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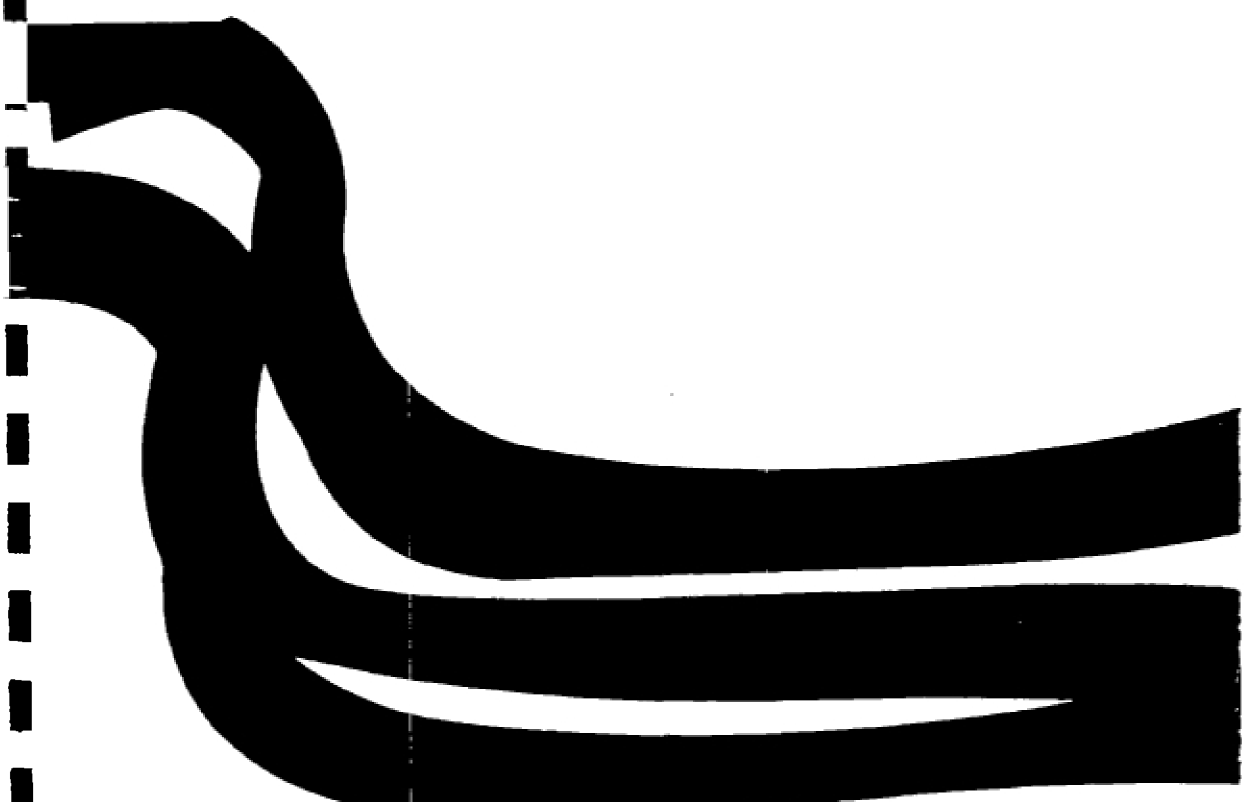
Department of Primary Industries and Energy

Low Cost Sewerage Options Study



Australian Water Resources Council
Water Management Se

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

AUSTRALIAN WATER RESOURCES COUNCIL
Water Management Series No. 14

LOW COST SEWERAGE OPTIONS STUDY

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AUSTRALIAN WATER RESOURCES COUNCIL

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The Water Management Series presents reports of Australian Water Resources Council committees and working groups. Inquiries concerning AWRC publications should be directed to the Department of Primary Industries and Energy, Canberra.

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Information on other documents dealing with the same or similar matters as this publication can be obtained by searching the STREAMLINE database using similar descriptors.

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PREFACE

This report discusses several waterborne low cost sewerage options that are available to small towns and communities which do not have adequate facilities for the disposal of domestic sewage and cannot afford the cost of a conventional sewerage reticulation scheme. Circumstances specific to each location will dictate which are the most appropriate options. Guidelines to assist in the identification of those options are included.

This report is aimed at towns which have an adequate water supply and for which waterborne sewerage systems are appropriate. In arid areas with insufficient water to operate waterborne sewerage systems, other 'waterless' options will need to be considered, including pit and vault latrines and aquaprivies. However, these waterless systems are not considered in detail in this report. Nevertheless, references to publications dealing with these systems are given.

Preparation of the report was undertaken by the consultants, Binnie & Partners Pty Ltd, arranged by the Department of Water Resources, Victoria acting on behalf of the Australian Water Resources Council. The study was undertaken under the guidance of a Steering Committee which included members of relevant water authorities from each Australian State.

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ACKNOWLEDGMENTS

Preparation of this report has been arranged by the Department of Water Resources, Victoria acting on behalf of the Australian Water Resources Council (AWRC). The study was financed partly by AWRC and partly by the water authorities represented on the Steering Committee.

Many individuals have contributed to the preparation of this report and their assistance is acknowledged. Of particular note is the help received from the members of the Steering Committee who not only assembled information relating to alternative sewerage activities in each of their States, but who also guided the study and reviewed drafts of the report to ensure that the outcome addressed the real needs of small Australian towns and communities. The Water Technology Committee of the AWRC also reviewed the preliminary draft of the report and submitted valuable comments.

SYNOPSIS

There is a need to upgrade existing domestic wastewater disposal practices in many of the smaller towns and communities of Australia. Conventional gravity sewerage has been considered till now as the solution. However, the costs associated with a conventional system can place considerable strains on available financial resources.

This report identifies eight alternative sewerage systems which may be more economical than conventional sewerage, but which can nevertheless provide adequate protection of public health and the environment. The alternative sewerage systems discussed in this report are :

1. On-site treatment and disposal
2. Modified drainage
3. Septic tank effluent pumping
4. Variable grade gravity sewers
5. Common effluent disposal schemes
6. Grinder pumps
7. Vacuum sewers
8. Modified conventional sewerage

In addition, the report discusses several low cost treatment systems which may be considered for use with small town sewerage systems. These include (1) lagoons or ponds, (2) oxidation ditches, (3) package treatment plants and (4) wetlands treatment systems.

The advantages and disadvantages of each are discussed, and guidelines are given to identify the conditions under which they would be most suitable. Indicative construction and operating costs are also presented.

A selection questionnaire has been developed to assist in the identification of the most appropriate options for a town or community. The use of the questionnaire is illustrated in a case study for the Victorian town of Port Campbell, where it is shown that significant cost savings could possibly be obtained by construction of an alternative sewerage scheme rather than a conventional gravity reticulation system.

The questionnaire and guidelines given in the report are only a broad first step tool aimed at identifying the apparently most economical alternatives to a conventional sewerage scheme for a small town or community. Considerably more work then needs to be carried out to confirm that the preferred option selected in the first step is feasible, economically attractive, and acceptable to the community and the relevant authorities.

Successful implementation of alternative sewerage systems will probably need changes to existing institutional and financial arrangements. The alternative systems generally rely more heavily on increased on-site components and reduced common or public works. To ensure reliability of performance of the on-site components, it may be necessary to resort to management systems which place the responsibility for operation and maintenance for the whole system, including works on private property, with the servicing authority. Also, consideration should be given to allow approved alternative schemes to be eligible for subsidy or other government assistance on at least an equal footing to conventional sewerage.

Finally, there is a need to formalise specific Australian design criteria for some of the options identified in this study, and to institute a well structured educational program to alert water authorities and the public to the potential for reducing costs by adoption of alternative sewerage schemes.

1. INTRODUCTION

1.1 Background

There are several hundred small towns and communities in Australia that do not have a satisfactory domestic wastewater disposal system. The majority of these small towns already are served by on-site septic tank-soil absorption systems (ST/SAS), but frequently these systems are inadequate due either to inappropriate design and construction features or poor operation and lack of proper maintenance. In some cases, the homes have only a toilet waste ST/SAS but lack a treatment and disposal system for sullage, which is discharged directly to street stormwater drains (sometimes open drains). In a few instances, villages are served predominantly by pan systems or latrines.

The situation described above threatens public health and can have adverse environmental implications including offensive odours, unsightly conditions and pollution of natural water bodies which receive the partially treated or untreated wastewaters.

Now that the major cities and towns in Australia have been provided with sewerage systems, attention is being focused on the more isolated and smaller, lower density, unsewered urban developments with a view to minimising existing health risks and adverse environmental impacts. The traditional approach, and the one generally expected by communities, has been to provide conventional gravity reticulation systems similar to those used in the larger metropolitan areas. The conventional systems have been selected because they provide a high level of service. The wastewaters produced in a premise rapidly leave the site and enter the off-site reticulation system which is the responsibility of the relevant sewerage authority. There is no involvement by residents in this process, unless on-site system blockages occur for which the owner is responsible (e.g. root intrusion, pipe breakages, pipe blockages). Threats to public health are minimised, and the environment generally is protected by the treatment and disposal system which is usually provided at the downstream end of the collection system.

There is little doubt that existing domestic wastewater disposal practices in many of the smaller towns and communities need to be upgraded, but the traditional approach of providing a conventional sewerage system with the highest level of service needs to be reconsidered. Because the economiesof scale that can be obtained with a large sewerage system serving medium to high density metropolitan centres cannot be obtained in smaller, lower density and often isolated urban developments, unit costs (i.e. cost per premise) of smaller conventional sewerage systems can be high, sometimes more than twice the unit costs of larger systems. The higher unit costs can place considerable strain on the financial resources available to those communities.

There are several options lying between the existing unacceptable domestic wastewater disposal practices and the conventional reticulated gravity sewerage systems. The options provide modified levels of service, in that some of the responsibilities for operation and maintenance of the systemare passed to the owner/occupiers of the premises being served. However, the options can provide adequate protection of health and can adequately safeguard the environment.

These modified levels of service can be provided by alternative sewerage systems at a lower total cost to the community (i.e. 'you get what you pay for'). Therefore, providing the owner/occupiers are prepared to accept those levels of service, their increased responsibilities, and possibly personal costs depending on how the system is financed, substantial cost savings to the public authority can sometimes be made. These options should therefore be considered for the upgrading of existing domestic wastewater disposal facilities in any town.

A considerable amount of work has already been carried out in Australia and overseas with alternative sewerage systems. Unfortunately, much of the Australian work has not been publicised, and there has been considerable duplication of effort. There are no comprehensive guidelines in existence in Australia which can assist in the process of identifying alternative lower cost solutions to existing unsatisfactory domestic wastewater disposal arrangements.

Preparation of this report is the first step toward the identification and co-ordination of the work already undertaken and the preparation of guidelines that will assist in the selection of alternative low cost sewerage systems for small Australian communities.

1.2 Objectives

The objectives of the study are included in the brief prepared for this study, a copy of which is included in Appendix A, and are as follows:

(i) to undertake a comprehensive review of the available information relating to alternative approaches to collection, treatment and disposal of domestic sewage and sullage;

(ii) to prepare an overview of the state of present technology of alternative sewerage systems;

(iii) to prepare guidelines to assist in selection of the most appropriate technology for the sewering of small communities; and

(iv) to identify any perceived deficiencies in present technology and make recommendations for further specific research if considered necessary.

2. SEWERAGE OPTIONS FOR AUSTRALIAN TOWNS

This chapter identifies the alternatives to conventional sewerage practice that should be considered when evaluating options for upgrading the sewerage systems of existing towns. Detailed descriptions and discussions of the systems identified are given in the subsequent chapters.

2.1 Appropriate Technology for Australia. Waterborne vs Waterless

There is a very broad range of systems that can be used for the disposal of domestic wastewaters, from the basic pan system to the conventional reticulated sewerage system. Some use very small quantities of water and some use relatively large volumes of water as the carrier of the wastes.

The low water use systems, referred to in the literature as 'waterless' systems, are in widespread use in developing countries which often have inadequate water supplies. These systems include pans, pit latrines, pour-flush toilets, aquaprivies and double vault composting toilets. Pan systems involve direct discharge of toilet wastes to a collection pan located underneath the toilet seat or squatting plate. When full, the pan is removed and emptied. Pit latrines use the same principle, except that the wastes are discharged to a below ground pit where they are stored until the pit is filled. The toilet is then relocated. These systems in Australia are also referred to as long drop vault latrines. An improvement to the basic pit latrine involves adding an external vent, and this arrangment is referred to as a ventilated improved pit (VIP) latrine. Pour-flush toilets use a water seal in the discharge pipe to the pit, rather than direct discharge, and the wastes are flushed by manually pouring a suitable quantity of water into the toilet bowl. Aquaprivies employ direct discharge via a drop pipe into a septic tank soil absorption system; the drop pipe terminates below the water surface in the tank, to form a simple water seal to minimise odour and insect nuisances. A double vault composting toilet is a batch composting unit in which the vaults are alternately used and then left to compost.

The decade 1981 - 1990 has been declared by the United Nations as the International Drinking Water Supply and Sanitation Decade, and the World Bank and the Asian Development Bank have recently funded much research and development work that has resulted in improved sanitation in developing countries using the waterless systems. Other waterless systems include the incinerator toilet and chemical toilet.

In modern day Australia, however, there is generally little scope for use of the low cost waterless systems except in isolated outback communities with severe water shortages, in some remote National Park amenities, and in other special circumstances. Most of Australia's population already has an adequate water supply system, be it a reticulated town water supply, a groundwater supply or a rainwater supply, and most are served by a waterborne sewerage system.

The major thrust of this review is the identification of options for the provision of improved domestic wastewater disposal facilities for existing small towns and communities. The majority of these towns are served already by a septic tank system, at least for toilet wastes. The expectation of most residents would be to remain on a waterborne system, and conversion to a waterless system would be considered a retrograde step which would not be widely accepted. It would therefore be inappropriate to consider anything other than a waterborne sewerage system for widespread use in Australian towns and communities.

Deletion of waterless systems from consideration for widespread use in towns and communities does not mean that these systems are considered unacceptable per se. They all have merit in that they conserve water and therefore can be attractive in specific and special situations. Vault latrines and ventilated improved pit (VIP) latrines are used in towns with inadequate water supplies. Composting toilets have and are being used successfully, but generally by individuals who have an interest in recycling the waste and the required dedication to operate the system acceptably. Chemical toilets are used successfully on construction sites and in some homes. Some incinerator toilets have been installed in Australian homes but they have not been popular.

2.2 Criteria for Consideration of Alternative Systems

The four overriding criteria governing the appropriateness of alternative sewerage systems for Australian towns are as follows :

- they should provide cost savings when compared to conventional sewerage systems
- they should provide adequate protection of public health
- they should provide acceptable protection of the environment
- they should be acceptable to the community (which implies generally that they should be waterborne systems).

In addition, there are several other criteria which need to be taken into account. The systems should be reliable and relatively simple to operate. Highly mechanised systems or systems that require a high level of operator attention would not normally be appropriate for small towns, particularly remote ones. They should be flexible, particularly regarding future development of the community, but also in terms of catering for seasonal influxes of tourists. It would seem inappropriate to construct expensive community sewerage systems if the future of the town is in question or significant population decreases are likely to occur. On the other hand, small towns which are expecting significant population growth, or even proposed new towns (e.g. satellite villages or townships surrounding large towns providing high levels of employment) may be well advised to plan ahead to avoid some of the problems which can occur with some of the alternative schemes (e.g. groundwater contamination by high density of soil absorption systems). Systems that can cope with large seasonal population variations are also needed.

A further consideration is the ability to cope with different types of development within a community, i.e. residential, commercial, industrial, recreational. Combinations of systems may be required to handle some of these situations, e.g. provision of a reticulated sewerage system for a relatively high density commercial area in a township served primarily by septic tank systems. There must be compatibility between systems that are used in combination with others.

The last consideration is a demand for a large community scale effluent recycle or reuse scheme. This may lead to a preference for off-site treatment of wastewater rather than on-site household disposal systems.

2.3 Appropriate Sewerage Options

Based on a review of published information and the selection criteria discussed earlier, several technologies have been identified which could be used in Australian towns. They can be classified into the following broad groups :

(i) On-site Systems - in which the wastewater is treated and disposed of on individual allotments. The systems involve either septic tanks or aerobic systems and disposal either by subsurface soil absorption systems, by surface irrigation or by evapotranspiration to the atmosphere. Regular removal and further treatment of sludge produced by the treatment process is necessary. Detailed discussions of on-site systems are given in Chapter 3.

(ii) Reticulation Systems - in which the wastewater is collected by an off-site system and conveyed to a remote area for treatment and disposal. Some of the reticulated systems incorporate on-site treatment by septic tanks prior to disposing of the effluent to the off-site collection system, and these systems also require regular removal of sludge. These systems include the South Australian common effluent disposal (CED) system, the septic tank effluent pumping (STEP) system, the variable grade gravity sewer (VGS) system and the modified drainage (MD) system. Others do not use a septic tank, and all household wastes are removed from the site. These systems include the grinder pump (GP) system, the vacuum sewerage (VS) system and the conventional reticulated gravity sewerage system. Also included is modification to the conventional sewerage (MCS) system, in which accepted design and construction rules are relaxed (e.g. smaller pipe sizes, flatter gradients, shallower sewers, curved sewers, vertical drops, fewer manholes, etc. are all permitted).

The on-site storage of raw wastewaters in a holding tank and periodic removal by tanker involves high recurrent costs and is therefore not considered an appropriate community wide option. The system may be useful in specific isolated situations where no other solution exists, and in some cases where commercial/industrial developments exist but a piped reticulation system is not available or on-site disposal is not possible. Holding tank systems may be useful as temporary facilities or as part of a staged implementation program.

The combined raw sewage/stormwater system is not considered appropriate either. This form of sewerage was used widely during the early part of this century, and many towns worldwide are now rueing that decision because of health risks, odours and the difficulties of treatment. Modified drainage is akin to combined sewerage, but because it accepts only septic tank effluent or partially treated sullage, the difficulties are not comparable because raw toilet wastes are excluded from the system. It is noted that it is illegal in some States to dispose of partially treated effluent or sullage to drains.

Detailed discussions of alternative reticulation systems are given in Chapter 4.

2.4 Options for Off-site Treatment

The reticulated sewerage system options referred to above all include a treatment and disposal component, and there is a broad range of options available. The type of treatment system required and the degree of treatment necessary is usually determined by the environmental constraints required to protect the ultimate disposal location for the effluent.

However, the cost of the treatment system will usually be only a small proportion of the total cost of a sewerage scheme (about 10 to 20 per cent); the greater majority of the system cost is associated with the effluent reticulation system. For example, in a recent CED system in the South Australian town of Nairne, where around 600 premises were connected to a scheme which provided treatment by a lagoon or pond system, the cost of the reticulation system, excluding any on-site costs and connection of individual properties to the system, amounted to around 88 per cent of the system cost. There is therefore little value in considering too many alternative treatment options for small community treatment systems as only small savings in total scheme costs would ensue.

A lagoon or pond system followed by land disposal of treated effluent will usually be preferred because this system is economical to construct and operate, and has been proven to be satisfactory, particularly for the smaller schemes where pollutant loadings are low and adequate land area is usually available. In coastal areas, discharge to the ocean should be considered because it usually offers an economical disposal alternative.

Where lagoon systems cannot be used because of unavailability of land, a more compact treatment system is needed. Oxidation ditches fall into this category, and as a result are in widespread use throughout Australia. Another system, the package treatment plant, has also been popular for use in the smaller communities or for pockets of development (e.g. commercial and industrial areas) within towns.

Where nutrient removal is required prior to discharge to inland waters, the treatment systems discussed above may be inadequate and special nutrient removal facilities will be required. Conventional nutrient removal technology tends to be sophisticated and expensive and requires careful operator attention. As a possible alternative, attention is being given world wide to 'natural' treatment systems involving wetlands, marshes, artificial reed beds, etc., because of their reported ability to remove some nutrients from wastewaters, their simplicity because of their minimal use of electro-mechanical equipment, their low energy consumption and their reported low operation and maintenance costs. However, the performance of these systems, particularly in nutrient removal, is still under assessment. Nevertheless, in the few cases that nutrient removal for small community wastewaters is required, consideration should be given to these wetland systems.

Detailed discussions of alternative treatment systems are given in Chapter 5.

2.5 Quantity and Characteristics of Domestic Wastewaters

Because some of the options can involve segregation of domestic wastewaters for separate treatment, as well as treatment of both raw sewage and septic tank effluent, this Chapter ends with a brief summary of the basic characteristics of raw sewage and septic tank effluents before proceeding with the discussion of options.

Domestic sewage generally consists of five separate streams, (1) toilet wastes, (2) kitchen sink wastes, (3) bathroom basin wastes, (4) bath and shower wastes and (5) laundry wastes. The toilet wastes are referred to also as blackwater, and make up of the order of 30 per cent of the total flow, depending on the capacity of the toilet flush tank. The other four streams, comprising about 70 per cent of the flow, are referred to collectively as greywater, or more commonly in Australia, as sullage.

Sewage flow rates depend on several factors, including number of persons in the household, their habits, and their lifestyle. Unit sewage flows in Australia are usually in the range 150 to 250 L/c.d, and a value of 200 L/c.d is commonly adopted for design flowrates. Around 60 L/c.d of the flow is toilet waste, and the remaining 140 L/c.d is sullage. It is noted that with increasing use of water conservation techniques, unit sewage flow rates may decrease.

Typical concentrations of common pollutants in domestic sewage are as follows :

Biochemical oxygen demand, BOD_5	:	200 - 250 mg/L
Suspended solids	:	200 - 250 mg/L
Total nitrogen, as N	:	30 - 40 mg/L
Total phosphorus, as P	:	7 - 10 mg/L
Coliform bacteria	:	10^7 - 10^8 org/100 mL

Roughly half the daily amounts of BOD_5, suspended solids and phosphorus are contained in the toilet wastes, which are also responsible for most of the nitrogen and bacteria. The sullage contains the remainder of the pollutant load, and because it constitutes the majority of the flow, the sullage is a relatively weak stream with BOD_5 and suspended solids levels in the range 150 to 200 mg/L. Sullage often carries bacterial contamination derived mainly from laundering soiled clothing.

Septic tank effluent is also a relatively weak stream, as the majority of settled solids are removed in the tank. Typical BOD_5 concentrations are 150 to 200 mg/L, and typical suspended solids levels are 80 to 100 mg/L.

3. ON-SITE SYSTEMS

This Chapter discusses on-site treatment and disposal systems. Treatment is accomplished by either septic tanks with or without sand filters or aerobic treatment units, but disposal can be carried out in several ways depending on site conditions and climatological factors. The salient features of the most common on-site systems have been summarised in the Data Sheets included at the end of this Chapter. Each sheet contains a schematic diagram depicting the system, a brief description, a list of advantages and disadvantages, and indicative construction and operation costs.

3.1 Treatment Systems

On-site treatment can be accomplished by septic tanks, septic tanks followed by sand filters, or aerobic treatment systems (sometimes preceded by septic tanks).

3.1.1 Septic Tanks

The septic tank provides a very basic form of treatment comprising sedimentation of settleable solids, flotation of oils and fats, and digestion (stabilisation) of the stored sludge. This renders the wastewater amenable to further treatment or disposal by percolation into the soil. The solids and scum that are stored in the tank need to be removed periodically, and facilities need to be available for the treatment and disposal of these sludges (septage).

Septic tanks often have acquired a bad reputation. Unfortunately, this is not because their principle of operation is at fault but because of either inadequacy in the design of the unit, or because it has been poorly maintained, or, most frequently, because the disposal system which follows it, i.e. the soil absorption system, has failed.

It is generally accepted now that the volume of a tank should be at least three times the volume of wastewater produced daily, on average, in the home. This will provide for adequate storage of solids and scum and will keep the average requirement for sludge pumpout to a reasonable frequency (say three to four years). This translates to a minimum volume of around 3000 L per tank. Double compartment tanks are usually recommended to minimise adverse effects of turbulent discharges on effluent quality.

The majority of septic tank users get their tank pumped out only when there is a problem, by which time the effluent quality has deteriorated significantly and is probably causing problems at the disposal location. However, an adequately sized and properly managed septic tank will provide a satisfactory degree of treatment of domestic wastewater for subsequent on-site subsurface disposal.

3.1.2 Sand Filters

Sand filters are used for further treatment of the effluent from septic tanks when a higher degree of treatment than that provided by a septic tank alone is required, for example, if it is necessary and permissible to discharge the effluent to an open stormwater drain system or a watercourse, or it is desirable to reuse the water for lawn irrigation.

Sand filters have been used for many years in Australia, particularly in Victoria, and are very effective. They are usually designed on a loading rate of 50 L/m^2 d, and an average household would require a filter area of around 20m^2. Provided the preceding septic tank is operated and maintained carefully, a sand filter system can give many years of trouble free operation. However, they are expensive to construct, and may have a limited life (10 - 15 years) because the sand eventually clogs if high loading rates are consistently applied.

Queensland has successfully developed a compact sand filter/mound system which would normally receive all-purpose septic tank effluent, as well as a sand trench system intended to receive greywater septic tank effluent. The effluent from each of these systems is then available and safe for irrigation onto home gardens. These systems offer an economical alternative to an aerobic treatment plant. The sand used in the Queensland systems is coarser than the sand specified for the Victorian filters.

3.1.3 Aerobic Treatment Systems

Another alternative when high quality effluent is required is the package household aerobic treatment system. There are about a dozen aerobic treatment plant systems which have been approved or are being considered by Australian health authorities and which are designed specifically for individual homes. The reaction to these units has been mixed. There are nine systems which have been approved by the relevant health authority in NSW. Four of them are accepted in South Australia, but only two of those nine are approved in Queensland and one in Tasmania. Four others are being considered by Queensland. Victoria has approved only two other systems and a third is under test. One Council in the Upper Yarra Valley region east of Melbourne encourages their use, yet an adjacent Council has banned them because of unsatisfactory performance. A list of approved brand names as at March 1988 is given in Table 3-1.

TABLE 3-1 - APPROVED HOUSEHOLD SEWAGE AEROBIC TREATMENT PLANTS

	NSW	SA	VIC	QLD	TAS
Envirocycle	•	•		•	•
Supertreat	•	•			
Biocycle	•	•		•	
Clearwater	•	•			
Biomax K	•				
Biotreat	•				
Garden Master	•				
Model D10	•				
Parco Beaver	•				
Clearwater 80			•		
Aerotor			•	Pending	
Biorotor			Under test		

The systems all use biological processes for treatment. Some use septic tanks for pretreatment, while others have integral primary sedimentation compartments. Some use aeration tanks, some use rotating biological contactors and one uses anaerobic compartments as part of the treatment process. Some of the units are designed for surface disposal of the treated effluent and include disinfection; disposal is to garden irrigation or to stormwater drains. Brief descriptions of major features of the systems are as follows.

Envirocycle

These are circular units with five annular segments in series and two centre compartments. The annular segments comprise two primary sedimentation sections and three aeration sections. The centre compartments comprise one clarifier and one disinfection tank. Sludge from the clarifier is returned to the first primary sedimentation tank. Aeration is by a diffused air system and disinfection by chlorine. This is probably the most popular unit in Australia at present.

Supertreat

This is also a circular unit but which is designed to take septic tank effluent. The outer section is an aeration tank equipped with a coarse bubble air diffusion system. A small blower supplies compressed air. The inner section consists of a clarifier and a disinfection tank. Sludge from the clarifier is returned to the aeration section. Chlorine is used for disinfection.

Clearwater

A septic unit followed by a plastic media trickling filter in which the sewage trickles down over an inert media covered with biological growth. Sludge produced by the process is removed by settling and returned to the septic tank.

Biomax K

This unit comprises two submerged media anaerobic compartments in series followed by a coarse bubble diffuser aeration tank with separate blower, a clarifier and a chlorine contact tank.

Clearwater 80

A rectangular unit with integral septic tank, a turbine aerated tank and clarifier with sludge return to the aeration tank. Normally used for subsurface disposal of effluent, but chlorination is optional.

Aerotor

This system consists of a rotating biological contactor preceded by a septic tank. The contactor has three stages, and is followed by a clarifier with sludge return to the septic tank.

Biorotor

Another rotating biological contactor system similar to the Aerotor, and equipped with a chlorination system.

Other Systems

No details were received from other suppliers of household package systems when enquiries from manufacturers were made.

Advantages and Disadvantages

The major advantage of the package systems is that they are capable of producing a very good quality effluent, providing they are operated and maintained correctly. With disinfection, the effluent is suitable for irrigation of household gardens, and for discharge to street stormwater drains (where permitted). If not disinfected, subsurface disposal must be practiced, although this is not a common approach. However, because of the good quality, the effluent could probably be disposed of on a much smaller subsurface area than is required for disposal of septic tank effluent. Alternatively, existing subsurface systems on small lots which are inadequate for septic tank effluent disposal and which have failed could be used satisfactorily for disposal of aerobically treated effluent.

Another advantage of aerobic systems is that they are odour free.

There are, however, two main factors which mitigate against the more widespread use of these systems. First is their cost. On average, their installed cost is usually $4000 to $6000 which puts them into the same cost category as conventional sewerage. Energy consumption is relatively high and hence running costs are significant. Second is the need to run mechanical equipment continuously. The micro-organisms which treat the wastewaters need an almost continuous supply of air, which has to be provided by a blower, or a turbine, or a rotating disc. Failure of these critical components will render the treatment system useless and adverse consequences may occur in the effluent disposal system. A critical responsibility is therefore placed on the owner/occupiers, one which in many cases they will not be capable of meeting adequately. Available evidence supports this view. A further related factor in those systems which use disinfection is the need to keep up the supply of the disinfectant. Unlike with a swimming pool in which chlorination may be allowed to lapse for short periods without undue adverse impact, continual disinfection of household wastewater where above ground discharge is practiced is essential.

Another disadvantage of aerobic systems is the susceptibility of the micro-organisms to toxic materials which can find their way into household drains (e.g. cleaning agents). Also, prolonged periods of absence by the occupier during annual holidays or house resale can lead to inactivation of the micro-organisms with consequent effluent deterioration when restarted. Furthermore, primary sedimentation chambers generally need desludging on a one to two year basis.

It is obvious from the above that household package aerobic systems are not the answer for whole towns or villages. They do, however, have an important role to play in specific situations, and hence development of more economical, reliable and robust systems should be encouraged.

3.2 On-site Disposal Systems

The most commonly used on-site disposal system is the soil absorption trench which is designed to dispose of the wastewater by percolation into the soil. Several alternatives to the conventional trench system have been developed to cater for 'difficult' situations where trenches are not deemed to be appropriate. The majority of the alternatives still rely, however, on percolation of wastewater into the soil, but some encourage evaporation to the atmosphere and transpiration by vegetation. In general, the alternatives are used only when a conventional trench system cannot be used.

Failures of soil absorption systems are normally due to one of the following reasons:

(i) inappropriate site conditions - i.e. poor soil permeability, excessive rainfall, steep slopes;
(ii) excessive hydraulic loading - either because the system provided is undersized, or because of excessive water use;
(iii) premature clogging - due to carryover of solids from improperly maintained septic tanks; and
(iv) poor design and/or careless installation.

Recent research has provided a good understanding of the behaviour of soil absorption systems, and design guidelines are now available that will ensure long-term satisfactory performance of soil absorption systems. The basic principles and design guidelines are described below.

After several years of operation during which the soil receiving the wastewater progressively clogs, an equilibrium infiltration rate is reached. The rate of clogging of the soil/water interface is then equal to its rate of natural 'self-cleansing'. Provided a soil absorption system is designed to operate at or below the equilibrium rate of the soil involved, then the system should last indefinitely. Unfortunately, the equilibrium infiltration rates of most soils are low, usually ranging from about 10 L/m^2.d for clayey soils up to around

25 L/m^2.d for sands, although lower and higher equilibrium infiltration rates are possible. This means that to dispose of the wastewater volume produced in an average Australian household (say 1000 L/d), an absorption area in the range of 40 to 100 m^2 is necessary. Most soil absorption trenches are built with internal dimensions around 600 mm by 600 mm, so this means that the average trench length needs to be around 20 m in sandy soils and around 55 m in clayey soils. The length of soil absorption trenches in Australia are sometimes about half the theoretical length but more often several times shorter than they need to be to ensure long-term satisfactory performance.

To provide the absorption areas indicated above, a substantial area of land needs to be set aside for soil absorption. It is estimated that the minimum block area required in good soil conditions to accommodate conventional on-site soil absorption systems but still leave sufficient area remaining for other non-residential uses (garages, sheds, pools, rockeries, etc.), is 1100 to 1200 m^2. This requirement increases as soil suitability declines.

The bad reputation gained by on-site disposal systems has led several authorities in Australia and overseas to recommending minimum allotment areas of 4000 m^2 (1 acre) for on-site disposal systems, and this has discouraged the use of these systems particularly in new residential developments.

Other criteria governing the suitability of soil absorption systems have been developed, and they are summarised below.

- Slope of land - a surface slope of 20 per cent has been recognised as a limiting factor to the satisfactory performance of soil absorption systems.

- Depth to rock - at least 500 mm of soil is considered necessary between the bottom of the soil absorption area and bedrock or an impervious layer, for wastewater purification.

- Depth to groundwater - around 600 mm to 900 mm of unsaturated soil beneath the trench and above the highest seasonal groundwater table is required to minimise pollution of the groundwater.

The last two criteria effectively mean that depth from ground surface to groundwater or bedrock should be at least 1.2 m.

As indicated earlier, several variations to the conventional trench system have been devised to provide increased reliability (e.g. alternating systems), or to overcome the limitations described earlier. They include absorption beds rather than trenches where land area is limited, serial distribution systems on sloping land, mound systems where high groundwater exists, and evapotranspiration systems where soils with low permeability exist. Simpler systems (e.g. seepage pits or soakwells have been used in areas with high permeability (e.g. Perth). However, these are all variations on a theme, and generally would not be considered unless trenches were unsuitable.

Finally, above-surface disposal of highly treated effluent needs to be considered. The key requirement is again land availability. The area allocated to effluent disposal must be capable of accepting the effluent every day of the year, including winter, without run-off past the property boundaries.

Spray irrigation is usually practised, although drip feed systems are sometimes used. A suitable dedicated landscaped area needs to be set aside. NSW guidelines at present call for a minimum area of 100 m^2, although experience is showing that larger areas of up to around 350 m^2 may be necessary to contain all effluent from larger families. The disposal area must be separate from any recreational lawns or areas where fruit and vegetables are grown. Special materials need to be used for effluent disposal lines and fittings.

The major concern about surface disposal is that if the treatment system which precedes it malfunctions or fails, a potential health risk is created. Another concern is the spreading of aerosols (airborne diseases) from a fine spray or misting type irrigation system.

3.3 Segregation of Wastewaters

Segregation of domestic sewage into its two main components, i.e. toilet wastes and sullage, offers opportunities for efficient utilisation of different treatment/disposal avenues which some Councils, particularly in Victoria, have taken advantage of. As indicated earlier, one of the most common reasons for failure of on-site systems has been hydraulic overloading due to inadequately sized absorption trenches. If the sullage is diverted away from the toilet waste septic system, that system will very likely continue to operate satisfactorily in the long term, as it would receive only about 30 per cent of the total flow. The toilet wastes contain the majority of the pathogenic contamination, and this stream would be disposed of safely to the soil. The remainder of the wastewater, i.e. the sullage, needs to be disposed of separately and several options are available.

One option that has been attractive to several Councils in Victoria is disposal of the sullage to the stormwater system in recognition that health risks associated with this stream are relatively low. Pretreatment of the sullage in a grease trap or a separate septic tank can be practised. In Queensland, the Department of Local Government is experimenting with a sullage treatment method which involves passing the flow through a sand filled trench before disposing of it by an above surface irrigation method. Another option involves a separate off-site collection system for sullage only (either raw or pretreated in a septic tank) similar to a CED system, where the advantages would include reduced capacity required for the collection and treatment system.

A further option involving segregation of domestic wastewaters is to treat the blackwaters by a self-contained treatment/disposal system (e.g. composting toilet, incinerator toilet, chemical toilet) and to use the existing septic tank/soil absorption system for sullage only. The reduction in flows so obtained would result in better performance of the soil absorption system.

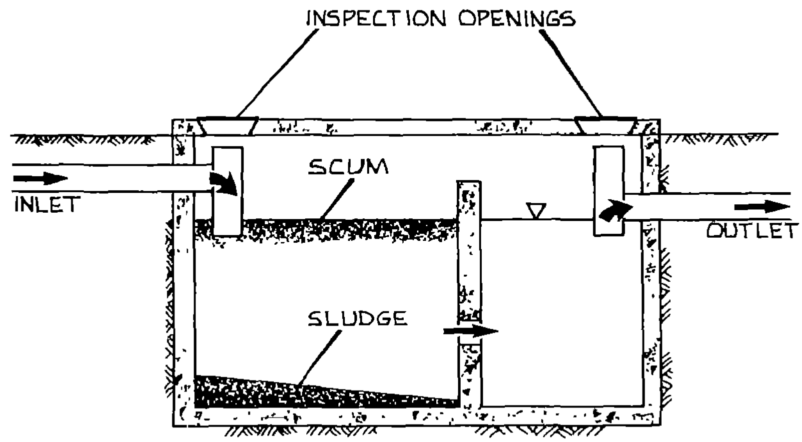
DATA SHEETS

for

ON-SITE SYSTEMS

ON-SITE TREATMENT

1. Septic Tank



Description: The most commonly recommended design for septic tanks for individual household wastewaters is a double compartment, rectangular or cylindrical, 3000 to 3200 L concrete or fibreglass tank. Each State has its own guidelines for design of tanks, but all provide the same basic functions of sedimentation and digestion of settleable solids, flotation of oils and fats, and storage of the solids. Gases are exhausted to the atmosphere by backflow through the inlet pipe and through the household piping vent.

Advantages

1. Inexpensive.
2. Does not require power.
3. Minimal routine maintenance.
4. Can handle shock hydraulic loads.

Disadvantages:

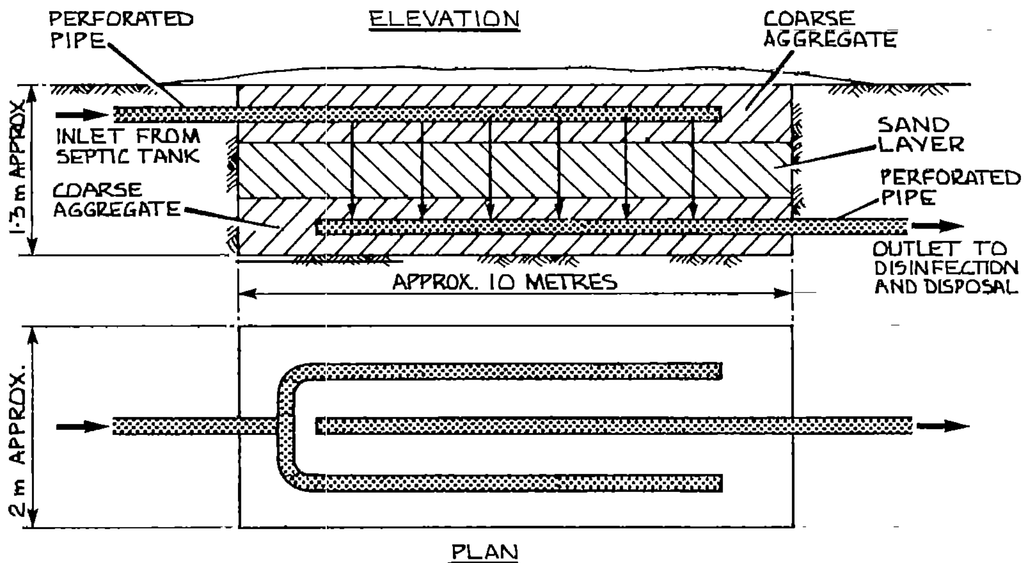
1. Provides only partial treatment.
2. Requires regular pump-outs of sludge (3 to 4 years).
3. Can be odorous (particularly during desludging).
4. Nearby treatment /disposal facility for septage required.

Indicative Costs:

Construction Costs : $600 to $1000 per allotment (excludes soil absorption system).

Operating Costs : $80 to $100 every 4 years for pumpout.

2. Sand Filters



Description : A sand filter is a bed of fine sand over which septic tank effluent is distributed and under which treated effluent is collected for subsequent disposal. Under current Victorian guidelines the bed area required for an average household is around 20 m^2 based on a loading rate of 50 L/m^2d. The sand bed provides a medium for aerobic bacteria to grow and treat the septic effluent and further purify it. A system of two sand filters with intermittent dosing may be used for situations where heavy loading is expected.

Sand filters followed by effluent disinfection can be used prior to off-site disposal, for example to a stormwater drain, or disposal by irrigation. They could be used to upgrade septic tank effluents prior to on-site subsurface disposal in limited-area locations.

Advantages:

1. Produces high quality effluent.
2. No odours.
3. Does not normally require power.

Disadvantages:

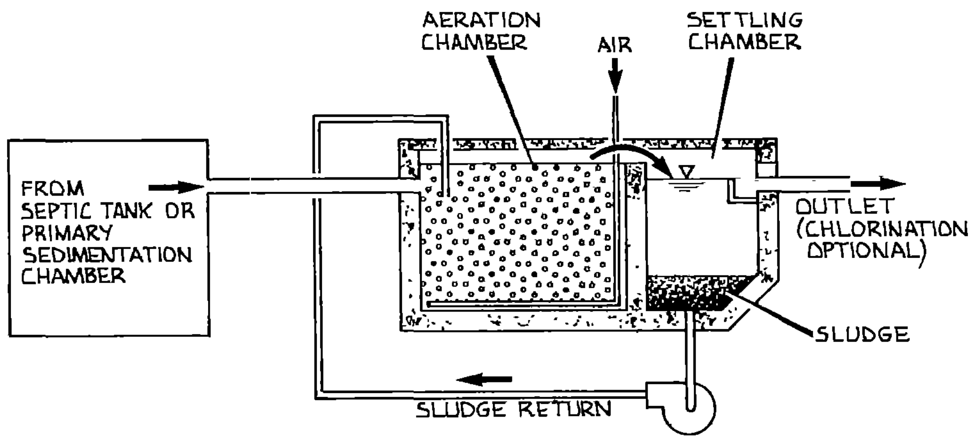
1. High installation costs
2. May have limited life and need periodic replacement (10-15 years). Alternatively larger beds could be used.
3. Needs dedicated area of land.

Indicative Costs:

Construction Costs : $2500 to $3500 per allotment, excluding septic tank

Operating Costs : $10 to $20/year for chlorine
$250 to $350/year if need to replace

3. <u>Aerobic Treatment Systems</u>



Description: Pretreatment is usually provided either in a conventional septic tank or in an integral primary sedimentation chamber. The small aerobic treatment systems vary in size, shape and configuration but all perform a similar task. Air and wastewater are mixed together in a small tank providing conditions for bacteria to degrade or digest the sewage to produce a high quality effluent. The mixture is settled to remove the biological mass which is returned to the start of the process and the purified effluent continues on for disposal. Disinfection systems are used if above-ground effluent disposal is practised. If subsurface disposal is practised, disinfection is not usually provided.

Advantages:

1. High quality effluent.
2. No odours.

Disadvantages:

1. High installation costs.
2. High energy costs are required for most systems.
3. High maintenance requirements.
4. Desludging of primary chamber required on a one or two year basis.
5. Bacteria susceptible to inactivation by toxic chemicals and absence of owner/occupier.
6. Susceptible to shock loads.

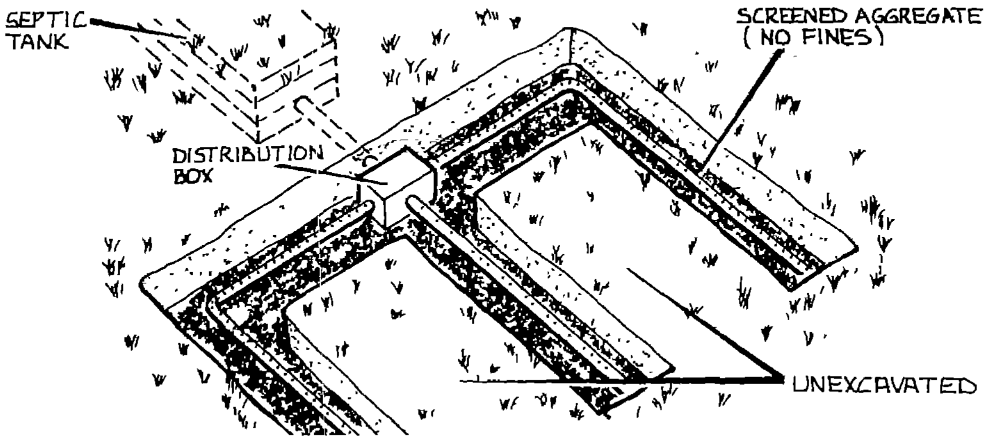
Indicative Costs:

Construction Costs : $4000 to $6000 per unit, excluding disposal system.

Operating Costs : Power $100 - 200/year
Desludging $20 - 30/year
Maintenance Contract $150 - $200/year (includes chlorine)

ON-SITE DISPOSAL

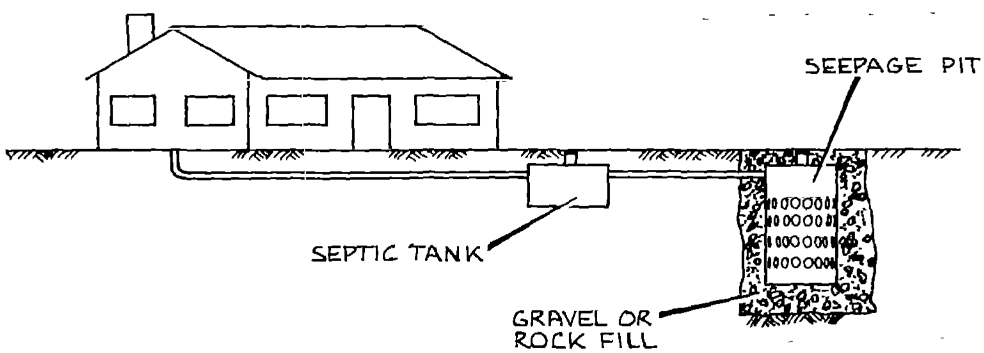
1. Soil Absorption Trenches



Wastewater is first treated in a septic tank or aerobic treatment unit. The effluent passes through a distribution box, along perforated pipework in trenches filled with crushed rock, and seeps into the soil where bacteria and oxygen degrade the contaminants in the wastewater. This is the most common on-site method for disposal of domestic effluent. A variation used in Western Australia consists of unfilled trenches with open brick walls and concrete covers.

The trenches are usually 500 to 600 mm deep and 500 to 500 mm wide. The length will depend on the design loading rate which is a function of the absorption capacity of the soil. Typical theoretical trench lengths under current guidelines vary from about 10 m in coarse sands in Western Australia to around 200 m for clayey soils in Victoria. See text for further discussion of loading rates.

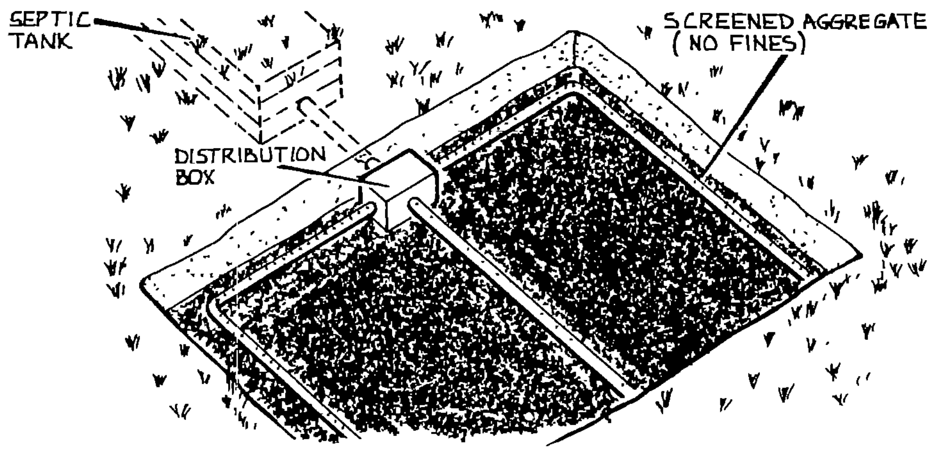
2. Seepage Pits



A seepage pit is simply a large hole lined with open brick or a precast concrete pipe with sidewall holes which allows seepage to the surrounding soil. This system is usually used in deep sandy soils having good seepage. (e.g. Perth). Pit size requirements are based on similar loading rates to those used for absorption trenches.

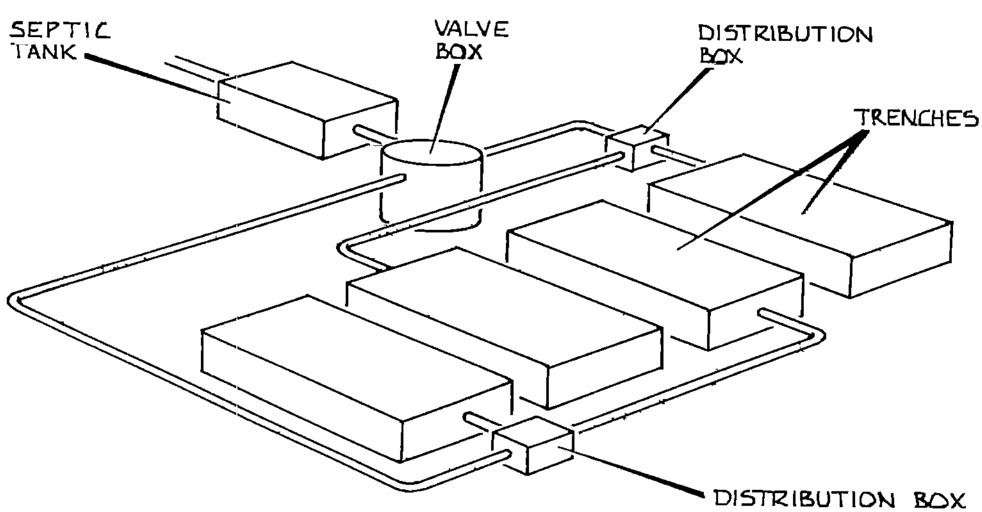
Because of concentrated discharge, these systems may not be suitable in areas where groundwater could be contaminated.

3. Soil Absorption Beds



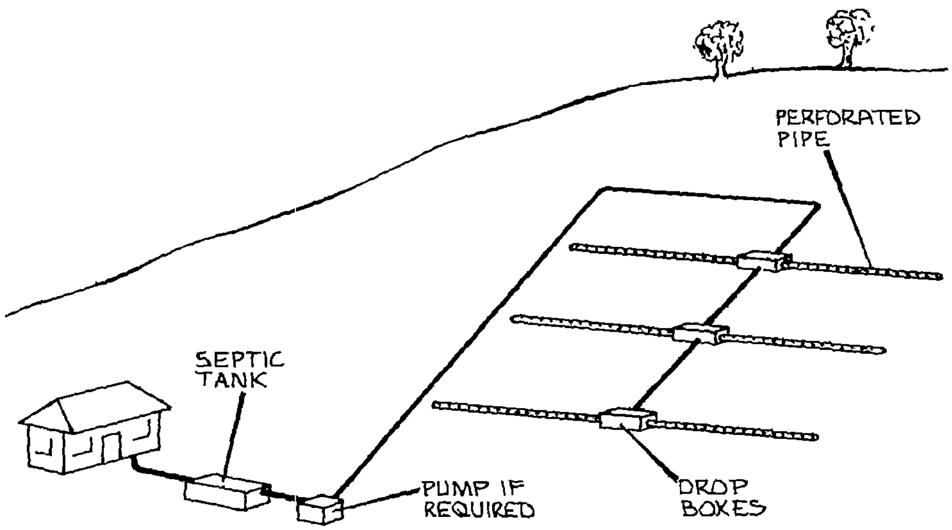
Similar to soil absorption trenches except that the pipework is arranged in a bed rather than trenches. This system is used where limited land area is insufficient for trenches. Loading rates are similar to those used for absorption trenches.

4. Alternating Absorption Trenches



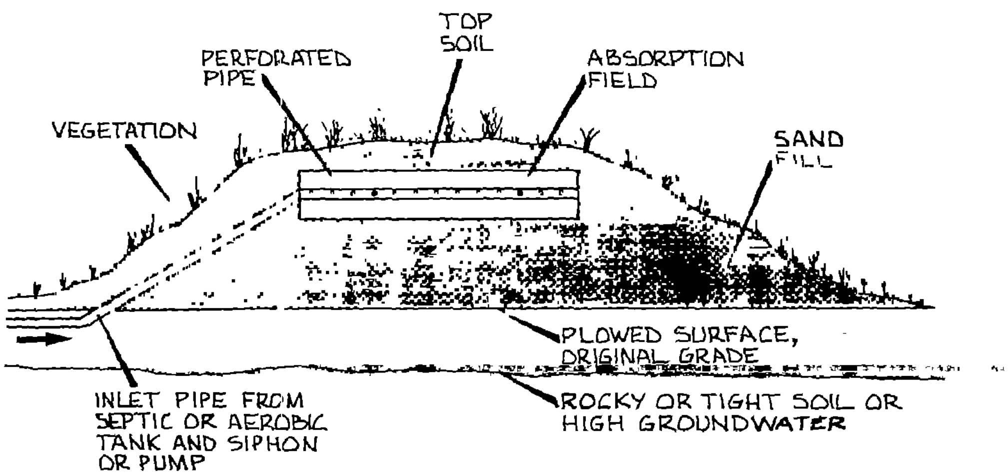
Two absorption trenches are provided and are used alternately. One is used for 6-12 months while the other is renewing itself. The advantage of this system is that the trench life is greatly extended and one system provides a standby if the other fails. A valve arrangement is used for switching from one system to another. Higher loading rates than those for conventional soil absorption systems can be used.

5. Sloping System-Serial Distribution



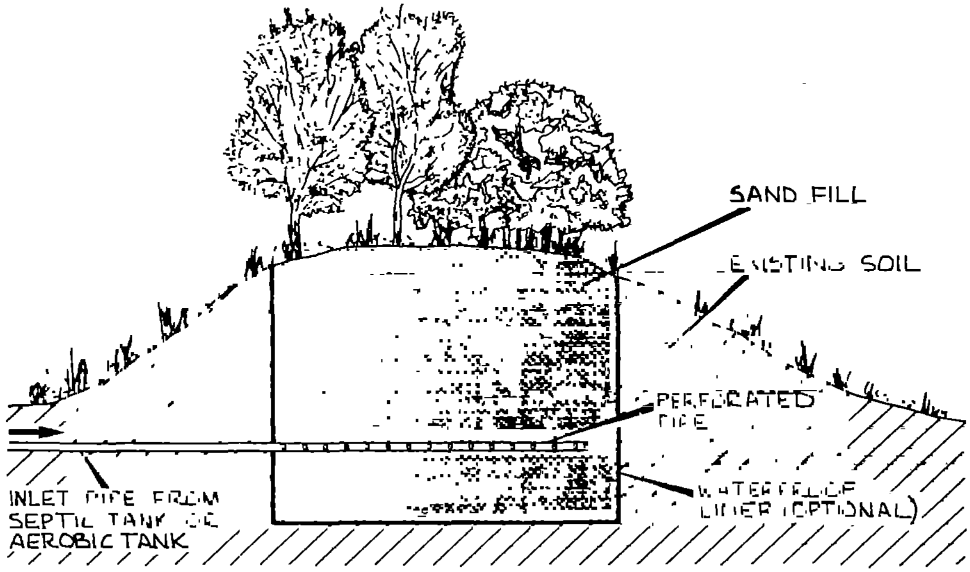
On sloping land some refinement of the conventional trench is required. Each absorption trench follows a contour of the slope and separate trenches are fedby drop boxes which regulate the liquid flow.

6. Mound Systems



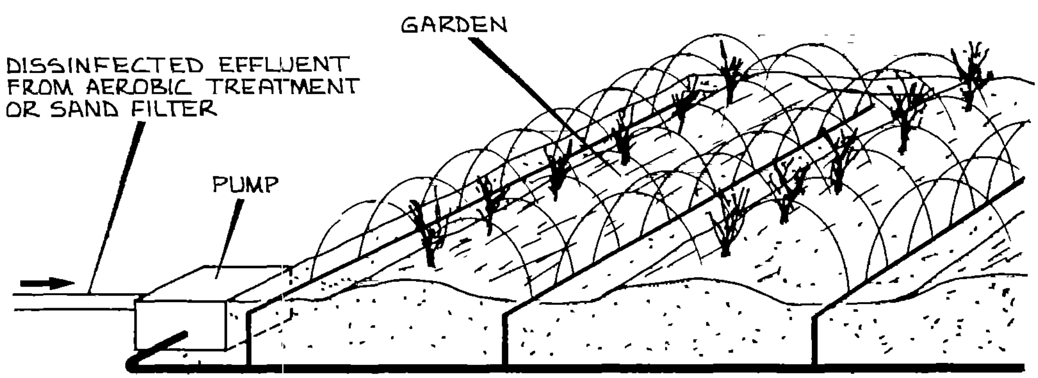
Effluent is pumped to a sand filled mound and distributed via perforated pipes located in gravel filled trenches. Effluent flows through the mound and is also evaporated and transpired with the assistance of mound vegetation. The system is used for areas with rocky or compacted soils or ground with a high water table where normal absorption trenches would not be suitable. Similar loading rates to conventional soil trench loading rates are used, and the mound systems have similar dimensions to absorption trenches and beds.

7. Evapotranspiration Beds



Evapotranspiration beds are used to transfer liquids to the atmosphere with the aid of suitable broad leaf plants without contaminating the surface or groundwater. Effluent is piped to a bed usually lined with an impervious membrane and distributed through a perforated pipe network into the fill soil (sand) where it is then taken up by vegetation and transpired through leaves to the atmosphere. The system is usually installed in areas of clay with low permeability or in areas of sand with very high permeability where groundwater protection is required. Loading rates depend on rainfall, and vary between 5 and 10 L/m^{2}d based on bottom area of bed.

8. Above-Surface Disposal



Above-surface disposal of treated effluent is permitted in some States, usually by sprinkler-type irrigation. High quality effluent as obtained by aerobic treatment or sand filter systems is a prerequisite. Minimum area requirement per household is 100 m^2 but larger areas are desirable to contain all effluent on the site.

Advantages of On-site Disposal Systems

1. No requirement for off-site collection and treatment.
2. No power normally required.
3. Minimal routine maintenance.

Disadvantages of On-site Disposal Systems

1. ~~Require relatively large areas.~~
2. Generally applicable to relatively low rainfall areas and permeable soils, although evapotranspiration and mound systems can overcome these constraints.
3. Regular clean-out of septic tanks required to prevent clogging of disposal works.

Indicative Costs of On-site Disposal Systems

Construction costs per household :

. Absorption trenches	\$1500 - \$2000
. Seepage pits	\$1000 - \$1500
. Absorption beds	\$1500 - \$2000
. Alternating trenches	\$2000 - \$2500
. Serial distribution	\$2000 - \$2500
. Mound systems	\$2000 - \$2500
. Evapotranspiration beds	\$2000 - \$2500
. Pressure irrigation systems	\$ 500 - \$1000

Operating Costs : Generally very low, as little routine maintenance is required.
In pumped systems, power costs would be \$5 - \$10/year.

4. RETICULATION OPTIONS

This Chapter discusses reticulated systems in which part or all of the wastewater is removed from the site for treatment and disposal elsewhere. In the former case, some on-site components are retained. Systems that remove part only include MD, STEP, CED and VGS. Systems that remove all the wastewaters include GP, VS and MCS. Data Sheets for these systems are included at the end of this Chapter. Table 4.1 presents a condensed summary of the relative characteristics of each system, including for comparison purposes on-site treatment/disposal and conventional gravity sewerage.

An approximate breakdown of costs of construction (excluding administration costs) of a conventional sewerage scheme is given in Table 4.2. These costs will vary from State to State, authority to authority, and project to project, and therefore are indicative only.

It is very clear from the Table that the highest individual cost items are excavation, backfilling and manholes. Hence, any alternative which targets these three areas should result in considerable cost savings.

4.1 Modified Drainage System

In this scheme, effluent from all waste septic tanks, or from sullage-only septic tanks, or just the sullage, is diverted to a piped stormwater system which conveys the wastewaters to a dry weather flow treatment system (normally a lagoon). Wet weather flows which exceed the capacity of the lagoon system are bypassed directly to the receiving waters.

Modified drainage could be used only where an existing piped stormwater collection system is available, or is planned. Discharge to open street drains is not acceptable. A further constraint may be imposed whenever concrete or cement pipes have been used because of the corrosive nature of septic effluent. Retention times in the system and potential for hydrogen sulphide generation need to be considered carefully, although it is noted that the majority of sulphate present in the raw sewage should have been converted to hydrogen sulphide in the septic tank and escaped to the atmosphere though the vent system. There is evidence that supports this

TABLE 4-1 RELATIVE CHARACTERISTICS OF SEWERAGE OPTIONS

OPTION	MAIN ADVANTAGES	MAIN DISADVANTAGES	MORE SUITABLE FOR	LESS SUITABLE FOR	ORDER OF COST PER LOT (excluding treatment and connection)	COMMENTS
ON-SITE TREATMENT/ DISPOSAL	. No off-site requirement. . No power generally if septic tank used. . High quality effluent if sand filter/ aerobic plants used.	. Pump-outs reqd. . Large area reqd.	. Large lots . Permeable soil for subsurface disposal.	. Small lots. . Poor soil. . Wet climates. . High density developments	$1000 for new septic tank. $1500 for new absorption trenches.	Attractive option if existing systems can be upgraded to new design criteria.
MODIFIED DRAINAGE	. Uses storm-water pipes as carrier. . Reduced organic loading at treatment plant. . No power generally required in reticulation system	. Pump-outs reqd. . Discharges dilute but untreated wastewater during high rainfalls. . Septic effluent.	. When piped stormwater system is available.	. When limited assimilative capacity of receiving waters exists.	$600-$1000 for connection. $1000 for new septic tank.	Inexpensive option but lower level of service. Preferable to take sullage only, with toilet wastes to septic system.
SEPTIC TANK EFFLUENT PUMPING	. Small pipes following terrain. . Reduced peaking factors. . Reduced organic loading at plant.	. Pump-outs reqd. . Power required. . Service of electro mechanical equip-ment required. . Septic effluent. Septage facility required.	. Unstable soils . High groundwater. . Rocky terrain. . Flat and un-dulating terrain.		$1500-$2500 Assumes exist-ing septic tank.	Attractive option if majority of town already served by septic tanks. Limited use where seasonal loadings exist.
VARIABLE GRADE SEWER	. Reduced blockage frequency. . Smaller pipes. . No power generally reqd. . Reduced peaking factors. . Reduced organic loading at tre[redacted]t plant.	. Pump-outs reqd. . Septic effluent. . Septage facility required.	. Flattish or gently un-dulating terrain. . Fair ground	. Rocky ground. . High ground-water. . Very hilly ground.	$1500-$2500. Assumes exist-ing septic tank.	Attractive option if majority of town already served by septic tanks

Table 7.1 cont.

OPTION	MAIN ADVANTAGES	MAIN DISADVANTAGES	MORE SUITABLE FOR	LESS SUITABLE FOR	ORDER OF COST PER LOT	COMMENTS
COMMON EFFLUENT DISPOSAL	. Reduced blockage frequency. . No power generally reqd. . Reduce peaking factors. . Reduced organic loading at treatment plant. . Smaller pipes.	. Pump-out reqd. . Septic effluent. . Septage facility required.	. Flattish or constant slope. . Good ground.	. Rocky ground. . High ground-water. . Very hilly ground.	$1500-$2500. Assumes existing septic tank.	Attractive option if majority of town already served by septic tanks.
GRINDER PUMPS	. Small pipes following terrain. . Septic tanks not reqd. . All sewage removed.	. Power required. Servicing of . electromechanical equipment reqd.	. Unstable soil. . High groundwater. . Rocky terrain. . Flat and undulating terrain.		$2500-$3500	Attractive option if town served by septic tanks. Limited use where seasonal loadings exist.
VACUUM SEWERS	. Small pipes following terrain. . Septic tank not reqd. . Aerobic effluent. . All sewage removed.	. Power required but centralised. . Servicing of electromechanical equipment reqd. but centralised.	. Flat terrain. . High groundwater. . Rocky terrain. . High population density.	. Hilly ground.	$3000-$5000	Attractive for new developments in flat, high groundwater table areas where costs of conventional sewerage would be very high.
MODIFIED CONVENTIONAL GRAVITY SEWERS	. All sewage removed. . Generally aerobic effluent. . Septic tanks not reqd.	. Increased maintenance.	. Flattish or constant slope terrain. . Good ground.	. Rocky ground. . High ground-water table.	$3500-$5000	May provide some inconveniences due to increased maintenance requirements.
CONVENTIONAL GRAVITY SEWERS	. All sewage removed. . Generally aerobic effluent. . Septic tank not reqd.	. Cost	. Flattish or constant slope terrain. . Good ground.	. Rocky ground. . High ground-water table. . Very hilly ground.	$4000-$6000	Provides the highest level of service.

TABLE 4.2 - DISTRIBUTION OF SEWERAGE RETICULATION COSTS

Item	Percentage of Construction Cost	
	Range	Average
Pipeline construction		
Excavation	12 - 26	22
Dewatering	6 - 8	7
Backfilling	14 - 18	15
Pipe materials	6 - 9	7
Pipe laying	6 - 9	7
Access	8 - 15	10
Maintenance/cleanup	5 - 7	6
Miscellaneous	3 - 10	7
Manholes	13 - 17	15
Property branches	3 - 5	4
Total construction cost		100

contention, but more information would be desirable. In the extreme case that a severe corrosion potential exists, normal cement based stormwater piping systems should not be used for a modified drainage system.

Modified drainage can provide a very low cost solution to an existing backyard pollution problem, and is particularly attractive for the smaller communities. It cannot be considered equivalent to a full sewerage system, because it allows some discharge of untreated (although dilute) wastewater at times. However, it also has the advantage of treating some of the stormwater, in particular the 'first flush' after rain. From a health risk point of view, it would be preferable to keep the toilet waste out of the modified drainage system as this stream is responsible for the majority of the pathogenic pollution. If the toilet wastes are included, great care should be taken to ensure that the septic tanks are adequately maintained and regularly desludged to prevent the discharge of solids. In homes served by a single septic tank system, a second septic tank for sullage may be required, and modification to on-site plumbing would also be needed.

Depending on the characteristics of the drainage system, it may be necessary to provide special facilities for removal of silt, debris and other foreign material which may find its way into the drainage system. In the case where the wastewater has to be pumped to a treatment facility, special difficulties may be encountered. Full gravity drainage systems are likely to have fewer problems. The magnitude of the potential problems needs to be assessed on a case by case basis.

4.2 STEP System

Considerable savings in construction costs can be made by pumping the septic tank effluents into small diameter UPVC or polyethylene pipes laid in narrow trenches at relatively shallow depths following terrain contours. The reticulation system does not need to follow natural drainage lines. Pipes can be redirected around obstacles. The system is particularly useful in hilly and undulating country, where there is rock outcropping or where high groundwater tables exist. They are suitable for flat ground also. However, special odour and corrosion problems may be encountered because of effluent septicity.

The main disadvantages of STEP systems are that the pumps, non-return valves and the septic tank itself need to be kept in good condition, otherwise failure of the system may occur. However, the potential inability to dispose of the household wastes should a failure occur is a good incentive to the owner/occupier to maintain those systems properly. In some locations in the USA, management schemes have been introduced whereby the responsibility for the on-site components lies with the sewerage authority.

Another disadvantage of STEP systems is the difficulty of undertaking repairs to the reticulation system. Whole sections may need to be isolated, and this would require shutting off individual home systems.

4.3 CED System

Common Effluent Disposal is a system in which septic tank effluent is collected in a gravity reticulation system similar to a conventional scheme. The system can be used wherever a conventional sewerage system can be used, as all components would be similar. The CED system would be more economical than a conventional system because of smaller pipes, flatter grades, fewer manholes, reduced peak flow (attenuation by septic tanks) and reduced treatment requirement because of absence of sludges. They have been used mainly in areas already served by septic tanks, and generally are not economical if new septic tanks have to be installed. Odour and corrosion problems due to septicity of the septic tank effluent (particularly in manholes) are more severe than in a conventional sewerage system.

4.4 VGS System

A VGS system is a variation of the CED system. It permits even more economical construction because inflective grades can be used. However, because some sections of the reticulation system will always be full, excessive slime growth on pipe walls may occur leading to possible blockage problems. Also, maintenance of the filled sections is more difficult.

4.5 Grinder Pump System

This system has all the advantages of a pressure sewerage system that the STEP system has, but does not use a septic tank. However, more sophisticated pumps are necessary because they have to cope with raw sewage solids. Recent improvements in grinder pump technology have made these units quite reliable. Similar problems in maintenance/repair of the pressure reticulation system to those of STEP systems are experienced.

4.6 Vacuum System

Vacuum systems have most of the advantages associated with small bore piping that pressure sewers have, and are therefore suitable for flat and undulating ground, where rock is outcropping or where there are high water tables. Septic tanks are not required. The vacuum equipment is relatively sophisticated and requires regular expert maintenance or replacement. The valves at each site also require maintenance, but these can be carried out on a contract basis.

4.7 Modified Conventional Gravity System

This is not a true alternative system incorporating specific features which differ from conventional sewerage, but an alternative method of designing and building a conventional system.

Design codes and standards for sewerage have been developed by sewerage authorities all over the world with the objectives of maximising the reliability of the collection system and reducing maintenance requirements. The practices have been aimed mainly at the larger more densely populated metropolitan areas and urban centres. The sewerage facilities for smaller towns and villages have usually been based on the same set of standards and codes as used in the cities, and this may be inappropriate. It could be argued that a reduced level of service may be acceptable for smaller communities, provided that the residents and water practitioners are prepared to accept some inconveniences (e.g. increased frequency of sewer blockages, the possibility of more frequent overflows during wet weather, vehicle access restrictions, partial control of allotments).

The Melbourne and Metropolitan Board of Works is currently (April 1988) carrying out a review of alternative sewerage systems applicable to the Upper Yarra Valley area, as part of a broad study of current standards.

A list of issues identified in the MMBW study that could provide potential for cost savings in conventional sewer construction, are given below :

Issues providing potential for major cost savings

- Reduction of minimum cover requirements.

- Raising of sewers above minimum cover requirements at control locations and providing appropriate protection.

- Use of UPVC sewer pipes instead of vitrified clay pipes.

- Use of 100 mm diameter sewers.

- Revision of required trench width dimensions for sewers at shallow depths.

- Reduction in depth of crushed rock backfill in trenches in roads where sewers are deep (cover exceeds 1 m).

- Use of horizontal and vertical curved sewers to appropriate design rules.

- Increase of spacing between terminal inspection shafts and adjacent manhole.

- Use of alternative bedding types including one which allows the sewer pipe to be laid on the excavation base.

- Reduction of design flows for branch sewers and downstream facilities.

Issues providing potential for minor cost savings

- Pairing of property branches.

- Close attention to termination point of sewer line with respect to allotment boundary.

- Relaxation of minimum grade requirements.

- Revision of maximum design loadings for sewers.

- Relaxation of imported fill and bedding material specifications to suit local supplies.

- Concrete encasement on steep grades at less than minimum cover.

- Use of 100 mm dia. property branches under roads.

- Use of partial control or alternative systems, such as pumping, on individual allotment basis.

- Increased separation between manholes and increased use of inspection shafts.

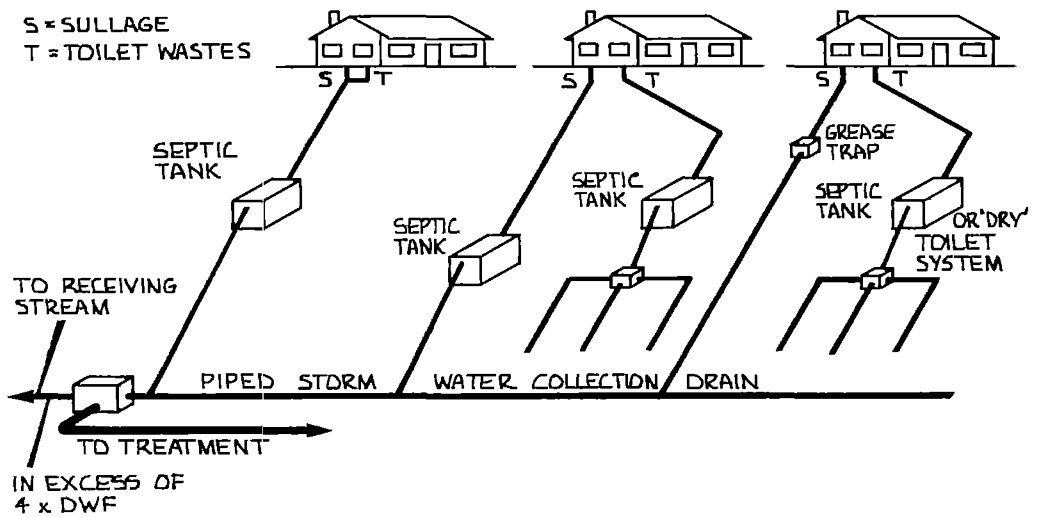
It is estimated that potential savings of around 15 to 20 per cent of construction and material costs could be achieved by adoption of the appropriate mix of these suggestions.

DATA SHEETS

for

RETICULATION OPTIONS

MODIFIED DRAINAGE SYSTEM (MD)



Description: Modified drainage is the combination of a portion of domestic wastewaters (septic tank effluent and/or sullage)and stormwater in the one piped system for conveyance to a treatment site. The treatment plant is designed to treat all waters up to (say) four times the design wastewater flow after which any extra is bypassed directly to the receiving stream. If sullage only is discharged, black waters are treated and disposed of on-site. Cannot be used with open stormwater drains.

Advantages:

1. Reduces pollution and health risks from backyards.
2. Inexpensive solution for areas with soil absorption problems and existing or proposed piped stormwater systems.
3. Stormwater, and particularly the 'first flush', is treated.

Disadvantages:

1. Discharge of dilute, but untreated effluent during high rainfall periods may cause environmental problems and health risks.
2. Septic tank maintenance still required.
3. Possible corrosion of cement based pipes if septic effluent is collected.
4. Special facilities for dealing with silt, trash and oils may be required.
5. Some effluents may have to be pumped into the drains if not commanded.
6. Septage treatment facility is required.

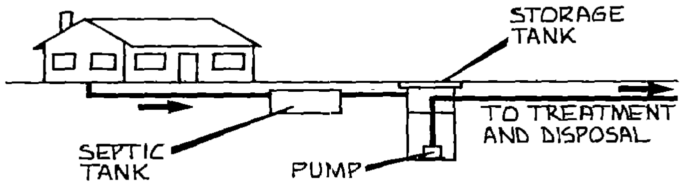
Indicative Costs:

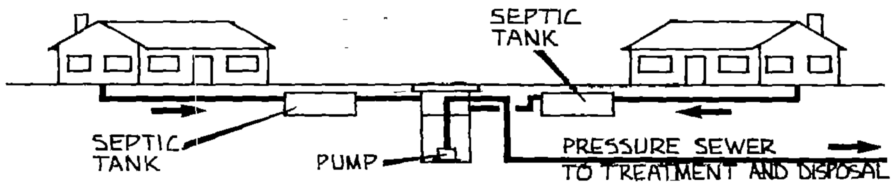
Assume stormwater system is existing, or if proposed, that it will be financed separately. Also assume existing septic tanks.

Construction Costs : $600 - $1000 per allotment (for connection of lot to drains). Allow additional $1000 if new septic tank is required. Excludes treatment costs.

Operating Costs : $80 - $100 everyfour yearsfor septic tank pumpout.

SEPTIC TANK EFFLUENT PUMPING SYSTEM (STEP)





Description: Effluent from the septic tank(s) flows to a storage tank equipped with a pump (submersible or externally mounted and equipped with isolating and non-return valves) which discharges the wastewater into a small bore reticulated pressure sewer system. The storage tank has sufficient volume to cater for pump failures of up to 24 hours. The pressure sewer can serve several hundred homes. Wastewater is discharged to a centralised treatment plant. STEP systems can be used for individual dwellings or in a cluster of dwellings. Septic tanks require periodic desludging.

Advantages:

1. Uses small bore pipes which can be laid at shallow depths following terrain, thus minimising construction costs. Particularly suitable for unstable soils, undulating terrain, high groundwater conditions, rock outcrops.
2. Infiltration/inflow is eliminated.
3. Low organic and solids loadings to treatment plants, which reduces treatment costs.
4. Peaking factors are reduced.

Disadvantages:

1. Effluent is septic and attention to odours and corrosion is necessary.
2. Relies on power supply for individual systems.
3. Septic tank needs periodic desludging.
4. Electromechanical equipment requires routine servicing.
5. Relatively high associated operation and maintenance costs.
6. Possible exfiltration from pressure sewer.
7. Septage treatment facility is required.

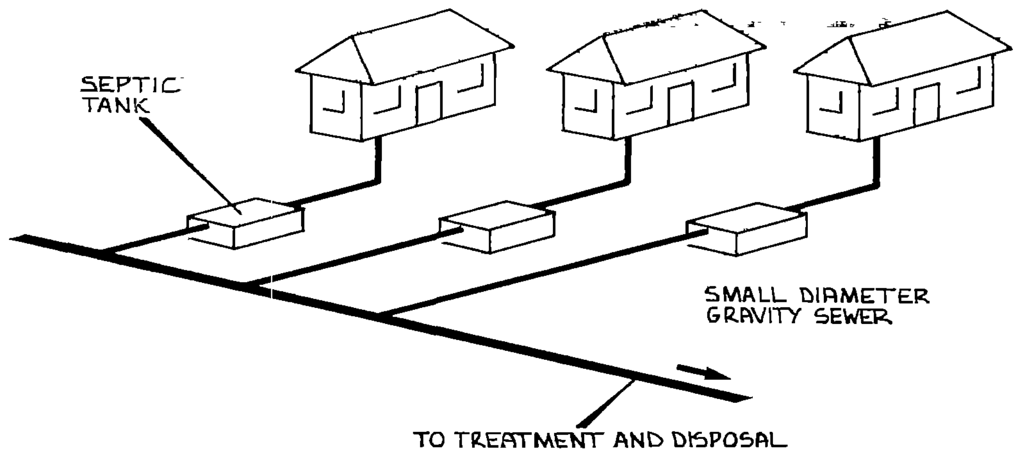
Indicative Costs:

Construction costs : $1500 - $2500 per lot including pump and excluding septic tank, connection to system and treatment facility.

Operating costs : - power $5 - $15 per annum
- desludging $80 - $100 every four years.

Pump costs : $600 - $1000 installed (for replacement).

COMMON EFFLUENT DISPOSAL SYSTEM (CED)



Description: The common effluent disposal scheme is similar to a conventional full gravity reticulation system except that wastes are firstly treated in a septic tank prior to discharge. The lack of settleable solids enables smaller diameter sewers to be utilised, laid at flatter grades and with lower self cleansing velocities. A majority of the manholes can be replaced with inspection openings.

Advantages:

1. Reduced frequency of blockages resulting in reduced sewer maintenance.
2. Reduced capital costs due to smaller pipes, flatter grades, fewer manholes.
3. Organic and hydraulic peak loads are reduced in the septic tank.
4. Reduced treatment requirements at centralised plant.
5. No energy requirement in collection system.
6. Reduced infiltration because of smaller pipes and fewer manholes.

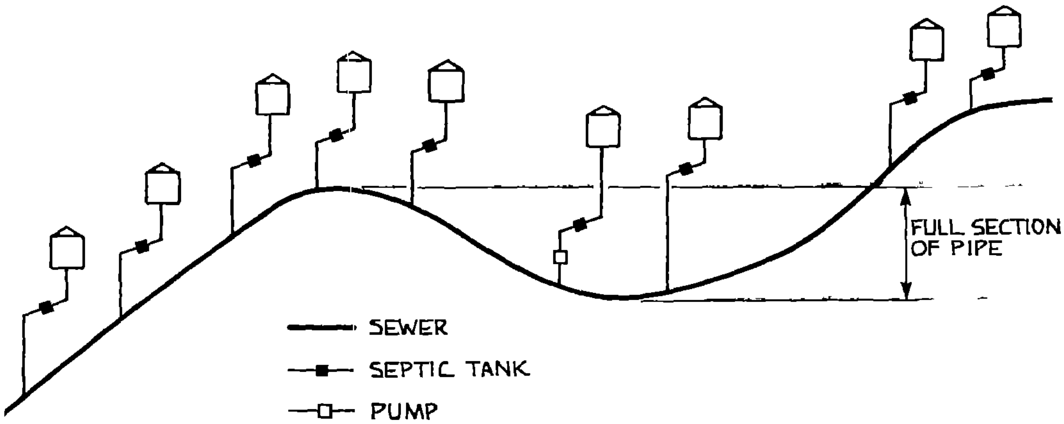
Disadvantages:

1. Periodic pumpouts of the septic tanks are essential to ensure adequate removal of solids and scum to prevent blockages in the sewer lines.
2. Septic effluent can cause corrosion (particularly in manholes) and odour problems.
3. Septage treatment facility required.

Indicative Costs:

Construction Costs	:	$1500 - $2500 per lot, excluding septic tank, treatment facility and connection of lot to system. Allow $1000 if new septic tank is required.
Operating Costs	:	$80 - $100 every four years for septic tank pumpout.

VARIABLE GRADE GRAVITY SEWERS (VGS)



Description: The system is similar to the Common Effluent Disposal scheme but it permits the collecting sewers to be laid at inflective grades, i.e., with a series of low points. The basic principle is the same as that of a sink trap. The complete system comprises a series of sink traps stretched out over a distance with net fall from inlet to outlet. The system can thus be laid at constant depth irrespective of grade. The system outlet must be located lower than the inlet of any house served by the sewer system. Some sections of the sewer will remain full at all times and this may cause maintenance problems. Premises in a valley section of the sewer which are below the sewer highpoint require pumps and valves similar to the STEP system, but overall the majority of houses discharge by gravity.

Advantages:

1. Reduced frequency of blockages resulting in reduced sewer maintenance.
2. Reduced capital costs due to smaller pipes, flatter grades, fewer manholes.
3. Organic and hydraulic peak loads are reduced in the septic tank.
4. Reduced treatment requirements at centralised plant.
5. Reduced energy requirement in collection system.
6. Reduced infiltration because of smaller pipes and fewer manholes.
7. Sewer can be laid at constant depth irrespective of slope.

Disadvantages:

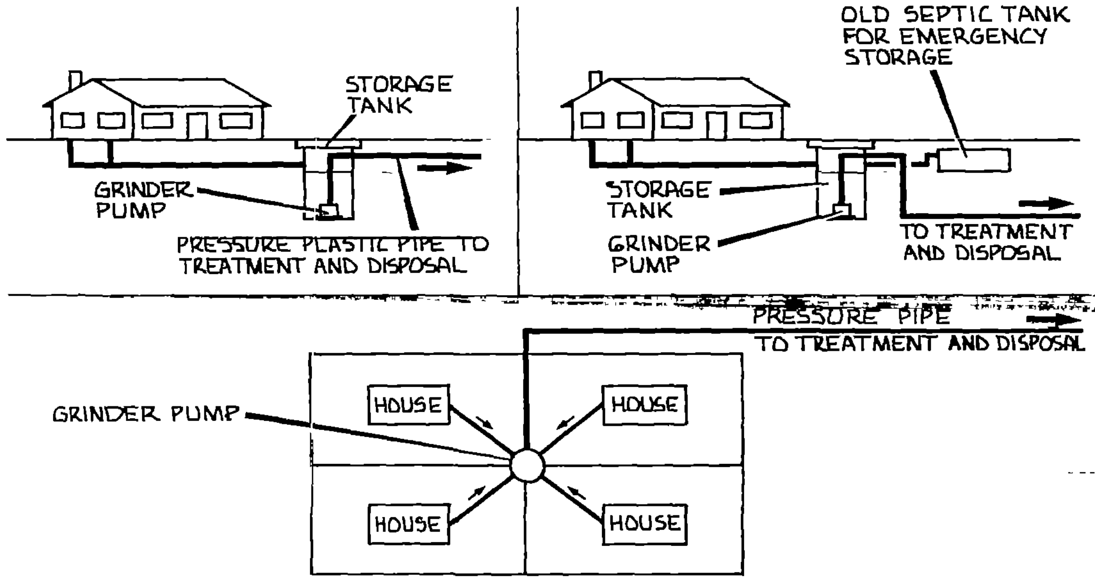
1. Periodic pumpouts of the septic tanks are essential to ensure adequate removal of solids and scum to prevent blockages in the sewer lines.
2. Anaerobic effluent in sewer can cause corrosion and odour problems.
3. Low points remain full of wastewater.
4. Pumps and valves may be required at some premises.
5. Septage treatment facility required.

Indicative Costs:

Construction Costs : $1500 - $2500 per lot, excluding septic tank, treatment facility and connection of lot to system.

Operating Costs : $80 - $100 every four years for septic tank pumpouts.

GRINDER PUMP SYSTEMS (GP)



Description: Grinder Pump Systems consist of macerating pumps capable of grinding normal constituents of domestic wastewater into small pieces and then pumping the wastewater to a small diameter (usually 30-50 mm for small communities) pressure sewer system similar to the STEP system. A septic tank is not required. Instead, a small wet well complete with the pump isolating and non-return valves and control equipment is installed. The wet well has one day's extra storage capacity to cater for pump failures. A single grinder pump can be used within a cluster arrangement for several homes to offset the installation costs.

Advantages:

1. Lower construction costs due to smaller piping and shallow narrow trenches. Also, piping can be redirected around obstacles.
2. Septic tanks are not required.
3. Infiltration is eliminated.
4. Pressure sewers follow natural ground profiles.
5. All sewage is removed.

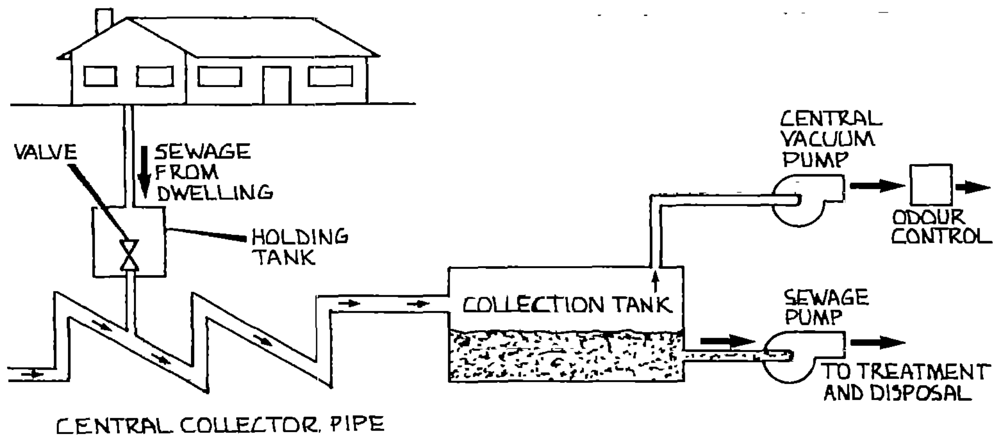
Disadvantages:

1. Higher operation and maintenance costs.
2. Relies on power supply to individual systems.
3. Grinder pumps are relatively expensive.
4. Possible exfiltration from pressure sewer.

Indicative Costs:

Construction Costs	:	$2500 to $3500 per lot, excluding treatment facility and connection to the system (based on one pump per lot).
Operating Costs	:	$40 - $60 per year for power.
Pump Costs	:	$1500 - $2000 installed (for replacement).

VACUUM SEWER SYSTEMS (VS)



Description: A vacuum sewer system comprises a centrally located vacuum source which draws sewage through a sewer network to a collection tank from where it is conveyed to a treatment facility. Each allotment, or group of allotments, has a holding tank (fed by gravity) and an interface valve. When the level in the holding tank reaches an upper limit, the valve is actuated and the tank contents are drawn as a slug of liquid into a small bore sewer. A volume of atmospheric air follows the liquid slug. The slug soon disintegrates and gravitates to a low point (tranportation pocket) in the sewer where it re-establishes. Subsequent flows of atmospheric air then push the slug further downstream and this action continues until the slug eventually reaches a collection tank at the vacuum pump station.

Advantages:

1. Sewer can be shallow, can follow terrain and can be redirected around obstacles.
2. Aerobic effluent.
3. No exfiltration from system.
4. Centralised power utilisation.
5. Takes all waste.

Disadvantages:

1. Regular maintenance of vacuum valves is required.
2. Needs standby electrical power.
3. Need for precise construction.
4. Potential for high infiltration due to negative pressure.
5. Limit on lift due to vacuum limitation.
6. Less tolerance to flows exceeding design values.

Indicative Costs:

Construction Costs : $3000 to $5000 per allotment, excluding treatment and connection to the system.

Operating Costs : $5 to $10 per allotment for power.

5. OFF-SITE TREATMENT OPTIONS

The wastewaters removed from allotments in the alternative reticulation systems discussed above must be treated before they can be discharged to land or to receiving waters. In addition, the alternatives that include on-site septic tanks or aerobic treatment plants require a system for treatment and/or disposal of sludges removed periodically from the tanks. This Chapter discusses the low-cost options that are available.

5.1 Range of Options

The type of treatment that must be given to the wastewater prior to discharge normally is dictated by the disposal location. Most often, conventional secondary treatment is necessary, involving removal of suspended solids and organic material (BOD_5) and effluent disinfection. In some cases, for example discharge to ocean, a lesser degree of treatment is acceptable. In other cases, more advanced treatment, for example removal of nutrients, may be necessary.

Conventional secondary treatment can be provided by a variety of biological processes, including the activated sludge system (in any of its various configurations), trickling filters, rotating biological contactors and lagoons.

Similarly, several sludge treatment and disposal systems are available, some sophisticated using chemical treatment (e.g. addition of lime), some using biological methods (e.g. anaerobic digestion) and some using disposal to landfill sites, subsurface trenches or ground spreading.

The more sophisticated treatment processes are usually applicable only to the larger sewerage schemes, where trained operators are available and back-up facilities for servicing equipment are at hand. The economies of scale that can be obtained by using the more advanced technologies make them cost effective. In small systems however, the same cost benefits are not obtained and the lack of manpower resources makes selection of an advanced treatment system inappropriate. Systems that are economical and simple to build and easy to run should be selected. Lagoon systems fall into that category and that is why most small towns and villages that already have a sewerage system use lagoons for treatment.

It has been assumed in this report that for most cases, a lagoon system will be appropriate, and that a suitable parcel of land outside the town boundaries will be available. Where this is not the case, or where more sophisticated treatment is required, other well proven systems should be considered. The most popular alternatives are expected to be oxidation ditches and package treatment plants.

The case of nutrient removal requires special consideration. The issue of eutrophication of inland waters is receiving much attention, both in Australia and overseas. In Victoria and New South Wales, there is a growing tendency by regulatory authorities to require removal of phosphorus and nitrogen from the larger wastewater flows prior to discharge. This attitude has not yet been applied to smaller flows. However, should it be, there may be difficulties in applying conventional nutrient removal technology to the sewerage systems of small, often isolated, communities. For this reason, a relatively 'new' process involving artificial wetlands and marshes, which is claimed can remove nutrients, is reviewed briefly. The wetlands systems are akin to lagoon treatment systems in that they are relatively simple to construct and operate.

A brief summary of the characteristics of lagoons, oxidation ditches, package treatment plants and wetland systems is presented in Table 5.1, and brief descriptions of each option are given below.

5.2 Lagoon Systems

Oxidation lagoons in Australia are usually designed to provide a detention time of around 30 days at average dry weather flow and to operate at a BOD_5 loading of around 80 to 100 kg/ha.d. The volumetric loading is usually in the range 5-10 g/m^3.d. The lagoon depth is usually 1.0 to 1.5 m. Higher loading rates are sometimes used in warmer climates.

Maturation ponds which are provided as a final polishing step and to ensure effluent disinfection, are designed for 30 days detention time also.

TABLE 5.1 CHARACTERISTICS OF COMMONLY USED TREATMENT SYSTEMS FOR SMALL SEWERAGE SCHEMES

SYSTEM	ADVANTAGES	DISADVANTAGES	APPROXIMATE CONSTRUCTION COST PER ALLOTMENT	COMMENTS
Lagoons	• No power req'd. • No special operator skills required. • Ability to take shock loads.	• Large land area req'd. • Effluent quality only moderate. • May need lining.	$300 to $500	Favoured if land is available. Simple to build, easy to run.
Oxidation ditches	• Moderate area req'd • Can remove nutrients. • Good quality effluent.	• Power req'd. • High energy consumption. • Skilled operators req'd. • Sludge disposal.	$500 to $800	Preferred to package plant if land available. Not suitable for very small populations.
Package treatment plants	• Small area req'd. • Good effluent quality.	• Power req'd. • Skilled operators req'd. • Sludge disposal. • Possible noise and odour. • Susceptible to shock loads of toxic chemicals.	$600 to 1,000	Particularly useful for isolated or special pockets of development within larger urban devel.
Wetland systems	• Nutrient removal capability. • No power req'd. • No operator skills required.	• Relatively large land area required • Slow initial development.	$400 to $800	Useful if nutrient removal is required and large area is available.

The lagoon systems used in South Australia with CED systems consist of a first 1.2 m deep 2:1 length to width ratio lagoon with a detention time of 36 days, followed by four smaller maturation ponds in series each providing 7.5 days detention. The design BOD_5 loading on the first lagoon is around 90 kg/ha.d, which is based on a domestic sewage BOD_5 loading of 50 g/c.d and a 25 per cent BOD_5 removal in the septic tank. The NSW CED design guidelines use a similar loading.

Selection and design of a lagoon system should take into account possible contamination of groundwater, and steps may need to be taken to prevent infiltration. Where available, natural clays can be used to form an essentially impermeable barrier. Otherwise, special liners may need to be used. This could significantly increase the cost of a lagoon system.

5.3 Oxidation Ditches

Oxidation ditches use the extended aeration form of the activated sludge process. A detention time of around 24 hours based on average raw sewage daily flow is usually provided in the main basin, which is preceded by screening equipment. Clarification can be provided in separate secondary sedimentation tanks with sludge return, or can be accomplished in the main aeration basin through intermittent decanting of supernatant. This latter form is commonly used in NSW.

Oxidation ditches are used where a large amount of land is not available. They normally consist of shallow basins equipped with horizontal brush aerators or vertical turbine aerators which induce a circulating flow around the basin. They can be adapted for biological nutrient removal, and this practice is becoming more popular with increasing requirements for nutrient removal imposed by regulatory authorities.

Main disadvantages are requirement for trained operators and maintenance personnel with special skills, high energy consumption, and the need for treatment and disposal of waste sludges produced by the process.

5.4 Package Treatment Plants

Package treatment plants are similar to the individual home aerobic treatment systems described earlier except that they are designed to handle larger flows from communities ranging from a few dozen to several thousand persons. They have found particular application therefore for small isolated communities or for pockets of development within larger urban areas. One ideal application used successfully in many locations is to service a commercial area in a town which is otherwise served by on-site disposal systems. They therefore should be considered also for this application in conjunction with some of the other alternative sewerage systems described earlier, including modified drainage, STEP, VGS and CED schemes.

The most common package system is the extended aeration plant, with similar basic characteristics as oxidation ditches but the aeration basins are constructed from steel and are several metres deep. They therefore occupy only relatively small areas and are ideal for locations where land is limited. Other popular package treatment plants employ biological trickling filters and rotating biological contactors rather than the activated sludge process. There are over 20 major manufacturers of this type of equipment listed in State telephone directories who can provide a range of equipment designed to suit particular applications.

The disadvantages of package treatment plants include need for skilled operators and maintenance personnel, requirement for sludge treatment and disposal, and in cases where it is required to locate them close to residential areas, possible odour nuisances and noise pollution associated with mechanical equipment. They are also susceptible to hydraulic overloading and toxic chemicals.

5.5 Wetlands Systems

Recently, attention has been focused by many researchers on natural systems for treatment of wastewaters and for removal of nutrients, and aquatic plants in particular have been identified as nutrient removal agents. Treatment systems utilising aquatic plants have received several names including aquaculture, artificial marshes, emergent wetlands and root zone biotechnology.

Aquaculture systems usually comprise shallow lagoons stocked with floating plants (macrophytes) through which the wastewater is passed. The other systems also comprise shallow lagoons but these are stocked with emergent reeds which are planted in soil at the base of the lagoon.

The aquaculture systems generally rely on uptake by the plants of nutrients in the wastewater, and the assimilated nutrients are removed from the system when the plants are harvested. The other systems combine biological pollutant removal processes with physical processes e.g. adsorption of phosphorus onto soils contained in the reed beds. High BOD_5 and suspended solids removals (greater than 90 per cent) can be obtained. Also, removals of faecal coliform bacteria in excess of 99 per cent have been reported, although on average the performance is not as good. However, incomplete nutrient removal is often experienced and consequently aquatic systems are not considered by many to be a reliable nutrient removal process.

Area requirements are 3 to 4 m^2/population equivalent for treating primary settled sewage. Capital costs depend on site conditions and for small works can be between $400 and $800 per allotment. Lower unit costs can be expected for larger works. Operating costs are said to be not more than about one quarter of those of conventional small works. The life of the system is claimed to be about 100 years, dictated primarily by saturation of soil with phosphorus compounds.

Several European RZM plants were inspected in late 1984 by a visiting party of representatives of the UK's Water Research Centre (WRc) and of several water authorities. A 60-page report was published by the WRc in August 1985 (revised and reprinted February 1986). Significantly, the WRc report drew attention to the absence of odour at some of the plants where odour might have been expected because of the hot weather at the time of inspection. The report gives a generally favourable view of the process and as a result, several plants are under construction in the UK.

The main disadvantage of a root zone treatment system is that it takes up to three years to become fully operational and an alternate system is required for wastewater treatment in the interim period. Another option is to sewer a community progressively over a two to three year period.

The RZM would appear to be ideally suited to a community serviced by a STEP, CED or VGS system, as the wastewater is devoid of grit and coarse solids which could cause blockage problems in the reed bed if they are not removed prior to the sewage being introduced to the bed. Implementation of the scheme could be carried out progressively, by gradually extending the wastewater collection system and connecting premises to it in accordance with the plants' capacity to receive additional flows.

However, this is not seen as a problem because most premises would already be served by a septic tank soil absorption system which could be kept in service until the treatment plant was ready to receive the flow. Furthermore, progressive implementation could suit budgetary constraints.

Wetland systems have been used primarily in colder climates, and their performance in warmer climates particularly in relation to odour and potential for insect breeding is unknown.

5.6 Septage Treatment and Disposal

A system for disposal of the sludge pumped out periodically from septic tanks, i.e. the septage, is required. On average, each septic tank will need to be pumped out every three to four years. Assuming 3200 L septic tanks are used, the total volume of septage will amount to between one and two per cent of the volume of raw sewage.

Current practices encompass a variety of methods, including disposal at municipal land fill sites, dumping into trenches and then covering the trenches, spreading onto ground and then tilling the ground, storage and drying in evaporation lagoons, and disposal to nearby sewage treatment plants. The pumpouts are usually undertaken by private contractors who are then responsible for adequate disposal of the sludge.

It is suggested that disposal of the septage should be taken care of as part of an overall wastewater management scheme. The land acquired for the wastewater treatment lagoons should be large enough to accommodate a septage disposal facility. Depending on climatic conditions, an evaporation system could be used for sludge drying. During winter, any supernatant overflows from the septage lagoons could be directed to the wastewater oxidation lagoons for treatment.

6. AUSTRALIAN DEVELOPMENTS

This Chapter discusses the approaches taken in the various Australian States to low cost alternative technologies for provision of sewerage services.

Australia, or more particularly South Australia, was the world pioneer in the development of an alternative method for removing wastewater from household sites for treatment and disposal elsewhere. Their CED systems were introduced more than 20 years ago, following acceptance that on-site soil absorption on relatively small suburban blocks in country towns was not working, and recognition of the serious health risks associated with uncontrolled discharge of septic effluents to open street drains. Costs of conventional sewerage were considered to be too high, and so alternatives were looked for, and found.

The remaining States have been slow to accept the South Australian experience, even though they were, and still are, facing similar problems with widespread failure of on-site disposal systems. Considerable research into methods of improving the performance of septic tank/soil absorption systems has been undertaken, however, and this has resulted in improvements to design and construction of new systems. Every Australian State can claim introduction of significant improvements aimed specifically at their own particular conditions and range of soil types. However, existing systems generally have been left in their poor state. In some cases, responsible homeowners have acquired a package aerobic treatment system to improve conditions on their own lot, but there generally has been little incentive to do this because of the relatively high cost involved. Nevertheless, vendors of this type of household treatment system claim that there are several thousand units installed throughout Australia, mainly in New South Wales.

The situation described above is gradually changing. The South Australian CED system is being looked at seriously in Victoria, New South Wales, Queensland and Western Australia. Vacuum systems are in operation in Victoria, New South Wales and Western Australia. STEP systems are in use in New South Wales, Western Australia and the Northern Territory.

Unfortunately, relatively little technical information is available about these systems. Nevertheless, their existence points to the increasing attention that is being given to these systems.

The efforts of the individual States are discussed below. The discussions do not include recent changes to septic tank/soil absorption practices adopted by each State, because these are considered to be variations on a theme. Septic tank treatment followed by some form of on-site disposal is an accepted and adequate form of sewerage, provided proper guidelines for design, construction, operation and maintenance are followed. Therefore, the discussions below concentrate on the alternatives that are available between the two more common forms of sewerage in Australia today - septic tank systems and conventional sewerage.

6.1 Victoria

Victoria has a few examples of alternative sewerage schemes. A CED system serving the alpine resort of Mt Baw Baw was installed around 10 years ago by the Forests Commission. Few details of the system are available, but it is estimated that up to 2000 persons are serviced by the system during peak seasons. The septic tank effluent is collected in a small diameter pipe system and treated in an aerated lagoon system. No operating problems are reported by the health officers of the Shire of Narracan.

A small CED system serving 20 dwellings at Boisdale, near Maffra, was also installed about 10 years ago. The septic tank effluents are conveyed to a lagoon system, which also receives wastewater from a large septic tank serving a nearby consolidated primary school with a student population of around 200. The soil absorption systems previously used in the township were abandoned because of failure due to periodic high water tables and fears of contamination of local bore holes. The Council arranges for pumpouts of the septic tank when required, but local householders pay individually for the service which is provided by contractors.

There are two locations where CED systems are under consideration, Katamatite and Yarroweyah, both in the Shire of Cobram. In both locations, toilet wastes are treated in septic tanks and disposed of in absorption trenches. Sullage is discharged without treatment to open street drains. The clayey nature of soils, coupled with the restricted area available on each household site, render on-site disposal of all wastes impossible. The Council is investigating the use of CED systems to serve these 2 townships of 200 (Katamatite) and 85 (Yarroweyah) persons.

Victoria is the birthplace of the term 'modified drainage'. It originated in the Shire of Buninyong, near Ballarat, in the late 1970s. Buninyong township was served by septic tank/soil absorption systems, some receiving all household wastes but some only for toilet wastes, in which case untreated sullage was discharged to open street drains. The soils in the area generally are impermeable and during winter months a high water table exists. The failure rate of septic tank systems was very high.

The township was not served by a piped stormwater drainage system either. In considering options for servicing the township with improved wastewater and stormwater drainage systems, the option of a combined septic tank effluent/sullage/stormwater collection system was looked at. It was decided that such a system had sufficient merits and a pilot scheme was constructed to serve 45 homes.

After consultation with rural landowners in the district it was concluded that it was inappropriate to discharge the combined wastewaters and stormwaters to the local creek without treatment, so a treatment lagoon was built to provide 30 days detention time based on the average daily wastewater flow. The lagoon inlet included a diversion structure which diverted flow in excess of four times the design flow directly to the creek so that during dry weather conditions and mildly wet conditions, the whole of the flow would be treated. Only in heavy rainfall when large volumes of runoff were collected, would bypassing to the creek occur. However, the bypass flow itself would be diluted and the receiving stream flow would also be high.

The system has been in operation for about eight years, with no apparent problems, although there were some nuisance odours during the initial months of operation. Little data are available on treatment performance, because during the first years of operation the lagoon never overflowed due to the suspected presence of a nearby mine shaft which apparently provided a drainage pathway. However, during the winter of 1982 the lagoon did overflow and tests indicated reductions of BOD_5 from 15 to 4 mg/L, suspended solids from 34 to 14 mg/L and E. coli from 15000 to 340 org/100 mL. More importantly though, the problem of emerging septic tank effluents in backyards and untreated sullage flowing down open street drains was solved.

The modified drainage system developed in Buninyong undoubtedly has merits in that it can effectively eliminate pollution risks from household backyards and streets. The treatment system, while not as efficient as a system treating wastewaters only, will provide a considerably higher degree of environment and health protection than discharge of untreated sullage. The author of the report on the Buninyong scheme quotes Mr R Otis, a leading US authority noted for his extensive research on low cost sewerage systems with the University of Wisconsin, as stating, when discussing the modified drainage concept: 'Your approach to solving the problems of wastewater collection and treatment in rural settlements is a rational one; one which I advocate ....'. It is interesting to note that this is the only reference to the rationality of alternative systems encountered in the extensive survey of published information undertaken for this low cost sewerage options study. Terms like cost-effective, affordable, acceptable, desirable abound; rational is a new one.

Another approach which has been used in Victorian towns is collection of untreated sullage in piped stormwater drains. This system is being used at Pyramid Hill in the Gordon Shire for 240 houses, at Strathmerton (140 houses) and Wunghu (about 60 homes) in the Shire of Numurkah, and in an aboriginal settlement at Lake Tyers in the Shire of Tambo. In all the above cases, toilet wastes are treated on site by a septic tank/soil absorption system, but sullage is discharged to the drains. The above systems do not yet include any treatment of the collected sullage/stormwater which is discharged to a watercourse, but this is under consideration as part of a staged program in Pyramid Hill, Strathmerton and Wunghu.

Victoria has one small vacuum system at the dockside amenities on St. Kilda Pier. There also are small systems serving factories, a laboratory and caravan parks, and one system is being planned to serve a new subdivision and industrial and recreational facility at Point Lonsdale, near Geelong.

The Geelong and District Water Board considered conventional gravity reticulation for this development, but this was discarded because of the very flat terrain and high groundwater table. If a conventional approach was used, ten pumping stations would be required and most sewers would be below the groundwater table. A vacuum system was selected for the 600 persons development, at about two thirds the cost of a conventional system.

There is an experimental reed bed system at Frankston.

6.2 New South Wales

New South Wales has not used the alternative systems identified herein to any great degree either. There is one CED system at Lightning Ridge near Dubbo, for about 600 persons, and another one at Deepwater near Tamworth serving 360 persons. Smaller systems have been used at Rankins Springs (35 persons), Hill End and Eugowra, and at several small aboriginal communities including Murrin Bridge, Collarenebri, Gingie, Namina, Bokal-Nee, Malabugilmah, Tabulam, Karuah, Caroona and Toomelah.

Small STEP systems have been used at Medowie, Blackhalls Park, Collarenebri, and Wilcannia.

New South Wales is perhaps the leading Australian state in the implementation of vacuum systems. The first and best known system is at Sylvania Waters, built by the Sydney Water Board to serve an ultimate total of around 600 properties. Other New South Wales vacuum systems include the recently constructed system at Minnamorra for 300 premises, one at Bonnett Bay and two are being designed for Tacoma and Kurnell. Port Botany has a small system for its container terminal. Systems are being considered for Karuah and Salamander Bay on Port Stephens.

Pilot scale work on aquaculture and wetlands systems is being carried out at Richmond by the Hawkesbury Agricultural College.

6.3 South Australia

The situation in South Australia is well known. There are over 80 towns presently served by CED systems, and new systems are continually being constructed across the State. About 40 000 properties are connected to CED systems at present. Design guidelines and criteria have been well documented and have been the basis of design of similar systems in the US and of most other Australian systems already in place. CED systems have been built to cater for populations ranging from a few hundred up to 5 000 persons.

A STEP system has been built at Renmark, one has been approved for construction in a subdivision at Paringa, and systems are being considered at Aldinga-Sellicks Beach and at Port Willunga.

6.4 Western Australia

The Public Works Department (now part of WAWA) in Western Australia has undertaken several alternative sewerage schemes for country towns. These include:

- In the early 1960s, the towns of Pingelly, Wundawie, Denmark and Kununurra were sewered. The schemes picked up septic tank effluent. The reason for doing this was to reduce the need for primary treatment at the treatment works. However, the reticulation system was designed using conventional criteria.

- In the 1970s, Wyndham and Ravensthorpe were sewered similarly to the four towns above, except that high density polyethylene pipes were used and the pipe gradients were relaxed- but not to the extent permitted by the South Australian CED design guidelines.

A STEP system was constructed in the early 1980s to serve several premises at Pelican Point on Matilda Bay in Perth. The properties consisted of a restaurant, a yacht club, two boating clubs, an office building and some public toilets. The system has operated successfully for about five years.

A trial of two different types of grinder pumps was carried out in Queen's Park, Perth, each one serving four houses. Apart from minimum maintenance problems, both systems have been judged to be satisfactory after around five year's operation.

The only known vacuum system in Western Australia is at Shay Gap, serving about 1500 persons in a mining community. No details of its operation are known. Vacuum systems were considered for canal developments at Mandurah, but were discarded in favour of conventional systems as they turned out not to be as economic as originally thought.

6.5 Queensland

Queensland has no examples of CED systems or pressure and vacuum sewers, although consideration is being given to CED systems for communities at Aratula, Yungaburra, Emu Park and Wallangarra. A small vacuum system for 20 buildings in Sanctuary Cove is being considered.

6.6 Northern Territory

STEP systems have been constructed at the 200 person aboriginal settlement at Peppimenarti and at a service and commercial area of about 170 blocks in Palmerston. It is understood that there are several other small STEP systems in the outskirts of Darwin, and it is intended to construct systems at Gapuwiyak (Lake Evella) for 300 persons and Alpurrurulum (Lake Nash) for 250 persons.

6.7 Tasmania

There is one CED system in Cygnet but no details have been obtained.

6.8 Summary of Australian Developments

There are around 130 locations in Australia where alternative wastewater collection systems have been built or approved. The largest concentration is in South Australia which has around 85 CED systems. The remaining 45 are scattered around the states. An approximate summary of existing alternative schemes is as follows :

ALTERNATIVE SEWERAGE SYSTEMS IN AUSTRALIA

CED Systems	:	107
STEP Systems	:	10
Grinder Pump Systems	:	2
Vacuum Systems	:	6
Modified (Sullage/ stormwater) Systems	:	5

		130

The above demonstrates that Australia has commenced to accept alternative low cost wastewater collection systems. More than 130 000 Australians (110 000 in South Australia) are being served by alternative collection systems. While this is less than 1 per cent of Australia's population, the proportion is probably greater than in any other developed country.

7. OVERSEAS DEVELOPMENTS

This Chapter reviews recent activities in developed and developing nations in the search for alternative low cost sewerage facilities.

7.1 Developed Nations

The majority of published information on alternative sewerage schemes has emanated from the USA, where during the last decade or so a variety of economical and technically simple innovations have been proven in practice under the umbrella of the EPA's Innovative and Alternative Technology (I/A) program. Other developed nations have not stood still, however. The search for low cost, low energy, low maintenance and simple systems is occurring around the world, although relatively little information is being published at present, presumably because of the relatively short time since the alternative technologies began to be seriously considered as long-term solutions to the sewerage problems in higher income nations.

7.1.1 United States

On-Site Treatment and Disposal

About one quarter of the US population, i.e. around 60 million persons, live in small communities or isolated dwellings scattered over the nation. The majority of these smaller urban developments are served by septic tank/soil absorption systems, many of them failing because of inadequate site and soil conditions or improper operation and maintenance procedures. Consequently, American researchers have been placing a lot of emphasis on development of improved on-site disposal systems.

The most comprehensive recent US work on on-site treatment and disposal of domestic wastewaters is the University of Wisconsin's Small Scale Waste Management Project carried out during the 1970s.

That research work showed how tenuous and unscientific much of the previous septic tank practice really was, and it prepared the way for further research and development across the country with the aim of formulating sound technically based guidelines for the design, construction, operation and maintenance of on-site wastewater disposal systems.

The Journal of the Water Pollution Control Federation publishes annual literature reviews dealing with all aspects of wastewater collection, treatment and disposal. The last four reviews (1984 to 1987) contain over 220 references dealing with on-site alternatives for treatment and disposal, covering the following aspects :

- health and environmental aspects
- performance
- management
- community systems
- hydrology
- pathogen transport and fate
- virology, microbiology and epidemiology
- soil chemistry and morphology
- attenuation of pollutants
- siting and design.

The underlying tenet in all of the US work seems to be that wastewater management based on continued use of on-site systems is cost effective and can provide adequate environmental and health protection. However, there are several provisos. First and most important, the site must be large enough and it must be capable of receiving and containing the amount of wastewater that is discharged to it. Several modifications to the conventional soil absorption trench have been tried successfully, including mound systems, alternating systems, evapotranspiration systems, pressure distribution/dosing systems, aquaculture, etc. Second, they must be operated and maintained correctly; poor operation and maintenance of on-site systems have been found to be the major causes of failure.

Third, they must not be used close to a source of groundwater. Pollution problems and outbreaks of disease can occur if proper precautions are not taken to keep pollutants away from groundwater.

Some work has also been carried out on waterless systems, including aerated vault latrines, composting latrines, pit latrines and chemical latrines, aimed mainly at Army encampments. The conclusions from this work generally are that applicability of waterless technology is limited by aesthetic and maintenance problems and in some cases by the relatively high purchase and operating costs. Also, it has been concluded that these waterless systems are not as safe (healthwise) as conventional septic tank/soil absorption systems.

<u>Alternative Sewers</u>

The findings of recent US work on development of viable cost-effective alternatives to traditional wastewater collection systems are contained in the Water Pollution Control Federation's Manual of Practice FD-12 entitled 'Alternative Sewer Systems', published in 1986. This report, which reviews vacuum, pressure and small diameter gravity sewer systems, claims: 'The following text has been prepared using a comprehensive analysis of all available information in the published literature and individual project information sources', and '... is the first consensus book on this subject and represents state-of-the-art systems in this rapidly expanding technology'. The manual is indeed a comprehensive text, comprising over 60 references (pre 1984) and addressing about 20 alternative projects.

At present, there are over 20 STEP installations, 80 grinder pump installations, 130 small diameter gravity sewer systems and around two dozen vacuum systems operating in the US. The better known alternative collection systems (because of separate dedicated papers) in the US include the following :

- STEP system at Pt. Charlotte, Florida, currently serving around 700 homes. This was originally built in 1968 to service only the waterfront lots and lots remote from existing services.

- STEP system at Glide, Oregon, designed to serve 7000 persons. Originally served by septic tanks/soil absorption systems, many of which failed due to unsuitable soils. Commenced operation in 1977.

- STEP system at Manila, California, serving 250 lots. Rural community with sandy and unstable soil, undulating terrain and high groundwater-table unsuitable for septic tank/soil absorption systems. Constructed in 1978.

- Grinder pump system at North Lajunta, Colorado, serving a population of 1100. Frequent failures of absorption fields and the close proximity of many shallow individual water supply wells created a potential health hazard. Became fully operational in 1982.

- Grinder pump system at Lake of Egypt, Illinois, serving about 800 properties. A lakeside development with inadequate provisionfor on-site disposal. Commenced operation in 1983.

- Grinder pump system at Weatherby, Missouri, serving 500 properties. Has been in operation for over 15 years.

- Variable grade gravity sewer system at Mt. Andrew, Alabama, serving 31 houses. A demonstration project which has been operated since 1975. Similar to South Australia's CED system, but allows inflective grades.

- Variable grade gravity sewer system at Westboro, Wisconsin, serving about 100 homes. Originally part of the Small Scale Waste Management Program of the University of Wisconsin.

- Vacuum system in Queen Anne's County, Maryland, constructed in 1981. Twelve vacuum stations serving 2500 homes and apartments.

- Vacuum system in County Squire Lake, North Vernon, Indiana, constructed in 1979. Seven vacuum stations serving around 2000 homes.

- Vacuum system at Lake Chautaugua, New York, with four vacuum stations serving around 1700 homes.

Design, operation and evaluation of alternative wastewater collection systems in the US over the last decade or so is rapidly convincing wastewater practitioners that these systems are no longer alternatives - they are viable, cost effective and permanent solutions to the wastewater collection, treatment and disposal problem. Close to one million persons are probably being serviced by these alternatives at this time. Design of electromechanical equipment required for some of the options has improved, and equipment is now available that can be expected to operate without maintenance requirements for 5 to 10 years.

It is anticipated that many more of these systems will be built around the US in the future to serve small towns and villages. The major obstacle to wider use of these systems appears to be unfamiliarity by both designers and environmental agencies. However, this is being rapidly overcome.

Alternative Treatment Technologies

On the treatment side, the I/A technology program has resulted in more than 400 innovative projects being funded. It is estimated that Federal, State and local investment in the decade since the I/A program started now exceeds US $5 billion, and that US $2 billion in life cycle costs have been saved. Interestingly, several of the projects being investigated in the US have been in use in Australia for many years. Some of the new designs tried out in wastewater treatment plants include the following :

- Overland flow (OLF) in which wastewater is fed onto the top of uniformly graded terraces and flows as a thin film over the vegetated soil surface (c.f. grass filtration at Werribee, Victoria).

- Intermittent sand filtration (ISF), in which effluent from septic tanks or aerobic treatment units is applied periodically to a bed of granular material. Perforated piping below collects and conveys the effluent for surface disposal (c.f. septic tank and sand filtration in Victoria).

- Sequencing batch reactors (SBR), in which the activated sludge process is carried out in just one tank (c.f. the Bathurst box in NSW).

- Wetlands marsh system - an artificial marsh and aquaculture system designed to polish effluents.

- Intrachannel clarification (ICC), in which a secondary clarifier is incorporated within an oxidation ditch thus eliminating the need for separate structures and a sludge return system. Referred to as 'boat' clarifier.

Lagoon systems are receiving renewed attention in the US because of their simplicity, reliability and suitability for small rural communities. It is generally possible to find a sufficient parcel of land outside the town boundary. Designers of STEP and small diameter gravity sewer systems are looking at lagoons favourably, as they can receive the effluent directly without any pretreatment (which has already occurred in the septic tanks) and so there is no need to provide any mechanical equipment nor even an electricity supply to the treatment site. However, it is understood that lagoons do not qualify as I/A technology, and this has perhaps stifled more widespread use of simple lagoon systems.

7.1.2 European Experience

There is evidence that European countries are also looking at low cost options, but unfortunately researchers and administrators do not have the same propensity to publish that the Americans do.

United Kingdom

British consultants seem to have concentrated their efforts on low cost sanitation for developing countries, and so there is very little information published regarding low cost systems in use in Britain.

Vacuum systems were first introduced into the UK in 1980, i.e. only eight years ago, with a system for 12 fully occupied wards of St. Johns Hospital in Chelmsford, Essex. The Anglian Water Authority's Peterborough sewage division has built two systems, one urban and one rural in Spalding, Lincolnshire. More recently, the Anglian Water Authority installed a vacuum system for a scattered community of 700 people in the village of Earl Stonham near Ipswich, because a conventional scheme would have been uneconomical in the very flat terrain. It is understood that there are at least another 10 small vacuum systems around the UK, and new ones are planned for at least six locations, one being the resewering of the streets in Dartford for Dartford Borough Council. The council chose a vacuum system because of the very congested underground services which would have made the laying of generally deeper and larger diameter conventional sewers very difficult.

The villages of Holton and Raydon in Bobergh District Council with a total of about 180 houses are served by a vacuum system, as is the Brighton Marina which berths 2300 vessels. A vacuum system is planned for a 120 person settlement in Powys, Wales.

No references have been identified dealing with the use of pressure sewers or small diameter gravity sewer systems in the UK.

In terms of alternative treatment, there has been interest recently in reed-based technology following the visit by a group of British engineers and scientists to Germany to inspect the latest developments in that technology. Systems are being constructed by the Anglian Water Authority at Acle near Norwich, by the Yorkshire Water Authority at Holtby in York and an experimental system by the Thames Water Authority. There are over 40 small commercial size installations in the UK in total.

Europe

Available information is limited, and usually consists only of references without any details. Pressure systems are apparently used quite extensively in the outskirts of Hamburg, Germany. Reed-based treatment systems are used extensively for small communities in Germany, with over 80 plants in existence.

Holland has several vacuum systems installed in poor soil where conventional gravity systems were considered inappropriate. The largest is at Dietne. Reed-bed treatment is also practiced. The Government is carrying out a research program on technology relevant to small communities yet to be serviced (about 10 per cent of the population).

Other European vacuum systems include Longeuil Annel, France (200 homes), Soljenar recreation area, Sweden (130 homes), and some systems in Belgium.

Modified drainage systems have apparently been used quite extensively in Italy, where treatment plants often receive a mixture of septic tank effluents, raw domestic sewage and stormwater.

Reed-bed treatment systems have been used in Denmark (more than 100 systems) and Austria.

7.1.3 Other Countries

Canada has a grinder pump system in Termagami serving 140 buildings scattered in rock terrain. Treatment is by anaerobic lagoons. Other pressure systems exist, but no details have been identified.

A vacuum system has been built at Bridgeview West, in British Columbia, Canada, to serve 700 homes.

Modified systems are used in Israel, and reed-based systems have been used in South Africa and Venezuela.

7.2 Developing Nations

There is a mass of literature on low-cost sanitation for developing nations. Much of it is repetitive, some conflicting and some of the ideas seem to be little tested in the field. The most authoritative information is contained in a series of publications from the World Bank which contain the findings of a two-year research project launched by the World Bank in 1976 as a prelude to the declaration of the International Drinking Water Supply and Sanitation Decade (1981 - 1990). This series alone contains more than 600 references relevant to low cost technology. Several other more recent publications are also available.

The overriding need in providing sanitation in low income countries has been one of simplicity. In many of these countries, water and power are unavailable or in very short supply, chemicals are very expensive, spare parts for any kind of machinery or fixtures are unobtainable and there are few skilled tradesmen able to undertake maintenance work. Hence robust simple engineering has been pursued. However, nothing startling has been identified. Much of the work has concentrated on improving the designs of the systems that are known to work. These systems include pit latrines, vault latrines, pour flush latrines, aquaprivies, cartage systems, septic tanks, and composting toilets.

Perhaps the most interesting new development in recent years in low income nations is referred to as Shallow Sewer Systems, in which small diameter sewers laid at very flat gradients and at shallow depths are used to carry raw sewage, not septic tank effluent. This system has been used successfully in high density low income urban areas in Brazil and Pakistan. Wastewater solids are flushed along the sewers by successive waves of wastewater. The solids progress in a sequence of deposition, transport, deposition, transport; this continues until the sewer has drained a sufficiently large area for the flow to cease being intermittent. The success of the system relies on a high frequency of wastewater production coming from dense urban areas in which a large proportion of the population is present for most of the time. This concept can be taken as the extreme limit of the design-rule relaxation concept examined in the MMBW Standards Study referred to earlier in which conventional sewerage design and construction practices are being examined critically with a view to reducing costs in the provision of sewerage to towns in the Upper Yarra Valley in Victoria.

7.3 Summary of Overseas Developments

The following points briefly summarise recent developments in various countries.

- Extensive research in the US has identified requirements for design, construction, operation and maintenance of on-site treatment and disposal systems. These systems can now be made to perform satisfactorily (given acceptable site conditions) and provide adequate health and environmental protection.

- Pressure sewer systems, including both grinder pump systems and STEP systems, are becoming increasingly popular in the US. Other developed countries including Canada and Germany are beginning to take an interest.

- Variable grade gravity sewer systems are gaining acceptance in the US, where even inflective gradients are permitted. They are also recommended for developing countries.

- Vacuum systems have been used in the US, the UK, Holland, France, Sweden, Belgium and Canada, and are gaining acceptance for servicing difficult areas.

- Shallow small bore sewers conveying raw sewage are being used in high density low income countries.

- Combined septic tank/stormwater systems (modified drainage) are used in Italy and Israel.

- Waterless systems are not considered appropriate for developed countries, for aesthetic, health, and maintenance related reasons.

- Several innovative treatment technologies have been developed. Considerable attention is being given to reed-based aquaculture systems in Germany, the US, the UK, Holland, Denmark, South Africa and Venezuela.

- Lagoon systems are receiving renewed attention in the US, particularly for small towns, because of their simplicity and reliability.

8. SELECTION GUIDELINES

This Chapter presents guidelines which can be used to identify the most appropriate alternative sewerage options for small towns and communities. The discussions are restricted to alternative collection systems, and do not deal with the alternative treatment systems identified in Chapter 5.

8.1 Comparison of Alternatives

Each of the alternative systems considered has characteristics which may make it the most cost-effective option under a given set of circumstances. The characteristics of the areas to be served by the sewerage system will have a major influence on the selection, together with whether the area is already served by on-site septic tanks. Another important factor is the ability and willingness to undertake the routine maintenance, in particular of pumping and vacuum equipment, but also of the septic tank itself (i.e. regular pumpouts). Other factors which also need to be taken into account are location of the treatment facility, and whether it is at a higher or a lower elevation than the residential area. In the former case, a pumped system may be appropriate, whereas in the latter a gravity system may be best.

8.2 General Rule

As a general rule, on-site treatment with a septic tank and subsurface disposal will be the most economical option, providing the allotment size is sufficient for a properly sized soil absorption system. In homes with an existing but inadequate ST/SAS, the soil absorption system could be upgraded at relatively low cost, provided institutional arrangements exist to enforce the upgrading. Otherwise, new systems could be constructed.

Where a suitable piped stormwater drainage system is available, modified drainage is also an inexpensive option, as it involves only a connection into the stormwater system and construction of a lagoon treatment system. From a health-risk point of view, it would be preferable to continue to dispose of toilet wastes through an existing septic tank/soil absorption system and dispose of only the sullage to the stormwater system. It would also be preferable to treat the sullage in a septic tank prior to disposal to remove silt and provide some attenuation of peak discharges.

Modified drainage does not provide a complete level of service and this may not be acceptable to the community or to relevant authorities.

A further constraint with a modified drainage system is the potential corrosion effect of septic sewage on cement-based stormwater piping systems.

Examples of potential applications of the other alternative systems are given below:

1. Septic tanks are already used in a town where downhill slopes lead to a treatment site and there is limited operation and maintenance capability. A CED, VGS, or MCS system should be considered.

2. As in the first example above, but the treatment site is located at a higher elevation than the town; a STEP system is a logical candidate, providing proper servicing of equipment can be assured.

3. If in the second example, septic tanks are not available or are considered to be unsuitable, a grinder pump system may be appropriate.

4. In flat, high groundwater table areas not served by septic tanks, or in rocky areas, vacuum sewerage may be the best option, particularly in high population density areas. Alternatively, grinder pumps could be used, and if septic tanks are available, a STEP system should be considered.

5. In flattish terrain with difficult ground and existing septic tanks, a VGS may be attractive because the grade can be altered to avoid difficult areas. If the ground is good, a CED system could be favoured. If septic tanks are not already available, a conventional sewerage reticulation system could be more appropriate. Cost savings could be realised by adopting a less conservative sewerage system, i.e. a modified conventional system.

6. In a town with a small permanent resident population but a large proportion of holiday homes used only seasonally, gravity based systems (e.g. CED, VGS) may be more appropriate than mechanically based systems e.g. GP, STEP, vacuum systems, which would remain

idle for long periods. Also, small bore grinder pump and vacuum piping systems designed for peak seasonal loadings may perform inadequately during off-seasons when low flow rates are obtained and scouring velocities cannot be maintained in the pipelines.

7. In towns anticipating substantial future growth, systems that do not need minimum scouring velocities (CED, VGS, STEP) may be more appropriate because they can handle a wider divergence of flows. It may be less costly in total cost to provide new developments with conventional sewerage systems.

8. In warmer climates, septic effluents may lead to increased hydrogen sulphide problems. Vacuum sewers may be attractive.

8.3 Information to be Collected

Prior to embarking on identification and selection of the most appropriate alternatives, certain information needs to be gathered concerning the town. The basic data required include:

1. population density and growth (permanent and seasonal)
2. allotment sizes, types, and distribution
3. soil types
4. typical topography, geology, hydrology
5. existing sewage disposal practices
6. existing stormwater disposal practices
7. possible treatment/disposal sites
8. climatic data (temperature/rainfall/evaporation)

8.4 Selection Questionnaire

The selection questionnaire shown in Table 8-1 (at end of Chapter) has been developed to assist in identifying the most appropriate options for a town. The basic format of the questionnaire is as follows:

First, determine whether there are any special considerations about a particular town which need to be kept in mind during the selection process. Then proceed to the questions.

Q1 Determine whether reuse of the town's wastewater is to be practised.

Q2&Q3 Determine whether septic tank/soil absorption systems and on-site disposal can be used for all household wastewaters in the long term.

Q4 Determine whether disposal of toilet wastes only on the site is feasible.

Q5&Q6 Determine whether modified drainage is feasible and acceptable. Options include all-waste septic tank effluent or sullage only depending on existing on-site facilities.

Q7 Determine whether existing septic tanks can be used as part of a sewerage scheme.

Q8,Q9 &Q10 If septic tanks are to be retained, determine which of STEP, VGS and CED is most appropriate.

Q11 If septic tanks are not to be used, determine which of VS, GP and MCS is most appropriate.

The questionnaire is a broad tool aimed at identifying the most appropriate options in order of cost, and cannot answer all the questions that may arise in a particular situation. However, flexible and intelligent use of the questionnaire will lead to possible options. In particular, where on-site treatment and disposal systems are concerned, it will not identify which particular type of soil disposal system (e.g. conventional trench, mound, evapotranspiration) should be used. In this case, the designer should refer to published guidelines to select the most appropriate on-site option.

In the case of modified drainage, once it has been identified that the system may be feasible, the designer must liaise with the Council and the relevant authorities (EPA, DCE, SPCC, PHD, etc.) to determine whether such a system is likely to be approved, and under what conditions. Also, the type of effluent that will be collected (septic effluent or sullage only) needs to be identified.

The use of the questionnaire is illustrated in the next Chapter.

TABLE 8-1 SELECTION QUESTIONNAIRE

Terminology :

- MD : Modified Drainage
- VGS : Variable Grade Sewers
- VS : Vacuum Sewers
- MCS : Modified Conventional Sewerage
- STEP : Septic Tank Effluent Pumping
- CED : Common Effluent Disposal
- GP : Grinder Pump Systems

CARE IN USE OF QUESTIONNAIRE FOR SPECIAL CIRCUMSTANCES

The optimum solution for a town may involve a combination of sewerage options for different sections or parts of the town. This may occur for example where there are differing physical conditions, where a large new development is anticipated, or where there are significant commercial areas, multi-tenanted buildings, industries, camping grounds, etc., where on-site components of a sewerage system may need to be kept to a minimum. In these cases, each part or section of the town may need to be considered separately. However, it is emphasised that if different systems are used, they must be compatible.

QUESTION NUMBER	QUESTION	ANSWER	COMMENT	ACTION
1	Is reuse of town's treated wastewater for landscape irrigation or other large-scale reuse scheme a desirable or attractive aspect of the proposed sewerage scheme?	Yes	On-site disposal on individual allotments is inappropriate.	Go to Q7
		No	All options should be considered.	Go to Q2
2	Are most allotments in town? A - less than 2000m^2 B - between 2000m^2 & 4000m^2 C - larger than 4000 m^2	A	On-site treatment/disposal of all household wastewaters is inappropriate.	Go to Q4
		B	On-site treatment/disposal may be appropriate, depending on site characteristics.	Go to Q3
		C	On-site treatment/disposal probably will be acceptable.	Investigate on-site systems

QUESTION NUMBER	QUESTION	ANSWER	COMMENT	ACTION
3	Is soil mainly sandy with good permeability, low groundwater table and good depth to bedrock, both more than 1.2 m from surface?	Yes	On-site treatment/disposal probably will be acceptable, despite smaller blocks.	Investig[illegible]e on-sit[illegible] systems
		No	On-site treatment and disposal of all domestic wastewaters is not appropriate.	Go to [illegible]
4	Can a toilet waste only absorption system be operated efficiently?	Yes	A toilet waste only absorption system in combination with an alternative sullage disposal system could be considered.	Go to Q5
		No	Any on-site absorption is considered inappropriate.	Go to [illegible]
5	Is the town provided with a suitable below ground stormwater system, or is one proposed in the near future?	Yes	Modified drainage could be considered.	Go to Q6
		No	Modified drainage is inappropriate.	Go to [illegible]
6	Is it considered that discharge of dilute untreated wastewaters at high rainfall times would cause detriment to the environment?	Yes	Modified drainage is inappropriate.	Go to Q7
		No	Modified drainage may be acceptable.	Investigate modifi[illegible] draina[illegible]
7	Is the town predominantly (i.e. greater than 75%) served by septic tank systems at present?	Yes	Septic tanks could be retained as part of sewerage scheme, to reduce costs. STEP, VGS and CED are options.	Go to Q8
		No	GP, VS & MCS are most appropriate options. STEP, VGS and GP could be considered.	Go to [illegible]1

QUESTION NUMBER	QUESTION	ANSWER	COMMENT	ACTION
8	Is there a large tourist influx?	Yes	STEP system inappropriate. VGS, CED are options.	Go to Q10
		No	STEP, VGS and CED are options.	Go to Q9
9	Is there a high groundwater table, or is treatment plant site located uphill from town, or is terrain very hilly?	Yes	STEP system may be preferable.	Investigate STEP System
		No	VGS and CED are candidates.	Go to Q10
10	Is the terrain rocky?	Yes	VGS is a candidate.	Investigate VGS
		No	CED is a candidate.	Investigate CED
11	Which of the following best describes the town? A - Flat, high groundwater table, relatively dense population. B - Flattish, good ground, relatively dense population. C - Any other combination of terrain, ground conditions groundwater conditions, population density.	A	VS is a candidate.	Investigate VS
		B	MCS is a candidate.	Investigate MCS
		C	GP is a candidate.	Investigate GP

9. CASE STUDY :PORT CAMPBELL, VICTORIA

The town of Port Campbell in the Shire of Heytesbury in Victoria has been selected as a case study to illustrate the use of the selection questionnaire developed in the previous Chapter.

9.1 Town Characteristics

Port Campbell, shown in Figure 9-1, is a seaport township with a permanent resident population of around 250. It is a popular tourist resort, having access to an ocean beach on Port Campbell Bay and being adjacent to Port Campbell National Park. The township comprises about 115 residences (permanent and holiday), around 50 vacant blocks, 8 commercial establishments, several hotels, motels and rental flats, foreshore amenities and a caravan park.

The population in the township can increase by a factor of almost 15 during peak holiday seasons. The estimated peak population is as follows:

Residents (permanent & holiday)	:	440
Hotel, motel, flat patrons	:	120
Campers	:	540
Day visitors	:	2500

		3600

It is expected that the township would grow through development of existing vacant blocks and construction of new rental accommodation to cater for increasing tourism in the area. However, more significant growth through development of new land is not anticipated.

The town lies in sloping land on either side of the Great Ocean Road. At the foot of the slopes is Port Campbell Creek which feeds into the bay adjacent to a sandy beach. The slope of the land is in the range 10 to 15 per cent. The soil is generally clayey, with relatively low permeability. Moderately hard limestone underlies the surface, although it is not known exactly to what extent. Depth to groundwater is believed to be around 1.0 m in the low lying caravan park area. High groundwater is not considered to be a problem elsewhere.

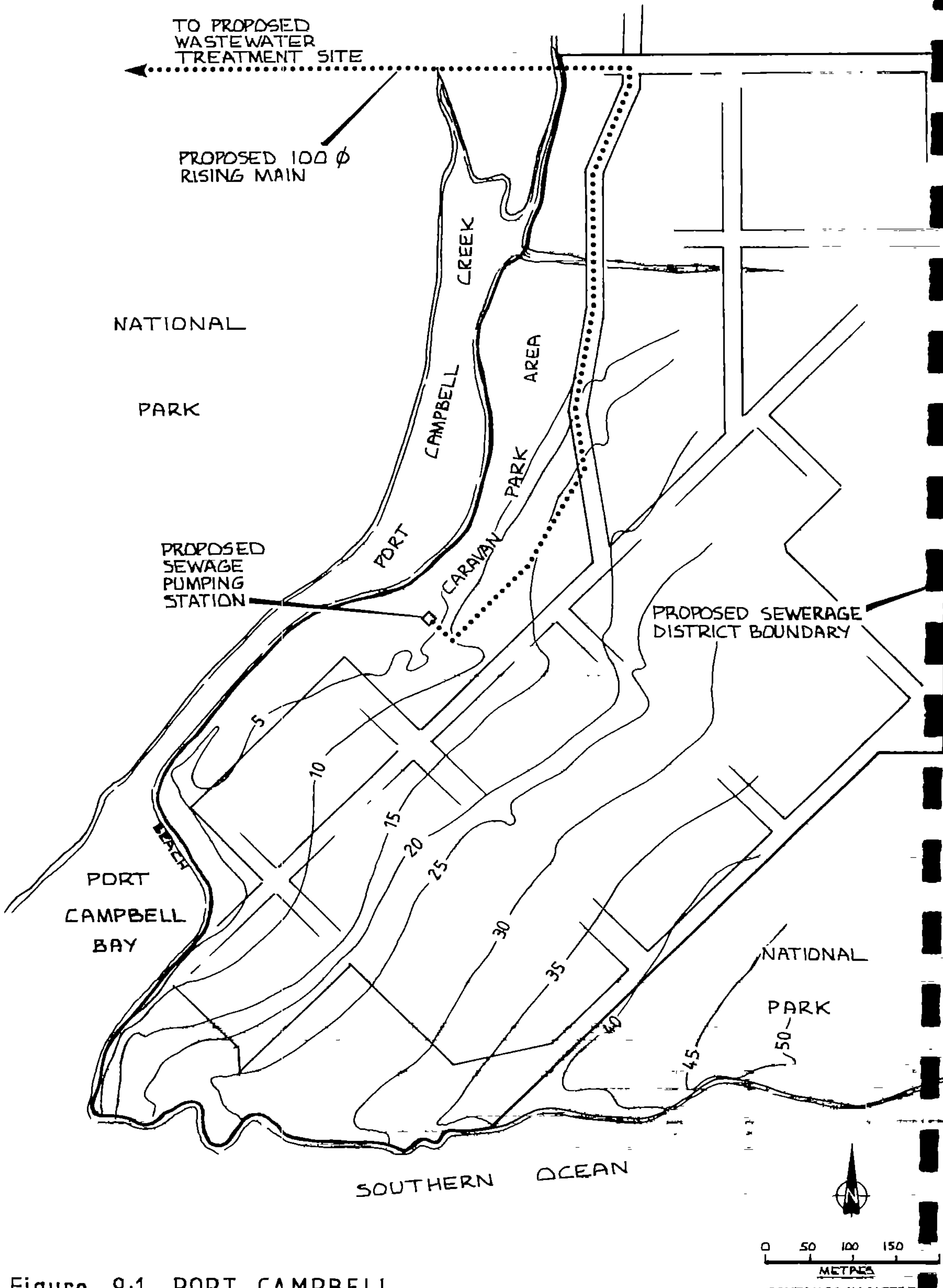


Figure 9·1 PORT CAMPBELL

9.2 Stormwater and Wastewater Disposal

The town has a below ground stormwater drainage system which discharges into the creek and onto the beach and enters the Bay waters.

Residences are normally served by toilet waste septic tanks and ground absorption systems which in general are operating satisfactorily. Sullage is usually discharged into stormwater drains, but in some cases it is discharged to on-site pits. The majority of sullage therefore enters the Bay. The pollution caused by the sullage and stormwater is considered unacceptable.

9.3 Previous Proposals for Upgrading Sewerage Facilities

Some years ago the feasibility of providing improved on-site treatment and disposal systems was investigated, but it was concluded that because of the relatively small blocks (most less than 1000 m^2), the poor soil absorption capacity and the high rainfall, on-site soil absorption for all household wastewaters generally was unsuitable. The provision of sand filters for effluent treatment prior to discharge to stormwater drains was also looked at, but the option was discarded because of its high cost.

In 1984, investigations were carried out with a view to providing a conventional sewerage system. A design was carried out and tenders for the construction of a sewerage system were called for. However, construction of the system was not proceeded with because of its relatively high cost. It is noted that at the time the investigations were carried out, it was recognised that a CED system probably was more economical overall (about 30 per cent) but since such a scheme would not attract Government subsidy at that time, the cost to the ratepayers of a CED would have been greater than for a subsidised conventional sewerage scheme.

9.4 Conventional Sewerage Scheme

The proposed conventional scheme consists of two separate catchments each draining to a single pumping station at the foot of the hill. A total of around 4500 m of 150 mm and 225 mm diameter pipes is required, together with 84 manholes. The majority of the gravity pipes would be located at between 1.0 and 2.0 m depth, but some of the sewers would be up to 6.0 m deep.

The pumping station would pump the wastewater through a 100 mm diameter rising main 2.0 km long to a treatment plant site located about 1.0 km due north-west of the town, across Port Campbell Creek on the opposite ridge. The 23 ha site would be used for treatment by lagoons in series, storage in winter, and land disposal by irrigation in summer. Ocean disposal of effluent from the lagoons has been considered as an option in the past, but has been discarded in favour of land disposal because of potential adverse impact to the marine environment off Port Campbell's National Park.

The estimated cost of the sewerage scheme at January 1987 levels was as follows :

Town sewers		
Reticulation	:	$500 000
Manholes	:	$103 000
Rising main	:	$117 000
Pumping station	:	$ 75 000
Irrigation system	:	$ 15 000
Treatment lagoons	:	$225 000
Land and easements	:	$ 55 000

		$1 090 000

Based on the potential total number of allotments in the town (about 180), the unit cost of the sewerage collection system, excluding any on-site facilities for connecting the rising mains, the pumping station and the treatment/disposal system, would be around $3300 at 1987 cost levels, or close to $3600 at March 1988 levels. The cost per existing building, including vacant lots, would be almost $5000 at 1988 levels. These unit costs do not allow for any subsidy.

The unit costs for the sewerage reticulation are in the typical range for conventional sewerage for small towns. Port Campbell is not a difficult town to sewer and it has no unusual features which might result in high unit costs. It has an average housing density with conventional sized building allotments.

The costs of the lagoon systems are considerably higher than those shown earlier in Table 5-1. The allowance for the Port Campbell lagoons is equivalent to about $1250 per allotment. However, this is attributed to the low loading rate adopted (about 30 kg/ha.d) and the large detention time (140 days).

9.5 Use of Questionnaire

This section illustrates the use of the selection questionnaire to identify the most appropriate options for alternative sewerage schemes for Port Campbell. A copy of a marked-up questionnaire for this town has been included as Table 9-1 (at end of this Chapter). An explanation of the answers selected is given below.

Special Considerations
There are eight commercial establishments, several hotels/motels and one caravan park, but no concentrated large commercial areas of significance. The caravan park may need special attention.

Q1 : Reuse of Wastewater
Answer : No. There would be no significant benefit associated with effluent reuse. The land irrigation method considered for effluent disposal is merely a disposal technique, not a deliberate attempt to reuse wastewater. Had the ocean been available for disposal, this method would have been selected.

Q2 : Allotment Size
Answer : A. The majority of blocks in town have an area of 1000 m^2 or less. Therefore, on-site treatment/disposal of all domestic wastewaters is inappropriate. This conclusion corroborates the earlier conclusion regarding the feasibility of on-site disposal by soil absorption; expensive methods such as sand filters or aerobic treatment systems to produce high quality effluent for discharge to stormwater would be required.

Q3 : Soil Types
Answer : Not applicable.

Q4 : On-site disposal of toilet wastewater
Answer : Yes, it is possible, as presently practised satisfactorily.

Q5 : Separate below ground stormwater system

Answer : Yes, therefore, modified drainage could be considered.

Q6 : Adverse impact of modified drainage scheme

Answer : Uncertain. There is no question that provision of a modified drainage scheme could improve water quality conditions in Port Campbell Bay very significantly, particularly because toilet wastes could continue to be treated on-site by soil absorption and only sullage could be discharged from each site to the stormwater (as at present). The initial flush of stormwater after rain would also be passed to the treatment plant for purification. The several existing stormwater discharge points at the foot of the town would need to be collected and taken to a central point, where a pumping station with an overflow could be constructed. All flows up to say four times the average dry weather flow could be pumped away from the town, and flows in excess of that volume could overflow into the Bay. Overflow discharge would be infrequent, generally only at times of heavy rainfall when climatic conditions would probably inhibit use of the beach in any case and dilution would reduce any adverse impact on the ocean. It is noted that because sullage only and not septic effluent would be collected in such a scheme, corrosion effects due to the characteristics of the waste would be minimal.

The combined wastewater would need to be pumped to a treatment site. The current proposal of lagoon treatment, winter storage and disposal by irrigation would be feasible. A smaller treatment system could be built because of significantly smaller flows (sullage only) and organic loadings.

Importantly, because of the significantly different nature of the wastewater, i.e. sullage only rather than sewage, it may be possible to reconsider ocean disposal after settlement as an option.

Pumping could create special difficulties at Port Campbell which have not been identified yet. An investigation would need to be carried out to establish the characteristics of the stormwater discharge to determine whether it carries excessive amounts of grit, debris, oil and grease or other pollutants which may render a pumping system inappropriate.

It is not possible in this report to consider all the environmental implications of a modified drainage scheme at Port Campbell. It does appear to be a possibility worth considering, particularly since it should improve existing conditions significantly. It may be possible to stage developments and build a modified drainage scheme and stormwater pumping station now which could be converted at a later stage into a wastewater pumping station if a separate sewerage scheme (conventional or otherwise) was contemplated for the future.

Should a modified drainage scheme at Port Campbell be unacceptable, then other options need to be looked at.

Q7 : Percentage served by septic tanks

Answer : Yes, the majority of homes have a septic tank, and therefore a STEP, VGS or CED system might be appropriate. However, the septic tanks generally are toilet waste systems only (about 1600 L capacity). Nevertheless, South Australian experience has shown that use of these smaller tanks in a CED system is adequate, and there is no reason why they could not be used in a VGS or a STEP system.

Q9 : Tourist Influx

Answer : Yes. Holiday residents, hotel/motel patrons, campers and day trippers can swell the population to almost 15 times the permanent resident population of around 250 persons. On this basis, a STEP system probably is not appropriate for two reasons. First, the pumping systems and piping would need to be designed for high wastewater flows which would occur only infrequently and for relatively short durations. Large systems would be required, with capacities considerably greater than required during off-season time. This would result in higher 'average' costs per allotment. Second, much of the system would remain idle during most of the year, and while this may save on wear and tear of equipment, it is not desirable to have mechanical parts idle in septic conditions for prolonged periods. Pipelines could also remain full of stagnant wastewater for months. Therefore, a free draining gravity based system would seem to be preferable.

Q9 : Hilly terrain, high groundwater terrain, uphill treatment plant site

Answer : This question is not really applicable to Port Campbell. However, a comment is appropriate. The one aspect which may have made a STEP system attractive is that the treatment plant site is uphill from the site. The individual pumps located on each site could have been designed to provide the required lift to convey the wastewater to the treatment plant site without the need of a main pumping station at the foot of the slope toward which all the sewage flows would gravitate. However, STEP systems in this case are not considered appropriate because of the need for the system to cater for a very wide range of flows.

Q10 : Rocky terrain

Answer : Generally no, although no exploratory drilling has been undertaken to determine the presence or extent of rock. However, the Shire's experience with construction of the stormwater drainage system is that moderately hard limestone underlies the area. Limestone close to the surface is relatively easy to rip. The design of the conventional sewerage scheme allowed for removal of hard rock by blasting for all excavation over a depth of 1.6 m. It is noted that over 80 per cent of the sewers in the conventional scheme would be laid at 0 - 2 m depth.

On the basis that rock is not widespread, a CED system would be the most appropriate alternative system for Port Campbell. However, if it is found that rock is more widespread than anticipated, a VGS system may be more appropriate. There could be benefits in having part of the town sewered using a VGS, and the remainder using a CED scheme.

Q11 : Not applicable in this case, as systems that use the existing septic tanks are more economical. Hence VS, GP and MCS systems are not preferred candidates.

9.6 Approximate Costs of Options

The cost of the conventional scheme, adjusted to March 1988 values, is roughly $1.32 million, comprising around $0.64 million for town sewers and $0.68 million for other components, as shown in Table 9-2. On-site costs, consisting of connection to the sewer, are based on $1200 per connection and 130 existing buildings.

The cost of CED sewers and connections has been based on $2000 per allotment (excluding connection and treatment), 180 allotments and 130 connections to existing buildings at $600 per lot.

TABLE 9-2 APPROXIMATE COSTS OF SEWERAGE OPTIONS FOR PORT CAMPBELL

ITEM	CONVENTIONAL SEWERAGE	MODIFIED DRAINAGE	CED SYSTEM
Sewers or drains	$642 000	$100 000	$360 000
Pumping station	80 000	70 000	70 000
Rising main	124 000	124 000	124 000
Lagoons	240 000	180 000	180 000
Land and easements	58 000	58 000	58 000
Irrigation system	16 000	16 000	16 000
Connection to system	160 000	(existing)	80 000
Complete system	$1 320 000	$548 000	$888 000

A modified drainage scheme could probably be constructed for about $0.55 million, or less than 50 percent of the cost of a conventional system. This cost does not make any allowance for the use of the existing stormwater pipes.

A CED or a VGS system could probably be constructed for about $0.90 million, or around 68 per cent of the cost of a conventional system.

9.7 Some Further Considerations

Port Campbell is not anticipating large future growth. Hence, solution of the pollution problem now, say by a modified drainage system, will solve the problem in the long-term. However, if this were not the case, and significant growth was anticipated, then modified drainage may not be an appropriate long-term solution and a CED scheme may be preferable at the outset, or at least as a second stage of development after an initial MD scheme. For towns in this situation, and even at Port Campbell should long-term growth forecasts change, it may be appropriate to set aside some land in new development areas which could be used for large communal septic tanks forming part of a CED system.

New development areas in towns served by MD systems could also be serviced by separate dedicated septic tank effluent sewers draining to an MD pumping station. The septic tank effluents would be given priority in pumping over stormwater by hydraulic design.

Separate dedicated septic tank effluent or even full sewage sewers having priority for pumping over stormwater could also be used to serve business or commercial centres with limited space or access constraints.

BLE 9-1 COMPLETED QUESTIONNAIRE FOR PORT CAMPBELL

rminology :

MD :	Modified Drainage	STEP :	Septic Tank Effluent Pumping
VGS :	Variable Grade Sewers	CED :	Common Effluent Disposal
VS :	Vacuum Sewers	GP :	Grinder Pump Systems
MCS :	Modified Conventional Sewerage	○ :	ANSWERS FOR PORT CAMPBELL

RE IN USE OF QUESTIONNAIRE FOR SPECIAL CIRCUMSTANCES

e optimum solution for a town may involve a combination of sewerage options for fferent sections or parts of the town. This may occur for example where there are differing physical conditions in parts, where a large new development is ticipated, or where there are significant commercial areas, multitenanted buildings, industries, camping grounds, etc, where on-site components of a werage system may need to be kept to a minimum. In these cases, each part or section of the town may need to be considered separately. However, it is phasised that if different systems are used, they must be compatible.

UESTION NUMBER	QUESTION	ANSWER	COMMENT	ACTION
1	Is reuse of town's treated wastewater for landscape irrigation or other large scale reuse scheme a desirable or attractive aspect of the proposed sewerage scheme?	Yes	On-site disposal on individual allotments is inappropriate.	Go to Q7
		(No)	All options should be considered.	Go to Q2
2	Are most allotments in town? A - less than 2000m² B - between 2000m² & 4000m² C - larger than 4000 m²	(A)	On-site treatment/ disposal of all household wastewaters is inappropriate.	Go to Q4
		B	On-site treatment/ disposal may be appropriate, depending on site characteristics.	Go to Q3
		C	On-site treatment/ disposal probably will be acceptable.	Investigate on-site systems

QUESTION NUMBER	QUESTION	ANSWER	COMMENT	ACTION
3	Is soil mainly sandy with good permeability, low groundwater table and good depth to bedrock, both more than 1.2 m from surface?	Yes	On-site treatment/disposal probably will be acceptable, despite smaller blocks.	Investigate on-site systems
		No	On-site treatment and disposal of all domestic wastewaters is not appropriate.	Go to Q[illegible]
4	Can a toilet waste only absorption system be operated efficiently?	Yes	A toilet waste only absorption system in combination with an alternative sullage disposal system could be considered.	Go to Q[illegible]
		No	Any on-site absorption is considered inappropriate.	Go to Q5
5	Is the town provided with a suitable below ground stormwater system, or is one proposed in the near future?	Yes	Modified drainage could be considered.	Go to Q6
	DECISION REQUIRED	No	Modified drainage is inappropriate.	Go to Q7
6	Is it considered that discharge of dilute untreated wastewaters at high rainfall times would cause detriment to the environment?	Yes	Modified drainage is inappropriate.	Go to Q[illegible]
		No	Modified drainage may be acceptable.	Investigate modified drainage
7	Is the town predominantly (i.e. greater than 75%) served by septic tank systems at present?	Yes	Septic tanks could be retained as part of sewerage scheme, to reduce costs. STEP, VGS and CED are options.	Go to Q[illegible]
		No	GP, VS & MCS are most appropriate options. STEP, VGS and GP could be considered.	Go to Q11

QUESTION NUMBER	QUESTION	ANSWER	COMMENT	ACTION
8	Is there a large tourist influx?	(Yes)	STEP system inappropriate. VGS, CED are options.	Go to Q10
		No	STEP, VGS and CED are options.	Go to Q9
9	Is there a high groundwater table, or is treatment plant site located uphill from town, or is terrain very hilly?	Yes	STEP system may be preferable.	Investigate STEP System
		No	VGS and CED are candidates.	Go to Q10
10	Is the terrain rocky?	Yes	VGS is a candidate.	Investigate VGS
		(No)	CED is a candidate.	Investigate CED
11	Which of the following best describes the town? A - Flat, high groundwater table, relatively dense population. B - Flattish, good ground, relatively dense population. C - Any other combination of terrain, ground conditions groundwater conditions, population density.	A	VS is a candidate.	Investigate VS
		B	MCS is a candidate.	Investigate MCS
		C	GP is a candidate.	Investigate GP

10. INSTITUTIONAL AND FINANCIAL ARRANGEMENTS

The previous chapters have focussed on technical aspects of alternative sewerage technologies. Economic considerations have been based on total costs to the community. However, there are also non-technical issues that will have to be addressed when consideration is being given to specific schemes.

To a significant extent the non-technical issues that have to be considered will vary from State to State within Australia, and within States there are also likely to be case-specific considerations.

It is not intended that this report should attempt to define the range of non-technical issues that may arise and even less will it attempt to define a set of solutions or a methodology to deal with them. Nevertheless, as the viability and acceptability of some alternative sewerage schemes can be contingent on non-technical aspects, the critical issues readily identified elsewhere, namely institutional and financial arrangements, are briefly discussed below.

10.1 Institutional Arrangements

A characteristic of conventional sewerage schemes is that only a small component of the total collection, treatment and disposal system is outside the direct care and financial responsibility of the sewerage undertaking. The owner/occupier is responsible only for the small on-site component.

The on-site component is normally simple pipework connecting home appliances to the sewer. It is generally trouble free. If anything does go wrong the consequent discomfort to the occupier is normally a strong incentive to the householder to take appropriate action well before it becomes a nuisance.

The alternative systems generally transfer some operation and maintenance responsibilities to the owner/occupiers. These responsibilities include regular maintenance pumpouts from septic tanks, attention to on-site soil disposal systems, and routine servicing of electromechanical equipment. In some cases, particularly the modified gravity reticulation systems, increased flushing and maintenance of the off-site reticulation by the authority can be anticipated, compared to that of a conventional system.

To ensure that the alternative sewerage systems perform satisfactorily in the long term, it is essential that the on-site owner/occupier's responsibilities are met consistently. It is this aspect that raises concern with many water administrators about some alternative technologies and which can lead to rejection of some of the options, and in the extreme to an attitude that only conventional sewerage is acceptable in the long term, no matter at what cost. The popularity of STEP systems in the US has suffered because of the fear that if septic tank systems are not maintained regularly, bypass of solids will occur and result in pump blockages. Similarly, small diameter sewers for septic tank effluents have not been too popular in the past because of fears of blockage of the common system due to solids bypass if individual septic tanks are not maintained. These fears, which are not wholly irrational, have tended to favour development of the grinder pump systems. Because they use pumps which are specifically designed to break down solids, the perception is that if they fail to operate they cause a problem to the occupier but do not lead to blockage of the common system.

Smaller water authorities in the US are increasingly resorting to management systems which place the responsibility for operation and maintenance of the whole system, including works on private property, with the authority. The responsibilities assumed by the authority would include regular desludging of septic tanks where they are part of a STEP or CED scheme. One Council in South Australia (Mt Barker) has already introduced such a system.

The Australian experience with septic tanks and pump-out systems has not been researched in detail but it appears that it has two characteristics. Firstly, operation and maintenance of septic tanks or other on-site facilities has always been the responsibility of the owner. Secondly, regular maintenance of septic tanks is not common, more typically they are pumped out when they go wrong.

Improved and regular maintenance of septic tanks will be an important factor in the success and acceptability of most alternative systems. It seems clear that the most satisfactory system would be to make this a responsibility of the sewerage authority, with the costs included in the charge rate for the whole service. Such an arrangement is in most cases not provided for in existing legislation.

10.2 Financial Arrangements

Conditions relating to payment for sewerage systems vary from State to State and even within States. For example, different subsidy schemes operate in each State, and within States qualification for subsidy can depend on the type of authority, the nature of the sewerage works, the costs of schemes, and the average costs met by consumers. Additionally there is the impact of developer contributions on new developments which basically result in full cost of on-site facilities together with contributions to trunk mains and sewage treatment plants being included in the initial purchase price for new homes.

The low cost alternatives will generally require an increased investment in the on-site component of the total system, that is for improved septic tanks in CED or VGS schemes, or for pumps and improved septic tanks in STEP schemes, or for pumps in schemes based on grinder pumps.

In new developments, it would almost certainly be administratively and probably economically desirable to use larger septic tanks serving a cluster of houses. In such cases on-site works would be virtually the same as for a conventional scheme and the septic tank (with or without pumps as required by the design) could be located on land owned by the sewerage authority.

In some States, the financial arrangements currently in existence tend to mitigate against lower cost alternatives, either by denying such schemes eligibility for subsidy or by failing to recognise the expenditure by owners in septic tanks or other facilities.

Consideration should be given to developing financial arrangements and tariff systems that seek to achieve equity between consumers when a new system is introduced. For example, it may be appropriate that the costs of all new septic tanks, whether on individual lots or serving a cluster of houses, should be borne by the sewerage authority. This would then allow authorities more freedom in deciding on the best technical solution. However, if this was done it would open an argument in favour of the authority paying for existing on-site facilities incorporated into schemes.

Additionally, consideration should be given to introducing legislation to allow approved alternative schemes to be eligible for subsidy or other government assistance on at least an equal footing to conventional sewerage. There is in fact an economic rationale to increase the subsidy level above that for conventional schemes if this serves the purpose of saving in overall costs. This scheme has been introduced already in the US.

11. FURTHER RESEARCH AND DEVELOPMENT

The brief issued for the study anticipated that deficiencies in the state of present alternative technology would be identified, and specifically requested that comments be included and recommendations be made for future research at a later date.

The options evaluated in the review are all basically proven, with the possible exception of wetlands systems, although these have been in operation in Germany for almost two decades and there is current on-going research on these systems in Australia. Comprehensive guidelines have been developed, particularly in the US, for septic tank/on-site disposal systems, and several Australian publications are available dealing with local conditions. The modified drainage concept is simple; the only area here where there may be some uncertainty is appropriate design flows and loadings. Also, some further information on sulphide content of septic effluents would be desirable. STEP, CED and VGS systems are in use in several countries, and US design guidelines are available. Similarly, grinder pump and vacuum sewer design is well documented. Perhaps the least known alternative system is modified conventional sewerage, but research is not required to develop design guidelines as it simply involves a less conservative approach than the one usually followed.

Therefore, no deficiencies that warrant further detailed research have been identified. What is necessary, nevertheless, is a need to agree on and formalise specific Australian design criteria for some of the options and to implement some comprehensive long-term monitoring program of alternative systems already in existence to obtain data that can be used to revise and refine the design criteria. This information will ultimately lead to the provision of efficient, effective and reliable low cost sewerage options for small Australian towns and communities.

A further key requirement is for an on-going well structured educational program that alerts water authorities and the public to the potential for reducing costs, either by adopting alternative schemes or by a closer hexamination of current design practices.

DEPARTMENT OF WATER RESOURCES

LOW COST SEWERAGE OPTIONS
STUDY BRIEF
DATED 30 OCTOBER 1987

1. BACKGROUND

Most of the larger cities and towns throughout Australia are served by a conventional fully reticulated sewerage system. The notable exceptions are Perth where about 300,000 people (nearly one third of the population of metropolitan Perth) live in areas which are served by septic tank-soil absorption system, and some 83 country towns throughout rural South Australia which are served by Common Effluent Disposal Systems.

In Victoria, there are only 12 towns with a population greater than 1000 which remain to be sewered. However, there are some 80 small towns which have indicated a desire for a reticulated sewerage scheme. Due to the higher unit costs for small projects, the costs of a fully reticulated conventional sewerage system for many of these small communities would place a severe strain on the financial resources of both ratepayers and Governments.

A highly capitalised sewerage system may also be a doubtful investment when the future economic viability of a particular town itself is in doubt (as is often the case). The situation in most other States is similar to that in Victoria.

Nevertheless, existing sanitary arrangements are often unsatisfactory, both from a public health and environmental viewpoint. Untreated or partially treated household effluents are frequently discharged into the street drains causing a threat to public health, offensive odours and unsightly conditions.

There is, therefore, an urgent need to consider alternative lower cost sewerage options.

While most States have recognised this situation and have been reviewing some of the available alternatives, there has been a considerable duplication and waste of effort through lack of a co-ordinated approach across the nation. To address this problem the Australian Water Resources Council has decided to arrange for the production of a State of the Art publication on the current technology of low cost sewerage options and preparation of guidelines for the selection of the most appropriate technology for the sewerage of small communities.

2. OBJECTIVES

The objectives of this study are:

(i) to undertake a comprehensive review of the available information relating to alternative approaches to collection, treatment and disposal of domestic sewage and sullage,

(ii) to prepare an overview of the state of present technology of alternative sewerage systems,

(iii) to prepare guidelines to assist in selection of the most appropriate technology for the sewerage of small communities, and

(iv) to identify any perceived deficiencies in present technology and make recommendations for further specific research if considered necessary.

3. PROPOSED APPROACH

The approach and methods to be used in the study should include the following:

3.1 Review of Available Information

A comprehensive review of available information (both local and overseas) relating to the collection, treatment and disposal of domestic wastewaters is seen as an essential first step in this project. The review should concentrate on technical issues, but institutional and health-related aspects of wastewater disposal should also be covered. Emphasis should be placed on appropriate systems which have low unit capital and operating costs and which are suitable for Australian small to medium sized urban centres.

The presentation of information should wherever possible include identification of the author, title and publisher of reference material. Unpublished items should be identified and only included with the author's consent. Any items which appear to throw new light on non-conventional waste disposal technology should be highlighted.

3.2 State of the Art Review

Based on the search of available information, the State of the Art review of alternative low cost sewerage options should :

(i) discuss the need for "appropriate" technology to be applied to provide a socially and environmentally acceptable level of service with a satisfactory standard of health protection at least cost,

(ii) describe the various technologies which are available for both on-site treatment and disposal and off-site collection, treatment and disposal of domestic sewage and sullage, including pan systems, composting toilets (solid wastes only), aquaprivies, septic tanks, pump-outs, proprietary systems (e.g. Envirocycle, Biocycle), Common Effluent Disposal Systems, Modified Drainage Systems (combined storm water/effluent drainage systems), vacuum and pressure systems for raw or partially treated sewage, lagoons, reed beds and other methods of low cost treatment and disposal,

(iii) describe systems available for waste treatment and disposal from multi-tenanted buildings (flats, hotels, shops, hospitals and industries) and suitability for use in places where off-site collection, treatment and disposal facilities are not available for the whole or part of a community,

(iv) comment on relative merits of each option including suitability for staged development, population size and type (tourist towns) level of health protection (possible problems with flies, mosquitoes and other insects, odours and waterborne diseases), environmental aspects, costs (both capital and annual, private and public), level of maintenance, and anticipated life of each option.

3.3 **Selection Guidelines**

One of the main objectives of the study is to develop guidelines to assist in selection of the most appropriate technology for any particular small community. There is considerable scope for development of an innovative approach to this task. The guidelines should enable the alternatives to be identified and allow the relative advantages and disadvantages to be compared.

3.4 **Further Research**

It is not anticipated that this study will be the forerunner of a series of further studies. However, the report should comment on any perceived deficiencies in the state of present technology which are recommended for further study at a later date.

4. CONSULTATION

A Steering Committee will be established to provide an overview of the study. The consultants will be expected to maintain close liaison with the nominated Department officer responsible for the study and to attend meetings of the Steering Committee as required.

5. REPORT

The consultant is to provide the Department with 50 copies of the final report. Final printing of the report shall not commence until authorised by the nominated Department Officer.

Except possibly for the cover, the whole of the report is to be in black and white and in A4 format (suitable for later reduction and reprinting in B5 format as part of the Water Management Series published by the Australian Water Resources Council)

The report shall become the sole property of the client and may be reprinted and amended as the client decides.

6. TERMS OF CONTRACT

It is expected that the attached Draft Agreement (based on the ACEA Guideline Agreement) will form the basis of the terms of contract for this commission.

7. TENDERS

The proposal should include:

- An appreciation of the study requirements.
- Expertise applicable to the project.
- Methods to be used in carrying out the study.
- A program for the various sections of the work.
- How the work will be organised.
- The capacity to undertake the commission within the time required.
- Names, qualifications and experience of key personnel to be engaged on the project.
- Method of liaison.
- Method of progress reporting.
- Any variations required to the Draft Agreement
- Any other relevant information.

8. TIMING

It is proposed that a contract will be let by the end of December 1987. Ten copies of the preliminary report will be required by 25 March 1988 for review by the Steering Committee, and 50 copies of the final report should be due for submission by 29 April 1988.

9. UPPER LIMITING FEE

It is expected that this project should be completed for a maximum fee of $35,000.

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GLOSSARY

General Terms

Aerobic	:	Containing oxygen
Anaerobic	:	Devoid of oxygen
Aquaprivy	:	Toilet system with vertical drop pipe located directly above a septic tank
Blackwater	:	Toilet wastewater
Greywater	:	Kitchen, laundry and bathroom wastewaters
Pit latrine	:	Toilet system comprising direct discharge of wastes to a below ground storage pit
Pour flush toilet	:	Toilet system with manual flushing
Sullage	:	Same as greywater
VIP latrine	:	Ventilated improved pit latrine. A pit latrine equipped with an external vent
Waterborne	:	A sewerage system using water as a carrier for the wastes
Waterless	:	A sewerage system using little or no water for waste carriage

Alternative Sewerage Systems

Common Effluent Disposal (CED)	A system with septic tank effluent being collected and conveyed in a gravity sewer. Also known as common effluent drainage, small diameter gravity sewers (SDG) and septic tank effluent reticulation (STER).
Grinder Pump (GP)	A macerating pump on each site grinds domestic sewage and pumps it into a pressure sewer system.
Modified Conventional Sewerage (MCS)	Similar to a conventional sewer system but with relaxed design and construction standards (i.e. slope, diameter, depth to cover, etc).
Modified Drainage (MD)	A system in which septic tank effluent, sullage, or both are discharged to a piped stormwater system. Includes treatment of combined stormwater and wastewater.
Septic Tank Effluent Pumping (STEP)	A pump at each site pumps septic tank effluent into a pressure sewer system. Also referred to as pumped CED in NSW.
Septic Tank/Soil Absorption System (ST/SAS)	A household wastewater treatment and disposal system involving treatment of the waste by settling in a closed underground tank followed by percolation of the effluent into the soil from a subsurface distribution system.
Variable Grade Sewer (VGS)	A small diameter gravity sewer which conveys septic tank effluent and can be laid at constant depth following terrain.
Vacuum Sewer (VS)	A system in which all sewage is conveyed by a vacuum at the end of the collection system.

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