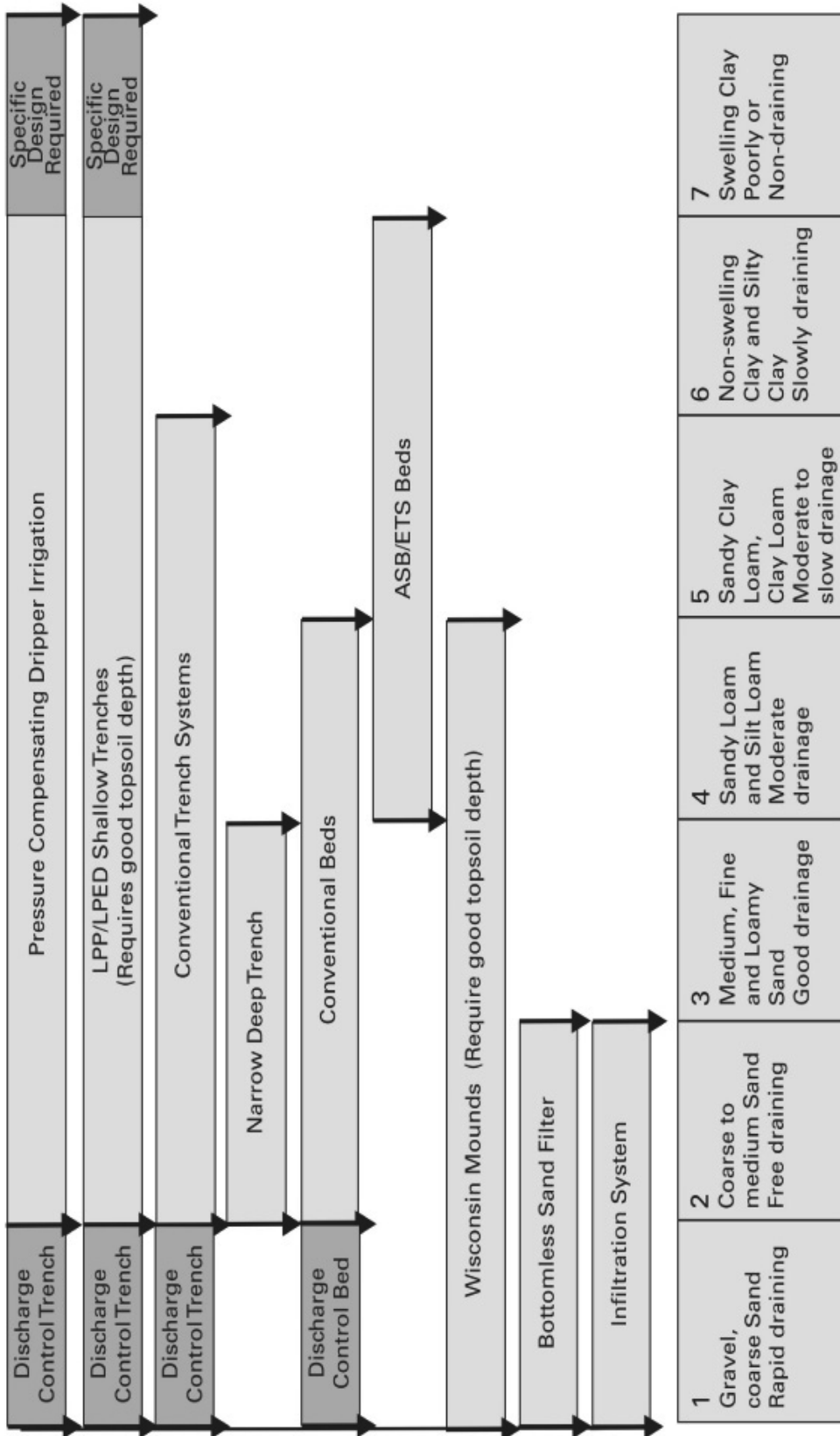


Table 5.2: Recommended Minimum Separation Distances According to Treated Wastewater Discharge Quality

Minimum Recommended Separation Distance	Wastewater Treatment Level				
	Primary (Septic tank plus effluent outlet filter)	Secondary (AWTS)	Advanced Secondary (Packed Bed Reactor)	Tertiary (Disinfection Note 9)	Advanced Tertiary ¹⁰ (Nutrient reduction & disinfection)
Buildings/Houses¹	3m	1.5 to 3m	1.5 to 3m	1.5 to 3m	1.5 to 3m
Property Boundary²	1.5m	1.5m	1.5m	1.5m	1.5m
Surface Water³					
Soil Category 1 ⁴	Note 4	10m	10m	10m	10m
Soil Category 2 - 3	20m	10m	10m	5 - 10m ¹¹	5m ¹¹
Soil Category 4 - 6	20m	15m	15m	5 - 10m ¹¹	5m ¹¹
Soil Category 7	Note 4	15m	15m	5 - 10m ¹¹	5m ¹¹
Water Supply bore⁵					
Soil Category 1	Note 4	20m	20m	10m	10m
Soil Category 2 - 3	20m	20m	20m	10m	10m
Soil Category 4 - 6	20m	20m	20m	10m	10m
Soil Category 7	Note 4	20m	20m	10m	10m
Groundwater^{6 & 7}					
Soil Category 1	Note 4	1500mm	1200mm	1000mm	900mm
Soil Category 2 - 3	1500mm	1200mm	900mm	600mm	600mm
Soil Category 4 - 6	1200mm	900mm	600mm	600mm	600mm ⁸
Soil Category 7	Note 4	600mm	600mm	600mm	600mm
Floodplain⁷ (Return Period Storm)	One in 100 year	One in 20 year	One in 20 year	One in 20 year	One in 20 year
Embankments/ Retaining Walls⁸	3m from the drainage material/cut batter interface or 45° angle from toe of wall excavation (which ever is the greatest)				

[All separation distances may vary dependant upon territorial authority requirements]

Notes:

1. Separation distances from houses of less than 3 m is only appropriate where drip irrigation land disposal areas are being used with low design irrigation rates, or where shallow subsurface systems are being used with equivalent low areal loading rates. Lesser distances may require approval from territorial authority. The reduced separation distances may be applied where the land application area is downslope from a dwelling and reduced distances applied where there are no windows in that wall.
2. Separation distances from boundaries of as low as 0.5m may be allowed in special cases by some territorial authorities where drip irrigation land disposal is used with low design irrigation rates (e.g. 3mm- 5mm/day), or where shallow subsurface systems are being used with equivalent low areal loading rates and slopes descend to and not away from the land disposal area.
3. Separation distance from surface water area is defined as the areal edge of the land disposal system (design area plus surrounding absorption buffer) to the edge of the waterway (pond, lake, swamp, stream, river, defined stormwater channel). These separation distances also apply to ephemeral or stormwater channels, although decreased distances may be allowable when the disposal area is downslope of the watercourse and/or when on flat/gently sloping sites.
All of the above only applies to subsurface land application. An increased separation distance allowance is necessary on sloping sites and where surface application is proposed. Where lines are placed on the ground surface, whether or not they are also covered in mulch or similar, there is a risk of short circuiting along the interface between

3. *(continued) the topsoil and covering material with limited in ground treatment. In such situations, an additional separation distance allowance is necessary depending on ground slope. For 10 to 25° slopes, a proportionate additional 2 to 10m is appropriate.*
4. *For discharge of effluent into Category 1 & 7 soils specific design considerations are required. Where groundwater quality protection is required in Category 1 soils (gravels) the level of in ground treatment will be limited unless measures are taken to slow the soakage rate Refer to Chapters 9 and 10). Discharge of primary treated wastewater into Category 7 soils is not appropriate. Special design considerations are required where there is no alternative.*
5. *Separation distances from water supply bores should be reviewed on a case by case basis; distances can be dependant upon the soil type, depth of the bore, its casing depth and quality, water usage, the direction of groundwater flow, presence or absence of down stream users in addition to the quality and quantity of the wastewater being discharged.*
6. *Groundwater or groundwater cutoff trench clearance distance is defined as the vertical distance from the base of the land application system to the highest seasonal water table level. To minimise the potential for an adverse impact on groundwater quality, clearance distances should be maintained at all times. Where insufficient groundwater clearance is available the ground level can be raised by importing topsoil or similar as well as improved wastewater treatment. [See also Section 4.4.3.]*
7. *Groundwater separation distances and limitations on discharges within certain floodplains may be reduced on a case by case basis as part of a discharge consent application.*
8. *When determining minimum distances from steep embankments or cut slopes, the type of disposal system must also be taken into account. Such clearances may need to be increased in areas where slope stability is of concern.*
9. *Disinfection refers to the reduction in number of faecal coliforms per 100mls of wastewater and the level of reduction is likely to vary depending on site constraints. A maximum number of 200 CFU/100mls is accepted here as the minimum level of reduction*
10. *The nutrient type and level of reduction is dependent upon the site constraint and risk level. The maximum total nitrogen level is 10mg/l.*
11. *In the Auckland Region, a discharge consent will be required where there is potential for wastewater to impact on water quality, such as where the surface water separation distance is less than 10m, or greater distance where the slope is greater than 20°.*
12. *Disinfection refers to the reduction in number faecal coliforms per 100mls of wastewater and is likely to vary depending on site constraints. A maximum number of 200 CFU/100mls is accepted here as the minimum level of reduction.*
13. *The nutrient type and level of reduction is dependent upon the site constraint and risk level. The maximum total nitrogen level is 10mg/l.*

5.6 ET (EVAPOTRANSPIRATION) ASSIST

Regardless of which type of on-site land disposal system is proposed, care should still be taken in the siting and layout the land disposal system to take advantage of sun and wind and natural vegetation to maximise evapotranspiration (ET) assist. Existing plant growth on-site can be turned to advantage in deciding what type of system to use. Major construction disturbance can be avoided and natural bush etc. retained by the use of shallow trenching or covered surface drip irrigation disposal systems. This retains both soil and vegetation characteristics at levels which maximise both soakage and ET disposal.

For engineered ET systems selected plant species can be utilised to provide ET assist. This can be achieved in two ways, or a combination of both:

- Design area planting, Refer to Section 10 (e.g. ETS beds planted with selected grasses, or plants, or shrubs, or trees).
- Design area retained in grass only, and downslope areas laid out in plants, shrubs, or trees which feed on designed downslope seepages.

Appendix G sets out details of specific ET assist plantings suitable for northern areas in New Zealand. Local water tolerant plantings of high ET capacity can be determined from enquiries of local horticultural advisers.

5.7 RESERVE AREA REQUIREMENTS

A reserve area is always required and is to be available for use in the event of system failure or underestimation of daily wastewater production. The success of the on-site wastewater management system can be influenced by a whole host of factors, including:

- Household size;
- Water use practices/changes in occupants;
- Total effluent volume and peaking factors;
- Quality variations;
- Design and construction/installation practices;
- Rainfall impact;
- Unidentifiable leaks/infiltration; and/or
- Operation and maintenance attention.

All of the above could affect the overall performance of an on-site system, even in the event of a most conservative design approach. Given that the design and implementation process is not an exact one, a reserve area allocation is always required as an element of the design process. The reserve area is set aside for future extension of the land disposal system. Guidelines for reserve area provisions based on the land disposal method and effluent quality are in Table 5.3 as follows:

Table 5.3: Reserve Disposal Area Requirements

Land Disposal Method	Minimum Reserve Area Allocations*
Subsurface Drip Irrigation (Pressure Compensating)	33% - 100%
Surface Drip Irrigation (Pressure Compensating)	50% - 100%
Shallow Trenches	100%
Standard/Deep Trenches	100%
ETS Beds**, Aerobic Soakage Beds and Trenches	100%
Shallow Trenches (with Secondary Treated Effluent)	50 - 100%
Secondary Effluent to Trenches or Beds (with double loading rate***)	150 - 200%
Infiltration systems	100%
Mound systems	100%

* An additional 40-50% reserve allocation should be added where the design flow is based on greywater only with all toilet wastewater discharged to a compost toilet. Further discussion of this requirement and composting systems is provided in Section 7.8.2.

** ETS means Evapotranspiration Seepage Beds which are covered further in Section 10.3.

***At the time of printing, double loading rates for secondary treated wastewater were not approved within the Auckland region.

Notes:

1. The lower reserve areas can be applied where conservative higher wastewater production rates have been used to design flow assessment and lower irrigation rates used for determining the land disposal area requirements.
2. Reserve area can be reduced where secondary effluent is proposed.
3. In all cases 100% reserve area is required with primary effluent, except in areas with out a permanent power supply where 40 to 50% reserve area is permitted in the Auckland region due to the more conservative approach to wastewater management.
4. Where a variable reserve area is indicated above, then factors such as density of development, slope of land disposal area, potential for further site development, exposure to wind and sun, shall all be considered in arriving at a design recommendation.
5. Where design flow is based on assumption of water reduction fixtures, more than 50% reserve should be provided due to uncertainty concerning longterm water production.
6. Lower Reserve Area requirements may be allowed compared to those above, where there is reduced potential for adverse environmental effects and therefore for future use of the reserve are due to use of lower loading rates and increased contingency allowances within the design. Reserve allocations can be reduced by up to 25% that recommended above in the event loading rates are significantly less to the satisfaction of the consenting authority than the minimum recommended for the relevant disposal system, Soil Category and effluent quality.
7. Additional reserve area must be allocated where there is doubt concerning the actual water usage and/or there is a possible lack of conservatism in the establishment of the design flow volume.

5.8 COMPLETION OF SITE EVALUATION ASSESSMENT AND LAND DISPOSAL SYSTEM SELECTION

In order to finalise an appropriate location for a land disposal system, following is a summary of the necessary steps:

- **SUM OF SITE CONSTRAINTS** - All aspects of the site, determined from the site assessment (following consideration of all factors listed in Sections 5.2 to 5.3), both positive and negative, must be given due consideration as well as regard to the allocation of minimum separation distances as specified in Section 5.5. The combination of all these constraints should be combined with the site development plan to determine an appropriate location and area available for land application of wastewater.
- **DISPOSAL SYSTEM DESIGN PARAMETERS** - Environmental constraints and soil types, established in accordance with Section 5.4, should then be combined to identify the quality of the final treated wastewater required, then the appropriate treatment methodology, the most appropriate land application methodology and finally, the soil loading rate determined. Additional land must also be allocated as reserve area for potential future use. The total area of land that must be allocated for on-site wastewater management can then be determined.
- **DESIGN FOR OPERATION AND MAINTENANCE** - Lastly, in siting the treatment and land disposal system, the requirement for access to the on-site system for operation and maintenance purposes should be considered. Treatment units, which require desludging via pump out, must be located so as to enable ready access for maintenance. Land application systems must be located away from areas of vehicular or pedestrian traffic so their operation is not compromised by activities on the ground surface such as high use lawn areas.

5.9 FINAL SITE ASSESSMENT REPORT

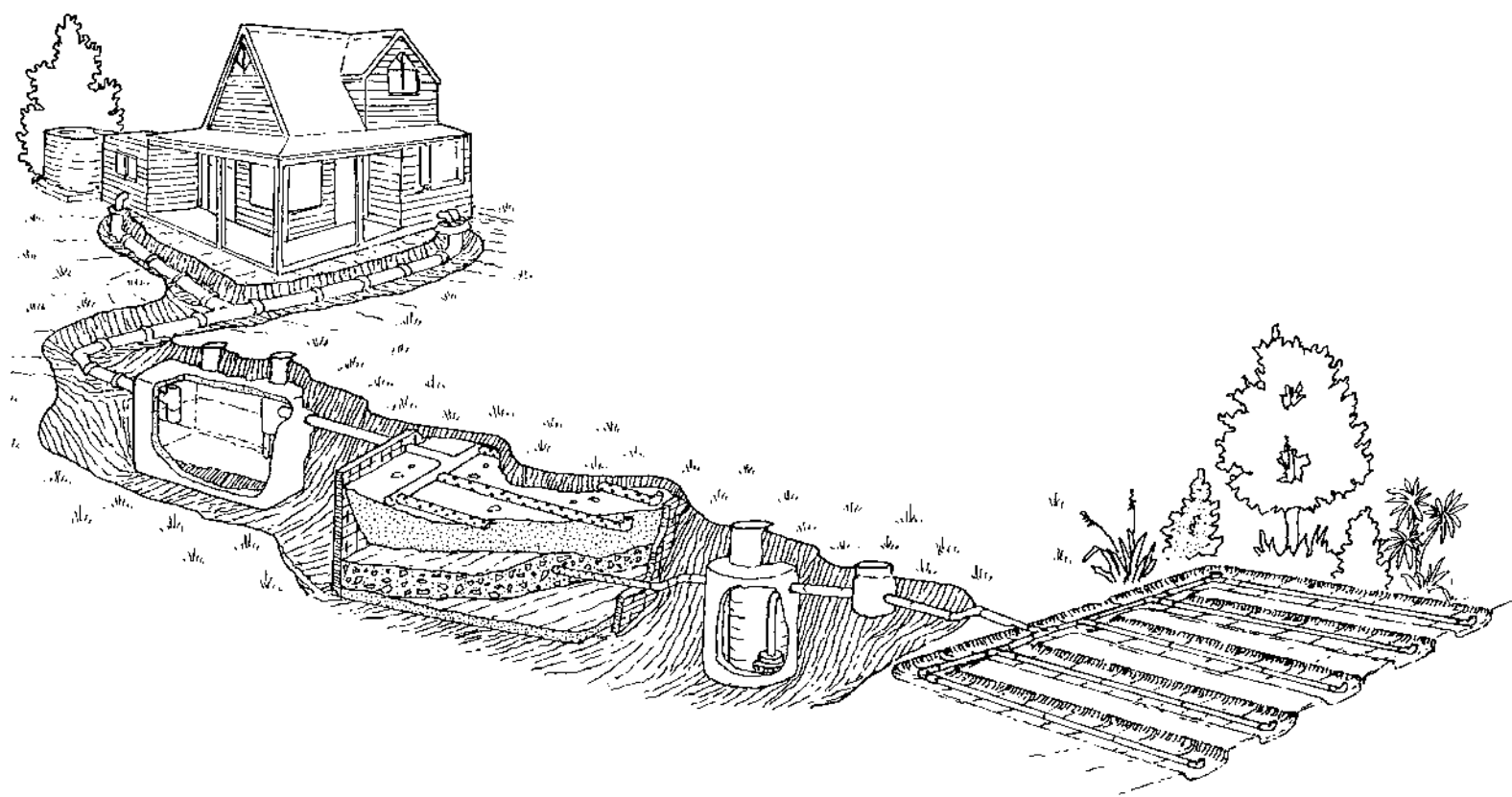
A Site Assessment report should accompany all design proposals for on-site wastewater treatment and disposal systems. In summary, a Site Assessment Report should include details of the investigations undertaken in accordance with Sections 5.2, 5.3, 5.4 and 5.5. In particular, it should include investigation results of (inter alia) full soils description from each subsoil investigation pit or borehole, borelogs, soils categorisation and justification, depth to groundwater if identified within the critical depth, along with surface constraints including vegetation cover, and distance from surface water.

The report should always be accompanied by a Site Plan. A Site Plan must include the following features and specific details:

- The location of property boundaries;
- Buildings;
- Paved areas;
- Retaining structures;
- Boreholes and/or test pits;
- Vegetation cover;
- Slope angles;
- Surface water drains/streams;
- Location of existing and/or proposed wastewater treatment and disposal system components if known, reserve areas and drainage;
- Any other relevant features;

- A North point; and
- Latest revision date (this is particularly critical in the case where several revisions may be prepared)

An adequate narrative explanation of the reasons for the design recommendations arising from the site and soil assessment procedures should also be incorporated within the full design report. Again, the form in Appendix E, titled "On-site Wastewater Disposal Site Assessment and Subsoil Investigation Checklist", outlines the key issues that should be covered in a standard Site Assessment Report and in the case of more straightforward sites and system designs, once completed may substitute for a separate site assessment report.



6 > Design Flow Volumes

6. DESIGN FLOW VOLUMES

The conventional treatment and disposal systems typical in the past are no longer appropriate in many situations in New Zealand. Along with rapid changes in many facets of life in the 20th century, conventional small septic tank and trench systems can no longer adequately treat nor dispose of modern wastewater flows, and improved technology treatment and disposal systems are increasingly necessary. Changes that have led to this situation include the following [Ref 5]:

- Use of modern cooking oils often do not solidify nor separate and float on cooling like those used in the past;
- Increased use of highly effective degreasers and other powerful cleaning agents;
- Increasing concentrations of non-biodegradable synthetic clothing fibres in domestic laundry wastewater, and chemicals from other discharges;
- With increasing travel, pathogens can access areas where local populations have a lower acquired immunity;
- The combination of water conserving appliances and fixtures with the use of food garbage grinders and increased food wastage, increases the concentration of organic matter and nutrients in the wastewater;
- Increased use of antibiotics, hormones, pharmaceuticals, pesticides, which are difficult to biodegrade and in significant concentrations, can have a toxic effect on treatment systems; and
- Increasing population densities in areas reliant on on-site systems, such as beach settlements, peri-urban and previously rural areas.

A key feature towards ensuring sustainable system design is to address these changes in water usage and contaminant loads, and to ensure a conservative approach is taken with the establishment of the design flow volumes. A similar argument applies to the need for improved treatment and disposal technologies and standards, as covered in detail in Chapters 7 to 10.

6.1 POPULATION DATA

Design flows should be based on the maximum possible number of persons occupying the premises to be served, and a per capita wastewater flow allowance according to the nature of that occupancy (e.g. full time, part time). Occupancy levels for individual households and for commercial facilities, are set out in Table 6.1.

6.2 WASTEWATER DESIGN FLOW ALLOWANCES

Wastewater design flow volumes will depend upon the nature of the facility being served, the per capita water consumption rates, and the use of any water use reduction fixtures employed. Per capita water consumption is likely to be significantly influenced by the type of water supply provided. Representative design allowances from the literature are set out in Table 6.2. The lower per capita values set for facilities on roof water tank supplies reflects the fact that user constraint will ensure good water use habits. For motels, community halls, schools, factories and camping grounds dependent on roof water supply, ample notices must be posted and maintained in all water use areas to ensure reminders regarding the need for care in water use are before users at all times. If water use constraint cannot be guaranteed, then the larger allowances associated with community water supply should be used.

To some extent the per capita wastewater flow allowances may over estimate actual flows; this however will provide a factor of safety in overall system design. The allowances for full water reduction fixtures include reduced flush toilets (with 6/3 litre flush options), spray faucets, shower

flow restrictors, fixed orifice flow control valves and low water consumption washing machines. Where only partial water reduction fixtures are provided for, an appropriate adjustment should be made. Significant additional reductions in the wastewater discharge volume can be achieved from greywater recycling or recycling secondary treated and disinfected wastewater back to toilet cisterns. However, there are increased operation, monitoring and maintenance requirements for recycle systems. Auckland Public Health Protection have expressed significant concerns about potential risks involved with the use of recycling systems in public or commercial facilities. Therefore, in the Auckland Region, such systems are considered discretionary activities, requiring an ARC discharge consent.

Care is required when predicting wastewater flow particularly when least conservative flow rates are applied and the factors of safety are reduced. Underestimation removes the buffering provided by systems designed using conservative flow rates and could result in overloading and failure of part or all of the on-site system.

In some situations figures may be adjusted by the designer where actual flow figures based on robust water meter readings and in some cases, occupancy numbers are also available. In some cases detailed measurements or local knowledge of comparable facilities can give accurate assessment of design flows; in other situations special applications may enable significant adjustments to the design loading of the effluent disposal system to be made in conjunction with flow allowances (e.g. for seasonally occupied facilities). Designers should always use peak daily flow allowances and not average flow as the use of less conservative lower figures can lead to significant under design and system failure.

6.3 DETERMINATION OF DESIGN FLOW VOLUME

The design flow volume is determined by multiplying the peak occupancy of a facility by the design flow allowance per person per activity. The rest of this section provides data for establishing a design flow volume.

6.3.1 Design Occupancy Numbers

Normal design practice for intermittently loaded systems such as dwellings in holiday/recreational areas subject to occasional or regular weekend use, and fulltime occupancy (and indeed excess occupancy) at summer vacation periods, is to provide an on-site system sized for permanent use. Many approving agencies insist on this approach on the basis that in the longterm, there is an increasing likelihood of permanent occupancy of many such dwellings, particularly if they are located in coastal and/or retirement areas. In addition, the fact that a full size disposal system is installed from the outset means that reserve capacity is available to cope with the overload situation during holiday season, when extended families/groups take up residence for several weeks at a time.

Table 6.1 provides outside design occupancy allowances recommended for design purposes for types of dwellings/accommodation facilities.

Table 6.1: Occupancy Allowances

Facility	Occupancy For Design Purposes
Homes	
Number of Bedrooms [Notes 1, 2 & 3]	
1	2
2	4
3	5
4	6
5	8
6	9
Hotels & Motels	
Guests	Maximum Occupancy/number of beds
Staff	Maximum number of staff.
Hospitals [Note 4]	
Patients	1 per bed [Note 3]
Staff	Maximum Number of Staff
Retirement Villages [Note 4]	
1 bedroom	1.3p per unit
2 bedroom	1.3p to 2.0p per unit
3 bedroom	2p – 4p per unit
Staff	Maximum Number
Notes:	
<ol style="list-style-type: none"> 1. It is usual to adopt a minimum occupancy of 4 persons (equivalent to a 2 bedroom dwelling) for existing rural residential cluster developments. 2. In situations where large modern dwellings are proposed which have additional rooms beyond those allocated as dining, lounge, bedrooms, (e.g. "family", "recreation", "games", "office", "study", "sewing", "work" rooms) which could have potential to be utilised as bedrooms with different furnishings, an additional occupancy allowance is to be made on the basis of 1 extra person times the ratio of the total floor area of the additional room(s) to that of the smallest designated bedroom and rounded up to the next whole number. 3. Design occupancy should allow for a seasonal peak, not just the average daily flow. Holiday homes tend to have intermittent occupancy but when occupied are likely to have a higher occupancy than a continuously occupied dwelling. An allowance in design occupancy should be made for the seasonally higher flows. 4. Occupancy data in this table is from the literature and observed levels. A higher water use/person should be allowed in facilities providing community care unless specific water meter data is available. Retirement village average occupancy from observed rates and the literature is 1.3 people per unit with occasional overnight guests. In the case of retirement homes occupancy should be based on the number of beds per bedroom. 5. In the Auckland region, in the event that the designer does not design for the predicted flow from the full potential occupancy, it will be necessary to monitor the wastewater discharge flows via a resource consent. 	

6.3.2 Design Flow Allowances Per Person

Table 6.2, specifies recommended design wastewater flow allowances for standard dwelling as well as a range of other domestic facilities, including accommodation facilities, commercial restaurants/factories and public meeting/toilet facilities in non-reticulated areas.

Table 6.2: Domestic Wastewater Flow Allowances – Per Capita

SOURCE	Typical Wastewater Flow Allowance	
	[Note 1 and Note 2]	
	On-site Roof Water Tank Supply	Reticulated Community or Bore Water Supply
Permitted Activity Flow Allowances in the Auckland Region [Note 3]		
A. Up market/Luxury households with Extra Wastewater Producing Fixtures including fixtures such as garbage grinders; dishwashers, modern shower or bath facilities or other comparable fixtures [Note 4]	220	220
B. Households with Standard Fixtures including 11litre flush water cisterns; automatic washing machine and dishwasher [Note 5]	180 – 200	200
C. Households with 11/5.5 or 6/3 Flush Toilet(s) and Standard Fixtures , low water use dishwasher and NO garbage grinder [Note 6]	160	180
D. Households with 6/3 Flush Toilet(s) And Standard Water Reduction Fixtures and NO garbage grinder [Note 7]	145	165
<i>A water meter is to be fitted to either the water supply tank outlet or secondary treated wastewater discharge where the design per capita flow rate is less than 145L/p/d and sites without permanent electricity supply where the per capita design flow is less than 120 l/p/d.</i>		
E. Households with Full Water Reduction Fixtures on all water outlets, NO bath and NO garbage grinder [Note 8]	120	145
F. Households with Full Water Reduction Fixtures Without Permanent Electricity Supply [Fixtures as per Note 7, and Note 9 also applies]	100 – 120	120
For The Use of the Flow Allowances Below a Discharge Consent Is Required in the Auckland Region		
G. Decreased Flow Allowances for Households with Full Water Reduction Facilities as above (Including 6/3 dual flush toilet systems, standard water reduction fixtures and NO BATH) [Note 10]	100 to <115	135
H. Households with Full Water Reduction Facilities Plus Reclaimed	95 to 100	100 to 115

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Water Recycle for toilet cistern flushing [Note 11]		
I. Households – Black water Only (Based on an 11litre flush toilet) [Note 12]	66	
J. Households – Black water Only (Based on a 11/5.5 flush toilet)	45	
K. Households – Black water Only (Based on a 6/3 flush toilet)	25	
L. Households – Grey water Only (with Extra Water Reduction Fixtures) [Note 13]	95 to 100	100 to 115
Commercial Flow Allowances for Standard Fixtures		
Motels/Hotels [Note 14]		
- Guests, resident staff		220
- Reception rooms		30
- Bar trade (per customer)		15 to 20
- Restaurant (per diner)		30
Restaurant/Bar/Cafe [Note 15]		
- Per dinner patron		30
- Per lunch patron		25
- Per bar patron		15 to 20
Lunch Bar (per customer)		
- Without restroom facilities	10	15
- With restroom facilities	15	25
Community Halls		
- Banqueting	20	30
- Meetings	10	15
Marae [Note 16]		
- Day only visitors		40
- Day plus overnight visitors		150
Schools (pupils plus staff) [Note 17]	12 to 15	15 to 20
Public Toilets (including hand wash) [Note 18]	10 – 20	10 – 20
Camping Grounds [Note 19]		
- Fully serviced	100	130
- Recreation areas	50	65
Rest Homes/Hospitals [Note 20]	220	250
Retirement Home		
- Per Resident [Note 20]	200	220
- Per Day Staff	40	50
Day Staff		
- High Water Usage e.g. some factories [Note 21]		60
- For ALL Standard Facilities (above)		40
- Facilities with Full Water Reduction Fixtures [Note 22]		20-30

Notes:

1. *These flows are recommended **minimums** for design purposes (unless actual comprehensive water usage/flow records along with actual occupancy numbers are available). In some instances ranges of design flow rates are provided to reflect the inherent uncertainty associated with actual per capita wastewater production.*
2. *Where a site is reliant on water supply being supplemented by water tanker, the design flow allowances based on reticulated water supply must be applied.*
3. *In the Auckland Region, use of the following household flow allowances apply to on-site system designs for dwellings authorised as ARC Permitted Activities.*
4. *Extra Wastewater producing fixtures include fixtures such as garbage grinders; dishwashers, modern shower or bath facilities or other comparable fixtures.*
5. *These include 11litre flush water cisterns; automatic washing machine and dishwasher. No garbage grinder unless other water saving measures such as low flush 6/3litre toilet cisterns.*
6. *Standard Fixtures include dual flush 11/5.5 or 6/3litre toilet cisterns, and includes standard automatic washing machine, but a low water use dishwasher, no garbage grinder.*
7. *Standard Water Saving Fixtures include dual flush 6/3litre toilet cisterns, and includes aerator faucets, shower flow restrictors, water conserving automatic washing machines and restricted, standard automatic washing machine and dishwasher, no garbage grinder. Further, a water meter is recommended and is a requirement in the Auckland Region for any systems with design flows based on allowances less than this level.*
8. *Full Water Reduction Fixtures include the combined use of the dual flush 6/3litre toilet cisterns, shower flow restrictors, low pressure aerator faucets (taps), front load/low water consumption water conserving automatic washing machines and LOW water use dishwasher, NO garbage grinder, NO bath AND fixed orifice flow control (FOFC) devices* in ALL water use outlets or flow restriction valves to achieve the following flow rates: Laundry faucets: 10L/min, Kitchen faucets: 9L/min, Bathroom faucets: 6L/min, Shower rose: 9L/min. A water meter is required for any design flow based on low water allowances assuming full water reduction fixtures are in place, to ensure flows can be monitored to verify fixtures are maintained in place.*
9. *The Reduced allowance for sites not connected to a continuous electricity supply (such as Great Barrier Island), which reflects the inherent water conservation on such sites with the reduced reliance on high water consumption appliances. Water usage on sites with poor electricity supply and with low water pressure supply is considered equivalent to that from houses with full water reduction fixtures. However, if such appliances are installed, the normal design allowances should be applied.*
10. *Design flows for Households with Full Water Reduction Facilities and no Bath if a design flow of less than 115litres per person per day (for roof water supply) and less than 140litres per person per day (for reticulated water supply) is used.*
11. *Design flows allowances as for Notes 6 and 7 plus on-site recycle to toilet cisterns for flushing. The flow allowance reflects the removal of toilet flush water from the land disposal system. The designer must be aware that the wastewater treatment system is to be sized to treat the prewater conservation flow volume (to account for the same or higher BOD load).*
12. *Flow rates to be applied where only the blackwater from toilets is to be treated and discharged to land disposal.*
13. *Flow rates to be applied where only the greywater is to be treated and discharged to land disposal. The lower design flow is only to be applied where there is no bath. Applicable where solids from kitchen and toilet waste flows are excluded from the wastewater stream. For households with low water use facilities in accordance with Note 6, the lower end of the range applies; for standard household domestic facilities, the higher range applies [see Note 8].*

* At the time of printing, trade names of effective FOFC devices include Trident and Jemflow

14. *Evidence does not support lower water usage by staff or guests of commercial premises, so no differentiation is made to the flow allowances according to the water supply source. Some reduction (up to 25%) may apply to the per guest water usage allowance if laundry, is undertaken off-site.*
15. *Evidence does not support lower water usage between roof water and reticulated water supplies usage by staff or guests of commercial premises, so no differentiation is made to the flow allowances according to the water supply source. For bar patrons, it is assumed that there is minimal if any food served, other than odd bar snacks. Where meals are served, meal water usage allocations apply per patron. In bar facilities, where water full reduction fixtures are installed on all water usage outlets and patrons are only present for short periods, a water usage allowance of 10litres per person may be appropriate.*
16. *Assumes that lunches and lunch/dinners will be served, and that overnight visitors have access to showers but not to laundry facilities. Water meter readings should be installed to provide added certainty to the accuracy in the design flow allowance. The designer should be aware that water conservation measures installed in commercial premises eg; bars, restaurants may not provide the same level of savings as achieved by domestic uses. Unless specific metered water consumption information is available conservative flow allowances should be applied*
17. *Based upon experience in the Auckland area, these values for schools are conservative. Recorded flows appear to be up to 15litres/person/day on rainwater tank supply, and 15 to 20 litres/person/day on community or borewater supply. For design purposes, figures from the lower end of the range should be supported by actual water usage records otherwise the higher figure should be used. Additional allowances also need to be made in the design flows for schools that also have cafeterias (with on-site catering) and/or gyms with shower facilities.*
18. *For low water use toilets with 6/3litre flush cisterns, standard public facilities, the lower end of the range applies; for modern upmarket toilet facilities, the higher range applies.*
19. *Recreation areas with no showers or communal cooking facilities.*
20. *Flow allowances for individual dwellings within a retirement village may be based on the recommended flow allowances for households or alternatively on flow meter rates where these are available. Where extra care facilities are provided the actual per capita rates will be higher than standard rates provided and a conservative design allowance should be applied.*
21. *Increased water usage allowances are appropriate where staff activities likely to involve regular cleaning of themselves and/or the facilities e.g. rural food preparation factory. Where staff are likely to use showers, the designer should consider all the activities the activities being undertaken by staff and rates higher than 60litres per person per day may apply.*
22. *Lower water usage allocations apply where staff water usage is likely to be minimal due to short hours and full water reduction fixtures (equivalent to the allocation for a café customer). The provision of flow reduction fixtures may not result in significant water usage reduction for staff due to equivalent cleaning needs irrespective of the water fixture devices.*

The basis for the recommended flow allowance allocations for standard dwelling facilities is provided further in Table 6.3 below:

Table 6.3: Flow Allowance Reduction Calculations for Household Flows

FLOW ALLOWANCE Litres/Person/Day	CALCULATION	JUSTIFICATION
B. Standard Fixtures 180 – 200 L/p/d		Toilet use flow volume based on 5 flushes/d @ 11 litres/flush l(L/f) s 11 L/f x 5 f/p/d = 55L/p/d (Toilet use only)
C. Household with 11/5.5 or 6/3 litre flush 160 L/p/d	180 L/p/d – 22 L/p/d = 158 L/p/d	Dual flush 11/5.5 L flush 1flush x 11 litres plus 4 flushes x 5.5 litres = 33l/p/d OR 22 litres less per person per day
D. Household with 6/3 litre flush and Water Reduction Fixtures 145 L/p/d	180 L/p/d – 37 L/p/d = 143 L/p/d	Dual low flush 6/3 litre 1 flush x 6 L plus 4 flushes x 3 L = 18 L/p/d OR 37 litres less per person per day
E. Household with Full Water Reduction Fixtures 120 L/p/d	145 L/p/d – 26 L/p/d = 119 L/p/d	Dual low flush PLUS water reduction valves etc having an 18% reduction from water saving devices is 26 L/p/d giving a total % reduction from 180 L/p/d to 120 L/p/d of 35% (made up of 20% for 6/3 toilets and 15% for water reduction fixtures)
For Use of the Following Flow Allowances in the Auckland Region, an ARC Discharge Consent is Required. (Excluding allowances In Option F. in Table 6.2 of 100 to 120 L/p/d for Households without a Permanent Electricity Supply)		
G. Household with Full Water Reduction Fixtures and No Bath 115 L/p/d	120 L/p/d – 5 L/p/d = 115 L/p/d	No Bath allow 5 litres/person/day
H. Households With Full Water Reduction Facilities Plus Recycle to Toilet Cisterns 95 – 100 L/p/d	120 L/p/d – 18 L/p/d = 102 L/p/d	Dual low flush PLUS water reduction valves PLUS recycling of secondary treated and chlorine disinfected effluent for reuse in toilet cisterns reducing the discharge volume to 100 l/p/d (or 95 L/p/d with NO bath). (Made up of 18 l/p/d reduction for toilet cisterns off 120 L/p/d.)
I. Households Blackwater Only (based on 11 litre flush) 66 L/d	11 L/flush x 6 flush/p/d = 66 L/p/d	Toilet use flow volume based on 5 flushes/d @ 11 litres/flush. (Toilet use only)
J. Households Blackwater Only (based on 11/5.5 litre flush) 45L/d	2 flush x 11 L + 4 flushes x 5.5L = 44l/p/d	Toilet use flow volume based on Dual flush @ 11/5.5 L (Toilet use only)
K. Households Blackwater Only (based on 6/3 litre flush) 25 L/d	2 flush x 6 L + 4 flushes x 3 L = 24 L/p/d	Toilet use flow volume based on Dual low flush 6/3 litre. (Toilet use only)

From Table 6.3 from ARC experience, and from further literature [Ref 2 & 3] toilet or blackwater flows are considered likely to constitute in the order of 10% to 30% of the total per person daily flow allowances and typically in New Zealand 20% to 25%. In situations where water reducing fixtures are already in place, blackwater flows from toilets are likely to be a lower proportion of the total daily water usage and represent in the order of 15% to 18% of the total water usage. In the event wastewater flow volume from toilet water usage can be deducted from in the design flows, such as where composting toilets are used or where treated wastewater is recycled for toilet flushing, it is appropriate that a conservative approach is taken for establishing the remaining wastewater flow for design purposes and that the lower percent reductions are made.

6.3.3 Alternative Data

Table 6.2 is by no means meant to be a exclusive list of water allowances according to facilities – designers will find it necessary to make estimates of daily flow allowances for other types of wastewater generating sources as appropriate. In such circumstances, their design report should outline justification for the data adopted. The USEPA On-site Wastewater Treatment Systems Manual (2002) [Ref 3] provides a comprehensive listing of design per capita flow rates, based on American practices, that are in some cases considered conservative figures in the New Zealand context.

Actual flow data can provide more certainty of actual water usage than more generic (although usually conservative) flow prediction figures, and is a good means of verifying the proposed design flow volume. Flow meter readings and occupancy numbers need to be recorded on a daily basis at the same time each day for a representative period (at least a number of weeks) for the existing activity and then extrapolated to represent predicted peak flows under the future maximum occupancy/usage conditions. Again, a precautionary approach needs to be taken when predicting design flows to ensure sufficient system capacity to accommodate flows from peak events.

6.3.4 Water Use By Fixtures

Average water use by domestic fixtures provides an indication of the wastewater source and volume per fixture (Table 6.4), based on the United States. Care is required when evaluating average individual fixture water use as the actual production per fixture can vary significantly depending on how the homeowner manages water use and operation of various appliances. For example, average washing machine wastewater production is 22% of the daily total. However, daily wastewater production derived from clothes washing can be significantly higher where all the washing is done on one or two days over a weekend. This can result in overloading of the treatment and land disposal systems unless there is adequate buffering in the system.

The recommended design flow allowances in Table 6.2 include a factor of safety, not provided in the following data of per fixture water usage. Water reduction fixtures particularly Fixed Orifice Flow Control (FOFC) devices can make a significant reduction in typical water usage. Information on FOFC devices is provided in Appendix J.

In all cases, it is critical that all occupiers of homes dependant on on-site wastewater disposal, understand the implications of concentrated use of high water consumption appliances over a short time period and that their use is moderated. In any event, wastewater production from a typical home is concentrated over two short periods of the day with the highest production being concentrated first thing in the morning and dinner time in the evening. Package treatment plants, aerobic wastewater treatment systems and sand/textile filter systems and controlled pump dosed disposal systems, can have a significant positive effect on buffering the flows throughout a day.

Table 6.4: Typical Percentage Domestic Water Use by Fixtures

Fixture	Typical % Range [Ref 3]	Typical % Range [Ref 2]
Toilet [Note 1]	26.7 (22.6 – 30.6)	30 (20 – 40)
Shower / Bath [Note 2]	16.8 (11.8 – 20.2)	20 (15 – 25)
Washing Machine	21.7 (17.8 – 28.0)	20 (15 – 25)
Dishwasher	1.4 (0.9 – 2.2)	7 (5 – 10)
Taps	15.7 (12.4- 18.5)	10 (8 – 12)
Leaks & Other Domestic Usage	16	13 (10 – 17)

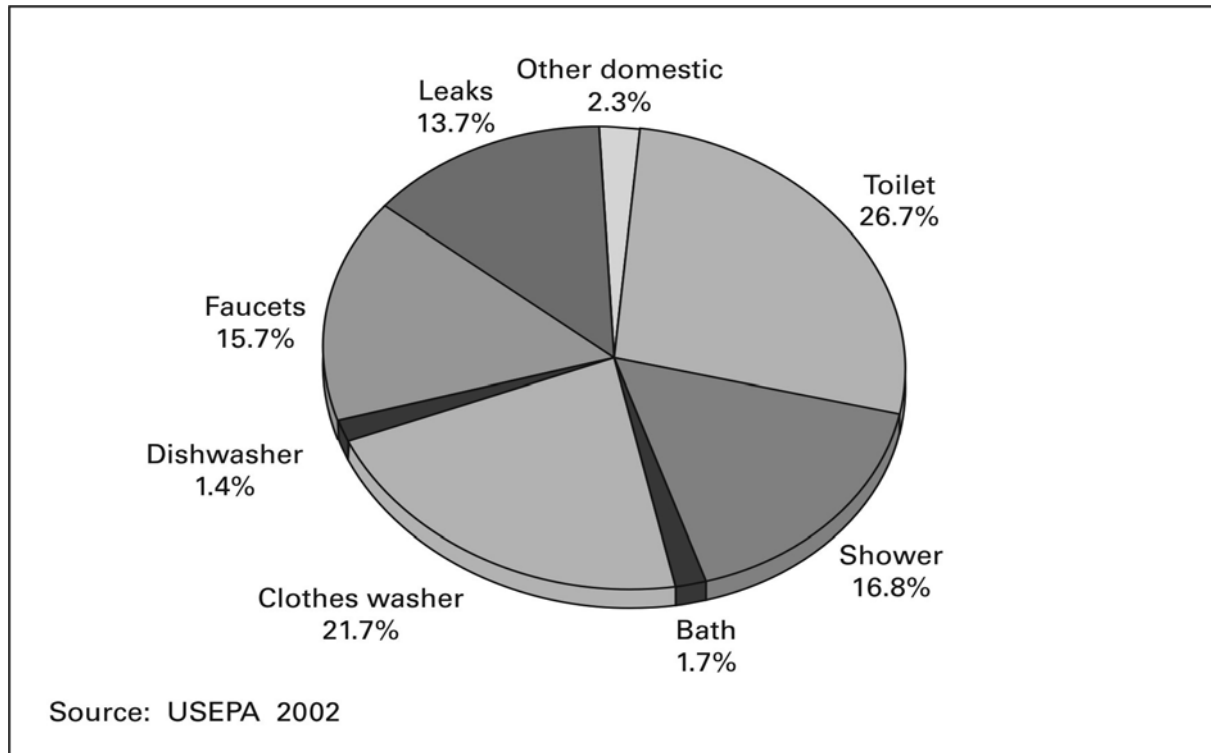
Sources: Crites & Tchobanoglous (1998) and USEPA (2002) [Refs 2 & 3].

Note:

1. Toilet use based on United States examples using on average 11 to 22.5litres/flush [Ref 2]. Lower percent flows are representative of New Zealand toilet systems, as suggested in Section 6.3.2, this can range from in the order of
2. Average shower water use is dependent upon individual showering habits and the length of showering. When estimates are being made it is important to allow a factor of safety and over rather than under estimate potential water usage.

The estimate for shower/bath facilities is not considered conservative. In the New Zealand context, it is recommended that an allowance of 25% to 30% is provided for all bathroom facilities. Further detailed data on water usage by fixtures is available in the paper by Carew [Ref 40], which provides data from a study of at least four water usage events of each appliance in up to 8 houses in a New South Wales, Australia, township.

Figure 6.1: Typical Domestic Water Use



Patterson, [Ref 41] provides a detailed comparison of actual water usage data for water consumption from 92 various washing machine types. The paper provides consistent data that front loading washing machines use significantly less water than top loading washing machines. The data suggests a difference of 30 to 40% for similar load sizes. While this difference in flows between machine types is noted, caution should always be applied when determining design flows, as machine types will usually change with changes in dwelling occupancy/ownership, such that any conservatism in the design of the wastewater system will immediately be lost. It is therefore recommended that in all cases, while benefits of front loading washing machines should be recognised, there should not be a corresponding reduction to the design flow.

6.3.5 Intermittent Flow Scenario

An example of an alternative flow scenario might be a community hall, marae, or sports ground clubroom facility where daily and/or overnight social and recreational occupancy is quite intermittent or confined to specific days of the week or month. The design report should address with such cases as follows:

- a. A day by day (and/or night by night) maximum occupancy scenario should be drawn up;
- b. The per person flow allowance values are assigned for the individual user groups, from Table 6.2;
- c. A weekly or monthly total flow is assessed;
- d. An average daily flow volume is estimated for the weekly or monthly period;
- e. The land disposal system is then sized on the basis of this daily average flow;
- f. The maximum daily flow discharge volume to the land application system is checked to ensure that sufficient storage capacity for that flow is available within the treatment system; and
- g. If sufficient peak flow storage is not available in the designed treatment system, the capacity of a separate or supplementary storage system is determined.

6.3.6 Other Contaminated Wastewater Flows

Swimming pool backwash water is a wastewater flow and it is critical that it is managed and discharged in a manner that will not affect the sewage wastewater disposal system. In the Auckland region, Rules under the ARC Proposed Regional Plan: Air Land and Water (PRP:ALW) cover the discharge of contaminants to land. In TP58, the Rules concerning the discharge sewage wastewater are outlined in Chapter 2 and further in Appendix C. Criteria for other contaminant flows are introduced below.

6.3.6.1 Rural Wastes

The disposal of rural wastes must be in accordance with the Permitted Activity (PA) criteria in a regional rule or the discharge will require a resource consent for the discharge of contaminants. Rules under Rural Wastes – Discharges to Land or Water under the PRP:ALW plan covers the discharge of rural wastes and specifies permitted and controlled activities for the collection, storage and land application of many types of rural waste.

6.3.6.2 Pool Backwash Wastewater

General

The screening and filtering of pool water retains gross solids as well as other contaminants from the pool water, in the filter. Regular backwashing is required as routine maintenance of the filter to remove trapped material. Swimming pool backwash will usually contain pool chemical residues and

sludge residue of inorganic and organic particles from the pool water filtration process and is considered a contaminated wastewater flow. The discharge often needs to be addressed on a new site at the same time that the system design for sewage wastewater disposal is addressed. Pool backwash discharges are mentioned here, as swimming pool backwash water is a wastewater flow and it is critical that it is managed and discharged in a manner that will not affect the sewage wastewater disposal system.

Backwash Wastewater Treatment Options

In the past, backwash has been directed into a soakage pit, trench or directly onto ground surface. There is a growing awareness that some treatment is appropriate to remove suspended solids and wand to protect the receiving soils. However, due to their potentially high chemical and/or contaminant content, filter backwash wastewater flows cannot be treated in the same treatment system the domestic wastewater, as the chlorine or other chemicals in the backwash can severely impair biological activity. Therefore, separate systems are necessary.

The treatment options include:

- a. *Standard gravity tank* –allows settling of the solids prior to discharge. As the flow is normally only at a frequency of once or twice per fortnight tanks have often been too, small based on storage capacity for the peak flow and some storage of accumulated solids. The rapid backwash discharge rate can resuspend the collected solids, defeating the purpose of treatment. Therefore a larger multi compartment tank is necessary if treatment is to be by gravity tank.
- b. *Gravity Tank with effluent filter* – effluent filters retain gross solids of 3mm or greater so are unlikely to retain fine solids removed form a sand filter. Also the rapid influent turbulent conditions could reduce particle sizes to less than 3mm.
- c. *Pumping from the settling tank* – this has the advantage of allowing installation of a fine disc filter prior to disposal but cost of pumping to disposal is not usually justified and the filter could require regular hosing down.
- d. *Inline filter* – installation of a filter directly after the backwash outlet before discharge to land is the most practical treatment option, as it enables use of pressure from the pool's pump. The filter does require maintenance after each backwash cycle to prevent clogging or damage to the pump, so this will need to be undertaken by the homeowner as part of their routine pool maintenance.

Backwash Wastewater Disposal

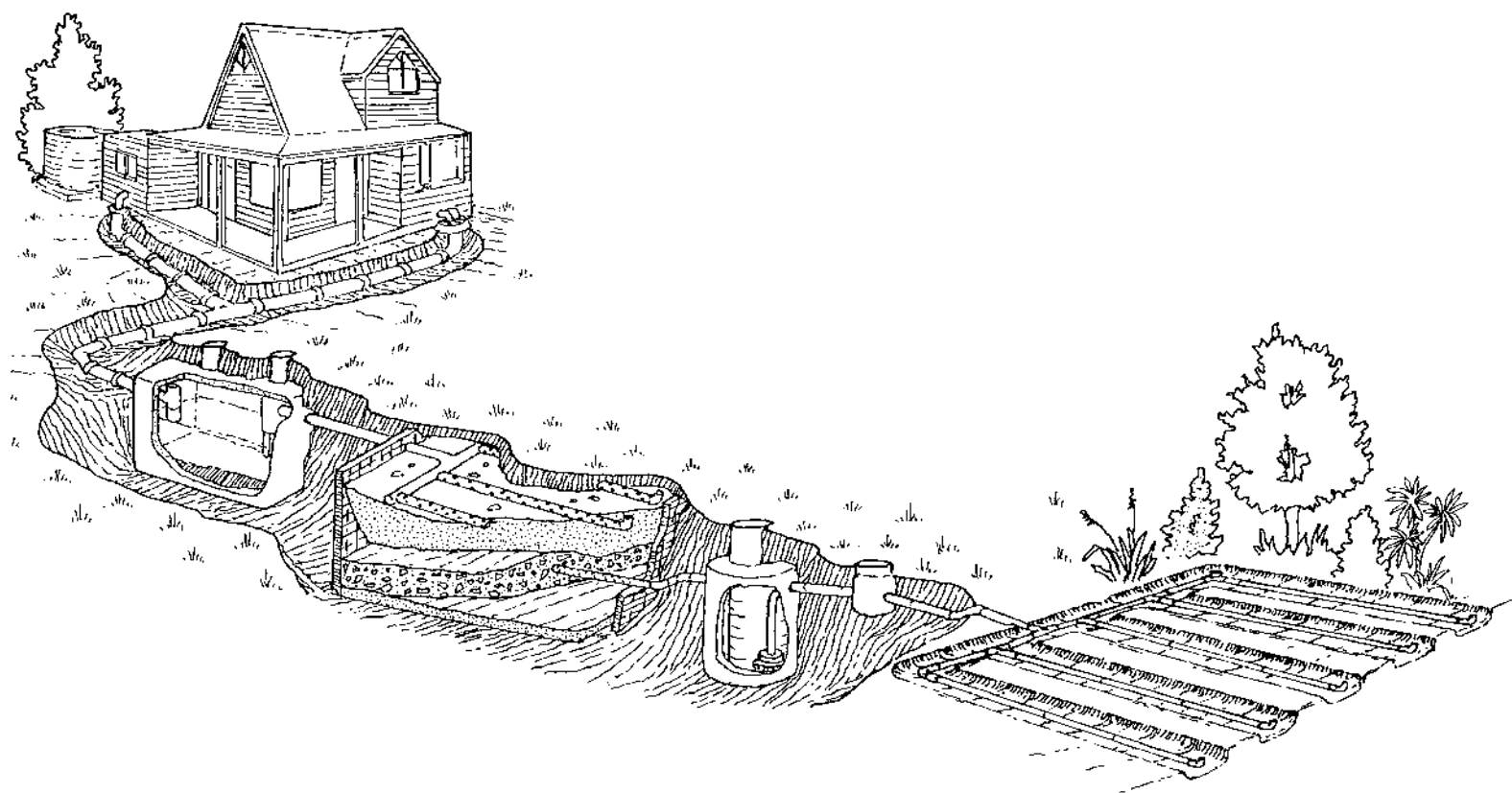
Backwash water disposal must be in accordance with the Permitted Activity (PA) criteria in a regional rule or the discharge will require a resource consent for the discharge of contaminants. A rule under Other Discharges of Contaminants to Land and Water under the PRP:ALW plan covers the discharge of swimming pool filter backwash water. Rule (number 5.5.59 in the version notified October 2001) specifies that the Permitted Activity is:

"The discharge of swimming pool filter backwash water to land, in a manner that does not result in runoff into surface water."

Due to the intermittent nature of backwash flows, a standard flood and rest system is suitable. This can consist of a large trench or pit designed to accommodate the entire backwash volume per discharge, allowing gradual soakage over until the next discharge. Following are some recommendations for the design of a land disposal system for swimming pool backwash water to assist meeting this PA criteria:

- The daily design flow volume should be based on the maximum predicted backwash volume divided by the minimum number of days between backwashes, to get an average daily flow volume;
- Treatment may or may not be required depending on the volume involved, the concentration of contaminants removed in the backwash process and on the receiving environment and potential for contact with surface water. Minimum treatment would involve an inline filter as discussed in d) above, prior to disposal; and
- A drainage trench or pit should be installed that has a void capacity between aggregate equivalent to the total backwash volume, and with a basal floor area to enable each backwash to soak away over the days between each discharge. The latter should be based on the predicted basal soakage rate depending on the soil type averaged over the number of days between discharges (further information on soakage trench and pit design is provided in Chapter 10).

TP58 daily trench loading rates can be referred to as a guide according to soil types (with the loading rates averaged over the discharge cycle). Generally higher rates are ok on the basis that limited intermittent soil saturation of the backwash trench is ok, providing it dries out before the next discharge. In Auckland clay soils rates up to 20mm/day averaged over the number of days between discharge may be adequate. Property owners should be wary that soils might clog over time if there is a high sodium content in the discharge. Gypsum or lime can then be applied to the soils depending on the soil conditions to assist soakage.



7 > Wastewater Treatment Options

7. ON-SITE WASTEWATER TREATMENT OPTIONS

7.1 INTRODUCTION

The term “treatment” refers to all technologies used to retain and treat wastewater residuals prior to discharge of the treated effluent to a land disposal system (such as pressure compensating dripper irrigation, seepage trenches, or evapotranspiration beds).

All components of an on-site system, thus provide “treatment” of the wastewater residuals, to a varying degree. The treatment stages can be engineered to achieve specific design objectives in terms of minimising public health and environmental risks. The various treatment technologies provide a range of treatment levels. Design specifications are provided in this chapter for the following core treatment systems. These are listed by the stage of treatment that they provide in increasing order of degree of treatment:

<i>Primary Treatment:</i>	Traditional septic tanks [TST] (without an outlet filter). Conventional septic tanks [ST] (with an outlet filter).
<i>Secondary Treatment:</i>	Aerobic treatment plants [AWTS] (aerated wastewater treatment systems biofilter treatment units).
<i>Advanced Secondary Treatment:</i>	Septic tank/textile filter units [ST-TF] (recirculating textile filters). Septic tanks/sand filter units [ST-SF] (intermittent sand filters; recirculating sand filters; also known as packed bed reactors).
<i>Tertiary Treatment:</i>	ST-SF/TF with disinfection unit (chlorination or ultra violet (UV)). ST-SF/TF with nutrient reduction (with or without disinfection).

A number of other additional treatment methodologies are introduced further in this section. The information on a number of these alternatives is predominantly informative only due to a lack of availability of clear design specifications for these less common alternatives.

Table 7.1 sets out indicative effluent quality ranges taken from the literature for domestic wastewater and a range of on-site treatment units. Effluent quality from the same types of facility can vary significantly depending upon the activities occurring on the site. All treatment units must comply with the requirements of the Building Code (Clauses G13 and G14) as set out in the First Schedule to the Building Regulations 1992), and be installed in a manner that enables ready access for maintenance, including desludging.

The choice of treatment system and level of treatment (primary, secondary, tertiary) will be based on the site evaluation and assessment of environmental effects but in any event is to be designed to minimise the potential detrimental impacts on the environment from land disposal of wastewater.

Design of the wastewater treatment system must also take into consideration the measured or projected wastewater flow, the wastewater source and therefore strength, and the intended short and longterm use of the facility. Wastewater strength is a very important consideration when evaluating design and treatment options. For example, domestic wastewater has a significantly lower organic content than restaurant derived wastewater, which requires careful design consideration to avoid organic overloading and failure of the treatment and land disposal systems. It is important to recognise that a reduction in wastewater flow through the installation of water conservation fixtures in the domestic situation does not reduce the organic loading in the wastewater stream and therefore the wastewater treatment system should be sized for the prewater conservation hydraulic loading. Hydraulic and organic loading rates can be reduced by eliminating appliances such as in sink garbage grinders. The use of in sink garbage grinders on sites with on-site systems is strongly discouraged.

Table 7.1: Typical Domestic Effluent Quality Ranges – On-site Treatment Options

Treatment Unit	Typical Concentration g/m ³						FC
	BOD ₂	TSS	NH ₃	NO ₃	Total Nitrogen	PO ₄	Cfu per 100 ml
Raw Wastewater (mixed value)	250 to 350	300 to 400	Varies	<1	Varies	10 to 30	10 ⁶ to 10 ¹⁰
Raw Greywater	180 to 240	130 to 160					
Traditional Septic Tank							
- Septic Tank (poor operation)	7 to 250	80 to 110	40 to 60	<1		10 to 20	10 ⁶ to 10 ¹⁰
- Septic Tank (good operation)	120 to 150	50 to 70	20 to 30	<1	40 to 100 Typical	7 to 20	10 ⁵
- Greywater Tank (average operation)	50 to 80	30 to 50					
- Digestive Tank (average operation)	60 to 100	40 to 60					
- Two stage septic Tanks (in series)	70 to 120	40 to 60					
Conventional Septic Tank							
- Septic Tank with Outlet Filter	70 to 120	30 [Note 3]			40 to 100		
- S T plus Intermittent Sand Filter [Note 4]	<10	<10	0.5 to 10	20 to 25	25 to 40 [Note 7]	7	4x10 ² to 10 ⁴ [Note 9]
- S T plus Recirculating Sand Filter	< 10	< 10	2 to 4	30 (avge) [Note 6]	15 to 40 [Note 7]	< 1 to 10	10 ² to 10 ⁴ 99% reductn
- S T plus Recirculating Textile Filter	< 15	< 15	0 to 5	30 (avge) [Note 6]	30 to 60 [Note 7]	5 to 15	10 ³ to 10 ⁴ 99% reductn
- S T plus Recirculating Textile Filter with N reduction					Approx 10 to 15 [Note 8]		
- S T plus Recirculating Sand Filter with N reduction					75% Reduction [Note 8]		
- AS – AWTS [Note 5]	20 to 50	20 to 100	<1	35	25 to 60 [Note 7]	4 to 10	3 x 10 ³
- AS – AWTS Plus Sand Filter	<10	<10	<1	35			
- Tertiary Disinfection							[Note 10]

(This table is based on Table 6.1 in TP 58 Second Edition, but has been revised and updated with USEPA 2002 Table 3-19, Fact Sheet 10 Table 21 & Fact sheet 11 Table 2 [Ref 3] and Crites & Tchobanoglous 4-14 and 4-16 [Ref 2])

Notes:

1. The typical concentrations are to be used as a guide only as the concentration of constituents in wastewater are highly variable.
2. Data based on indicative values from the literature (and in some cases on estimates) and NOT on recorded New Zealand information.
3. Total suspended solids level following an effluent outlet filter is dependent upon the type of filter and hydraulic flow [Ref 2]. Some literature indicates TSS following some filter types may be significantly higher e.g. up to 70 g/m³.
4. ST refers to Septic Tank.
5. AS- AWTS refers to activated sludge aerobic wastewater treatment plant
6. The effluent quality obtained from the more sophisticated treatment system is reliant upon the system design, loading rate and being correctly operated and maintained.
7. Treated wastewater output quality can vary significantly from the above typical values and is dependent upon the wastewater influent composition.
8. Lower nitrate concentration can be achieved following an additional nitrate reduction cycle.
9. The percent reduction with intermittent sand filters is better than that achieved by recirculating filter systems, due to the single pass and lower loading rate.
10. The level of disinfection and reduction in indicator organisms is dependent upon the level of and type of disinfection and is reliant on regular monitoring and maintenance.

Typical raw domestic wastewater component concentrations and treated wastewater concentrations achievable using current treatment technology commonly used for on-site systems are presented in Table 7.1. The concentrations presented are taken from the literature, which indicate that wastewater concentrations are highly variable. As such, Table 7.1 should only be used as a guide. The literature from which the wastewater concentrations have been predominantly sourced is from the United States and therefore may not accurately represent typical wastewater concentrations in the New Zealand situation. Higher per capita water consumption in the United States is likely to result in reduced concentrations compared to New Zealand. Specific wastewater concentration testing is recommended where there is concern that concentrations may exceed typical domestic strength and/or where good understanding of influent quality characteristic is critical for treatment system design and/or operation.

7.2 PRIMARY TREATMENT

7.2.1 Septic Tanks General

The septic tank is typically used to provide primary treatment prior to either discharge into the ground via an infiltration system or prior to a secondary treatment stage. It is the oldest and still the most common component of any on-site wastewater system. Providing it is adequately sized, in many cases it can also be the most effective single component of a treatment system.

A conventional septic tank is a simple solids settling and scum retention unit (Figure 7.1A) in which the accumulating sludge in the base of the tank biodegrades and consolidates slowly under the action of facultative and anaerobic microorganisms. The tank operates as a passive low rate digester, with wastewater passing through as predominantly a plugflow. The solids separation is by a stratification process of ascending or descending particles, depending on the density of the particles relative to water. The separation and biodegradation are natural processes that do not depend upon the use of additives for any assistance.

A septic tank collects greywater (kitchen, bathroom and laundry) and blackwater (toilet waste) and provides an environment for settling of solids and floatation of oils, grease and fat (scum). The solids and scum stratification results in the development of a clear zone in the middle, which is relatively free of solids. It is from this clear zone that effluent is discharged from the septic tank. Poor separation within the septic tank is likely to result in poor effluent quality.

The total capacity of a septic tank is divided into:

- a. Air space at the top and above the scum layer, which in the case of a pumped system includes capacity for 24 hours emergency storage volume above the high water level alarm sensor;
- b. The scum layer;
- c. The clear zone or settling zone; and
- d. The sludge layer at the base.

In order for effective settlement of solids and floatation of scum to occur within the septic tank, adequate capacity is critical to ensure sufficient wastewater retention time. As solids and scum accumulate the volume of the clear zone is progressively reduced resulting in reduced settlement and floatation efficiency and increased potential for solids carry over.

As a minimum requirement, septic tanks should be constructed to AS/NZS 1546.1 (1998) standards. The tanks must be structurally sound and watertight to operate effectively and prevent ingress of groundwater and surface water and leaching of wastewater to groundwater. Infiltration results in hydraulic overloading of the wastewater treatment and land disposal system and flushing of solids and grease from the septic tank. Leaky tanks, including risers, pipe inlets and pipe outlets are unacceptable. Small septic tanks (less than 4,500litres) have limited capacity for storage of solids and scum and require more frequent pumpouts to provide capacity for an effective clear zone. The higher cost of installing a larger septic tank is usually offset by the reduced pumpout frequency requirement.

Regard should also be had for climate. In tropical climates the biochemical breakdown of solids and scum can almost be completed in the septic tank. In cooler climates, the microbiological activity is restricted such that biochemical breakdown is less efficient [Ref 44]. The septic tank design capacities in this manual are suitable for the moderate northern New Zealand climate. In significantly cooler climates where the natural biodegradation process may be slower, a more conservative approach may need to be taken in the septic tank sizing and in the determination of pumpout frequency requirements, which will need to be increased if biodegradation is impaired.

In all cases, the use of garbage grinders is not recommended in facilities discharging to septic tanks as they significantly increase the scum accumulation rate, which can be in the order of up to one third the scum capacity, although they contribute very little to any increase in sludge accumulation. Grease from the kitchen is detrimental to septic tank performance and should be collected and disposed to refuse wherever practical in preference to the wastewater system. It is very important that homeowners are aware that inappropriate substances should not be disposed of down the drain if the septic tank is to operate. Technical Sheet I-2 in Appendix I provides a list of *Do's and Don'ts* for the homeowner to care for the operation of the septic tank.

The performance of all septic tanks is significantly enhanced by the addition of an outlet solids control device. Traditional septic tanks do not typically include an effluent outlet solids control device (outlet filter), but they can be readily retrofitted to existing septic tanks at the outlet tee pipe. It is recommended that an effluent outlet filter is fitted to the final septic tank outlet in all cases. There is a range of outlet solids control devices available. These are required in all septic tank systems in the Auckland region and are discussed further in Section 7.2.6.

7.2.2 Septic Tank Capacities for Households/Individual Dwellings

There is a range of septic tank volumes recommended in the literature for individual houses, usually based on the number of bedrooms. Septic tank capacities required for combined domestic wastewater flows ("all waste"), and for separated flows comprising toilet ("blackwater") wastewater and kitchen, bathroom and laundry ("greywater") wastewater are set out as informative recommendations in AS/NZS1547:2000 - Appendix 4.3A [Ref 1], and the same information is reproduced here in Table 7.2. The USEPA "On-site Wastewater Treatment Systems Manual" [Ref 5] recommends that septic tanks have at least 3,700litres capacity for individual dwellings. Septic tank capacity is determined on the basis of the daily wastewater production, which in the case of an individual dwelling, is based on the number of bedrooms or dwelling occupants and the design per capita wastewater production rate.

A minimum retention time within the septic tank of 24 hours is typically recommended. However as the volume of solids and scum increases, the working volume and thus the retention time for the influent flow are reduced, increasing the risk of solids carryover to the secondary treatment stage or to the land disposal system. Therefore additional capacity needs to be provided for the accumulated solids and scum layers.

A rule of thumb for establishing required septic tank capacity for facilities other than individual homes, is that the minimum design capacity should be based on two to three times the estimated daily wastewater flow volume. This is based on the septic tank maintaining a minimum 24 hours hydraulic retention time when the tank is 50% to 65% full of sludge and scum, at which point it should be pumped out.

It can take in the order of three years for an effective biomass to develop within a septic tank. If septic tanks are pumped out too frequently, then effective microorganisms are lost and the rate of increase in the solids accumulation volume increases (due to the decrease in effective biodegradation processes). The benefits of a larger tank capacity far outweigh the additional cost. The actual cost difference between a 3000 and 4500 tank size is not large, and yet overtime there are significant cost savings from the less frequent pump out requirements and also further on going benefits from more effective microorganism performance. The most benefit is gained from an increased tank size, where the tank is also fitted with an effective outlet filter.

Table 7.2 provides guidelines for determining the approximate minimum septic tank capacity requirements for tanks serving dwellings.

Table 7.2: Septic Tank Capacities for Dwellings

Type of Wastewater	AS/NZS 1547:2000				USEPA 2002		TP58 2004
	No. of Persons		No. of Bedrooms		No. of Bedrooms		No. of Bedrooms
	1 to 5	6 to 10	1 to 3	4 to 6	1 to 3	4 to 6	1 to 4
Tank Capacity	(litres)	(litres)	(litres)	(litres)	(litres)	(litres)	(litres)
All Waste	3000	3500-4500	3000	4500	3750	6200	4500
Blackwater Only	1500	1800-2500	1500	2500	NA	NA	2500
Greywater Only	1800	2100-2700	1800	2100-2700	NA	NA	3300

Notes:

1. TP58 tank size calculation is based on sludge accumulation rate of 80litres per person per year, a pump out frequency of seven years and 24 hour retention time for the peak daily flow volume, using 200litres per person per day (This provides a buffer hydraulic retention capacity for pulse flows. A lower per person per day flow volume allowance does not provide such capacity and should not be used.)
2. In general allow 1000litres for sludge and scum accumulation over 7 years for greywater tanks and 1200litres for blackwater tanks.
3. Tank capacity allowance of 200litres/person for all waste tanks is greater than the per capita daily flow allowances to provide for hydraulic buffering. For greywater, the design capacity is 33% greater to compensate for the same flow intensities as the larger all-waste tanks.
4. TP58 tank volumes are based on a tank including an outlet filter. Larger tank sizes are necessary with an outlet filter so that there is less hydraulic load on the filter surface.

7.2.3 Institutions & Commercial Septic Tanks:

A design example for determining septic tank capacity requirements in systems serving commercial accommodation facilities is provided in Table 7.3 below:

Table 7.3: Capacity Criteria – Institutions & Commercial Septic Tanks

Type of Wastewater Flow	Settling Volume Allowance (litres/person/day)	Sludge/scum Accumulation Capacity Allowance/person (litres/person/year x 5yrs)	Total Settling Volume Capacity (litres/person) [Note 1]
	24 hours Settling Volume Allowance		
All Wastewater	200	80 (400 litres /p/ 5yrs)	600
Blackwater	60	50 (250 litres /p/ 5 yrs)	310
	Greywater 36 Hours Settling Volume Allowance		
Greywater	160	40 (200 litres /p/ 5 yrs)	320
Commercial Food Premises	Requires specialist design and more frequent pump out.		
Notes:			
<ul style="list-style-type: none"> <i>All waste septic tanks: 24 hours settling volume at a capacity allowance of 200litres per person per day, plus 80litres/person/year allowance for scum/sludge accumulation over five years.</i> <i>Blackwater septic tanks: 24 hours settling volume for daily blackwater flows at a capacity allowance of 60litres per person per day, plus 50litres/person/year allowance for scum/sludge accumulation over five years.</i> <i>Greywater septic tanks: 32 hours settling plus hydraulic buffering volume at a capacity allowance of 160litres per person per day, plus 40litres/person/year allowance for scum/sludge accumulation over five years.</i> <i>Trade Waste Tanks (e.g. for restaurants) require more frequent pump out and additional specialist design considerations over and above the requirements of the above domestic type flow component. Therefore there is no trade waste sizing criteria listed in this manual.</i> 			

7.2.4 Septic Tank Capacities (Multiple dwellings/institutions)

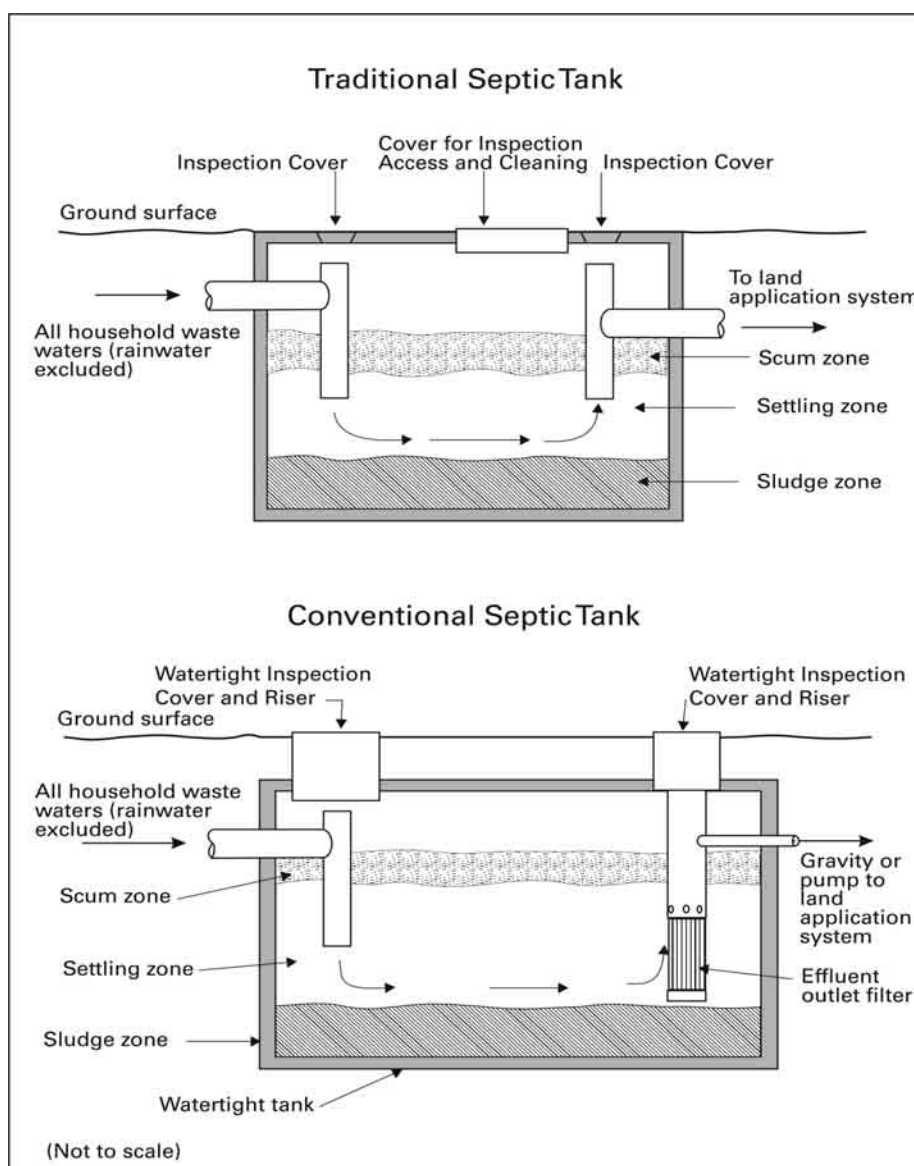
For tanks serving institutions or accommodation units (flats, apartments, motels) with design populations greater than 10 persons, then the above capacity requirements can be adjusted to accommodate shorter pump out schedules such as once every 12 or 18 months. However frequent pumpout will compromise anaerobic decomposition within the tank by removing the bacteria. The literature indicates it takes at least 3 years for optimum digestion to develop with in the tank.

For commercial premises, where the domestic type waste flow is produced by nonresidential employees or customers that are present for only part of the day, then the equivalent person sizing requirements must be determined in order to use Table 7.3 for determining tankage requirements.

The total scum/sludge accumulation allowance is assessed by taking the total wastewater flow per day and dividing it by the appropriate per person flow allowance for households in Table 6.2.

Adjustments will have to be made for the increased rates of solids accumulation in the case of catering or restaurant facilities to allow for extra waste from kitchen sinks and garbage grinders. Larger septic tanks are likely to be required to serve such facilities, due to the potential higher solids accumulation volumes in the septic tanks, which are also likely to require more frequent pumpouts. (This should be based on designer experience and local knowledge and result in larger tanks and more frequent pump out). For existing facilities the wastewater to be treated should be characterised by metering and sampling the wastewater stream to determine BOD₅, total suspended solids, oils & grease. For new facilities wastewater strength characterisation should be based on and referenced to published [Ref 3] or similar existing facilities.

Figure 7.1: Schematic of Typical Septic Tanks



7.2.5 Composition of Treated Wastewater From Restaurant Septic Tanks

Table 7.4 below demonstrates the higher contaminant concentrations in wastewater from commercial kitchens treated in septic tanks. (It is not clear whether the systems sampled also included grease traps). The contaminants of greatest concern are the elevated BOD₅ and oil and grease concentrations compared to those levels in standard domestic wastewater. Additional treatment system components need to be provided to treat wastewater from restaurants and similar premises. Options for addressing the increased BOD₅ and oil and grease concentrations in such wastewater are discussed further below.

Table 7.4: Average Septic Tank Effluent Concentrations of Selected Parameters from a Range of Commercial Establishments

Source	Wastewater Composition							
	BOD (mg/L)	COD (mg/L)	TSS (mg/L)	TKN (mgN/L)	TP (mgP/L)	Oil/Grease (mg/L)	Temp (°C)	pH
Restaurant	582	1196	187	82	24	101	8-22	5.6-6.4
Restaurant	245	622	65	64	14	40	8-22	6.6-7.0
Restaurant	880	1667	372	71	23	144	13-23	5.8-6.3
Restaurant	377	772	247	30	15	101	16-21	5.7-6.8
Restaurant	693	1321	125	78	28	65	4-26	5.5-6.9
Restaurant	261	586	66	73	19	47	7-25	5.8-7.0
Bar/Grill	179	449	79	61	7	49	8-22	6.0-7.0
Motel	171	381	66	34	20	45	20-28	6.5-7.1
Typical Domestic	180		80	68	16	25		

Source: [Ref 2] and [Ref 5]

7.2.6 Grease Traps

Grease Trap Design

Grease traps are critical for assisting with the removal of grease, oil and fat from the wastewater stream and to reduce the flow of grease through the system, protecting downstream components of the treatment and land disposal system from premature clogging. Grease traps are typically applied to wastewater derived from restaurants, cafes, laundromats, hospitals and institutions producing wastewater with a high fat, oil and grease content rather than individual homes.

Reduction of oil and grease from the waste stream has become more difficult with the increased use of certain types of oil used in cooking. Many of these oils are soluble at relatively low temperatures. Grease traps are required as pretreatment for AWTs and ST-SF/TF systems for restaurant or similarly higher strength wastewater. Only wastewater from the kitchen is discharged into the grease trap. For individual homes, the septic tank provides adequate control of grease, although it is important that grease from utensils and cooking are not discharged to the household wastewater system. The concentration of oil and grease can be significantly reduced by wiping plates and bowls with paper towels prior to washing in water. Paper towels can be put in the rubbish or composted.

Grease trap design is similar to a septic tank, relying on cooling the grease and flotation while clearer water is removed from the central zone. Typically the grease dissolved in the hot influent water must be cooled sufficiently to allow the grease to solidify and to trap oils by flotation. To be effective the grease trap must retain the fluid for sufficient time to allow cooling and flotation or for at least 30

minutes [Ref 2] at the instantaneous peak flow. Grease and fat removal is improved by increasing the grease trap capacity and retention time and therefore enabling improved cooling. Also bypassing flows containing solids from the in sink grinder directly to the septic tank is recommended. Combining high solids waste with the waste stream impairs grease trap performance and necessitates increased pump out frequency. The use of an in sink garbage grinder will increase the rate of development of the scum layer in a septic tank and unless the tank is fitted with an effluent outlet filter increases the risk of solids carryover to the land disposal system. The use of an in sink garbage grinder with septic tanks is not recommended.

Most grease traps have in the past been significantly under sized, as they were designed for average flow not instantaneous peak flows. Modifications for improved performance of existing grease traps include placing the inlet below the water surface, and the outlet close to the base of the tank. Placing tanks in series or using multi chambered tanks improve efficiency.

The grease trap volume required for effective separation of oil and grease typically varies from 1 to 3 times the kitchen average daily design flow volume, while in general, the larger the tank volume the better the overall performance. A minimum grease trap volume of 4500litres is recommended. Multi chambered grease traps are more effective than single chamber tanks. The inlet is normally situated within the water zone and the outlet closer to the bottom of the tank. The connection between chambers should be located closer to the base of the tank to minimise the potential for short circuiting but not so low in the wall as to be clogged by settled solids. Typically the connection is more effective using a number of 150mm diameter holes in the connecting wall in preference to one large connection hole.

Grease Trap Operation and Maintenance

Restaurant wastewater strength is higher than household wastewater typically containing elevated levels of grease, oils and fat and solids. Consequently the depth of scum and sludge build up requires regular monitoring and may require removal as often as every three months or more frequently depending on the wastewater source and restaurant kitchen management practices.

Restaurant operators should be discouraged from discharging waste wine and other alcohol, milk, oils and grease into the wastewater stream as these components have a high BOD₅ demand and have a significant negative impact on the wastewater treatment system performance and cost. The use of a simple rubber scrubber and wiping with a paper towel to remove grease from plates prior to rinsing or washing can achieve a noticeable reduction in oil and grease in the wastewater stream.

The use of proprietary 'under sink' grease and oil reduction systems in addition to grease traps can minimise the quantity of oils, fats and greases discharged into the treatment system, but as they require use of chemicals, this increases system operation costs. The effectiveness of grease converter systems in reducing BOD is uncertain.

Wastewater containing a high organic load discharged from a septic tank will also cause premature clogging of the land disposal system by coating the infiltrative surfaces and causing excess biomass formation. Products resulting from excess loading of the infiltrative surface include; slimes, sugars, ferrous sulphide and metals such as iron and manganese [Ref 3].

7.2.7 Septic Tank Effluent Outlet Filters

Outlet filters, also known as outlet solids control devices are very effective and relatively low cost items that are fitted to the outlet of septic tanks and can lead to a considerable improvement in the performance of the whole wastewater treatment system. They ensure that solids of a size of generally 3mm or greater are retained within the septic tank rather than being discharged into the secondary treatment system and/or to the land disposal system.

It is now the norm for all single stage or two stage tanks or multi chamber tanks to be fitted with effluent outlet filters in place of an outlet tee. The purpose of the outlet filter is to capture those larger suspended solids that have not settled, or have been re suspended by hydraulic turbulence. Not all suspended solids are held back by the outlet filter. Fine suspended matter will still pass through the filter openings to the land disposal area. However, by controlling the discharge of suspended matter to the land disposal system, treatment capacity within that system can be maintained, and its life prolonged.

Outlet filters can be placed within some three general configuration categories as shown in schematic diagram presented in Figure 7.3:

- Type A: Single or multiple mesh tubes.
- Type B: Single or multiple slotted tubes.
- Type C: Multiple plate disc dam module.

Outlet filters are under continuous development with many models available commercially. Examples of some types are shown in Figure 7.3. The earlier United States mesh tube models have been extensively monitored, and indicate that effluent suspended solids following a mesh outlet filter can be controlled to close to an average of 30g/m³ TSS compared to 80 g/m³ output from a well performing conventional septic tank with only an outlet tee [Ref 2]. Such filters can enhance both the suspended solids and organic matter (BOD₅) removal performance of the septic tank. It is not feasible to determine the relative performance levels of the three type categories or of individual products, although manufacturers tend to emphasise the importance of relative slot/mesh size and overall filter surface area. External access for maintaining the outlet filter has to be provided.

Those filter units, which only require wash down maintenance at the same frequency as septic tank pump out (desludging) have an operational advantage over those requiring more frequent wash down. When washing down outlet filters, the built up slime growth should be discharged back into the septic tank. Because maintenance of effluent filters involves bringing service personnel into contact with fresh or partially degraded waste, special handling measures and precautions should be part of the management process. It is important that the riser providing access to the outlet filter is of sufficient diameter to allow easy access for desludging the septic tank without restricting access around the filter in tank support.

While some research indicates that an increased pumpout interval may be necessary as a result of the use of an outlet solids control device, there is also contrary evidence that the retention of biomass within the tank enables more efficient biodegradation of the retained organic material, decreasing the need for frequent pump outs. It is recommended that traditional septic tanks be pumped out at a minimum of three yearly intervals. Where effluent outlet filters are in place, this can be delayed to when the combined depth of scum and sludge occupies 50% of the tank volume. Actual pump out frequency will depend upon the facility being serviced by the septic tank and the solids production, and it is always recommended that some of the sludge biomass material be retained within the tank to provide a stable bacteria population.

All septic tank effluents are considered to be *primary* treated, the advantage of a tank including an outlet solids control device is the better control of solids, protecting the land disposal system, and decreasing the frequency that desludging is likely to be required.

7.2.8 Septic Tank Configurations

Comparison of Traditional, Conventional and Two Stage Septic Tanks

A traditional tank is a single chamber unit of rectangular construction. Oval or circular tanks are also used in such cases and it is recommended that the total surface area of the tank be not less than that of the same size rectangular tank, with the separation of the inlet and outlet tee being a minimum of 1.5m. Spherical tanks cannot meet the surface area requirement above, but are still satisfactory as their bulk is centred at around half depth. A conventional septic tank now includes a solids outlet control device in place of the outlet tee located at the outlet of the last septic tank in series. Tank configurations include:

- Conventional septic tank (includes an outlet solids control device);
- Traditional compartmented tanks (a single chamber tank incorporating a perforated partition wall); and
- Traditional two stage tanks (two separate tanks in series, or a twin compartment tank with tee inlet/outlet connecting the compartments);

Compartmented Traditional Tanks

Compartments separated by a partition wall are an optional configuration for the conventional septic tank. Where tanks are precast under factory conditions, fabricating internal partitions will increase the cost of the manufacturing process. Partition walls are usually placed to divide the tank into two compartments in the ratio by volume of 2:1. This was believed to provide some improvement in treatment performance over a single compartment tank of the same overall volume due to the hydraulic buffering effect provided by the first compartment, thereby smoothing the flow through the second, and reducing the potential for carrying over of solids into the further treatment stages and/or into the ground disposal system. Tanks with compartments may need to be desludged more frequently than those of equal size without compartments, as the bulk of sludge settles in the first compartment. While it is favourable that compartmented tanks may enable some increase in the solids retained within the septic tank, they can still be resuspended and discharged and therefore are nowhere near as effective as more modern outlet filters.

Future modifications to conventional septic tank designs may involve further development of upflow presettlement anaerobic compartments and tube settling stages [Ref 6].

Two Stage (or Dual) Traditional Septic Tanks

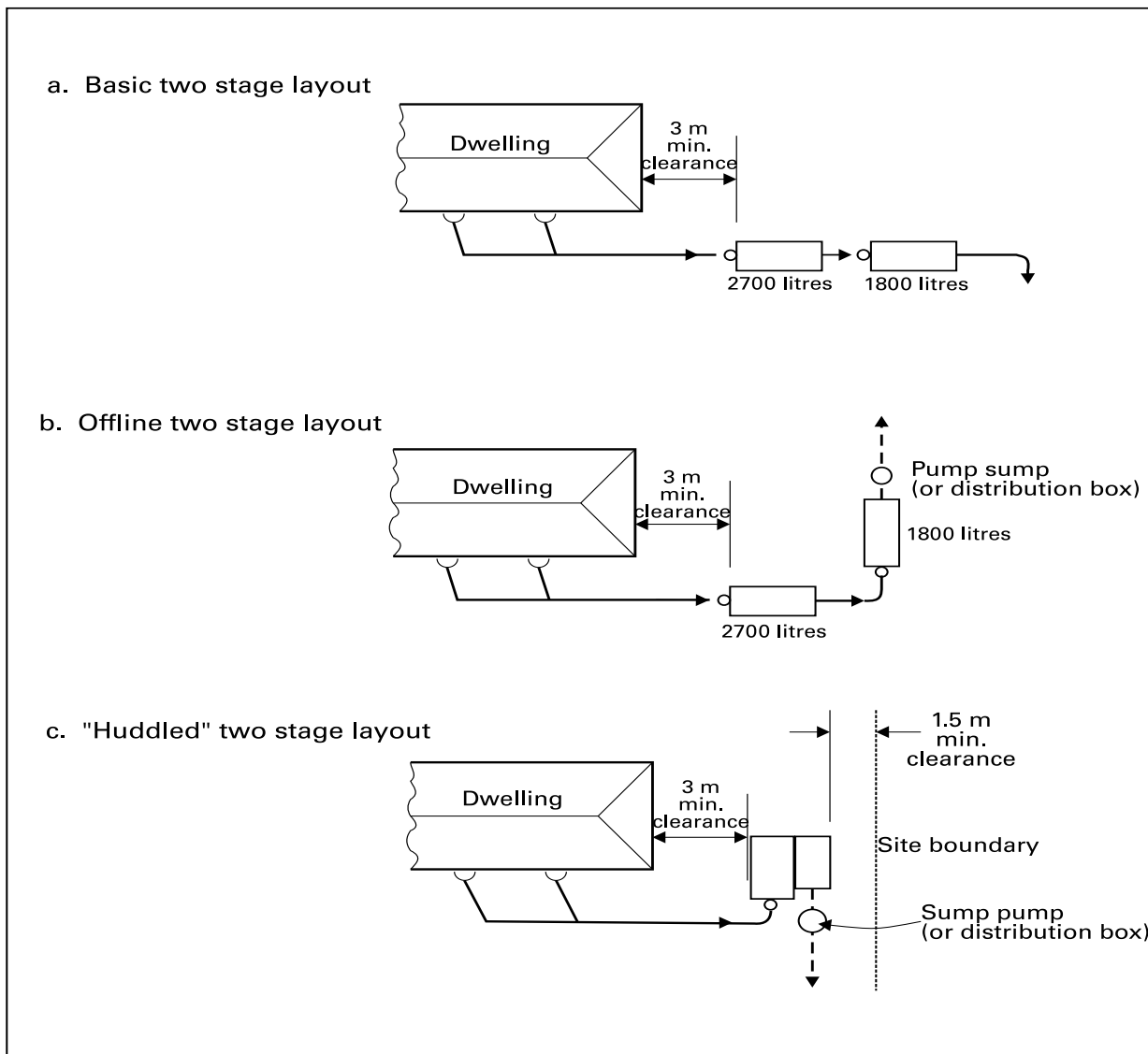
These may be of two types. The first is where two septic tanks are arranged in series. With a total combined capacity equal to one and two thirds of the first stage tank, the two stage dual tank system is used to provide improved primary effluent quality. It is considered that some hydraulic buffering is provided within the first stage tank, thus enabling resettling of any fine solids carried over into the second stage unit. Table 7.5 sets out recommended capacities of two stage (dual) septic tank systems. Figure 7.2 shows example layout configurations for installation of series dual tank systems. Two stage septic tank systems have now been superseded by the installation of larger septic tanks with outlet filters. Research indicates that dual septic tanks are not as effective at reducing suspended solids as effluent outlet filters fitted to a single large septic tank [Ref 3]. Outlet filters should always be installed on the outlet of the final septic tank.

Table 7.5: Capacities of Dual Septic Tank Systems

Population Served (Persons)	Basic Size-litres (First Stage)	Additional Tank-litres (Second Stage)
5	2,700	1,800
9	3,300	2,200
12	3,700	2,500
15	4,100	2,700
20	4,800	3,300

Note: Capacity independent of water supply source.

Figure 7.2: Dual Septic Tank Layouts



7.2.9 Tank Materials and Construction

The performance requirements and performance criteria for septic tanks as a product are set out in AS/NZS 1546.1:1998, "On-Site Domestic Wastewater Treatment Units – Part 1: Septic tanks".

The availability of precast panel modular septic tanks for *in situ* assembly raises the question of structural and water tightness integrity following installation. These risks include; distortion, breakage, failure of seal between panels and resultant water infiltration or exfiltration, and associated public health and environmental risks. Septic tank integrity is extremely important particularly in New Zealand where soils are prone to shrinkage and swelling in response to seasonal moisture content variation. To provide certainty in these situations it is important the *in situ* installation is undertaken by the manufacturer or agents fully trained, and accredited by the manufacturer and that appropriate warranty provisions are incorporated in the sale and installation agreement.

7.2.10 Design for Maintenance

AS/NZS Standards require that access to septic tanks for maintenance purposes be provided by means of lids (and risers where necessary) brought to just above ground surface level, and designed and installed in a manner that prevents entry by surface water and unauthorised persons. This should include measures to ensure that children cannot open lids.

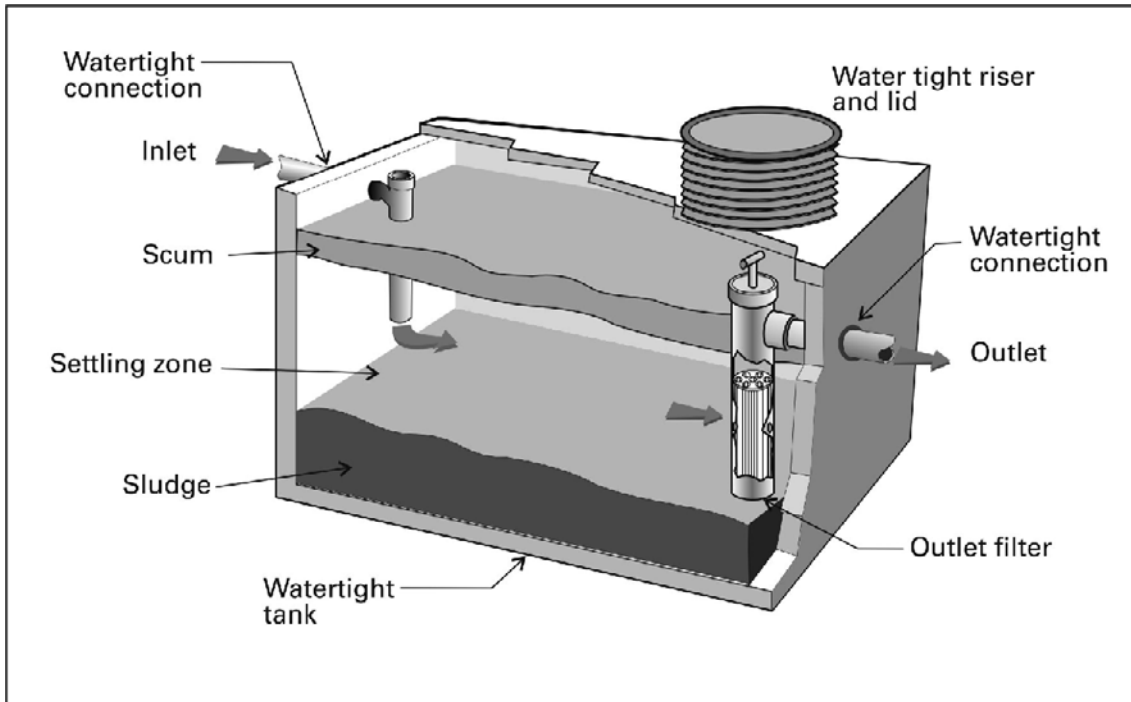
Tanks should be located on the property, and relative to buildings, so that there is no impediment to access by pumpout equipment at the time desludging takes place. Vents should be designed so that there is no opportunity to desludge through the vent pipe.

Desludging (pump out) frequencies have traditionally been set at 3 to 5 years. These pump out intervals are a preventative measure aimed at managing the potential for solids carry over into the land application area. As discussed in Section 7.2.6, experience with the more recent larger septic tanks that also have an effluent outlet filter solids control device, has indicated that their larger settling volume together with effluent outlet filter enables much better solids retention, stabilisation and consolidation, thus delaying the need for preventative pumpouts at such frequencies.

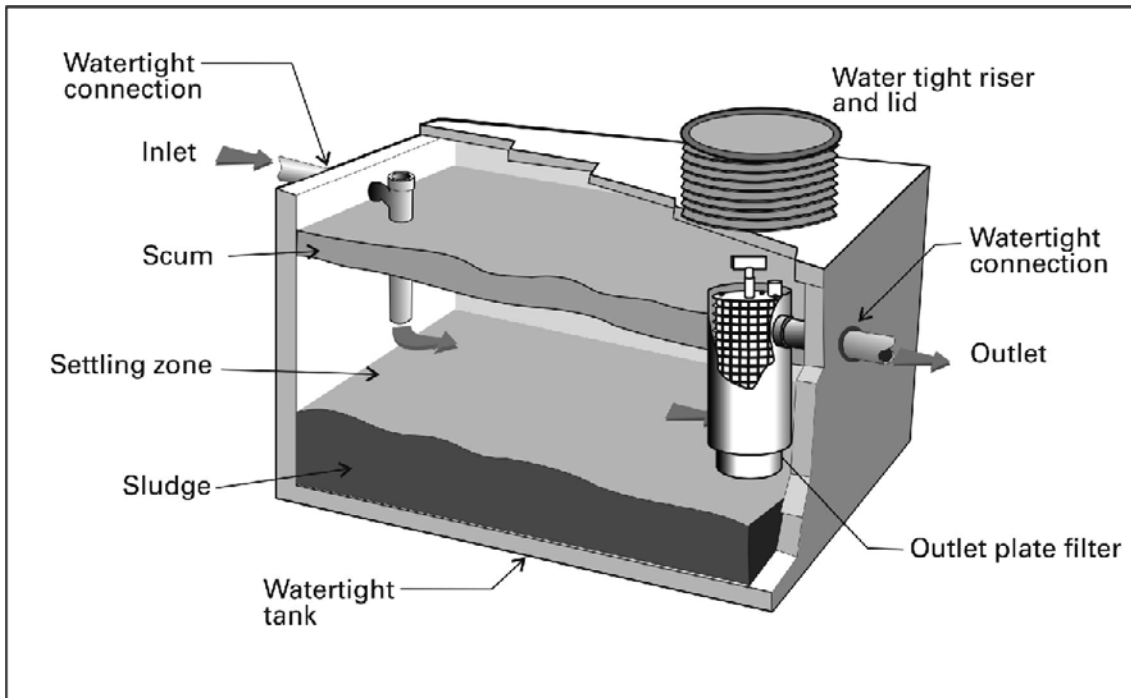
Additives may have a role as a temporary measure in controlling odour producing conditions in situations where overloaded or under maintained septic tank units are awaiting corrective attention. However, normal tank operation utilises the bacteria inherent in the waste itself [Ref 3], which additives can interfere with and interrupt the treatment process. Therefore, the routine use of septic tank additives is not recommended. It is more appropriate that actions are taken to upgrade the treatment system and/or reduce wastewater flows to mitigate the actual cause of the odour.

Figure 7.3: Examples of Septic Tanks with Effluent Outlet Filters

Type A: Single or Multiple Mesh Tube Outlet Filter



Type C: Multiple Plate Disc Dam Module Outlet Filter



7.3 SECONDARY TREATMENT – AERATED WASTEWATER TREATMENT SYSTEMS

7.3.1 Aerated Wastewater Treatment Systems (AWTSs)

Aerated secondary treatment systems (AWTS) for domestic wastewaters from single or multiple dwellings, institutions, commercial or public facilities have variously been known by a number of terms including:

- Household package plants (a general term).
- Aerated septic tanks (a common Australian term).
- Home aeration plants (TP 58 2nd edition 1994).
- Aerated wastewater treatment plants AWTP and ATP.
- Continuous flow, suspended growth aerobic systems CFSGAS [Ref 5].

These terms, often used interchangeably, generally apply to the use of blower aeration for supply of dissolved oxygen and mixing of a suspension of bacterial sludge in an aeration tank, which is the biological treatment approach that tended to dominate the early development of these small household treatment plants. This type of aerobic biological secondary treatment process is based on the extended aeration modification of the “activated sludge” process, which in modern terminology is referred to as the “suspended growth reactor” process. However, the “trickling filter” (or biofilter) fixed growth reactor process has also been adapted for household use as an alternative aerated secondary treatment system to follow septic tank treatment.

There is thus a distinction in the physical configuration of these two aerated processes, which is characterised by the method of aeration (i.e. how dissolved oxygen is transferred to the biological slimes that accomplish treatment of the organic matter in the applied primary effluent) and the use of suspended growth media. The Joint Australia/New Zealand Standards have chosen to refer to both processes by the single term AWTS (aerated wastewater treatment system). For this New Zealand design manual a distinction has been made as follows:

- AS-AWTS (activated sludge – aerated wastewater treatment system) for the suspended growth reactor unit;
- BF-AWTS (biofilter – aerated wastewater treatment system) for the fixed growth (with submerged media) reactor unit;
- TF-AWTS (trickling filter – aerated wastewater treatment system) for the fixed growth reactor unit.

7.3.2 Activated Sludge – Aerated Wastewater Treatment Systems (AS-AWTS)

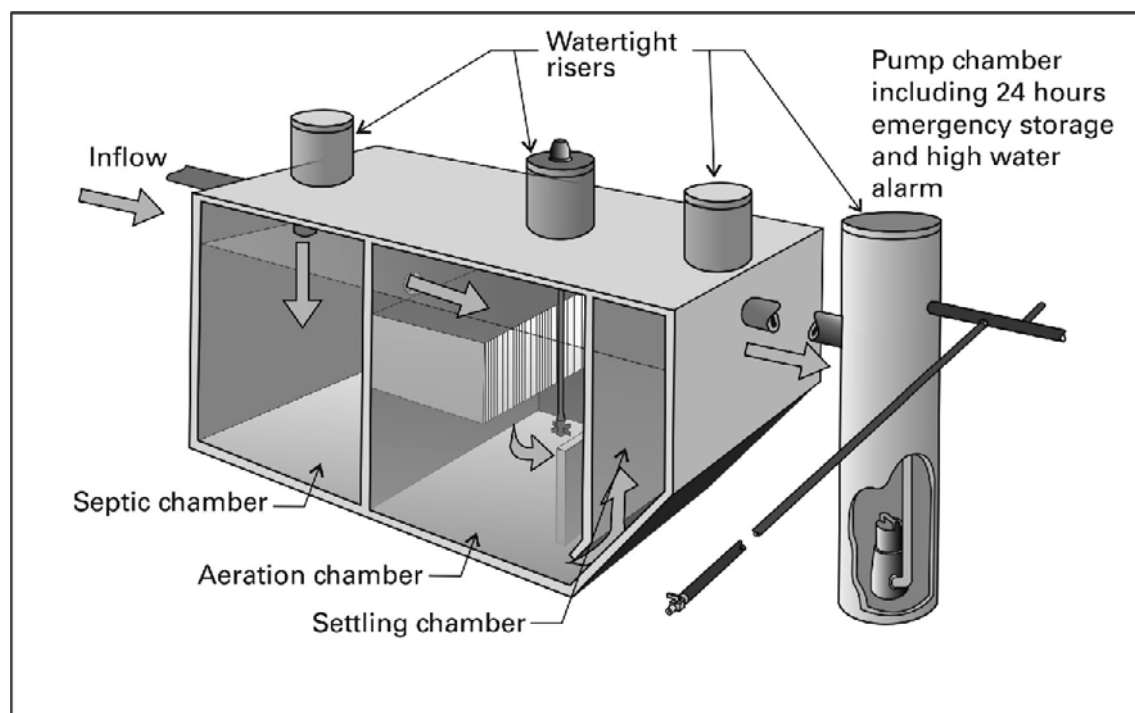
A typical unit will incorporate a primary treatment septic tank with the overflow transferred to the aeration compartment by an outlet tee that may incorporate an outlet filter (refer Section 7.2.8). Air is supplied for aeration and mixing of the suspension of activated biological slimes by either a blower and sparge pipe, or a rotating impeller/aspirator unit. The overflow from the aeration compartment is then passed to a settling compartment for suspended sludge recovery and return before the final treated effluent enters a pump well for distribution to a land disposal system. Some units replace the settling chamber with an outlet filter to pass final effluent from the aeration chamber direct to the pump well.

Blower driven aeration systems also provide air for airlift pumps to transfer recovered biological sludge back to the aeration compartment and/or the septic tank. A skimming device on the settling compartment may also be used to return floating scum/sludge back for treatment in the septic tank.

Impeller/aspirator aeration units may have a set of settling plates in the settling compartment for solids recovery, with a small solids pump to recycle sludge to the aeration compartment, or dispose of it to the septic tank.

Variations of the AS-AWTS include SBR (sequencing batch reactor) units, which operate in a fill and draw operational mode with recycle to achieve both biological treatment of organic matter as well as nutrient stripping of nitrogen products, specifically nitrates. In another variation, the aeration compartment may contain modules of submerged plastic media to assist in developing a submerged fixed film with the objective of providing better biological stability to the treatment process.

Figure 7.4: Typical Activated Sludge – Aerated Wastewater Treatment System



7.3.3 BF-AWTS (Biofilter – Aerated Wastewater Treatment System)

The biofilter uses a durable media (usually of plastic material), which is submerged in the wastewater in the aeration chamber, to develop surface attached bacterial slime growths that feed on the organic material in the waste. Air for dissolved oxygen supply is provided either by external blower or submersible pump powered venturi. Air may be released below the media or into the water outside the media in a manner, which causes the aerated water to flow down through the media. A typical BF-AWTS unit will incorporate a septic tank with outlet filter, an aeration chamber with submerged media, a clarifier in the outlet chamber and pump chamber. Sludge is returned to the septic chamber either through the air lift pump, a separate sludge pump or a bypass from the aeration pump.

Biological growth on the submerged media results in lower sludge production volumes than in an AS-AWTS without media. Media may also provide stability to the treatment process, which is a particular advantage for places that have intermittent or seasonal occupancy.

7.3.4 TF-AWTS (Trickling filter – Aerated Wastewater Treatment System)

A typical unit will incorporate a primary treatment septic tank with the overflow transferred to a pump chamber for delivery to a distribution system which doses the top surface of a bed of media contained within the secondary treatment unit. The primary treated flow trickles down through the media bed with the aerobic biological communities growing on the media surfaces absorbing the organic material in the flow while being supplied with oxygen from the air circulating naturally through the media void spaces. Ageing biological sludge sloughing off the media is captured in a final settling chamber underneath the media unit. The decanted final flow of secondary treated effluent enters a pump well for distribution to a land disposal system. Biological sludge accumulating in the final settling unit is recycled back to the septic tank compartment.

The media on which the biological slimes grow in the secondary treatment unit may comprise either beds of randomly packed plastic modules, sheets of corrugated plastic, or hanging strips of durable material. The arrangement of and type of media will vary depending on the brand and model of the particular commercial product. A recirculation pump may be provided in the final settling tank to return treated effluent with or without sludge solids back over the surface of the media to dilute the incoming flow from the septic tank.

7.3.5 Recommended Loading Specifications and Tank Sizing

Crities et al (1998) provides guidance on typical sizing required for most extended aeration activated sludge processes. It specifies the required size according to the average organic (BOD) load being applied into the system as 0.08 to 0.24 Kg BOD/m³/day [Ref 2]. Other system designers in the Auckland region have indicated that the design of their systems are based on a load of 0.25 to 0.30Kg BOD/m³/day. ARC does not have information on the effectiveness of systems according to the organic load per cubic metre of tank treatment capacity.

7.3.6 Implementation and Application of AWTS Systems

AWTS systems are typically designed, manufactured, installed and maintained by specialist companies. They come in a wide variety of configurations and sizing. The tanks from which the plant is assembled should meet the product standards in AS/NZS 1546.1:1998. The secondary treatment effluent quality performance standard specifications set for AWTS systems are as follows:

- BOD₅ (five day Biochemical Oxygen Demand) equal to or better than 20g/m³.
- SS/NFR (Suspended Solids/Non Filterable Residue) equal to or better than 30g/m³.

AWTS systems are more susceptible to upset by randomly generated wastewater than some alternative wastewater treatment systems. Reported BOD and TSS output efficiency from well operated systems are BOD 10 – 50gm/m³ and TSS 15 – 60gm/m³. Some studies have reported lower discharge quality (elevated contaminant levels) resulting from surge flows, variable loading and inadequate maintenance [Ref 5].

Due to the high biomass concentration within an AWTS system, the final settling/clarification stage following the aeration tank is critical, to ensure a satisfactory effluent quality. In some plant designs, the clarification chamber provides insufficient retention time for clarification of peak flows. Other problems can relate to poor settling of biomass in an unstable plant. To avoid carry over of solids into the land disposal system, an additional filter is also critical. To avoid blocking, these need to be checked and cleaned regularly.

Where subsoil soakage systems are used in a land disposal area, AS/NZS 1547:2000 allows higher loading rates at this secondary effluent quality than for septic tank primary effluent. This effluent quality is also suitable for subsurface pressure compensating drip irrigation, but must be passed through additional filtration before dosing to the drip lines. Filtration requirements are dependent upon the drip irrigation line suppliers recommendations. In the Auckland Region the use of higher loading rates with secondary effluent is not accepted as a Permitted Activity. Lower soil moisture level results in longer wastewater retention times within the soil enhancing in ground treatment.

There are unknown risks associated with increased secondary effluent (low organic content) loading rates including potential for deeper penetration of pathogens and reduced soil treatment of contaminants such as nitrogen. These risks are increased when soil moisture is elevated during and following rainfall, potential for surface runoff into stormwater and surface water drains and contamination of waterways and beaches. Elevated hydraulic loading rates in well drained soils increases the nutrient point load and impact on groundwater whilst reducing potential nutrient reduction that can be achieved through low application rates and widespread distribution into topsoil.

Additional filtration to 120 or 130micron level is recommended following an AWTS to trap excess solids that can be discharged from an AWTS, particularly when performance specifications are not met, resulting in increased risk of solids carryover to the land application system. In most situations, the above effluent standards can only be met where the wastewater loading intensity and pattern is maintained on a consistent basis, within the design specifications and proportionate to the aeration supply. Also the system must be maintained in accordance with the performance requirements specified by the manufacturer/supplier and be regularly maintained. The provision of filtration at the AWTS outlet introduces a higher than normal operation and maintenance requirement [Ref 6]. Due to the potential for blockage if not maintained, particularly in the event of high solids carryover, they will normally require regular checks and cleaning by hosing down by the site owner/occupier.

Due to their special tuning needs, all AWTSs require on a consistent basis by an experienced operator, Operation and Maintenance (O&M) contracts are critical and are a condition of regulatory approval for use of AWTSs. Three to six month inspection frequencies are the norm, and except for the most stable influent flow and type of plant, three months are recommended as the minimum necessary to achieve consistent performance. The USEPA also recommends a three month inspection frequency [Ref 3]. Such O&M servicing contract arrangements must be maintained for the life of the system. O&M servicing will include, for example checks on the dissolved oxygen level in the effluent as well as from time to time full analyses of BOD₅ and TSS levels. Removal of scum/sludge via pumpout of the septic tank compartment will also be required at intervals based on operating observations and experience. Further details of package plant operation and maintenance requirements are provided in Section 7.3.7.

7.3.7 Which AWTS To Use?

As AWTS Standards within the AS/NZS 1546 series are performance based, there are no requirements for specific design elements such as tank compartment sizes and configurations, or for aeration capacity per unit of organic matter to be treated. Thus there is a great variety of AWTS configurations and sizings available. The protocol for testing performance within the AWTS Standard relates to a specific treatment scenario that need not be replicated under all field conditions into which individual units are likely to be installed and implemented. Hence, key questions that can be asked of an individual manufacturer/supplier/installer are:

- What is the performance experience in terms of effluent quality (over what number of treatment plants, and under what duty delivered by those plants)?
- How often should the unit be serviced, and what is the annual cost of this?
- How consistent is the treated wastewater quality and how much data from which to draw this conclusion?
- What is the running cost in terms of annual power consumption?
- Is the AWTS noisy or odorous?
- If intended for a holiday home, is the system stable under intermittent wastewater loading with long periods of no wastewater inflow? (Systems are likely to take a while to stabilise during which period they could be odorous, so it's important to ask how long this could take.)

It is important to secure a performance guarantee from the supplier for the rated duty of the system, the suggested guarantee time being three to five years. Normal product guarantees will be offered in any case, but the performance guarantee needs to relate to the AWTS meeting the effluent quality parameters on a consistent basis. The parameters to be tested are typically only Biochemical Oxygen Demand (BOD₅) and suspended solids (SS), unless the system is specifically required to also decrease faecal coliform levels and/or nutrients in which case, further analyses for these parameters should be undertaken and checked against the manufacturer's specifications. The tests should be continued until the discharge quality analyses are within the manufacturer system design specifications for at least four consecutive samples.

During the performance guarantee period, the manufacturer should be required to undertake quarterly effluent quality assessments, the results of which should be provided to the purchaser and the Council in the case of a discharge consent. These results will aid the purchaser and authority in checking that the AWTS is achieving its design specifications, and aid the manufacturer/supplier to assess the actual loading against the rated duty, and to fine tune the treatment operation accordingly.

For the future, the successful application of AWTS units will depend on their ability to produce consistent effluent quality under all types of loading situation and with minimum commitment of operation and maintenance supervision [Ref 6].

In the Auckland region, for an AWTS to be satisfactory for installation on sites as a secondary treatment system required by some Permitted Activity rules, their design must comply with the ARC design and performance specifications, stated in Section 7.5 and also in Technical Sheet F-1 attached. Where treatment systems cannot meet this criteria, the supplier must specify what criteria they can realistically achieve. Then, in the Auckland region, the ARC or an appointed representative consultative expert forum will then classify the plant and the type of on-site design situations where the plant may still be suitable, such as types of disposal systems and receiving environments where less than secondary discharge quality and elevated suspended solids levels may not be of concern.

7.3.8 Operational and Maintenance Considerations

The use of AWTS units for fluctuating or intermittent loadings as at holiday homes or institutions such as schools poses a design and operational challenge. The activated sludge in suspension within the AS- AWTS is more sensitive to loading variations than the fixed film biomass in the TF- AWTS. The manufacturers claim both systems can be run on "idle" during the low load period, and then be reactivated in advance of an expected load increase. The degree of "idle" and the nature of response to load increase should be discussed with the manufacturer/supplier during the evaluation of treatment options.

AWTS units with biomass in suspension all have higher running costs to operate the aeration system than filter type systems. AS-AWTS are prone to discharge biomass to the disposal system which should be trapped by a disc filter or similar installed in line following the discharge pump. In a poor performing system these can clog quickly and will need to be cleaned frequently. In such cases it is important that problems with plant performance are remedied as soon as practicable and the filter is maintained in place. It should not be removed to avoid the need for maintenance.

The designer/maintenance provider should be aware that pump failure could result from progressive filter blockage and from the resulting increased head that the pump must operate against unless the disc filter is maintained clear. The site owner/occupier should be made aware of the minimum filter maintenance requirements. A solution adopted in the past by some system suppliers and system owners to avoid the regular maintenance requirements, has been to simply remove the filter itself. If a disc or similar filter is removed and there is continued direct discharge of effluent with elevated suspended solids levels to the dripper irrigation system, then there is a high risk of premature emitter blockage within the irrigation lines. A regular line flushing maintenance programme will also reduce the risk of premature blockage, but again it is critical that the disc filter is maintained.

Successful operation requires regular maintenance and compliance with the manufacturers management guidelines. All AWTSs require maintenance on a consistent basis by an experienced operator. Contracted three to six month inspection are necessary and three monthly inspection frequency is recommended as the minimum in most cases at least until the influent flow and the system performance is fully stabilised, to achieve consistent performance. The USEPA [Ref 3] recommends a three month inspection programme to ensure proper operation and treatment is within design levels. As with any wastewater system, AWTS units will fail if they are not designed, installed, maintained and operated properly in accordance with the manufacturer's recommendations [Ref 3].

Regular discharge quality analysis as recommended in Section 7.3.7 above and further in Section 7.5.5 should verify actual system performance and whether or not certain systems actually have performance problems in conditions with fluctuating load. A summary of minimum maintenance requirements is provided in Appendix I, TS I-3.

7.4 ADVANCED SECONDARY TREATMENT –PACKED BED REACTORS

Advanced secondary treatment involves a similar aerobic biological treatment process as secondary treatment, but with generally more controls in place to optimise the treatment process. Such controls include, even and frequent (24 to 28 times/day) dose loading, recirculation, controlled distribution methodologies and controlled contact time. These enable a higher effluent quality to be consistently achieved. The effluent quality expected from advanced secondary treatment systems for the purpose of this manual (on the basis that wastewater will be discharged to land) is a biochemical oxygen demand (BOD) level of better than 15mgO/l and a suspended solids (SS) level of better than 15mg/l. Some systems can achieve a quality that is consistently better than BOD:SS of 10:10, which equates to the specifications in some literature for advanced secondary treatment.

Advanced secondary effluent quality can be more reliable than that from activated sludge based systems under typical household loading variations, and the cost of the technology is justified where reliability of high quality effluent is essential to successful operation of the land application system [Ref 6], providing further protection against potential adverse environmental effects.

7.4.1 General

Sand filter design in New Zealand previously followed older Ministry of Works design guidelines. However, these designs have been superseded in recent years by international sand filter design technologies. Proprietary systems using this design technology are now available and are in common use in New Zealand. The sand filter is essentially an aerobic fixed film bioreactor also termed a packed bed reactor (PBR) and as such are a very stable process and quite resistant to flow variations [Ref 3].

The modern sand filter system comprises primary septic tank including an outlet solids control device to protect the sand filter from the carry over of solids and to minimise maintenance requirements. Old style Ministry of Works sand filter designs were loaded by flooding the filter surface resulting in the development of a surface clogging layer which required regular maintenance for ongoing operation of the sand filter. However surface flooding for distribution of wastewater resulted in applied wastewater tracking to the lowest point on the filter surface, overloading, inferior treatment and clogging of the filter sand. Modern distribution methods comprise a shallow surface located pressure pipe network providing pressure dosed even distribution across the entire filter surface. Applied wastewater filters through the sand and is collected by an underdrain. The decreased maintenance requirements of modern sand filters means that such systems are suitable for individual houses as well as larger institutions without daily maintenance requirements by a trained maintenance specialist.

When designing a sand or textile filter and determining the design surface area it is important that both the hydraulic and organic loading rates are considered. The recommended hydraulic loading rate for proprietary sand filter design, unless stated otherwise, is typically for lower strength domestic wastewater following primary conventional septic tank treatment. In situations where wastewater is from another source, for example a restaurant, the organic content can be significantly higher than can be treated by a standard hydraulic/organic design loading rate. As with any wastewater treatment system, where a sample of the wastewater to be treated can be taken the organic strength should be determined and if necessary the sand filter hydraulic loading rate altered to take into account the higher organic loading. In situations where it is not possible to measure wastewater strength a conservative hydraulic and organic loading rates should be adopted. In such situation, it may be necessary to expand the wastewater treatment system capacity once the facility is operational and in the event that wastewater strength exceeds the predicted strength.

Proprietary sand filters comprise two types, Intermittent Sand Filters (ISF) and Recirculating Sand Filters (RSF). Some suppliers refer to ISF units as “sand contactors” or iPBR units “intermittent [sand] packed bed reactor”, and rPBR units as “recirculating [sand] packed bed reactors”. The advantages of packed bed bioreactors over AWTs are that they:

- i. Are more stable under variable hydraulic loading;
- ii. Are stable under intermittent hydraulic loading;
- iii. Have low operation and maintenance requirements;
- iv. Are capable of consistently producing a nitrified effluent with low BOD and TSS.

The designer must also be aware that sand/textile filters can fail for the following reasons:

- i. Poor construction allowing ground/stormwater infiltration into the system causing hydraulic overloading;
- ii. Hydraulic overloading from wastewater flow exceeding design flow;
- iii. Organic overloading exceeding design organic loading;
- iv. Poor or lack of maintenance.

In the event that a sand filter is subject to excessive and prolonged hydraulic or organic overloading the sand will clog resulting in surface flooding of the filter and possibly requiring complete replacement of the sand.

Pressure sand filters, which are mechanical filtration devices typically used for treating swimming pool water, and stormwater sand filters are not appropriate technology for treatment of domestic or commercial wastewater.

7.4.2 Intermittent Sand Filters (ISF)

New Zealand design practice has evolved from the earlier Ministry of Works and Development guidelines [Ref 7]. Such units can be designed to serve single dwellings and upwards in size, but it must be remembered that their successful performance is dependent upon regular maintenance attention.

The Ministry of Works Design has more recently been superseded by significant advancements in proprietary designs. Typical maximum design loadings are set out in Table 7.6, and construction details in Figure 7.5. One of the most critical advancements in sand filter design has been the placement of an outlet filter in the septic tank to reduce the suspended solids content prior to discharge to the sand filter. This along with timer controlled pumped dosing and improved surface distribution systems overcome the problem of biomass clogging the sand filter surface, thereby reducing maintenance requirements and improving their performance. Although dosing control by float switches is often used, it is not recommended, because the resulting wastewater doses and resting times are unequal which can lead to plug flow rather than thin film flow, development of anaerobic conditions and premature clogging of the filter [Ref 2]. A sand filter will still be subject to biomass clogging if the hydraulic and/or organic loading rate exceeds the design criteria (Tables 7.6 & 7.7).

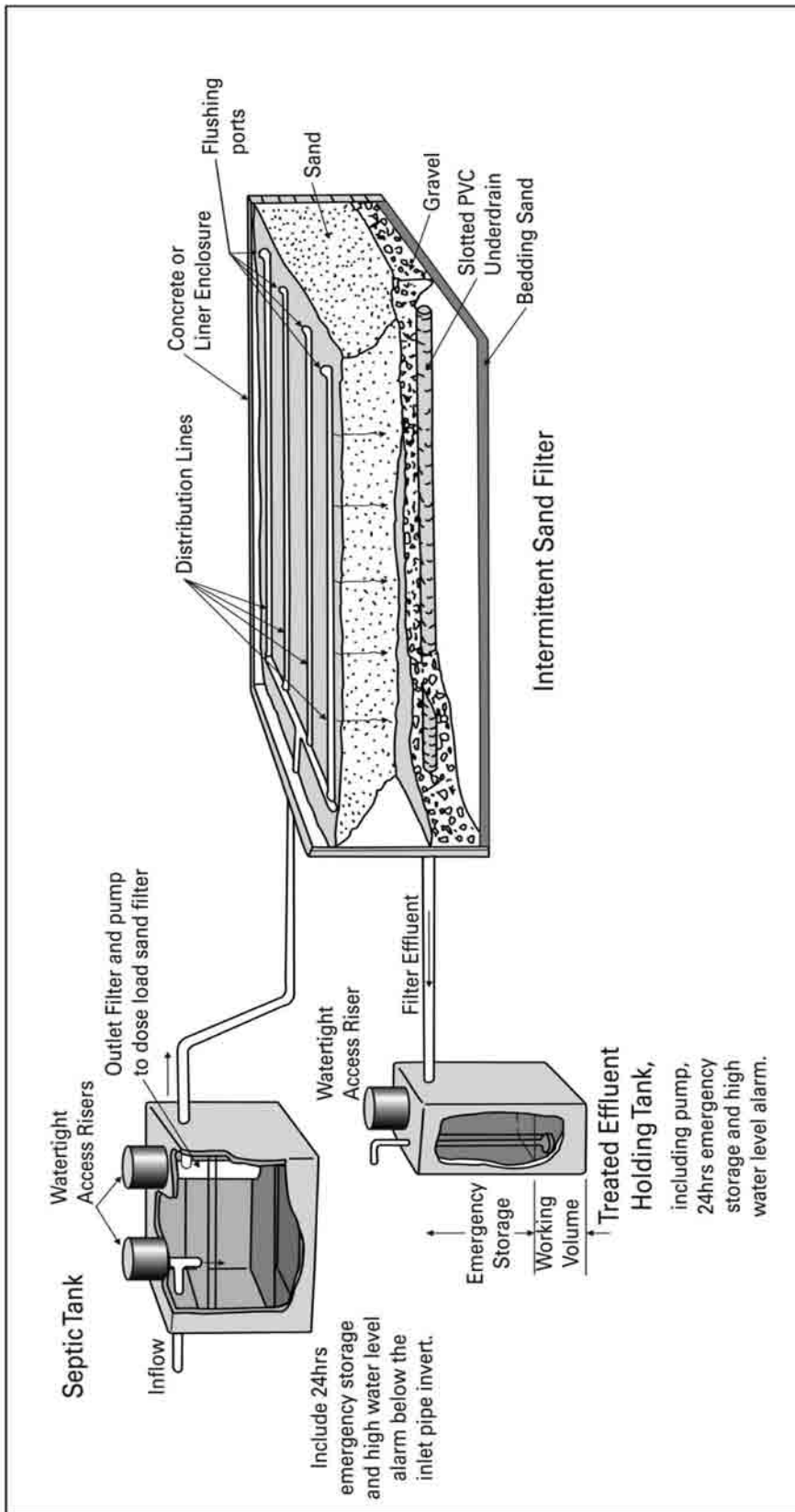
A pumped dosing system is required to achieve even distribution of wastewater across the design surface area, whilst timer dose loading provides optimum performance. Where sand filters are not timer dose loaded, their performance is likely to be more in the realm of standard secondary treatment system (AWTS), with a similar theoretical effluent quality.

ISF units are designed to treat the wastewater in a single pass. ISF units are suitable for treating wastewater flows from individual households and upwards, however, they are generally best suited for treating flow volumes and strengths typical of wastewater flows from single or multiple households. Once the design flow volume becomes too high, so also does the total footprint required for the single pass ISF unit and they become less cost effective compared to recirculating sand filter systems. ISF units are very effective at reducing bacteria, BOD₅ and suspended solids. The level of reduction is dependent on design and in particular loading rates applied as many small timer controlled doses over the entire day. Typical output performance results for intermittent sand filters are presented in Table 7.9.

Table 7.6: Typical Design Loading – Intermittent Sand Filters

	Typical Design Value
Hydraulic Loading	40 to 100mm/day (typical New Zealand value 80mm/day)
Organic Loading	0.0025 – 0.01 kg BOD/m ² /d
Dosing Frequency	12 to 48 times per day
Effective media size (d ₁₀)	0.25 to 0.75mm
Uniformity Coefficient	< 4 typically 3.5
Depth	600mm to 900mm
Treated Wastewater Tank	24 hrs emergency storage plus working volume
Notes:	
<ol style="list-style-type: none"> 1. <i>Special design values dependent upon treatment requirements [Ref 2].</i> 2. <i>The above design rates are for domestic strength wastewater discharged through a septic tank effluent outlet filter.</i> 3. <i>Sand must be durable and free of fine silt, clay and organic particles.</i> 4. <i>Effective media size d₁₀ is defined as the 10% size by weight, determined by wet sieve analysis.</i> 5. <i>Uniformity coefficient is d₆₀ divided by d₁₀. UC indicates whether individual particles are of a similar size or if there is a wide range of particle sizes.</i> 6. <i>Multiple sand filter units are not required where wastewater is passed through a septic tank outlet filter prior to dosing to sand filter.</i> 7. <i>Sand grading in accordance with installers/suppliers specification.</i> 8. <i>Design parameters from the literature [Ref 2 and Ref 3].</i> 9. <i>The designer is advised to use conservative design parameters.</i> 	

Figure 7.5: Typical Components of an Intermittent Sand Filter



7.4.3 Recirculating Sand Filters (RSF)

Recirculating Sand Filters or multi pass sand filters treat wastewater by recycling wastewater through the sand filter 3 to 5 times, based on forward flow from the septic tank, prior to discharge to the disposal system. Generally recirculating sand filters are used to treat higher flow volumes (e.g. >3000 litres/day) such as from large institutions or from cluster housing as in subdivisions. They are also used to treat high strength wastewater (with elevated organic loads), such as that derived from restaurants. They are also particularly effective in treating intermittent wastewater flows, such as that from schools that are subject to extended rest/no flow periods, as the recirculating nature of the system continues and maintains a healthy biomass population within the reactor.

Filtered septic tank wastewater is discharged into the recirculation tank, which also collects treated recirculated wastewater discharge from the sand filter. Dilution of the septic tank wastewater by treated wastewater lowers the organic concentration such that the bacteria in the sand filter can treat it more readily and therefore allows a higher hydraulic loading rate than can be applied to ISF units. The appropriate hydraulic and organic loading rates to prevent premature clogging of the filter are dependent on the filter media grain size, which is coarser than that used for ISF units.

There are a number of proprietary RSF unit designs available on the New Zealand market. However not all are true RSF units and should in fact be designated intermittent single pass sand filters. A RSF unit comprises:

- i. A water tight septic tank with an effluent outlet filter;
- ii. A recirculation tank into which primary septic tank wastewater is discharged, within which mixing with treated wastewater that has already passed through the sand filter occurs; and
- iii. An open sand filter to allow free air flow (not soil covered or sealed).

It is critical that wastewater flow into the recirculation tank is free of gross solids. Typical design loadings are set out in Table 7.7. The recirculation tank should have sufficient capacity for one day of wastewater flow allowing for buffering of peak flows during the day. Design of the flow splitting assembly to achieve 3 to 5 passes through the filter is critical or wastewater may only receive one pass and be inadequately treated prior to discharge. The recirculation volume is critical for long term performance of the sand filter such that the organic load can be processed without clogging the interstices between sand grains. Secondly recirculation must continue even when there is no primary wastewater flow over an extended period into the recirculation tank to maintain a healthy aerobic bacterial population in the sand filter due to continued access to a food source. Discharge should only occur when the recirculation tank is full. If the recirculating sand filter design does not fulfil these criteria it is defined as a single pass intermittent sand filter and must be designed as an ISF.

Recirculating sand filters must be timer dose loaded to achieve optimum longterm performance. Dosing the sand filter on demand by siphon or float switch operated pump can result in hydraulic and organic overloading and clogging of the filter media. Demand dose loading results in wastewater discharge onto the sand filter in a reduced number of doses, concentrated around the time when peak wastewater flow volumes are produced in contrast to timer dosing which buffers wastewater produced during the day over 24 hours (Section 7.4.4). Demand dose loading means applied wastewater movement through the sand filter is loaded as a concentrated plug rather than a thin film flow which better maintains aerobic conditions in the sand media, better retains the biomass and significantly improves the longterm treated wastewater quality.

Although dosing control by float switches is often used, it is not recommended, because the resulting wastewater doses and resting times are unequal which can lead to premature clogging of the sand filter [Ref 2]. Where RSF units are not timer dose loaded, their performance is likely to be more in the realm of standard secondary treatment system (AWTS), with a similar theoretical effluent quality. Recirculating sand filters are capable of consistently producing a high quality, highly nitrified effluent. Total Nitrogen reduction of 40% to 50% can be readily achieved [Ref 2]. Typical performance results for recirculating sand filters are presented in Table 7.9. Recirculating sand filters wastewater quality is close to or match intermittent sand filters in removal of BOD, TSS and nitrogen. Intermittent sand filters are more effective in reduction of faecal coliforms but this reduces with increased hydraulic loading rates [Ref 2 & 3].

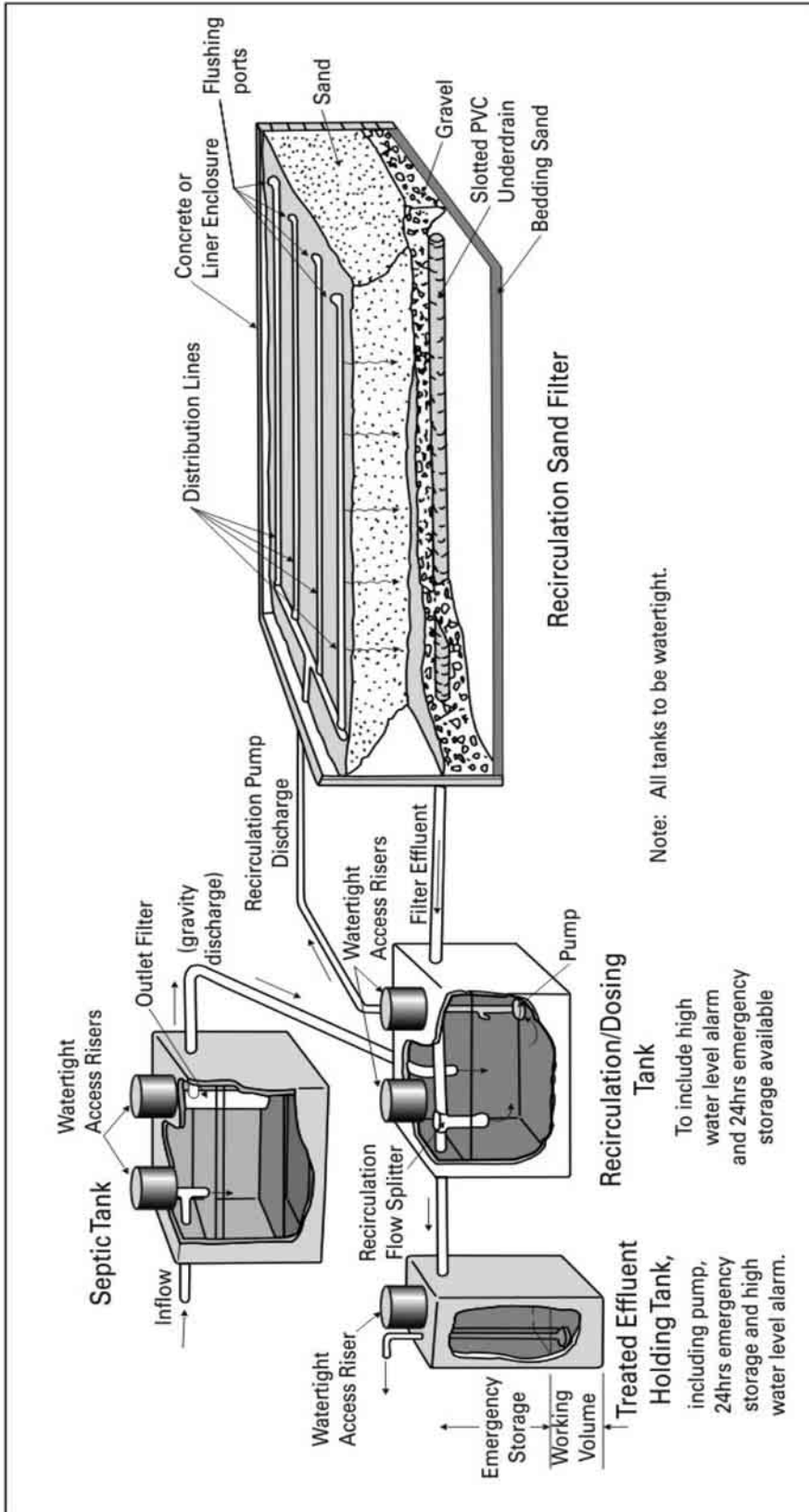
The advantages of recirculating sand filters over intermittent sand filters are:

- Higher design hydraulic loading rate reduces the sand filter footprint;
- Reduced raw material costs;
- Capable of treating high strength wastewater;
- Reduced capital costs compared to intermittent filters; and
- They have a nitrogen reduction option.

Table 7.7: Typical Design Loading – Recirculating Sand Filters

	Design Loading
Hydraulic Loading	120 to 200mm/day. Typical 160mm/day
Organic Loading	0.01 – 0.04 kg BOD/m ² /day Typical < 0.025 kg BOD/m ² /day
Dosing Frequency	48 to 120 times per day
Effective media size (d ₁₀)	1 – 5mm Typical 2.5mm
Uniformity Coefficient	< 2.5 Typically 2.0.
Depth	450mm – 900mm Typically 600mm
Recirculation Tank Volume	0.5 – 1.5 x Daily flow (typical 1 day) plus 24 hours emergency storage or gravity flow to treated wastewater tank
Treated Wastewater Tank Volume	1 days flow plus working volume
Notes:	
<ol style="list-style-type: none"> 1. The above design rates are for domestic strength wastewater discharged from a septic tank including an effluent outlet filter. 2. Organic loading and hydraulic loadings are independent variables which are dependent on the wastewater source. 3. Specific design values dependent upon treatment level required [Ref. 2]. 4. Sand must be durable and free of fine silt, clay and organic particles. 5. Effective media size d₁₀ is defined as the 10% by weight, determined by wet sieve analysis. 6. Uniformity coefficient is d₆₀ divided by d₁₀. UC indicates whether individual particles are of a similar size or if there is a wide range of particle sizes. 7. Sand grading in accordance with installers/suppliers specification. 8. All pump chambers to include 24 hours emergency storage. 9. The above are guideline values from US literature [Ref 2 & 5]. 10. If recirculating sand filter systems are not timer dose loaded, then there is less certainty with regard to consistent wastewater quality. Classifying these systems “advanced” is possibly questionable. 	

Figure 7.6: Typical Recirculating Sand Filter



7.4.4 Textile Filters

The fixed film textile filter (FFTF) has been developed in the USA as an alternative to the sand filter, and although not superseding sand filters in the final effluent quality produced, they do provide some significant advantages. FFTF systems are also referred to as recirculating textile packed bed reactors (rtPBR). FFTF can achieve a treated wastewater effluent quality of between that achieved by sand filters and extended aeration treatment plants. There are currently two types of textile filter:

1. Textile packed bed reactors using layers of textile chips and,
2. Textile fixed film filters.

The engineered textiles are highly absorbent providing a significantly larger surface area for biomass attachment, space for air and the biological treatment of wastewater components than that provided by sand filter packed bed reactor media. The manufacturers claim loading rates can be increased by 5 to 20 times that achieved for intermittent sand filters depending on influent quality. The current domestic (single dwelling) textile filter footprint is about 1m² and can treat up to about 1000 litres per day compared with a sand filter footprint of about 10m² required to treat up to 1000 litres per day. They are also designed to operate by recirculating the treated wastewater through the filter 3 to 5 times, based on forward flow from the septic tank, prior to discharge to the disposal system.

Textile Filter Loading Rates

Sand filter and textile filter wastewater treatment requirements are commonly assessed by a hydraulic loading rate that relates back to areal loading of the filter media exposed surface area (surface loading rate) and expressed in litres per square metre per day (l/m²/d). The surface loading rate, in the case of sand filters, takes the depth of sand, grain size and pore space between grains into account.

Textile and foam media is characterised by a very high material surface area, compared to sand filters, provided by a very high number of pore spaces for attachment of biomass required for treating the wastewater. The textile or foam is also free draining so as not to retain applied wastewater and maintain aerobic conditions for biomass respiration. The very high media effective surface area allows the use of significantly higher hydraulic loading rates than is possible with sand media. The effective material surface area is the entire media surface area per unit volume (m²/m³) and is the true surface area of textile media.

In the case of various textile media filter systems a surface loading rate expressed as litres per surface square metre will vary between the various systems depending on the type of textile (textile or foam) and configuration of textile used for example, textile arranged as tightly packed sheets hanging in a vertical configuration or foam chips. In either case the effective material surface area will be dependent upon the textile type, depth, density and configuration of media. The expression of surface area loading is misleading but a readily understood means of expressing the loading rate, which in reality reflects the total material surface area of the media and not just the surface area of the textile filter pod or basket. The actual surface area of two textile filter systems may be entirely different but each system may be capable of treating the same daily wastewater volume to a similar effluent quality. In the case of textile foam, the material volume loading rate allows a better comparison between the various textile filter systems.

Factors influencing textile filter performance include, pretreatment (septic tank) volume, recirculation tank volume and recirculation ratio. A smaller tankage volume will require a higher recirculation ratio to achieve a similar treated effluent quality. The more efficient textile will require a smaller tankage capacity.

The standard domestic textile filter footprint, excluding septic tank, recirculation tank and treated wastewater holding tank requirements is therefore variable. The surface area of textile of two systems currently available range from about 0.5 - 1m² compared with a sand filter of about 10m² required to treat an equivalent wastewater volume. Available systems have different configurations, one having the textile housed in a pod on the top of the tank and another housing the textile within a basket inside the recirculation tank but suspended above the treated effluent water surface. Surface areal loading rates range from about 1,100 to about 2,100l/m²/d for domestic strength wastewater and domestic units can treat about 1,000 to 1,500litres per day per unit.

Foam filters are a separate type of textile being coupons of foam placed in a housing or basket and onto which recirculated effluent is applied. Foam trickling filters comprising coupons require a larger receptacle to contain the foam media as the foam is not as densely packed as textile sheets and therefore has a smaller effective material surface area than textile. Material loading rates can be expressed as litres/cubic metre of foam/day and can be described as 'fill volume' instead of material volume. Surface loading rates for domestic effluent are in the order of 2100l/m²/d.

Advantages of textile filters over sand filters are:

- Their small footprint.
- They are not significantly impacted by variable wastewater flows.
- They are compact and the lightweight of the textile allows modular prefabricated construction and simplified installation.
- The textile is contained in a watertight module.
- The textile material is easily maintained.

Disadvantages of textile filters over sand filters:

- Textile filters achieve a slightly lower treated wastewater quality than intermittent and recirculating sand filters.

Table 7.8: Typical Textile Filter Treated Effluent Quality

Parameters (mg/L)	Typical Concentrations
BOD ₅	15
TSS	15
TN	Average 10 to 30
Note: <i>Nitrogen reduction is an optional feature. The level of N reduction is dependent upon a number of factors and will vary between sites.</i>	

Recirculating Textile Filters have a nitrogen reduction option operating in a similar fashion to an RSF/rPBR. The level of nitrogen following the reduction process can be expressed as Total Nitrogen or as a percentage reduction, typically in the order of 40% to 50%. Treated wastewater output quality is of secondary effluent standards, approaching that of ISF/iPBR and RSF/rPBR systems.

Textile filters are recirculating packed bed reactors and are therefore suitable for sites having intermittent or variable wastewater production volume and strength. Textile filters are a patented proprietary product and are to be designed by the supplier based on influent quality and daily wastewater flow volume.

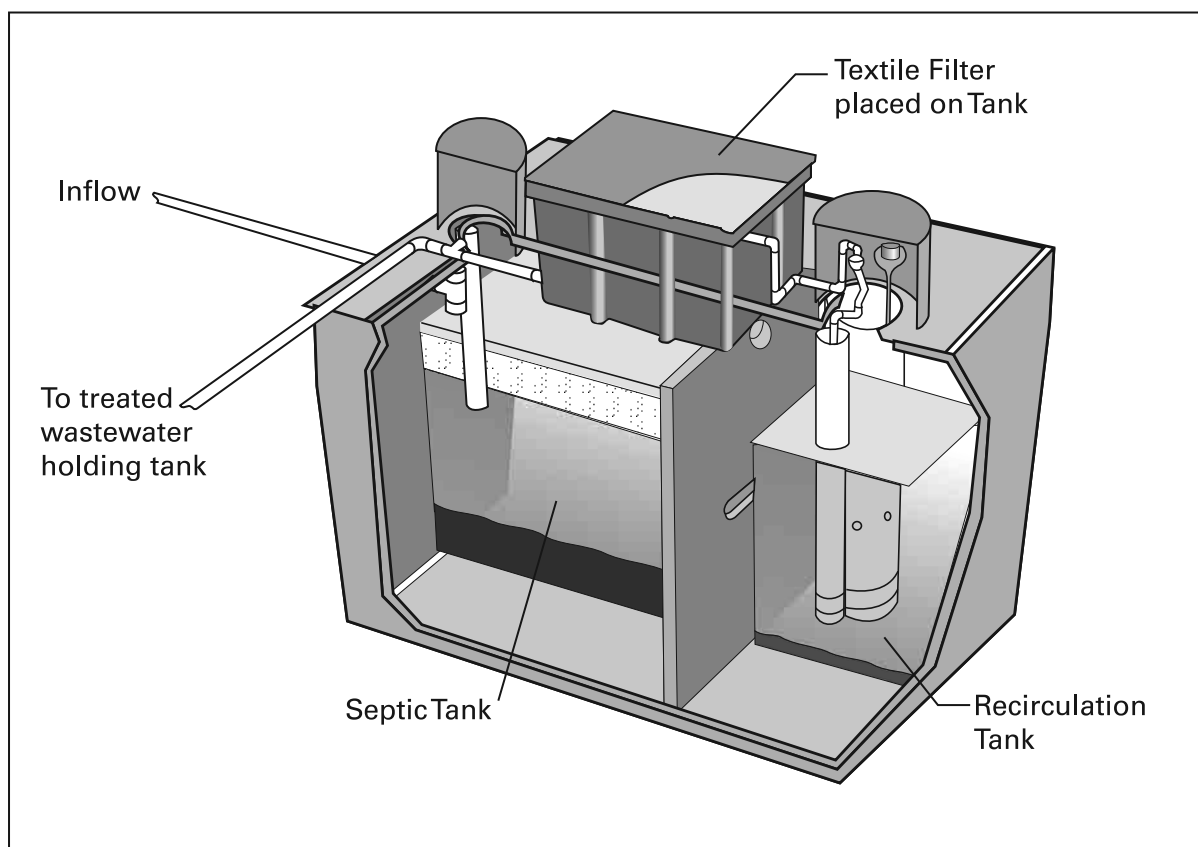
There is some uncertainty concerning the actual discharge quality that can be achieved by textile filters, predominantly based on student research presented to the ASAE 2004 conference in the United States. The validity of this research has also been questioned by a textile system

manufacturer on the basis of the procedures and interpretation used. The rtPBR system performance in question has been tested in the USA by NSF International and certified under ANSI/NSF Standard 40 for Residential Wastewater Treatment Systems. Average results from the NSF40 evaluation for treated wastewater quality were CBOD_5 of 5mg/l and average TSS of 4mg/l at a surface loading rate of 1,185l/m²/day.

Following in Figure 7.7 are two examples of textile filters available on the New Zealand market. Example A shows a textile filter located on top of a septic tank and recirculation tank. Example B shows the textile or foam filter located within the treatment tank unit.

Figure 7.7: Typical Components of Recirculating Textile Filter

Example A



Example B

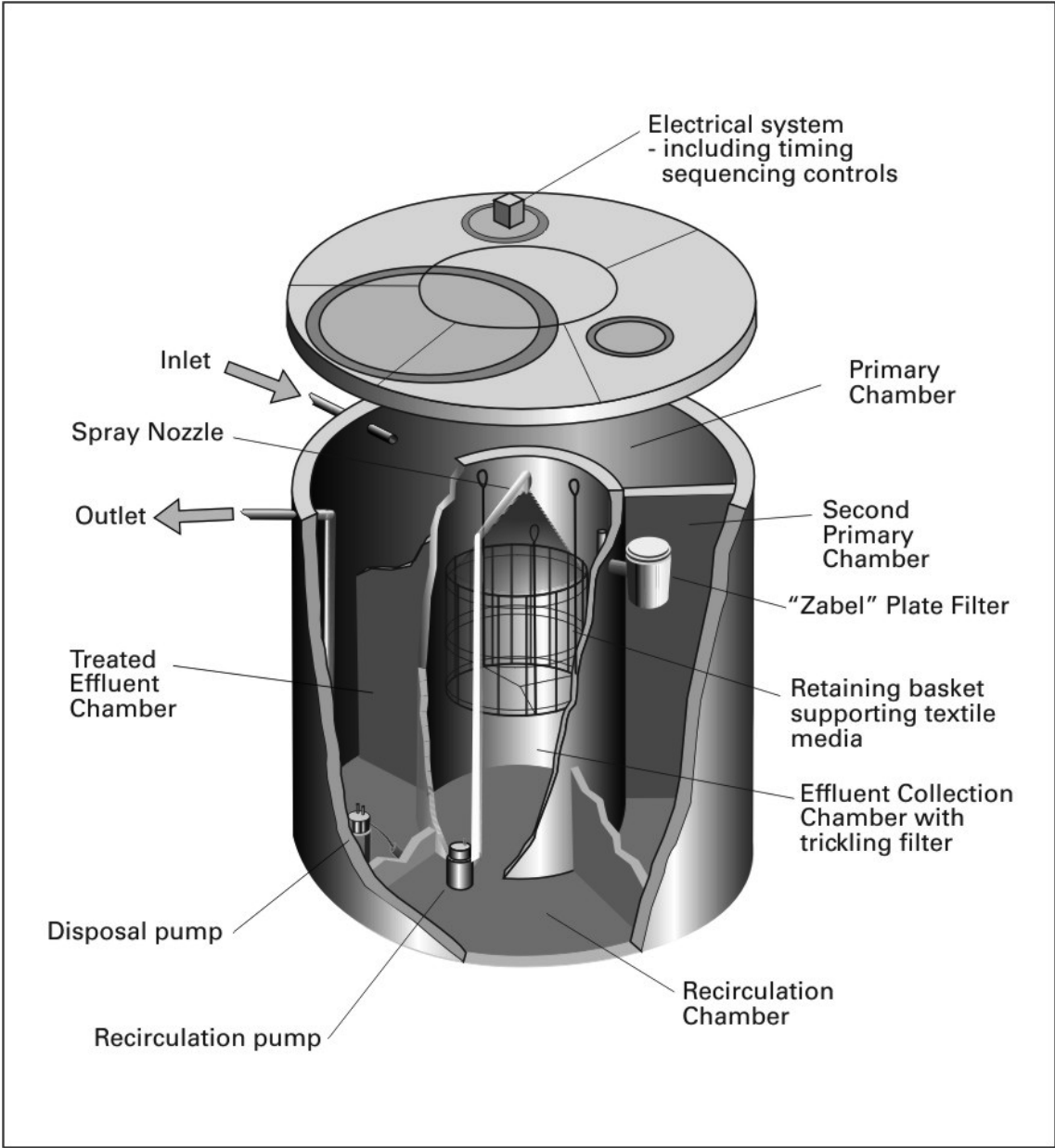


Table 7.9: Typical Performance Values for Conventional Septic Tanks and Secondary Sand/Textile Filter Systems

	Septic Tank with outlet filter	Intermittent Sand Filter	Recirculating Sand Filter	Textile Filter
BOD₅	120 – 200mg/L	<10mg/L	<10mg/L	<15mg/L
TSS	30 – 50mg/L	<10mg/L	<10mg/L	<15mg/L
NH₃	20 – 60mg/L	0.5 to 10mg/L	0 – 15mg/L	0 – 5mg/L
NO₃	<1mg/L	20-25mg/L	30mg/L (average)	
Total N	40 – 100mg/L		10 – 40mg/L (40% - 50% reduction)	5 – 30mg/L [Note 2]
PO₄		7mg/L		
FC	10 ⁵ – 10 ⁸ per 100mls	400 – 10,000 per 100mls	10 ² – 10 ⁵ /100mls (99% reduction) [Note 3]	10 ³ – 10 ⁵ /100mls (99% reduction) [Note 3]

Note:

1. Based on a range of values from the literature.
2. Nitrate reduction is an optional feature for textile filters.
3. The number of faecal coliforms following treatment dependent upon influent numbers.

7.4.5 Sand and Textile Filter Dose Loading

Sand filters and textile must be dose loaded and to achieve optimum performance they should be dose loaded by timer controlled pump over 24 hours to even out the daily peak flows. The use of siphons or pump operated by float switch to dose the sand filter is not appropriate unless there are power supply problems. If sand filters are loaded by a siphon or float switch operated pump, all of the wastewater load will be concentrated during the daily production peaks. Where the hydraulic, solids or organic loading rate exceeds the capacity of the sand filter this can lead to the development of anaerobic conditions, clogging of the pore spaces between sand grains and wastewater ponding on the surface between applications. Timer dose loading buffers wastewater production peaks by storing excess peak production in the septic tank, recirculation chamber or pump chamber and pumping out a predetermined dose volume at predetermined intervals over 24 hours allowing uniform loading. It ensures the wastewater doses and resting times are equal, and achieve many small metered doses allowing for thin film flow around the sand grains and maintenance of open pore space optimising wastewater treatment and virus reduction. Other advantages of timer dosed loading over demand dosed loading are:

- It provides for maintenance of and enhances aerobic conditions in the sand filter;
- It enables the systems to be more robust, ensuring a more consistently high quality final effluent;
- It enables consistent longterm treatment performance level; and
- The sand filter systems have lower maintenance requirements.

Although dosing control by float switches is often used, it is not recommended, because the resulting wastewater doses and resting times are unequal which can lead to premature clogging of the sand filter.

Concentrated plug flow through the filter results in saturation of the filter porous media, incomplete treatment of wastewater and development of organic and inorganic materials to the extent that pore space becomes increasingly clogged.

7.4.6 Bottom less sand filters

A bottom less sand filter is a special version of a mound land disposal system, and these are covered within Section 10.6.

7.4.7 Which Filter Packed Bed Reactor System To Use?

There are no exact guidelines in the literature for the design of all types of filter packed bed reactor treatment systems and there is a variety of system configurations and sizings available. Key questions that can be asked of an individual manufacturer/supplier/installer are:

- What is the performance experience in terms of effluent quality (over what number of treatment plants, and under what duty delivered by those plants)?
- How often should the unit be serviced, and what is the annual cost of this?
- How consistent is the treated wastewater quality and how much data from which to draw this conclusion?
- What is the running cost in terms of annual power consumption?
- Is the system noisy or odorous?
- Is the textile/foam readily serviceable?
- If intended for a holiday home, is the system stable under intermittent wastewater loading with long periods of no wastewater inflow? In the case of recirculating systems do they continue to recirculate when there is no wastewater flow to maintain conditions for bacteria activity. (Some systems are likely to take a while to stabilise during which period they could be odorous, so it's important to ask how long this could take.)

It is important to secure a performance guarantee from the supplier for the rated duty of the system, the suggested guarantee time being 3 to 5 years. Normal product guarantees will be offered in any case, but the performance guarantee relates to the treatment system meeting the effluent quality parameters on a consistent basis. The parameters to be tested are typically only Biochemical Oxygen Demand (BOD₅) and suspended solids, unless the system is specifically required to also decrease faecal coliform levels and/or nutrients in which case, further analyses for these parameters should be undertaken and checked against the manufacturer's specifications.

The tests should be continued until the discharge quality analyses are within the manufacturer system design specifications for at least four consecutive samples. During the performance guarantee period, the manufacturer should be asked to undertake quarterly effluent quality assessments, the results of which should be provided to the purchaser and to the Regional Council in the case of a discharge consent. These results will aid the purchaser and authority in checking that the system is achieving its design specifications, and aid the manufacturer/supplier to assess the actual loading against the rated duty, and to fine tune the treatment operation accordingly.

Table 7.10 provides a summary of the key design characteristics and performance standards of the various filter systems available:

Table 7.10: Summary of Key Characteristics of Packed Bed Reactor Filter Systems

SAND FILTERS /PACKED BED REACTORS
<p>Intermittent Sand Filter</p> <ul style="list-style-type: none"> • Single pass. • Suitable for lower strength wastewater. • Hydraulic loading rate typically 40 to 100L/m²d. • Biochemical loading rate is also very important being typically 0.0025 - 0.01kgBOD/m³. • More suited to individual dwellings than large systems. • Large footprint compared to multiple pass. • Usually open and therefore subject to rainfall infiltration. • Produce extremely small sludge volume. <p>Treated Wastewater Quality</p> <ul style="list-style-type: none"> • Very effective at reducing faecal coliform level from 10 million CFU to less than 10,000 CFU/100mls claim less than 400 CFU/100mls. • Produces a nitrified effluent average 30g/m³. • Little reduction in phosphates. • Biochemical oxygen demand less than 10g/m³. • Total suspended solids less than 10 g/m³.
<p>Recirculating Sand Filter</p> <ul style="list-style-type: none"> • Multiple Pass i.e. wastewater is pumped onto sand filter 3 to 4 times. • Treated wastewater mixed with untreated wastewater causing dilution, reduced strength. • Dilution allows use of higher loading rates. • High loading rates reduces sand filter foot print. • Typical hydraulic loading rates 1,100 to 2,100L/m²/d. • Biochemical loading rate is also very important & typically 0.01 to 0.04 kgBOD/m². • The means to ensure even split of treated effluent and recirculation is very important for successful operation. • They should maintain recirculation even when there is no wastewater inflow into the system. • Usually open and therefore subject to rainfall infiltration. • Produce extremely small sludge volume. <p>Treated Wastewater Quality</p> <ul style="list-style-type: none"> • Very effective at reducing faecal coliform level but not to the same extent as ISF - expect a 99% reduction. • Produces a nitrified effluent average 30g/m³. • Little reduction in phosphates • Biochemical oxygen demand less than 10g/m³. • Total suspended solids less than 10g/m³.

Recirculating Textile Filters

- Sand is replaced by an engineered fabric.
- Some use vertical sheets of fabric and others have textile blocks placed in layers.
- Typically they are multiple pass.
- Textile has a much larger surface area for biological growth than sand filter and therefore a higher hydraulic loading rate is possible.
- Typical hydraulic loading rates 1,700L/m²/d but typically less than 1,700L/m²/d.
- Significantly smaller footprint than sand filters.
- Contained in water tight modules.
- Textile can be easily maintained in the event of excess biological growth.
- Produce extremely small sludge volume.

Treated Wastewater Quality

- Very effective at reducing faecal coliform level but not to the same extent as ISF - expect a 99% reduction.
- Produces a nitrified effluent average 30g/m³ but additional N reduction is possible with nutrient reduction cycle.
- Little reduction in phosphates
- Biochemical oxygen demand less than 15g/m³.
- Total suspended solids less than 15 g/m³.

Pre Treatment Requirements for all packed bed reactors/ filter systems

- Septic tank and outlet filter to reduce Total Suspended Solids.

Wastewater Loading To Filter

- Must buffer wastewater flows over 24 hours.
- Wastewater must be timer pump dose loaded onto sand/textile filter as a series of small doses.
- Flood dose loading not appropriate as results in uneven distribution across sand filter surface.
- Distribute onto sand/textile filter by pressure pipe network.
- Typical dosing frequency 48-120 doses per day for recirculating sand filters.

Sand Media

- Sand must be specifically graded.
- Sand must be clean and free of fines.

Important Criteria For Successful Operation

- Stormwater and groundwater infiltration into system must be excluded to minimise the filter area and maintain peak design flow.
- If influent design biochemical oxygen demand exceeded significantly on a regular basis there is a very high risk that the sand filter will clog or textile filter surfaces blind off with excess biological growth.
- Timer dose loading of wastewater important for optimum consistent treatment quality. Results in many small doses over 24 hours to maintain thin film flow through the filter rather than plug flow.
- On demand dose loading results in the wastewater being discharged onto the sand/textile filter at the time of wastewater production and concentrated at breakfast, lunch and dinner peaks.
- Wastewater must be distributed evenly across the entire surface for consistent treatment quality.
- Wastewater pumped onto filter must be low in suspended solids to prevent clogging of the infiltration surface.

Some Advantages

- Sand textile filters can produce a consistent high quality wastewater so long as the are well design, installed and the influent volume and strength is within design parameters.
- Very low operator input is required.
- Very low operational costs compared to traditional wastewater treatment systems.
- Very low sludge production from the sand/textile filters.
- Can be expanded with additional modules/sectors.
- System can be remotely managed and monitored via an internet connection.

Some Disadvantages

- Sand filters have a relatively large footprint.
- Sand filters can be difficult to renovate if overloaded and clogged by biological sludge. May require sand replacement (textile filters more readily renovated).

7.5 KEY DESIGN CRITERIA FOR ALL SECONDARY PACKAGE TREATMENT SYSTEMS

This section covers the necessary key design criteria that secondary package treatment systems must meet to comply with TP58 design principles. In this section, the term *secondary package treatment systems*, includes both *secondary* and *advanced secondary* treatment systems i.e. Aerated Wastewater Treatment Systems (AWTS) plants and Packed Bed Reactor (PBR) Plants (covered in Sections 7.3 and 7.4 TP58 respectively).

7.5.1 The Purpose of Design Criteria for Secondary Treatment Systems

The objective of any wastewater treatment system is to provide an effluent quality that is compatible with satisfactory longterm operation of the land application system and to achieve an effluent quality that is sufficient to minimise effects on the receiving environment. Secondary wastewater treatment systems treating domestic wastewater are designed to achieve this by providing a primary treatment stage (either within or prior to the package plant system) to remove settleable solids and floatable oil and grease, and then by providing a secondary treatment stage, in which biodegradation of remaining organic contaminants occurs in aerobic conditions.

Maximum biodegradation of the contaminants in wastewater by secondary treatment processes requires the provision of optimum conditions for biological activity. This includes the provision of favourable conditions for biological growth in the treatment system, a balance between the “feed” (organic load in the influent flow) and the microbial growth and the appropriate aeration rate proportionate to the feed concentration and microbiological populations. It is important that any suspended biomass generated in the secondary treatment process is removed from the final effluent by settling or filtration prior to disposal. This latter stage is most important to ensure a good final effluent quality and to reduce any potential for blockages and slime build up in the irrigation/disposal lines, enabling even distribution throughout the irrigation field and improving the effective life of the irrigation system.

Following in Sections 7.5.2 to 7.5.4, are key design performance requirements for AWTS and Packed Bed Reactor systems. Design criteria are provided to ensure that the plants can adequately achieve the required performance objectives. However, to achieve a satisfactory level of performance, it is important to note that the actual plant performance is also dependent upon appropriate plant operation and management processes in response to the influent flows and concentrations, and on regular monitoring and maintenance. This needs to be verified on a case by case basis in accordance with the system installation, start up inspection and sampling methodology and installation certification specified below in Section 7.5.6.

It should be noted that variations on the following key criteria might be appropriate in cases where other components of the system are sized or designed differently to compensate for any difference.

7.5.2 Primary Chamber Design Criteria

The larger the primary treatment chamber, the more it will be capable of achieving bulk solids removal and separation of oil and grease, which is critical to the performance of the secondary treatment system and the final effluent quality. The larger the primary tank the better the conditions will be for some anaerobic biodegradation of the organic material and the better the storage capacity to balance the flows to the secondary treatment system. These factors contribute to dramatically reducing the required pumpout frequency and provide for better sludge quality and system health.

The primary treatment chamber is the cheapest and most effective component of the whole package treatment system. It is buried underground so its actual footprint is seldom a major design concern. Yet it is also frequently the component most commonly undersized. This then has the effect of compromising the performance of the rest of the treatment process. Not only will a large size primary treatment capacity decrease the necessary frequency of septic tank pumpouts and achieve a better sludge quality and degradation process, it will also have a significant effect on the final treated effluent quality that can be achieved. However, in the case of some AWTS systems, there also needs to be regard for the need to balance the extent of primary treatment provided against the need for sufficient feed to enter the biological secondary treatment system. Extended primary treatment can also lead to aged primary wastewater and poor sludge quality.

Primary treatment and storage capacity can be provided either within the whole package plant prior to and separate from the secondary stage (which may severely restrict the capacity available), or in a tank prior to the treatment system.

Required Primary Treatment Design Criteria:

- A. *Minimum combined total retention capacity prior to secondary treatment of at least 3 to 5 days average flow volume, unless the supplier has verified to ARC satisfaction that sufficient final effluent quality is achieved in the secondary treatment process, to achieve the required secondary discharge standards specified in 4A below and that less than 3 days primary treatment is sufficient. (The higher end of this scale becomes more important where there is a significant requirement to consistently achieve a high final effluent quality.)*
- B. *No potential for overflows or cross contamination from primary chamber to any secondary chamber, caused by any surging or blockages in outlet, e.g. where the primary chamber is within the whole treatment plant unit, the walls of the primary chamber must be of full height and sealed.*
- C. *An effective Effluent Outlet Filter must be installed at the outlet of primary chamber to retain any solids with a particle size of 3mm or greater and to prevent such solids entering the aeration chamber. (Ideally this should achieve a primary effluent suspended solids concentration in the order of 30 mg/l or less.)*

7.5.3 Design Criteria for Secondary Treatment Systems

AWTS Treatment Plants

Properly sized, operated and maintained AWTS plants can provide satisfactory secondary treatment for household wastewater flows. Shock loads, large variance in the organic load and flow, insufficient flows and/or significant temperature variations can all adversely affect their biological performance and discharge quality. To perform well, the following aspects of the design and operation need to be well tuned for the circumstances particular to each system and site:

- Sludge return rates;
- Control of the mixed liquor suspended solids concentrations;
- Anti foaming measures;
- Aeration rate controls;
- Provision for scum and grease removal from the final clarifier; and
- A means for the continuous removal of accumulated sludge from final effluent chamber.

Adequate retention time in the final clarifying chamber and an appropriate sludge return rate are critical for good performance. It has been suggested by one supplier that the sludge return rate becomes even more critical with conventional aeration plants than with extended aeration plants. Exact design criteria for each of these above aspects depend on the combined design of all features within the system; so generic design criteria cannot be specified here.

More detail of these systems, including recommended design criteria for sizing of extended aeration package treatment systems, are provided in Section 7.3 of TP58.

D.1. *The quality of the final effluent from a AWTS system shall be better than or equal to a Biochemical Oxygen (BOD₅) and Suspended Solids (SS) concentrations of 20 gO/m³ and 30 g/m³ respectively. However, where ten or more samples have been taken with 90% of samples complying with these limits, the system shall be considered satisfactory. (As specified in point 13 below, a minimum of two consecutive complying samples are necessary for commissioning purposes to verify a system complies with these standards.)*

Where treatment systems cannot meet this criteria, the supplier must specify what criteria they can realistically achieve. In the Auckland region, ARC or a similar appointed consultative expert forum will then classify the plant and the type of on-site design situations where the plant may still be suitable, such as types of disposal systems and receiving environments where less than secondary discharge quality and elevated suspended solids levels may not be of concern. (BOD₅ levels of up to 30 gO/m³ may be acceptable in some systems discharging to land where there is no potential for impact on natural waters, but SS levels must be less than or equal to 30 g/m³ for sustainable long term performance of most drip irrigation systems.)

7.5.4 Design Criteria for Advanced Secondary Treatment Systems

Packed Bed Reactors/Filtration Systems

It is critical that the different forms of secondary filtration treatment systems (Sand/Textile Filter Systems), also known as Packed Bed Reactors, are appropriately sized for the maximum influent flows. The systems need to be dosed to optimise the conditions within the reactor system and thus the health of the microorganism population and the overall performance of the system.

Key design criteria for these systems, including details of dosing regime and loading rates and system sizing, are provided in Section 7.4 of TP58:

D.2. *The quality of the final effluent from an advanced secondary filtration treatment system shall be better than or equal to a Biochemical Oxygen (BOD) and Suspended Solids (SS) concentrations of 15 gO/m³ and 15 g/m³ respectively. However, where ten or more samples have been taken with 90% of samples complying with these limits, the system shall be considered satisfactory. (As specified in point 13 below a minimum of two consecutive complying samples are considered necessary for commissioning purposes to verify a system complies with these standards.)*

Where treatment systems cannot meet this criteria, the supplier must specify what criteria they can realistically achieve. In the Auckland region, ARC or a similar appointed consultative expert forum will then classify the plant and the type of on-site design situations where the plant may still be suitable, such as types of disposal systems and receiving environments where less than advanced secondary discharge quality may not be of concern.

7.5.5 Design Criteria for Other Associated Treatment System Components

Final Treated Effluent Filter

Manufacturers of drip irrigation systems require a minimum suspended solids level for effective operation and performance of the irrigation lines and will usually specify a maximum level not to be exceeded. To achieve this limit, a disc filter or constant flush screen filter near the outlet of the plant, is frequently required depending on both the performance of the treatment system, and the maximum solids level specified by the irrigation system supplier to improve the effluent quality to the irrigation lines. Disc filters are usually constructed with aperture hole sizes of 120microns in a well designed treatment system. The cleaning frequency of outlet disc filters should be less than the routine three monthly contracted maintenance frequencies. Where the filters require a higher level of maintenance, this is indicative of a treatment process not performing to the required standard, resulting in a high level of solids carryover and/or of a process that requires immediate servicing. It is not usually indicative of an overly effective or of a faulty screen filter. This is discussed further in Section 7.3 7 above. As a minimum, the following is required:

- E. *Effective effluent disc (or a screen or a mesh filter with constant backflush), fitted in the discharge pipe, between the discharge point from the treatment process and the irrigation lines, to retain all solids greater 120-130 microns within the system, OR verification to ARC standards that the treatment system itself will consistently achieve better than the treated wastewater quality parameters specified by the irrigation system suppliers.*

Alarm System

The alarm system must be designed to activate the occupiers to take remedial actions as soon as practicable once the alarm is activated. The inclusion of both a visual as well as an audible alarm is appropriate, as an audible alarm while immediately noticed, is also easily muted and forgotten, and the addition of a light is a cheap but critical feature. Audible alarms are to comply with all New Zealand audible alarm and security standards.

- F. *A malfunction alarm system must be installed to activate in the event of failure of the aeration blower system and/or the in the event of a high water level in any of chamber within the system and/or in the pump chamber.*
- G. *An audible alarm unit, as well as a visual alarm unit, must be located in a prominent place within the dwelling or office facilities.*

Safety Components

- H. *There must be a leak proof and durable lid on the top or side of the whole system that prevents ingress of surface water run off and is secured to prevent access by unauthorised personnel and yet is readily accessible for maintenance or replacement. All risers must also be sealed.*

Emergency Storage

- I. *A minimum emergency storage volume of at least 24 hours capacity above the alarm trigger level is required in the pump chamber. Otherwise a combination of the equivalent emergency storage must be provided within the whole system, with automatic overflow between sections should it be required. This is providing that excess wastewater will not have access to the clarifier chamber or other lead to cross contamination of other sections.*

Electrical Equipment

- J. *All electrical connections and componentry in the system must be in accordance with New Zealand standards (i.e. in accordance with the criteria in AS/NZS 3000).*

Additional Key Criteria – Applicable To Whole AWTS System

- K. *Systems must be manufactured to the Standards in AS/NZS 1546:3, “On-site Domestic Wastewater Treatment Units, Part 3: Aerated Wastewater Treatment Systems”, particularly in terms of the Design Requirements specified in Section 2.5, and must also in accordance with the other relevant design criteria specified in this list above and in Sections 7.3 and 7.5 in TP58, whichever is the more stringent.*

Particular, key criteria that must be noted within AS/NZS 1546:3 standard are design flows (the average influent quality the plant must be designed to handle), and design considerations (a variety of additional design provisions that must be included within the system). AS/NZS 1546:3 also provides provisions for the design of tanks and fittings, tank construction, design loads, emergency storage capacity, materials selection, mechanical equipment, electrical equipment, effluent pumps, alarm systems, and disinfection criteria.

7.5.6 Treatment System Installation Requirements

System Installation

- L. *All secondary treatment systems should be installed by registered drainlayers or by a suitably trained and experienced installer. Installation should be undertaken in accordance with the practices covered in Chapter 12 and specifically with key aspects listed in Section 12.1, and in particularly Sections 12.1.3.1 to .7.*

System Start up Inspection and Sample Analysis

- M. *Within three months of commissioning of the system, the system supplier and/or installer shall inspect the system to verify that it has been properly installed and shall collect a sample of the final effluent in a sterilised sample vessel (minimum 1 litre). The sample shall be taken to a registered laboratory for analysis of Biochemical Oxygen Demand and Suspended Solids concentrations, to verify the plant’s performance.*

If the first sample is not within the limits specified in TP58 (criteria D1 and D2 and in section 7.3 or 7.4) for the type of system installed then sampling should continue and recent modifications made to system operation tuned until the average sample results verify that the system performance is in accordance with the above discharge standard for the system type or, in the Auckland region, until an exemption to this standard for that treatment system, is approved by the ARC. The tests should be continued until the discharge quality analyses are within the manufacturer’s system design specifications for at least two consecutive samples.

ARC may provide an exemption to this sampling criterion in the case of a proven system supplier with an exemplarity performance record, for systems in a range of situations, with systems running at design capacity.

System Installation Certification (or equivalent Producer Statement)

- N. *The Sample Analytical Data and the Installation Certification (or equivalent Producer Statement) shall be forwarded to the approving authority within 6 months of system commissioning (or at a later date by arrangement).*

As stated in Sections 7.3.6 and 7.4.7 above, it is important that the purchaser secures a performance guarantee from the supplier for the rated duty of the system, the usual minimum guarantee time being 3 to 5 years. Normal product guarantees will be offered in any case, but the performance guarantee should also relate to the treatment system meeting the effluent quality parameters on a consistent basis.

If the system is specifically required to also decrease pathogen levels and/or nutrients, in addition to testing for Biochemical Oxygen Demand (BOD₅) and suspended solids, further analyses for levels of indicator organisms, usually faecal coliforms, (and/or Enterococci, and/or E.coli levels depending on the receiving environment) and/or analysis of nutrient levels (Total Nitrogen, Ammonia, Nitrate and Total Phosphorus) may be required and checked against the manufacturer's design specifications.

For sensitive receiving environments where a discharge consent is required, the consent conditions may require that the manufacturer undertakes quarterly or more frequent effluent quality assessments on an on going basis or at least during the first few years of operation (e.g. for the performance guarantee period). The results of which should be provided to the purchaser and Regional Council in the case of a discharge consent. These results will aid the purchaser and authority in checking that the system is achieving its design specifications, and aid the manufacturer/supplier to assess the actual loading against the rated duty, and to fine tune the plant operation accordingly.

7.5.7 Maintenance Contract Requirements

- O. *The system supplier or equivalent qualified wastewater treatment system operator shall provide the purchaser with the option of a Maintenance Contract for regular 3 monthly maintenance of the system (6 monthly maintenance contracts may be appropriate in special cases where stable system performance is proven), at the time of installation and by the time the purchase is complete. (This is described further in Section 12.2.7.)*
- P. *The site owner or the owners representative shall enter into and maintain in force a signed Maintenance Contract for the on going maintenance and operation of the secondary treatment AWTs system or for the advanced secondary treatment filtration system.*

7.5.8 General System Maintenance – Owner Responsibility

- Q. *In addition to contracted system maintenance, the owner of an on-site wastewater system has their own responsibility to undertake system maintenance to minimise adverse effects of the discharge on the receiving environment. The maintenance should be undertaken in accordance with the Management Plant provided by the system installer (refer Section 12.2.8) and regard should also be had for the Remedial Procedures for System Failure covered in Section 12.2.10 and in the Information Sheets in Appendix I. The duty of every person to avoid, remedy or mitigate adverse effects on the environment is stated in Section 17 of the Resource Management Act 1991.*

7.6 TERTIARY TREATMENT

7.6.1 General

Tertiary treatment usually refers to engineered microbiological or nutrient reduction following secondary treatment. This section refers to the reduction of microorganisms by disinfection treatment. Nutrient reduction is discussed in Chapter 11, which further addresses environmental effects of contaminants in treated wastewater. Disinfection of wastewater is required where environmental constraints exist and to meet discharge consent conditions. The New Zealand Public Health Guidelines [Ref 8] relating to land disposal of effluent may have relevance for institutional situations involving larger volume flows.

Disinfection refers to the selective reduction of disease causing bacteria, parasites and viruses remaining within secondary treated wastewater and is typically achieved by chlorination, ultraviolet (UV) or ozone disinfection. Disinfection does not kill all microorganisms from the wastewater, and this is what differentiates disinfection from sterilisation, but it should limit their ability to reproduce, decreasing their effectiveness.

The mechanism of disinfection depends on the method used but broadly results in, damage to the cell (cell wall or the cells RNA and DNA) resulting in death or prevention of replication. The characteristics of the wastewater (including Total Suspended Solids, Organic content from BOD₅ and COD, pH, Hardness) can impact on the effectiveness of disinfection. Other factors include contact time, concentration of the disinfectant, temperature, and concentration of organisms.

For disinfection to be effective and for wastewater to achieve an acceptable aesthetic quality, wastewater must first be treated to a consistently high quality (15gO/m³ BOD₅:15g/m³SS as a minimum quality and in many cases, better than 10gO/m³ BOD₅:10g/m³SS is required). The organic content of treated wastewater high in BOD₅ and SS results (i.e. in a greater disinfection treatment high chlorine demand by the treated wastewater or greater UV light intensity) before effective disinfection can be achieved and can result in ineffective UV disinfection.

Low quality treated wastewater can also result in discoloured and odorous recycle water. Recycling of wastewater should only be considered where there is certainty that wastewater can be treated effectively and the treatment and disinfection system can be closely monitored to ensure the required recycle water quality can be achieved and maintained.

Small scale disinfection units suitable for on-site effluent application require regular maintenance to ensure that full effectiveness of the equipment is achieved. Chlorination systems require regular addition of chlorine and ongoing monitoring to ensure the necessary chlorine residual is maintained for disinfection to be effective. The light tubes in UV systems must be cleaned regularly to maintain transmission effectiveness.

7.6.2 Chlorine Disinfection

7.6.2.1 General Information

Chlorine is the most commonly used disinfectant for the following simple reasons:

- It is very effective;
- It can be easily monitored for the effective chlorine residual; and
- It is relatively easily maintained and it is relatively inexpensive.

However, the ARC in most cases opposes the use of Chlorine for the treatment of wastewater immediately prior to discharge to land. When chlorine is in contact with organic contaminants remaining in treated wastewater, the molecules can combine and form chlorination by products”.

It is due to concern about potential cumulative impacts of the chlorination by products on the receiving soils and in water that the ARC opposes additional and usually unwarranted use of chlorine prior to discharge to land.

The type and form of the chlorine byproducts vary by not only the water quality and disinfection conditions, but also by the types of organic molecules in the dissolved organic carbon [Ref 39]. The byproducts can include organochlorines, also known as total organic halides (TOX), and trihalomethanes (THMs) (e.g. chloroform), which are of concern if in contact with surface or drinking waters. A chlorinated furanone called MX is of concern when found in water supplies as it is carcinogenic and can have a bioaccumulative effect, which can have longterm toxic effects where concentrations buildup in the receiving environment. THMs are more likely to be present in the environment as a result of combustion processes [Refs 39 and 42].

The other risks of using chlorination as a disinfection process include inadequate contact time prior to discharge and excess residual chlorine itself having a toxic effect on microorganisms in the receiving soils. These risks decrease if the disinfected wastewater is sufficiently dechlorinated by a demand dose flow proportionate sensor system and by holding the flow in a storage chamber that ensures sufficient contact time prior to discharge.

Despite these risks, chlorination is generally a well accepted means of disinfection where risks to public health are considered to outweigh any corresponding environmental risks. This is considered the case for the reuse of wastewater where there may be a risk of human contact but not where wastewater is applied directly to land, where direct human contact should be unlikely.

The degree of chlorination required will depend on the destination and reuse of the wastewater, as well as the sensitivity of the environment into which the wastewater is to be discharged and the volume and the quality of the wastewater to be disinfected. The designer should only use proprietary equipment when including chlorination within a wastewater treatment system. In the Auckland region, it is likely that a discharge consent will be required where wastewater systems are dependant upon chlorination to achieve the discharge quality required to achieve the acceptable level of environmental impact.

Where chlorine is used in wastewater discharged into or near surface waters, it is important that the discharge consent places minimum and maximum limits on the FAC levels, due both to the need for surety of the disinfection process and to the need for consideration of the sensitivity of aquatic organisms. In future, increasing regard may also need to be had into the potential effects of disinfection by products on the receiving environment. Further information on recent research into the formation and persistence of disinfection by products in subsoils and groundwater is available on www.water.usgs.gov/ogw/pubs/ofr0289/cr_fatedisinflect.htm [Ref 39].

Further information on chlorine disinfection systems and their use in disinfecting treated wastewater prior to recycling for reuse primarily for toilet flushing is provided in Section 7.7.3 to 7.7.5 below.

7.6.2.2 Operation and Maintenance

Small scale disinfection units suitable for on-site effluent application require regular maintenance to ensure that full effectiveness of the equipment is achieved. To be effective, a chlorination system must achieve a final chlorine level in the disinfected wastewater of at least 0.5mg/l free available chlorine (FAC) or chlorine residual, following a minimum contact time in the order of 30 minutes. A design minimum detention or contact time (CT) to achieve the required chlorine residual will need to be specified in the design. Additional precautions in the design, which ensure that the chlorine residual is not excessive i.e. is maintained as close as is practicable to the desired range of 0.5 to 1.0 mg/l, should also be specified.

Chlorination systems require regular addition of chlorine to the disinfection unit. Care is always necessary when storing and handling chlorine based chemicals and should be in accordance with manufacturers instructions.

Effective chlorination prior to reuse should achieve a faecal coliform level of less than or equal to 10 faecal coliforms (MPN or CFU) per 100ml. Ongoing monitoring is required to ensure a 0.5ppm chlorine residual is maintained for disinfection to be effective. For on-site chlorination systems of wastewater prior to reuse for toilet flushing, this can be achieved by a regular swimming pool chlorine dip test, (daily or twice weekly, at least until the system has stabilised). Less regular calibration by analysis of a chlorinated sample at a registered laboratory for the FAC and for faecal coliform levels is also critical to determine the actual effectiveness of the disinfection process.

7.6.3 Ultraviolet (UV) Disinfection

7.6.3.1 General

Ultraviolet light is a physical disinfection method, using UV radiation to penetrate the walls of cells and disrupt nucleic acids. The advantage of UV disinfection is that it is an effective disinfection method that does not result in the formation of toxic by products from chemical reactions. UV effectiveness depends on the characteristics of the wastewater, the UV intensity, the period of time the microorganisms are exposed to the radiation and the reactor configuration [Ref 9].

The most effective means of improving UV effectiveness is to reduce the number of colloidal material and other particles in the wastewater [Ref 9]. UV requires a wastewater having very low suspended solids to achieve a suitable turbidity, otherwise shadowing of bacteria in suspension and those attached to particulate matter results in ineffective disinfection. It is for this reason that untreated greywater, with its often high suspended solids and high turbidity levels is unsuitable for UV disinfection, although this has been attempted in the past. To provide more certainty in consistent good discharge quality for effective UV treatment, all wastewater should be secondary treated. Wastewater that has had advanced secondary treatment by sand or textile filtration is most appropriate for UV disinfection. Treatment by AWTS with disc filter should also be suitable for UV disinfection, providing secondary treatment discharge standards are achieved. However, UV units require regular maintenance to ensure the tube surfaces are clean and UV transmission intensity is not reduced.

7.6.3.2 Components of a UV System

The main components of a UV disinfection system are mercury arc lamps, a reactor and ballasts. The source of the UV radiation is either a low or medium pressure mercury arc lamp with low or high intensities.

The optimum wavelength to effectively inactivate microorganisms is in the range of 250 to 270nm. The intensity of the radiation emitted by the lamp dissipates as the distance from the lamp increases. Low pressure lamps limit essentially monochromatic light at a wavelength of 253.7 nm. Standard lengths of the low pressure lamps are 0.75 and 1.5m with diameters of 150 to 200mm. The ideal lamp wall temperature is between 35 and 50°C [Ref 9].

Medium pressure lamps are generally used for large facilities with approximate 15 to 20 times the germicidal UV intensity of low pressure lamps. They disinfect faster and have a greater penetration capability because of the greater intensity. However, these lamps operate at higher temperatures and therefore have higher energy consumption.

There are two types of disinfection unit designs: contact types and noncontact types. In both, the wastewater can flow either perpendicular or parallel to the direction of the lamps, with the lamps lying either horizontal or vertical direction. In the contact units, a series of mercury lamps are enclosed in quartz sleeves (or Teflon tubes) to minimise the cooling effect of the wastewater and in the other, the UV lamps are suspended outside a transparent conduit, which carries the wastewater to be disinfected, the latter being less common. In both types the ballast (control box) provides a starting voltage for the lamps and maintains a continuous current.

7.6.3.3 Advantages and Disadvantages of UV Disinfection

Advantages of UV compared to other disinfection options are outlined in Table 7.11 below [Ref 9]:

Table 7.11: Advantages and Disadvantages of UV Disinfection

Advantages of UV	Disadvantages of UV
It is effective at inactivating most viruses, spores and cysts.	Low doses may not effectively inactivate some viruses, spores and cysts.
It is a physical process rather than a chemical disinfectant, which eliminates the need to generate, handle, transport or store toxic or hazardous chemicals.	Microorganisms can sometimes repair and reverse the destructive effects of UV through mechanisms of photoreactivation (with light) or dark repair (in the absence of light).
There is no residue produced that can be harmful to the environment or humans.	Preventative maintenance is critical to control fouling of the tubes and maintain effectiveness.
It is user friendly for operators.	Turbidity and total suspended solids (TSS) in the wastewater can render UV disinfection ineffective.
It has a shorter contact time than other disinfectants, (in the order of 20 to 30 seconds with low pressure lamps).	UV disinfection (particularly using low pressure lamps) is not as effective on effluent with TSS levels above 30mg/L.
It requires less space than other methods	It is not as cost effective as chlorination but costs become comparative when chlorination dechlorination is used and chlorine handling costs are considered.

7.6.3.4 Factors Affecting UV Effectiveness

The following matters need to be addressed at the design stage to ensure UV treatment achieves the level of disinfection necessary and are the key parameters to be considered when designing a UV system and determining lamp strength and exposure time [Ref 9]:

- a. Wastewater Flow within the Reactor – This will be determined by the manufacturer’s design but it is important that the UV system has a uniform flow with enough radial mixing to maximise exposure of any microorganisms to the radiation. The reactor must be designed to eliminate short circuiting and/or dead zones where UV exposure is less than that required so the system is less efficient and there is inefficient use of power.
- b. Radiation Intensity – UV intensity is affected by the age of the lamps (this is addressed further in 7.6.3.5), lamps fouling and the configuration and placement of the lamps.
- c. Wastewater Quality – The main parameters effecting UV effectiveness are the suspended and colloidal solids and, the microorganism density, in addition to actual flow rate. These are the factors that most determine how much UV radiation can reach the target organisms, through the wastewater. Other parameters that affect UV disinfection include water hardness (which affects the solubility of metals that can absorb UV light or carbonates that can precipitate on the UV tubes), pH (affects metals solubility and carbonates), humic materials and iron (have high absorbency for UV radiation) and BOD (only if a large proportion is in the humic or unsaturated form, when it will decrease UV transmittance).

7.6.3.5 UV System Maintenance Requirements

On going operation and maintenance procedures are critical to ensuring that sufficient UV radiation is transmitted to the microorganisms for effective dieoff, so optimum clarity through the tube and treated wastewater is critical as is the effectiveness of the ballasts, lamps and reactor. Following are details of the core maintenance requirements for any UV system [Ref 9], although the maintenance frequencies can be system specific and should be advised by the supplier at the time of installation:

Tube Cleaning

Inadequate cleaning of the UV tubes is one of the most common causes ineffective UV disinfection. The quartz sleeves or Teflon tubes can be cleaned by mechanical wipers attached to the tubes, ultrasonic means or by chemicals. Manual chemical cleaning is the most common method for on-site disinfection systems. Chemical cleaning is usually done with citric acid, but mild vinegar and sodium hydrosulphite can be used without normally producing harmful by products depending on the wastewater. Noncontact systems are most effectively cleaned using sodium hydrosulphite. The frequency of tube maintenance required is system and wastewater flow dependant. The minimum cleaning frequency should be advised by the supplier at the time of installation.

Tube Replacement

The average lamp life ranges from one year to one year and seven months and normally should be replaced not long after one year of operation. The on/off cycles should be set in response to manufacturer recommendations, noting that repeated cycles will reduce lamp efficiency. Quartz sleeves can last about 5 to 8 years but should be replaced after 5 years, unless otherwise advised by the supplier.

Ballasts

The ballast (control box) must be appropriate for the lamp system. The box must be ventilated to protect against excessive heating. They can last up to 15 years but are usually replaced after 10 years.

Where discharge consents specify bacteria limits in the final wastewater, particularly where wastewater may come in contact with natural waters, the UV disinfection system should be pilot tested prior to commissioning the whole system, to ensure that the UV intensity and other factors are appropriate for that situation.

7.6.4 Ozone Disinfection

Ozone (O₃) is a highly reactive oxidant for reduction of bacteria, viruses and protozoa and is more effective than chlorine. The disadvantages are that ozone is highly unstable and must be generated on-site, it is therefore expensive, and the effectiveness of ozone disinfection cannot be measured immediately. There is no residual action.

7.7 USE OF TREATED WASTEWATER EFFLUENT (REUSE / RECYCLING)

7.7.1 General

In most New Zealand situations with on-site systems, once treated, the treated effluent is discharged to land for disposal, as detailed in Chapters 8 – 10. However, there is increasing interest in reusing treated wastewater or greywater. In situations where property owners wish to consider use of treated wastewater effluent for domestic purposes, to supplement or replace potable supply for uses such as toilet flushing or irrigation, it is critical that this is managed in a public health, social and environmental safe longterm sustainable manner.

Property owners and developers increasingly consider options for the use of treated effluent as a popular option for managing water demand and wastewater disposal. Use of reclaimed wastewater can reduce demand for potable water supply in areas of limited supply (relatively uncommon in the Auckland region) and more importantly, can significantly reduce the treated wastewater discharge volume and thus the land area required for its disposal. In situations where there is insufficient area on a site to accommodate the peak treated wastewater discharge volumes, the combination of water flow reduction fixtures and treated wastewater reuse can significantly reduce wastewater discharge volumes. However, in practice, the reduction in total daily discharge volume from reuse, tends to be overestimated, which can result in severe problems with under sized disposal systems. For this reason caution is required wherever reliance on reuse is proposed within a design. Table 6.2 above, provides guidelines on appropriate reductions in design flows allowances for different forms water usage, flow reduction fixtures and recycling.

The Ministry of Health strongly advises against the domestic use of treated wastewater effluent. This applies to the use of treated greywater as well as treated blackwater, since greywater has a high bacterial and BOD contaminant load [Ref 42]. (Further background on the reuse of greywater is provided in Section 7.7.6.) This view is in recognition that in practice, on-site and decentralised wastewater treatment systems are often not sufficiently reliable to ensure consistent water quality, such that domestic use of treated wastewater represents an avoidable and real hazard [Ref 42]. The ARC's experience has been with few exceptions that treated effluent reuse systems have not performed to design specifications and have failed to consistently meet resource consent conditions.

The risk of cross connection between reclaimed water and potable water is significant, particularly given that many people build, renovate and maintain their own homes and often with rudimentary knowledge of sanitation. Cross connection has also occurred in municipal scale effluent reuse systems (in Holland), leading to large disease outbreaks [Ref 42].

This section of TP58 sets out ARC's requirements for any such treated wastewater effluent reuse/reclamation system. Design and performance criteria and monitoring requirements for all reuse systems need to be stringent to mitigate any public health risk. *In the Auckland region, a discharge consent is required all cases where reuse (for recycling) of treated wastewater is proposed.*

Following is a summary of the minimum requirements of ARC and Auckland Regional Public Health Services (ARPHS) for any wastewater reuse system in the Auckland region.

7.7.2 Options for Domestic Use of Treated Wastewater

7.7.2.1 Types of Reuse

Reclaimed (and disinfected) water may be suitable for (although it is not recommended):

- Flushing toilets;
- Subsurface irrigation of gardens, including fruit trees and bushes, but not root crops);
- Filling ornamental ponds where there is no direct human contact; and
- Fire fighting (for larger decentralised systems).

The Ministry of Health advises against reclaimed water being used (where there is any potential for human contact or contact with stormwater drains) for [Ref 42]:

- Manual watering of lawns and gardens by sprinkler or handheld hose;
- Garden hoses, washing cars, walls, windows etc. (NB. this is also prohibited by ARC where the treated wastewater may access stormwater drains or natural waterways); and
- Construction purposes.

Reclaimed water must never be used for:

- Drinking;
- Cooking or kitchen purposes;
- Personal washing such as baths, showers and hand basins;
- Washing clothes;
- Household cleaning;
- Swimming pools, spas;
- Recreation e.g. playing under sprinklers;
- Spray irrigation for crops that are eaten raw or unprocessed;

7.7.2.2 Reuse Requirements For Different Scales of On-Site Systems [Ref42]

a. Individual Households

As noted above, the Ministry of Health opposes domestic reuse of treated effluent from on-site systems because of their unreliability and inconsistency. A reuse system should only be considered for households where water supply is restricted and other water demand reducing methods (such as appropriate flow reducing fixtures, water efficient appliances, subsurface garden irrigation of treated effluent etc. and finally possibly also composting toilets) are insufficient. Domestic reuse should only be considered for toilet flushing, and not for any other uses, as listed above [Ref 42]. The minimum treatment system requirements are an advanced secondary level of treatment (involving septic tank with outlet filter followed by and intermittent or recirculating sand or textile filter with discharge quality as specified in Section 7.4 above), followed by chlorine disinfection system in accordance with the specifications described in Section 7.7.4 below.

b. Decentralised systems

Some suppliers of decentralised wastewater treatment systems offer the option of returning treated effluent to properties for disposal or reuse. Disposal to land is covered in Chapters 8-10.

Irrigation of fruit trees and crop plants where there is no direct contact with the crop, by drip irrigation and other subsurface irrigation methods should meet the same requirements as for land disposal. Use for toilet flushing will require chlorine disinfection in accordance with the specifications described in Section 7.6.2 above. It is unlikely to be practicable to install separate chlorinated and unchlorinated reuse systems from a decentralised wastewater treatment plant, if there are demands for different forms of reuse. The return of water to contributing individual properties for ground disposal or irrigation purposes where practicable by controlled wastewater distribution system is preferable than reuse for toilet flushing for managing larger volumes.

c. Centralised or Municipal systems

TP58 does not cover reuse of treated effluent from municipal sewage treatment plants.

7.7.3 Consent Requirements for Reuse

Auckland Regional Public Health Services (ARPHS) require that if reclaimed water is to be used for domestic purposes, its use must be limited to toilet flushing and some types of land irrigation [Ref 42]. In the Auckland region, treated effluent reuse for domestic purposes is a discretionary activity and all such systems will require approval from ARPHS, and will also require a discharge consent from the ARC, which also authorise the discharge of the remaining proportion of the wastewater flow. The reuse system and plumbing also needs to be covered by the Building consent, and therefore reuse system components need to meet relevant Building Standards.

7.7.4 Disinfection Requirements for Wastewater Reuse

7.7.4.1 Chlorine Disinfection System Requirements

Disinfection of treated effluent prior to domestic reuse (i.e. for toilet flushing) is a necessity to ensure removal of pathogenic organisms. The preferred method is chlorination using automated flow proportionate chlorine dosing with continual on line monitoring by redox probe to ensure chlorine doses are sufficient and that the required 0.5ppm chlorine residual is maintained. The key components include:

- A chlorine contact tank;
- A chlorine supply;
- An automatic proportional flow chlorine dosing system with a redox probe to maintain effective Free Available Chlorine (FAC) at >0.5 mg/L (with pH 6.5 – 8.5);
- Alarm system (audible and preferably visible) if FAC goes outside set limits or if the chlorine supply is low. Automatic notification to maintenance contractor is required for any decentralised system or system serving public toilet or other facilities;
- A separate chlorinated wastewater holding tank;
- Separate pipe work componentry with dedicated plumbing (coloured and labelled as non potable) and non standard fixtures. All non potable water supply must be clearly marked and plumbing/fixtures coloured to reduce risks of erroneous connections; and
- Signs on any accessible outlet informing the user that this is not drinking water.

7.7.4.2 Comments Concerning Alternatives to Chlorine Disinfection Methods

Other chlorination methods (tablets or fixed rate or intermittent dosage) are unreliable and therefore unsuitable, especially when flow of reclaimed water from the treatment system is intermittent [Ref 42]. UV and ozone disinfection are not suitable, as their effectiveness requires certainty that the treated wastewater will be of consistently high quality.

Alternative systems involving the application of chlorine tablets are not considered as appropriate as an automatic chlorine dosing system, due to the significant potential for excessive or insufficient chlorine doses. An example of one such type of system involves the aeration of greywater, which is then filtered and chlorinated prior to reuse. The chlorine is administered as a tablet with the quantity of chlorine dissolved being dependant on the flow rate past the tablet. The recycled greywater is then recycled to the toilet cistern via a small 12v pump when the toilet is flushed. A similar system involves application of chloride tablets to the toilet cistern. In both these systems, it cannot be assumed that without actual automated demand dosing and monitoring controls within the system that the actual chlorine dosage will consistently achieve higher than 0.5mg/l FAC. It can also not be assumed that the chlorine level will also be low enough to avoid elevated chlorine levels affecting the performance of the sensitive microorganisms in the biological treatment system or in the receiving environment.

Due to the inherent risks with these systems, they are not considered appropriate, as there are viable alternatives that provide a lower level of risk. Use of any such applications would require sufficient justification within the consent process that the risks referred to above are adequately mitigated. Other alternative disinfection processes, including options of ultraviolet treatment or ozone treatment, are not considered sufficiently robust to provide adequate certainty that the disinfection doses will achieve the required level of pathogen dieoff on an on going basis and therefore are not suitable [Ref 42]. Such options will only be considered on a case by case basis, through a consent process.

7.7.4.3 Discharge Quality Standards for Reuse

Treated disinfected wastewater must meet the following criteria prior to reuse for toilet flushing:

- Microbiological: < 10 faecal coliforms CFU (or MPN) /100ml;
- Turbidity: < 2NTU (24 hour average) and < 5NTU (at any time);
- FAC – 0.5mg/L or pH adjusted equivalent; and
- pH: 6.5 – 8.5.

Also the following treatment system discharge quality standards are also recommended (in 95% of samples) to ensure that the disinfection process is most efficient:

- BOD – \leq 10mgO/L.
- SS – \leq 10mg/L.

Table 7.12 provides a comparative list of discharge quality standards required by other international authorities and specified in literature and specifies the standards required in the Auckland region by TP58.

Table 7.12: Discharge Quality Standards Required by Other International Authorities and from other Literature [Refs 43, 14 and 2]

Parameter	1	2	3	4	5	TP58 Standards
Faecal Coliforms (CFU (or MPN)/100ml)	Non detectable		<10	<1	0 - 14	\leq 10
Total Coliforms (CFU (or MPN)/100ml)		2.2		<10		
Turbidity (24 hr ave) NTU	\leq 2	\leq 2			3	\leq 2
Turbidity (maximum) NTU	\leq 5	\leq 5	\leq 2			\leq 5
Chlorine Residual (FAC) (g Cl/m ³)	\geq 0.5	\geq 0.5	\geq 1.0		\geq 0.5	\geq 0.5
pH			6.5 - 8.5			6.5 – 8.5
Suspended Solids (mg/l)			5		5	\leq 10
BOD ₅ (mg O/l)	10				5	\leq 10
Notes:						
1. USEPA (1992)						
2. Crities et al (1998)						
3. ANZECC (1996)						
4. NSW Guidelines (1993) "NSW Guidelines for Urban Residential Use of Reclaimed Water"						
5. Waitakere City Council (1995) "Water Cycle Strategy"						
SOURCE: Adapted from Gunn (1998) [Ref43], and further from USEPA (1992) and Crities (1998) [Refs, 14 and 2]						

Treated disinfected wastewater need not be disinfected with chlorine prior to reuse for Food crop irrigation where no contact with edible portion.

7.7.4.4 Monitoring and Maintenance Requirements

The performance of the chlorine disinfection system should be monitored to confirm it continues to operate satisfactorily. The regular monitoring of free available chlorine (FAC) is required, and may be imposed as a condition of consent to ensure FAC levels remain above 0.5mg/litre.

- For household systems, a simple swimming pool chlorine concentration test is useful on a daily basis until there is certainty that the chlorination system is stable and then on a weekly to two weekly basis, with occasional professional analyses undertaken to validate that test and to calibrate the redox probe.
- For decentralised or public toilet reuse systems, continuous on line chlorine monitoring, with alarm to the maintenance contractor.
- Daily or weekly home test kit tests for pH, turbidity and FAC.
- Periodic sampling for analysis of microbiological levels at a registered laboratory and the other parameters specified above.
- Regular calibration and cleaning of the redox probes. Sensor probes must be cleaned each service, at least 6 monthly or more frequently for systems serving flows larger than from a single household. Probes are a consumable item and most will foul and need to be replaced within approx 12 months.
- Testing frequency should be increased whenever results show disinfection has been inadequate and then continued until remedial action is taken and the testing results are satisfactory.

All consents for decentralised system require a current operation and maintenance contract covering all aspects of the system. These management contracts and plans will be overseen by the relevant approving consent authority (i.e. ARC in the Auckland region).

7.7.5 Precautions for Reuse

a. Signage

- Notices should be placed in any public areas where effluent is recycled warning users that the toilet cistern water is non potable.

b. Cross Connection Precautions

Special precautions need to be taken when considering resource and building consent applications to ensure that all practical steps are taken to prevent any future cross connection. Precautions for all types of reuse reticulation drainage systems include:

- Wherever potable water is to be available for top up requirements, it must be delivered via a backflow preventor.
- Pipes for redistribution of reclaimed water must be of a different colour to water supply and raw and disinfected treated wastewater pipes, and must be labelled separately on the pipe as not being potable water.
- Pipes must be separated from drinking water and sewage pipes (They should be in different trenches and where practicable separated by at least 300mm).
- Non standard taps and fixtures, which do not allow garden hoses or other equipment to be attached to the reclaimed water system must be used. Preferably there should not be any taps connected to the reclaimed water system.
- The only reused water outlets within buildings shall be toilet cisterns and there shall be no faucet connections providing any forms of reuse water outlets.

c. Disinfection

- A robust disinfection system is critical for any wastewater reuse to reduce any health risk in the event of human contact. Criteria for chlorine disinfection are provided in Sections 7.7.4.1 and 7.7.4.3.

d. Regular Monitoring

- Regular monitoring of the recycled treated wastewater is critical to ensure disinfection is adequate and effective to minimise health risks from reuse. Daily, weekly or monthly chlorine dip test sample testing is likely to be required with periodic analysis by a professional laboratory to calibrate home testing methodology with testing frequency increased whenever results show unsatisfactory disinfection until remedial action is taken.

Further information on operation, maintenance and monitoring of chlorine disinfection systems is provided in Section 7.6.2.2 above.

7.7.6 Greywater Reuse

7.7.6.1 Greywater Composition

Greywater is wastewater from all other domestic sources within a household other than toilets. As estimated in Section 6.3, greywater is estimated to constitute in the order of 65 to 90% of total in house water usage, although is more typically likely to be in the range of 60 to 80%.

Reuse of greywater has traditionally been considered relatively safe and cheap due to its lower organic content and perceived low bacterial concentrations than in typical domestic wastewater, which also contains toilet wastewater (blackwater). Nevertheless, it is necessary to be aware that greywater has been confirmed to have a very high faecal coliform bacteria concentrations, in the order of only one to two orders of magnitude less than standard domestic wastewater i.e. in the order of 10^3 coliform bacteria per gram [Ref 13] and up to 10^6 to 10^7 coliform bacteria per gram [Refs 10 and 42] compared with 10^8 coliform bacteria per gram for typical combined wastewater. It can also have a high concentration of strong household washing and cleaning chemicals. These contaminants need to be removed from the greywater flow as they do from any wastewater, to lessen any potential for cumulative adverse effect on both the receiving soils and/or threat to public health.

Minimum greywater treatment requirements are covered in Section 7.8.1 below.

7.7.6.2 Demand for Greywater Reuse

In the New Zealand situation, trends towards separation and then reuse of greywater is not as common as in Australia and elsewhere internationally. This is likely to be due to the fact that the demand for water for reuse is significantly less in this country due to the ample rainfall most of the year. Secondly, it is likely to be due to the technology in advanced secondary treatment systems now in common use. These achieve a high final effluent quality in the reuse system, which result in there being limited additional advantages to justify the further cost of separating and then of separately treating the greywater flow.

7.7.6.3 Greywater Reuse

Where separation of greywater and reuse for domestic purposes is proposed (such as toilet flushing), it will still need to be treated sufficiently to achieve the equivalent of advanced secondary treatment quality followed by chlorine disinfection. Disinfection needs to be undertaken in accordance with the guidelines in section 7.6 and further precautions provided in Section 7.7.5.

Where a homeowner wishes to reuse greywater from shower and laundry wash water for manual irrigation purposes and is careful with general chemical and detergent usage, less treatment (than the level of standard wastewater treatment specified in Section 7.8.1 is necessary for greywater) may be allowable. However, to ensure adequate precautions are in place, to ensure any processes are sustainable and to ensure the processes are acceptable to Auckland Regional Public Health Service (ARPHS), this should only be considered through the consent process and regional council approval obtained, particularly if greywater reuse will be depended upon as a permanent means of disposing of greywater.

7.8 ALTERNATIVE TREATMENT OPTIONS

7.8.1 Greywater Systems

7.8.1.1 Greywater Design Volume

Greywater is the wastewater from all other domestic sources within a household other than blackwater from toilets. Due to the significant contaminant levels in typical greywater [Ref 10], the design and sizing of a greywater treatment and disposal system should be based on that for normal domestic wastewater, as covered in Sections 7.2 to 7.4. With the types of highly effective on-site wastewater treatment systems now available, it is generally more cost effective to collect and treat the black and grey wastewater flows together, particularly where there is a proposal to reuse a portion of the treated wastewater flow.

Further details of greywater composition and the requirements for greywater treatment, disposal and reuse requirements are addressed below.

7.8.1.2 Greywater Design Volume

From Table 6.3, "Flow Allowance Reduction Calculations for Household Flows", toilet blackwater flows are likely to constitute in the order of 15 to 30% of the total per person daily flow allowances. In situations where there is a need to reduce wastewater flows, water reducing fixtures are likely to already be in place, decreasing the percent water usage in the toilet and the percent water saving from composting toilet is likely to be more in the order of 15 to 18%. For the purposes of establishing a wastewater design flow volume to represent the remaining waste flow (greywater flow volume), it is appropriate that a conservative approach is taken and the lower percent reduction used.

Wherever practicable, wastewater treatment and disposal systems should be sized as if the blackwater (toilet wastewater) is also discharged into the system, should this become the case in the future. It is particularly common for new owners to wish to decommission composting systems once they experience any problems that occur from lack of adequate care and maintenance.

7.8.1.3 Greywater Treatment

As raised above, greywater from kitchen, bathrooms and laundry flows has been proven to have a significant contaminant load, including high levels of indicator bacteria and the presence of potentially disease causing microorganisms. Due to the significant contaminant levels, the design and sizing of a greywater treatment disposal system should be based on that for normal domestic wastewater. With the types of highly effective on-site wastewater treatment systems now available, it is generally more cost effective to collect and treat the black and grey wastewater flows together, particularly where there is a proposal to reuse a portion of the treated wastewater flow.

The sizing of the greywater treatment system must be in accordance with the guidelines for standard domestic wastewater treatment systems provided in Sections 7.2 to 7.4, TP58. Due to the significant greywater contamination levels, as a minimum, advanced primary treatment is required. This should involve a septic tank sized to enable adequate solids separation and with an outlet filter to prevent gross solids carryover. It is important that the septic tank(s) is sized appropriately to prevent resuspension of settled material in the event of large influent plug flows e.g. from bath or laundry discharges.

7.8.1.4 Greywater Disposal

The sizing of the greywater on-site disposal system must also be in accordance with TP58 guidelines (Sections 9 and 10). Without more than elementary primary treatment, greywater can pose a significant risk to public health. Where greywater has only had primary wastewater treatment, disposal via a form of subsurface disposal system is likely to be more appropriate than via a shallow irrigation system. Direct drip irrigation or other forms of shallow land disposal options, of grey water without further biological or secondary treatment should usually be avoided due to its potential high BOD and bacteria content, which could lead to slime growths within the emitters and uneven wastewater distribution and eventual system failure.

Where disposal via shallow drip irrigation purposes is proposed, secondary discharge quality of BOD:SS levels of 20mgO/l:30mg/l is likely to be necessary. Advanced secondary treatment is required instead of secondary treatment if there is uncertainty whether the final quality of secondary treated greywater will comply with the necessary quality limits required to ensure longterm effectiveness of the drip irrigation system.

7.8.2 Composting Systems

7.8.2.1 Composting Toilets

A composting toilet is a well ventilated container that provides an optimum environment for biological and physical decomposition of unsaturated, but moist human excrement, under sanitary controlled aerobic conditions. The primary objective of composting toilet systems is to contain, immobilise and/or destroy pathogens and to accomplish this in a manner that is consistent with good sanitation (minimum human contact or contact with disease vectors such as flies). The process should produce an inoffensive and reasonably dry end product that provides low to minimum risk if handled [Ref 11].

Composting toilets were originally commercialised in Sweden and have been an established technology internationally there for more than 30 years. They usually require little or no water and produce an essentially dry composted product, in the order of 10 to 30% its original volume for disposal [Ref 11] (providing the compost system is designed and operated properly).

Composting toilets have gone through several phases of popularity in New Zealand. While they are often perceived as an environmental approach, in contrast, many people have a less favourable view of the need for keeping, turning and emptying composted human excrement [Ref 6]. However, where an operational commitment by the owner exists, such systems can be successful in reducing household wastewater volumes. However, due to the uncertainty about the consistency of this commitment by different household users, compost systems are never appropriate in rental properties, and only in commercial or public premises, where a permanent maintenance contract is held with a contractor who will undertake frequent inspections and the required system maintenance and where caution can be assumed in the cleaning chemicals used.

7.8.2.2 The Need for Greywater Treatment

Wherever compost toilets are connected to residential dwellings, there will still be a requirement for a greywater treatment and disposal system to be installed on the site. Due to the potential for elevated faecal coliform and potential pathogen levels in greywater, it needs to be disposed of in accordance with the standards for typical domestic wastewater. Further information on greywater treatment and disposal systems is provided in Section 7.7.6 and information on greywater reuse is provided in Section 7.8.1.

7.8.2.3 Types of Composting Systems

Human excrement is mostly water with urine 98% water and faeces more than 70%, such that the actual amount of solid material being less than 50kg per person per year. Compost toilets break down solid waste material by biological decomposition. Domestic Composting systems consist of mixing solid human faecal matter, often with a bulking agent (such as sawdust or other organic material to enhance aerobic conditions and to provide a media for micro organism growth), stabilising the mixture in the presence of air, allowing biodegradation in warm moist conditions and then removal and disposal of the resulting compost material.

The composting occurs by action of natural bacteria and fungi to breakdown the organic matter in the excrement into an oxidised humus like product. The process is affected by the air heat and moisture conditions, which should be managed to optimise the process [Ref 11].

The smaller compost is often walled off from the bathroom itself but still located such that they are still easily accessible for maintenance. Other larger units can be located under or outside the dwelling.

There is a wide variation in types of systems, features and costs of toilet systems available. The most common type of composting systems for domestic use is the enclosed compost system, which is sealed to control temperature, oxygen and odour emission. In vertical reactors the materials are loaded through the top of the reactor and composted material is removed from the base. Oxygenation can be provided by forcing air up from the bottom through the composting mass and via a variety of design alternatives to this. The most common uses comprises a chamber directly adjacent to or below the toilet(s), which is enclosed except for a maintenance hatch, air admittance valve and a removal chute for access with a hand auger.

Toilets should not be installed in preference to conventional toilets unless the owner is confident that they will be appropriately used and maintained over the long term. Questions that the purchaser should ask when determining whether to install a composting toilet system, include:

- *Perceived acceptability – Are you comfortable with the system and with any guests using it? Does it look all right? Does it smell?*
- *Ease of Use – How easy is it to learn to operate the system? Does it remain awkward after regular use?*
- *Ease of Maintenance – How often is routine maintenance required? How long does maintenance take? Is it unpleasant for tedious? What special skills are necessary and are they easy to adopt?*
- *Reliability – How likely are things to go wrong with correct use? Are there weak points in the system? Can they be tolerated or easily corrected? Is there after sale service and how much is covered by the warranty?*
- *Robustness against misuse – Will things easily go wrong if the system is misused? Is it fragile or easily disturbed?*
- *Robustness of design and construction – Is it built to last? Will it weather well?*

Alternative types of toilet systems other than composting toilets that are not covered in this manual include:

- Dewatering toilets – treatment is by dehydration and pasteurisation;
- Incinerating toilets – treatment is by total combustion;
- Liquid chemical toilets – treatment is by a sterilising fluid; and
- Dry bucket toilets – limited treatment is by use a dry soak material.

7.8.2.4 Design Features of Composting Systems

The main design features of a composting toilet system include the following [Ref 11]:

- a. A dry or microflush toilet(s) discharging to a composting unit;
- b. A screened air inlet and an exhaust system or vent to remove odours and heat, water vapour, carbon dioxide and other by products of aerobic decomposition;
- c. A mechanism to provide the necessary ventilation to support the aerobic organisms in the composter;
- d. A means of draining and managing excess liquid and leachate;
- e. Process controls to optimise and facilitate management of the process; and
- f. An access door for the removal of composted material (humus).

The composting unit must be designed to separate the solid and liquid fractions and produce a stable humus material with a faecal coliform level of less than 200MPN (or CFU) per gram [Ref 11]. The compost unit can be heated using solar power or electricity to provide and maintain optimum temperatures.

Vents make a big difference to odours and fly problems and should discharge at a high point outside the building well above the highest window. The warm air around the compost rises naturally if the vent is generously sized (for a passive vent) or powered with an electric fan. The may need to be screened e.g. with a metal gauze to prevent flies and other insects. If there is no vent, the compost air will discharge via the toilet itself generating odours and attracting flies.

The main process variations are continuous or batch composting. Continuous composts are single chambers where excrement is added to the top and the composted product is removed from the bottom. Batch composts are two or more compost units that are filled then left to cure without continuous addition of new potentially contaminated excrement. There are many different methods of alternating between compost units.

The special features of composting toilet systems depend on the system type and can include dry vaults (pit privies and composting toilets), wet vaults (nonflush or lowflush systems) and a range of selfcontained toilet systems (dehydrating and incineration toilets, chemical toilets). Proprietary systems such as composting toilets and other self contained toilets systems are sized by the manufacturer to handle the design occupancy, and should be installed, operated and maintained in accordance with the manufacturer's guidelines.

United State standards governing the minimum materials, design, construction and performance of composting toilet systems is the "American National Standard/NSF International Standard ANSI/NSF 41-1998: Nonliquid Saturated Treatment Systems".

7.8.2.4 Conditions Required for Effective Composting

The predominant microorganisms that breakdown the solid waste in the compost unit are bacteria and fungi. The microorganisms require favourable *moisture content, temperature and oxygen levels*. These are the factors that have the most impact on an effective composting process and are discussed further below [Ref 11]:

- i. *Moisture Content* – Moisture enables microorganisms to hydrolyse the organic compounds by biochemical processes into simple forms for use as an energy source in metabolic processes. Moisture should be between 40 to 70% with the optimum level around 60%. Excess moisture creates low oxygen conditions and can result in foul odours. If the compost is too dry the microorganisms will die off and the composting will slow.
- ii. *Temperature* – Heat is produced during the biodegradation process and some is retained within the compost. In summer conditions, the compost may need to be mixed more often and additional moisture provided due to the elevated temperatures. In lower winter temperatures, the biodegradation process can be a lot slower and less mixing and moisture is required.
- iii. *Oxygen Level (Aeration)* – Maintaining an aerobic environment in the composting unit is the most important factor for growth of the microorganisms. Sufficient aeration assists to control the moisture content and to minimise nitrogen loss through the production of ammonia resulting in foul odours. Aeration can be improved by mechanical mixing or by adding woodchips or sawdust to the composting material. This is discussed further in (iv) below.
- iv. *Nitrogen* – The microorganisms that breakdown solid wastes require a source of nitrogen. Nitrogen is critical for biological growth and a shortage of nitrogen severely slows the composting process. For an effective composting, material should normally be blended to have a Carbon to Nitrogen ratio of 30:1 by weight. Carbon to Nitrogen levels for various forms of organic materials are in the order of the data ranges in Table 7.13.

Table 7.13: Carbon to Nitrogen Ratio in Organic Materials

Organic Material	Typical Carbon:Nitrogen Ratio (Weight to weight)*
Human Faecal Wastes	6-10
Sewage Sludge	5-16
Vegetable Wastes	11-19
Grass Clippings	9-25 (Average 17)
Leaves	40-80
Refuse (Food scraps and mixed paper)	34-80
Paper from domestic refuse	130-180
<i>Effective Compost Material</i>	<i>30-40</i>

Source: [Ref 12]

As indicated in the above table, the carbon level in human waste alone is usually insufficient for effective composting and the excess nitrogen, indicated by the low carbon:nitrogen ratio, can lead to ammonia volatilisation. To increase the carbon level in the compost material, the process can be supplemented by the addition of woodchips, sawdust, paper, food scraps or green waste to the compost. In compost units where most urine drains to the bottom and out of the solid compost material, the nitrogen levels are reduced meaning that there is a reduced need for an additional carbon source [Ref 11]. The compost system supplier/manufacturer should provide advice on the types and volume of additional carbon material that should be added, with this depending on the size and design of the unit and its level of use.

(v) *pH* – Optimum pH is between 6.5 to 7.5. While the formation of organic acids may drop the pH, other biochemical compost processes buffer this effect, so pH is not typically a concern to the user.

In an effective compost system, pathogens are impacted by waste products from the aerobic/anoxic bacteria and fungi populations, which are toxic to pathogens, and by their exposure to unfavourable conditions (this exposure is time and temperature dependent). Literature indicates that most disease causing bacteria and viruses will not survive for more than two months in wastewater and for more than four months in soils, at 20 to 30 degrees Celsius [Refs 2, 11, 12 and 13]. In effective compost systems, particularly where there is adequate heat, this survival time may be somewhat reduced.

7.8.2.5 Benefits of Composting Toilets

The key advantages of such systems are the actual or perceived environmental benefits of eliminating excrement from sewage wastewater. This can result in a less contaminated raw wastewater flow, reduced treatment requirements and in a reduction in the total wastewater volume that then needs on-site disposal.

The key advantages and disadvantages of composting toilets are summarised in Table 7.14 below:

Table 7.14: Key Advantages and Disadvantages of Compost Systems

Advantages of Composting Toilets	Disadvantages of Composting Toilets
Systems do not require water for flushing, reducing domestic water needs.	Maintenance of composting toilet systems requires more responsibility from owners and users than conventional wastewater systems.
Reduced quantity and strength of wastewater to be disposed of on-site, and the size of the land disposal system.	Removing the final product is an unpleasant job, particularly if the system is properly installed, operated or maintained.
Can be well suited at remote sites where conventional on-site systems may not be feasible, due to lack of power and/or water and due to the maintenance requirements of conventional systems.	Improper maintenance can make cleaning difficult, increased health hazards and odour problems. Poorly installed or maintained systems can lead to unprocessed material and corresponding odours.
Most have low power consumption.	Most require some power source (to assist with ventilation and/or mixing).
When self contained, they reduce the need for transportation of wastes for treatment or disposal (although the final product will need a formal method of disposal).	Must be used in conjunction with a greywater system. The wastewater system may be undersized and fail if a new house owner decides to replace the compost toilet with a conventional toilet.
The burying of composted human waste around tree roots and nonedible plants can enhance growth of surrounding vegetation.	Health risks and aesthetic issues with the handling and disposing of composted excrement.
They can accept other forms of household waste, in particular kitchen waste, reducing household refuse.	Too much liquid residual (leachate) in the system can disrupt the composting process. They need to be regularly drained and properly managed.
Providing the waste is fully biodegraded and all pathogens are destroyed in the composting process, they can reduce pathogen levels discharged to the environment.	Smaller units may have limited capacity for accepting peak or shock loads.

7.8.2.6 Risks from Use and Maintenance of Composting Systems

In a review commissioned by ARC, the major disadvantages associated with composting systems in the Auckland situation were summarised as follows [Ref 13]:

- Composted material is a hazardous waste that must be handled such that it does not pose a health risk. As such, it needs to be buried for at least twelve months before incorporation within gardens where it can be in contact with humans. There is reference in the literature to helminth (worm) egg surviving in buried compost in excess of three years, so in the case of public garden areas, compost should preferably be applied in areas where close human contact is unlikely and/or where access is restricted.
- Composting microorganisms need a regular food source to ensure continued effective biodegradation, and therefore unless the systems are located on remote sites where odours are a less of a concern, they must not be located on sites subject to irregular or intermittent use.
- Unless the correct conditions are maintained (water content, temperature) there is a high risk of odours.
- The systems require frequent regular manual maintenance but are seldom adequately maintained by owners.
- Mature compost is usually also contaminated by fresh waste, though filtration of blackwater or from untreated waste falling onto the outer section of the pile.
- Auckland Region Public Health Service advises against any direct contact with compost systems except by professional contractors or by people trained and experienced in appropriate methodologies.
- A solids disposal management plan for either on or off-site disposal is required to minimise potential for human contact with a contract with a professional waste removal contractor required for any off-site removal and disposal.

Information on risks from composting systems is available from a discussion document prepared for ARC by Roberts G. S. (2002) "Health Risk Assessment of Composting Human Waste" [Ref 13]. This report confirmed that sewage effluent and human faecal matter can contain a wide variety of pathogens, predominantly originating from the human population serviced by the compost system. (Faecal matter contains up to 10^{12} bacteria per gram with bacteria representing approximately 9% by wet weight.)

Risks from domestic composting systems are linked to exposure to pathogens from the use and/or maintenance of the compost systems and exposure to the system end product. A susceptible host may come into contact with pathogens directly by ingestion of compost particles, by inhalation of dust/aerosols or by absorption into a lesion/abrasion. A susceptible host may also come into contact with pathogens indirectly by contact with soils, vegetation or food crops contaminated by composted material or by contact with such material that has been in contact with vectors such as flies. Gastroenteritis was identified as the most common illness likely to result from exposure to human faeces or inadequately matured compost, with other diseases possible depending on the contributing human population, the effectiveness of the composting process and on fungi that grow on the surface of the compost [Ref 13].

7.8.2.7 Measures Required for Minimising & Mitigating Risks During Handling

Composting systems must be installed by professionals, sized to the capacity required and the owner must be provided with clear maintenance instructions on installation. Only people who understand the necessary maintenance requirements should operate them to ensure that the core maintenance needs are undertaken as required, in accordance with the required safety precautions further in this section. *Compost systems are not appropriate for everyone, and particularly not for those who are unfamiliar and/or unwilling to undertake the critical maintenance requirements.*

Composting systems operated and maintained on a private single dwelling ultimately requires the owner to use their own discretion to minimise their exposure to any health risks. To mitigate some of the risks identified above, owners need to take significant care when carrying out any maintenance. Where there is any uncertainty concerning the correct maintenance and compost disposal procedures, owners need to enter into a maintenance contract with an authorised contractor for the off-site removal of the material or arrange for it to be buried for at least twelve months, subject to adequate separation from ground water (refer Chapter 5).

Composted humus material from composting toilets needs to be handled much more cautiously than 'ordinary' garden compost. It should be buried for approximately 12 months before further handling or distribution in a garden. It can then be mixed with soil or other materials, but shouldn't be used anywhere near food crops or areas where there is ready access by people, especially children [Ref 42]. Compost is best used mixed into the soils as a soil amendment, not a mulch and nor a fertilizer. It can improve the drainage and aeration of clay soils if mixed with plant wastes.

Following is a list of precautionary measures required for the minimisation of risks associated with maintenance of composting systems and/or contact with composted material [Ref 13]:

- i. Reduce Pathogen Content in the Waste
 - Assume all waste is hazardous and accordingly treated with caution.
 - Maintain the Compost at 55 degrees for 3 days in a static pile or buried for 12 months prior to contact with land surface OR have the compost removed by a licensed waste removal contractor.
 - Restrict use of composting toilet systems for public facilities if viable alternatives exist, unless remote from electricity and/or water supplies and professional maintenance procedures are in place.
 - Discourage use of public composting toilets in the event of a disease outbreak.
 - Organic material should be air dried to 75% solids to meet vector attraction reduction requirements.

(Note: Roberts referred to mechanical or windrowing processes [Ref 13]. However, such practices for on-site systems are discouraged by ARPHS in light of the resulting increased health risk [Ref 42]. Such practices would be more appropriate for municipal scale composts, where the process is professionally managed. ARC requires that the handling and disposal of any composted material, particularly if sourced from off-site, discharge onto land surface be subject to a resource consent in accordance with ARC regional rules for application of sewage solids to land. At the time of printing, the relevant rules are covered in ARC Proposed Regional Plan: Air Land and Water, decision version 2004.)

- ii. Reduce Risk of Inhalation:
 - Wear protective clothing whenever handling the compost unit or its materials. A face mask and ideally goggles should also be worn during all maintenance actions.
 - Disposal of waste should only be undertaken in areas where public access is restricted.
 - Organic material should be turned frequently to minimise fungal growth.
- iii. Reduce Risk of Ingestion
 - Bury compost for at least 12 months to a minimum depth of 150mm and in an area where it will not be in contact with any consumable plants for surface waters, prior to its use for soil amendment.
 - Restrict access by children to any areas containing compost.
 - Maintain immunisation of all waste removal contractors and any persons undertaking maintenance on public facilities.
- iv. Reduce Risk of Abrasion
 - Wear protective clothing, including thick gloves and appropriate footwear at all times during maintenance and disposal.
 - Wash all protective clothing or handling equipment cautiously, and disinfect gloves after use.

Other more general maintenance requirements include:

- v. Caution with the cleaning agents used near and/or discharged into the compost toilet unit, in accordance with the system supplier/manufacturer's instructions.
- vi. Periodic mixing of the compost material, in accordance with the system supplier/manufacturer's instructions, unless a mixing mechanism is otherwise provided through the design of the system. This is most important for continuous single chamber systems, where new material may mix randomly with composted material.
- vii. Regular addition of organic bulking agents for a carbon source and to enhance porous conditions for air distribution in accordance with the system supplier/manufacturer's instructions. (This is discussed further in Section 7.8.2.4 iv.)
- viii. In cooler winter conditions, heating of the compost unit may be required to levels specified by the manufacturer.
- ix. Regular removal of composted end product in accordance with the system supplier/manufacturer's instructions (likely to be anything from three monthly to two yearly).

Other general design precautions include:

- x. Wherever practicable, the main on-site wastewater treatment and disposal system should also be sized as if the blackwater (toilet wastewater) is also discharged into the main system, should this become necessary in the future, such as in the event the current or new owners choose to replace the composting unit with a conventional toilet.
- xi. Wherever the design wastewater flows are reduced due to the inclusion of a composting toilet (so that the wastewater flow consists predominantly of greywater), the disposal system reserve allocation must be increased by an additional 40-50%. (This is covered further in Section 7.8.2.8.)

If proper effective composting has taken place, the end product should be inoffensive and relatively "safe" to handle [Ref 11], but precautions are always necessary due to uncertainty concerning the potential for poorly composted pockets to be present within the humus material.

Where a homeowner is not prepared to undertake the necessary maintenance requirements on a regular basis, as specified by the system supplier/manufacturer and in conjunction with the relevant safety precautions, they should either decommission and replace the composting toilet or enter into a maintenance contract with a professional system maintenance contractor. The maintenance contract should require that regular maintenance be undertaken at the frequency recommended by the manufacturer. Should the owner choose to completely decommission the system, they should arrange for the toilet wastewater to be combined into the on-site disposal system (following approval for any modifications to increase the wastewater system capacity from the relevant local authority). Until the on-site system has been appropriately upgraded, they should arrange for all waste to be collected and disposed off-site by commercial waste removal contractors.

7.8.2.8 ARC Regulations for On-site Composting Toilets

Wherever the design wastewater flows are reduced due to the inclusion of a composting toilet (so that the wastewater flow consists predominantly of greywater), the disposal system reserve allocation must be increased by an additional 40 to 50%. This is necessary to ensure that the wastewater system can accommodate the full potential wastewater flow volume that could be generated on the site should the composting toilet be decommissioned in future. This requirement is also specified in the Notes within Table 5.3. Where this full reserve allocation is not available, the wastewater system will not comply with TP58 design criteria and the system will require a Controlled or a Discretionary consent from ARC.

7.8.3 Alternative Treatment – Vermiculture Processing

7.8.3.1 Design Features of Vermiculture Systems

Several proprietary vermiculture systems are available on the market, each incorporating slightly differing design concepts. These include essentially dry systems that process faeces only, others that process all the black wastewater flow or the total domestic wastewater flow. The use of a vermiculture system does not remove the requirement for standard treatment of the liquid wastewater (black and greywater), to an adequate standard for discharge to a land disposal system, in accordance with these guidelines (refer Section 7.8.1). The requirement for a standard on-site treatment and disposal system as well as the vermiculture system, often renders the addition of a vermiculture system less cost effective.

The blackwater processing unit handles toilet solid wastes and can be installed to service a new dwelling or retrofitted to existing dwellings. Waste flow from the flush toilet is directed onto a bed of organic mulch or bark, which filters out the organic waste and toilet paper, allowing the resident worm population to degrade the waste. The unit has a compartmented tank to which flows must be manually directed on an alternating basis to provide filtering and maturing cycles in order to ensure worm populations are maintained and protected against “drowning”. The liquid stream from the unit is directed to the septic tank, which also collects the greywater from the dwelling. The removal of toilet solids thus reduces the rate at which sludge and scum builds up in the septic tank. Mature solids are removed from the unit in accordance with a maintenance schedule as recommended by the manufacturer/installer.

The ‘all waste’ processing units can be similar in size to a septic tank, and incorporate a prepared bed of filter media and mulch/compost above a drainage collection system in the base. Wastewater flows from the dwelling discharge onto the accumulating mass of organic solid material building up on the bed of the unit, with the filtered liquid being collected and discharged by pump or gravity (as required) to either further treatment or direct to a land disposal system. The filtered solids material is seeded with worms that generate humus and worm castings. The liquid flow from a vermiculture

system is considered equivalent to advanced primary treated wastewater and needs to be disposed of according to relevant guidelines above and regulations

7.8.3.2 Maintenance Requirements of Vermiculture Systems

In all cases to be effective a worm population needs to be protected from harmful chemicals and supplied with a regular food source. In a number of cases in the Auckland region, the worm populations have proved to be too sensitive to maintain on a sustainable level and the systems have become virtually ineffective. As a minimum, vermiculture systems should only be considered for use in situations or at residential facilities, where the occupancy or usage is stable and where public access to toilet facilities is restricted. This is due to the need for regular influent flows to be maintained within the capacity of the worm population, risks to the system from harmful chemicals or other substances to be discharged into it where there are a large number of people using a facility and the need for there to be routine contact with the solid material that builds up in the system.

Household organic wastes and paper can be added to the unit in limited quantities according to the manufacturer's instructions, via a garbage chute to provide diversity in food source for the worm population. Mature waste matter is removed periodically by auger from the centre of the degrading pile of solid material. The system provides a twin wastewater and garbage servicing alternative to the septic tank.

Since worm casts are not heat treated during the biodegradation process it must be assumed that the pathogen content is higher than that of composted material. There is no available data (published or from suppliers) to suggest otherwise. As such, the solids phase should be handled as a hazardous substance and treated in *at least* the same manner as compost (as discussed with regard to maintenance of Compost Systems in Section 7.8.2), unless it has been tested and certified to comply with current public health guidelines for safe reuse.

There still remains a public health risk and potential for direct contact with waste when composted and partially composted solid material is removed for burial. All the risks covered in Section 7.8.2.6 also apply to vermiculture systems.

Because maintenance of vermiculture units involves solids removal processes that may bring personnel into contact with fresh or partially degraded waste material, special handling measures and precautions should be part of the management process. The appropriate precautionary measures for minimising any risks from composting toilets in Section 7.8.2.7, also apply equally to maintenance of vermiculture systems. The remaining greywater component must also be treated in the same manner as an all waste treatment and disposal system.

As specified for generic composting systems, it is important that vermicomposting systems are only installed by professionals and only operated and/or owned by people who understand and will comply with the maintenance requirements, will ensure these are undertaken in accordance with the required safety precautions above. Auckland Region Public Health Services (ARPHS) have expressed concern with the need for the system owner to undertake routine handling of solids material from vermiculture systems. Again, it is recommended that the solids material be collected by a commercial waste collection contractor who can dispose of it off the site in an authorised manner.

7.8.3.3 ARC Regulations for On-site Vermiculture Toilets

In accordance with the requirements for more generic composting toilets in Section 7.8.3.2, wherever the design wastewater flows are reduced due to the inclusion of a composting toilet (so that the wastewater flow consists predominantly of greywater), the disposal system reserve allocation must be increased by an additional 40-50%. This is necessary to ensure that the wastewater system can

accommodate the full potential wastewater flow volume that could be generated on the site should the composting toilet be decommissioned in future. This requirement is also specified in the Notes within Table 5.3. Where this full reserve allocation is not available, the wastewater system will not comply with TP58 design criteria and the system will require a Controlled or a Discretionary consent from ARC.

7.8.4 Peat Bed Treatment

7.8.4.1 General

The use of peat bed systems as a means of secondary treatment of septic tank effluent has been utilised in the US since the 1980s, with commercial systems becoming available during the 1990s. An Australian household pilot plant achieved significant reductions in suspended solids, BOD₅, nitrogen, phosphorus and faecal coliforms with minimal maintenance. Design criteria for and performance results for the pilot plant have been published [Ref 28]. Eventually phosphorous saturation of the peat occurred, although the lack of continuous monitoring prevented the defining of an absorption life or capacity for the bed system. The effluent quality is suitable for land application and re-use of water for landscape enhancement via drip irrigation.

Initial trials established that an Australian reed sedge peat and a New Zealand sphagnum moss peat achieved equivalent performance, and the pilot system was subsequently installed with reed sedge peat. However, a sphagnum moss peat bed treatment unit is also known to be working well. Design criteria for and performance results for the pilot plant have been published [Ref 27].

7.8.4.2 Peat bed design and operation

No design rules for peat bed treatment systems are presented in this edition of this manual. Specialist design services should be engaged to implement peat bed systems. Although a minimal maintenance requirement has been found to be an attribute in the Australian pilot peat bed system, it is recommended that experienced supervision be maintained under an operation and maintenance contract to ensure that performance is assured on a seasonal basis. Hence system users should expect significant monitoring and reporting requirements to demonstrate design assertions.

Due to the uncertainty concerning specific recommended design criteria, potential environmental effects and risks to public health from constructed peat bed systems, any proposal to construct a peat bed system within the Auckland area will require a discharge consent.

7.8.5 Constructed Wetland Treatment

7.8.5.1 General

Natural wetlands have been used for wastewater treatment for much of the last century. Research on the use of constructed or artificial wetlands for wastewater treatment began in Europe in the 1950's. Constructed wetlands are artificial wastewater treatment systems that consist of shallow or submerged ponds or channels (less than 1m deep), which are planted with aquatic plants, and which rely on natural microbiological, physical and chemical processes to treat and break down contaminants in wastewater. They are typically lined with impervious clay or synthetic liners and should be engineered to control the flow direction, water level and retention time in the wetland. To facilitate even water flow, they usually contain a porous media such as rock, gravel or sand.

In New Zealand, constructed wetlands have often been used following oxidation pond treatment and prior to discharge to water in small scale municipal treatment plants. They are seldom used for on-

site domestic applications, in comparison to standard septic tanks and other secondary treatment systems (discharging to land disposal).

Problems with wetlands can include difficulties maintaining even flow through the wetland, difficulties maintaining vegetation in extreme conditions and difficulties ensuring consistent water depth and even flow for optimum plant growth and thus wetland performance. Where they are poorly designed and/or significantly undersized for the influent strength and/or flow, monitoring data shows that they can severely compromise final effluent quality, with the anaerobic conditions leading to decreased dissolved oxygen levels and increased ammonia concentrations. (These effects increase toxicity of the discharge to aquatic life where the wastewater is then discharged into natural water).

Guidelines used in the United States for designing wetlands are provided in the USEPA "Manual for Constructed Wetlands – Treatment of Municipal Wastewater" [Ref 15]. The USEPA Manual (part 1.6) introduces a number of misconceptions concerning the design and performance of wetlands, which raise doubts concerning their application and design and performance. The misconceptions discussed involve uncertainty concerning characterisation of complexities in wetland systems and lack of useful or representative design data, that wetlands actually provide insignificant aerobic treatment from oxygen leached from plant roots compare to likely oxygen demand in wastewater applied at practical loading rates, that wetlands do not provide significant nutrient (nitrogen and phosphorus) reduction. The USEPA Manual proceeds to describe design construction startup and operational issues. It further acknowledges the insufficient data available but applies what data it considers to be of adequate quality to set design details for wetland systems with practical limits on their potential performance capabilities.

7. 8.5.2 Types of Wetlands

Constructed wetlands are believed by some designers to be a viable option for providing improved treatment to primary treated wastewater or for providing further polishing of secondary treated wastewater. All wastewater discharging into constructed wetlands should at least have prior primary treatment via a septic tank with outlet filter (detailed further in Section 7.2 above), with the wetland serving to further treat the primary treated wastewater prior to discharge to a land disposal system. The latter type, which enhance the polishing of treated wastewater, tend to require significantly less land area, as they can receive wastewater at a much greater application rate per square metre. The type of land disposal system will need to be designed in accordance with TP58 criteria with consideration of the site constraints (refer to Chapters 5, 9 and 10).

Wetlands for wastewater secondary treatment comprise two types:

- Surface flow treatment wetland (SFW);
- Subsurface flow treatment wetland (SSFW).

Surface flow wetland (SFW) systems comprise shallow open ponds planted with emergent species of wetland plants rooted in the bottom soils of the pond. In some cases the pond surface area may be fully covered with emergent plants; in other situations, open water spaces may exist between clumps of emergent plants.

Subsurface flow wetland (SSFW) systems comprise one or more shallow beds of uniformly graded granular media up to 600 mm depth, with wetland plants rooted within the media. Horizontal flow wetlands pass effluent through the media from one end of the wetland bed to the other below the media surface. SSFW systems are the more commonly utilised systems for individual household or institutional wastewater servicing applications. Treated effluent discharge from all wetland systems must still be managed by an appropriate land disposal system. Vertical flow wetlands pass flow through the granular media either in free draining down flow configuration for collection in an under

drainage system (rather like a planted filter bed) or in a submerged upflow configuration with decant just below the media surface (rather like a planted upflow filter bed).

7. 8.5.3 Wetland Design

The siting, sizing and wetland plants selection process will be specific to the locality, the facility to be served, and to the type of wetland system to be provided and so specialist advice should be sought. The wetland, and the land disposal system, are all part of an integrated system and as such, their design needs to be undertaken by or in conjunction with a consultant that is with good level of experience in successful wetland system design, construction and operation

Crites [Ref 2] notes that design of wetland systems often is based on assumptions of ideal plug flow but unfortunately in reality, conditions for plug flow seldom exist and instead nonideal preferential flow paths develop. It provides methodology for determining the impact of nonideal flow on the performance of an otherwise assumed plug flow reactor.

Crites also provides methodologies for calculating constructed wetland treatment kinetics and effluent quality variability:

- Constituent Removal and Transformation Mechanisms;
- Process Design Considerations (based on detention time, organic loading rate, hydraulic flows, bed dimensions, vegetation harvesting and in the case of SSFW wetlands, media type and depth);
- Detention time for nitrogen removal;
- Loading Rates for phosphorus removal;
- Modelling the removal of key parameters (BOD, TSS);
- The impact of detention time on observed BOD and TSS removal rate constants;
- Effects of Temperature on BOD, TSS and nitrogen removal;
- Impact of vegetation Decay; and
- Composition of Effluent BOD.

It further provides advice concerning the following key physical features:

- Inlet and outlet structures;
- Recirculation; and
- Liners.

Process design procedures for SSFW wetlands list the following steps:

- Determine the limiting effluent parameter removal requirements (for BOD, TSS and Nitrogen) with an allowance for plant decay concentrations;
- Determine detention time;
- Calculate the required area for nitrogen/ammonia removal;
- Determine the bed area based on the detention time required assuming worst case conditions then increase the area by a 15 to 25% safety factor;
- Calculate the cross sectional area needed to hydraulically accept the flow and determine the width required by dividing the area by the required depth; and
- Determine the length necessary to achieve the required bed surface area.

7. 8.5.4 Wetland Planting

The correct plants are crucial for the proper functioning of SFW wetland systems. SSFW wetlands can function without plants but most studies have shown that appropriate planting can significantly enhance treatment (pathogen and nutrient removal) [Ref 16]. Plants provide the physical media to promote settling and growth of biofilms, assimilation of nutrients, a source of organic carbon for denitrification, dispersion of flows and other physical effects that enhance wetland qualities.

Expert advice is often necessary for determining appropriate plant species in constructed wetlands. Plant species should be chosen on the basis that they can [Ref 16]:

- Tolerate local environmental conditions;
- Tolerate proposed wastewater strength and have a high contaminant removal capacity;
- Establish and proliferate easily to the extent required;
- Reasonable resistance to weed invasion; and
- Not pose a significant weed risk in the surrounding environment/catchment.

A summary article by Mr Chris C Tanner in *Water and Wastes in New Zealand* (Nov 2000), provides representative lists of key constructed wetland plant species, supplementary wetland species and weed species to avoid, in the New Zealand context. The article also provides advice on planting, plant establishment and aftercare. Direct reference is made to Tanner et al [Ref 16], amongst other literature sources. Further information on wetland planting preparation and native water tolerant plants is also provided in ARC Wetland Fact Sheets nos. 1 and 2., although these are more focused on restoration of natural wetlands than on high nutrient tolerant plants for constructed wetlands and in TP58 Appendix G.

7. 8.5.5 On-site Wetland Systems

Small scale on-site constructed subsurface wetland systems are available for used on-site systems have been developed for the New Zealand situation. One brand used in the Auckland region for on-site systems, reportedly proven in Europe, involves 600mm graduating porous media from fine sand to scoria above an impermeable liner. Evidently stage one of the planted wetland design involves solids removal and stage two enhances removal of nutrients and pathogens. The reported advantages of these systems include the decrease in wastewater volume by evapotranspiration through the treatment process. This advantage is likely to be severely reduced in winter and lost in wet weather where stormwater also collects in the treatment system, as it does in a sand filter system. There are no precise design sizing, planting or performance specifications or knowledge of longterm maintenance requirements available for inclusion in TP58. At the time of writing, in the Auckland region, these on-site wetland systems are only approved on a case by case basis through the consent process.

7. 8.5.6 Wetland Operation

Once installed, wetland systems will also require experienced supervision under an operation and maintenance contract to ensure that optimum wetland performance is maintained on a seasonal basis. Maintenance and reporting is an expected requirement to demonstrate design assertions.

The design, installation and operation criteria for Wetland wastewater treatment systems are outside the scope of TP58. As raised above, due to uncertainty concerning characterisation of complexities in wetland systems and lack of useful, representative clear design specifications for on-site scale wetland systems in New Zealand, and the corresponding potential risks in the event of inappropriate designs, all wetland system design proposals in the Auckland region will require assessment on a

case by case basis, via the ARC consent process. Where design uncertainties can be addressed, risks of human contact are mitigated and there is a commitment to maintenance by the system owner, they will not be discouraged. However, in all cases where there is potential for surfacing of wastewater and/or discharge into or near natural water, consultation will be required with the Medical Officer of Health.

Unless specific wetland design criteria (in terms of wetland sizing, layout, profile, planting density and species) has been proven by robust on going monitoring criteria for similar strength wastewater with a comparable flow regime, in the absence of sufficient design specifications in TP58, close regard should be had to reputed literature concerning wetland system design (including that above or better). Consents should require regular monitoring for wetland key performance indicators, particularly where doubt remains concerning actual performance standards that will be achieved. Crites [Ref 2] suggests monitoring indicators include influent and effluent DO, BOD, TSS, Temperature, Nutrients, Metals, Bacteria (depending on the receiving environment) and others. Monitoring of sediments and vegetation should also be considered. Vegetation monitoring should include extent of plant coverage, identification of plant and weed species and regular recording of plant health.

7.8.6 Oxidation Ponds

Lagoons for individual households are rarely applicable for on-site treatment for single households, but there may be rare cases where a designer may consider them to be appropriate for institutional and commercial facilities. Specialist design advice will be required to size both the treatment system and the land disposal system to accommodate both the treated effluent and accumulated rainfall. The use of ponds is not encouraged as they can present odour, operational and hydraulic disposal problems, in addition to real health risks. In the case of small scale systems, where alternative disposal options would otherwise exist, discharge to water is most unlikely to be favoured by regulators, Tangata Whenua or the general public.

The design, installation and operation of oxidation ponds for wastewater treatment is outside the scope of TP58 so any proposal including the use of ponds in the Auckland region will require an ARC discharge consent and in all cases, consultation with the Medical Officer of Health.

7.8.7 Holding Tanks – On-Site Storage Prior to Off-site Disposal

Wastewater storage or holding tanks can be useful in situations without electric power supply and where the treated wastewater needs to be pumped to the land disposal system. In such circumstances the pump may be driven by an electric generator powered motor or directly by an internal combustion engine. It is not appropriate under these circumstances to use a low capacity pump with automatic level controls to pump on demand and rather it is preferable to restrict the period power is required to a short period each day. A 24 hour holding tank can follow the treatment unit, and this is then pumped out in the evenings when the generator is in use, or alternatively by starting up the internal combustion engine driven pump at a fixed time each day.

Wastewater storage or holding tanks can also be a last resort solution in an attempt to remedy a failed on-site system. Such a tank can be provided as a temporary measure until an off-site servicing solution is implemented. It would normally be far too expensive to depend a holding tank and regular pump outs for on off-site removal and therefore in most situations, a holding tank and is not considered to be a viable longterm solution. The only situation where they have proven viable in the Auckland region is in intensive existing commercial areas, where there is insufficient land for complete on-site wastewater disposal and yet the scale of the business is such that off-site disposal becomes an economic option.

In the Auckland region, local authority District Plans usually require that sites in nonreticulated areas, have an appropriately sized on-site wastewater disposal system to accommodate all the wastewater generated on the site, with the design discharge volume conservatively established based on peak flow predictions in accordance with TP58 (refer Chapter 6). Approval is also likely to be required from the local Council for any proposal to rely on off-site disposal. Rather than depend on off-site disposal, it is normal that any new development is instead required to be reduced in size to ensure that there is capacity on the site for the peak predicted wastewater volume. As such, reliance on off-site disposal only becomes a viable option in emergency situations for existing developments where there are no viable alternatives.

Any proposal requiring on going complete dependence on off-site disposal is outside the scope of TP58 and should be referred to the local Council and to the Medical Officer of Health.

Where required to handle full household wastewater flows the holding tank should be sized to provide a minimum of 7 days storage, although this can depend on the availability and capacity per load of the pumpout service. Installation of full water saving devices should also be provided (i.e. restricted/reduced flush water closet, spray faucets, showerhead restrictors, suds saver washing machines) wherever there is reliance on holding tanks in order to reduce the daily volume to be disposed of. The tank must be fitted with a high level alarm system set at such a level as to provide two full days extra reserve storage. The unit should be located for easy access via pump out vehicle, should have no overflow, and be designed and sited so that when empty, flotation due to high groundwater levels does not occur (Figure 7.7). Logistically it is often difficult to dispose of large volumes of wastewater off-site and it is particularly difficult rely on on going tank pumpouts without this also leading to a corresponding risk of tank overflow in the event of any delay.

Figure 7.7: Holding Tank

