WET AND DRY CONSERVANCY:
Politics and practicalities of on-site sanitation

by

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STATEMENT

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the Thesis, and to the best of the Candidate's knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the Thesis.

Signed Leonie Crennan ....

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ABSTRACT

This research explores the status of on-site sewage treatment in Australia with particular focus on composting toilets, and the transfer of the technology to a developing country application. The study began with a request from the Department of Parks Wildlife and Heritage in Tasmania, to inspect and evaluate composting toilet installations in the World Heritage Area and determine why they were not performing satisfactorily. The investigation was extended to a survey of composting toilet installations on the East Coast of Australia, predominantly in areas managed by public recreation institutions.

In an attempt to remedy some of the problems encountered in the survey of composting toilet facilities, design, installation and monitoring of a number of batch composting toilet systems were undertaken in a variety of contexts. Trials of these custom built public composting toilets were conducted at two remote high-use sites in the World Heritage Area in Tasmania, and at a road-access cafe facility in a New South Wales national park. Domestic installations were trialed in urban and rural locations in co-operation with local government in southern Tasmania and in the Northern Rivers district of New South Wales.

Field research and literature review in Japan and China explored the status of on-site sewage treatment in those countries and its relationship to the use of centralised reticulated sewerage systems. The findings of this review are related to Australia's current sanitation practice and future potential management. Contact was also developed with public recreation land managers in the United States and Canada and co-operative efforts were made to review on-site sanitation options in national parks.

A cultural and technical trial of composting toilets funded by the Australian Government aid organisation, AusAID, extended the technology developed in the above trials to the island of Kiritimati in Kiribati in the Central Pacific,

and assessed the value of the application from a social, political, administrative, environmental and technical point of view.

From the above investigations it was found that there are situations where centralised reticulated sewerage treatment is neither affordable or appropriate, and that water borne on-site options are also not practical. Those situations are probably best suited to dry conservancy techniques. The research, development and promotion of this technology has been undertaken by small business which has sometimes resulted in appropriate installations. On-site sewage treatment is generally limited by a lack of adequate infrastructure. The practical investigations in the study establish that even in the most constrained research circumstances, dry conservancy technology can be improved and does have the potential to provide an appropriate sanitation option. The thesis argues that on-site sewage treatment merits the provision of comprehensive institutional support, and a review of practice in other countries indicates directions that could be explored. Improvements in Australia's sanitation practice also has serious implications for technology transfer to developing countries.

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CHAPTER ONE

CHALLENGES TO SANITATION PRACTICE

It is generally recognised that contaminated water and the inappropriate disposal of human excrement are interrelated. To correct that problematic relationship it is suggested in this thesis, that a strategy of 'wet' and 'dry' conservancy be undertaken by those institutions that have been entrusted with the responsibility of water and sewage management.

In practice this would suggest that water is not squandered or 'wasted' and that sewage is not squandered or unnecessarily mixed with water to become 'waste water'. This requires a change of attitude in both the users and the managers of water and sanitation systems. Water borne sewerage systems and an unlimited supply of clean water are seen as the prerequisites of successful modern societies (Bureau of Sewerage 1995: 4). And the introduction of sewerage systems did coincide with the reductions of epidemics in countries such as Britain in the nineteenth century (Sidwick 1976: 66). But social and environmental conditions have radically changed since that time and a revaluation is necessary. That revaluation may be most effectively achieved by educated participation at all levels of society, not by imposition from a controlling authority, or by sporadic, uninformed, unsupported adoption of alternative techniques in a desperate attempt to move away from obvious misuse. Education could benefit from being integrated with practical experience, and will require the unconditional assistance of those who have money and power.

Centralised waterborne sewerage systems have been the primary method of domestic and industrial sewage disposal in Western industrialised countries for the last 100 years. While there are circumstances where sewerage technology is practical such as high rise urban environments, there are now long and short term problems that have become apparent with this method. These problems are generally acknowledged by both traditional administrators and concerned environmentalists. The bureaucratic infrastructure and the predominant lifestyle that is serviced by that infrastructure requires a 'technological fix' to the problems created by sewerage treatment (Lloyd 1993: 72). It is assumed that by additional investment in advanced technology, sewage can be more effectively treated (Annaka 1995: 4). Unfortunately, these innovations have often created further problems 'downstream' (Costner et al. 1986: 9).

An alternative approach is to rethink the paradigm of mixing of human and industrial by-products with potable water, piping the influent to a central filtration plant and discharging the 'treated' effluent into rivers and the seas. A re-evaluation of this methodology has taken place among some individuals in administrative bodies and to a larger extent within the community (Riggle 1990: 69). In various regions and towns, Australian citizens have formed associations to protest imposition of what they perceive as inappropriate sanitation technology in their districts (Crennan 1992: 47).

These protests have usually been unsuccessful in the immediate situation, but there is a growing inclination among administrators to consider public opinion, partly as a political necessity and partly because the problems that confront them are becoming financially and technically overwhelming (ACT Electricity and Water 1994: 6).

At a meeting with schoolchildren involved in a lagoon remediation program in Hobart, Tasmania, on Thursday June 15, 1995, the Australian Prime Minister, Paul Keating commented:

> A lot of these (environmental) problems come from sewerage plants and this is going to be one of the great challenges for Australia in the future, how we deal with waste... sewerage is a major problem. In fact the biggest investment is not in telecommunications or Telecom cables but in the sunk cost of the sewerage system...Essentially they are transport systems which transport tonnes of waste from one place to another and they often end up in the wrong place (The Mercury, Hobart, 16/6/1995).

A recent example of improved public relations is the funding of community research groups ('Peak Environmental Groups') by the Sydney Water Board[1] to provide suggestions for environmentally sound management of sewage disposal (Pers. obs. 1993-1994)[2], (Dowsett et al. 1995). This approach is more publicly acceptable than substantial investment in the opinion of overseas consultants (Beder 1989), and the consequent implementation of expensive short term solutions, and unpopular technological strategies, such as extended outfalls (Beder 1991: 88; Macdonald 1991: 91; Joint Select Committee Upon the Sydney Water Board: 1994).

Although improved community consultation is taking place, practical application is slow to follow. In some instances, public land managers and private individuals have taken the situation into their own hands and installed alternative technology from the limited range available on the open market. Examples of this activity will be examined in some detail in this thesis to illustrate the social, economic and political forces that govern attempts at more environmentally responsible management. There is much to be learnt from these situations as to what is the most effective strategy for introducing alternative technology, particularly if it challenges an established lifestyle or practice.

Some local government organisations in Australia and other countries have initiated progressive campaigns to educate and involve the public in conservation of water (White 1994a; Waterwise Queensland 1994: 19). The conservation of water, both in quality and volume, and the conservation of the resources contained in sewage are inter-related, and may best be managed through an informed discriminating process that responds to actual need rather than perceived or generated need. This process necessitates a more democratic involvement by the community in resource management strategies, particularly in the allocation of funding for research and installation.

It is suggested that resource management institutions should be a vehicle for implementing solutions to the community's real needs, not a self serving body that acts to justify its own existence. Institutions are often slow to respond to altered requirements due to the inertia of large organisations, but also because individuals within the organisations may be reluctant to explore

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[1] Now known as 'Sydney Water' since becoming a corporation.

[2] Throughout this thesis, certain statements are justified through personal observations (Pers. obs.) of the author. Such observations cannot be comprehensive but they lend support to the statements made.

more appropriate strategies for fear that their particular activity or contribution will become redundant (Martin 1979: 47). The challenge of providing an alternative livelihood for people engaged in work that may be ecologically degrading is an essential consideration in environmental politics. Reluctance to admit that a technology or strategy is inappropriate and requires revision can also occur among advocates of what appears to be more sustainable practice, particularly in the face of criticism from the dominant paradigm (Harper and Thorpe 1994: 14).

1.1 Participatory inter-disciplinary research

The aim of this thesis is to establish that the concept of wet and dry conservancy could be beneficially applied in sewage treatment and water usage and that a practical step to ensuring this process is to adequately fund and support research, development and management of on-site or decentralised sanitation[3]. The study is both participatory and multi-disciplinary and addresses aspects of certain inter-related questions.

> Is there a legitimate practical need for on-site treatment?
> Is that need satisfied?
>
> Do on-site systems, in particular dry conservancy technology, provide adequate treatment?
>
> What can be done to enhance the provision of on-site treatment where required?
>
> What are some of the implications of increasing the options in on-site treatment?

In answer to these questions, illustration of the current status of on-site research and development in Australia will be provided by examining the author's experience in this arena. The global potential and implications of the issue will be considered in an informative context through field investigation in Japan and China and through cross-cultural technology transfer in the Pacific.

[3] 'Sanitation' as it is used in this thesis refers to the Australian Oxford Dictionary meaning: "arrangements to protect public health, especially by drainage and the efficient disposal of sewage". It does not refer to the United States of America usage of garbage or rubbish disposal.

Results of the author's research in dry conservancy techniques will indicate the potential for development by demonstrating what can be achieved on limited funding and in unfavourable circumstances.

The research and development of on-site alternatives in Australia is slowly occurring in a piecemeal fashion usually in response to crisis. This thesis proposes that it is time that on-site sanitation research, development and management in Australia was undertaken in a cohesive, comprehensive, pro-active fashion.

The study does not conform to a traditional research format which presents a problem, related theory, methodology, results and conclusion. It does not claim to be a controlled experiment. There are minor quantitative components to the study such as temperature, usage and pathogen monitoring, but thorough analysis of this data is the subject of future technical papers. For the purposes of this study the significance of the quantitative component is to demonstrate what is possible in support of the broader proposition of what may be desirable. The study could be considered an example of 'action research' in the sense that it has dual aims of action and research:

> action to bring about change in some community or organisation or program, research to increase understanding on the part of the researcher, or the client, or both, and (often some wider community) (Dick 1992: 2).

The investigations described in the thesis involved the author's response and participation, and circumstances arising out of that participation required further response (Carr and Kemmis 1986: 18). While impartial analysis of the outcomes is undertaken, the author's participation in the research precludes what could be regarded as scientific objectivity and lends itself to qualitative review (Argyris et al. 1985: 54). However, it is suggested that the detailed sequence of events in a number of the Chapters could be likened to the description of steps taken in a laboratory to conduct an empirical study, and the conclusions drawn from those events has equal validity to results and conclusions from quantitative research (Checkland and Scholes 1993: 5). Although this study is multi-faceted and is informed by many different physical and social circumstances, the conclusion presented is focused and simple.

A multi-disciplinary approach is most appropriate to exploring and presenting the complex web of factors that influence the current status of on-site sanitation in Australia and elsewhere. While the thesis is a record of technical trials in a variety of circumstances, political, social and environmental factors created the opportunity for the research, determined its pace and extent, and significantly affected outcome. The challenge in a single study of this nature is to give those factors their due without the inquiry becoming diffused and diluted, and to present the process comprehensively and concisely for evaluation. In support of adopting this comprehensive position, it is indicated that the multi-disciplinary perspective pursued in the early stages of this study facilitated constructive development in the later stages by allowing the application of broad based experience and skills to a water quality problem that appears to have been created by a compartmentalised, specialist approach to sanitation in the past (refer Chapter Seven).

Much of the thesis is written as a record of events as they occurred. During the four year period of research there has been significant government and community expansion of interest in, and application of on-site treatment (Joint Select Committee Upon the Waterboard 1994: 147). Some of the changes that have occurred have been stimulated by this study. The author's primary technical focus in this field has been the design, installation maintenance and usage of composting toilets. The content of the thesis is an historical record, from the author's point of view, to allow qualitative analysis of the achievements, obstacles and challenges being created in this field, and to emphasise that one of the most important components of the evolution of decentralised sewage treatment is social rather than technical. The technical aspects are covered in the author's trials in this area, but as previously mentioned, it is not the purpose of this thesis to provide scientifically controlled trials.

The technical innovations were conducted in-situ in response to an urgent practical need which motivated provision of the necessary funding and opportunity for design, installation, maintenance and monitoring. It is considered that the designs are more realistically tested in the field where the idiosyncrasies of users, location and management can be assessed, although this approach reduced control over the parameters of the trials and the collection of reliable data (Kroshel 1981: 6).

1.2 Composting theory and practice

As this is a multi-disciplinary study which attempts to cover social, political and environmental issues relating to the design and application of composting toilets, a summary of relevant composting theory and practice may provide a useful technical background to the broad based investigation.

Composting animal and vegetable 'rubbish' is an ancient agrarian practice in Asian countries (King 1911; Handreck 1993: 2). The use of human excrement as a fertiliser also has a long history, and is associated with widespread parasite infection and other enteric diseases in populations that practice direct recycling of sewage (Scott 1952: 22). Composting of human excrement was developed and refined partly in an attempt to make this inexpensive and accessible fertiliser hygienic and pathogen free (Van Vuren 1949: 80; McGarry and Stainforth 1978: 5).

Composting is a very complex biochemical process and this summary can only outline the contributing elements that are interdependent upon each other.

1.2.1 Oxygen, carbon and nitrogen

Composting is most commonly defined as an aerobic process, i.e., the decomposition or stabilisation of organic matter by organisms which utilise oxygen and develop cell protoplasm from the nitrogen, phosphorus, potash, various micro-nutrients, and some of the carbon within the organic material. Carbon is also an energy source and is respired as carbon dioxide (CO_2) in addition to the production of heat and water vapour. The dual role of carbon as an energy source and component of cell protoplasm necessitates much higher quantities of carbon than nitrogen (refer Figure 1.1).

> The stoichiometric formula for glucose oxidation: $C_6H_{12}O_6 + 6O_2$ --- $6CO_2 + 6H_2O$ + HEAT, matches closely the dry solids loss of commercial composting. This confirms that the prime organic component, cellulose, is the main energy source in the composting process where adequate available carbon is supplied (Fahey 1992: 1).

Carbonaceous material should have a high carbon/nitrogen (C/N) ratio, e.g. 30/1, and the carbon should be readily available.

The addition of carbonaceous material, or 'bulking agent' to a compost pile also has a role in aerating the pile.

> A prerequisite to optimising growth conditions, and maximising heat output is a pore size distribution that has both good aeration through macro-pores and adequate sites for bacterial activity in smaller pores. The role of mixing (faeces and bulking material) to achieve this should not be underestimated (Chapman 1993: 18).

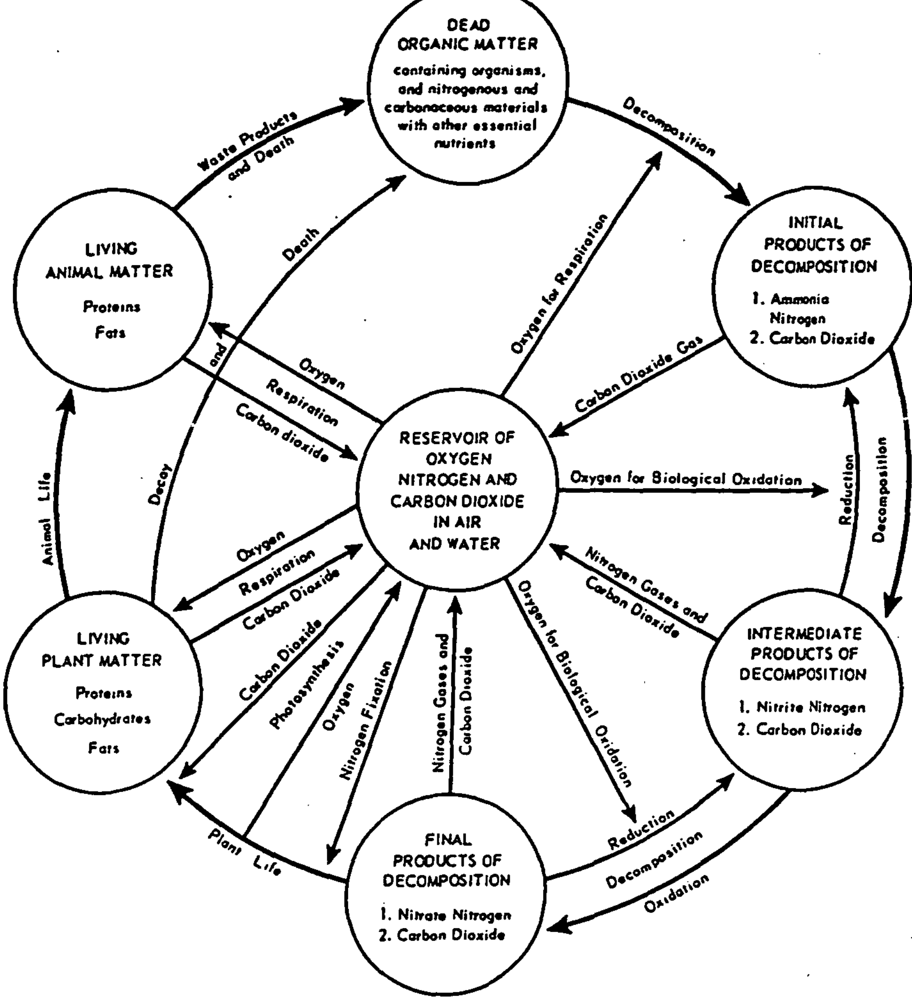
1.2.2 Moisture

As an aqueous medium is required for microbial processes, and micro-organism utilise substrate that is dissolved in water, moisture content should be in the range of 40-60% wet mass. Below 40%, that is, 40g water +60g dry matter, micro-organism mobility and solute diffusion is reduced, thus slowing down decomposition (Chapman 1993: 16). Above about 60%, the pore spaces become saturated and oxygen is not available which leads to anaerobes taking over from aerobes and causing the production of unpleasant odours, low pH and a material that may still contain human pathogens and be toxic to plants (Handreck 1993: 6).

1.2.3 Micro-organisms

Hundreds of species of micro-organisms, predominantly fungi, bacteria actinomycete contribute to the decomposition of the pile by utilising the organic material for energy and growth. They in turn may be consumed by second level decomposers such as the many different species of invertebrates, some of whom also break down the organic material to make it accessible to the micro-organisms. The micro-organisms become part to the pile as natives of the organic components. Over 20% of the dry mass of human stool can be bacteria, and "municipal solid waste is known to contain around 2.3×10^8 coliforms and 3.9×10^4 faecal coliforms" per gram (Chapman 1993: 28).

Microbial activity is self regulating and temperature is the dominant physico-chemical parameter. Compost samples taken from the 35°C to 50°C zones in a monitored pile exhibited the greatest microbial activity, while above 60°C increasingly low rates of metabolism have been observed (McKinley et al. 1985: 39).



<u>FIGURE 1.1</u>

Illustrates the cycle of carbon and nitrogen in the aerobic process.
(Gotaas 1956: 14)

1.2.4 <u>Heat</u>

A mix of animal droppings and leaf litter on the forest floor will undergo a composting process, and where there is adequate oxygen, optimal pH and moisture, much heat is generated by the oxidation of carbon to CO_2. "For example, if a gram molecule of glucose is dissimilated under aerobic conditions, 484-674 kilogram calories of heat may be released" (Gotaas 1956: 15).

Collecting the organic material in a container or in a sufficient pile will provide insulation which can allow pile temperatures to rise to 70°C. Composting temperatures are generated by mesophilic organisms in the range from 19°C to 45°C, and by thermophilic organisms in the range from 45°C to 60°C. A small group of thermophiles may remain active above 65°C. It is the generation of heat which is considered beneficial from a human and agricultural health perspective as it can sterilise the pile and eliminate pathogenic bacteria and protozoa, ova, cysts, most weed seeds, and human and plant viruses (Handreck 1993: 11). However, as mentioned in section 1.2.3 the higher temperatures that most effectively destroy pathogens can slow down microbial and invertebrate decomposition of the pile when temperatures reach above 60°C.

1.2.5 pH

Depending on the bulking agent used in a compost heap the pH may initially be slightly acidic due to the acidic nature of plant cell sap. As metabolism occurs, further acid formation from microbial oxidation of carbohydrates and sugars will cause an even lower pH in the early stages of a compost pile (Handreck 1993: 7). Ammonia is formed particularly in the thermophilic stage which causes the pH to be alkaline. Ammonia may then be used as a nitrogen source for protein synthesis by mesophilic organisms and the pH becomes neutral when the pile has composted. It is suggested, therefore, that testing the pH can be used to monitor composting progress (Safton 1993: 11). Low pH at low temperatures can favour fungal growth which may compact the pile. High pH at high temperature shows evidence of decreased pathogen indicator count (Chapman 1993: 13).

1.2.6 Anaerobic decomposition

The putrefaction of organic material in the absence of oxygen is also considered by some to be a 'composting process', partly because there are anaerobic pockets in any compost pile and partly because some bacteria are faculatively aerobic or faculatively anaerobic. These bacteria can grow in aerobic or anaerobic conditions but are inclined to prefer one more than the other (Gotaas 1956: 17). In terms of waste management, anaerobic composting is less favourable because the process gives off unpleasant odours, does not generate as much heat for sterilisation of pathogens as aerobic composting, and has a slower rate of decomposition.

Anaerobic organisms utilise nitrogen, phosphorus and other nutrients to metabolise cell protoplasm, but unlike the aerobic process, reduce nitrogen to organic acids and ammonia, produce CH_4 (methane) from the carbon compounds not used in cell protein, and H_2S (hydrogen sulphide) from the reduced organic compounds which contain sulphur such as mercaptans. Some heat will be generated by putrefaction, but

> in the anaerobic dissimilation of the glucose molecule, only about 26 Kcal of the potential energy per gram-molecule of glucose are released as compared to 484-674 kcal for aerobic fermentation" (Gotaas 1956: 17).

Methane can be burnt and will then produce large amounts of heat and CO_2. Anaerobic decomposition which can take place in 80% - 99% moisture is used in water borne on-site and centralised sewage treatment systems. Compacted organic matter such as the material in pit latrines where oxygen is excluded will decompose anaerobically in 40% - 75% moisture.

1.3 Composting toilets

Much of the recent information available on composting relates to composting of municipal waste or sewerage sludge. If it involves the composting of raw human excrement it is usually of material that has been removed from the toilet, mixed in bulk with carbonaceous material, and treated off-site in large scale sealed or open systems (Van Vuren 1949: 82; Scott 1952: 152; McGarry and Stainforth 1978: 7), (Pers. obs. Japan 1993).

Composting toilets, on the other hand receive and treat the excrement on-site. Users defecate and urinate in a container limited in size by installation and maintenance parameters, which is designed, in principle, to minimise contact between the contents of the pile and humans or the environment. The user or maintenance personnel add bulking agent or carbonaceous material when required so the pile is created over time. The context and design of the compost toilet creates different biological and physical environments to that of the domestic garden compost pile or large scale municipal waste, sludge or raw excrement composting.

Because composting toilets are so named much of the criteria for effective composting summarised above is applied to this on-site dry conservancy technique. However, the performance of composting toilets indicates that different processes may be at work to create an acceptable end-product. Assessing a composting toilet by reference to the above criteria may be missing the point that the composting toilet is a social construct as much as technical device and therefore its success is as much determined by cultural issues as by physical conditions. As a result of this study, the author suggests that the criteria for effective composting toilets should be low and convenient maintenance requirements, inoffensive end-product, pathogen destruction or significant reduction, and minimal environmental contamination or damage. The practical implications of these criteria are covered throughout the thesis.

1.3.1 Batch and Continuous Systems

There are two main types of composting toilets: the continuous system which is a single container in which excrement is deposited by the user and compost is theoretically removed from the end-product chamber; and the batch system which is two or more containers that are alternated so that the 'active' container is being used while the pile in the 'fallow' container has time to compost without the addition of extra excrement and potential for re-contamination (Feacham et al. 1983: 68). Principles and applications of the continuous and batch systems will be discussed in greater detail in Chapter Two.

1.3.2 Other studies of composting toilets

The available literature on composting toilets falls into four main categories and has been produced by regulators, environmentalists, appropriate energy institutions, public land managers, owner-builders, and post graduate research students to:

(1) assess performance, with common emphasis on removal of pathogens or pathogen indicators;

(2) monitor certain processes such as temperature and usage;

(3) experiment with design, installation and monitoring; and

(4) review composting toilet design and performance to promote, or argue against, the concept as an alternative to the centralised sewerage dominant paradigm.

Information often overlaps between the four categories, but only occasionally includes a comprehensive coverage of all four. A selection of significant publications is detailed below. Maintenance and design characteristics and problems referred to in this literature review will be clarified in Chapter Two.

A 1958 World Health Organisation publication recommended that sewage disposal should conform to the following guidelines:

> 1. The surface soil should not be contaminated.
>
> 2. There should be no contamination of groundwater that may enter springs or wells.
>
> 3. There should be no contamination of surface water.
>
> 4. Excreta should not be accessible to flies or animals.
>
> 5. There should be no handling of fresh excreta; or, when this is indispensable, it should be kept to a strict minimum.
>
> 7. The methods should be as simple and inexpensive a construction as possible. (Wagner and Lanoix 1958: 39).

In the same publication, a basic alternating batch composting toilet, or 'double vault privy' is detailed. This toilet is expected to function anaerobically as the chambers are dug into the ground, but it involves the addition of organic 'rubbish' as bulking agent. After 9-10 months fallow period the compost can be removed and used for fertiliser. "Close supervision by health and agriculture officials and systematic education and follow-up are required during the first two years or more of operation" (Wagner and Lanoix 1958: 39).

In 1972 Dr. Clarence Goleuke, Research Biologist, Sanitary Engineering Research Laboratory at the Berkeley Campus of the University of California stated, in a review of composting processes,

> In concluding this section on public health, it is emphasised that the beneficial effects of composting can be realised only

> by careful control of all phases of the process. Care must be taken that all particles are exposed to high temperatures and that all particles receive full exposure to the process. In view of the well nigh impossibility of maintaining perfect control at all times, the composting of night soil or of raw sewage sludge should be undertaken with great reluctance. The resulting compost should be subjected to heat sterilisation. If not sterilised, its use should be restricted to applications that involve no human contact directly or indirectly (Goleuke 1972: 68).

In 1973, the Institute of Microbiology at the Agricultural University, in As, Norway, studied 21 commercial units over 150 days that were loaded with faeces and urine periodically and seeded with salmonella and polio virus. Escherichia Coli density was counted in the original pile and the end-product. After four weeks the Escherichia Coli had significantly reduced and no salmonella or polio virus were detected (Guttormsen 1977 and 1979).

A five year study in Tanzania, (1973-1978) of site-built concrete batch and continuous toilets concluded that batch systems required less maintenance and were therefore preferable to continuous systems from a public health and cultural standpoint (Windblad and Gurak 1977: 20).

In 1978 the Research Department of the Appallachian Mountain Club conducted a review of remote area sanitation options for the New Hampshire Water Supply and Pollution Control Commission in the United States and recommended continuous composting toilets, as long as they had at least a half an hour maintenance a week. These recommendations were based on Guttormsen's work in Norway, commercial supplier's (Clivus Multrum) promotional literature and interviews with parks personnel who had recently installed composting toilets (Ely 1978: 9).

In 1978, a Masters Research student at the Centre for Environmental Studies at the University of Tasmania, Australia reviewed commercially available 'dry toilets' and concluded that they were expensive, required too much maintenance, were unaesthetic, did not treat greywater or liquid run-off, relied on the unpredictable user and were a sure source of the spread of disease. For these reasons the writer could see no justification for replacing the flush toilet with a composting toilet (Hrasky 1978).

In 1979, the Research and Development Division of the National Centre for Appropriate Technology in Montana, USA, under contract with the Community Services administration, prepared a guide for home owner-builders on commercial and site-built composting toilets. It was recommended that prospective owners thoroughly review the literature before choosing a design, be sure that a composting toilet suited one's living situation and practical needs, experiment with basic composting in order to understand the principles, talk to other people who have a composting toilet. If the home owner should choose to build their own toilet then they could monitor temperatures, odour generation, insect populations, appearance of pile, liquid build-up, and end-product appearance over a period of twelve months. The monitoring was to provide information upon which to base any needed modifications, enable the householder to determine if the composting toilet was functioning properly, and contribute to the scarce knowledge base on composting toilet function (Adams et al. 1979: 10). The study advised that pile compacting in slant based chambers, and excessive liquid build up, fly infestations and minimal evaporation, were problems that had been experienced with a variety of composing toilet designs.

In relation to pathogen kill the comment was made that,

> in much of the literature on compost toilets, it is stated that it is the generation of this pasteurising heat that theoretically insures the sanitary aspects of the composting toilet. However, the pile must be of sufficient size to ensure heat insulation, and the moisture and nutrient (C/N) balance must be maintained...it is virtually impossible to assure that all of the pile will be subjected to these temperatures and pasteurised, even with frequent turning...Time is really the most important factor...the longer the pathogens remain in an alien environment, the more likely that their numbers will be reduced because of lack of suitable nutrients and suitable environment for propagation (Adams et al. 1979: 9).

One year was the recommended minimum time before the end-product would be safe to use.

In 1979, Rodale Press in the United States published a guide to composting which discussed the Clivus Multrum and Toa Throne composting toilets and the effect of assisted ventilation on heat generated by the pile, to the extent that temperatures had rarely been recorded above 90°F (32°C). The composting toilet was distinguished from the accelerated decomposition of a domestic compost heap as it would take four years for compost to be produced by a composting toilet as "this much time is needed for material to accumulate and for pathogens to be destroyed by competition with other organisms over time" (Minch and Hunt 1979: 91).

In 1980, Sim Van der Ryn, California's State Architect, founder of the Farallones Institute and Professor of Architecture at the University of Berkeley, California, had published an analysis of wet and dry on-site toilet systems, and grey water treatment designs which included the Farallones batch on which the principles of the toilet designs in this thesis are based. The publication, which had developed out of previous technical bulletins (Van der Ryn 1974), also addressed the social and political factors that determine the relationship between centralised sewerage technology and on-site treatment (Van der Ryn 1980: 99). The issues are not dissimilar to those that exist today, and which are explored in this study. The Farallones Institute had been investigating composting toilets since 1972, and had observed that 'low temperature mouldering, mainly anaerobic' was the decomposition process in composting toilets (Kroschel 1981: 4). The Farallones batch was installed in a Zen monastery in California in the mid 1970s and was visited by the author in September 1994, where it appeared to be still providing an effective sanitation facility.

In 1977, an attempt to improve performance, a management program of domestic composting toilets at the Farallones Rural Centre included weekly manual turning of piles with a pitch fork and regular addition of straw or grass clippings. Thorough temperature monitoring during that time recorded thermophilic activity (sometimes above 60°C) in the centre of the piles, but laboratory analysis of six month old compost indicated viable parasite ova and larvae (hook worm and round worm) had survived (Kroshel 1979: 180). The householders were reluctant to keep up the maintenance program, particularly as pathology results were not encouraging (Kroschel 1981: 6).

Much of the United States literature on composting toilets in the late nineteen seventies was stimulated by the 'back to the land movement', environmentalists' concerns regarding the pollution of water by sewerage treatment and the potential to replace chemical fertilisers with recycled 'natural' products (Stoner 1977; Costner et al. 1986). Similar drivers existed in Australia but have only become apparent in recent years (refer Chapters Two and Five). Advocates of composting toilets in the United States struggled to convince regulators of the technology's viability as an effective sanitation system. Some government institutions co-operated by funding a number of studies into modifications and performance, and public institutions responsible for remote site access assessed composting toilets for their applications.

The United States Department of Energy funded a Small Scale Appropriate Energy Technology Grants Program to trial solar heating of commercial and site-built composting toilets for domestic and public application. This was in response to the increasing cost and complexity of commercial units which were using electricity to operate fans and heating devices, in an attempt to improve performance. The results of the study, published in 1981, indicated that the solar heating techniques used were not successful, partly because they created artificial conditions that were not compatible with a sensitive biological process. Greenhouse conditions were preferred. Useful information was gained regarding evaporation rates, construction materials for site-built units and liquid handling. The performance of the site-built units was considered more promising than that of the continuous system commercial unit, and both were most suited to seasonal use, without overloading (Kroschel 1981: 23).

The United States Forestry conducted a two year field review of composting toilets at five different geographical locations to determine whether composting toilets could replace their problematic pit and vault systems. Samples from 26 bin composters (separate container which composts material from a can toilet), and 7 continuous systems (Clivus Multum and site-built) were tested for pathogen indicators, volatile solids, total solids, COD, ash, moisture content, temperatures and pH. Management issues such as maintenance, caretaker administration, quality control assurance, monitoring and training were also assessed (Smith 1981: 3). The results suggested that bin composting produced higher temperatures than the continuous systems, neither system reduced coliform counts to recommended levels, active maintenance resulted in aerobic composting, COD and ash contents were high indicating that more composting could be achieved, and liquid build-up, compacting and channelling were a problem in the continuous systems. It was considered that composting toilets could be suitable in Forestry locations if trained maintenance and monitoring personnel were consistently available (Smith 1981: 9).

Twenty eight composting toilets were studied over an eighteen month period (1979-1980) for the United States Environmental Protection Agency. The study included Clivus Multrums, site-built continuous systems and Farallones type batch systems. Physical and chemical analysis of the pile was conducted, and the invertebrate population was examined. Samples of fresh material were taken from the top of the pile as well as from the core and from the end-product chamber. Twenty toilets were screened for parasites and one had a positive results in the core section. None of the samples collected from the end-product chamber of each of the twenty eight toilets contained human parasites (Enferadi et al. 1986).

The United States National Parks Service conducted a 'Remote Area Management, Waste Disposal' project to identify an appropriate sanitation option for remote sites that are without power, water, vehicle access or adequate soil depth. Existing commercial dehydration, 'Shastra', toilets and composting toilets were assessed, and two site-built National Parks prototypes were installed and evaluated at high altitude sites. Nine Clivus Multrums were included in the study and all had liquid build-up and ventilation problems. Addition of bulking agent was a difficulty as it had to be transported to the site, stored and added at irregular maintenance visits, but units operating at less than 50% recommended loading appeared to function with little attention. None of the units had been operational long enough to produce an end-product.

> As part of the compost process, the solid material is supposed to move down the sloping bank bottom. None of the units demonstrated any evidence of such movement (Jensen 1984: 4-70).

Reduction in volume of original material had taken place and this was an advantage for remote applications. The study was considered to be too short to be any more conclusive, and further monitoring was recommended.

The United States Army investigated composting toilets and aerated vault latrines as a potential alternative to their commonly used pit toilets, unaerated vault latrines, and chemical toilets. Comparative costs, operation and maintenance requirements, Army applicability and user acceptability were assessed (Scholze et al. 1986: 63). The study included the installation and monitoring of 16 composting toilets at three Army installation sites and a telephone survey of 93 public installations across the United States and Canada ranging from state and national parks to highway rest stops and nature centres. Most operators surveyed had not removed an end-product, so were uncertain whether or not the piles were composting (Scholze et al. 1986: 68). Operation and management practices varied greatly in public installations according to availability of labour, remoteness of site, motivation, and understanding the principles of composting toilets. Most units were reported as performing satisfactorily in terms of reducing volume of material and eliminating unpleasant odours associated with basic sanitation facilities. Most operators surveyed considered the labour associated with maintenance of composting toilets was less costly than pumping costs for vault latrines or digging costs for pits. As a result of the study, composting toilets were recommended as a workable alternative to pit, chemical and unaerated vault toilets for Army application (Scholze et al. 1986: 81).

A 1982 publication discussed composting toilet performance tests prepared by the Agricultural Research Council of Norway. The advantages of composting toilets were seen to be that they do not use water, the end-product is a dry material that is easy to handle, the toilet can be placed in the house[4] unlike the pit toilet, the volume and strength of effluent is greatly reduced compared with water borne treatment. The disadvantages were limited capacity, flies, poor mixing of paper and faeces, complicated care and maintenance, odours outside with down draft and inside when fan stops, and difficult installation (Molland 1982: 247). The tests focused on instructions for installation and use, materials for construction, necessary care and maintenance required, capacity, end-product and odour (Molland 1982: 250).

In 1983, a paper was presented to the United Nations Commission for Human Settlement on Nordic experiences with composting toilets. 5 000-7 000 commercial composting toilets were sold per year in Sweden and Norway, at that time, primarily for holiday or remote rural cabins. The systems referred to had no drainage so all liquid had to be evaporated. It was reported that

> inclined-floor toilets (of which there are 5-10 models on the market) have a relatively low capacity (2-3 persons), the wastes have to be raked down, and the toilets do not function

[4] At that time composting toilets were permitted inside the house in Scandavia, but in Australia it is only recently that this has been permitted.

> satisfactorily in practice, at least not when used in residences. They cannot be recommended for continuous use (Molland et al. 1983: 11).

It was found that the carousel batch alternating type, and the small continuous systems using a fan and a mechanical mixer, functioned more satisfactorily. A hundred composting toilets in Norway had been investigated over three years and problems were said to be caused by poor fabrication, incorrect installation and incorrect use. The study suggested that if composting toilets can work in cold northern countries then they should be useful in warmer developing countries, and that research should be conducted to develop appropriate systems by "skilled personnel with strong biological background and advanced techniques" (Molland et al. 1983: 17).

Since 1976, an alternating batch composting toilet, the Dry Alkaline Fertiliser Family (DAFF) latrine (or Letrina Abonera Seca Familiar, LASF) has been used in Guatemala. The toilets are not used for urination, as it is collected separately and watered down for direct application on plants. The above ground installation is built out of concrete blocks and bamboo and the bins are alternated every 4-6 months, depending on the size of the family. The end-product is a dry odourless material with a friable consistency and has a coliform count of

> less than 4 000 per gram (wet weight), and helminth eggs are fewer than 8 500 per gram with a viability of less than 30%. This microbial quality is considered safe for reuse. Local farmers regard the DAFF latrine as useful because: it provides a readily available, low-cost fertiliser and soil conditioner which 'noticeably' improves crop yields (quantitative yield data are not available); and it is an odourless household sanitation facility that avoids the need for indiscriminate defecation in the fields (Mara and Cairncross 1989: 51).

Ash is added to the pile, (which results in high pH) and as the compost is worth US$12 per 50kg bag and a family of five can produce 10 bags annually, the cost of the latrine ($140) which includes training and promotion can be covered in little over a year.

Other studies in the 1980s included a two year trial at Purdue University, Indiana, USA, to improve air flow and odour control on slant based continuous composting toilets (Engelder et al. 1986: 40), and an examination of health risks associated with maintenance and use of public waterless toilets, including a compost toilet, which found, that no coliform were detected in the liquid run-off from the compost toilet[5] compared with high counts for other systems (Schloze et al. 1985: 963). The Winthrop Rockefeller Foundation funded a review of composting toilets which included useful data on content and volume of domestic by-products and observed that the main obstacle to dry conservancy sanitation in the United States is the public aversion to on-site treatment of excrement within the home (Lombardo 1981).

Interest in composting toilets in 1990s has been rekindled as environmental consciousness has become more mainstream. In the United States there are many new designs on the market (Riggle 1990: 71). In Australia there are similar trends which have increased pressure on regulators to approve installation of composting toilets in residences. One of the outcomes of lack of institutional support for the research and development of on-site sewage treatment, and in particular composting toilets is the limited recent literature available on the subject. As has been demonstrated by this literature review, in the 1970s and early 1980s there were many publications on the topic, primarily produced by alternative technology institutes in Europe and North America which flourished in that period.

However, there have been a couple of recent unfunded studies that have produced very useful data. A thorough two year microbiological study of seven commercial and owner built batch and continuous systems was conducted by a masters research student and supported by local government in northern New South Wales, Australia. The research found that commensal organisms and internal parasites being deposited in the composting toilets studied were not detected in the end-product (Safton 1993: 72).

A masters research student (with whom the author has regularly exchanged information) at Lincoln University New Zealand examined heat loss, evaporative cooling, energy transfer and experimented with a range of bulking agents for use in composting toilets. The study found that thermophilic composting will be difficult to maintain because:

[5] This is contrary to the author's tests which have revealed high coliform counts in compost toilet liquid run-off (see Chapters Three and Five).

1. airflow needs to be controlled to minimise evaporative cooling (this is counter to the requirement for odour removal)

2. the nature of the watts/temperature relationship implies that, for any combination of insulation/surface area of reactor, there is minimum energy density required before the pile will rise to thermophilic temperatures. This minimum density will be difficult to achieve without having continuous removal of exhausted compost (Chapman 1993: 121).

It was also established that composting will initiate at 4°C, excess urine will retard composting process, and non degradable bulking agents can reduce heat of the pile.

A trial of three composting toilets was undertaken in the Federated States of Micronesia in the Pacific in 1992. The toilets were received favourably, with some cultural obstacles, but compost had not yet been produced at the time of the final report on the project (Rapaport 1993: 12).

1.4 Structure of this thesis

The research for this thesis covers practical issues of design, installation and maintenance and monitoring of usage, temperature and pathogen (indicator) destruction in composting toilets in a number of Australian locations and in a Pacific atoll environment. The technical issues are viewed from the broader social and political context in which they are addressed.

The separate components of the study are arranged in part historically, and in part to support the development of the thesis proposition. The outcome of one component led to the next in time, but certain developments also occurred concurrently.

Chapter One has briefly described the subject area, discussed the approach to the subject, provided a technical summary of composting and dry conservancy sanitation principles and reviewed some of the relevant literature.

Chapter Two details the status of composting toilets installations on the East Coast of Australia at the beginning of this study in 1992, to illustrate typical technical and administrative problems that required attention in a variety of on-site sanitation applications in recreational areas.

Chapter Three describes improvisations and innovations in response to the technical problems that were encountered in the surveys detailed in Chapter Two. The study also provides an example of what can be achieved through the efforts of a couple of individuals if goals synchronise, despite a shoestring budget, a remote and unpredictable context, and extreme conditions for monitoring.

Chapter Four examines the process of consultation and experimentation in on-site sanitation for an accessible high-use public recreation area. The study illustrates the limitations that can be created by research and development within an institution that is hampered by conflicting agendas, uninformed regulators, inadequate communication channels, and is motivated by goals other than technology improvement and appropriate education. The Chapter indicates the inefficient use of public resources that can occur, despite the best intentions, when experimentation is undertaken but clear mandates for research are not operating.

Chapter Five details unfunded community contribution to research and development of semi-rural and urban on-site sanitation technology and illustrates the potential for improvement if appropriate institutional support was provided.

Having examined the limitations of research, development and management of dry conservancy on-site sanitation in Australia in the preceding Chapters, the sixth Chapter explores Japanese development in this field and the relationship between on-site and centralised sewage treatment in Japan. The Chapter suggests the lessons that Australian sanitation mangers may learn from the Japanese experience and indicates the global implications of addressing these issues appropriately.

Chapter Seven describes sanitation technology transfer in the Pacific region and reflects the positive international ramifications of improved research and development in Australia. The project emphasises the importance of social and cultural considerations in sanitation application and again illustrates the limitations created by inadequate supportive infrastructure and remote site development.

Chapter Eight summarises the findings of the study and looks to the future for the development of inter-disciplinary institutions that have a mandate to address the technical, social, environmental and administrative aspects of on-site sanitation.

CHAPTER TWO

COMPOSTING TOILET INSTALLATIONS ON THE EAST COAST OF AUSTRALIA

In most coastal areas of Australia there are active community groups attempting to persuade their local government representatives to cease discharging partially treated or untreated sewage into waterways.[1] Some areas are upgrading reticulated systems at considerable expense, but even with secondary or tertiary treatment, a percentage of the effluent will be pollutants, and the practicalities of water borne technology remain problematic. Reticulated systems require large volumes of water which in turn require dams to feed them. Resources contained in the sewage could be regarded as wasted when fed into rivers and the ocean, and can cause detrimental impact on those ecosystems (Crennan 1992).

It is obvious that alternative methods of sewage treatment are needed. There are on-site alternatives which treat the influent as close as possible to the source thus providing a system most suitable for the specific pollutants and avoiding mixing 'wastes' and transporting them to distant waterways (Harper and Thorpe 1994). There are strategies for source reduction, re-use and re-cycling in the centralised reticulated systems, for example, re-use of treated effluent is being trailed on woodlots and golf courses (Machno 1990; Fox 1990), and water conservation campaigns are being successfully conducted by some Councils in NSW, Queensland and Western Australia (White 1994a and b). Dual reticulation systems aim at re-use (Denlay and Dowsett 1994; Ius 1994). In some parts of the USA and Europe sewage effluent is treated to a potable standard (Law 1994).

Included among the domestic on-site alternatives are aerated waste water treatment systems (AWTS, which are septic tanks with a second tank providing

[1] Regular media accounts and contact with resident and environmental groups indicate this is a common concern.

extra disinfection so the effluent can be used for irrigation) which could be referred to as a 'wet' method of treatment (Martens and Warner 1991). Composting toilets which are a 'dry' method of treatment have been attracting increasing interest in both the private sector and among public recreation institutions.

In both cases the currently approved units have been researched, manufactured and promoted by small business. This can be a limitation as often the motivation to be commercially viable can inhibit thorough research, adequate pre-sales consultation and after-sales support and advice. This constraint is not placed upon traditional sewerage systems. They are funded by public money and have a vast technical and bureaucratic infrastructure to support them. Despite this support there has been relatively little environmentally protective innovation in the last one hundred years (Lloyd 1993: 72). This study suggests that it could be in the public interest if alternative sewage disposal, research, and implementation was given even a small percentage of the funding and infrastructure provided to traditional sewerage techniques.

If the alternative techniques are not carefully implemented and maintenance or pollution problems arise, then this has been fuel for the argument that the traditional methods should remain. Often the alternatives are subjected to much more harsh official scrutiny and criticism than the sewerage systems that have been discharging poorly treated sewage into waterways for decades.

This thesis will explore some of the ramifications of this biased approach. From this study it appears that the lack of government funding for thorough monitoring and public education and the reluctance of Health Departments to give approval for on-site systems (other than septic tanks which have a dubious performance history), even where sewers are not available, has sometimes resulted in 'alternative' on-site technology being applied inappropriately. For example, a number of approved composting toilets on the market, originally designed for domestic use, have been enlarged to take the increased volume in public recreation installations, such as in National Parks. These venues can be an attractive market because regulatory bodies, such as Health Departments and Councils, have less control and to some extent the recreation institution can make up its own mind what disposal method is best for that situation. They are also inclined to be more adventurous in trying innovative technology, especially if it has a reputation for improved environmental protection and low maintenance, and because there are very few on-site treatment options available. Also there is an assumption that technically orientated staff, such as Rangers, will be on hand and equipped to take care of maintenance and any malfunction.

However, it is apparent from the survey of composting toilet applications detailed in this Chapter, that many of these institutional characteristics can work against a successful composting toilet installation. Public recreation institutions are sometimes hierarchically cumbersome and it may take many months before complaints and observations from ground staff regarding the merits of a particular system reach decision makers in Head Office, and many more months before anything is done about those observations. Rapid turn over of Ranger staff often means that people who do not know how to recognise indications of malfunction, or what to do if they occur, are continuously being introduced to the situation. Some staff do not consider it part of their duties to handle raw sewage and avoid dealing with the installations altogether, neglecting essential maintenance such as unblocking run-off drains, which can result in the composting toilet flooding. If the composter is in a remote high-use region, there is the added problem of infrequent inspection by maintenance staff, and dependence upon the common sense of the user.

This is not to say that composting toilets should not be used in these situations. They can be a simple inexpensive environmentally benign solution to sewage disposal problems as Chapters Three, Five and Seven will indicate, and are preferable to water borne treatment, especially in sensitive areas. It would seem more practical that, with the support of appropriately skilled personnel and specialised infrastructure, public recreation composting toilets should be designed and built on site to suit the climatic and geographic limitations of the location, and the maintenance capabilities of the field staff. It would help if there was consistent user and staff education regarding their function. Staff may also be likely to take a more active interest in a local design, than in something imported at considerable expense from a distant unspecialised market.

In the late 1980s, the Department of Parks Wildlife and Heritage in Tasmania, Australia, was one of the public recreation institutions that installed composting toilets in national parks in an attempt to provide more environmentally sound sanitation in sensitive areas. This was an alternative to the pit systems which were considered to be contaminating ground water and leaving large deposits of excreta that may cause ongoing pollution problems (Smith 1980). Twenty two commercially supplied composting toilets were installed in Tasmanian National Parks of both the continuous and rotating batch types (see Figure 2.1).

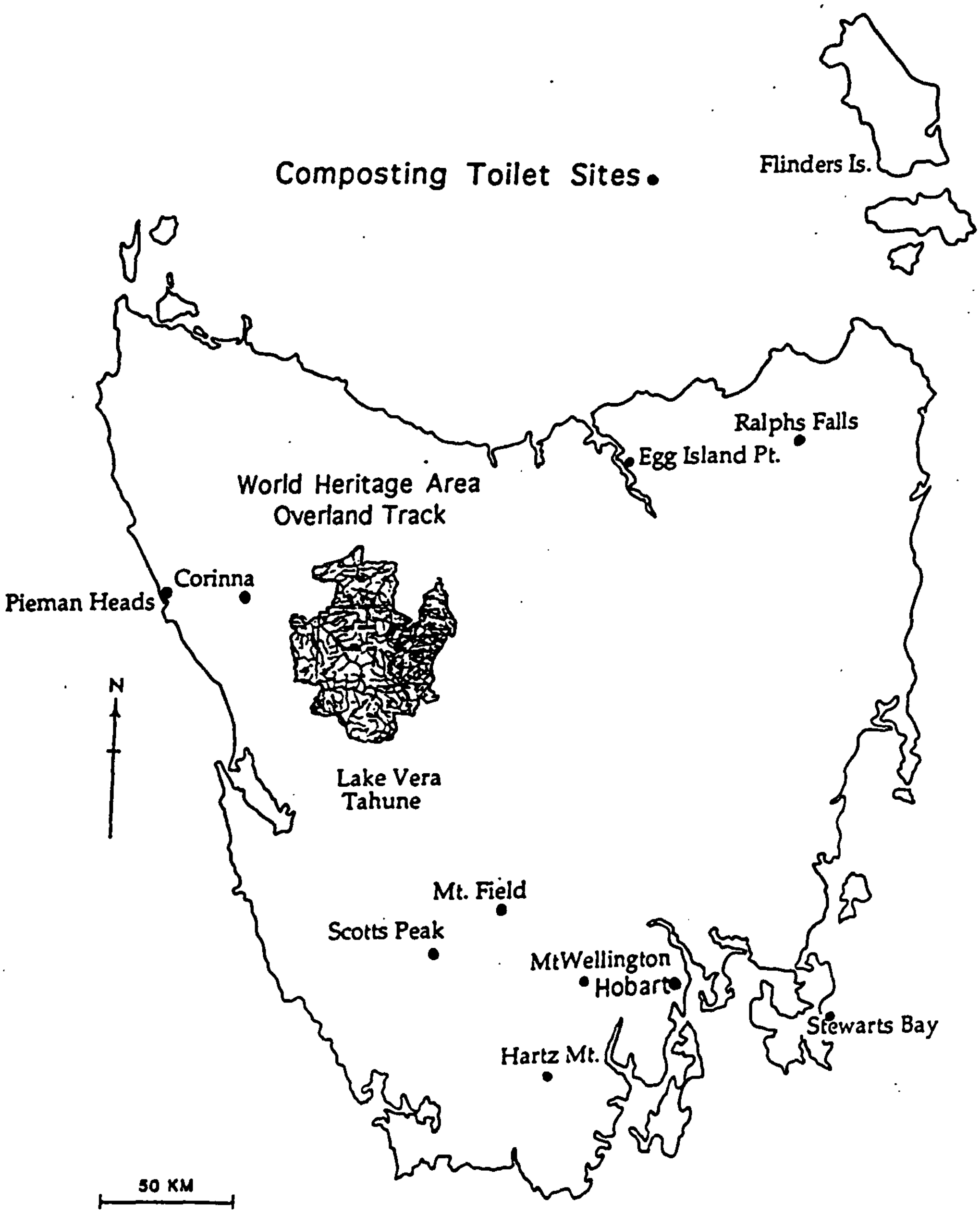


FIGURE 2.1

Map of Tasmania showing public composting toilet sites

At the time of installation there were only two commercial composting toilets approved by relevant Health authorities in the eastern states of Australia. One was the Clivus Multrum, a continuous system that originated in Scandinavia and was manufactured by an Australian firm, and the Rota-Loo a rotating batch system, also adapted from an overseas design and manufactured by an Australian company, Environmental Equipment Pty Ltd.

From the manufacturers' information it was understood that compost could be expected to be produced from the toilets at least within a couple of years. However staff were engaged in removing raw excreta from the chambers of the toilets, under very unhygienic conditions, some years after installation.

In response to this crisis, the Department of Parks, Wildlife and Heritage in Tasmania engaged the author as part of this Doctorate research to:

1. Inspect and evaluate the performance of all composting toilets in the World Heritage Area and survey field staff about their experiences and suggestions with regard to installation, design and maintenance.

2. Determine why the systems are not working. This may involve controlled experiments with systems in place in the field or at the University. Recommendations should follow from this on the appropriate management regime the Department needs to put in place to ensure optimum performance of the existing toilets. This would include design of the building, maintenance, bulking agent type and quantity, temperature etc.

3. Recommend a standard design based on a commercially available toilet that will work in Tasmania. This design should include the type of building etc. to optimise performance as well as the appropriate management regime.

If the design of the current commercially available systems is inappropriate for Tasmanian National Parks, recommend modifications and or a new system that will have an optimum chance of working (Pers. comm. Rose March 1992).

The agreement was for 1992 only as it was assumed that all this could be achieved in one year, and funds were allocated by the Department toward expenses. The study became part of this PhD research into the planning and management of on-site sewage disposal technology and its relationship to water quality protection.

The project of assessing and advising upon the condition of the composting systems in Tasmanian National Parks began by inspection of the toilets on the Overland Track in the Lake St Clair-Cradle Mountain World Heritage Area Park in central Tasmania (see Figure 2.2). After the Overland Track field trip, inspections were made of other Clivus Multrum and Rota-Loo units throughout Tasmania.

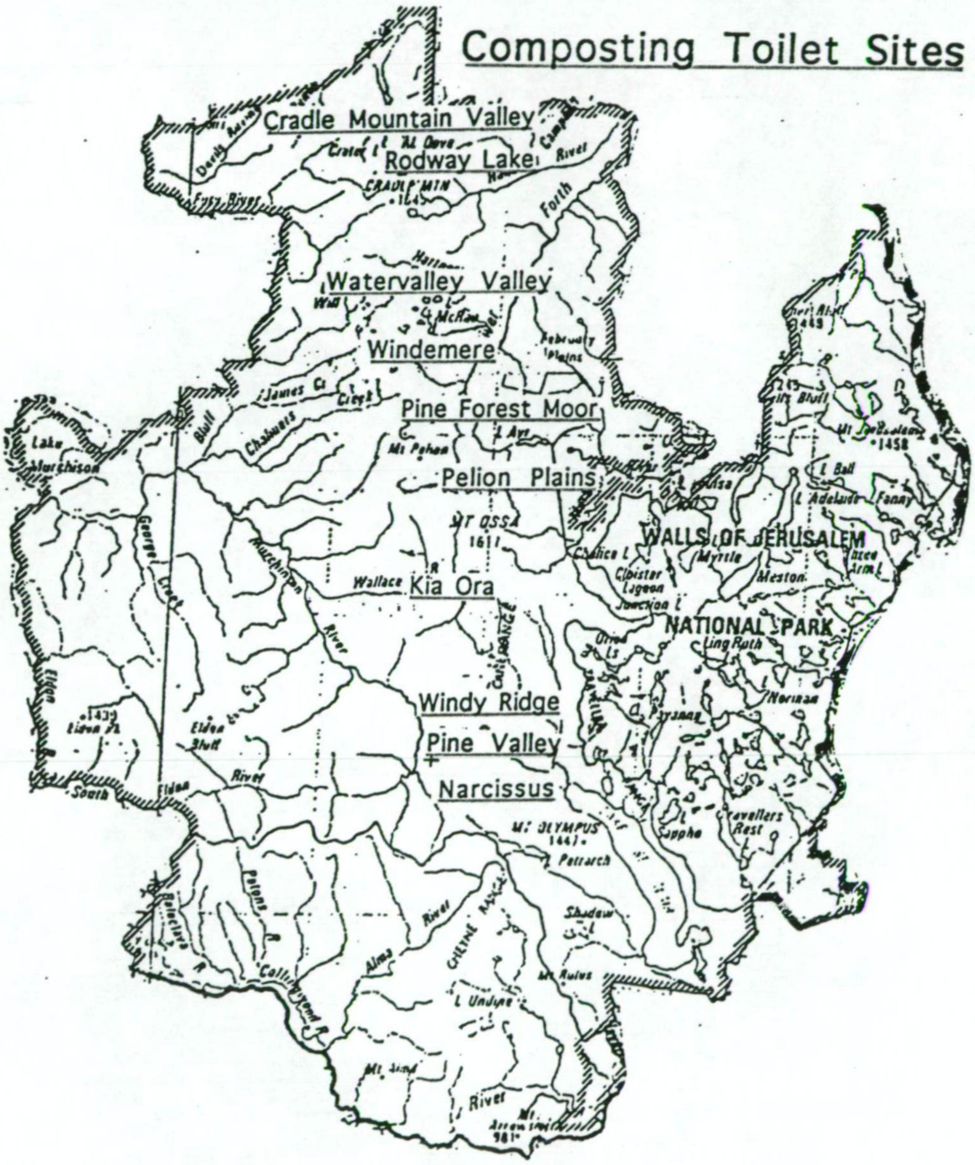


FIGURE 2.2

Map of Overland Track: World Heritage Area.

None of the Clivus Multrums or Rota-Loos inspected in the Tasmanian National Parks were working according to expectations. The end-product in all cases was a slurry or a dense wet mass of predominantly undecomposed excrement, toilet paper and bulking agent. As composting was not taking place, liquids were not being evaporated and therefore run-off of undesirable high nutrient effluent into the environment was occurring at each toilet site. Pathogen levels of the run-off were also recorded to be high.

At first the author assumed that the general malfunction was exclusively due to the cold wet conditions in Tasmania, as experience in New South Wales, with non-commercial composting toilets had always been positive. However, literature review and preliminary enquires with Clivus Multrum users in other Australian States indicated that common problems with Clivus Multrums included

- the pile failing to flow through to the end-product chamber resulting in a compacted mass (restricted aeration),

- the weight of the non-flowing pile bearing down on the air rails or baffles causing them to collapse,

- the drainage outlet becoming blocked causing flooding, and choking of air rails. (Jensen 1984: 4.10; Schloze et al.1986: 68) (Pers. Comm. Angwin March 1992).

In an introductory telephone discussion with the Manager of Clivus Multrum Australia Pty Ltd in Queensland on March 30, 1992, he said that lower ambient temperatures results in a considerable reduction in capacity for compostable material, i.e. the 09 Clivus tanks in the Parks with a 'normal' capacity for 36 000 uses are reduced to a capacity of 4 000 uses in an environment where ambient temperatures are below 10°C for much of the year. The author queried the wisdom of selling the large 09 tank that necessitated an awkward installation, if less than one sixth of its capacity could be used in Tasmanian alpine conditions. The Manager responded by suggesting that the author conduct her own investigations of Clivus installations to evaluate suitability and performance, and provided the names and addresses of some other Clivus customers to contact (Pers. comm. Beeson March 1992).

An 'in-house' study by the Department of Parks Wildlife and Heritage of the Clivus and Rota-Loos had been under way for some time but little progress had been made. It seemed advisable to inspect Clivus units in other States in Australia before making an assessment of the systems' current condition and potential capability in Tasmania. There seemed little point in continuing to undertake time consuming and expensive analysis of samples prior to observation of the systems' performance in more favourable circumstances.

This Chapter provides a description of the composting toilets at the time of inspection to illustrate the range of locations that were considered appropriate to composting toilet installation and the difficulties that can arise with inadequately supported on-site sanitation applications. To date, composting toilets have almost always been applied as a last resort, where water borne systems have failed or are impossible to maintain and where pits are inappropriate because of high ground water, and little concentrated research has gone into their development. Chapter Two also traces part of the process that led to the author exploring technical alternatives and advocating comprehensive administrative reassessment.[2]

2.1 Clivus Multrums in Tasmania

This section summarises the investigation of twenty one Clivus Multrum composting toilets in Tasmania (see Figure 2.3), and two custom designed units. It is a chronological record of the author's site inspections and meetings with relevant personnel, including information and observations provided by maintenance and administrative staff.

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[2] a) The smaller Clivus Multrums are referred to as 07s in this Chapter, although some people refer to them as 08s.

b) Spot check pile temperatures were taken on occassions where equipment was available and functioning reliably. More consistent and accurate temperature monitoring was conducted during the batch composting trials detailed in Chapters Three and Five.

c) Information reported to the author by staff on duty at the time of inspection at each locality was given to the best of their knowledge and may contain minor inaccuracies. There is a high turnover of staff in public recreation areas and records vary in extent of detail. Perceptions as to what constitutes compost also varies. This experience is reflected in surveys conducted of composting toilets in other countries (Schloze et al. 1986: 63).

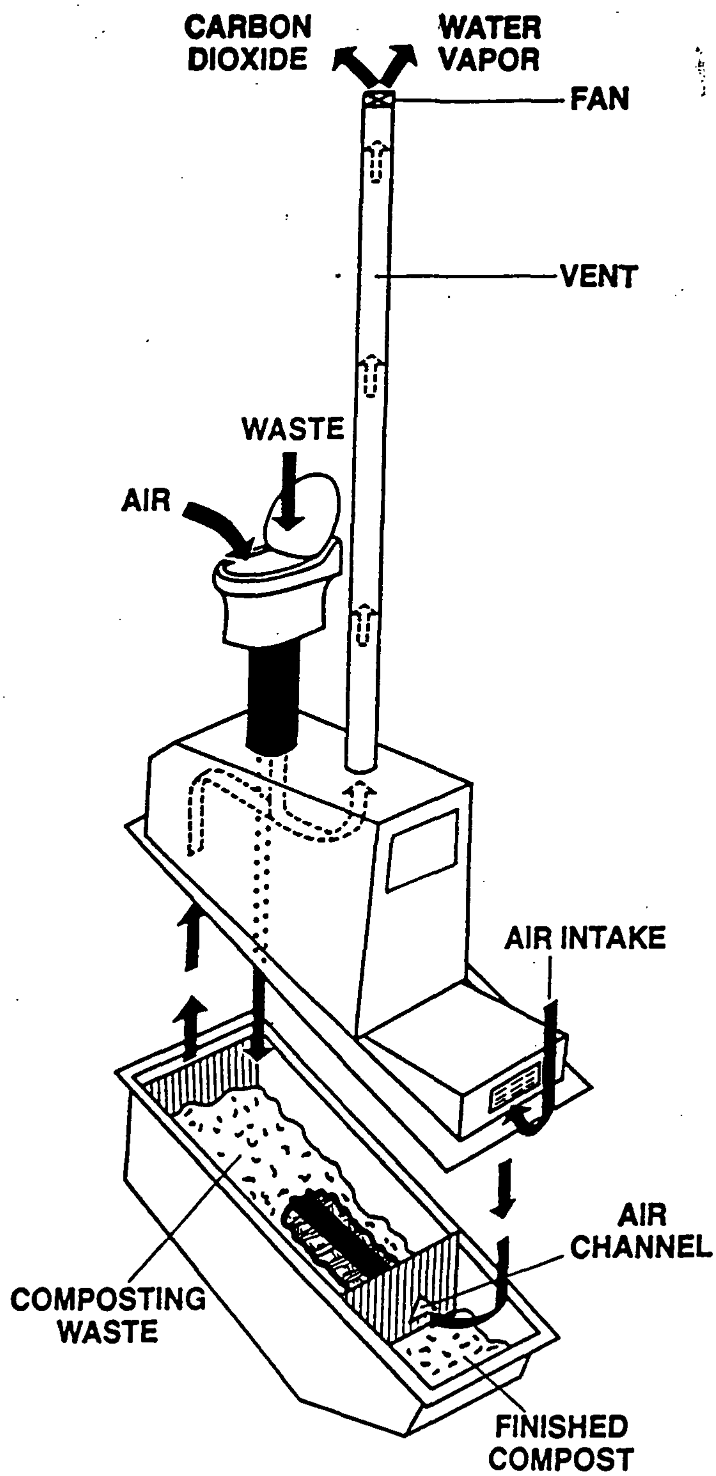


FIGURE 2.3
Clivus Multrum composting toilet.

Sections 2.1.1 to 2.1.9 cover installations on the Overland Track in the Cradle Mountain-Lake St. Clair World Heritage Area which was maintained by the Department of Parks, Wildlife and Heritage. Access to toilets on the Overland Track between Cradle Mountain and Lake St Clair is only by foot or helicopter. Registration indicates that 4 000 - 6 000 people walk the Track each year. . The toilets are installed at altitudes 800-1000 m. The 1991 temperature range in Cradle Valley in summer was 4.3°C to 15°C. The winter range was -7°C to 7.3°C. The rainfall recorded in Cradle Valley in 1991 was 2590.2 mm. These conditions are typical of the climate in this area.

2.1.1 Rodway Lake - Scott Kilvert hut. Overland Track

Inspected March 20, 1992.

This 'home-made' unit installed by Ranger Bob Hamilton consisted of a dual purpose septic tank with the baffles removed and a false floor inserted. It had been placed on its side and an access port cut above the half way mark which provides relatively easy access. Local leaf litter is added twice a month. The tank drains well through a pipe at the access end. It appears to be adequately vented (without a fan). There were signs on the pile of moisture running back down the vent which is a design fault with all the composting toilets inspected. The back of the composting chamber was north facing to maximise solar heating. The unit was not insulated, and was installed in a reasonably sheltered site.

The refuse near to the access door in this toilet appeared to be of a good moist consistency and in the early stages of aerobic decomposition. Because the original intention of the field trip was to inspect the Clivus and the Rota-Loos, samples or temperature were not taken from this unit, but in retrospect, its condition was of significant interest because it was working relatively efficiently compared to the other composting toilets in the Park. A second inspection was warranted but did not occur during the study period. It was reported to be still working satisfactorily in 1995 (Pers. comm. Bugg April 1995). Usage is relevant, but the fact that decomposition was occurring raised interesting questions regarding temperature and/or bulking agent being the issue with the Clivus units in Tasmanian alpine conditions.

2.1.2 Waterfall Valley. Overland Track

Inspected March 20, 1992.

One 09 unit was installed March 1988. The original tank was close to full, and it was intended to be replaced in 92/93. The compost access area contained what appeared to be 'starter' (undecomposed woody matter including pine needles collected locally) some excrement and toilet paper, which had slid forward into the chamber.

After 4 years there was little sign of composted material. A sample taken 50 cm into pile appeared to be unaltered excrement mixed with straw. The odour confirmed this assessment. Ambient temperature was 8.5°C at 3.30pm on the day of inspection.

Mushroom compost had been applied as bulking agent. This is probably not a good idea as the material is damp before application, may be higher in nitrogen than other bulking agents and does not provide dry porous aeration. Plain straw or fine chaff could be a better option in this case, but mixed with wood shavings and a little dolomite to reduce acidity. The internal vent rails or baffles in the composting tank were buckling under the weight of the uncomposted material.

Samples of green slime taken 10 metres from the outlet pipe contained a profusion of algal growth strongly smelling of hydrogen sulphide suggesting artificially elevated nutrient levels atypical of the area .

The toilet structure was insulated with double Sisalation and batts. No glazing was fitted on the roof over the unit or door. The composting tank was unpainted and white. The structure was sheltered by a nearby hillside. A solar panel for the ventilation fan was sited on a pole uphill from the toilet for improved exposure. Condensation from vent pipe dripped back into the pile.

2.1.3 Commercial hut. Waterfall Valley. Overland Track

Inspected March 20, 1992.

One 07 unit was installed at the back of a commercial hut on a ridge running down the centre of the valley. The hut is used by walkers guided by a commercial trekking company. The end-product in the compost access area was a black liquid. There was leaking around the base of the chamber, or else the run off was not draining away. Algal growth was building up at the edge of ridge where the run-off had seeped away from the toilet tank. There was no insulation or protective shelter covering the tank from the weather.

The pile appeared to be well mixed with bulking agent such as wood shavings but the pile was not decomposing.

The four 07 Clivus Multrums which are installed at the commercial huts have all been in operation since January 1988. During the 1991/1992 season 700 overnight campers passed through the huts. Maintenance is erratic. Usually sawdust is added to the pile when the party is vacating the hut. In a telephone conversation on 22 June, 1992, Ken Latona, manager of Cradle Mountain Huts, reported that in October 1991 all hut toilets except Windy Ridge were emptied of a "wet mush". Latona stated that the roof of the 07 chambers indent when the pedestal hole is cut in them, and then water leaks through the fitting. He endeavoured to correct this by putting tin roofs over some of the tanks.

2.1.4 Windemere. Overland Track

Inspected March 21, 1992.

The first 09 unit was installed in January 1988. The internal baffles collapsed under the weight of uncomposted material. The second 09 was installed in April 1991 to replace the damaged unit. The first 09 was removed from the shed and left at the back of installation. It was full of undecomposed material.

The end product in the compost access area of the second 09 was a thick dark liquid with floating excrement and covered with small black flies. The park Ranger Henk Shinkel was concerned that insufficient starter was applied in the new tank, however some signs of decomposition have should been apparent after one year (Pers. comm. Shinkel March 1992).

The ambient temperature was 10°C at 9.30 am on the day of inspection. The pile temperature was 8.6°C which suggests no aerobe activity. The sample and temperature were taken 500 mm from the top of pile. The sample appeared to be raw faeces.

The back of the toilet shed faced just west of north and was insulated with Sisalation foil and batts. The door covering the unit was corrugated iron. There was no solar glazing. Algal growth was apparent in shallow pools 20 metres from the toilet building. Mushroom compost had been used for bulking agent.

2.1.5 Commercial hut. Pine Forest Moor. Overland Track

Inspected March 22, 1992.

One 07 unit was installed under the hut. The compost access area was full of liquid excrement. The drop zone had a strong ammonia smell. The unit appeared to have slightly drifted away from its fittings due to the moist ground.

Grey water from the kitchen and bathroom was being released into tea tree and pandani forest without filtering. The receiving area had blackened soil with white scum. Separate grey water systems are required when dry biological toilets are used in domestic circumstances. The managers of the huts had not undertaken to provide this treatment at any of the Overland commercial accommodation facilities.

The unit was unpainted, without insulation and shaded by forest except in mid summer at high noon. It was considered by the author to be an inappropriate place for a hut and toilet to be constructed because of the fragile and damp environment.

2.1.6 Pelion Plains. Overland Track

Inspected March 23, 1992.

One 09 unit had been installed in March 1991. The tank had filled up rapidly due to considerable traffic at Pelion. Space had been provided underneath the toilet building for a second tank to increase capacity and to allow more time for composting before the tanks needed to be emptied. The Pelion site is an intersection for many tracks and a popular camping location. A second tank would be required before the following summer. The toilet building was well insulated with Sisalation, batts and a glazed roof was installed over the unit

The tank was bulging at the sides and showed signs of leaking. The compost access area was full of starter (local leaf litter) almost black in colour. A hollow had developed underneath the baffles. The pile was not flowing through. The drainage appeared adequate. A strong ammonia odour emanated from the tank. The solar panel was inadequate to maintain the charge to keep the fan moving.

2.1.7 Commercial hut. Pelion Plains. Overland Track

Inspected March 23, 1992.

One 08 unit was installed underneath the hut. The compost access area was full of liquid excrement. The tank was sitting in wet sludge. It appeared to be either not draining (though the drain did not appear to be blocked) or leaking. The tank sides were bulging and black water was leaking out of the seam. The unit faced south east. There was no insulation provided to the tank. Downhill from the hut appeared to be contaminated by greywater from the hut.

2.1.8 Kia Ora. Overland Track

Inspected March 22, 1992.

One 09 unit had been installed in March 1991. This toilet was maintained by the Lake St. Clair Ranger Station at the southern end of the park. The drain had blocked and had caused overflowing in the compost access area. The internal baffles were blocked by overflow. There was a very strong hydrogen sulphide smell perceptible 40 metres from the toilet. An obstruction was removed from outlet and liquid excrement drained away into the adjacent button grass. Wood shavings were being added irregularly by bushwalkers. The Ranger, John Purtell, reported that the system received little maintenance from staff. The design of the toilet shed was compact and was set neatly into an artificial rise. It was comprised of a 50 mm thick wooden frame with a sloping glazed door facing north. The tank was painted black and the vent system drew air from beneath solar glazing in the roof.

2.1.9 Commercial hut on Windy Ridge. Overland Track

Inspected April 18, 1992.

One 07 unit painted brown, was set in the ground up to the base of end-product chamber. It was facing north, with no roof or protection from the weather. Thousands of large brown insects flew out of the inspection hatch, on opening. The end product chamber was full of a dry mixture of saw dust, small pieces of toilet paper and organic material. The Cradle Hut manager, Ken Latona, reported that the material had been honeycombed by mice and he thought they were "working it over" (Pers. comm. Latona April 1992).

At the time of inspection there were no obvious signs of mice. The end-product did not smell unpleasant. The end-product was covering the vent baffles and had filled the drainage area and therefore needed emptying. The material in the inner tank, which had been covered with insects was predominantly raw sewage. The ambient temperature at 12.30 pm was 13.2°C and the pile temperature was 13.6°C. Certain insects do have a significant role in the breakdown of excrement. Certainly, the system had the most decomposed end-product among the Clivus Multrums on the Overland Track but it is not apparent whether the breakdown was caused by insects and mice, or by the biological process of composting. Obviously the unit was not sealed against vermin.

2.1.10 Huon Camp Ground. Scotts Peak. Parks, Wildlife and Heritage

Inspected April 1,1992.

Unlike the preceding installations on the Overland Track, this toilet has road access. The site is visited by 10-15 overnight campers every weekend throughout the year. In the fishing season 30 overnight campers may use the site. The altitude is 320 m. Winter temperature ranges from -5°C to 10°C. The average annual rainfall is 2 750 mm.

One 09 had been installed in 1990 in a corrugated iron shed with a perspex door over the tank. The Ranger, Phil Wyatt reported that the unit was started with 1 m of saw dust, pine needles and leaf litter (Pers. comm. Wyatt

April 1992). The ventilation fan had been replaced three times due to breakdown, and had been connected directly to the solar panel so it only worked during daylight hours. Rangers had not received any complaints of odour from clientele. It had been observed that flies had reduced since the tank had been painted a dark colour inside and out. The tank enclosure had been fitted with an inclined access door facing just west of north but shaded by large trees.

The end-product was very moist sawdust and a mixture of raw and partially decomposed faeces, and toilet paper. Ambient temperature at 5. 50 pm on the day of inspection was 5.7°C. The temperature 450 mm down into pile was 15.5°C which indicated some biological activity generating a 10 deg. increase on the ambient temperature. Bulking agent had rarely been added, nor was the pile often raked. In low use situations, it often appears that it does not make much difference whether bulking agent is added or not.

2.1.11 Ralphs Falls on Mt. Victoria. Forestry Reserve

Inspected April 3, 1992.

This toilet was installed at a road access site. Day visitors number one or two a week in winter and approximately fifty a week in the summer. One 09 unit was installed in 1990 in a wooden structure. There was no drain. Some black seepage was visible under the tank, but there was no detectable odour from the seepage.

The unit was started with local hardwood shavings and a bale of oat straw. Twice a year a bag of shavings and half a bale of straw was added and mixed in the pile by the Forester. At the time of inspection, it had been six weeks since the last addition of bulking agent and raking. The tank contained a dry mix of bulking agent, excrement that was raw and in various stages of decomposition, and toilet paper. The tank was very clean. Forester, Greg Hickey reported that before the bulking agent was added there was a 750 mm conical pile of partially broken down excrement and toilet paper (Pers. comm. Hickey April 1992). The ambient temperature was 11.8°C at 12 noon on the day of inspection and the pile temperature was 8.6°C. The toilet was installed at an altitude of 600 m.

2.1.12 Egg Island Point on Tamar River near Launceston. State Reserve. Parks ,Wildlife and Heritage

Inspected April 3, 1992.

This toilet has road access and is a picnic area for day visitors. The usage was unknown but it appeared from the contents of the tank that usage was low. The toilet location has a much milder climate than the alpine installations. On the day of inspection the ambient temperature at 4pm was 20.4°C.

One 09 unit was installed in 1988 in a concrete bunker set into the ground. The vent was outside the shed encased in galvanised iron. A turbine fan was installed with no battery or solar panel. The end-product chamber was half full of dry local leaf litter that appeared to be starter that had slid forward. The tank was quarter full of raw faeces, toilet paper, cans , bottles and sticks. Bulking agent had not been added on a regular basis.

2.1.13 Cradle Valley Waldheim Huts. P&O. Maintained by Parks, Wildlife and Heritage

Inspected April 7, 1992.

This toilet has road access and is used by day visitors and people staying in overnight cabins. The usage was unknown. The average occupation of the cabins in 1991 was 35 people a night. Thousands of day visitors inspect the Waldheim huts each year but it is not known how many of them use the toilets. The toilets were installed at an altitude of 900 m.

Two 09 units had been installed in mid 1989 in concrete bunkers at the back of the toilet blocks. The installation was designed by an architect employed by P&O who appeared to have little understanding of how composting toilets function or are maintained. The run-off was connected to a separate sewerage system. The units were started with Oregon wood shavings, and leaf litter was added during daily raking and service.

By December, 1989 , the tank nearest the Waldheim Chalet was becoming full. For the tank to be almost full in that time, it indicated that usage was above estimations. P&O maintenance personnel, Tony Coates reported that one cubic metre of "soggy shavings" had been removed. In February 1990, both tanks were emptied of a cubic metre each of a combination of faeces, toilet paper, and wood shavings in sodden condition. In June 1990, and November 1990, a cubic metre of "hard clay like mixture" was removed. This process was repeated four times during 1991. The vent baffles broke in that period, and Coates sought help from Ian Beeson of Clivus Multrum. The response was not considered helpful and did not appear to take into consideration the seriousness of the problem (Pers. comm. Coates April, 1992). Pea straw had recently been used as a bulking agent.

In July 1992, Technical Officer, John Walters flooded the tank nearest the Chalet. With a high powered hose and other tools, he broke up the material so it could be sucked out by a sewage disposal agency. The unit was then scrubbed out and false floors and false walls were installed in an attempt to improve aeration and evaporation. A generator powered heater will be used to warm the air intake. The effect of the modifications was monitored. The Waldheim Clivus' were selected for this trial partly because they are easily accessible and there is power available at that site. In addition, if they cannot be made to function, the tanks will have to be demolished in order to remove them from the bunkers.

The tank was reported to have been able to contain three times as much material since modifications were installed and when emptied was found to contain a partially decomposed pile which was much easier and less offensive to remove. However, the tanks will be replaced at some time when funds are available, and a more appropriate system is selected (Pers. comm. Walters April 1995).

2.1.14 Lake Dobson on Mt. Field. Hobart Walkers Club

Inspected April 14, 1992.

This toilet is accessed by road and short walk to the club's hut. Overnight visitors visit the hut throughout the year. The club members have financially contributed to the installation of the composting toilet so they take a special interest in its maintenance. Like most users of the Clivus Multrum, they chose the composting toilet because of its reputation for environmental protection. The altitude of the installation is 1030 m. The average annual rainfall is 1500 mm. The winter temperature range is 0-5°C to 10°C. The summer temperature range is -1°C to 22°C.

One 09 unit had been installed in November, 1989 in a workshop extension within the hut. At the time of inspection, the end product area was full of damp saw dust which did not smell, and the unit was very clean. When the material was raked forward the pile in the tank did not drop down despite being up to the access hatch. This suggested that the pile had compacted on the baffles which was a common problem observed in the 09 tanks.

Bulking agent had been added by the users. This was a successful method of maintenance, except that the scoop placed in the toilet was too large and the percentage of bulking agent in the pile was excessive. The ambient temperature outside the hut was 15°C at 2pm on the day of inspection and the pile temperature was 11.5°C.

The club was advised by the author to empty some of the pile as soon as possible to prevent further compacting. Ken Carpenter, a member of the Walking Club reported in a telephone conversation on June 24, 1992, that 30 litres had been emptied from the tank. The material removed which was probably starter, was predominantly damp saw dust and had no offensive smell. The pile had compacted and had to be prodded through the pedestal and access hatch, and scooped out from below and above the air rails in order to move it (Pers. comm. Carpenter June 1992).

It was suggested to the club that next time material is removed, it be tested for pathogens since the appearance is relatively good.

2.1.15 Trousers Point on Flinders Island. Parks, Wildlife and Heritage

Inspected May 22, 1992.

This toilet had road access and was used by day visitors and overnight campers. The usage was unknown. Ranger Hugh Sinclair estimated that 60 people a night would stay in the camping area in the summer and Easter holiday periods. Very few people stay there in winter. The winter temperature range is 1°C to 15°C and the summer range is 7.2°C to 25°C, with high humidity. The toilet was installed 1 m above sea level.

The unit was installed in 1989. This composting toilet was referred to as a

"Clivus copy". However, on inspection it was found to be a continuous system with a false floor. There were four pedestals and 2 urinals. The urinals flowed directly into an absorption trench as did the run-off from the tank. The tank was 7 m long and 1600 mm deep. The unit was vented from under the false floor by a 7 m piece of polypipe with no fan.

The pile, which was sitting on a starter bed of pine needles and local leaf litter was in an advanced state of decomposition. Bulking agent was never added to the pile. It was raked approximately twice a year. There was no offensive smell in the tank which was prefabricated concrete set into an artificial rise. Access to the pile was easy through a 1500 mm high door at one end of the tank. The facility cost $3 000 for labour and materials (excluding the wages of Rangers Sinclair and Napier).

Don Napier, (a former Ranger at Flinders who designed the installation), reported to the Compost Toilet Working Group in Hobart on August 27, 1992 that he had initially considered installing a Clivus. On inquiry to other users in Australia he had been discouraged by accounts of malfunction. He had then researched alternative designs particularly the non-commercial systems conceived and used by owner builders. The facility at Trousers Point was a combination of those ideas and experience (Pers. comm. Napier August 1992).

The location, with sandy soil for drainage, periods of little use, and relatively mild climate is an advantage over mainland Tasmanian environments. However certain aspects of the design were considered to be a definite improvement on the Clivus Multrum 07 and 09.

In May 1995, it was reported that the installation was full of 'raw sewage' (Pers. comm. Boyle 1995).

2.1.16 Mt. Wellington . Hobart Council

Inspected June 2, 1992.

This toilet has road access and is used by day visitors. Numbers were unknown. Superintendent Tony Bennett estimated that during the peak season of January-February, nine bus loads a day visit the summit. There are usually 45 people per bus and sometimes there are queues waiting to use the toilet. There was no method in place to record usage. The toilet was installed at an altitude of 1270 m.

Two 09 units had been installed February, 1989 in an underground cellar with an access ladder. Run-off was draining into rocks below the cellar. When toilet seats were left open, snow often filled the tanks but there appeared to be no problem with the drainage coping with that volume of liquid. It was not known where the liquid drained to. It was intended to build a holding tank into the cellar to monitor quantity of run-off.

In December, 1989, end-product had been removed that was assumed to be starter. In October 1990, 140 litres of "dark mouldy" material were removed from the two tanks. Bennett remarked that staff did not claim a Sewage Rate for the operation which they would have done if the material was in any way offensive. The end-product was used on staff gardens.

A constant unpleasant odour in the toilet room was corrected by replacing the inner vent fans and the battery with a turbine fan. It was discovered that the vent fans had been installed in reverse. In February 1992 a regular maintenance schedule was begun: the installations checked twice a day, and two litres of wood shavings were applied to each pedestal once a day, apart from the periods when the facility was snowed in. The female tank was reported to receive more usage. The urinal was removed because males were urinating on the floor of the toilet room and they seemed to be able to use the pedestal more successfully.

At the time of inspection the female tank contained large quantities of toilet paper, wood shaving and some raw excrement. The male tank contained copious amounts of wet wood shavings and some raw excrement and toilet paper. In a telephone conversation with Superintendent Bennett on September 1, 1992, he reported that the material in the tanks was "steaming" and there was no offensive smell. Ian Beeson from Clivus Multrum, Australia Pty Ltd took a sample on August 27, 1992 to be tested for pathogens and intended to pass on results. It was suggested to take at least 5 samples throughout the lower end of the pile to get a reliable indication of pathogens as there are often pockets of different materials present.

The temperature in the cellar where the composting tank was stored can be 5 to 8°C warmer than the ambient temperature which may contribute to the relative effectiveness of these Clivus units compared to other alpine installations in Tasmania. In addition, the daily maintenance, efficient drainage, and the lesser load on the tanks by day visitors compared to overnight campers would make a difference. It is generally accepted that overnight campers deposit more faeces than day visitors. To make any kind of accurate assessment of the units capability, usage figures are necessary. However, at least some decomposed material was being produced.

2.1.17 Stewarts Bay. Parks Wildlife and Heritage

Inspected June 4,1992.

The toilet was installed at a road access site used by day visitors as a picnic area Usage was unknown but presumed to be low. The bay is relatively protected and the installation is 2 m above sea level.

Two 09 units had been installed late 1988 in a cellar under the ground. Access to the cellar was down a ladder. This kind of installation increases the possibility of faecal contaminated material on the floor of the cellar, contaminating the hands of staff as they climb the ladder. Run-off was drained under the building and appeared to be causing a seepage 20 metres down the hill to the left of the facility.

There was very little material in the tanks which suggested low usage. Ranger Nick Bates confirmed that usage of the area was moderate. The male tank was not draining properly so the material in the end-product area was an anaerobic slurry. Very little bulking agent had been added to either pile. The urinal drains into the tank as does the grey water from the hand basin. It was advised that these should be diverted into an efficient absorption trench to reduce liquid input to the pile (Pers. comm. Bates June 1992).

The material in the female tank was partially decomposed excrement and toilet paper on a solid bed of woodshaving starter. The greywater also drained into this tank. The rotary fans are not working but there is no odour in the toilet room or the cellar so this does not seem to be a problem. Aeration of the pile without assisted venting appears to be adequate, probably because the piles are so small and the cellar is well aired.

2.1.18 Lake Vera. Frenchman's Cap. Parks Wildlife and Heritage

The units referred to in 2.1.18 and 2.1.19 on Frenchman's Cap Mountain were not personally inspected due to unfavourable weather during the period of the survey. The information was provided by District Ranger, Mark Bryce.

Access is by foot or helicopter. In the period July 1991 - June 1992, 728 walkers registered for the walk to Frenchman's Cap. Most people stay at Lake Vera on the way up the track, and then again on the return journey, so the toilet at that hut probably receives twice as much use as the toilet at Tahune. The average annual rainfall for the area is in excess of 1200 mm.

At an altitude of 560 m, one 09 unit was installed in January 1991. The building has a solar collector built into the roof and the warmed air is vented directly into the tank. This system designed by Mark Bryce and G. Rodgers was working effectively. The unit was started with brushcut grass laid to just below the baffles. Grass was left in a container for user application. Run-off drained into a 10 m soakage trench which is 200m from the nearest water course.

In November, 1991 the toilet was inspected by Parks staff and 120 litres of damp grass was removed from the end-product chamber. The 20-30 litre pile in the tank was in the early stages of decomposition. There was some food scraps in the tank, but no rubbish had been dumped. Pea straw was flown in to replace the grass as bulking agent to reduce the possibility of introduction of exotic species. It was intended to remove the battery, and connect the fan directly to the solar panel to reduce cold air being drawn through the pile.

2.1.19 Tahune. Frenchman's Cap. Parks Wildlife and Heritage

At an altitude of 1000 m, one 09 unit was installed in 1989. There is no solar collector on this unit. Run off drained out of the tank, across the cement slab and into Tahune Creek. Samples taken of run-off in March 1992 gave pathogen results that were "dangerous to animals". It was indicated that the Creek was contaminated. The drain had been connected to a soakage trench but was disconnected not long after installation because it was blocked.

Wood shaving bulking agent had been added by the users. In April 1991, there was an offensive smell and raw sewage in the tank. Forty litres of dry leaf litter was mixed into the pile, and when it was inspected in November 1991, there was some decomposition and the smell had reduced. At that time, 60 litres of wood shavings starter was emptied from the end-product chamber. The pile had compacted and did not slide down into the gap created beneath the baffles. Straw was stirred into the pile and there was a strong ammonia smell when it was disturbed (Pers. comm. Bryce July 1992).

2.1.20 Hartz Mountain. Parks, Wildlife & Heritage

Inspected June 25,1992.

This toilet had road access and was used by day visitors, but the usage was unknown. Ranger Shane Hunniford reported that people visit the mountain when it snows, and over the summer holidays, but the rest of the year it is very quiet. The altitude of toilet installation is 760 m. The average annual rainfall is 1754 mm. The winter temperature range is 0.2°C to 5.9°C and the summer temperature range is 7°C to 17°C.

One 09 unit had been installed in 1991 in a corrugated iron shed underneath timber toilet room. The run-off was discharged into an absorption trench. A solar glazed door had been installed over tank. No insulation was provided in the shed. The tank was painted black. Air was drawn through the glazed solar collector on the roof and vented to the inside of end-product chamber which was sealed. This is an effective device for warming the toilet room, and the air being drawn into the pile. On the first day of inspection the ambient temperature was 6°C at 2.30 pm, and the temperature of the air passing into the vent was 23°C. However, the outlet of the pipe would be cut off if the end-product chamber filled up. There was a 1 m pile of excrement, toilet paper and straw in the tank and black liquid in the drainage section. The pile was dry and not odorous. The fan was connected directly to the panel.

A university data logger was installed on this unit for six months to monitor a number of processes, including the impact on the pile of the warmed air from the solar collector. Temperature was monitored constantly at 10 different points, and the average was recorded every 30 minutes, at each point. The solar collector, pile and ambient temperatures are plotted in Figure 2.4.

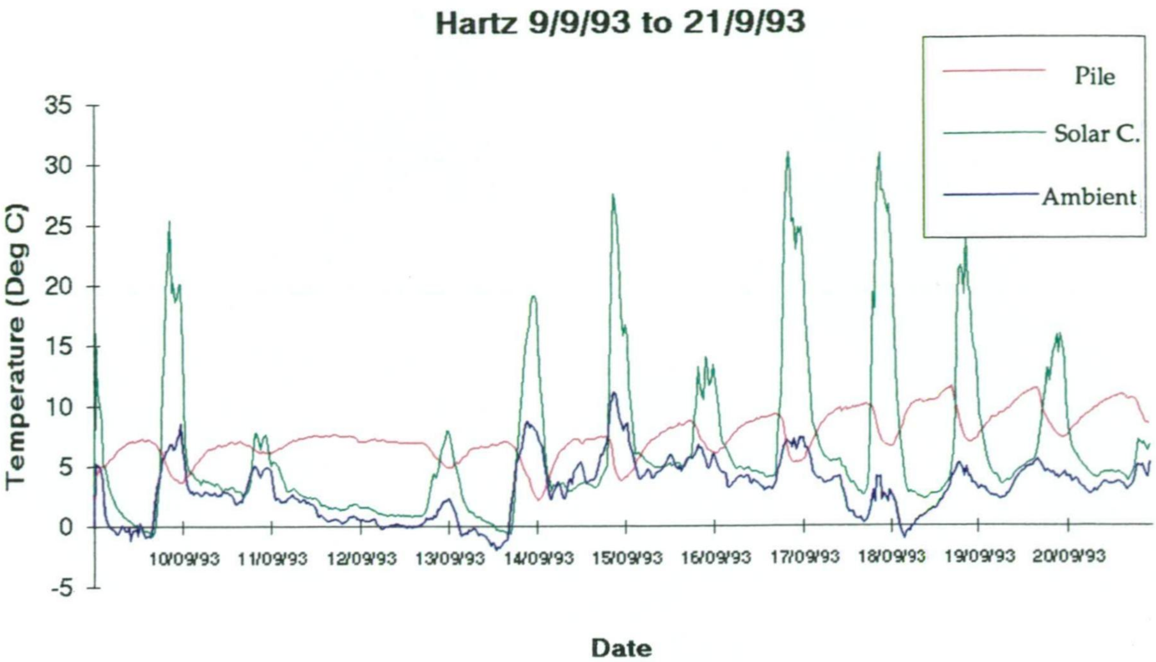


FIGURE 2.4
Temperatures: pile/solar collector/ambient.

Despite the attempt to provide heat assistance to the pile, the pile temperatures remained low and seemed unaffected by the temperatures reached in the solar collector. This differs from the pile temperatures recorded in the Cage Batch pile discussed in Chapter Three at 3.2 where temperatures in the mesophilic range were maintained.

2.2 Clivus Multrums in Queensland

This section summarises the investigation of forty five Clivus Multrum composting toilets in Queensland (see Figure 2.5). It is a chronological record of the author's site inspections and meetings with relevant personnel, including observations and information provided by maintenance and administrative staff.

Range of Composting Toilet Sites Covered in Survey

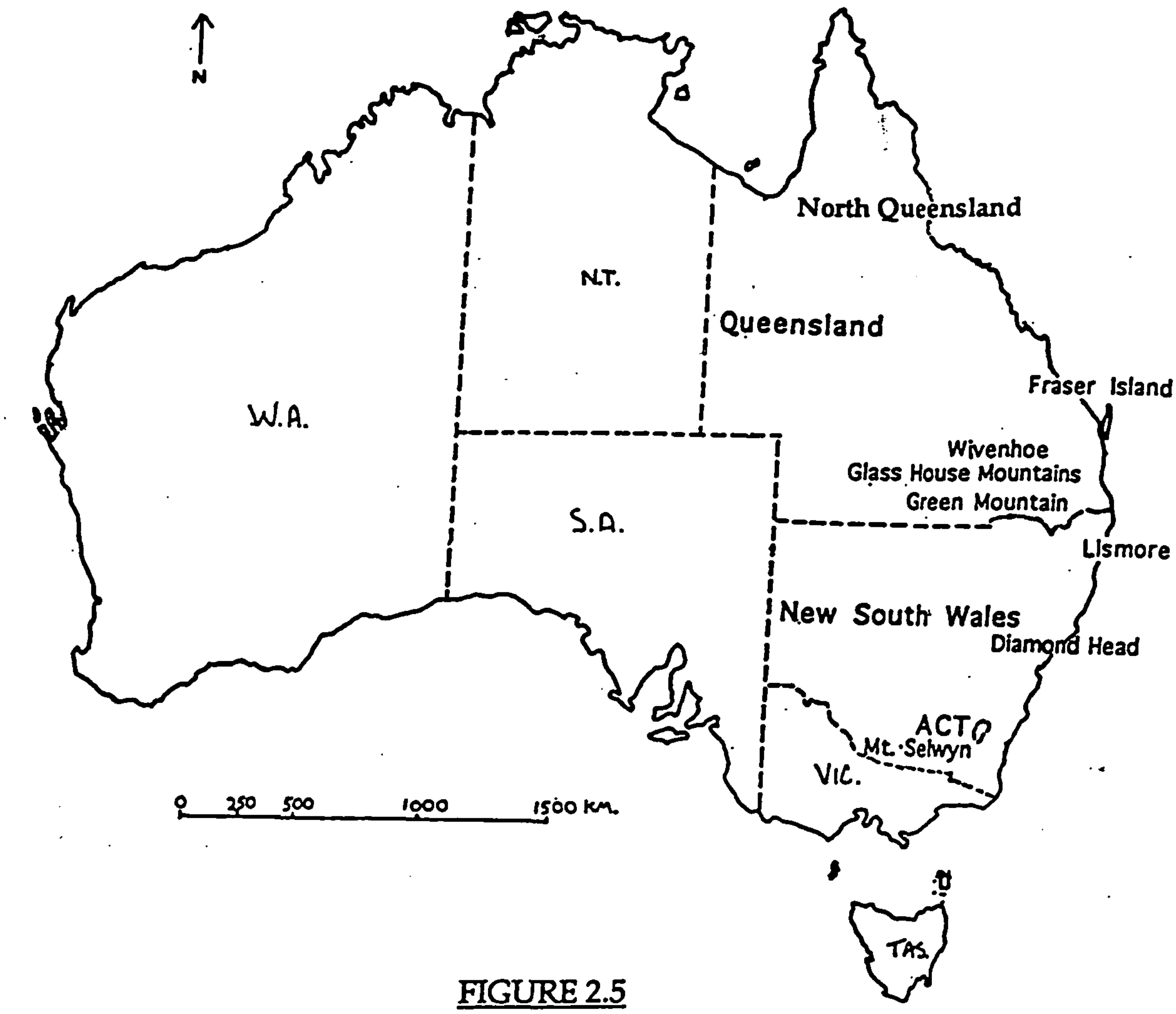


FIGURE 2.5
Map of Australia.

2.2.1 Logans Camp Ground. Wivenhoe Dam public recreation area. South East Queensland Water Board

Inspected April 24 & 27, 1992.

This toilet facility had road access and was used by overnight campers numbering 300-400 most weekends throughout the year and all school holidays. The composting toilets were the only toilets on site. Pump-outs were used for greywater from showers and hand basins.

Four 09 units were installed in 1989 in a cellar under the facilities block. The temperature recorded consistently around 20°C in the cellar. The drains sometimes flooded and could not cope with the runoff from the tanks. Ranger Frank Mills suggested that bigger drain pipes were necessary and constant attention was needed to prevent blockage occurring.

Since the toilets had been commissioned stratification had occurred in piles in the form of a perched water table with uric acid crystals "setting like concrete" (Pers. comm. Mills April 1992). The piles had built up, compressed and were very difficult to remove. The vent baffles broke under the weight. Staff were very reluctant to maintain the tanks which were quite odorous and unhygienic. Eighteen months prior to the author's inspection, the units were cleaned out, single new baffles installed and large amounts of winnowed wood shavings (pine wood Hysorb animal bedding) had been used as bulking agent.

The maintenance procedure 12 months prior to inspection was 8-10 litres of loose woodshavings and a couple of litres of water added by staff, daily, to each unit during busy periods and at least three times a week during lower usage times. The pile was raked bi-weekly during busy times and weekly during lower usage times. The ranger reported that material was removed 5-6 times a year. Tools had been adapted by staff to facilitate maintenance of the peculiarities of the 09 tank. The volume of end-product was approximately half the original volume of faeces and bulking agent. The end-product was reported to have been broken down faeces in a recognisable wood shaving mix. The ranger stated that constant consistent maintenance was the key to success. Results of Health Dept. tests of end-product have not been returned at the time of inspection but were later provided. E. Coli/g counts for compost samples ranged from <30 to 1.1x 10^6, and for liquid effluent E.Coli/mL counts ranged from <30 to <0.3 (Pers. comm. Gould June 1992).

2.2.2 Sheep Station Creek. Wivenhoe Dam public recreation area. South East Queensland Water Board

This toilet block had road access with 200 day visitors a week using the toilet during normal periods. Usage also included 15 regattas a year with crowds of 13 000 people attending for a couple of days.

Six CM40 units had been installed in 1991 with twelve pedestals and six urinals. The urinals and run-off discharged into a holding tank. The CM40 has a stated capacity of 200 000 uses (Clivus Multrum Australia Newsletter) and, while having greater capacity than the 09, the tank is also lower and wider reducing the likelihood of compacting and giving easier access to the pile. Problems occurred with installation due to the top of the tank being too flexible and requiring reinforcing for secure fitting.

At the time of inspection the pile consisted almost entirely of a large quantity of wood shaving bulking agent. Solar operated fans were installed inside the vents. The installation cost approximately $140 000 (Pers. comm. Mills). The facility had been operating less than a year. The composting toilets' performance would provide an indicator of the efficiency of the CM40 in Queensland's climate with very regular maintenance and 'shock loading' of day visitors.

2.2.3 Booloumba State Forest Park. Queensland Forestry

Inspected April 25 1992.

This toilet had road access and was attached to a camp ground which served approximately 14 000 overnight visitors and 3 500 day visitors annually. There was also a septic tank toilet at the lower end of camp ground. It was estimated that 40% of overnight visitors used the Clivus. Summer temperatures range from 16°C to 31°C and winter temperatures range from 6°C to 17°C.

One 09 unit had been installed with two pedestals and a urinal. The urinal and run-off discharged into the holding tank. Bulking agent was added and the pile raked once a week. Ranger Eric Glassop reported that the unit had been restarted three times because it was not composting. Ian Beeson from Clivus had been on-site for the last two clean-outs including replacement of broken vent baffles. Maintenance had been exactly as directed by Beeson, but the unit had continued to perform inadequately. Garden worms had been added to assist decomposition and had been found in the back section of the tank on emptying (Pers. comm. Glassop April 1992). At the time of inspection, the tank had been recently restarted using some of the old material as starter.

2.2.4 Sunday Creek Rd Field Study Centre. Queensland Education Department

Inspected April 26, 1992.

This toilet block had road access and was attached to a hostel that accommodated 30 children a night, continuously throughout the year. The new toilet facility replaced pit toilets at a cost of $175 000 and had been functioning for one month.

Three 09 units were installed in 1992 with six pedestals and three urinals. Run-off was diverted to a holding tank. Daily maintenance entailed the addition of 10 litres of wood shavings added for every 150 uses and the pile was raked three times a week. The ventilation fans had failed in the first couple of weeks and a strong ammonia smell had developed. At the time of inspection the piles consisted of copious amounts of wood shavings, the fans had been fixed and there was little offensive smell. The units had been installed with single air vent 'rails' or baffles rather than the double baffle system originally fitted in the 09.

2.2.5 Jimna Fire Tower. Queensland Forestry

Inspected April 26, 1992.

This toilet had road access. It was adjacent to a lookout tower which attracted an unknown number of visitors for sightseeing. A small picnic area was provided but most people climbed the 44 m tower and then departed. The tower was installed at an altitude of approximately 500 m. Yearly temperature range is 5°C to 28°C and average annual rainfall is recorded at 700 mm.

One 09 had been installed in 1987 with two pedestals and one urinal. The tank had been recently emptied due to the internal vent baffles breaking. Forester Peter Kraus attributed breakage to rubbish dumped in tank. He described the material that had been removed as having a "good smell and texture and rotting down well". Half a rubbish bin of wood shavings was added in each chute per week (Pers. comm. Kraus April 1992). At time of inspection very strong ammonia fumes were detected from the tank. The urinal outlet fed into the tank near inspection hatch. Black liquid was observed around the end-product chamber. Run-off from the tank discharged through a grid and drained behind the installation. It was noted that the toilet was installed in an attractive timber building with wheel chair access.

2.2.6 Glass House Mountains State Forest Park. Queensland Forestry

Inspected April 27, 1992.

This toilet block had road access. The facility served lookout and picnic area for day visitors. A septic tank toilet was provided on site for males. From September to April each year the site served 200-300 visitors a day and in winter, 100 visitors a day. People usually stayed for an hour or so then departed. It was unknown how many people used the toilets.

Two 09 units were provided for females with two pedestals. The original facility had been burnt down and rebuilt 18 months prior to inspection. Three times a week a bucket of fine pine shavings was added down each pedestal and the pile was raked. Occasionally leaf mulch was added. Run off and grey water discharged into an absorption trench. At the time of inspection the end-product appeared to be enriched wood shavings and there was no offensive smell. Input was predominantly urine and toilet paper.

Maintenance personnel, Cliff Grahame, took a consistent interest in the system and was satisfied with its performance. He reported that he much preferred the composting toilets to the septic tank toilets because there were no maintenance problems that were associated with providing water to the septic toilets, and the composters generated minimum discharge to the environment. Considerable precautions had been taken against the theft of solar panels and vandalism when the original 09s were replaced (Pers. comm. Grahame April 1992).

2.2.7 Coochin Creek State Forest Park. Queensland Forestry

Inspected April 27, 1992.

This toilet block had road access and was attached to a camping ground which served twenty overnight visitors on weekends. Very few people used the camp ground during the week. The annual temperature range was 20°C to 35°C and the toilets were installed 1 m above sea level.

Two 09 units were installed with two pedestals into one tank, for the use of females, and one pedestal and two urinals into the second tank, for males.

Twice a week a bucket full of bulking agent was added to each pedestal and the pile was raked once a week. The tanks had been emptied two months previously of 15 rubbish bins of faecally enriched wood shavings. The end product was disposed of around pine trees in a nearby plantation. The end-product had the appearance of dark damp wood shavings.

Cliff Grahame reported that he expected to empty the tanks every 10 months. At the time of inspection, the male tank was producing black liquid in the front drain. It was reported that more men used the camp ground than women, for fishing expeditions, which explained the extra strain on the male tank (Pers. comm. Grahame April 1992).

2.2.8 Goomburra State Forest Park. Queensland Forestry

Inspected April 28, 1992.

This toilet had road access and was attached to a camp ground that served one hundred overnight visitors on weekends. There were very few visitors in the winter, from May to September. On public holidays, such as Easter there could be up to 2 000 visitors. The annual temperature range was -7°C to 36°C, with low humidity. During mid winter the temperature was often not above 10°C. The area experienced dry winters.

One 09 unit had been installed in 1986 with two pedestals. The toilet was consistently maintained by Neil Jones who applied 40 litres of very fine wood shavings (exotic pine, cypress, ironbark) to the tank each week, and raked the pile at least twice a week. It was three years before the first end-product was removed, and it consisted of enriched sawdust. Half a cubic meter had since been removed annually, and Jones reported that the volume of end-product was 10% of the original quantity (Pers. comm. Jones).

At the time of inspection the internal vent baffles or 'rails' had broken and the unit was full with a slurry in the end product chamber. The slurry was reported to have been due to be due to a shock loading from 2 000 campers at Easter. The baffles had been broken for some time but this had not affected the efficiency of the unit, according to Jones. The end-product had been dumped in a nearby exposed pit, and faecal matter and toilet paper was observed to be well broken down in the residual wood shavings.

In 1990 two extra 09s had been installed on site due to satisfaction with performance of original unit. It had taken two years for these units to fill in conjunction with the first unit. Material in the end-product chambers appeared to be blackened moist wood shavings. This may have been starter. Neil Jones emphasised the need for consistent inspection to ensure a well mixed pile, with large quantities of bulking agent and attention to drainage. He recommended that the same person be responsible for maintenance as it required a familiarity with the consistency of the pile and experience to recognise signs of malfunction. Toilets were inspected 2-3 times a week depending on the number of visitors.

2.2.9 Eli Creek. Fraser Island . Department of Environment and Heritage

Inspected July 21 & 22, 1992.

The toilets referred to in 2.2.9 and 2.2.10 had road access. Fraser Island is an ecologically sensitive area with low nutrient vegetation and a high freshwater table. The 'perched' lakes are also very susceptible to pollution as they do not drain. The average yearly rainfall is 1150 mm. The average temperature in the high use season is 25°C, with a yearly average of 21°C. The extensive area to be protected, and the number of tourists visiting the island, presents a daunting management challenge.

The toilets at Eli Creek were reached by road access along the beach. The toilet block was installed at sea level and was used by day visitors. There were no accurate usage figures. In 1991, during the peak season (i.e. the 60 days in the December to January period) it was estimated by Queensland Forestry that 35 000 people visited Eli Creek, or 560 per day average, or on peak days about 700 per day. Most visitors arrive at the site for a brief visit and then depart. The input to the tanks was, therefore, more urine than faeces.

Three 09 units had been installed in 1989 with three pedestals and two urinals. The run-off drained into the sand behind the toilets. The facility had been maintained by John Hedges for the last 34 months. The systems were not composting.

Queensland Forestry, who installed and managed the facility before National

Parks took responsibility, considered that malfunction was due to overload. They reasoned that, whilst the tank's capacity (as claimed by the manufacturers) is 300 per day they could cope with 160 uses each i.e. 480 per day over short periods provided there were regular low use days to allow the material to commence the composting process. If 70% of the visitors used the facility then on peak days about 490 uses would be received against 480 theoretical capacity. It was assumed that the problem arose during prolonged heavy use over the Christmas/New Year period when the toilets were receiving 500 uses per day, which is an overload of 60-70% (Pers. comm. Angwin July 1992).

John Hedges reported that the quantities of urine from both male and female toilets keep the pile wet despite copious additions wood shavings. After 11 months the pile was within 300 cm of the top of the tank. The tanks then needed to be emptied. The bottom layer of the pile was "rock hard" and would not respond to prodding from above through the pedestal, or to being raked from below. A firehose from a firefighting truck was used to brake up the pile and the slurry created was removed by hand using buckets. The material from the tank was deposited in a pit in the sand next to the facility. The process took two people seven hours (Pers. comm. Hedges July 1992).

Hedges recommended that the fibreglass tanks needed strengthening particularly around the access door and baffles. In addition, he suggested an access panel in the midsection would facilitate emptying. He reported that there have been problems with corrosion in the exhaust fans.

At the time of inspection, Queensland National Parks was contemplating increasing the number of units, but before doing so, it was suggested by the author that it could be useful to consider that the malfunction may not be due entirely to overloading. The biological process of composting requires a balance of moisture, carbon/nitrogen, temperature and aeration. Composting can be inhibited when the urine input is excessive. It was advised that the type of use a facility receives needs to be carefully examined and the system designed accordingly.

2.2.10 Lake Birabeen. Fraser Island. Department of Environment and Heritage

This toilet block had road access, and was installed 150 m above sea level.

The facility served day visitors and usage numbers were not known but it was estimated that 300 bus and tour people visit the lake each day in the busy season.

Two 09 units were installed in September 1986, with a male and female pedestal and a urinal. The run-off drained into sand behind facility. Half a tin of Hysorb wood shavings was added to each pedestal each week. This was increased in high usage time. In general, staff found it difficult to report how much bulking agent was used and the amount varied according to what was perceived as being needed.

At time of inspection, the material in the male tank was very moist and the bulk appeared to be suspended on the internal vent baffles. The material in the female end-product chamber was dry and papery. The holding tank contained copious amounts of toilet paper which appeared to be acting as an absorbent. The Ranger, Dave Redman, reported that material removed in February, 1992, had been moist with no offensive smell (Pers. comm. Redman July 1992). The end-product had been partially buried in the sand behind the facility. Toilet paper, sanitary pads, tampons and rubbish were discernible in amongst the wood shavings. It appeared that soil organisms had broken down all faecal matter in the partially buried pile.

2.2.11 Binna Burra Lamington National Park. Queensland National Parks and Wildlife Service

Inspected July 23 & 24.

The toilets referred to in sections 2.2.11 to 2.2.13 were installed in Lamington National Park. Lamington National Park, 100 km south of Brisbane is the most significant area of rainforest in South East Queensland. The park of 20 100 ha and the adjoining Border Ranges National Park of 30 000 ha in New South Wales protect a variety of vegetation types growing on soils derived from a huge shield volcano centred on Mt. Warning. The park appeared to be seriously understaffed and underfunded, while the concessionaries were doing a 'roaring trade' with the tourists. The altitude of the Park is approximately 1000 m. The yearly average temperature was 15°C and average annual rainfall was 2300 mm.

One 09 unit was installed at Binna Burra in 1989 on a roadside near the

Visitor's Centre serving day visitors. Approximately 550 cars stop at the Visitors Centre between Monday and Saturday and 250 cars on Sunday with an average of three persons to each car, but it was not known how many people use the toilet.

There was a male and female pedestal and run-off drained out of the tank and over an adjacent cliff. The unit was full and the material had not composted. Some material had been removed to provide more capacity. It was due to be emptied and restarted.

Ranger Andrew Quirk reported that a wheel barrow of leaf litter was added each fortnight and once every 3-4 weeks, 3 buckets of vegetable and fruit scraps were added (Pers. comm. Quirk July 1992).

2.2.12 Daves Creek Lamington National Park. Queensland National Parks and Wildlife Service

One 06 unit had been installed in camping area on a walking track. The usage was approximately 12 campers a week. The toilet was not serviced. The tank was very small. It was set into the ground and an air vent was open allowing access for animals and soil organisms which appeared to be feeding off the pile. There was a slight faecal odour. The unit was functioning like an exposed pit. The internal vent baffle had been broken or eaten away. Shavings and leaf litter were detectible in the end-product chamber.

2.2.13 Green Mountain. Lamington National Park. Queensland National Parks and Wildlife Service

Three 09 units had been installed in 1990 in a camping area with road access serving 150 - 180 campers per night. Approximately 10 g of wood shavings are added per use by the public. The toilets are maintained on daily basis. A heater had been installed in July 1991 and warmed air ducted into each unit from April to September, 24 hours a day. The pile temperatures were consistently monitored. The highest temperature measured in the pile, since heating, was 29°C which is in the lower mesophilic range generated by composting. On the day of inspection the pile temperature was 14°C at 5.30 pm. The yearly average temperature at the installation is 15°C, and the average annual rainfall is 2300 mm.

Ranger Neville Hague reported that emptying of some end-product had been necessary every three months. The tanks had been emptied by pump-out to sewage works at a cost of $350 for each tank. On other occasions material was dug out and emptied into garbage bags. The Gold Coast City Council had tested the 'dry' material and found that the Faecal Coliform and Faecal Streptococci bacteriological counts were far in excess of EPA(US) guidelines for compost and consequently the bagged waste was not accepted for disposal by Council. Some of the material appeared to consist of enriched wood shaving with negligible smell, but pathogens were apparently still present. Single baffles had been bought from the local Clivus Multrum company to replace the double vent baffles or 'rails', and installed at the same time as the heaters.

It was reported that Clivus Multrum Pty Ltd was to replace two of the 09s with CM40s in the hope that the extra capacity would allow longer time for composting. The change over would cost National Parks approximately $14 000. The Department hoped to recoup some of their cost by using the 09s elsewhere (Pers. comm. Hague July 1992).

2.2.14 North Queensland. Queensland Forestry

This section covers reports received in answer to a questionnaire, forwarded to the author by Executive Engineer, Colin Angwin, September 1992, and discussed subsequently by telephone.

2.2.14(i) Five Mile Creek near Cardwell. NQ

One 09 unit was installed in September 1991, serving 20 visitors per day during busy season and 2 per day during the off peak period. 5 litres of planner shavings were applied by staff once a week. No problems were reported up to the time of the survey, and no end-product had been removed. Yearly average temperature is 27°C and rainfall is 1850 mm.

2.2.14(ii) Tully Falls near Cardstone. NQ

Two 09 units were installed in September 1991 serving 100 people a day during the busy season. 5 litres of planner shavings were applied to each tank by staff once a week. Fans were cleaned every week. It was reported that an extra solar panel needed to be installed on the roof to get fans to function. No end-product had been removed. The yearly average temperature is 29°C and rainfall is 2000 mm.

2.2.14(iii) Kauri Creek. Tinarro Dam. NQ

One 09 unit was installed in late 1991 and recorded 50-80 uses a day in heavy periods. Approximately one handful of softwood shavings per person was applied by staff. The toilet was reported as "working well and warm air was felt when opening compost access hatch". No end-product had been removed. The toilet is installed at an altitude of 752 m.

2.2.14(iv) Fong On Bay. Tinarro Dam. NQ

Two 09 units were installed 1989 and recorded 100-200 uses a day in the peak period (for a maximum of 4 days). 0-20 uses were recorded a day in the off peak period. Softwood shavings were applied by staff depending on usage. "Tanks are inspected daily over peak periods. Twice weekly in normal conditions. It is extremely important that staff are trained on maintenance and what to look for. Correct amount of bulking agent is critical and varies with uses." No end-product had been removed. The survey reported that the toilet was installed at an altitude of 752 m. The yearly average temperature is 20°C and average annual rainfall recorded at 1390 mm.

2.2.14(v) Emerald Creek 15 km SE of Mareeba. NQ

One 09 unit was installed September 1989, recording approximately 30 uses per day in peak times and 0 -10 uses per day in off peak times. Approximately one handful of softwood shavings per person was applied by staff. "Problems with straw. Careful attention to moisture content due to dry conditions." No end -product had been removed. The yearly average temperature is 23°C and rainfall is recorded at 1079 mm.

2.2.14(vi) Downfall Creek. Tinarro Dam. NQ.

Two 09 units were installed in December 1990 recording 100-150 uses per day over peak periods of 4 days. Staff added 2 handfuls per person softwood shavings. "Toilet is in constant shade. Temperature seems low compared to other units. Problems experienced with liquid build-up. Particular attention to stirring bulking agent in. Extra bulking agent required". No end-product had been removed from the chamber. The toilet was installed at an altitude of 752 m. The yearly average temperature is 20°C and average annual rainfall is recorded at 1390 mm.

2.3 Clivus Multrums in New South Wales

This section summarises the investigation of twenty four Clivus Multrum composting toilets in New South Wales (see Figure 2.5). It is a chronological record of the author's site inspections and meetings with relevant personnel, including observations and information provided by maintenance and administrative staff.

2.3.1 Diamond Head. Mid North Coast. National Parks and Wildlife Service

Inspected April 29, 1992.

The toilet block had road access and was attached to a camp ground which served overnight and day visitors. 7 000 camper registrations were recorded from January to April, with often four people in each camp. Day visitors were unknown. Toilet was installed 3 m above sea level. The winter temperature range is 6°C to 20°C and the summer range is 16°C to 31°C.

Four 09 units were installed in 1990. The units were pumped out Christmas 1991/92. On the day of inspection, the Ranger on duty was unfamiliar with the history or maintenance of the toilets, so it was difficult to obtain information. One tank was flooded due to the drain being blocked. The other three tanks contained the usual mix of excrement, toilet paper and pine wood shavings. The end-product chambers contained material in various stages of decomposition. The piles appeared to be stuck above the double vent rails or baffles.

In a telephone conversation on May 25, 1992, maintenance personnel, Ron Harmer reported that bulking agent was raked into the pile every second day. He believed the problems with the systems had been due to inadequate installation of venting, and the chutes protruding too far into the pile causing the tank to fill up quickly. He also thought that the tanks would perform better if they were insulated from the sea breeze, and the run-off outlets were enlarged to prevent blocking. Hammer considered that the Clivus Multrum required skilled installation and maintenance, and should be advertised as such.

Initially hardwood shavings were used, but were recently replaced by pine shavings. There had been difficulty with the solar panel/ battery/ fan system, and the fans only lasted 3-12 months (Pers. comm. Harmer May 1992).

2.3.2 Myall Lakes. Hunter District. National Parks and Wildlife Service

Attempts to meet with Ranger Rosemary Black at Yagon and Broughton Island camping areas were unsuccessful. It was not possible to inspect the inside of the tanks. Information on the units, dated May 15, 1992, was forwarded to the author by Ms. Black. The toilet had road access and was installed 20 m above sea level . The winter temperature range is 6°C to 20°C and the summer range is 15°C to 30°C.

O9 units were installed at Broughton Island in December 1990, and at Yagon in May 1989. All toilets were started with coarse hardwood shavings. Regarding **Broughton Island**, the Ranger reported "This toilet has only been installed 18 months. Because of its location, very little is known about it". Wood shavings were left at the toilet to be added by users.

Yagon. The usage was unknown, but it is a popular area. Each time the author has stayed at this camp ground over the last 10 years, there have been at least 20 campers there. The problems that were reported as being encountered with these units include malfunctioning fans (partly due to incorrect installation), blocked drainage and flooding, stolen panel, inadequate aeration, and broken baffles. Ian Beeson the agent of Clivus Multrum offered to help install the new baffles (kits costing $250 each) if his travel expenses from Queensland were paid. The tanks have been pumped out twice because they were full of raw sewage. In November 1991, the baffle kits were installed after the pump out. An end-product similar to mushroom compost was removed on one occasion. Bulking agent was previously saw dust but was changed to wood shavings. Efforts were being made by staff to add and mix bulking agent at least once a week and more often in busy periods. It was believed that bulking agent was not added often enough previously (Pers.

comm. Black May 1992).

2.3.3 Schlink Hut. Kosciusko NP. National Parks and Wildlife Service

Inspected May 5, 1992.

This toilet has road access for maintenance vehicles. Exact usage was unknown. During the skiing season, July-September approximately 60 ski-tourers may camp at the hut a night. Over Easter 10-150 people camp at the site. There are very few visitors for the rest of the year. The altitude of the toilet is 1800 m. Rainfall is low, as it is predominantly a snow region with an average minimum temperature of 5°C and average maximum temperature of 12°C. In the high use season the average minimum is 0°C and the average maximum is 5°C.

One 09 unit was installed in May 1991 (in conjunction with the Snowy Mountain Authority) in a cellar under a brick building. The tank is wrapped in foil lined fibre glass batts. The run-off is collected and there were plans to trial evaporation through a tray under the tank.

Air is drawn across a vertical solar collector on the northern wall of the building and vented through insulated ducting directly into the end-product section of the tank. The normal air inlet on the tank, and all possible leakages are carefully sealed. A second fan powers a vent which draws air from the top of the tank. The fans are connected directly to solar panels so that air is only drawn into the pile when it can be warmed. This may mean that air supply to the tank could become insufficient. Sawdust bulking agent is added by users. The pile is raked fortnightly in winter, and approximately once a month during the rest of the year.

Architect, Alistair Henchman reported that the temperature in the cellar never dropped below freezing point even when the building is covered with snow. Temperatures being monitored with a data logger include ambient temperature in the cellar, the in-flow point into the tank, and the air leaving the vent. It was suggested by the author that the pile temperature also be monitored. At the time of inspection the pile was low, dry, and had a slight ammonia smell. The end-product chamber was full up to the baffles with wood shavings, soil and soap powder. The inside of the tank was very clean. This unit was the most conscientiously monitored Clivus Multrum toilet inspected, and although usage was low, the results would be relevant for composting in alpine conditions without the assistance of electric heating

2.3.4 Mt Selwyn Snowfields Pty Ltd. Kosciusko National Park

Inspected May 6,1992.

This toilet block had road access, and served day visitors. Approximately 1000 skiers a day visited this facility for 80 days between June and October. The toilet block was installed at an altitude of 1580 m with a winter temperature range of -4°C to 15°C and a summer temperature range of 0°C to 30°C

Nine 09 units were installed in 1986 in a brick basement underneath the lodge. The basement was heated to 25°C for the 80 days usage. For the remainder of the year the temperature did not drop below 10°C in the basement. There were 6 pedestals and 1 'floor waste' draining into the three male tanks. Twelve pedestals and 1 'floor waste' drained into the six female tanks.

Approximately 5 600 litres of run-off per season drained into a holding tank which was pumped out. A levelled pile, less than one meter high, of fresh material was added to each composting tank over the season. Maintenance personnel, Errol Clarke reported that approximately half that amount was removed from the units at the end of each season and used as fertiliser around fruit trees. The material appears to be a lumpy mix of sawdust, toilet paper and decomposed faeces. Clarke estimated that the material at the bottom of the tank has at least 12 months to break down before it is removed.

The daily maintenance schedule consisted of unblocking the drainage holes in the end-product area, adding 2 litres of sawdust three times a day to each pedestal, and raking the pile. Clarke reported that at least one drain becomes blocked each week. If not attended to immediately these blockages caused problems with the pump into the holding tank.

The end-product in 1992 was apparently better than usual and did not clag because Clarke had not pumped back the run-off over the pile during the summer. This also had given the pile a very strong ammonia smell. He had previously used this method because he thought the pile should stay damp. Also, last winter they had applied bulking agent three times a day instead of once a day, as in former years. He thought this gave a better mix and was

part of the reason the end-product was more friable this year. Errol Clarke made a special request that people do not contact him for "free advice on how to maintain the Clivus, as a result of his positive report" (Pers. comm. Clarke May 1992).

2.3.5 Gemby Rinjah Tourist Resort. Blackheath. Blue Mountains

Inspected May 11,1992.

These toilets have road access to overnight cabins. 4-6 people stay in each cabin most of the year. The resort is at an altitude of 1065 m with a winter temperature range of -2°C to 10°C, a summer temperature range of 10°C to 32°C and an annual rainfall of 650 mm.

Two 07 units were installed in April, 1987 underneath cabins. The units are not enclosed against the weather. One "icecream container" of softwood shavings were added to the pile each week, and the occupants of the cabins disposed of their fruit and vegetable scraps into the toilets.

The units had been emptied three times since installation. Two wheelbarrows of end-product were removed from each unit. Peter Quirk, the manager of the resort, reported that the material was still moist after 18 months, but after two years, it was quite dry. It was buried in the garden and after some months has been completely broken down by soil organisms. The material was lumpy organic matter with obvious signs of toilet paper. It had a mouldy smell. The NSW Health Department had tested the end-product, and was satisfied that pathogens had been eliminated (Pers. comm. Quirk May 1992).

2.3.6 Blue Waterholes. Kosciusko NP. National Parks and Wildlife Service

It was not possible to meet Ranger, Lynette Evans at Blue Waterholes on May 6, 1992, as intended, but information was later forwarded. The toilet had road access for day visitors and campers. The toilet usage was not known. During summer school holidays 30-50 people stay in the area per day and the rest of year there were approximately 10 visitors per day. The toilet was installed at an altitude of 1200 m with a summer temperature range of 15°C to 26°C.

One 09 unit was installed in 1986. The toilet was started with 1.5 cubic meters of sawdust. Bulking agent has varied over the years including straw, added infrequently by staff as the toilet is quite remote.

Ms. Evans had written: "3-4 years ago drainage of excess fluids was blocked with tap. 2 years ago agent came and advised us to remove tap which we did. 1992 painted cement slab dark colour to absorb heat. Insulation added. June 1992 toilet pumped out as it did not work. Found the air vents had collapsed. Am starting again. Air vents will be replaced, bulking to be used with wood shavings, attempts will be made to let visitors add a cupful of bulking agent. Other problems included visitors using the toilet as a bin. When it was pumped out plastic bags of garbage (bottles etc.) were found" (Pers. comm. Evans July 1992).

2.4 Clivus Multrums in the Australian Capital Territory

This section summarises the investigation of four Clivus Multrum composting toilets in the Australian Capital Territory (ACT) (see Figure 2.5). It is a chronological record of the author's site inspections and meetings with relevant personnel, including observations and information provided by maintenance and administrative staff.

2.4.1 Googong Dam. ACT Parks and Conservation

Inspected May 7, 1992.

The toilet block had road access and served day visitors. The usage was unknown. 25 000 people a year visited the area but it was not known how many use toilet. There is a septic tank facility at the lookout. The altitude of the installation is 670 m with a winter temperature range of 1°C to 12°C and a summer temperature range of 12°C to 27°C. Annual rainfall is recorded at 670 mm.

Two 09s were installed in 1990 in a concrete basement under a timber building. The units were started with soil and sawdust. Straw rice hay was used as bulking agent. 3/4 of a bale of straw had been added to each tank over 18 months. The piles were not raked. A watering system has been installed through the back vent baffle to re-circulate run-off which is contained in the tank.

Manager, Paul Higginbottom, reported that he was advised by the local Clivus Multrum agent to turn off the fan because the pile was too dry. Turning off the fans for 8 months did not cause the system to smell, or any other problems. At the time of inspection the piles in both tanks were low, and appeared slightly too moist, but this may have been because of the watering system. The piles consisted of a loose mix of straw, toilet paper and some excrement. It appeared that usage was low, or possibly mainly urine. There was no offensive smell in the tanks.

Further information forwarded stated that "three dust bin loads" of starter had been removed from the end-product chamber. The pile, despite being small, had compacted above the cavity created and had not moved forward. Ian Beeson from Clivus had suggested replacing straw with wood shavings as a bulking agent (Pers. comm. Higginbottom June 1992).

2.4.2 Bulls Head. Namadgi. NSW/ACT Border. ACT Parks and Conservation

Inspected May 7, 1992.

This toilet had road access and served day visitors. The usage was unknown. In summer 20-30 people a week would visit the picnic area, and in winter, 200 a week, mainly on the weekends. The toilet was installed at an altitude of 1200 m with a winter temperature range of -2°C to 10°C, and a summer temperature range of 10°C to 18°C. Average annual rainfall was recorded at 800 mm.

One 09 unit was installed in 1986 in a concrete and stone cellar underneath a brick toilet block. The unit replaced a septic tank facility because water often froze in the pipes. It was started with soil and wood shavings. Run-off was discharged into an absorption trench in NSW. The pile was very low and consisted of a mix of pine shavings, toilet paper and partially decomposed excrement. Rough pine wood shavings were added once a week. Ranger, Steve Welch reported that the temperature in the cellar never exceeded 10°C and dropped below zero in the winter (Pers. comm. Welch May 1992).

2.4.3 Deeks Drive. Stromlow. ACT Forestry

This toilet had road access and served day visitors. Because a well known sportsperson trained here, 50 people a day did likewise. On "big event days" 200 people would use the area. Exactly how many used the toilet was not known. The average ambient temperature is 18°C.

One 09 unit was installed in March 1987 in a concrete cellar under a timber toilet block. Forester, Aidan Flannagan reported the tank had been emptied in January 1992 and had to be "picked and scraped out". It was difficult to get information on this unit as staff were quite hostile about the system. In December 1989, when the pile was not composting, they had been advised by Ian Beeson of Clivus Multrum to add more bulking agent, and since then had added "a couple of buckets every few days". The tank had also been emptied at that time.

It appeared that a starter bed had not been laid down after the clean out in January, 1992. The pile had a strong ammonia smell. The cellar was dark, airless and cramped to work in. The area was subject to vandalism and the battery, fan, and solar panel had been stolen on different occasions. Since the facility was so close to Canberra, staff strongly advocated switching to a pump-out system.

2.5 Implications of the Clivus Multrums Survey

2.5.1 Observations

It appears from this inspection of a selection of Clivus Multrums on the East Coast of Australia that the Clivus may produce decomposing end-product in the following circumstances:

- if the input is predominantly urine and usage is constant, a large enough quantity of wood shavings needs to be added regularly to soak up the moisture and reduce the ammonia concentration, e.g. Glass House Mountains Lookout (refer 2.2.6.).

- if the in-put is a mixed pile (overnight deposits of urine and faeces) in constant use in low temperatures, then usage needs to be low, well drained and aerated, and regularly supervised, e.g. Gemby Rinjah at Blackheath (refer 2.3.5).

- if the in-put is a mixed pile and has moderate use, then the maintenance needs to be at least twice a week, and the pile should have a long low use period and a warm summer, e.g. Goomburra in Queensland (refer 2.2.8.).

- if the usage is high, constant and a mixed pile, then the unit requires large quantities of bulking agent, constant ambient temperature above 18°C, maintenance at least every second day, and regular emptying, e.g. Logans Camp ground at Wivenhoe Dam (refer 2.2.1.)

- if the usage is high for a season then left for a long fallow period, and is a mixed pile in low temperatures, then the units will benefit from being in a heated building, daily maintenance for the seasonal use and management which restricts the deposit of new material to less than 3/4 of the bin in each unit, e.g. Mt. Selwyn ski resort (refer 2.3.4).

Other than the end-product at Gemby Rinjah (which used kitchen scraps as bulking agent) decomposition of faecal matter and sometimes toilet paper, is the only reduction in the volume of the original pile. Wood shavings are slow to break down and may provide very little carbon to aerobes as it is not in an accessible form in the tough lignin. The micro-organisms resource carbon in other ways, for example, from insect carbon dioxide emissions (Pers. comm. McQuillan 1993).

Although the above installations have end-products in the latter stages of decomposition, it cannot be said with any certainty that pathogens have been eliminated, since only the samples from one end-product at Gemby Rinjah had been tested and produced negative pathogen indicators. Nor can it be said, without monitoring the pile, that the decomposition has definitely been caused by the biological process known as composting. However, if the material is buried in the ground (in an area not sensitive to high nutrients, and at a reasonable distance from water courses), soil organisms should complete the process in a couple of months, depending on the nature of the pathogens in the pile. Some pathogens require exposure to heat for certain periods to ensure sterilisation, which is why monitoring the temperature of the pile is useful (Fordham 1990).

There is nothing intrinsic in the Clivus design that is mysteriously conducive to composting. The tank is merely a container devised for the acceptance of the user. It is large and inclined so that it need never be fully emptied, and so that it can fit underneath a house that is raised, or in a cellar.

Some of the Clivus characteristics may inhibit composting. For example the baffles or vent rails will not provide oxygen to aerobes once the rails are covered by the pile. The air is drawn through the rails and up the back baffle and out the vent. This can aerate the pile under the rails while the pile is very low but once the tank fills up, the only ventilation is provided by the porosity of the bulking agent, as long as it does not compact. The drainage in the end-product chamber is inclined to cause flooding or a saturated base to the pile while the top dries out. The continuous system allows fresh material and pathogens being deposited in the top of the pile to contaminate the bottom of the pile which may have successfully composted. As previously mentioned, the added height of 09 is conducive to compacting.

None of the 'successful' end-products inspected from the Clivus Multrums resembled the fine soil-like material that had been observed in the non commercial owner-built designs in New South Wales. This may be due to the fact that the owner-built designs use bulking agent such as vegetable scraps which break down, and the Clivus Multrums use wood shavings which are residual.

2.5.2 Inappropriate installations

It appeared that there were also non-technical reasons for the relatively low performance rating in the composting toilets surveyed. These reasons had to do with the history of the original design and the manner in which the Clivus Multrum was introduced to public recreation institutions in Australia and other countries.

The Clivus Multrum was developed in Sweden in 1939 by Rikard Lindstrom. It was used in family holiday accommodation for the holiday period, and then left during the rest of the year until the next season (Lindstrom 1975: 443). As previously mentioned, the design is known as a 'continuous' system which means material can be added to it, and end-product removed from it without having to empty the whole tank. However, it was not originally designed for continuous use in the sense of it being a system to be used constantly throughout the year (Harper and Thorpe 1994: 13).

The units functioned in a situation where there was a period when no new material would be added to the pile. This respite would facilitate the composting or decomposition process. The usage of the 09 Clivus units at Mt. Selwyn in Kosciusko National Park is successful partly for that reason. In, addition, the pile is increased by less than a cubic metre of new material each season and the installation is attended daily. The usage is, in fact, similar to that of a family in a holiday house. The units in Scandinavia were installed inside a warmed building and this is also the case at Mt. Selwyn (refer 2.3.4.).

The 07 and 08 models of the Clivus are most like the original design in size (Lindstrom 1975: 439). Official acceptance of composting toilets in Australia had been reluctant and evasive, prior to this study, particularly for domestic usage. It appears that usage of composting toilets in public recreation venues was seen by the commercial suppliers partly as a means of introducing the concept to the wider market without too much regulatory interference. For that application, the tank needed greater capacity, and the mid-section was added to create the 09 model. This modification also seems to have created problems. The extended height increased the likelihood of compacting particularly in the centre of the pile, and reduced the possibility of adequate aeration. These two limitations necessitated considerable quantities of bulking agent to keep the pile friable and porous and even these measures did not always work.

Clivus Multrum promotional literature and videos showed installations in recreation areas throughout North America. In an attempt to gain from their experience, the author wrote to nineteen of the parks in Canada and the States explaining what was happening in Tasmania with the Clivus Multrum and the Rota-Loo, and asking whether they used composting toilets, and if not, what sewage disposal system did they use, especially in remote areas. None of the fifteen park managers who replied to enquiries were currently using a Clivus or other kind of composting system. They used pump-outs, aquatic macrophyte systems, pits, vaults, septics and haul-out systems. Some recommended contact with other parks who may be using composting systems.

These contacts were pursued and after some correspondence led to the author's attendance at a Composting Toilet Conference held at Yosemite National Park in California in the United States of America in September 1994. (To indicate range of public utilities interested in composting toilets the agenda and attendees at the conference are listed in Appendix A). From that Conference, related correspondence with park managers who did not attend the Conference, and published literature it was apparent that the United States and Canadian experience with commercial composting toilets in recreational areas reflected that of Australian park managers both in successes and difficulties (Jensen 1984: 4.1; Scholze et al. 1986:38).

An unexpected outcome of the initial 1992 enquiries to Canadian and North American parks shed further light on the application problems associated with the marketing of the Clivus Multrum. One of the parks in Canada that had been contacted by the author became alarmed at the difficulties being experienced in Tasmania, and put 'on hold' an order for Clivus units. The Clivus company in America and Canada alerted the Manager of Clivus Multrum Australia Pty Ltd (Pers. comm. Beeson August 1992). He travelled to Tasmania from Queensland, and inspected three of the World Heritage Area composting toilets on the Overland Track by helicopter on August 25, 1992 with Parks staff, and the new Tasmanian Clivus agent.

In a discussion between the author and the Clivus Multrum Manager on August 26, 1992, he acknowledged that the 09 had certain design faults. These included the weakness of the internal air 'rails' or vent baffles, the disinclination of the pile to slide forward because of the tank's pot-bellied shape, the position of the baffles, the incompatibility of the original electrical system, and the inadequate drainage particularly in some units. The Manager admitted that the units were sent from the manufacturer to the client without inspection, and some were of inferior quality. It was intended that the CM40 would correct the design faults. In the United States, the 09 equivalent has been superseded by these models for a number of years (Pers. comm. Beeson August 1992).

In order to provide some compensation to the Department of Parks Wildlife and Heritage for the difficulties caused, the Manager of Clivus Multrum Pty Ltd offered, at his company's expense, to provide labour to clean out the tanks in the World Heritage Area, replace the broken vent baffles, and effect other modifications to ensure the systems have maximum opportunity to function. Mr Beeson also agreed to supply and install the new CM40 model to the Department "as long as the composting toilet is properly monitored" (Pers. comm. Beeson) The tanks were emptied in October 1992, and Parks paid for helicopter time for transport. However, in February 1995, three of the Clivus Multrum toilets on the Overland Track were again emptied of raw sewage using hired labour and helicopter transport, at a cost to the Department of $11 000 (Pers. comm. Firth April 1995), despite being maintained strictly in accordance with the manufacturer's directions. In the United Kingdom, the CM40 has since been replaced by the 'Clivus M1' which includes a sealed sump for surplus liquid underneath the main unit and a recommendation to use worms to accelerate decomposition (Harper and Thorpe 1994: 14).

Despite the fact that the Clivus Multrum has been designed for over 50 years, and in use for the last 30 years, the current models in Australia were being trialed 'in the field', often at the expense of the customer, presenting a threat to staff health, and causing pollution of the environment. This is false economy in the long term. Already a strong prejudice against composting toilets, in general, had developed among staff who have had to handle raw sewage and malfunctioning units. These events support the proposition, developed further in the conclusion to the thesis, that it would be expedient for Government organisations to be funding research into this significant method of on-site sewage treatment, but the funding should be supplied by those authorities responsible for sanitation. It does not seem appropriate that research funding is in the form of inadvertent subsidies to manufacturers by institutions whose primary purpose is the management and conservation of 'natural' areas.

2.5.3 Lack of pre-sales consultation and after-sales support

Several of the staff who participated in the East Coast of Australia composting toilet survey reported that when the toilets were appearing to malfunction and they sought help from the manufacturer, assistance was not forthcoming. This was particularly so in locations a long distance from the manufacturer's base in Brisbane, such as Tasmania, (refer 2.1.13). Clients in the Brisbane area reported receiving some practical assistance when their units malfunctioned (Pers. comm. Angwin June 1992).

On August 27, 1992 the Clivus Manager addressed the Compost Toilet Working Group Meeting at Head Office of the Tasmanian Department of Parks Wildlife and Heritage and referred to the toilets he had inspected, and to a number of the issues discussed with the author on the previous day. The Melbourne based partner of Clivus Multrum Australia Pty Ltd and the Tasmanian agent also attended the meeting. The Manager began his address by saying that "this meeting should have taken place five years ago". This statement implied that many of the problems experienced in the parks could have been avoided if thorough pre-sales consultation and after sales support had taken place.

There are many considerations that need to be addressed before a particular design is recommended. One of the critical issues is projected visitation numbers. The predicted quantity and type of usage is considered essential in planning a composting system. The in-put of day visitors generating a high percentage of urine requires different design and maintenance to the mixed pile from overnight users. Rota-Loo and Clivus both claim 36 000 uses for their large tanks. The Manager of Clivus Multrum Pty Ltd admitted in the discussion referred to above that these figures come from the States, and he does not know how they are calculated (Pers. comm. Beeson August 1992).

The Clivus Manager explained that the 09 can handle less than 6 000 uses in Tasmanian alpine conditions because the pile needs more time to decompose in below 10°C conditions. However, material held in a Clivus tank for three years in the Queensland mountain climate (e.g. Binna Burra, refer 2.2.11) had not decomposed despite warm summers, so the lack of decomposition must be due to other factors beside temperature. In addition the pile in the basic composter at Rodway Lake (refer 2.1.1) on the Overland Track was in the early stages of decomposition three months after being deposited.

There were inadequate and confusing data presented in relation to the Clivus Multrum performance. It was suggested in discussions with the Manager that thorough monitoring should be conducted by the company in a variety of Australian conditions, to provide customers with realistic information to evaluate the product's capability in relation to their requirements.

The advertised statement that the system will take three years to produce an end-product has meant that some customers have not realised that their system was not working until three years have passed. They had mistaken an odour free toilet room as a sign of composting in progress. An aerobic pile does not smell, so this would be indicative if fans were not used to draw off odours. When fans have malfunctioned, which has occurred at most sites inspected, the signs of malfunction have became apparent. Even then the customer had sometimes assumed that the anaerobic state of the pile was caused entirely by the fans failing.

After attending the Composting Toilet Working Group Meeting on August 28, 1992, one of the Technical Officers, circulated a memo recommending that no modification to the existing Clivus Multrums be undertaken, or any new Clivus installed, until the Department sought Crown legal advice on the matter (Pers. comm. Western September 1992). An examination of legal remedies was suggested at the outset of the investigation, but given the prolonged and laborious nature of the legal process, and the urgency to provide functioning toilets in the World Heritage Area for the coming summer, this direction could be impractical, and possibly not conclusive. However, the recommendation reflects the prevailing dissatisfaction with the product, the pre-sales advice, and after-sales service.

2.5.4 Responsibility of customer

While composting toilet manufacturers have obligations to their customers within the capabilities of small business, it appears from this study that potential problems would be reduced if the customer also takes responsibility for choosing an appropriate system for their application. Public recreation institutions are to be encouraged to persist with composting toilets as they can offer an inexpensive and relatively simple method of waste disposal and environmental protection, in appropriate circumstances (refer Chapters Three and Five). However, planning and management needs to be well informed, discerning, and co-ordinated with the invaluable feedback of staff working 'in the field'. This applies to all selections of on-site treatment. The experience of other institutions and districts can also be networked. It could be useful if those making final decisions were advised by a small representative on-going working group, which draws all these contributions together.

When selecting a composting toilet design, maintenance requirements are an important issue for public recreation institutions to thoroughly review. Among other issues, designs for composting toilet facilities should consider the convenience of maintenance staff. For example, it is advised that ladders into cellars, cramped head and elbow room, and units that require low bending to empty the tanks should be avoided (Okawa 1994: 2). Design considerations for composting toilets are explored in more detail in Chapters Three and Five.

A related issue of concern for a public recreation institution is the requirement for adequate grey water treatment where bathing and cooking facilities are provided in combination with a composting toilet. Grey water systems are now being developed in the public and private sector and in association with this study (ACT Electricity and Water 1994: 120), (refer 5.8.4). It has been an aspect of the ignorance and unfamiliarity surrounding composting toilets that, once a water borne sewage system is not used, people are inclined to forget to deal with the grey water (refer 2.1.5).

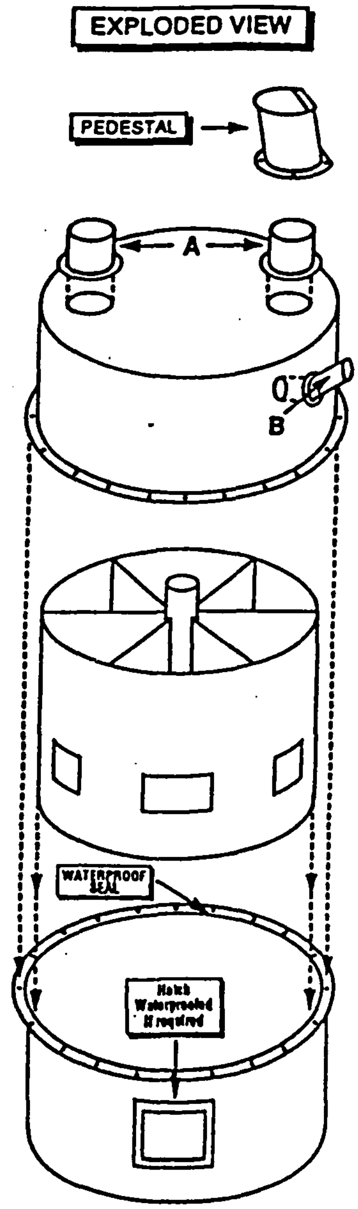
2.6 Rota-Loo composting toilets in recreational areas

Concurrently with the survey of Clivus Multrum composting toilets described in 2.1 to 2.5, an inspection of a number of Rota Loo composting toilets was also undertaken. The surveys of the two systems are described in separate sections because, although there are some similar issues involved in terms of the impact of marketing, the design types are quite different and it is considered that the Rota-Loo has distinctive advantages and disadvantages in application.

2.6.1 Background to Applications of the Rota-Loo composting toilet

The Rota-loo is a 'batch' composting system which has 4-6 bins on a carousel that are rotated with use (see Figure 2.6). Two Maxi Rota-Loos were installed in the autumn of 1990 at the Lake St. Clair National Park in Tasmania, and one Maxi Rota-Loo was installed at Pieman Heads in the State Reserve which is controlled by the Dept. of Parks, Wildlife and Heritage (see Figure 2.1, Map of Tasmania).

Between January 1992 and June 1992 the Maxi Rota-Loos at Narcissus Hut and Pine Valley were inspected on a number of occasions to assess the reason for inadequate decomposition. The material removed from these toilets was also inspected and discussions took place with staff who have been engaged in maintenance.



<u>FIGURE 2.6</u>

Diagram of Rota-Loo Composting Toilet.

The excrement in the toilets was not breaking down and the chambers had to be emptied of the raw material in order to accommodate further usage.

Raw sewage had been regularly removed by staff from the restricted end-product hatch and shovelled into barrels. These containers were eventually helilifted to the Ranger Station and emptied by Parks staff at a local sewage depot (Pers. comm. Plowman, Purtell and Thurston, January - June 1992).

In order to reduce the unsightliness of the toilets, and to provide some protection from the weather, the toilets were originally installed below ground in a timber insulating frame. On the assumption that the material would decompose in the manner described by the manufacturers, the service pit was designed to accommodate one person emptying an hygienic, lightweight, decomposed material from the end-product hatch (Pers. comm. Dwyer 12/6/92). When the toilets malfunctioned and required emptying, shovelling up raw excrement from the service pit became a health hazard for maintenance staff (see Figure 2.7).

Air flow to the central inlet vent was inadvertently restricted by the timber frame, but not totally sealed against aeration. Reduced air flow would have been drawn from under the solar glazing that was installed over the access pit, through the cracks in the timber insulation framing and down the central air inlet vent into the pile chambers. It does not appear that this restricted air flow would be sufficient to prevent decomposition if all other factors were favourable.

In February 1992, the author contacted Terry Lustig of Environmental Management Pty Ltd in Sydney and advised him of the situation at Lake St. Clair. Mr. Lustig informed Colin Martin of Environmental Management Pty Ltd who visited Lake St. Clair in March and made certain recommendations to rectify the situation. He strongly advised that the units be re-installed above ground in a solar collector installation, preferably a Soltran unit distributed by Environmental Equipment Pty Ltd.

2.6.2 Rota-Loos in locations other than Tasmanian World Heritage Areas

As with the Clivus Multrum installations, the author sought to understand the problems with the Rota-Loos in Tasmania by investigating installations in other States

Of the public recreation Rota-Loos inspected at Wivenhoe Dam in Queensland, Pieman Heads in Tasmania and the Blue Mountains in New South Wales, the units that were working successfully had heaters in the liquid holding tank which supply heat of around 65°C. The liquid is evaporated, and the warm air is drawn up through the pile to assist with decomposition. In addition, the whole unit is warmed by convection. The manufacturers claim that the heater is not an essential factor in the design, but Colin Martin communicated to the author by phone on 29 May 1992, that there were no public recreation Rota Loos functioning successfully in Australia, currently, without electric or solar heaters, regardless of climate or location.

FIGURE 2.7

Rota-Loo Service Pit

The material removed from the 4 electrically heated Rota Loos, at Gemby Rinjah holiday resort in the Blue Mountains area of Blackheath which was inspected in May 1992, was a paper like mash which had been tested for a low pathogen count and approved by health regulators (Pers. comm. Quirk 11/5/92). The five units inspected in the nearby National Park had electric heaters in the base of each carousel and a separate liquid holding tank, which is also heated, to handle any excess liquid not evaporated in the single units. There had been some problems with the electrics, and complaints of a strong ammonia smell when the heater in the liquid holding tank was evaporating off the urine. The rangers were considering only turning on the holding tank heater at night to avoid public exposure to the smell (Pers. comm. Manson 11/5/92).

The Rota-Loos in the Goverts Leap National Park were installed in 1991 and indicated that the manufacturers considered it necessary for ample provision to be made for containing and evaporating liquid in the high rainfall, low temperature conditions at Blackheath.

The 4 Rota-Loos at Wivenhoe Dam in Queensland, inspected in April 1992, which were installed in a Soltran installation, were not functioning satisfactorily possibly due to inadequate supply of fresh air, and excessive heat within the solar collector. The units initially filled faster than anticipated and had to be emptied of raw sewage (Pers. comm. Mills April 1992).

On inspection, in April 1992, the toilets had been closed for 10 months to allow the next load of material in the chambers time to break down. Very little decomposition had taken place at the time of inspection. The Rota-Loo had previously produced a very dry material when the damper on the Soltran collector had failed to open and the unit had overheated. At the time of inspection, the ambient temperature was 25°C and inside the Soltran collector the temperature was 43°C. Composting should be easily achieved without any heat assistance in ambient temperatures above 15°C if other factors are favourable. It is surprising that a solar collector was installed in the South East Queensland climate.

It was reported that a low usage Rota-Loo/Soltran installation in the same recreation area produced a satisfactory end product until the toilet block was burnt down by a lighted roll of toilet paper being thrown down the chute (Pers. comm. Glindeman April 1992). There have been problems with bearings collapsing in the carousel. The manager of Environmental Equipment Pty Ltd, Colin Martin stated that the units at Wivenhoe were "not strictly Rota-Loos and were the first Soltran installation in Australia" (Pers. comm. Martin 29/5/92). However, they were advertised in Environmental Equipment Pty. Ltd literature as examples of significant Rota-Loo applications (Environmental Equipment 1991: 17).

The three Rota-Loos installed by the concessionaire in the Corinna holiday cabins in western Tasmania were inspected in June 1992 and were not functioning satisfactorily. The manager reported (Pers. comm. Poulson 9/6/92) that they had been advised by the manufacturers, who visited the site, to install the units under the cabins enclosed in concrete with no provision for drainage because it was assumed that all the liquid would evaporate with the assistance of a small amount of solar glazing in the roof of the installation. This advice was in keeping with Environmental Equipment Pty Ltd literature which states "And, because Rota-Loo is completely self contained, there is no need for septic pits, plumbing or drainage. Which means you can install a Rota-Loo anywhere, even next to ecologically sensitive waterways" (Environmental Equipment 1991: 3).

Evaporation had not occurred and the pile chambers were flooding. There was neither space nor access to install plumbing or a generator powered heater underneath the chambers. The manager intended to install a heat lamp in the small installation enclosure to heat the air drawn through the pile. The lamp would operate during the fixed number of hours each day when the camp generator was running. In order for this to work, it was necessary to first siphon out some of the excess liquid in the base of the unit as it was approximately 18 cm deep and would inhibit air flow. Siphoning the liquid would be very difficult, because of the nature of the toilet design and installation.

It was reported that a Maxi Rota-Loo had been installed in a Soltran solar collector on the Routeburn Track at 900 m in Mt. Aspiring National Park in New Zealand. A telephone report advised that dry matter had been produced in one chamber and varying decomposition had occurred in the other five chambers on the same carousel (Pers. comm. Kennett 7/4/92). Further detailed information was provided by a postgraduate student, Paul Chapman. With consistent monitoring and maintenance an "acceptable compost" was produced (Pers. comm. Chapman July 1992). Due to maintenance requirements the composting toilet was later removed and replaced by a septic system (Pers. comm. Chapman December 1994).

It was also reported that an electrically heated Rota-Loo has recently been installed by the Banks Peninsular District Council at Diamond Harbour in the Canterbury region in New Zealand (Pers. comm. Turner 22/6/92).

2.6.3 Rota-Loo at Pieman Heads

A Maxi Rota-Loo was installed near the Pieman Head shacks in February 1991. The unit is raised above somewhat swampy ground and installed in a timber enclosure with a north facing solar collector access cover. This provided for relative easy observation and attendance. As with the units at Corinna, drainage was not installed. The solar collector did not provide sufficient heat for evaporation, and the chambers flooded. By April 1992, 10 cm of liquid had accumulated in the bottom of the tank. The situation was not as critical as at Corinna because the installation is easily accessible and the usage is less demanding (Pers. comm. Norris May 1992).

In April 1992, the liquid holding tank was showing early signs of decomposition. The material was primarily urine soaked toilet paper with very little faeces as the users are day visitors from the river cruise (approximately 2 000 people per year visit on the cruise boat, not all would use the toilet) and occasional shack owners. In summer, some visitors who accessed the area by four wheel drive vehicles would also use the toilets. The copious amount of toilet paper was serving as bulking agent.

2. 7 Evaluating the suitability of Rota-Loos

2.7.1 Usage

As previously mentioned, it is important to have a reasonable knowledge of actual and potential usage when planning a composting toilet system. Compost toilets must not be overloaded (Cook 1991: 5). Estimating the probable usage of a Rota-Loo is essential prior to installation. Unlike a Clivus Multrum composting toilet, there is no latitude with the Rota-Loo once the capacity has been filled. They cannot serve as a holding tank beyond the volume recommended for composting. If the carousel is full before the first chamber has had time, and suitable conditions, to decompose, then maintenance staff will be forced to empty the raw sewage from the extremely awkward and small end-product hatch, as had happened at Pine Valley and Narcissus Hut locations. In the Clivus Multrum, if the material is not decomposing and the unit is full, a small amount can relatively easily be removed from the end-product chamber and the rest of the pile dragged forward (if it has not compacted), to give more capacity.

Previous promotional Rota-Loo literature (Environmental Equipment 1990: 1) stated that Maxi Rota-Loo had a capacity of 30 000 uses per year as long as only one in 10 defecated. This proviso was omitted in later literature, but from the experience at Lake St. Clair it would appear that the former estimation of a Maxi Rota-Loo's capacity is more accurate. The six chamber carousels at Narcissus and Pine Valley filled completely at least once in the 1991/92 summer. Monitoring of toilet usage has not previously been conducted but it was roughly estimated that the two locations do not attract more than 4 000 overnight visitors a year.

2.7.2 Assessment of the Rota-Loos at Narcissus Hut and Pine Valley

A significant inhibition to favourable conditions for composting in these installations appears to be that the material is contained in very moist cold conditions in its installation below ground level, and there is not sufficient solar heat assistance to correct this. Water often collects in the floor of the service pit and although the unit is mounted in a wooden frame, it can be assumed that water collects around the base of that frame. (It was not possibly to verify this without removing the framing and/or the unit). This water would maintain cold conditions possibly reversing the positive protective effects of below-ground installation.

Inside the unit, the liquid run-off from the pile chambers drained into a holding tank at the base of the carousel (see Figure 2.6). In ideal circumstances, all this liquid evaporates, but if necessary the remainder is treated through some kind of effective absorption trench. The drainage system should not be relied upon as a method of moisture reduction as the liquid draining out of the system is likely to be highly contaminated and, therefore, below the standard permitted by health regulations for emissions from sewage treatment systems (Molland 1982: 253). In the unheated units at Narcissus Hut and Pine Valley, the chilled liquid lying in the holding tank below the drain outlet would provide a cold moist environment across which the air is drawn through the pile.

At the Composting Toilet Working Group meeting held at Parks' Head Office in Hobart in May 1992, it was resolved that the Rota-Loo toilets at Narcissus Hut and Pine Valley would be closed to the public in their present installation. It was suggested by some rangers that, while the units remained closed, it may be worth venting warmed air directly to the central inlet to test whether there was any consequent improvement in decomposition. On the basis of this suggestion, the toilet at Narcissus Hut was inspected on June 6, 1992 with the Rangers and a hole was drilled in the wooden frame to allow unrestricted air flow to the central air inlet. The following day a hole was drilled in the frame of the Pine Valley toilet. Venting the air into the hole from the top of the solar glazed service pit was discussed.

However, on inspection of the Rota-Loos at Pieman Heads and Corinna, and further research, it was advised with reasonable certainty that the material would not decompose in the present installation, and it was also possible that it would not decompose in a Rota-Loo at the Narcissus Hut or Pine Valley locations even if a large solar collector of the Soltran type were installed around the unit above ground.

The malfunction of the Rota-Loos at Pine Valley and Narcissus Hut were not due to inefficient maintenance, but rather to usage beyond the units' capability in an unfavourable environment. The system was not able to compost the material deposited in it in the time available because the design and installation did not appear to allow for sufficient drainage, heat generation and aeration.

It was likely that the decision to request the public not to urinate in the composting toilets (which was a resolution of the Composting Toilet Working Group meeting in May 1992) would ease the strain on the Rota-Loos' capacity to evaporate liquid. However, the reduction of urine would be partial if people responded to this request, as most people automatically urinate when defecating. The probable 30-40% reduction in urine would not be enough to facilitate decomposition in the present Rota-Loo installations, and the question remained whether it is worth the expense, labour and environmental impact of re-installing the units above ground in a solar collector installation.

2.7.3 Advantages of the Rota-Loo

From research conducted it appeared that the Rota-Loo had proved itself a successful composting toilet when it was installed with an electric heater. The material appeared to decompose as much from dessication as from the biological process known as 'composting'. This observation was based on inspection of the end-product removed from the heated Rota-Loos at Blackheath in the Blue Mountains.

The design of the Rota-Loo has the advantage of a closed or 'batch' system rather than the continuous system. The Clivus Multrum as previously discussed is an example of a continuous system because fresh material is continuously added to the upper section of the pile while, in theory, decomposed material is regularly removed from the end-product section of the pile.

Once a Rota-Loo chamber is full, it is closed off until, ideally, the material has composted. This means that no new material is added that will interfere with the process of decomposition, or contaminate the pile with fresh pathogens. This contamination can occur in the continuous system. In addition, the relatively small chambers of the Rota-Loo ensure that the pile does not get so weighted that it compacts, which was the common occurrence that had been observed in the large 09 models of the Clivus Multrum, as previously discussed.

The concept of the carousel holding the 4 or 6 chambers is an efficient use of space and an easy method of changing from one 'batch' container to the next, when the former is full. A series of smaller chambers rather than one large chamber also gives more opportunity to observe performance and correct malfunctions. If malfunctions occur in one chamber it need not affect the whole carousel. Another advantage of the Rota-Loo is that is does not require raking or addition of bulking agent with each use as is the case with the continuous system, and as long as it is heated, and the usage is correctly anticipated the Rota-Loo appears to function with the minimum of maintenance.

2.7.4 Disadvantages of the Rota-Loo

A disadvantage of the Rota-Loo is the small size and cramped position of the end-product hatch which makes maintenance and emptying extremely awkward if the unit malfunctions. Emptying is further complicated by the position of the baffles placed diagonally up the pile chambers. Even if a composting toilet normally functions well, allowance has to be made for the times that it may fail, due to vandalism, 'shock' high usage or other unanticipated events. Access to the pile must be convenient, and as hygienic as possible, particularly in public recreation applications.

It appears that the design is also limited by its complex and indirect venting system. Figure 2.8 indicates the route of the air flow: The air is drawn down the central air-inlet, through the liquid holding tank and up into the baffles in the chambers, through the pile (providing the baffles are not blocked by material) and up the vent. It is not a passage that would draw air naturally if there were no fan to facilitate it. If there is any problem with evaporation of the liquid in the holding tank, then the air flow can be obstructed or cooled and moistened as it passes through or across the liquid.

The maintenance limitations and the indirect air flow were serious disadvantages in a location like Lake St. Clair where the unit had to emptied by Park staff who should not be expected to deal with raw sewage especially in such restricted conditions, and the local climate is not conducive to effective evaporation or appropriate aeration in such a design. Thus, the toilets needed considerable heat assistance to work and a powerful fan to draw air through the complex venting system. The artificially created draught of air is often too forceful, and without warming exposes the pile to chilled air.

Heating requires a consistent source of energy. Solar or portagas seem to be the only choices at a location like Lake St. Clair The exposure of a naked flame in proximity to flammable gases has its risks. A solar installation of the size and expense required to provide the necessary heat assistance would need to have a considerable history of success before it could be recommended. Pieman Heads was the only solar heat assisted Rota-Loo in a temperate climate in Australia and there the usage was very low, predominantly urine content, and at a lower altitude and in less severe weather conditions than Narcissus Hut and Pine Valley. And it remained to seen whether the Pieman Heads toilet would be successful.

2.8 Conclusions

Table 2.1 provides an overview of the composting toilets surveyed and discussed in this Chapter. It is difficult to give an abbreviated description of the end-product at the time of inspection as it varied so much from site to site. For the purposes of this overview, a composting toilet that is obviously malfunctioning has a definite 'no' in the compost column, and where the unit is underused or the pile is showing very early indications of change, 'not yet' is applied. 'Partial' refers to decomposition that is apparent but not complete.

From the survey described in this Chapter and summarised in Table 2.1, it is apparent that a small percentage of the composting toilets investigated had provided the sanitation service that was anticipated when they were installed. In quite a few cases a health hazard had been created by their use. As discussed, there are a number of factors that have contributed to this situation.

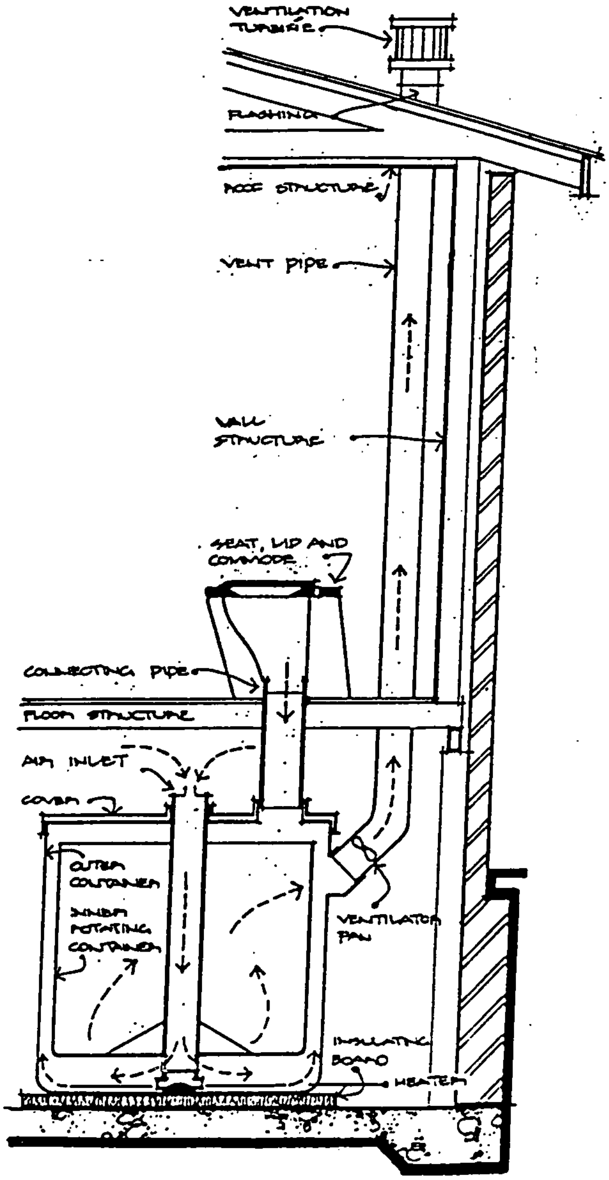


FIGURE 2.8

Diagram of airflow in Rota-Loo composting toilet.

TABLE 2.1

Summary of Composting Toilet Survey, January-July 1992

TASMANIA				
Place	**Installed**	**Authority**	**No. and type**	**Compost**
Rodway Lake	1990	National Parks	1 Site-built	partial
Waterfall V.	3-1988	National Parks	1 C. Multrum	no
Waterfall V.	1-1988	Commercial	1 C. Multrum	no
Windemere	1-1988	National Parks	1 C. Multrum	no
Pine Forest	1-1988	Commercial	1 C.Multrum	no
Pelion Plains	3-1991	National Parks	1 C.Multrum	no
Pelion Plains	1-1988	Commercial	1 C.Multrum	no
Kia Ora	3-1991	National Parks	1 C.Multrum	no
Windy Ridge	1-1988	Commercial	1 C.Multrum	partial
Scotts Peak	1990	National Parks	1 C.Multrum	no
Ralphs Falls	1990	Forestry	1 C.Multrum	partial
Egg Island Pt	1988	National Parks	1 C.Multrum	no
Cradle Mt.	1989	P & O	2 C.Multrum	no
Mt Field	11-1989	Walkers Club	1 C.Multrum	partial
Flinders Is.	1989	National Parks	1 Site-built	partial
Mt Wellington	1989	Hobart Council	2 C.Multrum	no
Stewarts Bay	1988	National Parks	2 C.Multrum	partial
Lake Vera	1-1991	National Parks	1 C.Multrum	partial
Tahune	1989	National Parks	1 C.Multrum	no
Hartz Mt.	1991	National Parks	1 C.Multrum	no
Narcissus	1990	National Parks	1 Rota-Loo	no
Pine Valley	1990	National Parks	1 Rota-Loo	no
Corinna	1990	Commercial	3 Rota-Loo	no
Pieman Heads	1991	National Parks	1 Rota-Loo	partial

Table 2.1 continued

QUEENSLAND				
Place	**Installed**	**Authority**	**No. and type**	**Compost**
Logans Camp	1989	Water Board	4 C. Multrum	partial
Sheep Station	1991	Water Board	6 C. Multrum	not yet
Booloumba	1990	Forestry	1 C. Multrum	no
Sunday Ck	1992	Education Dept.	3 C. Multrum	not yet
Jimna Tower	1987	Forestry	1 C. Multrum	partial
Glass House	1990	Forestry	2 C. Multrum	yes
Coochin Ck	1990	Forestry	2 C. Multrum	yes
Goomburra	1986, 1990	Forestry	3 C. Multrum	yes
Eli Creek	1989	Env. & Heritage	3 C. Multrum	no
Lake Birabeen	9-1986	Env. & Heritage	2 C. Multrum	partial
Binna Burra	1989	National Parks	1 C. Multrum	no
Daves Ck	1989	National Parks	1 C. Multrum	no
Green Mt.	1990	National Parks	3 C. Multrum	no
5 Mile Ck NQ	9-1991	Forestry	1 C. Multrum	not yet
Tully Falls	9-1991	Forestry	2 C. Multrum	not yet
Kauri Creek	1991	Forestry	1 C. Multrum	not yet
Fong On Bay	1989	Forestry	2 C. Multrum	not yet
Emerald Ck	1989	Forestry	1 C. Multrum	not yet
Downfall Ck	1990	Forestry	2 C. Multrum	not yet
Wivenhoe	1989	Water Board	4 Rota-Loo	no

NEW SOUTH WALES				
Place	**Installed**	**Authority**	**No. and type**	**Compost**
Diamond Hd	1990	National Parks	4 C. Multrum	no
Broughton Is.	1990	National Parks	1 C. Multrum	not yet
Yagon	1989	National Parks	1 C. Multrum	no
Schlink Hut	1991	National Parks	1 C. Multrum	not yet
Mt Selwyn	1986	Commercial	9 C. Multrum	yes
Gemby Rinjah	1987	Commercial	2 C. Multrum	yes
Bl. Waterhole	1986	National Parks	1 C. Multrum	no
Goverts Leap	1991	National Parks	1 Rota-Loo	not yet
Gemby Rinjah	1989	Commercial	4 Rota-Loo	yes

Table 2.1 continued

Table 2.1 continued

AUSTRALIAN CAPITAL TERRITORY				
Place	**Installed**	**Authority**	**No. and type**	**Compost**
Googong Dam	1990	Parks & Conserv.	2 C. Multrum	partial
Bulls Head	1986	Parks & Conserv.	1 C. Multrum	partial
Deeks Drive	1987	Forestry	1 C. Multrum	no

Both the Rota-Loo and Clivus Multrum composting toilets were originally designed for domestic use. This application means that the usage is lower, more easily anticipated, and maintenance is carried out by the users who are on-site and highly motivated to ensure that the toilet functions well. The prejudice against composting toilets among health regulators and some sections of the public in Australia has inhibited widespread domestic use. The relative administrative flexibility and autonomy of public recreation institutions has made them an obvious market for commercial brands, and a venue for increasing public acceptance of the concept of composting toilets.

The manufacturers are to be acknowledged for achieving legitimisation in a cautious, and sometimes hostile regulatory context. Composting toilets can be an inexpensive, environmentally benign, responsible alternative to water-borne sewage treatment and their use should be encouraged. However, the designs of the approved commercial composting toilets available in Australia in 1992 did not take into consideration certain technical and maintenance demands experienced in public recreation applications, particularly in remote areas with difficult climatic conditions like Tasmanian National Parks.

These observations have not been lost on the manufacturers. The Rota-Loo representative had indirectly acknowledged the limitations of the currently installed Rota-Loo design installed at Narcissus and Pine Valley by advising that Environmental Equipment Pty Ltd were designing a Rota-Loo that has "removable chambers on the carousel that can be flown out individually, because rangers probably shouldn't be expected to handle raw sewage" (Pers. comm. Martin 29/5/92).

The circumstances described in this Chapter indicate that more attention should be given by the Australian manufacturers/distributors of composting toilets to accurate assessment of customers' needs and conditions, customer education, correct description of the product's capabilities, and ongoing service and support. These necessary provisions are partly unavailable because on-site treatment is provided by small business. The situation has slightly improved since 1992, partially as a result of this study drawing attention to the problems and limitations that have plagued users of composting toilet for decades. A number of grants are now supporting research other than this study. However, the important development and application of on-site sewage treatment technology and planning would be expedited by receiving a percentage of the government funds injected into the infrastructure and research that supports reticulated centralised sewerage systems. Comprehensive research, public education programs and municipal on-site management strategies are not within the capabilities of small business to provide. Until this recognition occurs, purchasers of composting toilets in Australia will probably continue to be frustrated by limited choice, inadequate pre-sales advice and unsatisfactory after-sales service.

The next Chapter details the attempts that were made to remedy the technical problems that became apparent in the above survey of the Clivus Multrum and Rota-Loo composting toilet applications. It also illustrates what is possible on a minimum budget and furthers the argument that given reasonable support, the research and development of on-site sanitation may have much to contribute in addressing the pollution and management problems caused by the treatment and disposal of human excrement.

CHAPTER THREE

SANITATION INNOVATIONS IN REMOTE AREAS

The last chapter detailed the status of composting toilets in recreational areas on the East Coast of Australia at the time this study was initiated in 1992, and explored the implications of the results of that investigation in regard to the limitations of on-site sanitation research and development in Australia. This Chapter will detail the improvisations that were undertaken in an attempt to remedy some of the technical problems exposed by the composting toilet installation survey, and will indicate the potential for broader innovation if research and development in this field was given appropriate institutional support.

The innovations summarised in this Chapter were possible through funding from the facilities budget of Tasmanian National Parks, the efforts of a couple of committed staff from Parks, and some assistance from Centre for Environmental Studies personnel. The research and development of this composting toilet design, (which is showing potential for alleviating the problems of remote site sanitation and may have other application), was conducted under difficult physical conditions, and with a minimum research budget to cover expenses.

It could be argued that this is the one of the purposes of PhD research, and it is an appropriate process that a number of government funded institutions should co-operate to make this possible. However, the author suggests that this was a matter of luck or coincidence that certain individuals within these institutions were available to work together to facilitate the innovations. Until this study was undertaken, there had been very little sustained publicly funded research into composting toilet innovation in Australia. This is despite the fact that traditional waterborne sewerage technology and on-site waterborne systems (i.e. septic tanks) have not always performed satisfactorily, and in the more extreme cases such as areas of World Heritage value, cannot even be considered as a means of treatment because of environmental and practical constraints.

The research described in this Chapter was crisis driven and many aspects of the subject were sparingly dealt with during the period of research, and then only if there was a functional need to do so. Other vital considerations were not dealt with at all, such as comprehensive education of maintenance staff and users, full biological and chemical analysis of the pile, moisture content and evaporation rates.

Despite the limitations, these applications have provided a relatively inexpensive, low maintenance sanitation system in high use World Heritage Area sites for two and a half years, as well as providing an opportunity for research and development. The results from the batch trials described in this Chapter indicate that the 'Cage Batch' design is a suitable technique for the collection, drainage and desiccation of human excreta and will, over a period of time, allow aerobic decomposition from microbial and invertebrate activity. The compost that has been produced consists of enriched partially decomposed bulking agent, which has a very low or nil pathogen indicator count. There was no visible sign of residual faecal material. The design does not require that the pile be turned or mixed, although it may have to be flattened at the end of the summer season to maximise full use of the bin's capacity. This means that staff contact with the raw material is minimised. As neither installation has had to be emptied, ease of removal has not yet been tested at the time of writing, but the cages are designed to avoid bending or back strain for any maintenance. All these features are considered desirable in remote site sanitation applications (Pers. comm. McConnell July 1995).

Improvisation and experimentation with composting toilets and other on-site systems has been conducted within public recreation institutions such as the United States National Parks, and also by the US Army, in an attempt to provide adequate sanitation in remote and sensitive areas (Jensen 1984; Scholze et al. 1986; Engelder et al. 1986: 41; Worman 1989; Barsheid 1991: 44; Arnold 1993) (Pers. obs. September 1994). As was discussed in Chapter Two and 3.1, the batch composting toilet is a long established design type, (Harper and Thorpe 1994: 15), but the particular configuration of the features of the Cage

Batch are novel, as far as the author is aware, and the conditions under which the design was developed required resourceful adaptations to satisfy sanitation demands. If these innovations can be achieved under the stringent circumstances that are described in this Chapter, what progress could be made with adequate institutional support where the agenda is exclusively to further on-site treatment and management, and to improve the protection of water quality?

The step by step process of design, construction and monitoring of the Cage Batch composting toilet is detailed in this Chapter to illustrate the restrictive circumstances in which research and development took place, and also to present the time-frame, method and reasoning by which the concept was developed. An account of two composting toilet trials is presented separately although the development of the second trial was dependent upon the first and occurred concurrently (refer 3.3). The first trial was conducted on the Overland Track at Pelion Plains (refer 2.1.6) and the toilet was installed in November 1992. The second trial was conducted at Pine Valley (refer 2.6.1) and the toilet was installed in December 1994.

3.1 A batch alternative to the continuous system

As described in Chapter Two at 2.1.6, a single 09 Clivus Multrum was installed by the Tasmanian Department of Parks Wildlife and Heritage adjacent to the walker's hut at Pelion Plains on the Overland Track in central Tasmania, Australia in March 1991 (see Figure 2.2). The unit filled up rapidly due to the considerable number of hikers visiting Pelion. As the material was not breaking down, little reduction in volume had occurred in the twelve months of use. The tank needed to be emptied before the 1992/93 summer season.

The installation is not accessible by road. It is a three day walk to the Plains from either end of the park. Walkers and campers use the toilets, and usage was unknown. An approximate guess is that 6 000 people a year pass through Pelion Plains, but it is not known how long they stay, or how many times they use the toilet. It is a popular intersection for a number of walks. The toilets are installed at an altitude of 850 m. The 1991 temperature range in summer was 4.3°C to 15°C with a winter range of -7°C to 7°C. Rainfall recorded in nearby Cradle Valley in 1992 was 3 500 mm. These conditions are typical of the climate in this area.

The composting tank was installed in a shed that was cut into the ground and insulated with Sisalation and batts. A solar glazed roof covered half the shed. The shed was constructed to accommodate two 09 Clivus Multrum composting chambers.

As mentioned at 2.5.2, in October 1992, Clivus Multrum staff emptied the tank, and with the assistance of Parks staff, the raw sewage was flown out by helicopter. The emptied tank was restarted according to the manufacturer's specifications.

Considerable funds had been spent purchasing and installing the commercial composting toilets in difficult and remote locations and they were not handling the usage as anticipated. To prevent environmental damage and health problems some sanitation system was required to be provided to Park visitors. Using the bins as holding tanks and then emptying them of raw sewage was a health hazard to staff, and flying out the material is very expensive, so this process was unsustainable. Although an alternative was urgently needed, the Parks administration was unwilling to fund any other commercial system unless it was well proven in these circumstances (Pers. comm. Smith January 1992).

After consideration of the results of the composting toilet survey, described in Chapter Two, it was decided at the August 28, 1992 Composting Toilet Working Group meeting at the Department of Parks Wildlife and Heritage Head Office in Hobart, Tasmania to trial a custom built composting toilet in the Pelion Plains facility. An alternating batch composting system had been considered for some time. It was first recommended in the mobile 'Wheelibatch' format (discussed in Chapter Five) in March 1992 after the author had inspected the malfunctioning Rota-Loos at Narcissus Hut and Pine Valley (refer 2.7.2).

As discussed in Chapter Two, the Clivus Multrum is a continuous composting system in the sense that sewage is continuously added to a single pile and treatment occurs over an extended period as the pile slides slowly down into the end-product chamber. It is assumed that material in the end-product chamber is uncontaminated by the new material being deposited at the top of the pile. A batch composting system has two separated chambers. One chamber is used for a period, usually six months to a year, and then it is closed and left to compost for twelve months while the second chamber is used. This allows decomposition without new contamination, and batch toilets are often simpler to construct and maintain, although there has been significant success with owner built continuous system composting toilets in other States of Australia (refer Chapter Five).

A new structure containing a batch system was initially recommended for Pelion as a high use area. The Ranger then responsible for toilets in that section of the Park, suggested that the design be built into the existing building, by removing the current Clivus tank to create space for two separate receptacles. This would save the construction of yet another building and would be less expensive particularly if the batch trial failed (Pers. comm. Shinkel September 1992). Parks administration was anxious not to incur any more expense than was absolutely necessary to satisfy basic sanitation requirements.

The plans for the design were discussed by fax, and in person with Parks staff and rough sketches prepared. Building materials were ordered, and heli-lifted to the Pelion Plains site in October, 1992.

On November 4-11, 1992, Parks' staff who had not been involved in design discussions, manually dragged the current Clivus[1] out of the Pelion toilet shed, and installed an expanded metal cage under the two pedestals based on the design suggested. The cage formed the false floor and the false walls of the batch composting chamber (see Figure 3. 1). Due to a misunderstanding of the nature of a batch system by the construction team, and the inability of the author to be on-site, at that time, to supervise construction, the chamber was not divided into two separate areas.

The Clivus Multrum tank was not transported off site in case the batch trial failed and the other Clivus Multrums which had been emptied and restarted in the Park (refer 2.5.2) performed more satisfactorily in the next season. In that case the metal cage would be removed and the Clivus would be re-installed. As the Clivus Tank was heavy with raw faeces it was difficult to shift it without mechanical assistance, so it was left at the back of the building, obstructing one of the access doors.

[1] It was estimated that the compacted sewage in the tank weighed approximately one tonne (Pers. comm. Bugg November 1992).

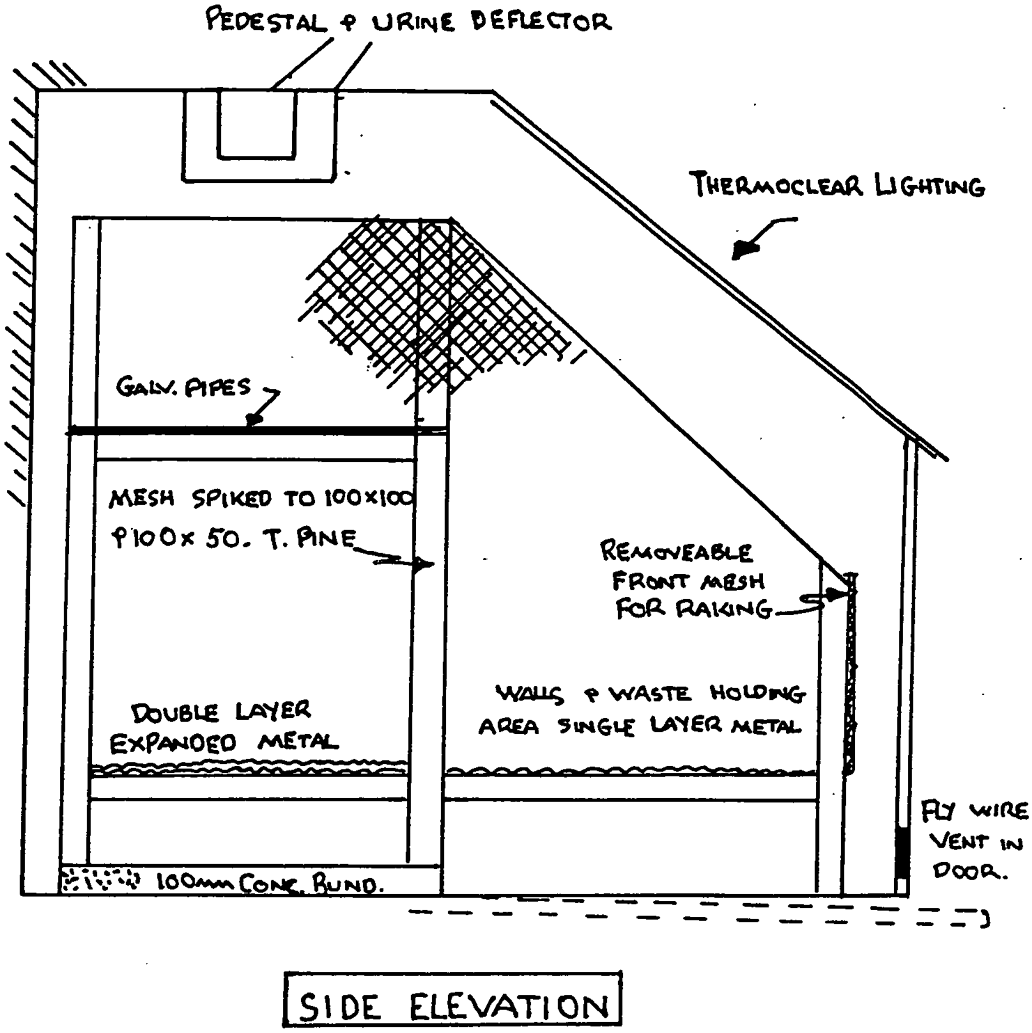


FIGURE 3.1

Sketched design of Pelion Cage Batch.

The walls of the shed (which had previously been covered with batts and Sisalation) were lined with marine ply and efforts were made to eradicate any cracks where flies could enter. The concrete floor of the shed sloped into a central drain which connected to a 75 mm pipe that drained into an exposed cedar chip bed.

A second false floor of fixed galvanised pipes was installed a meter below the pedestals. It was originally intended that, if a second false floor was installed, the pipes would be movable, to prevent build up of material, particularly so close to the pedestals. The idea of a second false floor is to give the material an extra draining and aeration as it passes to the central pile. Usually, the second false floor is far enough away from the pedestals to allow time for some breakdown, so the material can then filter to the first false floor.

As it happened, the material built up very quickly on the false floor under the pedestal and did not have time to break down. Because the pipes were fixed it was not possible to juggle the material through, and it was awkward to rake it down onto the lower false floor. The author recommended that the pipes be removed as adequate aeration and drainage was provided by the design and the pipes created unnecessary maintenance problems and did not allow a heat conserving pile to build up on the lower false floor.

As two months of sewage had collected under the pedestal in use making removal of the pipes very awkward and unhygienic, it was suggested that Pile 1 be closed, and once the cage had been divided, that the pipes on the other side be removed and that chamber be opened for use (Pers. comm. Bugg December 1992). Although this would mean that a full season's material had not gone into the first batch, it would certainly make the alterations more tolerable to install. It was assumed that by next summer the material in Pile 1 may have broken down sufficiently to remove the pipes and hopefully empty and restart Pile 1 to allow a maturing or fallow period for Pile 2.

Marine ply was ordered for the separating wall and was heli-lifted in to Pelion on January 20, 1993. Senior staff of Parks administration inspected the installation before the separating wall was installed (Pers. comm. Rose and Sallans January 1993). The pile was already showing early stages of decomposition and indicated considerable micro-organism and invertebrate activity. Larger insects appeared to have been sealed out of the installation. The pile had been conscientiously raked by the Rangers.

There was a strong smell of ammonia which could be partly due to the liquid lying on the concrete floor of the shed which was assumed to be ground water, with the addition of faecally contaminated urine. The original building was not designed as a water proof cellar and it had been cut quite deeply into the ground.

On January 20, 1993 Parks Rangers removed the pipe false floor under the left hand pedestal, and installed a separating wall. Full protective clothing and face masks were worn to avoid possible exposure to pathogens in the active pile. As the gaps in a single sheet of the expanded metal are too wide, a second layer was added to the false floor at the front of the cage to reduce the likelihood of solid matter falling through. Two layers of expanded metal had been installed on construction, but only immediately under the pedestal. A mix of mushroom compost and wood shavings was laid down as an organic filter, and 'starter bed' for the pile.

Pedestal 1 was closed off and pedestal 2 was opened and immediately used by waiting visitors. The bulking agent container was filled with rice husks mixed with a small proportion of woodshavings. A Parks Technical Officer advised that National Parks in other Australian States had used rice husks in composting toilets with some success (Pers. comm. Walters January 1993). It was decided to experiment with rice husks as they compress for more efficient storage than woodshavings, and should be more likely to break down and provide accessible carbon to micro-organisms (Pers. comm. McQuillan). This might stimulate a more biologically active pile and hopefully result in a much reduced end-product. On testing, the husks absorbed 1/3 of applied moisture, which may be less than fine wood shavings, but not less than high resin coarse shavings. As the report of the rice husks' efficiency was hearsay, it remained to be seen how well they would work in practice. As Pile 1 was mixed with woodshavings, it would be useful to compare the rate of breakdown and residue, with the rice husk mix in Pile 2. (When the pile had completed its 'fallow' period and was inspected in April 1995 it was apparent that the rice husks had only partially decomposed, refer 3.2.6.).

A new Rotron fan was installed in the vent, and the Ranger intended to move the solar panel onto the roof for better exposure. The fan was connected directly to the panel which reduced cold air being sucked through the system in cloudy periods. It also eliminated the ongoing maintenance problems with the battery. One disadvantage was that there would be very little movement at night and extended cloudy periods may result in a build up of odours. As far as aeration is concerned, the size of the composting chamber and the mesh floors and walls would always provide adequate oxygen for pile organisms. A small mesh covered vent was cut into the lower left side door.

It was recommended that the effluent outlet pipe be attached to a barrel in order to collect the run-off. This would prevent pollution of the local environment while the composter was being trialed and would also indicate the amount of liquid produced relative to the number of uses. For this reason, it would be important to keep up the user record sheets, however inadequate, and it was strongly advised that a door counter be installed on this facility. It was intended that the contents of the barrel would be tested for pathogens to ascertain efficiency of the composting system and to predict possible pollution of the environment. A small pool of brackish run-off had collected at the end of the pipe at the time of inspection on January 20, 1993. Due to the remote nature of the site, the Clivus tank obstructing access and limited funding, neither the effluent collection system nor the door counter was installed at the Pelion toilet during the period of this study, but both were integrated into the monitoring system at the second batch toilet trial at Pine Valley which was opened in January 1995, (refer 3.3.8)

The batch system cost approximately $2 500 to install in what had been the space occupied by the Clivus unit, including labour, materials, and helicopter time (Pers. comm. Bugg January 1993). This was considerably less than the cost of purchasing and installing the pre-existing commercial composting toilet.

3.1.1 Limitations of initial batch trial installation at Pelion Plains

As the facility was designed to hold the Clivus units, there were several limitations that required compromise in what was called the Cage Batch design. For example, the pedestals were too close to the walls and a deflector was placed under the pedestal to rectify this situation. As previously mentioned the drainage system and maintenance access were also inappropriate due to the Clivus being left at the back of the toilet chamber (see Figure 3.2). More space for the piles could have been created by installing the false floor closer to the concrete floor.

The batch system at Pelion Plains was built firstly to supply an urgently needed sanitation service to the visiting public at that site, and secondly to allow experimentation to develop a more workable system than was currently being used in the World Heritage Area. However, the experiment at Pelion Plains was constrained by the following conditions:

- remote site;

- inclement weather;

- reliance on Parks staff for construction maintenance and monitoring who had little, or negative, experience of composting human excreta in on-site installations;

- dependence on user co-operation, particularly in regard to addition of bulking agent with minimum supervision;

- regular change of staff responsible for maintenance, and the consequent need for re-instruction;

- very cautious support from Parks administration resulting in limited funding and the requirement to adapt to a pre-existing building and set of circumstances;

- and decisions affecting the implementation of the sanitation trial had to be processed by the Parks administration and then incorporated into other construction and maintenance programs, thus determining the pace at which this study could be established and conducted.

For the purpose of this Doctorate study it would have been more practical to build the toilet at an accessible site preferably near the University. However the research was funded and conducted in response to an expressed need and that need was to be attended to in-situ. While this made controlled traditional research processes impossible, and reduced the production of reliable data from the trial, it tested the innovation in a realistic context.

3.2 Monitoring the Pelion Plains Cage Batch

Having designed and constructed the toilet, the next stage of the research and development was to monitor its usage and performance. This depended upon the co-operation of the Parks and University technical staff, and was also confined by the weather which determined visitor numbers and therefore usage, and accessibility to the site for maintenance, inspection of the piles and reading of the monitoring equipment. For the author and University staff to visit Pelion Plains from Hobart, it involved at least three days travel time, and weather conditions were always unpredictable and often extreme.

To ascertain whether the toilet is an appropriate system for the Tasmanian World Heritage Area, the study had to allow enough time for a bin in use to fill up and be closed for a fallow period. Including the circumstances which led to the construction of the Cage Batch (which are described in Chapter Two and the beginning of Chapter Three), this process of implementation and assessment had taken three and a half years.

FIGURE 3.2

Data collection at rear of composting chamber: left side access obstructed.

Monitoring included surveying user and staff acceptance, recording maintenance requirements, measuring pile and ambient temperatures, and assessing odour and physical characteristics of the pile. There was a strong ammonia smell in the chamber at the time the second batch was opened in late January 1993. Dolomite was recommended if this continued. The peak holiday period was in process, and the toilet was being consistently used. The Ranger turned the piles in early February and reported that the ammonia smell had decreased but was still present. Dolomite was not added (Pers. comm. Plowman February 1993).

On April 3 1993, the author's supervisor from the Centre for Environmental Studies, and a Ranger installed a data logger in the toilet (Pers. comm. Todd and Plowman April 1993). The piles were turned and Pile 1 was covered with a layer of mushroom compost for insulation through the winter. Eight temperature probes were installed in the following positions:

- in pile 1;
- in pile 2 (two probes);
- at the outflow air vent below the solar operated fan;
- above pile 2 on the solar glazing in direct sun;
- above the access doors out of direct sun;
- 10 cm above floor;
- outside chamber for ambient temperature.

A Ranger carried in a computer to record the readings off the data logger in May and June, 1993. After each reading she turned Pile 2 and relocated the probes. The data logger registered a rise in pile temperature in the days immediately following the pile being turned (see Figure 3.3). The temperature in Pile 2 recorded at 30°C to 40°C for most of April during which time the chamber air temperature recorded at 0°C to 15°C. In May and June, 1993, the pile temperatures were lower as were the chamber and outside air temperatures. Pile 2 recorded above 25°C to 30°C after turning in May, and

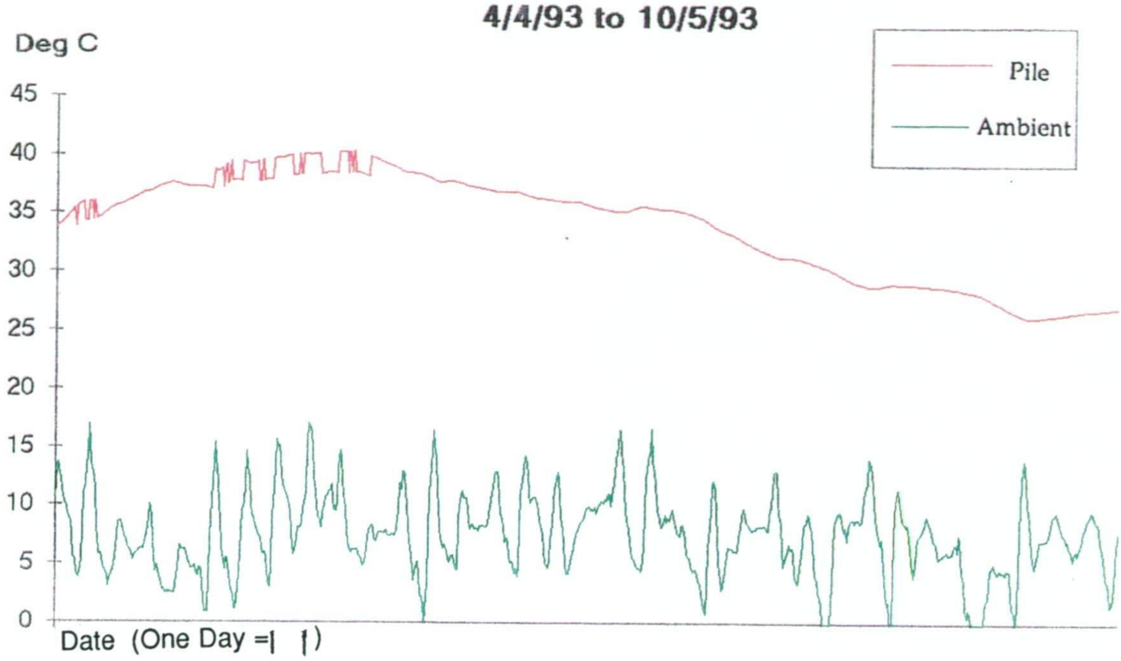
20°C to 25°C after turning in June. Further discussion of the temperature records is provided in 3.2.3.

A Technical Officer from the University of Tasmania, and the author inspected the piles after the winter on August 27, 1993. The readings were taken off the data logger, but Pile 2 was not turned. The chamber had an inoffensive mouldy smell. There were no indications of ammonia despite the pool of run-off/ground water on the floor of the chamber. Faeces in Pile 1 were still recognisable but had broken down to an organic texture and smelt of wet straw. The woodshavings used for bulking agent did not appear to have broken down at all. Pile 2 was partially reduced and also did not smell offensive apart from recent deposits. The rice husks used as bulking agent in this pile appeared to have broken down to a greater degree than the wood shavings.

3.2.1 Observations After the First Winter of the Pelion Trial

The temperature records suggested that the pile required 4-6 weekly turnings to regenerate heat producing micro-organism activity. These temperature rises are considered desirable because they will destroy pathogens if maintained for certain periods of time (for example, see Figure 3.4 for time/temperature kill for Ascaris eggs and enteroviruses). It had been an unusually mild winter that year in Tasmania which may have assisted somewhat in the decomposition of the piles. However the data logger recorded prolonged periods of low ambient and chamber temperatures that would test the capacity of the design to sustain mesophilic micro-organism activity. The frequent daily rise in chamber temperatures indicated that the solar glazing and insulation were effective in absorbing and containing heat for at least the daylight hours. The records of chamber temperature relative to the ambient temperature illustrate the degree of thermal effectiveness of the building design.

The August 1993 readings from the data logger revealed that the ambient temperature probe was no longer functional. According to the recordings it ceased to operate during the night so probably was interfered with by a nocturnal animal. It was intended to replace the battery in the data logger as soon as possible and reactivate the ambient probe and reinstall it with added protection. It appeared that an extraneous quantity of rice husk bulking agent was being added by the trackwalkers. This unnecessarily increases the volume of residue for disposal. A simple hopper system for bulking agent application was discussed but did not eventuate during the period of this study. The cup used as a scoop for the bulking agent had been removed at the time of the Autumn inspection, but it was suggested that it be replaced by a smaller container.



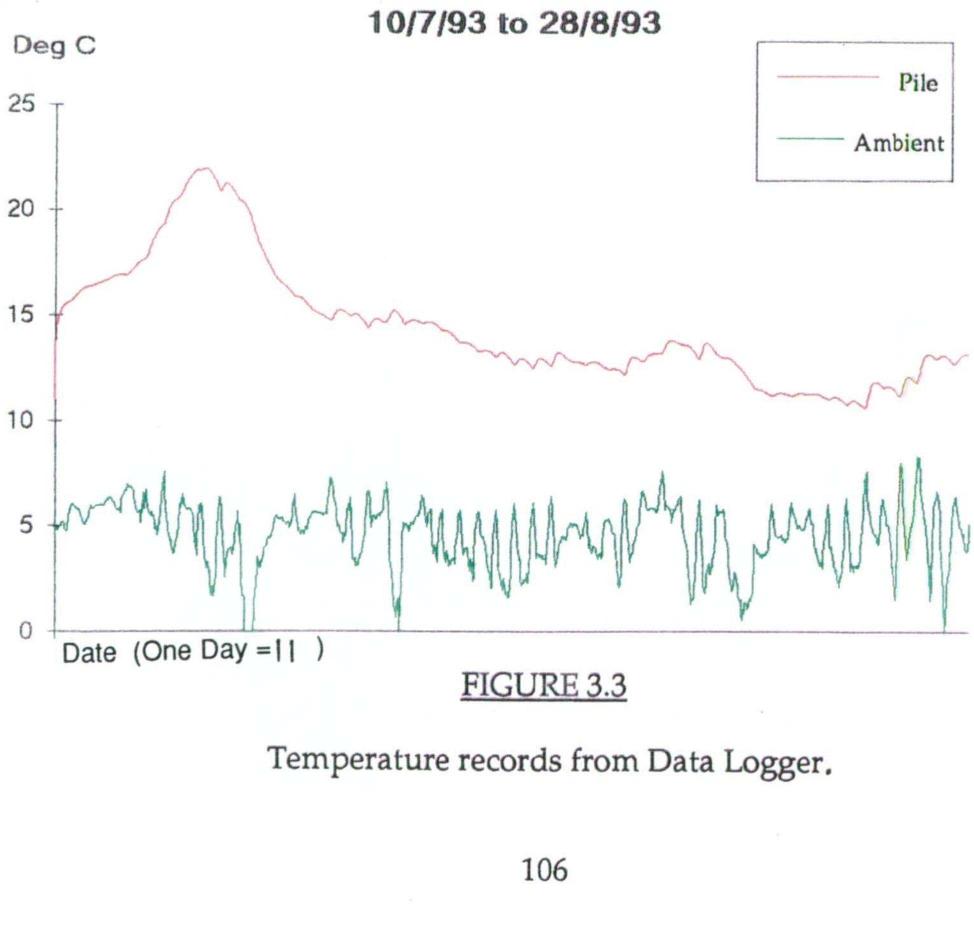
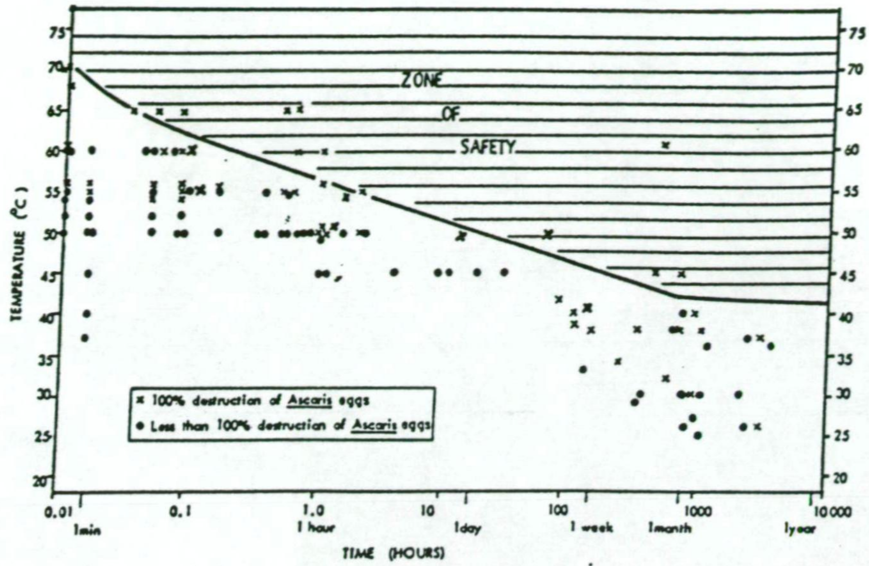


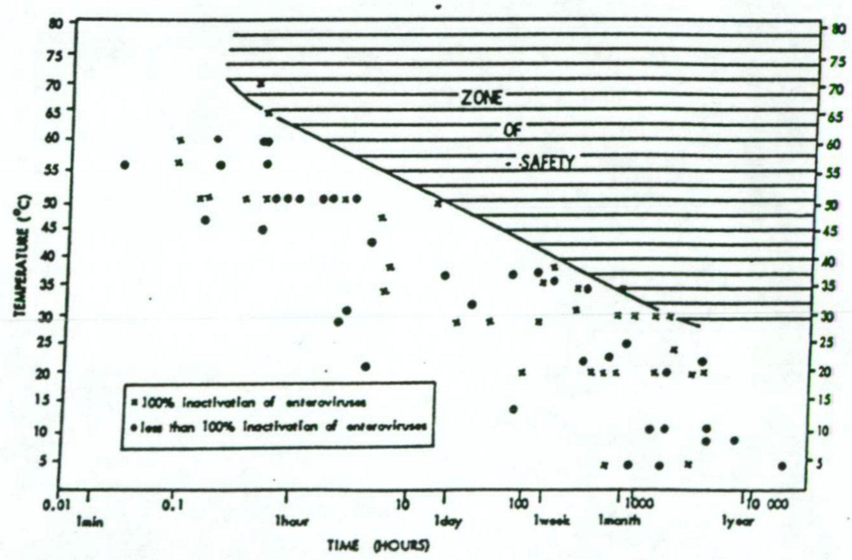
FIGURE 3.3

Temperature records from Data Logger.



The influence of time and temperature on Ascaris *eggs.* The points plotted are the results of experiments done under widely differing conditions. The line drawn represents a conservative upper boundary for death

ENTEROVIRUSES, POLIOMYELITIS, AND SIMILAR INFECTIONS



The influence of time and temperature on enteroviruses. The data probably also apply to adenoviruses and reoviruses. The points plotted are the results of experiments done under widely differing conditions. The line drawn represents a conservative upper boundary for death

FIGURE 3.4

Time / Temperature Pathogen Kill (Feacham et al. 1983: 163 and 391).

The design appeared to be handling the amount of urine that was deposited in the pile. Although a sign in the toilet requested that patrons did not urinate in the toilet, the urine input did include usage other than during defecation, especially when there were large crowds staying in the area. (Even in August it was observed there were 12 people staying for the weekend at the Pelion huts). Notices urging people to urinate out of the toilets will only be observed a percentage of the time. It was decided that it was not necessary to install a urinal in the Pelion design. This proposal had been considered for some time, to reduce the moisture and nitrogen load on the pile. It would not be advisable unless an effective nutrient inhibiting drainage system was also installed. Installing a urinal would also require some regular flushing system to reduce the odour in the collector.

In late 1993 the author recommended that the Clivus tank stored behind the toilet shed be removed. As previously mentioned it was retained in case the batch design did not work. At that stage, it was safe to advise that, at worst, the batch system would definitely act as a more efficient storage tank than the Clivus Multrum and may prove to be a successful waste disposal unit. The Ranger considered it would probably require helicopter assistance to move the tank to avoid having to remove 2 m^2 of dirt and rock to sledge the tank away from the toilet building (Pers. comm. Bugg December 1993).

On August 24 ,1993, a Sanitation Steering Committee meeting (which included the author) was held at Parks Head Office in Hobart. The possibility of installing a second Cage Batch trial at another location was discussed. Although the current rate of pile decomposition at Pelion was satisfactory, the performance of the system was not conclusive. It was considered that, in January 1994, it would be appropriate to take samples from both piles to test for pathogens and make an assessment of physical characteristics of the residue. The method of disposal of the residue, or end-product, had also to be discussed and trialed. It was mentioned at the meeting that future reduced funds may limit the options for disposal, and an on-site 'sacrificial dump' within the park may be considered if helicopter transport was not feasible (Pers. comm. Rose and Smith August 1993).

It was agreed at the meeting that it is not advisable to waste time and money and create environmental impact constructing any further Cage Batch units until it was reasonably certain the system was going to be effective. However, the performance of the Pelion design to date would justify a second trial incorporating improvements which were obviously expedient. This would begin the process of refinement of the design and provide further evidence of its limitations and capabilities. It was suggested that it would be useful to have a more comprehensive assessment before an appropriate standard design and management routine was proposed. This issue of a second trial was not discussed again until April 1994 (refer 3.3).

3.2.2 Summer 1993/4 maintenance and monitoring of Pelion Trial

The usage and performance of the batch composting toilet continued to be monitored during the second summer season. On December 1, 1993, Pile 2 was raked into a mound, and Pile 1 turned with a garden fork. The datalogger was removed and returned to the Centre for Environmental Studies for a battery change and reprogramming (Pers. comm. Plowman December 1993). The data logger had continuously recorded temperatures on the hour for eight months. From August 29 to December 1, temperatures in Pile 1 ranged from 8°C to 15°C, and in Pile 2 ranged from 14°C to 22°C. The piles were not turned during that time. Ambient temperatures ranged from -3°C to 14°C.

On December 16, 1993, both piles were raked and turned and the datalogger was reinstalled. The probes were located in the same positions except that no. 7 was attached to the external solar glazing roof to catch the full impact of the sun. On December 31, 1993 a strong ammonia smell in the toilet cubicle was reported by the Track Ranger (Pers. comm. Firth December 1993). The top of Pile 2 was 300 mm from the Cage ceiling and it was obvious that the batches or piles should be alternated as soon as possible.

On January 15, 1994, the probes were removed and both piles were turned and the probes reinstalled. It was reported that it was very difficult to turn pile 2 because it had become so large (Pers. comm Firth January 1994). Turning was also made more difficult by the construction of the cage which would need to be modified in a subsequent design. The maintenance Ranger strongly recommended a turning device as the job was unpleasant. Turning devices have been trialed in composting toilets with varying degrees of success and complication (Phoenix 1992). If the pile would compost sufficiently without tynes, it was considered that they are best avoided in this low maintenance context.

On February 17, 1994 it was noted that Probe 5 had fallen into Pile 2 and therefore was not recording the sun's impact under the glazed roof as anticipated. It was not apparent at which time this occurred.

During a heli-lift in early February 1994, it was intended that the Clivus composting toilet stored in front of Pile 1 would be removed. The Ranger had prepared the Clivus Multrum for evacuation but time did not permit removal by the helicopter (Pers. comm. Hamilton February 1994). It was reported that another heli-lift was scheduled for June 1994 and it was intended the Clivus Multrum would be removed then. (That would bring the number of decommissioned Clivus Multrums stored at Cradle Mountain Rangers Station to four, awaiting resale/disposal). The Clivus Multrum was eventually helilifted from Pelion in February 1995, and all units were transferred to other parks to be installed as sanitation storage tanks at low use sites (Pers. comm. Bugg April 1995).

On February 17, 1994, Pile 2 was closed and Pile 1 was re-opened. Before the batch was alternated, the readings from the data-logger were recorded onto the computer and samples were taken from both piles. A core and surface sample was taken from Pile 1 and a surface sample was taken from the middle of Pile 2. The pipes comprising the second false floor in Batch 1 were removed as had been necessary in Batch 2 in January 1993. As the gauge of the expanded metal floor of the cage was too wide, sticks were spread on the false floor to stop material from falling through, and the decomposed compost was laid as a starter bed for the new Pile 1. Pile 2 was raked into a mound and the remainder of the compost from Pile 1 was spread over it.

The probes were re-installed as follows:

Probe 1.....1/3 from base into Pile 2
Probe 2.....2/3 from base into Pile 2
Probe 3.....base of pile 1
Probe 4.....beneath fan vent
Probe 5.....in sun under solar glazing roof on cross beam of cage
Probe 6.....in composting chamber out of sun
Probe 7.....outside on solar glazing roof

Probe 8.....outside in shade.

Material that had fallen through the false floor and walls had collected in the ground water/run-off on the concrete floor of the composting chamber and gave off an offensive odour when shovelled onto Pile 2. This could be avoided by using a smaller gauge expanded metal. It was intended that an extra sheet of expanded metal would be heli-lifted to the site and be added to the false floor of Batch 1 in June 1994. However, this did not occur. At all times monitoring and maintenance of the toilet and the trial depended upon the availability of Parks staff to include these responsibilities in their many other activities. It also relied upon the staff's commitment to the trial, and the observations they passed on to the author for comment and response. If action was required then this had to be scheduled into other maintenance and heli-lift programs particularly if it involved supply of materials to the site. As the trial progressed two Parks personnel become increasingly committed to its success, as they considered that the Cage Batch had potential to provide environmental and public health protection in these difficult circumstances. These individuals also gave voluntary time to facilitate maintenance and monitoring of the trial.

3.2.3 Observations after the second summer of the Pelion Trial

The busy holiday season in Tasmania's National Parks slows down at the end of February. This was an appropriate time to evaluate the toilet after the second summer since installation. The evaluation included visual inspection and pathogen tests of the end-product from Pile 1, and some investigation of invertebrate presence in Pile 2. Pile 1 had been formed from November, 1992 to the end of January 1993, so it was not a full year's usage, but the 'fallow' period until February 1994 was typical of the proposed cycle.

On examination of Pile 1 on February 17, 1994, before the batches were alternated, there was no evidence of faeces. Pads and tampons (observed in Pile 1 earlier in the trial) had decomposed leaving only threads of string and partially decomposed plastic backing and the wood shaving bulking agent was recognisable but showed early signs of decomposition. The material was friable, had a faint smell of soil, and was less than half the volume of the original pile.

Pathogen tests of Pile 1 samples conducted at the University of Tasmania

AquaHealth laboratory produced an E.Coli count of 100/g in both the core and surface sample (Pers. comm. Garland February 1993). Possible cross contamination of Pile 1 could have occurred through the use of the same fork for turning both piles. Maintenance staff were advised that this should be avoided if possible. Separate tools for each pile were recommended by the author. It is quite likely that more complete sterilisation did not occur in Pile 1 as consistently low temperatures were recorded in the pile throughout 1993. Low temperatures which indicate reduced activity by heat generating aerobic micro-organisms may have been due to lack of sufficient volume in Pile 1. Temperatures in Pile 1 during the December 1993-February 1994 period ranged from 10-20°C which may have been mainly influenced by the ambient temperatures.

Given that sterilising temperatures were not sustained in Pile 1, the decomposition was considered to be very good and the pathogen indicator count was satisfactory. <100 E.Coli per gram passes NSW Health Standards for burying of compost into a garden bed and was a significant reduction. (Normal background level of raw sewage is E. Coli 1 000 000/g). It should be noted however that E.Coli are only indicator organisms and do not establish conclusively the presence or absence of cysts or viruses. Virus tests cost $300-$500 a sample and are conducted by well financed laboratories such as the Sydney Water Board (Pers. comm. Grohmann June 1992). Most sanitation authorities rely on Faecal Coliform tests. Viruses will be destroyed by sustained temperatures over certain periods of time (see Figure 3.4). There is no point in testing for viruses unless they are seeded or it is known for sure that they exist in the deposits (Safton 1993).

The sample from Pile 2 was examined with Dr. Peter McQuillan, Entomologist, at the Centre for Environmental Studies and the following invertebrates were identified: Sciaridiae (a small, <1 mm, black fly); Chloropidae (fly, 1-2 mm, that consumes bacterial slimes; and Rhizophagid mites (<1 mm detritvore generally found in drier dung). There were no maggots of blowflies (Calliphora spp.) which may because they were being suppressed by predators such as staphyinid beetles. It is unlikely that blowflies have not entered the composting chamber as the gauze across one of the vents was damaged for an extended period. There have not been any complaints of flies from users or rangers. It is also surprising that there was no evidence of local dung beetles, such as Onthophagus spp. The small sample taken obviously would not have captured all the mesofauna active in the pile. Activity of insects will vary with the seasons and at the successive stages of decomposition of the pile (Pers comm. McQuillan March 1994). If funding permitted, a year's study of the insect activity in the fallow pile would be an invaluable contribution to the understanding and management of compost toilets (Stoner 1977: 218).

Temperature range for Pile 2 during the period August - December 1993 ranged from 14°C to 22°C (see Figure 3.3). During December 1993 - February 1994 temperature in Pile 2 ranged from 38°C to 59°C. At times when ambient temperatures were 4°C to 15°C, the pile temperatures were consistently near 50°C. (Temperatures were recorded at the core of the pile where the probes were installed, therefore surface temperatures would be somewhat lower). This suggested that Pile 2 could be adequately sterilised of existing pathogens. The high temperatures may also affect the survival of certain types of organisms responsible for decomposition. Sustained 40°C to 50°C temperatures are likely to kill most insects in the pile. These insects play an important role in decomposition. While it is desirable, for complete pathogen kill, that 50°C temperatures are achieved, the batch only has to be sterilised once, and then it may be preferable to maintain lower temperatures to allow invertebrates and mesophilic micro-organisms to achieve decomposition in a comfortable stable temperature range. This appeared to be what had occurred in Pile 1. The texture and odour indicates almost complete decomposition, including initial breakdown of woodshavings, but the pathogen count revealed incomplete sterilisation in the samples taken.

The 1994 'fallow' period for Pile 2 at Pelion would test the design's capacity to compost a full 12 month size batch and indicate the residue left by rice husks. Pile 1 used wood shavings as bulking agent which only slightly decomposed in the fallow year. The active Pile 2 had used rice husks as bulking agent and it was hoped that their decomposition will be much more complete. At the time rice husks were recommended the rate of decomposition in a successful composting toilet system was not known. If the husks did not significantly reduce in volume, then research would need to be done for a more perishable bulking agent. In domestic units vegetable scraps are appropriate. In section 3.2.6 the rate of rice husk decomposition during the study period is evaluated.

To further reduce the end-product it was suggested that users could be asked to add the husks only when defecating. There was a disproportionate amount of husks in Pile 2 despite the small size of the scoop supplied. If the husks did not significantly decompose and thereby reduce the volume, a hopper was still considered worth investigating. Although people were urinating in the toilet, the composting process had not been inhibited by the input at that stage.

Probe 7 which was attached to the top of the solar glazing was absorbing two much heat from the fixture and giving unrealistic readings. The author requested that it be moved into the composting chamber, but still in direct sunlight. It was repositioned on March 3, 1994. Probe 3 had fallen into the ground water on the floor of the composting chamber and was repositioned into the centre of Pile 1 on April 4, 1994. Evidence of rodents in Pile 2 was observed (Pers. comm. Firth April 1994). The air vent mesh was damaged probably by animals seeking access to compost chamber. It remained open for some time allowing access to rodents. It was repaired after some months.

3.2.4 Trialing reduced maintenance of the pile

After the first year's trial it was considered that balancing the need for sterilisation (for health protection and minimally restricted disposal), with the need for physical decomposition (to significantly reduce volume and transform the sewage and bulking agent into an aesthetically acceptable material) may favour low maintenance. Collation of the temperatures from the data logger with records of pile turnings indicates that temperature increases occur after each turning. The batch design at Pelion had proved itself conducive to effective composting of a one-off small pile, i.e. Pile 1. Pile 2 was the regular size expected in the future as it was a 12 -14 month load. It could be argued that if decomposition in the larger Pile 2 is as effective, then it may be possible to limit the need for turning to once or twice a year. A possible maintenance program was suggested that the batch should be alternated in early January to make the most of the warmer months, turned, to bring the temperature up to sterilisation conditions and then left unturned to allow the invertebrates and mesophilic micro-organisms to establish the process of decomposition. The pile could possibly be turned a second time in November or early December making sure that the surface was turned to the middle of the pile.

For the above reasons it was recommended that the Pile 2 not be turned again until further notice. From February 1994 until the piles or batches were evaluated and alternated in April 1995, (refer 3.2.6), the only maintenance that the toilets received was cleaning of the toilet room, supply of bulking agent, repair of vent mesh, and leaking vent pipe. The piles were not turned.

3.2.5 Malfunction of monitoring equipment during 1994

Although one year's temperatures had been recorded during 1993, it was intended to observe the effect on temperature range if the piles were not turned or raked. Maintenance and reading of the data logger depended on the assistance of Parks personnel. Some Parks staff considered the temperature monitoring an academic luxury and the maintenance of the monitoring equipment an unnecessary burden. The important criteria for maintenance personnel was whether the toilet design produced inoffensive material of reduced volume which had a low or nil pathogen count (Per. comm. Bugg January 1994).

Other members of staff were prepared to support the temperature monitoring program and read the data logger between the author's visits. On May 21, 1994, a Ranger attempted to read the data logger and noted that it was malfunctioning. She contacted the author for advice on return to Hobart, and was requested to remove the datalogger for reprogramming. On July 13, 1994, despite it being the middle of winter, the Ranger revisited Pelion Plains and transported the datalogger to the University for maintenance.

On August 3, 1994 the same Ranger braved zero temperatures and flooding creeks to carry the data logger into Pelion Plains to be re-installed in the toilet (Pers. comm. Plowman July 1994). These circumstances are mentioned to indicate the extreme and stringent conditions under which the Cage Batch composting toilet was researched and developed, and the level of commitment of some Parks staff to the project. The author would not have taken such risks to maintain the temperature monitoring, and this aspect of the trial would have been impossible without the assistance of these individuals. The Ranger was advised by the author not to visit the site again until Spring.

On November 11, 1994, the Ranger attempted to read the data logger but again the system was not functioning and the data were not released. At the time probe 8 had been dislodged and was reinstalled.

On December 12, 1994, the information on the data logger was transferred onto the computer by the Rangers, the battery was changed, and the datalogger was reprogrammed. It was noted, at the time, that the pile readings were much lower than the previous year (Pers. comm. Plowman December 1994). Probes 1 and 2 were buried deeper into Pile 2. When the computer was returned to the University, there was no data recorded. It appeared that the computer was now malfunctioning and the data had been erased. This meant that there were no temperature data available for winter 1994, despite considerable effort to sustain recording. Therefore the impact on pile temperatures of not turning the pile was not ascertained.

As with repairs to the toilet, maintenance of the monitoring equipment and program was hampered by the extreme conditions of the site and circumstances of the trial. The ordinary tasks of observation and recording became major logistical undertakings thus making possible only the most speculative and basic assumptions about the composting process within the batch toilet.

3.2.6 Assessment of Pelion piles after fourteen months 'fallow' and usage

On April 22, 1995, the Pelion Cage Batch was evaluated for performance of a full batch cycle. The evaluation was by visual inspection and assessment of odour, and samples were collected for pathogen and carbon/nitrogen tests. The evaluation was attended by the author, a Parks Ranger and a PhD student from the Centre for Environmental Studies who is studying the use of composted human excreta in cultivation (Pers. comm. Berry 1995).

Pile 2 which had been 'fallow' for 14 months had reduced in volume by one third, had an inoffensive earthy smell and consisted of slightly decomposed rice husks (compare Figures 3.5 and 3.6). When collecting samples for testing, it was difficult to find any bulking agent that contained obvious organic matter. Samples were taken from the surface of the pile, the core and the lower left hand corner which was found, on emptying to be very damp due to a design fault in the bin. The samples were collected in sterilised containers and were transported the Mt Pleasant Government laboratory within 24 hours of collection.

The results are as follows:

Sample Details	Coliform/g	E coli/g	Enterococci/g	Salmonella/g
Surface	approx. 12 000	<10	320	nil
Core	400	<10	<10	nil
Base of pile	approx: 15 000	<10	approx. 140 000	nil

FIGURE 3.5

Pile 2 during active period

The coliform counts are consistent with the expectations for a compost pile. Less than 10 E. Coli or faecal coliform per gram is a very satisfactory result, in terms of pathogen indicator criteria, and what should be expected in a well composted material (Mara 1976: 13). Enterococci are more resilient and quite likely to persist in an environment like the compacted corner at the base of the pile. Their presence on the surface of the pile could be due to the traffic of mice who had nested in the fallow pile. The minimum count of all pathogen indicators at the core of the pile suggests a successful composting process.

FIGURE 3.6

Pile 2 after 14 month fallow period

Carbon nitrogen tests of the three samples gave the following results:

	Carbon %	Nitrogen %
Surface	30.0	2.65
Core	30.0	1.31
Floor of pile	27.50	3.37

This result could indicate that the original C/N ratio of the surface sample was middle of the range, the core sample had a high original C/N, and at the floor of the pile the C/N of the mix was well balanced. The mix at the floor of the pile may also have had a low unavailable carbon content (Gotaas 1956: 51). As the bulking agent is added by the user according to her/his inclination (despite specific directions), or added in bulk periodically by maintenance staff, or at times not added at all, it is to be expected that the mix of carboneous material and excreta will vary throughout the pile.

At the time of evaluation, information on the data logger was recorded onto the computer and the battery was changed. The summer season temperatures recorded on the data logger indicate that despite there being no turning of the piles, temperatures were maintained in the 20°C to 35°C mesophilic range.

The compost from Pile 2 was shovelled onto the new material in Pile 1 and Batch 2 was re-opened for use. Compost from the fallow pile was left in Batch 2 to start the new pile. Two and a half years of material was now stored in Batch 1. This pile would now undergo a fallow period until the end of summer 1995/96. If the toilet continued to perform successfully and less bulking agent is used in 1995, then it may be possible to further postpone the necessity of removing material from the site for another couple of years.

The issue of adequate treatment of liquid run-off from the composting toilet remains to be resolved. At the time of inspection in April, 1995, the effluent from the toilet mixed with ground water was draining above ground outside the back of the toilet. This had been the situation for several years. Tests had revealed that the pathogen count in this run-off was 2.6×10^4 Faecal Coli/100 mL (Pers. comm. Byers and Garland April 1994). It is intended that a simple solar steriliser will be trialed at the Cradle Mountain workshop during winter 1995 (Pers. comm. Bugg July 1995). The author will continue monitoring the Cage batch toilets.

3.3 A Cage Batch Trial at Pine Valley

Concurrently, with the latter stages of the Pelion trial, a second Cage Batch trial was established at another high use site on the Overland Track in the Tasmanian World Heritage Area. Although this trial was similarly constrained by being conducted in a remote site, it was more accessible than Pelion

Plains, and the success of the first trial reassured Parks administration so that they supported the installation with adequate funding and allowed the installation to be designed from the outset for a Cage Batch rather than adapt the design to a pre-existing building.

However as the Department was still affected by the previous large expenditure on inappropriate sanitation systems, (described in Chapter Two) consultation was slow and cautious, and involved senior staff from a number of divisions of the Department of Parks Wildlife and Heritage. The process of decision making, design and implementation are detailed in the following section of this Chapter to illustrate the procedures and caution exercised in an institution whose mandate is to provide sanitation facilities to the public but not to research and develop them. The description of events and issues involved also illustrate the context and method of the author's participatory research.

As mentioned in 3.2.1 a second trial had been discussed with project Steering Committee members in August 1993, and it was agreed that it would be appropriate to further test the design, to be sure that the positive results continued in a different location. A number of different sites for the second trial were discussed in the following months including Lake Rodway, Old Pelion Hut, Kitchen Hut and Cirque Hut, all locations on the Overland Track(see Figure 2.2). A decision regarding the toilet was delayed by the ongoing debate about the renovation of Cirque Hut or the building of a new hut at Waterfall Valley. There was intense community and Department discussion regarding these constructions. The renovation of Cirque Hut could have included the building of a Cage Batch in the budget, and a design had been prepared for that location. However, when it was decided to build a new hut at Waterfall Valley, it became obvious that a meeting of the people concerned was required to discuss the issues related to trial of a second Cage Batch.

A meeting was held on April 27, 1994 to further discuss a proposed second trial of the alternating batch system. The design would be based on the Cage Batch that has shown promising results at Pelion Plains since it was installed in November 1992. Present at the meeting were the Area Manager, the Senior Zoologist, a Botanist, the World Heritage Area District Rangers, a number of Track Rangers, and the author.

The issues that needed to be resolved at the meeting included the following questions.

- Should a second trial be installed?

- If yes, what location?

- If yes, how will it be funded, who will build it and when?

3.3.1 Should a second trial be installed?

There were a number of factors in support of a second trial.

- The cage batch design installed at Pelion Plains is relatively cheap, adaptable to usage and location variations, simple to build, and has easy access for maintenance and emptying. The first pile had produced compost in 12 months which did not have an offensive odour, was a third of the volume of the original material, and had a low E.Coli count, despite not recording high temperatures. The second pile had consistently recorded high temperatures which should produce a better compost.

- These results required verification through use and monitoring of an improved version and the opportunity to design, cost, build, maintain and test an installation which is intended from the outset to hold the alternating batch toilet instead of adapting a design to the Clivus building.

- It would be useful to collect and test run-off for quantity and quality and relate that to usage and temperatures recorded. The data collected would assist designing the most appropriate system for treatment of run-off. Attempts to estimate usage through user record charts at toilet sites had supplied limited information. Usage should be more accurately assessed to size the toilets correctly and prepare for quality and quantity of run-off. At Pelion Plains it was not possible to monitor run-off because the Clivus tank was stored over the drain from the batch system.

- A second trial would provide more information as to the volume and condition of compost so that the most efficient disposal of end-product can be planned.

- A second trial would provide twice as much data to make an informed evaluation of the cost, maintenance requirements, sustainability and environmental impact of the Cage Batch system. At the same time alternatives could be evaluated such as haul-outs, pits, and the ongoing performance of the Clivus toilets. A trial of walkers carrying out their own faeces had been conducted over 6 months by the author and had produced useful feedback. A haul out system was currently in operation in the Western Arthurs Range of the World Heritage Area. All these options needed to considered so that a comprehensive comparison could be made. Some sites may be more suited to particular systems than others, so all options should be examined.

It was considered that even if composting did not occur, the design would serve as a holding tank and allow for dehydration and some decomposition of the material and relatively simple removal of the end-product (Pers. comm. Sallans April 1994).

At the meeting the participants were asked if anyone had any objections to a second trial? There was some concern that yet another toilet construction was to be installed in the parks without being absolutely sure of its success. The Clivus Multrums, and to a lesser extent the Rota-Loos had been installed throughout the parks without an initial unit being trialed in Tasmanian alpine conditions, and staff did not want a repetition of this with all its attendant expense and problems simply because the Pelion cage batch had performed well for one year (Pers. comm. McConnell April 1994). This objection was quite justifiable (Refer 2.1.). Consequently, there were two courses of action available: to proceed with a second trial to duplicate and verify the results of the first trial, or to base decisions for further applications on an extended trial at Pelion. The meeting unanimously decided, with some reservation, to proceed with a second trial.

This raised the issue that had been discussed for over six months: at what location should the toilet be installed? To determine the location a number of questions were asked: what site requires another toilet and what staff centre is willing to be responsible for the trial?

3.3.2 <u>At what location should a second trial be installed?</u>

Most Parks districts were in need of more toilets but as there has been a moratorium on toilet installations since early 1992, as advised by the author, until a reliable system was developed, management had been tolerating existing inadequate conditions. Therefore the trial would be installed in a location that has an urgent need for a toilet and in a situation of high usage. It was important that a second trial is located where staff are willing to make the extra commitment that monitoring involves and be prepared for an installation that may not be successful and will then need to be removed. The location should also be reasonably accessible for regular monitoring and be suitable for a composting toilet. It was preferable that there are staff available at the chosen location who have been involved in the composting toilet installations and their performance over the last four years. Although it is desirable that as many people as possible are educated in the maintenance of composting toilets, much valuable time can be saved having the involvement of staff with accumulated expertise in the trial stage.

3.3.3 Funding, installation and time frame?

From the outset there had been an issue of funding for this second trial. It was agreed at the meeting that the funds should be provided from what remained in the area budget at the end of the financial year.

Conclusive results from the composting toilet trials were needed as soon as possible so that decisions can be made as to future installations throughout the parks . Therefore it was intended that the second batch trial be built as soon as practical to allow maximum time for use and monitoring.

The author wished to avoid covering old ground with new staff and raised this point. There was some discussion as to the usefulness of having staff who had built the Pelion trial assisting with the construction of the next trial. It was agreed that staff could be seconded if this was necessary (Pers. comm. Nagle April 1994).

3.3.4 A site is chosen

The possibility of installing the trial at Waterfall Valley was discussed. The new hut may attract larger numbers of walkers to remain overnight, and the existing Clivus Multrum installation may not be adequate to deal with those numbers. It had been reported that with regular emptying of small amounts of material and prodding the pile to move down the tank, the Clivus at

Waterfall Valley was performing better than in previous years (Pers. comm. Hamilton March 1994). However, if overnight camper numbers increased more capacity would be needed, and there were instructions to move the toilet as the path between the new hut and the toilet now passed over an archaeologically significant site. So rather than move the Clivus Multrum it would be practical to build a new toilet. The cost of a new toilet had not been included in the hut budget and it was considered by the meeting that it would be better to wait until the next financial year to build a new toilet at Waterfall Valley. The District Ranger for Cradle Mountain National Park agreed that if the Pelion batch continued to perform well then the new toilet could be a Cage Batch composting toilet (Pers. comm. Nagle April 1994).

After further discussion it was decided that Pine Valley would be a suitable site for the second trial of the cage batch composting toilet. Pine Valley in the Lake St. Clair National Park has high overnight usage, with people often staying a number of nights. The site had been serviced by the in-ground non-functioning Rota-Loo composting toilet since March 1990 (refer 2.7.2). The toilet was emptied of raw sewage by parks staff under very difficult conditions for a number of years, but more recently an external agent had been employed at $95 an hour to empty the carousel once a year. There was an urgent need for an alternative toilet at this site.

The Ranger, who had assisted in monitoring the batch trial at Pelion, and has had considerable experience maintaining the composting toilets on the Overland Track, worked as a ranger at Lake St. Clair. She was committed to assisting with a second trial. The site is a three hour walk from the boat at Narcissus so is relatively easy to access for maintenance and monitoring. The District Ranger was willing to have the batch composting toilet trialed at Pine Valley. However, he preferred a less conspicuous design than the other composting toilet installations if at all possible (Pers. comm. McConnell April 1994). It was agreed at the meeting that materials for the project should be purchased before the end of the financial year, but it would not be possible to build the toilet until Spring 1994.

It was decided that the toilet would be built by Lake St Clair staff with advice/assistance from the Ranger who had been working with the author on the Pelion Cage Batch, if this was necessary.

Details as to how the project would be funded would be decided between the Area Manager, the District Ranger and Assistant Director of Land Management.

3.3.4(i) Pressures motivating the decision making process

Many of the considerations described above would not be necessary within an institution whose mandate was to research and develop appropriate sanitation.

Given the many other concerns that must be attended to by Parks administration, the decision making process which allowed the second Cage Batch trial was relatively flexible and efficient. However, the primary object was to provide a workable sanitation system in a high use site, as soon as possible, and to replace the existing system which was a health hazard to maintenance staff. Once again the opportunity for further research and development was crisis driven.

3.3.5 Development

On May 25, 1994, the District Ranger, the author, and the Parks Assistant who would build the toilet walked to Pine Valley to select a site for the trial. The area was inundated with run-off from melting snow, so it was a useful time to eliminate lower ground sites. The possibilities that remained were the raised site that contained the in-ground Rota-Loo and also an adjacent abandoned pit toilet, and two nearby tent sites. The pre-existing toilet site had the most access to the sun and was closest to the hut of these three sites. It was also in direct line from the heli-pad which would facilitate transporting materials. There were certain limitations to this site: the trial outhouse would have to span the two meter hole that contained the Rota-Loo tank; the area was boundaried on one side by the abandoned pit toilet and on the other by bush and steep slopes so it would not be possible to lower and widen the building as was intended with a second batch design. However the Rota-Loo site was chosen, despite its limitations rather than disturb one of the tent sites with yet another toilet building. The clearings of the tent sites also had less access to sun, and a maximum passive solar heating was desirable to assist the composting process.

The new design was worked through on the floor of the Lake St. Clair workshop.

The installation was to be designed as soon as possible so materials could be paid for well before the end of the financial year. Although this urgency would mean that the project would be attended to immediately, it did not give much time for comprehensive consideration of all the design possibilities specific to the Pine Valley site, and it is preferable not to take on a project of this kind under this kind of pressure, if it can be avoided.

From past experience the guiding principles for the design were:

- maximise prefabrication prior to heli-lift;
- simplicity of design and construction to minimise maintenance and cost;
- ease and health protection of staff during maintenance;
- optimum combination of aeration, passive solar heating and insulation to assist composting process;
- adequate drainage to treat quantity and quality of run-off;
- aesthetic acceptability given the limitations of the site; and
- an installation that could be easily removed if the trial was unsuccessful.

3.3.5(i) Foundations and Plenum Floor

It was intended that the unit would be prefabricated as much as possible in the workshop to minimise on site construction and to address all potential problems before the materials are heli-lifted to the site. Working from the ground up, the first consideration was how the building would span the hole containing the Rota-loo and whether this could create long term problems for the foundations of the new toilet building as the tank and its contents decomposed. Removing the Rota-Loo was discussed but the tank would first have to be emptied of faeces, and then hauled out of the hole which was considered to be too difficult, under the circumstances (Pers. comm. McConnell).

A cement slab or a tray system under the bins were the two options to be considered. A cement slab would entail more work on site and involve a considerable quantity of cement to safely span the hole. It also made the installation more permanent. But the cement slab would provide a simple catchment area for run-off and material that may slip through the caged bins. The alternative tray system was initially rejected as it would be too awkward to remove in the restricted space of the site and problematic for connecting drainage. Later in the year, when construction was taken over by another Park Assistant, a modified tray system was chosen.

To allow the area under the caged bins to be easily swept out, 200 mm was to be left between the plenum floor and the floor of the bins. This space was more than is necessary in terms of evaporation or drainage but should assist to keep the installation clean and reduce odour. One of the limiting factors on the design was the necessity to keep the height of the building as low as possible to reduce its conspicuousness. Because the building had to span the in-ground Rota Loo and the site is a rocky outcrop, the foundations could not be lowered into the ground, and the site area available restricted horizontal extension of the installation. Other composting toilets in Tasmanian parks have been lowered into the ground to reduce the height and have often been sitting in ground water, or low lying water during rainfall. This has also made drainage and treatment of run-off ineffective. When the Rota-Loo was installed below ground, it was necessary to blast the required hole because of the rocky soil conditions.

3.3.5(ii) The caged bins

The height of the caged bins has been determined by the need for easy maintenance access and minimum bodily exposure to the pile contents, a calculated capacity to allow critical mass in the shape of the pile, and adequate aeration. The length of the cages is to allow maximum capacity for the expected usage at Pine Valley. The tanks of the Rota-Loo have been emptied of raw faeces and toilet paper every twelve months, so this provides an indication of the probable volume of material that will need to be treated annually by the batch system at this location. Although it is difficult to ascertain from the manufacturers, the volumetric capacity of the Maxi Rota-Loo has been roughly calculated at 1.25 m^3 (Pers. comm. Angwin June 1994). Combined with an equal volume of bulking agent and allowing for increased usage if all campers used the toilet, the maximum volume of material to be treated annually should be approximately 3 m^3. Each caged bin has a capacity which should allow at least a full year for the material to 'fallow' and the possibility of emptying the end-product into the new bin. This could mean that an off-site removal of compost may not be necessary more than once every two or three years. The front of the bins was to be lowered to facilitate material being shovelled from one bin to the other. This feature was accidentally omitted in the final construction.

The caged walls of the bins allowed maximum aeration and drainage of the pile. This is advantageous in terms of maximising oxygen supply to the micro-organisms and rapid removal of excess liquid but reduces insulation to the surface area of the pile. Heat generated by the pile is partially contained by insulating the internal walls of the building and lining them with Sisalation to reflect any heat generated back to the pile. A further compromise of conflicting needs is achieved by installing therma glaze doors to allow access of the sun's energy at the level of the cages, but restricting the size of the therma glaze panels to reduce the amount of heat lost out of the building at night.

The bins were individually constructed of expanded metal to increase airflow, and with a 100 mm space between the two cages to achieve some separation of the active and 'fallow' pile. The Pelion bins were separated by a marine ply wall but this was showing signs of deterioration, and the base of the pile against the wall had compacted. It was intended to prefabricate easily transportable modules and it was decided to construct individual bins despite the extra expanded metal that this involved.

3.3.5(iii) Outhouse and toilet room

The pedestals are made from fibreglass and are specifically designed for composting toilets, having a flared base to reduce adhesion of faeces and a firmly sealed lid and seat to control air flow, insect invasions and odours. There are two pedestals, one over each bin. When one bin is full, the pedestal is covered by a wooden box and the pedestal over the newly opened bin is used. In the toilet room a container is stored near the toilet for addition of rice husks by the user and a locked storage space has been included for excess bulking agent. It is important to control the amount of bulking agent that is available to prevent users overloading the bins.

The cladding of the building was treated pine. Although western red cedar was a cheaper option and a common choice, it was considered advisable to use a local timber rather than a subsidised import (Pers. comm. McConnell April 1994). The roof is gabled to give some shape to an otherwise box like building. The 300 mm vent pipes used in National Park vault systems in the USA were suggested but this idea was not adopted at the time (Cook 1991: 1). Venting consisted of a 100 mm plastic sewage pipe painted black and extending 900 mm above the roof line. Condensation and drips were be diverted in the u-bend. To eradicate moving parts in the design, it was decided to trial a passive ventilation system. This would also mean less cold air would be drawn across the piles. There was some risk that the air flow may reverse at night and odours may enter the toilet room. This had not occurred in other composting toilets in warmer climates where a passive vent had been used, but the low temperatures may cause the air reversal in this location (refer 5.8.5).

3.3.6 Construction of the Pine Valley Cage Batch

The Park Assistant, who assisted with design and was responsible for fabrication, resigned from staff mid 1994. This was initially unfortunate for the project as it takes time to educate Parks staff about the concepts involved, and to form a co-operative working relationship. It took some months to decide who would replace him, and fortunately the replacement had experience maintaining the Pelion Cage Batch and was able to contribute improvements to the design.

It took 24 working days for one person to prefabricate the entire installation including welding the metal bins. The prefabrication was completed late November, 1994. It was not possible to hire a helicopter for transport in the first weeks of December because of commissions in Antarctica. Transporting the load from the workshop to the toilet site was scheduled for December 16, but due to the redirection of the helicopter to bushfire control, the heli-lift did not take place until December 22. This meant that the installation took place in the middle of the peak visitation period. The heli-lift involved seven trips, but with more skilful packing this could have been reduced.

Three Parks staff constructed the building and toilet installation in five days with a carpenter/Summer Ranger assisting for two days. The bins were 'started' with twigs and local leaf litter and the toilet block was opened for use on the evening of Tuesday 3 January, 1995, and the counter recorded sixty uses by visiting campers, within a couple of hours (see Figure 3.7).

It was intended to have the installation at Pine Valley completed by the end of November 1994, to trial the toilet through a full summer season and particularly during the Christmas - New Year rush. Due to extenuating circumstances, such as staff resigning, administrative difficulties, and helicopters being otherwise occupied, the installation occurred about a month later than intended. However, in these remote and demanding circumstances that is not a serious or unusual delay, and there was still two months of peak summer usage to be trialed, before this study was concluded.

FIGURE 3.7

Cage Batch composting toilet at Pine Valley.

3.3.7 Maintenance and monitoring of Pine Valley Toilet. Summer 94/95

A door counter and Rangers' surveys monitored usage of the composting toilet during the summer holiday season. By the end of March over three thousand uses had been recorded. In early March, visitor complaints of unpleasant odour were investigated and it was found that bulking agent which had been added by the Summer Rangers was not supplied for visitor use after the ranger season was complete. Consequently no bulking agent was added for several weeks. The Summer Rangers had previously taken over bulking agent application because users were inclined to add far too much material. This is an ongoing education issue. In addition, the toilet seat was damaged and no longer sealing properly allowing ventilation to short circuit. Vents were also installed in the toilet room to improve ambience, but as they were installed under the eaves to avoid having to cut a hole in the roof, adequate ventilation was not achieved.

To monitor liquid production relative to usage, the drainage system was temporarily connected to a holding tank. Odours from the holding tank may be backing up the pipes and with the seat not sealing properly, these fumes could have been detected in the toilet room. The seat had since been repaired and bulking agent has been supplied for user application. Visitors were no longer complaining of odour. It was planned to disconnect the holding tank after the Easter visitation, and install a suitable trench system based on the monitored effluent discharge, but this will not occur until Spring 1995. Urine diverters may be necessary as the quantity of liquid produced has been considerable. This could also be due to the low evaporation rates typical of a new pile, and will be monitored.

User response has been monitored in conjunction with the Summer Rangers. Holiday Rangers were in attendance during the Easter break to complete this personalised survey strategy.

On January 10, 1995, a data logger was installed in the toilet building to record pile and ambient temperatures. Due to technical problems it was not possible to collect this data prior to the completion of the Doctorate study. Results from this data collection will be analysed in future papers, along with other aspects of the trial.

3.3.8 Observations after Autumn 1995 Inspection

The summer performance of the Cage Batch composting toilet at Pine Valley was evaluated on April 11, 1995, and the findings are described in the following sections.

3.3.8(i) In the composting chamber

On opening the rear doors of the toilet building to have access to the pile, a slight odour of ammonia was detected. A pile of composting material of approximately 3/4 sq.m had formed under the pedestal in the cage in use. The pile consisted of a mix of faeces, toilet paper and rice husks in the early stage of decomposition. Large numbers of small black flies (Sciaridae) were crawling over the pile. Steam was detectable rising from the pile as cooler air from outside the toilet building flowed in to the chamber through the open doors. As the computer to read the data logger was out of order and therefore not available to transport to the site, it was not possible to note the relative ambient and pile temperatures at the time of inspection.

The pile had formed to the front of the cage and rice husks were beginning to slip through the expanded metal access door. The rear section of the cage was almost empty. This was surprising as the pedestal had deliberately been installed over the centre of the cage, and it was assumed that an even cone shaped pile would form under the pedestal. It appeared from the position of the pile that as people sat on the pedestal facing the access door of the toilet room, the front of the cage was favoured for deposit by a couple of centimetres. This was an important observation for future refinement of the design as the uneven pile distribution would now require Parks staff to periodically rake the pile backward to take advantage of the full capacity of the cage. It had been intended that this type of maintenance would be minimised by this design. It was recommended to consider a deflector on the chute from the pedestal to help remedy the situation in this installation. In future installations the pedestal would be installed a few centimetres closer to the back of the cage.

The protective paint supplied by the manufacturers to protect the galvanised cage frames was beginning to peel off, as was the 'sticky back' foam that lined the chamber doors. The atmosphere in the composting chamber would appear to be too harsh for these preparations.

The liquid drainage system appeared to be working effectively. There was slight pooling of a dark liquid on the plenum floor adjacent to the drain.

3.3.8(ii) The toilet room

On opening the toilet room door an ammonia odour was detected. The room seemed humid and airless despite the recently installed vent. The toilet seat and lid had been damaged and were loose on the pedestal. The inadequate hinging system has been referred to the pedestal manufacturer who requested that the pedestals be returned to be repaired. This is not a practical suggestion at a site many kilometres from the nearest roadhead, where transport of goods is by foot or very irregular heli-lift. The loose toilet seat and lid would have allowed insects to have access to the pile, and caused short circuiting of the airflow, possibly contributing to the odour in the toilet room. As previously mentioned repair and maintenance at these sites is a major logistical exercise.

3.3.8(iii) Usage

Since commissioning of the toilet on January 3, 1995 until the day of inspection on April 11, the door counter had registered that the door had been opened 7 333 times. Based on the assumption that the door was opened and closed twice each time someone used the toilet, there had been 3 666 uses of the toilet. However, it is not known definitely whether the usage was for defecation, urination or both, or whether sometimes the door was opened merely for inspection of the toilet, maintenance, or for the toilet room to be used as private space to change clothes. These difficulties have been experienced by other public recreation institutions attempting to record toilet usage (Jensen 1984: F-3). An on-site survey conducted by Rangers, to broaden and substantiate counter data, suggests that most people used the toilet when they wished to defecate and at that time they also urinated. Only 2% of people surveyed had visited the toilet solely for urination, and they were all women except for one male. During the peak holiday periods there were 15-40 uses a night recorded by the survey at Pine Valley, and 20-40 at Pelion. 18 survey nights were completed at Pelion and 14 at Pine Valley. The Summer Rangers complained about having to do the survey as it was "embarrassing". A permanent Ranger conducted one of the spot surveys in January, 1995 and reported that the survey was "easy to administer and users very accepting of the survey. For a more accurate result, I would suggest that dedicated personnel undertake the survey next year" (Pers. comm. Plowman May 1995).

3.3.8(iv) Liquid effluent

During the period January 7 until April 11, 1995, approximately 359 litres of liquid run-off had been collected. Comparing this figure with the usage numbers from the door counter, it was estimated that each person using the toilet contributed 0.1 litre of liquid to the effluent collected. This does not account for moisture absorbed by the pile and evaporation particularly as the pile increased in size and heat was generated. However, as this was a large amount of effluent to be treated, a sign had been installed in the toilet room on March 1, 1995 to request people not to urinate in the toilet other than when defecating. The primary purpose of collecting the liquid run-off during the period of monitoring was to have an approximate estimation of capacity that would need to be treated in a drainage trench or other filtering/treatment system. To start a new pile in the middle of a peak holiday season means that there is no bulk to absorb the liquid and the pile is saturated from the outset. From this experience it was considered advisable to have the pile established before the high usage period begins, which would normally happen if the pile is started at the very beginning or the end of the summer season.

3.3.8(v) Evaluation

The slightly decomposed appearance of the pile and its somewat acrid odour was satisfactory for this period of collection and composting. The progress of the design to this date is a positive indicator for installation of the design at other sites. Any modifications required are unlikely to be substantial. However, another 12 months monitoring and observation would be necessary before a standardised design could be recommended to National Parks land management.

3.4 Implications of the Cage Batch Trials

As discussed in Chapters One and Two, the Department of Parks Wildlife and Heritage[2] in Tasmania, being aware of the environmental hazards of

[2] After a change in State government in 1993, the Department of Parks Wildlife and Heritage was reduced to a Division within the Department of Environment and Land Management and was renamed Parks and Wildlfe Service.

certain existing systems undertook to replace their pit latrines in the World Heritage Area with commercial composting toilets. The administration took the promotional material of the manufacturers at face value and installed the composting units throughout the parks without undergoing a trial period, or conducting a relevant literature review.

For a variety of reasons already discussed, the toilets were not able to accommodate the usage in that context and the systems became overloaded, and had to emptied of raw excreta by staff in precarious conditions. Having spent considerable funds[3] installing these toilets as a last resort, there were few alternatives left to the Parks administration to fulfil their obligation to provide sanitation facilities to the public in remote areas of high conservation value. One other possibility was to fly the material out from can toilets. This system is currently being trialed in the Tasmanian World Heritage Area. It has been utilised in the USA and Canada but Parks management personnel generally do not recommend it for economic and practical reasons (Ely 1978: 11) (Pers. comm. Collins September 1994).

In response to the crisis situation, the Tasmanian Parks administration has undertaken to develop an appropriate on-site sanitation system, despite not being mandated to do so, and their field staff not being trained or employed to participate in such investigations. The consequent research and development which is the subject of this Chapter produced a simple batch composting toilet design which focused on imitating, as much as practical, the composting conditions of organic matter on the forest floor (refer 1.2.4). The design emphasises minimum and easy maintenance, inoffensive end-product, pathogen kill, and minimum environmental impact. Progress was made but thorough research was limited by a number of circumstances surrounding the trials.

(1) The location of the toilets in a remote alpine area with high rainfall and frequent inclement weather precluded regular and consistent site attendance for supervision of maintenance and monitoring, and at times subjected monitoring equipment and personnel to stressful working conditions.

[3] Approximately $200 000 was spent purchasing and installing 11 commercial composting toilets in the World Heritage Area. This does not include installations at other National Park sites in Tasmania, or at the private huts within the Word Heritage Area (Pers. comm. Smith April 1994).

(2) Location of the toilet trials in a National Park entailed dependence on transient Parks personnel to facilitate the trial who were often disinterested or inexperienced in construction, maintenance and monitoring of composting toilets. Field staff also often had many other more pressing duties to attend to.

(3) Conducting the trial in-situ tested the design in realistic circumstances but involved dependence on the unpredictable and largely unmonitored behaviour of users particularly in regard to addition of carbonaceous material.

(4) Due to the location and available funds the trial could not include research into significant factors such as the chemical and biological processes within the pile, or the impact of invertebrate activity on decomposition.

(5) The initial Cage Batch trial at Pelion was constrained by the scepticism of Parks personnel after the failure of the commercial composting toilets. This caution reduced the funds available for construction and monitoring, and confined the author to improvisation within a pre-existing toilet building.

(6) The implementation of the trial within an organisation primarily concerned with the provision for recreational use, and protection of, national parks made the research component secondary to functional considerations. The primary agenda of land management determined the funding, time frame and extent to which the study could be established and conducted. As there was no established division or budget for sanitation research, expenses had to be covered from the construction and maintenance account.

(7) Normally a public recreation institution would select sanitation equipment after review of manufactured goods available from suppliers, as was the case with the purchase of the commercial composting toilets. Being involved in the design and monitoring of a sanitation facility was not established practice and had no precedent for process or support.

(8) As the first trial produced positive results, the Parks administration was

sufficiently reassured to install a second trial at a location which also required a functional sanitation facility. Although this site was somewhat less remote[4], and the installation was adequately funded many of the constraints described above still applied. For example: it has not been possible to read temperature records off the data logger for 6 months due to unavailability of computer equipment from the University; modifications to the Pine Valley toilet that were suggested by the author in April 1995 will not be implemented until November or December 1995 because of prior maintenance commitments and the inclement winter weather (Pers. comm. McConnell May 1995); and funds intended for a third trial in the summer of 1995/96 have been diverted to other construction programs that have exceeded their budget (Pers. comm. Rose July 1995).

While the circumstances described in this Chapter constricted research potential, it was partly because of these same difficult circumstances that the study occurred in the first place. If Parks management had not urgently required a sanitation alternative in this remote and sensitive area, the funds and opportunity for experimentation would not have been provided.

However, it is the author's proposition that these improvisations and improvements could be significantly enhanced if the process of innovation was supported by an appropriate infrastructure. It is also suggested that, given the limitations and problems created by centralised water borne sewage treatment and the few options available for on-site treatment, there is a legitimate onus on the traditional sanitation and regulatory institutions concerned to provide this support.

The next chapter describes a project that aimed at improving environmentally benign sanitation options at a high-use road-access site in a national park, and illustrates the difficulties that can arise when conflicting political agendas motivate the process.

[4] A site visit to Pine Valley from the University in Hobart involves at least two days travelling compared with three days minimum to Pelion Plains.

CHAPTER FOUR

SANITATION INNOVATIONS FOR HIGH-USE ROAD ACCESS SITES

The previous chapter described experimental responses to the technical problems that were encountered in the surveys of composting toilets on the East Coast of Australia. The study also provided an indication of what can be achieved despite a shoestring budget, a remote and unpredictable context, and extreme conditions for monitoring.

Chapter Four examines the process of consultation and innovation in on-site sanitation for an accessible high-use public recreation area. The study illustrates the limitations that can be created by research and development within an institution that is hampered by conflicting agendas, inadequate communication channels, and where technology improvement and appropriate education are secondary goals. The Chapter suggests that inefficient use of public resources can occur, despite the best intentions, when experimentation is undertaken but clear mandates for research are not operating.

The thesis is generally presented in an historical descriptive style, and this Chapter in particular is written in what could be described as a 'diary format' to allow an examination of the events as they unfolded and their implications for on-site sanitation research and development in this ad hoc context. As with Chapter Three, the chronological record documents the progress of this participatory research in the same way that step by step descriptions of method and findings would accompany controlled scientific experimentation. The case study is presented not as a criticism of individuals or institutions but as being representative of predictable difficulties that can and do arise in on-site sanitation development that lacks appropriate supportive infrastructure. Despite the difficulties encountered, the potential for the development of environmentally benign sanitation for high-use, road-access recreation sites is also illustrated by this case study. The relationship of the events described in the Chapter to the overall theme of the thesis is summarised in section 4.7.

4.1 The need for innovation at road access sites

As previously discussed, the problem of human waste disposal in public recreation areas has had a difficult history. The Southern Highlands region of New South Wales poses particular difficulties due its high rainfall. In many areas the soil has very low permeability. Pit toilets and septic tanks are used in considerable numbers in rural and semi-rural areas, and there are many instances where this results in environmental, health or aesthetic nuisance.

Concern about these issues, and a generally increased awareness in the community about the impact of human waste disposal have led to a number of public recreation institutions installing, or wishing to install, composting toilets, either commercially manufactured or custom-built.

The site discussed in this Chapter, Fitzroy Falls, has road access and it would therefore have been possible to use a pump-out or vault sanitation system as has become the preference for many similar recreation sites in North America (Cook 1991: 12). However the National Park developers wished to experiment with a non waterborne system because of environment protection concerns, and to reduce the quantity and cost of water requiring treatment from the site. The toilets were to be located at a visitor's centre adjacent to a waterfall lookout site, that may be visited by up to 600 000 people a year. The redevelopment of this area was to include a 100 seat cafe (this was later expanded to a 200 seat cafe). It was hoped that the cafe would generate funds for the National Park. The existing site had been serviced by a septic tank toilet block for over 30 years. It was suspected that the effluent from this system drained into the creek that fed the waterfall. The waterfall fed into a valley that served as a catchment area for municipal water supply. With the increasing stringency of regulations relating to water quality, a development of the size proposed would be unlikely to be permitted at such a sensitive site if a traditional on-site waterborne sanitation system was to be installed. The cost and practicality of connection to a reticulated system was prohibitive. It was also intended that the development offer an educational demonstration to the public of the benefits and practicalities of dry conservancy sanitation techniques (Pers. comm. Blakers September 1992).

An appropriate dry conservancy sanitation system was required for the Fitzroy Falls site and the question remained whether this should be custom built for this application or one of the existing commercial models should be used. A regulatory difficulty with custom-built composting toilets is that they are almost all different, although based on a limited number of designs which have appeared in the literature on the subject (Stoner 1977; Van der Ryn 1980; Costner et al. 1986). Local and State health authorities have been resistant to approving installations without adequate information based on operating trials under local conditions. Until recently, no such data existed in Australia. Licences had been issued to the commercially available composting toilet on the basis of an assessment of existing installations (Pers. comm. Lustig 1991).

In 1992, the regulations that applied to the commercially manufactured compost toilets allowed the installation of one brand in New South Wales, the Rota-Loo, and two brands in other States, the Rota-Loo and the Clivus Multrum (refer Chapter Two), and only outside of the scavenging area for current or likely reticulated sewerage schemes. In some districts, custom-built domestic compost toilets were tolerated as trials (refer Chapter Five). Many had been built by landowners without any reference to local authorities. Custom built composting toilets for high-use, road access public recreation areas were not in operation in New South Wales at the time the Fitzroy Falls project was initiated in 1992.

4.2 Initial consultation

On September 3, 1992, Les Blakers from the Queanbeyan office of New South Wales Parks and Wildlife Service contacted the author in Hobart, by phone, regarding a composting system for the re-development of the public facility at Fitzroy Falls. The suitability of currently approved composting toilet designs was considered and the possibility of a specific design for the Fitzroy Falls usage and location was discussed. Mr Blakers suggested a joint consultancy for that purpose, and the author recommended Dr. Peter Fahy from the Biological and Chemical Research Institute of NSW Agriculture. Dr Fahy had researched composting of human, animal and plant 'waste' for some years (Fahy 1992: 1).

On September 28, 1992, Mr. Blakers telephoned the author in Lismore, New South Wales to say that Dr. Fahy was interested in the project and arranged a meeting to discuss the matter on Monday 12 October, 1992 at Fitzroy Falls.

The following attended the consultation at Fitzroy Falls on October 12, 1992: Margaret Bailey, Project Manager for the development; Frans Sarlemyn, Site Manager; Les Blakers, Engineer; Dr. Peter Fahy; and the author. The site was inspected and a number of ideas were discussed including a revolving drum composting system, alternating 'skips' and the use of worms. It was agreed that the consultants would be paid, on an hourly basis, with travel expenses added. This was on the assumption that the initial consultancy to design an appropriate system may require 100 hours application from each consultant. The next conference date was fixed on November 16, 1992.

Between October 12 and November 16, 1992 telephone conversations and faxes were exchanged between Ms. Bailey at Fitzroy Falls, Dr. Fahy in Sydney and the author in Lismore and Hobart. The mobile alternating bin concept was expanded upon. Particular concerns were discussed: the need for the compost pile to be adequately aerated; the exclusion of insects from the bins; a reed bed grey water system for the cafe kitchen effluent and toilet hand basins; balancing manual maintenance requirements against the cost and maintenance of mechanised alternatives; local Council and Health Department approval; and the composition and quantity of bulking agent required. Ms. Bailey informed the consultants that the project was to be moved forward and may be in operation by April/May, 1993. If this was the case, it was intended that monitoring the system would be an integral part of this PhD research.

Kit Guyatt, a farmer and solar electrician at the nearby town of Penrose was contacted by the author, and agreed to receive the end-product from the composting toilets as fertiliser on his land. Mr Guyatt had studied at Wagga Agricultural College and was qualified to take soil samples, and conduct any monitoring that may be relevant and of interest regarding the impact of the compost on productivity and soil conditions on his land. He expressed the opinion that other landowners in the district would be interested in receiving the end-product (Pers. comm. Guyatt October 1992).

On October 27, 1992, the author attended discussions and presentations with the Lismore Waste Management Committee on the use of 'tiger' and 'red' worms for the breakdown of sewage sludge and municipal garbage. Worms were being used in an approved domestic composting toilet called the Dowmus inspected at the manufacturer's premises in July, 1992 in Queensland. (The unit was available to be purchased and installed for approximately $2 400 which was considerably less than the Clivus and Rota-Loo installations). Worms are a viable technique but monitoring of moisture, temperature and suitable bulking agent need to be maintained to ensure favourable circumstances for the worms. The author recommended worms as an option for facilitating composting at Fitzroy Falls, and informed staff about the Dowmus composting toilet.

During these first couple of months of consultation, communication was regular despite the distances between the various personnel, and individual efforts were being made to collect as much relevant information as possible and feed it back into the project deliberation process.

4.2.1 The mobile batch design

On November 16, Mr. Blakers, Ms. Bailey, Mr. Sarlemyn, Dr. Fahy, two volunteer workers, and the author, met at NSWPWS Head Office at Hurstville in Sydney. The author provided to the meeting rough preliminary sketches of a proposed batch system including the components of the mobile units and a diagram of the macrophyte greywater treatment system, as an initial basis for discussion (see Figures 4.1 and 4.2). The design of the mobile bins had been developed with the assistance of Dr. Stuart White of Preferred Options, Lismore, New South Wales.

Dr. Fahy reviewed the volume of material likely to be deposited in the composting bins and the impact of treatment (refer Table 4.1). The calculations were obviously speculative as it was not known exactly how many people would use the toilets or whether they would urinate or defecate. The figures were based on probable visitor numbers, and the author's research conducted in public recreation areas which indicated that the greater percentage of day visitors urinate in public facilities, and only a small percentage defecate. As most of the urine from the men's facility would be diverted away from the composting bins through the urinals, the bulk of the urine deposited in the composters would come from the women's facility.

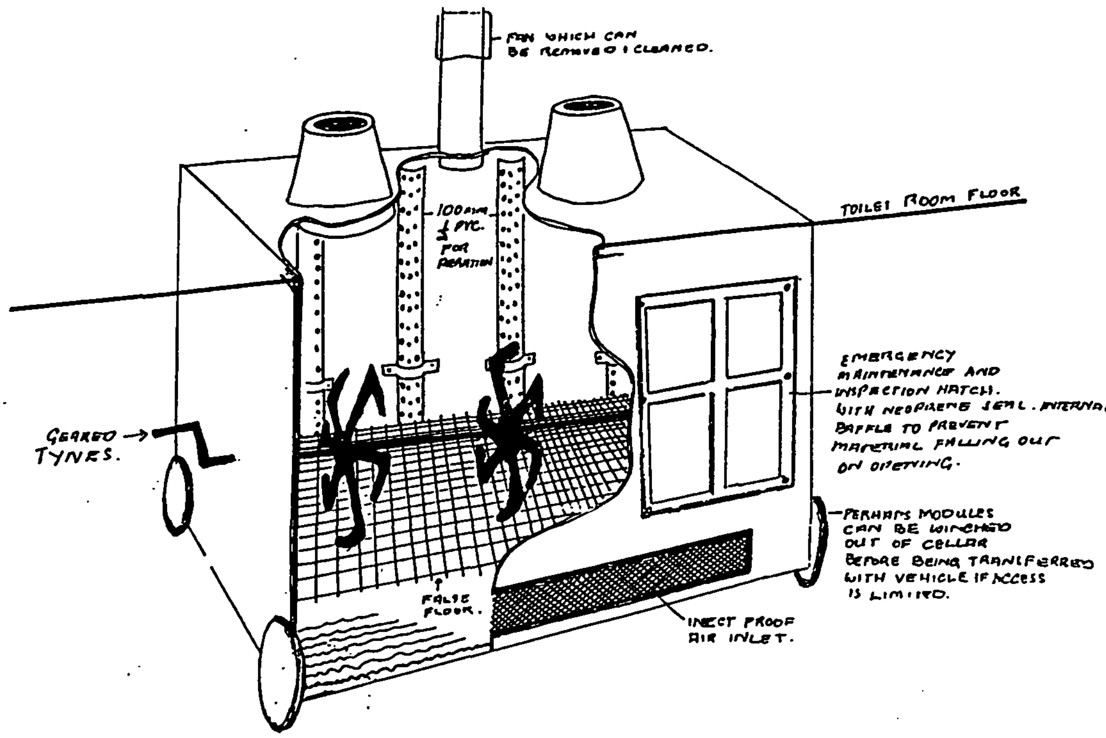


FIGURE 4.1

Preliminary sketch of mobile batch system.

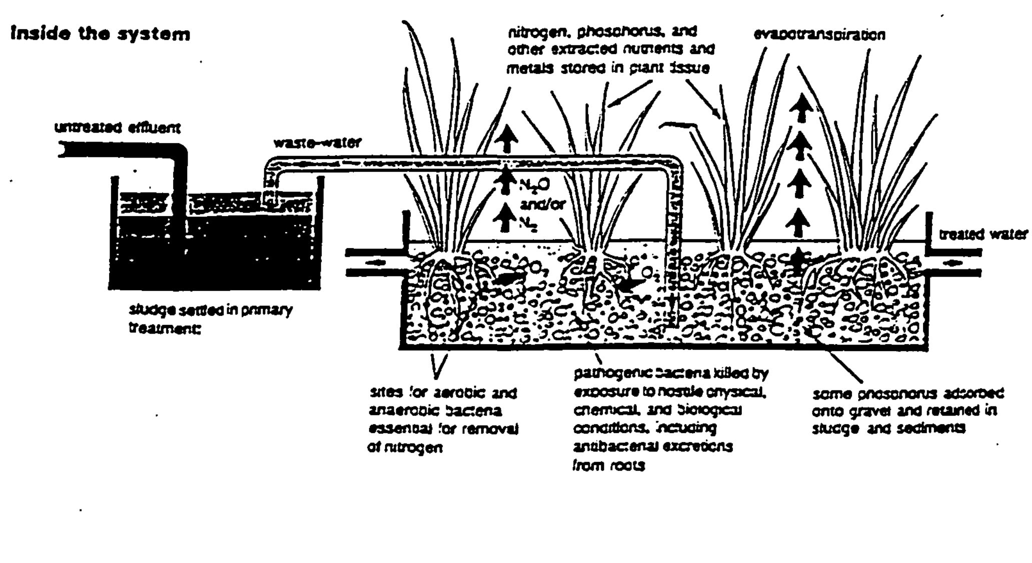


FIGURE 4.2

Preliminary sketch of greywater treatment system.

TABLE 4.1 Number of units of disposal per 1000 visitors.			
	Unit	**Water (kg)**	**Nitrogen (kg)**
Males			
Faeces	100	12.5	0.2
Urine	50	10.0	1.5
Total		22.5	1.7
Females			
Faeces	100	12.5	0.2
Urine	500	100.0	15.0
Total		112.5	115.0

It was decided at the meeting to eliminate the reed bed treatment and direct the urine into the run-off system, to be sterilised and disposed of as liquid manure. The grey water from the cafe would then be filtered through a grease trap/sedimentation tank and into an absorption trench.

This modification was suggested by Mr. Blakers to provide more site space and to avoid the cost and use of site space involved in installing the reed bed. Although the macrophyte treatment would have been an innovative and interesting component of the system, a positive outcome of this modification would be that the nitrogen rich urine would be included in the liquid manure end-product from the run-off system instead of being introduced into the local environment through the reed bed. The reed bed would absorb most of the nutrients but it is possible that a percentage would pass untreated especially in prolonged wet weather. It was suggested that Macrophytes could still be planted over the absorption trench, and in the receiving swamp to increase grey water purification.

It was also decided to house all the modules under the toilet block rather than build an off-site enclosure for the maturing period. This was to avoid having to meet regulatory demands for cleaning and maintenance in two locations, and to provide a consistent environment for all the modules. The dimensions of the toilet block would allow for the in-use and maturing modules to be housed in the cellar with space for transfer of the bins, and maintenance of mechanical appliances and the drainage system. It was not originally anticipated that this much space would be available under the toilet facility. The composting bins would still need to be taken off site to be emptied for disposal and restarted with a mix of mature compost and friable bulking agent.

There was considerable discussion regarding the tynes in the composting bins. The exact size and shape of the mixing/aerating device needed to be researched in order to facilitate optimum conditions in the pile. This issue also involved the false floor and whether it should be parallel with the floor of the bins or curved to meet the arc of the tynes. In the later case, there may have been a problem with the false floor mesh becoming clogged from the pressure of the tynes if the mesh was too fine, and material being pushed through the mesh if it was too porous. If the false floor was flat, then a filter of coarse bulking agent can separate the tynes from the false floor, making the dimensions of the mesh less critical, and reducing the likelihood of compacting. This would be most like the common batch systems described in Chapter Three from which the module concept was derived.

A combination of the two ideas was to have a curved false floor separated from the tynes by a filter bed of bulking agent. In this case, the bed may slide into the centre of the curve and compact, while the outer edges of the arc could allow unprocessed material to fall through the mesh.

The author's initial estimation of the cost of the modules was based on inspection of a large number of skips and the choice of one which would accommodate two pedestals and still be manageable to transfer. The skip size, 2 m x 960 mm x 970 mm, cost approximately $900. With modifications and fittings it was calculated that each module may cost $3 000. However, Mr. Blakers estimated that the cost was more likely to be $10 000 for each module, given geared and motorised tynes. At this price, the author considered that there seemed little economic advantage in designing a custom built model rather than buying an 'off the shelf' commercial composting unit. Further improvisation and some ingenuity should have been able to produce a less expensive module. It was suggested by Mr. Blakers that the initial capital cost of the bin was off set by the low ongoing maintenance cost of the mechanised system.

Mr. Blakers' estimation of the cost of each bin raised the question of the necessity of the tynes. The author's experience with batch systems has been with static piles which have produced acceptable compost. However, these piles included a mixture of faeces and urine, whereas the Fitzroy Falls installation could be predominantly urine. The tynes were introduced so that a large quantity of bulking agent, including mature compost, could be added at the starting of the bin, rather than being added by the user on each visit to the toilet, or on a regular basis by staff. When the pile was turned at night, the days' deposit would be mixed with the bulking agent. In addition, the vegetable scraps from the cafe kitchen could be added daily on a rotating basis to the bins, so every sixth day each bin would receive a quantity of this accessible carbon bulking agent which is automatically mixed with the rest of the pile. Effective mixing can ensure an appropriate carbon/nitrogen ratio as well as an adequate supply of oxygen to aerobic organisms (Pers. comm. Fahy November 1992).

The second important function of the automatic tynes was to ensure adequate aeration of the pile. However, the author considered that this may be provided simply by the false floor and the fan driven airflow through the unit, as is the case with a static pile.

An alternative to the tynes system, suggested by the author to reduce the cost of the module, was that bulking agent could be applied daily to each bin by staff, or with each use by the public, using a hopper for application. However, despite the maintenance of the mechanised turning system, this was generally considered the least demanding option, because of the expense and probable reluctance of staff to add bulking agent on a daily basis.

The early discussions revealed the backgrounds from which the team members viewed the project. Dr Fahy, with his considerable experience in large scale municipal composting was concerned that constant mechanical aeration of the pile should be provided. Mr. Blakers as an engineer and parks manager, was sceptical that the simple system suggested by the author could work without automated assistance, and preferred to avoid basic maintenance requirements by mechanising the system, thus increasing the cost of the bins considerably. The author based her recommendations on experience with alternating batch composting toilets, and regarded the Fitzroy Falls mobile bin as merely a modular version of the static pile design with an increased capacity. The author was concerned that with mechanisation, and a more complicated system, other problems would arise such as congestion of moving parts with faeces and bulking agent. These different points of view could have been constructive if consistent communication was maintained, as the expected volume of urine to be treated was a particular challenge of this site and required a creative solution.

4.2.2 Bulking agent

There was debate as to the most suitable bulking agent for the Fitzroy Falls composting toilet. The value of having a quantity of mature compost to provide active organisms and stimulate decomposition was agreed upon. Difference of opinion arose over the application of wood shavings. If a friable pile was to be achieved by the application of the bulking agent, then rough wood shavings are desirable. This would certainly be necessary if the pile were static. But it had been observed by the author (refer Chapter Two) that wood shavings are very slow to break down in an enclosed system and therefore possibly provide very little accessible carbon to organisms in the pile. In addition they cause the composting bin to fill up faster than is desirable. From the many commercial composting toilets inspected over the preceding 12 months, it was apparent exactly what shavings had been used as they remained intact after 1-2 years in the bin, even when the faeces and toilet paper had decomposed. However, if the end-product was removed from the enclosed composting chamber and buried or left in a pit, then the rate of decomposition of the woodshavings was increased, presumably because of exposure to more active soil organisms and a greater range of other micro organisms and invertebrates (refer 2.2.10, Fraser Island).

It was advised that if finer sawdust was used then breakdown may be more likely within the composting chamber, carbon being more available for assimilation, but aeration provided to the pile by the bulking agent would be reduced.

It was recommended that one unit be assembled and trialed during the building of the toilet block, in order that appropriate modifications could be made to the design of other modules, before assembly, if necessary. Pig faeces was considered to be a comparable material to use for this purpose because of its similarity to human faeces (Pers. comm. Fahy November 1992) (Chapman 1993: 106).

4.2.3 Design investigations

At the conclusion of the meeting on November 16, 1992, it was decided that Mr. Blakers and Mr. Sarlemyn would investigate costing and potential assembly of the 'skips', and availability of turning devices. In a telephone conversation with Ms. Bailey on December 1, she reported that Mr. Blakers had located a blending machine with a turning device fixed with neoprene brushes that would allow the tynes to be close to the false floor without blocking the mesh. Engineers in the Moss Vale area had also been contacted and expressed a willingness to make "anything needed".

On November 19, 1992 Dr. Fahy and the author investigated possible blending machines and mesh floors at the Biological and Chemical Research Institute at Rydalmere in NSW. In order to become more familiar with large scale composting of sewage, the site for composting one fifth of Sydney's sludge at Badgery's Creek, which was being monitored by Dr. Fahy, was also inspected. The scale of the compost windrows and the extent of mechanised aeration of these piles suggested the reasoning for Dr. Fahy's recommendations for the Fitzroy Falls installation.

Ms. Bailey reported on December 1, 1992 that there had been some delay in meeting with Council and the Health Department to discuss the proposed composting toilet and grey water design but said that she hoped it could be arranged before Christmas, in order to ensure that the project had approval. It was likely that the approval given would be on the basis of a monitored trial.

It was reported that a meter which had been installed on the water inlet to the existing flush septic system, to assist with usage estimation, recorded an average 350 flushes a day. This was a useful indication but as Ms. Bailey pointed out the toilet use may be higher than indicated, as some men would not flush the urinal with every use.

Information was necessary on volume of grey water likely to be generated by the 100 seat cafe. Grey water from toilet block hand basins would also pass through the filter system and absorption trench.

4.3 Negotiations with the regulatory authorities

In addition to the different perspectives provided by the project team, the regulatory authorities and their particular prejudices and constraints also contributed to the evolution of the Fitzroy Falls design. Their involvement had begun when the cafe development was first proposed.

Prior to the initial meetings with the author and Dr. Fahy on October 12 and November 16, 1992, the project personnel had discussed the site development with local Health Department and Environment Protection Agency authorities. At that stage septic tanks or some other method of waterborne sewage treatment was still being considered. Rainfall, soil absorption rates, trench sites and predicted effluent were discussed (Pers. comm. Sarlemyn November 1992). Because of the limitations of the site, it is unlikely that a large scale development would have been approved using traditional waterborne treatment without costly augmentation.

On December 12 1992, Mr. Blakers, Ms. Bailey, Mr. Sarlemyn met with Rob Aubery from the Environmental Protection Agency and Mr. Matthews from Goulburn Health Department. The consultants' preliminary proposal for the composting toilet system was presented. Mr Matthews had a number of queries regarding the project that prevented him from giving approval to the design as presented. Ms. Bailey reported that he was concerned about the 'experimental' nature of the design, and did not think heating or pasteurising the run-off was a viable method of pathogen kill. Nor did he approve of recycled water being used to flush the urinals. Because of these objections, the Health Department recommended that the heating system be eliminated and the grease trap/reed bed/absorption trench be used for the treatment of grey water and any run-off from the composting toilets.

The proposed disposal of the sterilised run-off as liquid manure also raised difficulties regarding EPA requirements for regulated disposal areas. It was not considered satisfactory that an appropriately qualified local land owner was interested in taking the material and monitoring its impact on his land. The authorities asked what would happen if he no longer wished to be a recipient of either the solid or liquid end-product? Although other people in the district were also keen to use the fertiliser on their land this was not considered a secure enough outlet. National Park land such as nearby Throsby Park was another possibility but Mr. Blakers was concerned this would restrict public use of the Throsby Park Estate.

The installation proposed for Fitzroy Falls was experimental in the sense that this particular design has not been used before. However, it was a combination of a number of systems that have proved effective in dealing with the ever increasing problems of human waste disposal. It is possible that some of the concerns that the project had raised for regulatory authorities were related to over design rather than inadequate design.

The proposed system was specifically geared toward eliminating problems that have been encountered in the usage of its individual components. Lack of experience of any of these components individually or in combination appeared to generate caution in the representative of the local Health Department. Other representatives of relevant regulatory authorities such as Council were less concerned with the experimental nature of the project, "as long as the Health Department approved" (Pers. comm. Ms. Bailey December 1993). If nothing else, it was considered that the proposed system had to be an improvement of the septic tank and inadequate drainage that had been in operation at the site public toilets for many years.

On December 16, 1992, Mr. Matthews, Dr. Fahy, Ms. Bailey and Mr. Blakers met at Throsby Park near Fitzroy Falls to discuss the methods and extent of pathogen sampling, the servicing of the unit and nutrient loadings and the nature of the experimental approval that Mr. Matthews reported would be required from the Health Department (Pers. comm. Ms. Bailey and Dr. Fahy December 1992).

On February 5, 1993, Mr. Matthews and Mike Cassidy, (also representing the Goulburn Health Department) met with Alistair Henchman, the National Parks architect involved with the project, Mr. Sarlemyn, and Ms. Bailey . On this occasion it was indicated that water from the hand basins should be directed through the grease trap and that the urinals be flushed with fresh rather than recycled water. It was estimated that the reed bed and storage facility should allow for a flow of 5 000 litres per day. If the flow was directed to garden irrigation, a 200 m trench would be required (Pers. comm. Ms.

Bailey February 1993).

On February 12, 1993, Mr. Blakers, Ms. Bailey, Dr. Fahy and the author met with Dr. John Bavor, Head of the Water Research Laboratory and Director of Microbiology at the University of Western Sydney, Hawkesbury to discuss the use of reed beds. The conditions at Elm Green, Fitzroy Falls were considered suitable for reed bed treatment of grey water and composting toilet run-off, with particular attention being given to the demands created by high rainfall.

On March 2, 1993 Dr. Fahy, Ms. Bailey, Mr. Sarlemyn and Mr. Blakers and the author met with Mr. Matthews at Fitzroy Falls. Mr. Matthews strongly recommended that the composting toilet/grey water treatment system be abandoned and septic tanks be installed with an off-site trench system. Mr. Blakers argued that because of the high rainfall in the area it was not practical to treat the extra water generated by flush toilets. Mr. Matthews expressed the opinion that the flush toilet water was an insignificant addition to the grey water and urinal flush, and that in general septic tanks were a reliable method of sewage treatment so why incur the expense and possible risk of failure of the proposed system. He stated that a significant back-up system was required particularly to handle the wet weather load. After lengthy debate, Mr. Matthews indicated that the composting strategy might be approved by the Health Department if a large enough septic tank was installed. The size of the septic tank and the absorption trench would be determined by the Health Department.

In order to attend the meetings referred to, most of the consultants, National Parks staff, and health department personnel travelled a minimum of two hours by car to the various conference locations. This required considerable organisation and co-ordination with other commitments. Despite the regular meetings little progress was made. The Health Department personnel had a mandate to approve recognised on-site sewage treatment installations. The proposed unfamiliar strategy required the initiative and support of a committed individual who personally recognised the value of the development. The reluctance of the local Health Department to support the composting/grey water treatment strategy contributed to the delay in the development of the site. The opening of the cafe and visitors centre was originally scheduled for autumn 1993. Then it was extended to winter 1993. The delays had a number of short term and long term ramifications.

As the author was due to conduct field work in Japan and China from March to June, there was pressure that plans for the on-site sewage treatment system be finalised by early March. It had originally been intended that the author would be present during the process of design and construction, but because of the delays this did not occur. In addition to the effect on the design of the conservative requirements from the Goulburn Health Department, a learning curve was occurring for each of the team members, but for a constructive outcome, some basic principles of effective composting within a toilet receptacle had to be observed, and thorough discussion of options sustained. The author's absence from Australia at this critical period further strained the already stretched communication lines.

4.4 Ongoing research and development

Mr. Blakers proceeded to seek design and construction costs for the composting bins. Palmers Engineering Pty Ltd of Griffith, NSW, quoted \$12 500 per bin and \$4 000 for design. This was an increase on the \$10 000 per mechanised bin estimated by Mr. Blakers, and a considerable rise in the \$3 000 estimated by the author for the original design (refer 4.2.1). A tumbler bin rather than tynes to turn and aerate the piles had been considered. A firm in Victoria quoted \$20 000 per bin for the tumbler design. On March 16, 1993, Dr. Fahy faxed the designs to the author in Japan for comment. The cost of providing mechanised turning did not seem warranted and the author suggested a hopper system to allow controlled addition of bulking agent through the pedestals. This would allow a return to the simple and much less expensive alternating batch system in Figure 4.1. Inspection and clearing access ports were also suggested.

On April 4, 1993, a status report was presented by Mr. Blakers which included the decision to proceed with the composting toilets as approved by the Deputy Director of New South Wales Parks and Wildlife Service. Although the tumbler bin was preferred to the paddles or tynes the former was 40% more expensive and so rejected as an option.

On April 7, 1993 a design and fabrication order including the mechanised tynes was placed with Palmers Engineering Pty Ltd for a prototype bin. Fabrication was commenced on April 7, 1993, and completed on May 10, 1993, and the prototype transferred to New South Wales Agriculture at Rydalmere for testing by Dr. Fahy. Prior to the transfer Dr. Fahy and Mr. Blakers travelled to Griffith, New South Wales, to inspect the fabrication of the bin.

On April 1, 1993 Ms. Bailey, Mr. Sarlemyn and Mr. Blakers met with Mr. Matthews at Fitzroy Falls for further discussion of the composting toilet design and location of effluent and grey water disposal. A septic tank with capacity to treat 27 000 litres would be required by the Health Department, and a 450 m length absorption trench to treat a maximum 9 600 litres per day of effluent (Pers. comm. Fahy July 1993).

In May, 1993, an Application to Test a Humus Closet was lodged with the Goulburn Office of the NSW Health Department. In an accompanying letter, the parameters to be monitored during the 12 month trial period of the composting system were detailed as follows:

FOR EACH BIN DURING COLLECTION PHASE.

1. Record turning times and duration
2. Sample weekly for moisture analysis on site.
3. Record temperature profile weekly.
4. Measure drainage from each bin weekly.
5. Record volume of additional bulking agent added.

OFF SITE ANALYSIS (2-3 MONTHLY.)

1. Microbial activity.
2. Total carbon.
3. pH.
4. Conductivity
5, Water holding capacity.
7. Air filled porosity.
8. Volatile solids.

FOR FALLOW BINS DURING TIME/TEMP. KILL PHASE.

1. Record turning times and duration.
2. Sample weekly for moisture analysis on site.
3. Record temperature profiles at least twice weekly.
4. Sample for pathogen indicator analysis at end of 2 month cycle.

In addition to the above, toilet door counters shall be installed for each cubicle and recorded monthly (letter from Mr. Blakers to Mr. Matthews 13/5/93).

On returning to Australia from Japan in July, 1993, the author inspected the prototype at Rydalmere. It was being tested with sewage sludge and wood shavings and bi-weekly additions of urea. The motor had been installed in front of the removal hatch which made emptying difficult (see Figure 4.3). Pig faeces had been suggested for the trial (refer 4.2.2), but using this material in that context was unacceptable to other staff at the Rydalmere site for reasons of hygiene. The results, therefore, were not really indicative of probable performance in a public toilet installation. The dimensions of the bin were surprisingly large and more complicated that the original design proposal in Figure 4.1 envisaged. Despite considerable expense and effort on the part of members of the project team to create a workable pilot study, the prototype did not provide much useful information for the final design. This was partly due to the lack of a convenient context for focused consultation among the team members regarding the design, and for unrestricted monitoring of the unit.

4.4.1 Regulatory boundaries shift

At this time, a shift in regional Health Department boundaries created a further shift in fortune for the project. Departmental responsibility for the health of Wingecarribee Shire was transferred from Goulburn to the Region of Western Sydney. The Western Sydney office was provided with the consultant's reports and proposals and other relevant details. On August 11, 1993, Mr. Blakers, Ms. Bailey, Dr. Fahy, Mr. Sarlemyn, and Mr. Matthews met with Dr Greg Stewart, Medical Officer of Health, Tony Bles from the Approvals Committee of NSW Health Department, and John Birkett, Senior Environmental Health Officer. Dr Greg Stewart was sympathetic to the project and appreciated, from reading the author's reports that it was aimed at improving current on-site technology (Pers. comm. Ms. Bailey August 1993). By this stage of the project, site plans had been prepared and construction commenced which accommodated the demands made by the Goulburn Health Department Office so the support of the Western Sydney Health Department did not allow for constructive review of the sanitation system's configuration. However, it did mean the project could proceed without further delay.

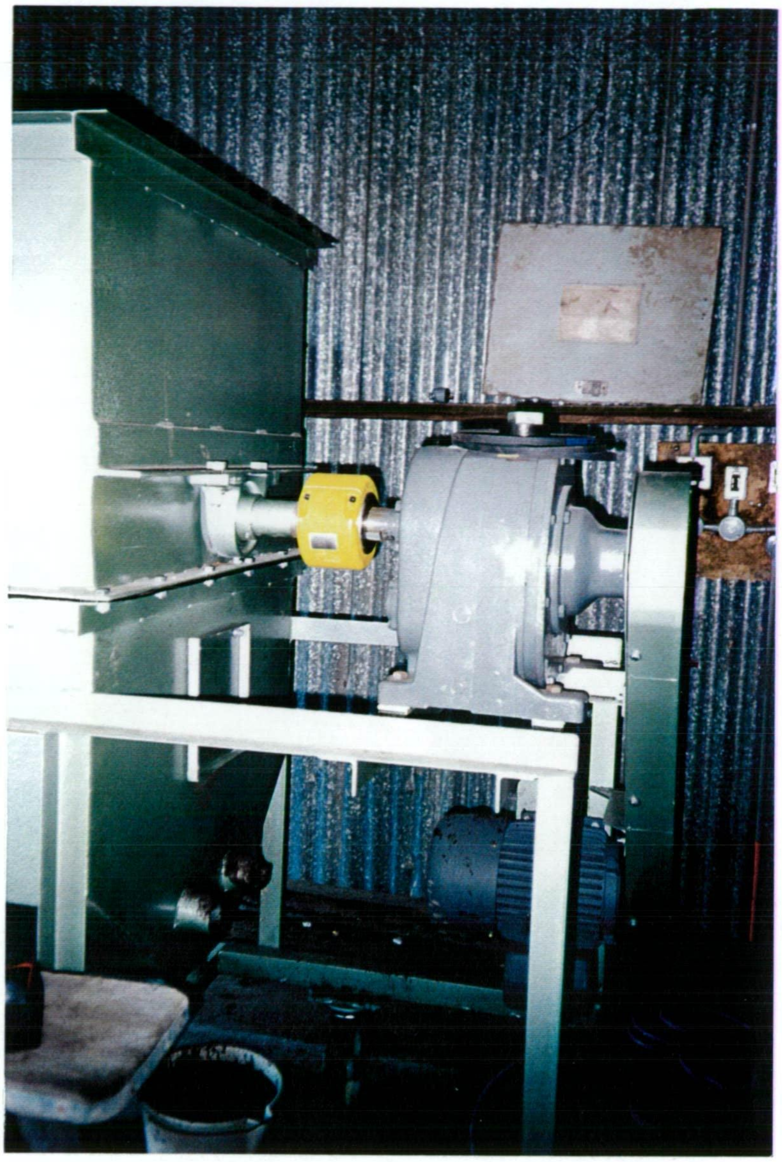


FIGURE 4.3

Mechanised mobile composting toilet bin

On August 25, 1993, confirmation was sent to Mr. Birkett at the Public Health Unit by Mr. Blakers which included the following:

Scheme of Operations

- Each compost bin is arranged to receive product from one male and one female pan.
- The product is mechanically mixed with the bulking agent which initially consists of approximately 75% hardwood sawdust and 25% pine bark chip.
- During the composting phase it is expected that additional carbonaceous material will need to be added eg kitchen

wastes, bran, starch wastes etc.

- The optimum moisture content of the bulking agent is 60% and additional moisture may need to be added during low use periods. During the high use periods some excess liquids may be produced by the bins which will be piped direct to the 27 000 litre grey water tank.
- If during the composting phase the temperature at the mid point of the mix falls below 40 Deg C, provision will be made to externally heat the bins.
- During business hours a negative air pressure will be maintained across each of the bins and within the pans by two in line 150 mm dia. fans located in the vent system.
- To maximise temperature rise within the mix these fans will be automatically switched off during the evenings.
- The top of the bins will be attached to the underside of the first floor level concrete slab by an air tight seal.
- Dr. Fahy from NSW Agriculture has estimated the working life of the compost mix to vary from a worse case of 6 months to a most optimum period of twelve months.
- At the completion of the operating period of the mix the bin will be removed from service and operated in a "fallow" phase for a period of up to 3 months. During this period the temperatures will be maintained if necessary by external means in order to achieve the time temperature curve for effective pathogen control.
- At the end of the fallow period the bin with the mix will be transported 500 meters to the Fitzroy Falls works depot where the mix will be self discharged for disposal off-site (as per EPA licence conditions) and a fresh load of bulking agent added and the bin returned for reuse.
- It is proposed to pump the grey water to an absorption trench disposal area subject to approval by the EPA.

...we have contacted Annette Fordham of Fordham Laboratories and she advises that for pathogen indicators we use the same procedure as for composted sewage sludge i.e nil salmonella and less than 100 E. Coli per gram as per the Australian standard. The former tests for faecal coliforms and streptococci are not advised (letter from Blakers to South Western Sydney Area Health Service 19/8/93).

4.4.2 Design principles compromised

One of the obstacles to the efficient conduct of this project has been the lack of ongoing consultation with both the composting system designers. While Dr. Fahy has had considerable experience in composting sewage sludge in large windrows, and extensive knowledge of composting in general, the author was aware of the particular difficulties and conditions created in composting toilets (refer Chapter Two) and these vary from those experienced in large scale composting (Chapman 1993: 8). Information as to progress or current problems of the Fitzroy Falls project was only gained through persistent telephone or fax enquires to National Parks personnel. For example, had the author been consulted about this conference and the subsequent letter to the Health Department, suggestions would have been made to exclude the commitment to externally heat the bins if the mid point of the mix falls below 40°C. Artificially heating the piles should only be necessary at the end of the fallow period, if it is clear that sufficient sterilisation has not occurred. Direct external heating (apart from providing insulation and conducive ambience) can interfere with the biological process of composting. In addition, the type and combination of bulking agent warranted discussion in a high urine input application like Fitzroy Falls. While the pine bark will provide aeration, it had recently been observed (refer Chapter Two) that the hardwood sawdust may be too high in lignin to provide sufficient accessible carbon in such a high nitrogen pile.

A further commitment that warranted discussion was the direction of the excess liquids from the composting toilet to the 27 000 grey water tank. This meant that the guiding principle of off-site disposal of toilet effluent was compromised, and the highest concentration of nutrients, and possibly pathogens, from the composter would now pass into the grey water treatment system, and into the local environment, with only the common septic tank and trench configuration for treatment. Although nutrient isolation and pathogen reduction would occur in the composting bins, the proximity of the existing toilet facility's septic tank and trench system to a water body was the original motivation for trialing a dry conservancy alternative. The principle of recycling the runoff as liquid manure had also been abandoned.

4.4.3 Project approved

However, the commitments in the letter to the Public Health Unit were sufficient to gain approval and support, with the following requirement:

> Monthly testing is to include the following:-
> - Salmonella, not to exceed 100 organisms per gram.
> - E. coli, not to exceed 100 organisms per gram.
> - Faecal coliforms not to exceed 100 organisms per gram
>
> (letter from Dr Greg Stewart to NPWS 15/9/93).

and a recommendation that approval for the septic tank and effluent disposal should be sought from the EPA.

The request for approval to the EPA had been made on August 18, 1993. It stated that the compost would be disposed of at Throsby Park Historic Site, at Moss Vale which is 74 ha of pasture land owned by NPWS and currently leased as a riding school to Ms Del Throsby. As the development had been commenced and the toilet facility was due to proceed within weeks in order to be completed for the proposed opening of the Visitors Centre in December 1993, urgent attention to the application was requested (Letter from Ms. Bailey to Greg Sheehy EPA, 8/8/93).

The EPA granted approval for a twelve month trial period but expressed concern "at the sizing of the disposal area and its location to a sensitive water way" and detailed contingent measures that must be taken if the storage tank reaches 75% capacity. The EPA would also

> monitor the operation of the disposal area and, should the disposal area fail or cause pollution of the nearby water course, the EPA will require that the disposal field be withdrawn from use and the effluent from the visitors centre be pumped out and disposed of off-site in a manner that will not pollute waters (letter from Mr. Hicks, Regional Manager Outer Sydney, EPA, to National Parks 22/9/93).

On September 27, 1993, Mr. Sarlemyn, Ms. Bailey and the author met in Sydney to discuss pedestals and fixtures. Mr. Sarlemyn and Ms. Bailey were provided with photographs of chutes and pedestals used in the domestic 'Wheelibatch' (refer Chapter Five), to indicate possible methods of installation, and the name of the supplier. Mr. Sarlemyn also wished to inspect the photographs of the prototype that the author had taken at Rydalmere. Despite being responsible for ensuring that the toilet building design easily accommodated the installation and maintenance of the bins, he had not had the opportunity to view the bin. He too was surprised at its dimensions, particularly of the motor, despite having seen preliminary drawings, and was concerned whether current building plans were adequate (Pers. comm. Sarlemyn 27/9/93).

Early October, 1993, drawings of the composting bins, dated 16/9/93, were received from Mr. Blakers (see Figure 4.4). An undated accompanying letter expressed the intention that the bins should be supplied by November and commissioned by Christmas 1993. On October 14, 1993, the author faxed to Fitzroy Falls staff the observation that the elimination of the false floor, in order to save cost, and to facilitate turning the pile, meant the composting bin was not longer modelled on the simple batch systems that had inspired its design. If the turning device was not used the pile would not be sufficiently aerated and would simply be a holding tank with improved drainage. Without an adequate false floor comparisons in performance with and without turning would not be possible. Also trialing of worms in the unturned pile would not be possible because of inadequate aeration.

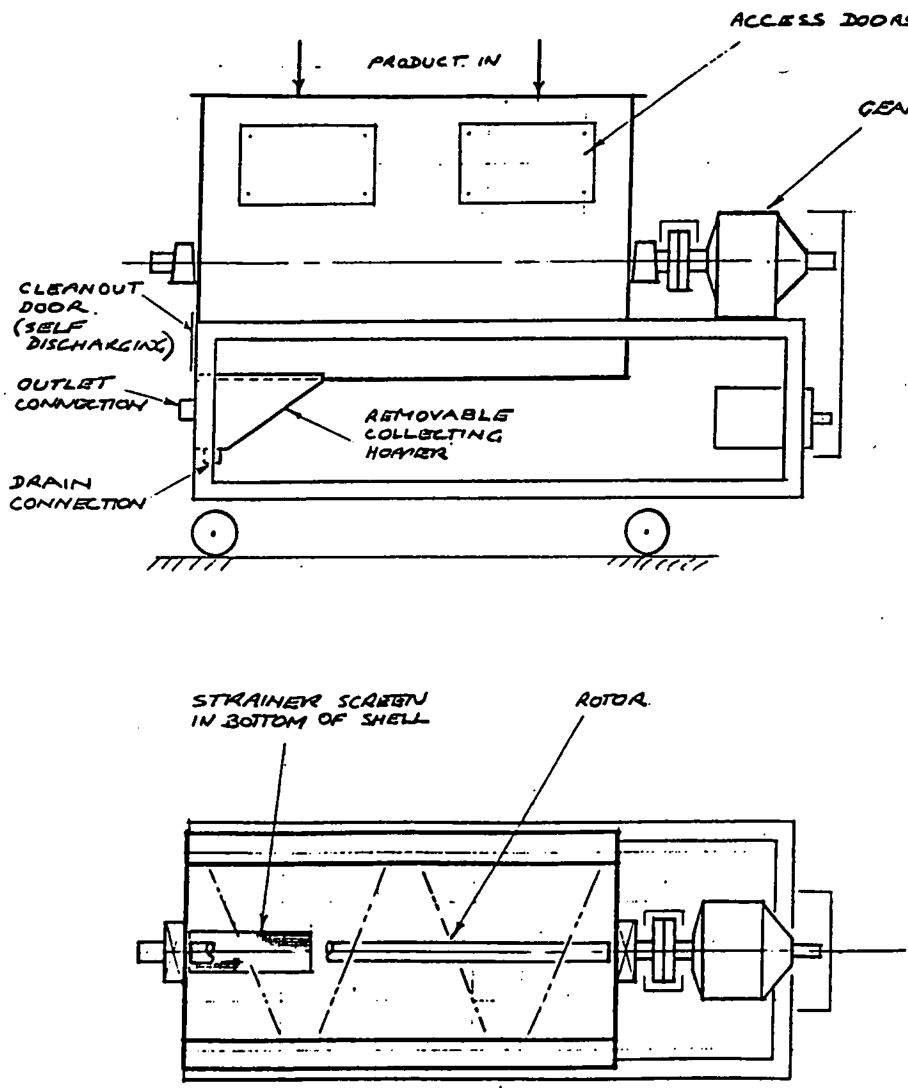


FIGURE 4.4

Mobile composting bin

Once more the toilet design had been changed without thorough consultation with the designers. This lack of communication not only affected the deliberations between Parks staff and the consultants. As indicated by Mr. Sarlemyn's ignorance as to the dimension of the prototype, critical information was not always supplied within the National Parks Service to people whose responsibility it was to facilitate the project. The research and development of the mobile alternating batch composting toilet for high-use road-access sites was being significantly compromised by the complicated context in which it was being trialed. The project team were distracted by many other commitments and the primary agenda as far as the Parks Service was concerned was to construct a $3 million Visitors Centre and 200 seat cafe at the Fitzroy Fall site. While provision of an acceptable sanitation system was a prerequisite for this development, it was not the primary object of the exercise.

4.5 A Change in direction

On October 19, 1993, Ms. Bailey telephoned the author and indicated that she agreed with the faxed reservations and was therefore considering the Dowmus composting toilet as an alternative, which had been recently advocated by Greenpeace and which used worms to assist in the breakdown (see Appendix B). She was attracted to the Dowmus because the tanks would cost approximately $2 000 each instead of $9-13 000 each for the alternating batch bins (refer 4.4), and the piles did not require turning. Ms. Bailey commented that the project was "running out of money" as the construction of what was now a 200 seat cafe was more costly than anticipated (Pers. comm. Bailey October 1993). The author advised that the worms may not survive the concentrated urine environment (Doube 1992: 19), emptying with the auger system could be slow and awkward in a multi tank installation, and that the Dowmus had been tested primarily in small family domestic applications. It was acknowledged, however, that the price was attractive and if the Dowmus worked according to manufacturer's claims, it was a simpler system, than the proposed mechanised alternating batch. Ms. Bailey was reminded that the initial meeting at Fitzroy Falls on October 1992 was informed of the existence of the Dowmus (refer 4.2).

On October 20-21, 1993, Mr. Sarlemyn and Ms. Bailey drove over 2 000 km return trip from Fitzroy Falls in New South Wales to the Gold Coast in Queensland to inspect a Dowmus installation. The author was requested to join them from Lismore but as very short notice was given and the Dowmus had already been inspected 15 months previously at Maleny in Queensland, the invitation was declined. Ms. Bailey agreed to report the outcome of the inspection on the return journey.

This trip would have been an opportunity to participate in the decision that would change the course of the trial. However, as with so much of the trial process, the expedition was unplanned and in urgent response to many pressures other than the requirement for research and development of an appropriate composting toilet design for the Fitzroy Falls site. There were also financial considerations. At this stage, neither consultant had received the promised remuneration for time spent on of the project which had greatly exceeded the original commitment (refer 4.2). The lack of acknowledgment for efforts already made lessened enthusiasm for further demanding involvement, particularly as the probable outcome of the project was becoming increasingly unrelated to the initial undertaking.

4.5.1 A substitute design proposed

As there had been no contact for almost a week after the inspection, a query was faxed to Fitzroy Falls and on October 27, 1993 Ms. Bailey telephoned to say that, as a result of the inspection, she intended to use the Dowmus composting toilets in the Fitzroy Falls development, if Mr. Blakers would approve of the change. Although it was preferred to use the Dowmus exclusively, the prototype alternating batch would also be trialed since "it had cost so much money to design and build" (Pers. comm. Bailey October 1993). It was advised that this plan should be discussed with Dr. Fahy, and the question was raised whether the agreement that he and the author would monitor the project would still apply.

On November 25,1993, the author attended a reed-bed workshop at Lismore Council Chambers given by Mark Moodie, a consultant and designer who has had considerable success with this method of sewage treatment in England. Attending the meeting was the Sales Manager of Dowmus, Peter Bacon. He reported among other things, that their system was being installed at Fitzroy Falls and there was no doubt it would work in that peak day-visitation application. He said they were so sure of their product that they had invested $300 000 in an international patent and were in the process of gaining Australia wide approval through a joint State Health Department application. This was for domestic and public use. An international market was on the increase, but there was pressure to increase sales to justify the patent investment (Pers. comm. Bacon November 1993).

What had begun as a public service inter-departmental exercise to research and develop an appropriate composting toilet design for a high-use public recreation facility, was now becoming a competitive venture to provide the cheapest sanitation option, as quickly as possible, so the establishment of the Visitors Centre and cafe could be completed. The marketing pressures on small business discussed in 2.5 were influencing unsubstantiated claims that the commercial composting system could definitely handle the usage at the Fitzroy Falls site.

4.5.2 Reservations concerning the Dowmus

On December 16, Dr. Fahy telephoned the author to report that Mr. Blakers did not favour the change of composting toilet design at this late date and had asked for advice as to the suitability of the Dowmus in the Fitzroy Falls installation (Pers. comm. Fahy December 1993). Subsequent to the telephone discussion, Dr. Fahy faxed advice to Ms. Bailey and Mr. Blakers outlining similar concerns as are referred to in the author's recent telephone conversation with Ms. Bailey (refer 4.5). He added that the filter lining the base of the Dowmus tank may develop a biofilm of micro organisms, "which in analogous situations, has been shown to eventually permeate the whole filter and clog it up" (fax from Dr. Fahy to NPWS December 1993). This could cause the liquid to back up and create an anaerobic and odorous pile.

Dr Fahy compared the alternating batch system with the Dowmus and advised continuation with the mobile batch design:

> The system we have collectively designed may appear to be over designed for the job, but this was essential considering the high load possibilities and is a commonly accepted safety principle of all effluent treatment system. We have a major unbalanced load problem to consider, potentially serous odour problems and high effluent standards to meet. We have designed an aerated system, based on the successes Leonie Crennan is having in Tasmania, and improved the probability of more effective stabilisation with mass turning. We have allowed for experimentation with Leonie Crennan's static aeration system simply by turning off the motor for trial. We have allowed for liquid removal without clogging up. We have allowed for breakdown and repair events with mobile

> bins, open panels, and extra bins. We have allowed for time temperature pathogen kill to Class A standard with augmented heat if necessary and a hands off system for easy removal of clean compost without any back breaking or health problems for the operator. In short we have met the design criteria that we were obliged to do. Dowmus does not meet many of these criteria (fax from Fahy to NPWS December 1993).

Certain details in Dr Fahy's letter required elaboration by the author. As previously mentioned the elimination of the false floor in the September 1993 version (refer Figure 4.4) of the composting bins did not allow experimentation with a static batch system. Other limitations in the system were outlined but it was acknowledged that these were probably the outcome of the research being conducted on a shoe string budget in rather a disjointed process of consultation, complicated by lack of experience among regulatory authorities. Perhaps if the project had been within the Western Sydney boundaries from the outset, the original concept of the overall site sanitation management may not have been so compromised. The NPWS personnel concerned were congratulated for pioneering this innovation and navigating the technical, political and bureaucratic obstacles, the trial had presented. It was recommended to proceed with the mobile alternating bins, and if Dowmus were convinced their system would work in that situation then a couple of their tanks could be included in the trial. To ascertain this, a discussion with a Dowmus representative, Dr. Fahy, NPWS personnel and the author was suggested (fax from Leonie Crennan to Ms. Bailey and Mr. Blakers 16/12/93).

4.5.3 Dowmus meeting

On January 27, 1994, Ms. Bailey, Mr. Sarlemyn, Andy Spate, a New South Wales Parks and Wildlife Service engineer, Dr. Fahy, and the author met with Dean Cameron, from Dowmus in Sydney. Mr. Blakers was about to take extended leave of the Service and was unable to attend. His withdrawal from the project at such a critical time was unfortunate as he has been one of the primary instigators of the innovative sanitation alternatives at the Fitzroy Falls development. It was initially planned that the development be completed before he took leave.

Mr. Cameron outlined the capabilities of the Dowmus, but advised that the "dry composting toilet may not be suitable for the Fitzroy Falls installation". Alternatively he recommended a 'wet' composting system which had initially been developed to treat grey water and now was being installed with flush toilets. He recommended recycling the 9 000 litres/day of grey water from the cafe through the Dowmus flush toilets and the composting/vermiculture tanks. The ability of worms and other aerobic organisms found in compost heaps, to thrive in water was discussed at length. Reported results for BOD, SS, nutrient and pathogen reduction from 5 domestic trials of this 'wet composter' were impressive and appeared to provide a much improved septic tank treatment system. Monitoring could be provided by Dowmus through government funding applied for with the assistance of the New South Wales Parks and Wildlife Service. Mr. Cameron suggested that if his wet Dowmus unit was not used, then the project team should consider a dry alternating batch composting system (Pers. comm. Cameron January 1994). He was informed that this concept had been researched and developed for the Fitzroy Falls application during the preceding 18 months.

The conference continued after Mr. Cameron had concluded his presentation. Ms. Bailey was keen to install the wet Dowmus system. Flush composting toilets were seen as an attractive proposition, eliminating all the perceived problems associated with the dry composting toilets. She acknowledged, however, that there were enough funds available to proceed with the alternating batch system (Pers. comm. Bailey January 1994). Dr. Fahy was interested to test the claims of the Dowmus representatives. It was decided, after some debate, to trial two Dowmus tanks, and 4 alternating batch bins with necessary alterations to the false floor of two batch bins to allow them to be trialed as a static pile.

4.6 Consultation deteriorates

On January 28, 1994, the author inspected the Fitzroy Falls site, with the intention to discuss installation details and any other problems which were not able to be attended to until the choice of model had been confirmed. This was the first on-site consultation in 12 months, and had been undertaken gratuitously. The construction of the toilet block and the 200 seat (the seating capacity had been doubled since the first consultation) cafe were well advanced. Extra clearance had been built into the composting cellars to allow for installation of the Dowmus tanks. When reference was made to the decisions of the preceding day's conference Ms. Bailey reported that the decision had been reversed overnight and that Mr. Spate was investigating the implications and necessary modifications to the facility to ascertain whether flush toilets and the Dowmus wet system could be installed exclusively. The grey water would not be recycled, and when asked whether the excess water generated by the flush toilets would exceed development conditions permitted by the EPA, Ms. Bailey replied that this would not be an obstacle (Pers. comm. Bailey January 1994).

Ms. Bailey was advised that it had come to the author's notice that one of the reasons Dowmus had developed a wet system was to overcome regulatory obstacles to the dry composting toilets and that the Fitzroy Falls project may be further delayed while this new proposal was approved. Ms. Bailey replied that the development would continue to use temporary flush toilets until the installation of the wet Dowmus system was facilitated (Pers. comm. Bailey January 1994).

At this point it was made apparent that further consultation regarding a dry composting system at Fitzroy Falls was not required from the author, and the file on this project was closed. However, in early March, 1994, Mr. Spate telephoned to ask how often the piles in the mobile batch bins should be turned. When queried as to why he wanted this information when the Dowmus system was to be installed, he replied that, on the contrary, it was now intended that the alternating mobile batch system would be used exclusively. This decision had been made "in response to the consultants' reservations about the Dowmus", although he personally "was not particularly happy with either system" (Pers. comm. Spate March 1994).

In a telephone conversation with Dr. Fahy on May 22, 1994 it was reported that Ms. Bailey had asked for advice to be given to a Sydney contractor who was to manufacture the alternating batch bins. The contractor, Gregory Micheal was considering the possibility of designing the systems without mechanised turning and was also concerned about insulation. The contractor also wanted to know the history of the design and why certain features had been incorporated. Dr. Fahy had not received copies of the new designs nor was the author contacted for comment during this process.

On June 9, 1994, the author telephoned Dr. Fahy to inquire whether any further development had taken place with the mobile batch bins. Dr Fahy reported that, when he had recently contacted Ms. Bailey about outstanding payment for both consultants, she had informed him that now the project included three Dowmus bins and three mobile alternating batch bins. There were no definite plans for monitoring although funding had been requested from the federal Department of Tourism (Pers. comm. Bailey June 1994).

On June 10 the author received a fax from Ms. Bailey:

> The rotary bins are almost complete -3 of. I need to know if you have any special requirements for any of them as part of the construction. ie false floors etc. We hope to have them complete and installed with the Dowmus bins by early July. Please either call or fax details. Your final payment is on its way (Pers. comm. Bailey June 1994).

This was the first communication with the author in four months and requested information that had been provided on many previous occasions. A return fax from the author pointed out the advisability of ongoing communication with the designers of a composting system especially where it was a new design that was being trialed. The fax stressed the importance of thorough monitoring, and requested that the current drawings of the bins be sighted so that advice as to the inclusion of essential features could be given.

Rough drawings of the modified bin were forwarded to the author by Dr Peter Fahy, on request, but no further communication was received from New South Wales National Parks Service.

4.6.1 <u>Reported update</u>

On April 16, 1995, the author contacted Mr. Gregory Micheal, the machinist who had taken over the fabrication of the mobile batch bins in mid 1994, to inquire what had become of the trial. He reported that three Dowmus bins and three mobile batch bins had been operating for seven months at the Fitzroy Falls installation. He had followed the design referred to in 4.4, (refer Figure 4.3) but added modifications "so it would work" including installing 4 tynes in each bin powered by a three phase motor instead of the original one phase 100 hp motor. The tynes turned at 7 RPM for 30 seconds once a week or once a day depending on the number of visitors "and when staff remembered".

Effluent from the hand basins and urinals was pumped through the Dowmus 'wet' composting toilets. The run-off from both toilet systems discharged into a septic tank (which also received the grey water from the cafe kitchen) and then the effluent was pumped to the top of a "nearby hill" and released to the environment. The mobile batch bins had produced very little effluent.

Problems experienced with the mobile bins and the Dowmus units were reported as :

- damage to the tynes from rubbish added by users, and by bulking agent containing blue metal aggregate accidentally added by staff;

- clogging of the metal sieves with fine bulking agent, and algae on another occasion, resulting in liquid build-up which turned the pile anaerobic. Prior to these incidents "worms added to one of the bins had been thriving";

- the 25 mm liquid drainpipe from the Dowmus had clogged and the bin had flooded and required pump out;

- the venting system from both toilets had caused odours in the toilet room due to fans being installed incorrectly, and differential pressure between one side of the building and the other.

Pathogen and chemical tests had been conducted, but pile temperatures were not being recorded. Mr. Micheal reported that both systems "were working well", although no compost had yet been produced and "the mobile bins could be maintained better". He said the Dowmus was likely to be preferred in the long run as it cost $2 900 a bin, while the mobile batch bins cost $7 000 each. It appeared from his comments that the mobile batch bins were being used as a continuous system and had not been given a fallow period. The toilets were to be monitored until mid-1995 with the assistance of a federal government grant. Monitoring was being conducted by Parks staff. Mr. Michael was unaware of the contribution by the author to the project. He considered the project successful "as a result of using composting toilets, no pollution is being discharged into the environment at the visitor's centre site" (Pers. comm. Michael April 1995).

4.7 Implications of the Fitzroy Falls experience

Whatever the outcome of the sanitation systems installed at Fitzroy Falls Visitors Centre, the process of research and development for this project reflects the obstacles and inefficiencies often experienced by development of on-site sewage treatment in Australia. This project was initially less handicapped than most. The development had been carefully considered for some years. The personnel involved were multi skilled, including an innovative architect and an imaginative engineer, a capable project officer, an experienced builder, and designers/consultants with considerable experience in composting in general, and composting toilets in particular. The development had the potential and support to be a significant educative model on such a public site, and was adequately funded.

4.7.1 Limiting factors to research and development

However, as this basic history of the sanitation project reveals, the creative process was hindered by the following conditions

(1) The personnel involved were normally located in Hobart, Tasmania, and within the State of New South Wales at Lismore, Sydney, Queanbeyan, Nowra and Jindabyne. The considerable distances between these places was one factor that contributed to infrequent meetings and inconsistent communication. This obstacle could have been partially overcome by phone conferences and exchange of faxes but the former were not initiated by the New South Wales Parks and Wildlife Service, and the latter only occurred when crises evolved that required the consultants' immediate assistance, or when progress reports were persistently requested by one of the consultants. When a change in direction was initiated, consultation with the designing collective was not conducted in a manner that would achieve a comprehensive review of the full potential of that proposed direction.

(2) Each of the personnel involved had other unrelated commitments and obligations, so only intermittent, and often crisis driven attention could be given to the sanitation project.

(3) The New South Wales National Parks and Wildlife Service was not incorporated to research and develop sewage treatment. It was forced

to undertake this process because traditional technology does not provide for the particular sanitation requirements in National Parks. Traditional treatment has also created many problems which environmentally conscious institutions would rather avoid.

(4) The Fitzroy Falls development involved a multi million dollar budget with all the political and administrative implications that such an expenditure entails. Although approval for the development depended upon acceptable sanitation being provided, the educational and environmentally benign focus of the composting toilet and grey water treatment system could be lost in the more immediate expediency of the overall development.

(5) Approval for the project depended upon the Health Department, an institution with little history of innovation and a strong conservative tradition. The alteration of the boundaries of the New South Wales Health Department's jurisdiction and the subsequent support for the project indicates that approval is also dependent upon the particular attitudes of the local individual within the Department. Strictly speaking a health inspector's mandate is to ensure that sanitation activities and installations comply with established guidelines. It is not his or her role to approve trials of innovations and supervise unprecedented procedures. Some local government health officers who have taken this initiative, have done so out of sheer frustration at the limited sanitation options available to them (refer Chapter Five).

(6) The delay and restrictions placed by an inexperienced regulatory authority created a pressure to compromise guiding environmental principles in order that the project may proceed on schedule. Internal financial and administrative pressures also increased as the project continued to be delayed and costs for the cafe mounted.

(7) Reluctance on the part of the New South Wales Parks and Wildlife Service to remunerate the consultants as agreed decreased personal and professional commitment to the process. This kind of cost saving is false economy and inefficient. There is less incentive to provide additional useful information and up-to-date feedback when contribution is not acknowledged.

(8) If the chosen technology is not accepted and supported by those responsible for installation and maintenance, then commitment to its success is unlikely. Pioneering a socially and technically innovative sanitation system requires the agreement of all concerned. If there are reservations, sufficient consultation should take place to have these reservations fully discussed, so at least there is an agreement to disagree. Politics and rivalry between the supporters of the two composting toilet designs contributed to the depletion of the scientific value of the project.

(9) The prime instigator of the project, Mr Blakers, left at a critical stage. It appeared that none of the other Parks team shared his conservation concerns or innovative vision and the project was left to be implemented by staff whose primary motivation and mandate was to have the site developed as soon as possible. The already intermittent process of consultation with the author and Dr. Peter Fahy ceased as Mr. Blakers left for long service leave. Those responsible for the design of the mobile batch bins were not included in the monitoring process. The genuine educational focus of the project was lost in the requirement to politically justify such a large tourist development on a sensitive water course in a National Park.

Despite the difficulties described in this chapter, experimentation in on-site sanitation technology for high use road access recreational areas was achieved within the Fitzroy Falls development. It is probable that experience gained in the trial of the Dowmus 'wet' composting system and the mobile batch bins in that location will inform further improvements in this field. It is the author's suggestion that the public resources applied to this trial may have been more effectively utilised had the research and development been supported by appropriate infrastructure.

4.7.2 Constructive alternatives

An institutionally supported, cohesive, multi-disciplinary team could efficiently research and develop individual on-site sanitation technology and management within an independent organisation set up for that purpose. (This is not to say that conflicting agendas and internal politics, of the kind described in this and other Chapters, would be absent in such an organisation, but at least a clear mandate could be a useful reference point from which to resolve differences, and provide direction).

Such a facility is included in the Sydney Water Board, for example, to research and develop improvements in centralised sewerage treatment. In fact, most aspects of centralised systems, such as sludge disposal, or pathogen testing, have specific research and development programs focused on their improvement. The individuals who work on these programs are in regular contact, (usually located in the same building, or at least in the same area) and if research is tendered to outside institutions or individuals, a thorough system of information exchange and support is established. For example Dr Gary Graham, a Virologist at a large Sydney Hospital was funded $3 million by the Sydney Water Board to set up a virus testing laboratory (Pers. comm. Grohmann July 1991), to ascertain the extent of pollution caused by the centralised waterborne sewerage systems.

It could also be possible for on-site sanitation technology and management to be researched and developed in the field by the institutionally supported multi-disciplinary team in co-operation with organisations that require custom built sanitation systems. This would maximise in-put from the public and resource managers while removing the responsibility for funding and monitoring from the host organisation.

The next Chapter examines domestic on-site sanitation innovations in urban and semi rural applications that had fewer of the administrative and political obstacles to negotiate than those described in the Fitzroy Falls project. Consequently more was achieved with less energy and stress. The account of this next project also illustrates what can be accomplished by community participation despite lack of funding, thus reinforcing the proposition of this thesis, that it would be expedient to provide appropriate support for on-site sanitation development and management.

CHAPTER FIVE

SANITATION INNOVATIONS FOR DOMESTIC APPLICATION

The last chapter examined the process of consultation and implementation of on-site sanitation for an accessible high-use public recreation area. The case study illustrated the limitations that can occur when research and development is conducted within an institution that is restricted by conflicting agendas and goals that have priority over technology improvement and appropriate education and management. The Chapter also illustrated that development is still possible even in contentious circumstances if the need for innovation is recognised and pursued.

Chapter Five details development in another area where on-site sanitation improvements are required and initiative has been taken to satisfy those requirements. The Chapter details unfunded community contribution to research and development of semi-rural and urban domestic on-site sanitation technology, and again illustrates the potential for progress if appropriate institutional support was provided.

The sanitation innovations are being trialed in northern New South Wales and Tasmania, two regions which have quite different climatic, geographic and demographic characteristics (refer Figure 2.5). However there is a similar need for experimentation and improvement in domestic on-site sanitation in both these regions.

As discussed in previous chapters, the development of human waste disposal options in areas not served by a conventional sewerage systems has had a frustrated history. The North Coast area of New South Wales, or Northern Rivers district, poses its own challenges due its high rainfall and high density semi-rural population growth. There has been extensive re-claiming of marginal and agricultural land by small acreage settlers. The soil in some areas also has low permeability. For many years, pit toilets and septic tanks, with their associated hazards, were the only on-site sanitation options in rural and semi-rural areas (Pers. comm. Norris December 1991).

In recent times there has been significant improvement in the standard of treatment provided by 'wet' on-site sewage treatment in the development of AWTS, Aerated Wastewater Treatment Systems (Martens & Warner 1991: 57). However, these systems are relatively expensive to buy (approximately $4 000), and maintain, having strict local government maintenance requirements. For those on tank water in dry areas or for those who wish to avoid water borne sewage treatment, dry conservancy options were very limited.

Similar limitations have been experienced in semi-rural and rural Tasmania especially in areas where traditional "shacks" have been constructed in large numbers on the shores of recreational waters. On the outskirts of cities such as Hobart, septics tanks are also presenting an ongoing pollution problem (Pers. comm. Baker February 1992).

Householders and small acreage land holders in both regions were requesting to try composting toilets as an alternative (refer 1.3.2). The regulations that applied to the use of commercially manufactured compost toilets in public recreation areas were more stringently applied in the domestic application. Again, only a few approved brands were available and only outside of the scavenging area for current or likely reticulated sewerage schemes. However, a significant number of owner-built composting toilets have been in use for many years in the Northern Rivers region, originally built without reference to the regulatory authorities. In the Lismore district a thorough monitoring program of owner-built and commercial composting toilets, focusing on human intestinal parasites, has been completed as a part of postgraduate research (Safton 1993). The research was supported by health department staff of the Lismore City Council as it was obvious the toilets were there to stay, and a preferable option could not be recommended given the circumstances. The research established that parasites found in the faeces of the users of the composting toilets and traced in the early stages of the toilet pile, did not appear in the end-product/compost (Safton 1993: 60). This suggests that composting toilets can provide effective sewage treatment by pathogen destruction of human excreta.

The domestic commercial composting toilets that had been available for some years were also relatively expensive ($4 000 - $6 000) and in some cases (e.g. Rota-Loo) require electricity to operate a de-humidifying element. This has been a deterrent to many householders who would otherwise be interested in dry conservancy sanitation, and therefore an incentive for the owner-builder to innovate. What had been unavailable was a standardised design for the owner-builder that is inexpensive, hygienic, easy to operate and has as many pre-assembled components as possible. A standard design could assist local authorities who may feel more comfortable to give approval to new requests if they had experience with the performance of that design. Whether people are given permission to install composting toilets or not, it is likely that the concept will continue to be applied in the Northern Rivers district, and other parts of semi-rural Australia. Local government health administrators, in the regions where this study was conducted, considered it to be preferable that these installations use the most effective designs and are regulated by well informed health authorities (Pers. comm. Norris 1992).

The goal of this component of the study was to establish whether a standardised design for the owner builder could be acceptable and approved by regulatory authorities. Before this was possible the design had to be thoroughly tested in typical circumstances and prove itself capable of hygienically producing a compost that was inoffensive and had an acceptably low pathogen count.

This Chapter describes the installation and extensive trialing of a simple and standardised domestic compost toilet on the North Coast of New South Wales and in South East of Tasmania. The toilet is a batch system using two or more modified 240 litre mobile garbage bins. The toilet design is called a 'Wheelibatch'. Fan forced ventilation and passive ventilation are trialed and compared in the various installations.

It was proposed to construct three operating toilets and trial them for at least twelve months in three different domestic situations within the Lismore local government area. It was also proposed that the toilets would be extensively monitored for their performance in co-operation with Lismore City Council staff, Dr Stuart White, the householders and the author through the Centre for Environmental Studies at the University.

In Tasmania, four units were to be trialed but only three were commissioned within the period of this study. One of those units, Installation C, (refer 5.8.3) was thoroughly monitored with the co-operation of the Chief Health Surveyor from Glenorchy City Council and all installations were trialed with the approval of the Director of Environmental and Public Health (Pers. comm. Jacobs 1992). Installation D was monitored with the co-operation of the Franklin Council Health Inspector, the author, and the owner-builder who is a University of Tasmania staff member. Installation E (refer 5.8.5) was monitored with the co-operation of the author and the owner-builder who is a potato farmer.

The Wheelibatch design was initially developed in response to the problems encountered in Tasmanian National Parks (refer Chapter Two) in January 1992. The design was presented as a possible fly-out alternative to the existing commercial designs, but was not taken up for that purpose despite interest by Parks staff. Park managers were reluctant to take on an untried system which would require a new outhouse design. The Cage Batch trial at Pelion Plains was the preferred course as it only required minor modifications to the existing toilet building (refer 3.1). The concept of the mobile alternating Wheelibatch design was developed in co-operation with Dr. Stuart White of Preferred Options, Lismore, (who has been an advocate of dry conservancy technology for many years), after extensive review of a range of continuous and batch systems both owner-built and commercial, and incorporated aspects of existing batch designs in New South Wales and Tasmania, and from the relevant literature (Stoner 1977; Adams et al. 1979; Kroshell 1979 and 1981; Van der Ryn 1980; Feacham et al. 1983; Gunn 1985; Costner et al. 1986; Fordham 1990).

For certain aspects of the design, acknowledgment is due to the composting toilet systems developed by David Berry from Rhyndaston, Tasmania and Lindsay Corben from Nimbin, NSW (Crennan 1991: 129). The use of the Wheelibin as a mobile container was the only element of the design that was assumed to be original at the time, in 1992, but it has since been indicated that others may have tried a similar idea. Unfunded community research and development of composting toilets has been undertaken for many years in Western countries, and has been resourced from an extensive background of human excrement composting in Asia and Africa (Van Vuren 1949: 106;

Scott 1952: 72; McGarry & Stainforth 1978).

The information contained in sections 5.1 to 5.7 covers the principles and proposed practicalities of the composting toilet trials as originally presented to local government authorities to gain approval for the research in 1992. Significant features of the installations, and what actually occurred in practice over three years, are summarised in 5.8.

5.1 Design principles

The guiding principles for the design of the Wheelibatch composting toilet were:

- adequate aeration of the pile through ventilation;
- isolation from human contact and the environment until complete composting has taken place;
- protection against excessive heat loss during cold weather;
- appropriate carbon-nitrogen ratios through use of supplementary organic material;
- appropriate moisture content;
- neutral pH;
- reduction of smell in the toilet room through ventilation;
- exclusion of hazardous insects, especially flies, from the compost chamber;
- adequate provision of information for users of the toilet; and
- adequate instrumentation and monitoring.

5.2 Operating parameters

From the literature it was assumed that composting toilets can tolerate a reasonable variation in operating parameters, but excessive departure from one or several parameters may cause failure of an aerobic system, usually resulting in incomplete decomposition or anaerobic fermentation. Problems can often compound each other. For example, too low a carbon-nitrogen ratio can result in low pH, and inadequate ventilation can result in too high a moisture content. As discussed in Chapter One, (refer 1.2.1-1.2.5) the most significant operating parameters for aerobic composting are those shown below, along with optimum values.

temperature	40-60°C
carbon-nitrogen ratio	25-35
moisture content	between 50 and 70%
pH	neutral (7)

5.3 A draft low cost design

In addition to the principles shown in Section 5.1 the proposed design considered the following:

- simplicity in design, construction and operation;
- maximise use of off-the-shelf components;
- maximise pre-assembly and therefore minimise building requirements;
- adequate chamber size;
- low energy requirements;
- utilise a simple method for the addition of supplementary organic matter;
- ease of maintenance;
- incorporation of simple and low-cost monitoring devices and methods;
- elimination of the need for contact with composting material;
- clear instructions for users.

As previously mentioned the design used a batch composting system with separate chambers.

The chambers are composed of modified 240 litre mobile garbage bins, which are an inexpensive, off-the-shelf item. The capacity depends on the expected usage rate, and experience and the literature indicated that 240 litres is appropriate for the average Australian household, i.e. four people (Gotaas 1956: 35). A 360 litre bin is also available, although not as cheaply as for the 240 litre bin , but the design principles and sketches shown in Figures 5.1- 5.3 would be the same except for scale.

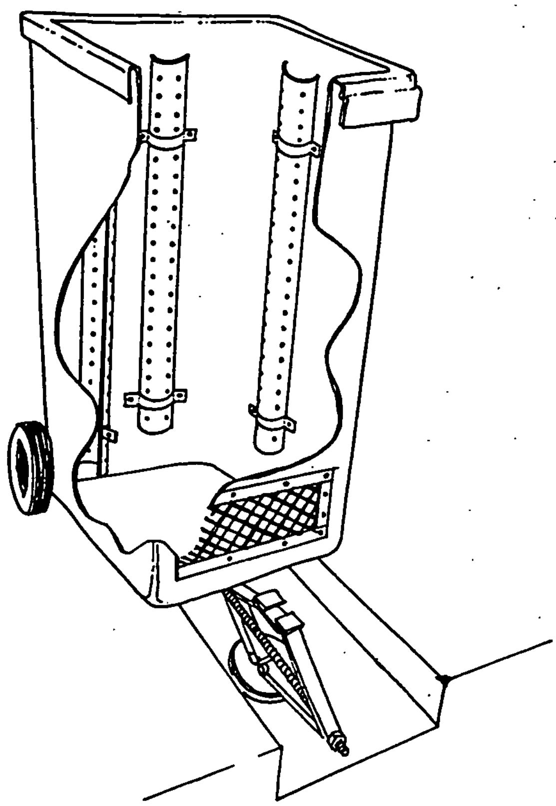


FIGURE 5.1

Wheelibatch bin

As shown in Figure 5.1 and Figure 5.2, the ventilation is achieved through a mesh-covered inlet, perforated chutes and a mesh false floor.

Air enters the bin through the mesh-covered cut-out at the base of the bin and comes in contact with the bottom of the compost pile through the mesh false floor. In addition there are three perforated ventilation chutes placed vertically up three walls of the bin to provide further aeration of the pile. These can be constructed from lengths of 100 mm PVC stormwater pipe which are cut lengthways and have a number of 8 mm holes drilled in them throughout their length. These chutes are held in place by metal strapping (or saddles) and rest on the mesh false floor.

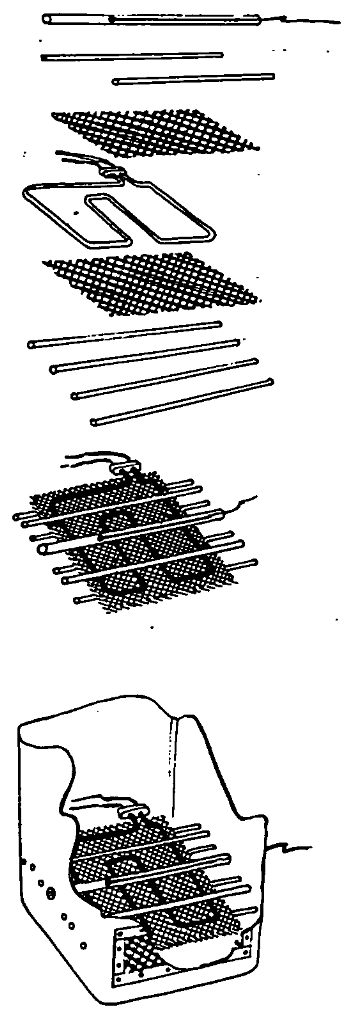


FIGURE 5.2

False floor, air-inlet and optional heating element in bin.

The ventilation can be assisted by an electric fan located internally in the vent pipe. This vent pipe is connected by a tee-piece to the toilet pedestal. A low point in the vent pipe is utilised to catch and drain condensation which would otherwise drip back into the compost bin. It is also possible to adequately vent the system without the use of a fan (Pers. comm. Corben 1991), (refer 3.3.5, 5.8.1, 5.8.5). The vent system is designed to provide ventilation not only for the bin which is in use, but also for the fallow bin which has already been filled. Venting to the fallow bin is achieved with a branch in the vent pipe connecting via an elbow to the sealed lid of the second bin.

The metal mesh false floor in the mobile bin can be held up by four 6 mm threaded rods which extend across the width of the bin and are secured by nuts on either end. In the original design, a heating element for cold climates is laid on top of this mesh false floor, with the terminals protruding outside the bin on the rear (wheel) side. A second mesh floor is placed on top of the element (forming a 'sandwich') and secured in place by two 6 mm threaded rods as before. This heating element was not trialed during the period of the study, even in the Tasmanian installations.

If a heating element was used, the thermostat which controls the element would be located about 150 mm above the false floor and held inside a hollow metal tubing which extends across the width of the bin.

The lid of the mobile garbage bin is removed and a thick rubber or neoprene seal is placed on the top lip. As shown in Figure 5.3, the bin is positioned underneath the pedestal opening and the whole bin is jacked or wedged up to form a tight fitting seal with a 415 mm PVC tube using (for example) an automobile screw jack. This screw jack can be located in a shallow trench between the wheels of the mobile bin, and the handle is accessible from the rear (wheel) side of the bin.

5.4 Liquid handling

The literature estimates that an average 5-person household produces 5 litres of urine per day (Laak 1974 cited in Lombardo 1981: 16). In a well operating system, most of this liquid will be lost through evaporation of moisture from the pile. Excess liquid drains through the false floor mesh to the base of the chamber and is dealt with in one of two ways.

(i) In the semi-rural trials, an overflow tube was installed on the side of the chamber, below the air intake mesh. This tube drain filtered excess liquid to an absorption trench.

(ii) In the two urban trials in NSW, and the semi-rural trials in Tasmania, it was planned that excess liquid would drain to an electric urn which acts as a holding tank. The electric element in this urn would be activated by a float switch and controlled by a thermostat and timer designed to bring the liquid up to 75°C for 10 minutes. This is sufficient to destroy all excreted pathogenic organisms (refer Figure 3.4), and allow the liquid to be drained off once cooled and used as manure. The urn is sealed except for a bleed to the main vent pipe to remove odours. In order to adequately design and apply the sterilisation urn system, the trial was commenced without the urn being installed and run-off was collected in a sealed container and regularly measured in one of the NSW urban trials. The urn system was trialed in one of the Tasmanian trials, with some difficulties (refer 5.8.2).

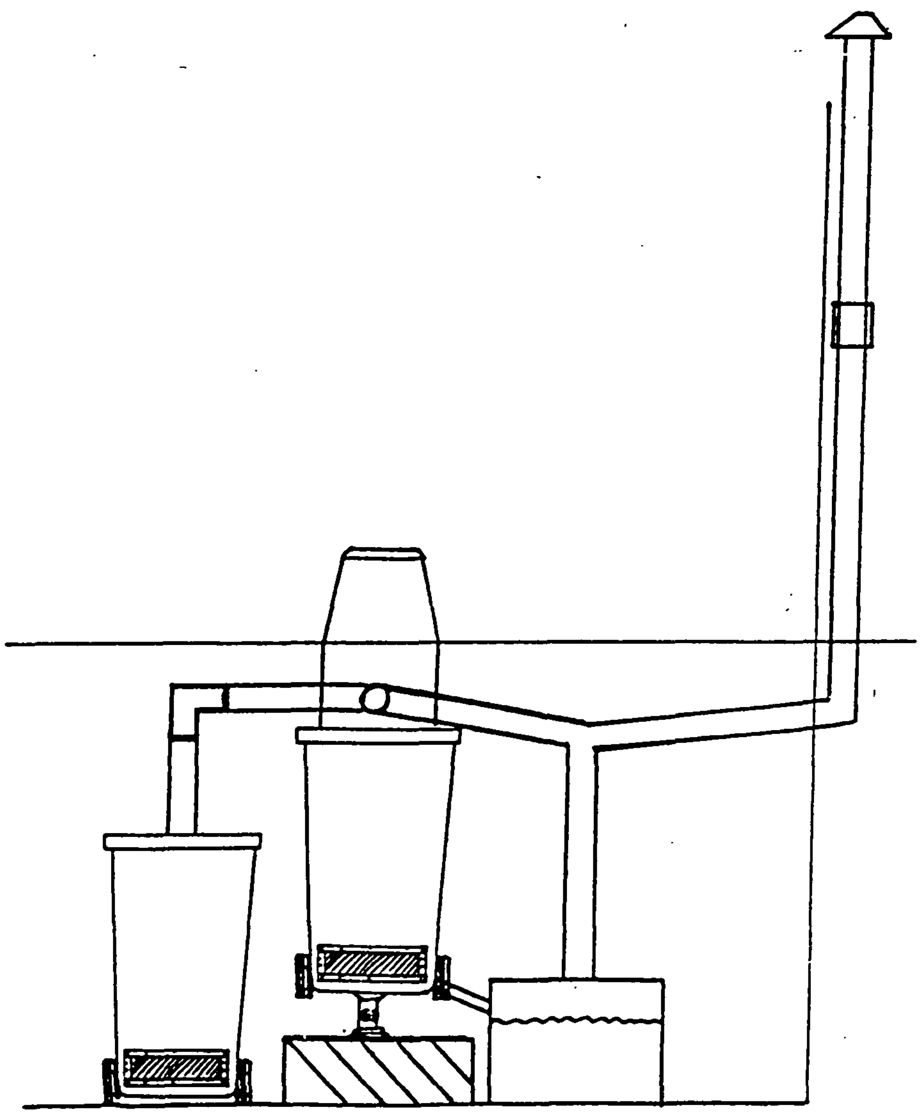


FIGURE 5.3

Active and fallow bins installed under pedestal.

5.5 Supplementary carbonaceous material

Human faeces and urine are rich in nitrogen, with a carbon-nitrogen (C/N) ratio of about 7 and 0.8 respectively. As the optimum C/N ratio for composting is said to be about 25-35, it is therefore recommended to add material to increase the carbon content. An appropriate bulking agent to use in a domestic application is organic kitchen waste as the carbon can be easily accessible. Kitchen waste can also be highly nitrogenous so it is advisable to have it mixed with other carbonaceous material (Taylor & Taylor 1994: 51). Other possible suitable bulking agents for this application could be rice husks, softwood woodshavings (not treated pine), leaves, bark, straw, grape marc, water hyacinth, recycled compost or a combination of some of the above (Chapman 1993: 14). While it is possible to design a hopper system that provides a 'flush' of material after each use, for the Wheelibatch trials the bulking material was added manually.

5.6 Monitoring

In order to maximise the information from the trial it was proposed that the operating conditions of the toilets be monitored, particularly the temperature and the carbon-nitrogen ratio. While this can be done most effectively with a datalogger, thermocouples, moisture sensors, pH meters and other monitoring equipment, there are cheaper and simpler ways of achieving the same end. In the absence of a datalogger, the temperature of the compost pile and the outside temperature can be monitored manually by the use of a inexpensive digital indoor/outdoor thermometer with a display in the toilet room which can be read on a regular basis and the result entered on the usage record sheet.

Moisture content can be monitored using a tensiometer and the pH can be determined periodically. Access holes were provided in the side of the bin which can be sealed with rubber stoppers to allow a thin scoop to be inserted. Due to lack of funds and time, pH, moisture and carbon/nitrogen of the compost was not monitored during this study (although pH was tested twice as described in 5.8.2 and 5.8.4).

The number and nature of uses were to be recorded simply by the users on a data sheet or log book. A mechanical counter mounted on the toilet seat is another option, but does not record the nature of the usage. It is useful to know approximately what relative quantity of urine and faeces is being deposited in the bins. The biological demands of the composting process vary with the quality and quantity of the deposits. For example, with high urine loads, the absorption qualities of the bulking agent are important and the pile has to be able to sustain the concentration of ammonia.

Membrane filtration testing for pathogen indicators was to be carried out on the composted material in the first batch at the point when the second bin was full. It was also intended that bacteriological tests of each batch of the drain-off liquid would be undertaken. This was only conducted on a couple of occasions (refer 5.8.2 and 5.8.4).

5.7 Operation and management

The main operating requirements of the toilet trial are the addition of bulking agent and the monitoring. Also, when the operating bin is full, the bins need to be changed over. It was originally anticipated that this would only happen once in the twelve month trial. If the design used is as per Figure 5.1, changing the bins involves a simple process of lowering the bin that is in use by releasing the screw jack, or whatever method has been used to fix the bin to the toilet chute. Then the lid is fastened to the bin with bolts, and the bin is wheeled to one side and attached to the extension vent pipe, as shown in Figure 5.3.

A clear informative notice for visitors or users unfamiliar with dry conservancy sanitation or waterless toilets was provided in each toilet room. The notice explained how composting toilets work and the nature of the trial.

Contact with all toilet material, including material that appeared to be fully composted, was avoided. Similarly any probes, scoops or other items introduced into the chamber were disinfected with boiling water and bleach or isolated from contact.

When the second bin was full, and after the contents of the first or fallow bin were tested for pathogens, the contents were to be disposed of under 30 cm of topsoil

5.8 The trials

As previously mentioned the 'Wheelibatch' design was trialed in the Lismore district in New South Wales and in South Eastern Tasmania. As these trials were unfunded and depended upon the efforts and financial contribution of the owner-builder, the trials were not conducted as thoroughly and systematically as may have been desirable in a scientific evaluation. However this is the current nature of research and development of on-site sewage treatment in Australia and the results achieved in each case add to the knowledge base of the suitability and efficiency of composting toilets in domestic applications. Many unanswered questions remain which could be the subject of further useful study.

It was planned that all the installations were to be trialed concurrently, but the owner/builders commissioned their toilets according to their individual time, energy and financial constraints. Consequently some of the installations were trialed for a full year within the period of this PhD study and others were installed over a lengthy period and are only recently in operation, but will continue to be monitored beyond the completion of this thesis. It was also intended that the author install a Wheelibatch in her urban residence as part of the Lismore City Council trial to monitor a second urban application. However, even though the bins were purchased and fitted in 1992, this installation has been postponed until after the PhD is completed, due to the demands of regular research travel. Monitoring at each site has been conducted in co-operation with the author, but was the responsibility of the householder. Consistent usage and pile temperature records were kept by each household participating in the trial. These records were much more reliable than similar attempts to record composting toilet usage in public recreation areas (refer Chapters Two & Three). Each household that participated in the trials demonstrated a committed interest in the monitoring of their toilet.

The fabrication of the fittings in the bins, pedestals and connecting chutes for the New South Wales Wheelibatch trials was undertaken by a commercial manufacturer. In each of the Tasmanian applications these modifications were fabricated by the owner-builders. In all cases the basic principles of the design remained the same.

5.8.1 Installation A

Location: Semi-rural, in Northern Rivers district of NSW.

Household: Two adults and one child. One adult and the child are away from home during the week days. The other adult was at home part-time. Visitors come to stay periodically.

Diet: Vegetarian

Climate:

Winter: average temperature range: 7.5°C to 20°C
Summer: average temperature range: 19°C to 29°C
Annual average rainfall: 1360 mm

Installation:

- The composting toilet was installed in a tiled bathroom next to the bath (see Figure 5.4).

- The bins were installed on a concrete slab designed to wedge them tightly into the pedestal chute protruding from the toilet room floor.

- Run-off was piped to a trench.

- Passive ventilation was achieved through a black 90 mm diameter pipe extending 1 metre above the line of the roof of the house.

- The bins were installed underneath the bathroom of a raised timber house (see Figure 5.5).

- Before use the false floor of each bin was lined with leaves and twigs to stop the compost falling through the mesh and 5 cm of garden compost was placed on top of the leaves.

- Vegetable scraps from the kitchen, wood chips and ash were used as bulking agent in the first bin. No meat scraps have been added to the bins.

FIGURE 5.4

Composting toilet pedestal in bathroom: Installation A.

Monitoring:

- Usage recorded by the users as per Table 5.1.

- A comparison of pile and ambient temperatures was recorded by the householder using a digital indoor/outdoor thermometer with a display in the toilet room that was read twice daily at approximately the same time and recorded on the data sheet. Temperature readings were commenced in the 8th week of use of the composting toilet.

- The compost was examined for physical characteristics of odour, texture and volume reduction, and tested for pathogens at the end of each fallow period.

FIGURE 5.5

Wheelibatch bins installed underneath house: Installation A.

TABLE 5.1

Typical usage record sheet for the five trials.

Data sheet

This is a composting toilet - part of a University of Tasmania research project.

Please put a tick (✓) in one or more of the boxes to show what you have put in. Please do not write anything in the temperature boxes.

Please put in a cupful of filler - from the pedal bin - after a poo.

Date	Liquid (wee)	Solid (poo)	Paper	Filler (rice husk mix)	Other (food scraps, tampons, etc.)	Events (spills, vomit, kids falling in, etc.)	Temperature	
							Internal	External
Saturday 29.4.95	✓✓✓✓✓✓	✓✓✓	✓✓✓✓✓✓✓✓	✓✓✓		AIR INLET DUCT LAGGED	13.5	11.2
Sunday 30.4.95	✓✓✓✓✓✓✓✓✓	✓✓	✓✓✓✓✓✓✓✓	✓✓		LOG FIRE IN LOUNGE USED FOR FIRST TIME	16.7	10.7
Monday 1.5.95	~~✓✓✓~~	~~✓~~	~~✓✓✓~~	~~✓~~				
Tuesday 2.5.95	✓✓~~✓~~	~~✓~~	✓✓✓~~✓~~	~~✓~~			16.1	9.2
Wednesday 3.5.95	✓✓✓✓	✓✓	✓✓✓	✓✓			15.4	7.9
Thursday 4.5.95	✓	✓	✓	✓				
Friday 5.5.95	✓✓✓		✓				15.1	7.0
Saturday 6.5.95	1 WEE WEE ✓ 1 BIG WEE ✓✓✓	✓✓✓	✓✓✓✓✓✓✓	✓✓✓			14.9	10.4
Sunday 7.5.95	✓✓✓✓✓✓✓	✓✓✓✓✓✓	✓✓✓✓✓✓✓	✓✓✓✓✓		ADDED LOCAL ANIMAL DROPPINGS + GRASS (1 HANDFUL)	14.7	8.6
Monday 8.5.95	✓✓✓✓	✓✓	✓✓✓	✓✓			14.2	9.2
Tuesday 9.5.95	✓✓	✓✓	✓✓✓✓	✓✓				
Wednesday 10.5.95	✓✓✓		✓✓				13.3	10.9
Thursday 11.5.95	✓✓	✓✓	✓✓✓✓	✓✓				
Friday 12.5.95	✓✓✓		✓				14.4	12.4

Cost:

Chute and bowl	$246.00
Pipes, flues, reducers etc	90.35
Two second hand bins and freight	65.00
Toilet seat	45.00
Foam seals	24.00
Bin modifications and fittings	483.00
Paint	6.00
Estapol for seat	15.00
Labour provided by owner/builder	-
Total	$975.35

Observations:

For the first three days of use when there were five people staying in the house the bin gave off a strong ammonia odour. Although it is predictable that the toilet may smell in the early days before the pile stabilises it was decided by the householder that users would be discouraged from urinating in the composting toilet other than when defecating. The smell improved within a couple of days. The second bin did not produce any offensive smell from the outset. As this is a rural location, people urinated outside the house, or in a temporary container in the bathroom in special circumstances.

It was necessary to repair or replace the foam seals between the lid and the bin when the bins were exchanged. The need for a more permanent and flexible sealing method was suggested.

It was necessary to extend the outlet pipe further into the greywater effluent drain to reduce odour. Maggots were found in the outlet drain when it was disconnected. The liquid outlet could be connected to the effluent drain underground to reduce the likelihood of flies being attracted to the joint.

From the third week of use it was observed that a small quantity of brown liquid was seeping over the edge of the bin (Pers. comm. Roberts August 1993). It was speculated that this was caused by the chute not fitting far enough into the bin. It was not possible to further insert the chute because it was obstructed by the air vents on the insides of the bin. This nuisance did not occur in Installation B. There was no offensive smell around the bins underneath the house.

In the fourth week of use it was observed that vinegar flies (*Drosophila spp*) had infested the bins. Measures were taken to reduce infestation. The vegetable scrap container in the kitchen was carefully sealed to prevent flies laying eggs on the scraps before they were added to the toilet pile. Seams and possible gaps in the toilet installation were also sealed. By the eighth week the vinegar flies were greatly reduced. This may have been due to the resealing or it might have been an event of the invertebrate ecosystem. Vinegar fly presence increased in periods of hot weather (Pers. comm. Roberts October 1993).

The wire mesh over the vent at the base of the bin repeatedly became loose providing possible entry for insects. Surface splits began to appear in the side of the bins probably caused by the expanded metal false floor being wedged into the bin too tightly and causing added pressure as the load increased. Due to lack of available time on the part of the researchers, the bins were modified by a local engineering firm. The technicians had not had previous experience in this field, and the modifications were inadequately applied and inappropriately expensive. The weakness in the walls of the bins may also have been caused by the age and previous use of the bin. It is recommended that second hand bins not be used in future, and persons familiar with the concept of composting toilets be employed to modify the bins.

A wooden toilet seat was initially installed on the toilet pedestal and it was constantly affected by condensation. After about 18 weeks' use the lid had warped providing an inadequate seal and the seat had cracked. The toilet seat may have been affected by the warm damp atmosphere in the toilet chamber. The householder suggested that as right handed people lean to the left to apply toilet paper, extra pressure is placed on that side of the weakened seat with no underneath support. She attached a piece of dowelling to the underneath of the new seat which appears to have strengthened it. Six coats of Estapol varnish on the lid did not prevent it from warping. (Pers. comm. Roberts March 1994). It was recommended that a seat and lid be designed to fit the custom built moulded fibreglass pedestal. This was undertaken in the trials described in Chapter Seven (refer 7.2.3 and 7.4.1).

Maggots had been consistently observed in the second bin. However adult flies were not observed. This phenomena has been noted in the Pelion Cage Batch trials at 3.2.3, and it was thought that it may be due to the presence of a predator in the pile. The maggots were later identified as larvae of soldier flies (Stratiomyidae) and are organic litter feeders often found on the forest floor. As comminuters they physically fragment material making it available to micro-organisms and provide some aeration to the pile. Soldier flies are sluggish and not attracted to foodstuffs so if they were able to leave the toilet chamber, they would not act as disease vectors and would escape to the outdoors as soon as possible (Pers. comm. McQuillan December 1994).

<u>End-product:</u>

On November 11, 1993, the first bin was removed and exchanged after 15 weeks of use. When the pile was inspected it was observed that the bin could probably have been left another two or three weeks before being closed, as there was more space available than could be estimated by looking down the chute. The wood chip bulking agent that was used in the first bin was replaced in the second bin by fine wood shavings.

After four months 'fallow' period the first bin was emptied. The contents had a faintly sweet earthy odour and consisted mainly of undecomposed wood chips and a dark soil like material and had reduced in volume by half. A sample was removed to be tested for pathogens but due to administrative complications between the local Council Health Officer and the NSW Health Department it was not tested within the required time (Pers. comm. White April 1994). Originally it was intended that a thorough microbiological study of the piles be conducted by Ms. Sandy Safton as part of her Masters research into the owner-built composting toilets in the district (Safton 1993). However because of delays in the installation of the 'Wheelibatch', Ms. Safton had completed her study and other avenues of funding for thorough pathogen tests (i.e. parasites and cysts) were not readily available.

The compost from the second fallow bin was tested on August 11, 1994 at the Richmond Pathology Service in Lismore and gave a nil pathogen indicator count for Salmonella, Faecal Coliforms and Enterococci. The active bins took approximately four months to fill and within that time, the fallow pile had composted. The third fallow pile was tested on December 7, 1995 and also gave a nil pathogen indicator count for Salmonella/Shingella, Faecal Coliforms and Enterococci. The same sample was tested again on January 31, 1995 with the same results.

Temperatures:

During the period of the study temperatures recorded in the active bins were maintained in the upper mesophilic range and appeared not to be significantly affected by ambient temperature range. During the winter months the pile temperature averaged 16.5℃ higher than the ambient temperatures.

5.8.2 Installation B

Location: Semi-rural, outskirts of Hobart, Tasmania.

Household: Extended family of six adults (including grandparents) and three children. Regular overnight stays of teenage friends and daily visits by neighbouring children. Two of the adults are usually at home during the day.

Diet: Meat and mixed

Climate:

Winter: average temperature range: 3°C to 11°C
Summer: average temperature range: 11℃ to 21℃
Average annual rainfall: 626 mm

Installation:

- A septic tank flush toilet system was disconnected and the composting toilet was installed in a separate toilet room inside the house.

- The bins were installed on a concrete slab and fixed by a rubber apron to the Colorbond aluminium chute protruding from the toilet room floor.

- Run-off was piped through a sterilising urn system and then to a moving irrigation system. An electric element was sealed in the urn inside a stainless steel tube. A thermostat kept the temperature of the liquid at 60°C. An overflow pipe directed the sterilised liquid fertiliser into the garden.

- Ventilation was achieved through a 100 diameter pipe with an electric fan. Air was drawn from the heated living room through the bins and expelled immediately underneath the eaves of the house roof.

- The bins were installed underneath a raised timber and corrugated iron house.

- A poly pipe vent frame was used inside the bins replacing the perforated chutes, metal saddles, mesh covered cut-out and the threaded metal rods (see Figure 5.6). The stainless steel false floor was supported on the poly pipe skeleton. A run-off pipe was installed 20 mm above the floor of the bin. Air was fed directly into the perforated poly pipe frame and was then drawn down through the frame and out the top of the bin. The entire internal structure is removable for easy evacuation and cleaning after completion of the composting process, and removes the necessity to puncture the bin to install fittings.

- Before use the false floor of each bin was lined with leaves and twigs to stop the compost falling through the mesh and 7 cm of garden compost was placed on top of the leaves.

- Saw dust, and occasionally vegetable scraps from the kitchen, ash and grass clippings were used as bulking agent in the bins.

<u>Monitoring</u>

- Usage recorded by the users as per Table 5.1.

- A comparison of pile and ambient temperatures was recorded by the householder using a digital indoor/outdoor thermometer with a display beside the bin under the house that was read morning and night at approximately the same time and recorded on the data sheet. Temperature readings were commenced in the first week of use of the composting toilet.

- The compost was examined for physical characteristics of odour, texture and volume reduction, and tested for pathogens at the end of each fallow period. The run-off was tested before and after passing through the urn sterilisation system.

FIGURE 5.6

Polypipe frame inside bin: Installation B.

Cost:

	Estimated value	Actual value
Base (of toilet room)	180	0
Bin (plus internal fittings)	260	160
Chute	105	50
Interior (including toilet seat)	333	80
Venting (in)	100	40
Venting (out)	255	105
Drainage (including urn)	240	190
Total	$1470	$625

'Actual value' includes only materials purchased specially for the toilet construction, and labour other than the householder's. 'Estimated value' is what the materials would be likely to cost if bought new. Neither cost included material and labour that was not used in the final installation, i.e. experimentation costs, estimated at:

Materials	$200
Labour	$600
Householders' research time	$200
Total	$1000

Observations:

The trial was commenced on May 24, 1994. To thoroughly test the system it was decided that normal usage would be made of the toilet including users on antibiotics.

Each bin filled up in approximately six weeks, but decomposition in the fallow took four to six months, so it was necessary to have seven bins in operation over the 13 month trial period. Due to lack of time and funds to fit out extra bins, the householder emptied the contents of the third active bin into an unmodified Wheelibin to fallow, so the modified bin could be reused. Without a false floor and aeration, the lower half pile became saturated and anaerobic, and decomposition slowed down. The use of the unmodified bin was not discovered by the author for some months.

The active bin was installed under the shaded side of the house which was consistently cool and often windy. It had been intended to close in this area as a warmed cellar but this did not occur during the time of the study. Access to the bins and emptying proved difficult due to constricted circumstances.

The fallow bins were stored in a glass house which provided shelter from the wind, and ambient temperatures ranging from 8°C to 25°C were recorded in the glasshouse.

The liquid 'sterilising urn' using a modified keg was replaced by an electric copper after the welding in the keg melted and failed to seal the fittings. The copper corroded around the rim and the element burnt out, and was replaced by an emersion element. Because neither unit was attached to the venting system due to lack of space near the active bin, the boiling liquid gave off a pervasive acrid odour. Further experimentation is required with the sterilising urn.

End-product:

Liquid run-off was initially collected in a 20 litre container without being sterilised to ascertain amount of liquid generated relative to user numbers and as a baseline for testing the run-off after sterilisation. On average the household generated 30 litres a week of liquid effluent. On May 31,1993 at 3 pm a sample was taken from the container and delivered to Aquahealth Laboratory at the University of Tasmania at 3.50 pm giving results of: "Total Colis/100mL < 1000, Faecal Colis 700 and E.Coli 700". This was a remarkably low count for run-off that is basically urine draining through fresh faeces. It was most unlikely that the composting process had become established enough to sterilise the material to that extent. Ambient temperature recorded on May 31 under the house near the bin ranged from 3.7°C to 11.6°C and internal bin temperature ranged from 11°C to 11.9°C. When queried about the results, Dr. Garland at Aquahealth tested the pH to see if it could have affected the count. The pH value was 9.41 which is also surprising and possibly due to conversion of nitrogen to ammonia and amines which would account for the very offensive odour of the sample. Dr Garland suggested that such a high pH value could partly explain the low coliform count, but was not a complete explanation (Pers. comm. Garland June 1994).

On October 11, 1994, a further sample of liquid runoff was collected from the composting toilet at the holding tank prior to the discharge into the sterilisation urn and submitted to Aquahealth Laboratory for analysis, giving the following results:

410 000 total Colis/100mL
260 000 Faecal Colis/100mL
260 000 Faecal Colis/100mL

These results are more predictable for effluent that is passing through a composting bin especially where the pile is only recently established.

On October 24, 1994, a sample of the liquid run-off was collected after sterilisation in the urn and was submitted to Aquahealth Laboratory for analysis, giving the following results:
<10 Faecal Colis/100mL.

This result indicated that heating the effluent to 70°C for one hour had greatly reduced the pathogen count. The laboratory report expressed regret that "background growth on the plates prevented us from obtaining a more accurate account" (Pers. comm. Garland October 1994).

A sample of the active pile collected on the same date from a recently 'started' bin (4 weeks) gave a reading of 6 000 Faecal Colis/g and a sample from a bin which had been fallow for 3 months (20 weeks since commissioning) gave a reading of <1 000 Faecal Colis/g.

On February 20, 1995 further samples were collected and tested at Aquahealth Laboratory giving the following results:

compost at 12 weeks <100 Faecal Colis/g
compost at 22 weeks < 100 Faecal Colis/g
compost at 38 weeks < 1 000 Faecal Colis/g
effluent after treatment <1 000 Faecal Colis /100mL

The laboratory assistant reported that, as it was not possible to filter larger quantities of samples, the effluent and solid samples could only be expressed as " <10 Faecal Colis/g and <10 Faecal Colis/g respectively" (Pers. comm. Kamperman February 1995).

Temperatures:

At the beginning of each active bin temperatures slowly climbed over approximately two weeks to reach the lower mesophilic range where they were maintained for the life of the active bin. Ambient temperatures under the house where the bins were installed ranged 13°C to 24°C lower than the bin temperatures.

5.8.3 Installation C

Location: Semi-rural, Huon Valley, SE Tasmania

Household: Two adults. Both work full-time away from home during the day. Occasional overnight stays of two adults and three children (two teenage) relatives.

Diet: Vegetarian, occasionally meat.

Climate:

Winter: average temperature range: 2.5°C to 12°C
Summer: average temperature range: 9°C to 21.5°C
Average annual rainfall: 850 mm

Installation

- The composting toilet was installed in a separate toilet room of a new house, off the hallway (see Figure 5.7).

- The bins were installed at the top of a wooden ramp mounted on a concrete floor within a closed concrete-walled cellar beneath the house (see Figure 5.8).

- The Colourbond aluminium chute protruding from the separate toilet room floor projected through a varnished waterproof plywood lid bolted to the top of the bin incorporating an expanded neoprene seal;

- The bin was raised to operating position with a second-hand automobile scissor jack

- The small (1-2 mm) gap between chute and plywood lid was sealed with silicone.

- Run-off was piped to a soakage trench 15 metres by 600 mm by 600 mm which also receives the domestic grey water.

- Ventilation was achieved through a 100 mm diameter pipe with an electric fan. Air was drawn from an area near the domestic hot water cylinder and expelled above the roof line.

- Aeration within the bins was achieved as in Figure 5.1 via perforated chutes, metal saddles, and mesh covered cut-out. Air was drawn into the bin below the false floor and up through the chutes.

- The bitumen-painted expanded metal false floor was supported on threaded steel rods.

- A run-off pipe was installed approximately 30 mm above the floor of the bin.

- Before starting to use the toilet, the false floor of the bin was lined with leaves and twigs to stop the compost falling through the mesh.

<u>Monitoring:</u>

Usage was recorded on a data sheet by the users as per Table 5.1.

A comparison of pile and ambient temperatures was recorded by the householders using digital indoor/outdoor thermometers with a display beside the toilet that was read once daily at approximately the same time in the early evening and recorded on the data sheet. Temperature readings were commenced in the first week of full time use of the composting toilet.

FIGURE 5.7

Pedestal in toilet room: Installation C.

Cost:

Timber ramp base + jack $32
Bin (second-hand, one) $40
Internal fittings $60
Chute $115
Interior (including toilet seat) $70
Venting (in) $40
Venting (out) $150

Drainage	$40
Seals/lid	$20
Inspection ports	$16
Thermometers	$50
Insulation (polybatts)	$30
Total	$663

FIGURE 5.8

Wheelibatch bins under house: Installation C.

Actual value includes only materials purchased specially for the toilet construction, and labour other than the owners'. Other costs are estimated at:

Labour $500

Observations:

The toilet was installed in October 1994 and full time use was commenced in January 1995. The toilet was used occasionally for two months during house building prior to occupancy.

A bulking agent mix of rice husks and small quantities of vegetable scraps and grass cuttings have been added to the pile.

The run-off pipe was originally 12 mm garden hose, mounted low down in the base of the bin. This hose clogged after approximately two months of use. A second pipe (polypipe) of 19 mm diameter was added and mounted higher in the base (approx. 30 mm from the bottom). This has drained adequately.

Insulation of the bin and venting of warm air has failed to prevent a gradual drop in pile temperature with the change of season. It was intended by the householder that a heating element either in or around the bin will be incorporated in the second bin design. The author suggested that prior to trying a heating element, the pile be stirred with a stick down the pedestal in case it has become compacted and aerobic decomposition is not taking place. The householder decided instead to wrap an electric blanket around the bin.

The householder was disturbed by the sound of the electric fan, so it was suggested by that the author that the fan be turned off at night. Adequate air supply to the bin will be provided by the fan being on a couple of hours a day. The householder reported that when the fan was off, the toilet room had an "unpleasant odour", so the fan was left on permanently.

The original bin design incorporated a vent below the false floor. This allowed the inflow of cold air at night. It was replaced by a 50 mm inlet pipe and connected to a warmed air source within the house, as in Installation B.

Temperatures:

Temperatures in the active bin recorded at an average of 4°C above ambient and so the pile temperature dropped to below 13°C in the winter months. At no time in the first six months of use had it reached the mesophilic range. In April, 1995, the householder wrapped the bin in insulation batts, but the temperature in the bin did not noticeably rise. In July 1995, the bin was wrapped in an electric blanket and within 22 hours the probe in the pile recorded a rise from 10°C to 25°C. It was suggested that the electric blanket be turned off to ascertain whether the temperature being recorded is due to microbiological activity or electric heating. The householder did not report back on this suggestion prior to the completion of this study. It is not clear why the pile in this bin has failed to reach mesophilic temperatures by microbial activity. It may be due to the toilet not being used regularly in the first months, and filling slowly during the rest of the period.

End-product:

The first active bin is due to be changed at the beginning of August 1995, so there has as yet not been any end-product to test. This bin will have been in use for nine months at the time of changing (Pers. comm. Abbot and Tilley July 1995).

5.8.4 Installation D

Location: Urban, North Coast, New South Wales

Household: Two adults, and one child visiting on a weekly basis.

Diet: Vegetarian

Climate:

Winter: average temperature range: 7.5°C to 20°C
Summer: average temperature range: 19°C to 29°C
Annual average rainfall: 1360 mm

Installation:

- For the purposes of the trial, a sewered flush toilet system was removed and the composting toilet system was installed in the bathroom next to the sink.

- The bins were installed on a concrete slab under the house.

- Run-off was collected in a sealed plastic container and monitored relative to usage. The liquid was periodically buried at a depth of 300 mm in the garden.

- Ventilation was achieved through a 100 mm diameter pipe with an electric fan. Air was drawn from the ceiling of the house through the bins underneath the house and expelled above the roof line.

- The bins were installed underneath a raised timber house.

- Before use the false floor of each bin was lined with straw to stop the compost falling through the mesh and 5 cm of garden compost was placed on top of the leaves.

Monitoring:

- Usage recorded by the users as per Table 5.1.

- A comparison of pile and ambient temperatures was recorded by the householders using a digital indoor/outdoor thermometer with a display in the bathroom that was read usually once daily at approximately the same time in the morning, (occasionally at a second time during the day or evening) and recorded on the data sheet. Temperature readings were commenced in the fourth week of use of the composting toilet.

- The compost was examined for physical characteristics of odour, texture and volume reduction, and tested for pathogens at the end of each fallow period.

Cost:

Bins (2nd hand)	$60
Freight on bins	$12
Bin modifications (commercial)	$438
Installation (40 hours labour)	$640
Pedestal	$200
Chute	$100
Seat	$50
Vent and cap	$40
Liquid drainage	$30
Concrete slab	$100
Total	$1 676

Observations:

The trial began on August 11, 1993. During the life of the first bin, both adults were working at home and as the toilet was used for all urination, there was a heavy liquid load. From September 5 until September 15, 1993, one of the adults was taking antibiotics. Kitchen scraps and some sawdust were added as bulking agent. Vinegar flies (*Drosophila spp.*) were observed in the pile and were controlled by lightly spraying pyrethrins into the bin. The first bin was changed on November 21, 1993.

When garden compost was added as a starter in the first bin, worms that were included survived well into the fallow period of that bin. During the fallow period the volume of the pile dropped by more than a third.

Small quantities of woodshavings were used as a bulking agent in the second bin and after the fallow period, woodshavings remained and desiccated organic matter which was just discernible as solid excreta. This confirms other findings (refer 3.2.3) that woodshavings break down very slowly in composting toilets but can serve well as an absorbent bulking agent (Handreck 1993: 9; Chapman 1993: 15).

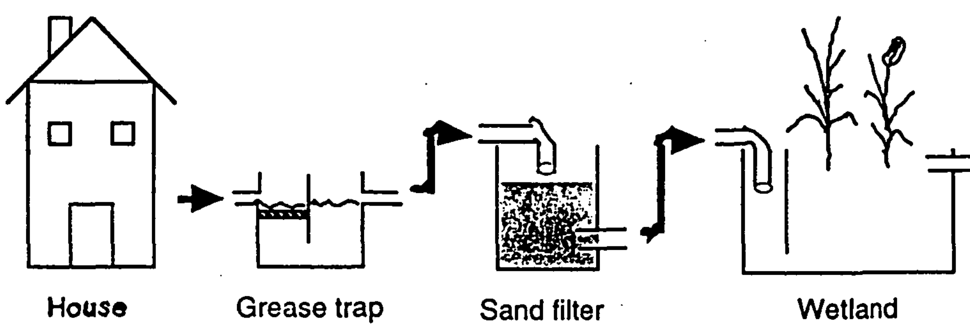
Rice husks were used as bulking agent in the third bin, and vegetables scraps are being used in the fourth bin, with occasional additions of rice husks when the pile 'appears too wet or fermenting' or when the householders are to be away from home for a few days. It will be useful to compare the end-products from these different bulking agent applications at the end of the fallow period of each bin.

Difficulties have been experienced with the drainage fittings, and these could be improved upon to avoid spills when the bins are alternated, and to streamline changeover.

A constructed wetland grey water treatment system (see Figure 5.9) has been installed on this site (Marshall 1995) and will receive the liquid run-off from the composting toilet, which averages five litres a week. The goal is to achieve a zero discharge of influent to the site, and the end drainage point of the house block will be monitored to ensure this. The householder aims to have no unpleasant odours, no impact on neighbours and no opportunity for contact with pathogen affected material from their closed wet and dry domestic by-products treatment system (Pers. comm. White June 1995).

Summary of System

Greywater pathway:
* From house
* to grease trap
* to sand filter
* to wetland
* to garden / holding tank



Greywater will ideally flow from the house to the wetland under the influence of gravity. A pump may be required to move treated water to a holding tank. Individual site layouts will determine flow regimes.

FIGURE 5.9

Grey water treatment system (Marshall 1995: 1): Installation D.

The grey water treatment system was constructed by the householder with the assistance of friends and research colleagues.

Cost of greywater treatment system

Fibreglass troughs	$ 1 000
Fibreglass holding tank	$980
Pipe fittings	$100
Gravel and sand	$200
Site preparation	$900
Installation (20 hrs)	$300
Pump	$250
Leaky pipe (80 m)	$160
Controls and wiring	$250
Flow forms	$375
Poly pipe and fittings	$250
Total	$4 765

End product:

The compost of two fallow bins has been tested during the period of the study and in both cases gave a nil pathogen indicator count when tested for Salmonella/Shingella, Faecal Coliform and Enterococci (Pers. comm. Tranter August 11 1994 and May 18 1995). The compost was friable and had a faint musty odour. Analysis of the May 1995 sample taken from 10 cm into pile tested at pH 7.02 and a sample from 50 cm into the pile tested at pH 6.97.

Liquid run-off was tested and gave the results shown in Table 5.2 (Pers. comm. Marshall June 1995).

Temperatures:

Temperatures in the active piles have been maintained in the lower to middle mesophilic range and appear to be little affected by ambient temperature changes.

TABLE 5.2

Analysis of liquid run-off from composting toilet (Pers. comm. Marshall June 1995)

Sample Date	07/06/95
Sample Time	1.00pm
Temperature, Celsius	17
Conductivity, uS/cm	36 500
pH	8.68
Suspended Solids, mg/L	-
Dissolved Oxygen, mg/L O_2	< 0.05
BOD_5, mg/L O_2,	2720
Faecal Coliforms, CFU/100mL	30000
Nitrite, as mg/L N	40
Nitrate, as mg/L N	654
TKN, as mg/L N	4775
Ammonia, as mg/L N	4500
Phosphate, as mg/L P	213
Smell	old urine
Visual colour	dark beer
Colour, Pt-Co units	-

5.8.5 Installation E

Location: Semi-rural, Midlands, Tasmania

Household: Two adults. Both work from home during the day. One adult is a vet so is often on call away from the house. The other adult is a farmer.

Diet: Meat and mixed

Climate:

Winter: average temperature range: 1.5°C to 10°C
Summer: average temperature range: 8°C to 21°C
Average annual rainfall: 560 mm

Installation:

- The composting toilet was installed in an insulated shed, which is serving as a temporary dwelling while the main house is being constructed. The main house is being designed to accommodate the Wheelibatch bins in a warmed cellar underneath a toilet room (Pers. comm. Wilson July 1995).

In the shed the pedestal is installed on a mezzanine floor above the bins.

- The Colourbond aluminium chute protruding from the mezzanine room floor attaches to the bin by a rubber skirt.

- Run-off is piped to a temporary soakage trench 1 m by 200 mm by 200 mm.

- Ventilation is achieved passively through a 90 mm diameter pipe painted black.

- Aeration within the bins is achieved as in Figure 5.1 via perforated chutes, metal saddles, and mesh covered cut-out. Air is fed into the bin below the false floor and drawn through the chutes.

- The expanded metal false floor is supported on threaded steel rods.

- A run-off pipe is installed approximately 30 mm above the floor of the bin.

- Before use the false floor of the bin was lined with leaves, twigs and straw to stop the compost falling through the mesh.

Monitoring:

Usage is recorded on a data sheet by the users as per Table 5.1. A comparison of pile and ambient temperatures was recorded by the householders using digital indoor/outdoor thermometers with a display beside the bin that was read once daily at approximately 6.30 am each morning and recorded on the data sheet. Temperature readings were commenced in the first week of use of the composting toilet. A second temperature probe will be installed in the fallow bin.

Cost:

Bins .... $95 x 2
Thermometer .... $30 x 2
Rubber $30
Chute... $30

Metal mesh	$60
Bolts, nuts	$20
Scrap wood for pedestal	$5
drainage fittings	$10
vent pipe (scrap)	$5
Total	$410

<u>Observations:</u>

The toilet was installed on March 30, 1995 and the first active bin was alternated on June 25. It could have been used for another three to four weeks, but the outlet started to leak, so the householder decided to change the bin at the same time as repairing the leak.

A bulking agent of saw dust, a litre of vegetable scraps every two days, and lime have been added to the pile. The author advised excluding the lime in the second bin, as it is preferable to first determine how the composting proceeds without these interventions (see Handreck 1993: 8).

The run-off pipe was 25 mm polypipe, mounted 30 mm in the base of the bin. In the second bin 50 mm pipe has been used with irrigation pipe fittings.

The householder reported that on 'frosty nights' the vent draught reversed and a stale urine odour was detected in the shed. These occasional odours are unlikely to occur in the new house where the toilet cellar will be well sealed and warmed.

The first bin was inspected after three weeks' fallow period and the pile had dropped 70 mm and was starting to decompose.

When the system was installed in the main house the installation will be made more robust and easier to alternate by:

(1) connecting the pedestal to the rubber skirt with one piece of Colourbond,

(2) cold vulcanising the rubber skirt to the seal over the bin rather than

using glue.

Temperatures:

Temperatures in the active bin recorded at 8°C the day the toilet was first commissioned and ambient temperature was 9°C. Over eighteen days the pile temperature steadily climbed to reach 23°C and for next two weeks remained in the low mesophilic range while ambient temperatures ranged 4°C to 13°C. When the ambient temperatures range dropped to -2°C to 8°C, the pile temperatures hovered in between 15°C to 18°C. During the life of the first active bin the pile temperature recorded an average of 11°C above ambient.

End-product:

The first bin had only been fallow for five weeks at the end of this study, so there has as yet not been any end-product to test.

5.9 Implications of the Wheelibatch trials

As previously stated the goal of this component of the study was to develop and trial an accessible standardised domestic composting toilet design for owner- builders that would be acceptable to regulatory authorities. In the Wheelibatch trials in the Lismore district the piles have reached what are recognised as composting temperatures (Chapman 1993: 22) and produced an acceptable compost with inoffensive odour, and a nil pathogen indicator count (Pers. comm. Tranter 1994/5).

The Tasmanian trial that has been established with sufficient time to produce a long standing fallow bin (Installation B) has been slower to produce an acceptable compost and this may be due to a combination of the climate, the consistently high urine load, and inadequate drainage. It is often thought that cold climates are responsible for ineffectual composting toilets but this is not necessarily the case as has been indicated by the Pelion Cage Batch trials (refer Chapter Three) and by the active pile temperatures recorded at Installation E, and early signs of decomposition in the fallow pile from that site, despite low ambient temperatures.

> It would appear that the minimum atmospheric temperatures must first drop below 25F [-3.9°C] before a decline in the

> compost temperatures can be expected. It appears, however, as if the magnitude of fall in the compost is also determined by the stage of development of the compost process. In the early stages, the temperature will be less inclined to fall than in the later, or advanced stages (VanVuren 1949: 81).

Low temperatures do appear to slow the decomposition down in the fallow period. For example fallow bins left out in the weather for the pile to decompose in Lismore, New South Wales produced a compost with a much reduced pathogen indicator count a couple of months faster than the fallow bins from the Tasmania semi-rural trial, Installation B.

However in both locations the full cycle of the Wheelibatch system has eventually produced the desired product. While the trial was approved by the State Health Department in Tasmania as necessary research to provide more effective on-site sanitation options (Pers. comm. Jacobs December 1992), the New South Wales Health Department has been less encouraging (Pers. comm. Norris July 1994). At a presentation by the author to a regional Environmental Protection Agency meeting at the Lismore City Council Chambers on November 16, 1993, describing the range of composting toilet innovations being trialed in this research study, a senior member of the EPA expressed hostile disapproval, particularly of the urban trial (Pers. comm. Noonan November 1993).

Monitoring of the Wheelibatch trials in New South Wales and Tasmania will continue beyond this study. The purpose in both regions is to satisfy regulatory authorities that the design will provide an effective hygienic composting toilet in a variety of applications. This has been established in the Lismore context but requires further verification in Tasmania. While the study has been a constructive process toward increasing on-site sanitation options, it has been limited by dependence on the time and funds available to the householder to install and monitor their toilet, and their willingness to follow the author's directions in the conduct of the trial. The trials in national parks described in Chapter Three and Four have at times involved inexperienced or disinterested personnel, but this is, in some aspects, less exacting than ensuring the co-operation of people in their homes where they prefer to be making the decisions that affect intimate details of daily life. At the same time, domestic trials allow more certainty and control of usage numbers and pile content than a public recreation area installation, and are likely to attract a personal commitment to the success of the trial. In either case more detailed research is required to establish guidelines and reliable data on such issues as invertebrate ecology in the pile, implication of temperature changes, bulking agent type and application, urine load limit, liquid run-off treatment and integration with greywater treatment. In addition, the bins could possibly be improved by being purpose manufactured for composting toilet usage, particularly as there have been an increasing number of requests for Wheelibatch installations beyond the owner-builder application.

The composting toilet trials described in this Chapter were initiated in response to an expressed need and request from the community and/or a local government body. More than 30 similar requests were refused by the author over the period of the study because of lack of time and resources to provide the most basic monitoring to any more installations than have been described in the preceding Chapters. In most instances, other than the urban Wheelibatch trial in urban Lismore (Installation D) the installations were primarily providing a practical sanitation service, where other options were not available or not desirable. The opportunity for design and monitoring was secondary, and yet under these circumstances, positive results have been achieved, which indicate the potential for further refinement and the wide scope for community education in this field.

It has been argued in Chapters One to Five that what has been achieved in a variety of unfavourable circumstances, including minimum budgets, conflicting agendas, and remote locations, could be enhanced by appropriate research and development infrastructure. The next Chapter indicates possible directions for institutional support of on-site sewage treatment in Australia, and pitfalls to avoid, by examining the Japanese experience in on-site sanitation research, development and administration, and its relationship to reticulated sewerage technology and management.

CHAPTER SIX

USEFUL LESSONS FROM JAPANESE SEWAGE TREATMENT STRATEGIES

As previously discussed in this thesis, wet and dry on-site solutions to sewage treatment have been developed and promoted primarily by small business in Australia. This has sometimes resulted in predictably diminished capability and appropriateness due to insufficient time and money for adequate networking, research and monitoring.

It has been argued that adequate research and development could be provided by those organisations entrusted with the provision of sanitation. However, such bodies have been reluctant or incapable of taking on this role, and are often dismissive of the full potential of on-site treatment.

An example of the cursory attention given to on-site treatment was apparent in the 1993 Sydney Water Board's long term planning deliberations. The Sydney Water Board began a 'Public Consultation' process with 'Peak Environment Non Government Organisations' on September 20, 1993 (to the Board's credit this twelve month consultation process has been a constructive step toward responding to the community's concerns) (Dowsett et. al. 1995). As part of the initial briefings of the Board's activities Steve Clary, Assistant Manager Master Planning, presented an overview which described the contributors to waste water, strategies available to the Board and "the people of Sydney", approximate costs of those strategies, and an outline of "choices Sydney will have to make" (Pers. comm. Clarey 22/9/93). Included in the presentation were options suggested by the public or regulators which the Board had apparently carefully considered. Among these were "10 000 EP (on-site) treatment plants" i.e. a decentralised strategy for Sydney's sewage treatment. Clarey stated that this "even included looking at composting toilets".

The on-site strategy was predicted to cost an additional ten billion dollars whereas secondary treatment and high dilution outfalls at the coast were likely to cost an additional one billion dollars, effluent transfer over the Blue Mountains would cost an additional six billion dollars, containment of wet weather overflows for the "five year event" would cost an additional 6 billion dollars, and non potable reuse of all effluent would cost 12 billion dollars. (Clarey 1993: 9). More detailed information concerning the investigation of the decentralised option was said to be in Volume 6 of the Strategic Plan for Wastewater and Stormwater. Examination of this report gave little evidence as to how this assessment was made. Possibly the absence of comprehensive investigation is due to the fact that sewage and water managers in Australia have had little recent experience of effective on-site treatment, especially of it being used extensively in an urban environment. Septic tanks have been widely used for many years in rural and semi-rural areas, but there has been associated problems with this technique and minimal effort to improve on it. As previously mentioned Aerated Wastewater Treatment Systems have raised the standard of on-site water borne sewage treatment but are relatively expensive and suffer the limitations of small business research and development, and reluctant local government management (Pers. comm. Baker February 1995).

Rather than dismissing an institutionally supported on-site strategy as impractical before it has been comprehensively considered, it could be useful to examine the experience in Japan on this issue. And to discuss on-site treatment, it is also necessary to examine its relationship to centralised technology and policy. This Chapter presents an overview of sanitation management in Japan and examines some of the complex related issues requiring resolution in that country. Reference is made to innovations in support of the preferred centralised paradigm to indicate what is possible where there is sufficient political will, and examples of the integration of centralised and on-site treatment provide models for future constructive configuration. These issues are examined not only because of their relevance to Australia's future sanitation practice and environmental health but also because the trends established by developed nations are having a decisive impact on the practices of many countries which are in the process of development.

While the preceding chapters concentrated on dry conservancy on-site sanitation, this chapter deals primarily with water borne treatment, as the issues involved relate to the status of both wet and dry decentralised sewage treatment.

Much of the information contained in this Chapter was gathered during a three month field excursion in Japan and one month in China, in 1993. The purpose of the journey was to explore the achievements and difficulties created by on-site and centralised sewage treatment in densely populated countries, one of which is 'developed' and the other is 'developing'. Personal interviews with sanitation personnel and local residents are supplemented by relevant literature. Cultural and political barriers made access to accurate information difficult. An ongoing exchange of information with sanitation personnel in both countries has been established and the cultural barriers are slowly diminishing.

6.1 Status of on-site sanitation in Japan

In Japan

> 122 592 000 people out of the total population, (124 043 000) are living in the designated area. About 62% or 75 800 000 people are using flush toilets, while the rest, 38% or 46 792 000 are using cesspits. 56% of people using flush toilets are supported by public sewerage systems, while the other 44% are using Johkasous (Watanabe, Kuniyasu & Ohmori 1993: 52).

In Australia, an equivalent on-site technology to the Johkasou is known as the Aerated Wastewater Treatment System, (AWTS) or Domestic Activated Sludge Treatment (DAST). In Japan, the Johkasou that treats black water only is called a Tandoku, and a system which treats a combination of black and grey water is called a Gappei. As of March, 1989, approximately 97% of Johkasous installed were Tandoku. Grey water from the houses using a Tandoku or a cesspit drains untreated into local waterways.

The cesspits, known in Japan as Kumitori (see Figure 6.1) are simple vaults installed under the toilet room which are pumped out by contractors and the material is taken to a municipal treatment works (Pers. obs. May 1993). The end product is usually distributed to farmers for fertiliser (Pers. comm. Matsui

May 1993). This is a traditional method of sanitation which has served Japanese homes for most of this century. It is simple, cheap and relatively benign environmentally, both at collection point and at the treatment plant. Unfortunately, the Japanese art of innovation has not been applied to adequate venting of these vaults and they sometimes produce a pungent smell, especially in summer. In the close confines of Japanese housing this odour can permeate the whole dwelling (Pers. obs. March - June 1993). For many decades people obviously accepted this inconvenience, using various additives to reduce or neutralise the smell. But with the increasing affluence of Japanese society the flush toilet has become an essential commodity "a key index of a nation's standard of living" (Waste Water Treatment System Association 1990: 1).

Approximately, fifty million people still use the Kumitori in Japan but this is not something Japanese sanitation managers are proud of even though this method of treatment of human excrement has the least environmental impact of all the current centralised and on-site strategies (Pers. comm. Takahashi May 1993). It is possibly because of this shame, particularly in the face of 'Western' scrutiny, that no efforts have been made to improve ventilation and thereby reduce the odour. The venting techniques used on vault toilets by public recreation institutions in the United States (Cook 1991: 23) could make the Kumitori acceptable as an ongoing method of treatment rather than an obsolete embarrassment that should be replaced as soon as possible.

Unlike Australia, this simple method of treatment is very much in place in Japan. The vaults are installed under buildings that are designed to accommodate them, an effective system of maintenance has been established and the people are accustomed to their use. If flush toilets had not become an essential status symbol, then the money saved in replacing them could be used to provide odour and insect infestation control, and guarantee effective grey water treatment, either on-site or through local centralised plants. In comparison, for suburban Australians to change to the widespread use of a Kumitori, considerable alterations in infrastructure and government and public attitudes would be necessary.

However, the flush toilet has become the desired option in Japan and not just the humble cistern and bowl. Despite the high cost of electricity, the majority of domestic flush toilets function electronically with a panel of switches for regulating the heated seat and operating a range of genital and anal washing devices. The function of the toilet is proudly explained to new guests shortly after arrival in a Japanese home (Per. obs. March-June 1993). With the acquisition of a flush toilet, most Japanese homes have also abandoned the traditional practice of squatting to defecate and adopted the Western practice of sedentary evacuation, so the squat plate over a horizontal bowl has been replaced by the pedestal and seat.

FIGURE 6.1

Kumitori squat plate over vault tank

Some people resist the change to the flush toilet, mainly because of the expense (Pers. comm. Rikiishi March 1993), but a combination of government and social pressure certainly requires the replacement of the Kumitori with a waterborne system. (Pers. comm. Watanabe, T. May 1993). From 1956, "the Ministry of Health and Welfare decided, as part of its waste-water policy, to foster the spread of small-scale waste water treatment facilities as community purifiers" (Waste Water Treatment System Association 1990: 4). When questioning sewerage engineers on the environmental justification for on-site flush toilets over the Kumitori, given that the Kumitori has no outlet from the vault to surrounding water ways, the reasons for its rejection were the problem of flies and offensive odour (the latter only occurred if the toilet cover was inadequately sealed, (Pers. obs 1993). When it was suggested that these problems could be eradicated, the reply claimed "the people's will" as the prime reason for the Kumitori's unsuitability and dismissal (Pers. comm. Yamada April 1993).

Providing Japanese people with centralised sewerage treatment has been, and will be, an expensive and lengthy process. The urban population ratio to the total national population in 1985 was 60.5% and is increasing mainly due to migration to the cities but also due to the encroachment of cities on agricultural land.

> Most construction must be undertaken in densely populated built-up areas where nearly all of the streets and roads have already been paved, thus presenting problems to sewer laying using the open cut method. Also it is difficult in Japan to acquire sufficient land for whitewater/sludge treatment/ disposal, particularly in densely populated urban areas (Kubo 1990: 1).

It is the intention of the Ministry of Construction and its implementation authority, the Japan Sewage Agency, that all of urban Japan will eventually be sewered and at least 70% of the population to be serviced by the year 2000 (Morioka 1990: 4). While this strategy is seen by environment protection authorities such as Hideyuki Mori, Assistant Director of the Environmental Management Division, Japan Environment Agency, as economically and environmentally unadvisable for regional cities (Pers. comm. Mori May 1993), the delay in its implementation has resulted in the widespread use of the Johkasou.

6.1.1 Differences in the history of on-site sanitation in Japan and Australia

The history of on-site usage in Japan and Australia is different, but has similar 'drivers' that produced opposite outcomes. In Australia, the promotion of the flush toilet coincided with widespread installation of centralised sewerage, with septic tanks being used only in outlying areas. In Japan, once people were connected to a reticulated water supply, the promotion of the flush toilet stimulated widespread innovation and use of on-site waterborne treatment because demand for this luxury facility far outstripped sewerage construction, despite a considerable injection of funds by the Ministry of Construction. On-site treatment continues to fulfil that demand notwithstanding the high priority given to sewerage development:

> the total amount of public investments in the coming ten year period will be increased to 430 trillion yen from 263 trillion yen recorded in the preceding decade of the 1980's, an increase of 1.6 times (Fujiki 1992: 5).

Currently, in Australia, there is increasing public interest in AWTS in an attempt to find an alternative to the environmental impact of centralised treatment, (and to facilitate development in sensitive and restricted areas, which can be environmentally counterproductive). In addition, an inclination away from water borne treatment altogether, toward dry conservancy methods such as composting toilets has led to the research and events which are the subject of this thesis.

6.2 Sanitation issues requiring resolution in Japan

As there has been very little research, negligible infrastructure or funding for on-site treatment, Australian experience is at an embryonic stage while Japanese experience has covered numerous administrative and technical hurdles, many of which are relevant to the Australian situation, as are the important issues Japan still has to resolve in this area.

While much progress has been made, the relevant sanitation issues that still need to be resolved in Japan can be considered under the following headings:

- the complexities created by conflicting perceptions of the value and roles of on-site and centralised treatment;

- the need for simplification of the administration of on-site sewage treatment which will facilitate all aspects of management including improved maintenance;

- the problems of disposal of Kumitori and Johkasou sludge;

- the need to provide adequate treatment of grey water.

Some of these concerns are common to Australia in a lesser degree but all can inform sanitation mangers' current and future practice. Australian waste Managers have very few guidelines for on site treatment. For example, The Laws and Ordinances detailed in 6.2.1 provide considerable information that allows Australia not to have to re-invent the wheel. The advantage in being at the advent of on-site treatment also allows Australia to improve on the Japanese experience technically and in terms of management.

6.2.1 The complexities created by conflicting perceptions of the value and role of on-site and centralised treatment

Before examining the conflicting perceptions of the relative value and role of on-site and centralised treatment it would be useful to outline the areas of management.

6.2.1(i) Jurisdiction

This is not a simple matter as there are many overlapping areas of administration. However, sanitation management in Japan can be broadly classified into four groups with respective funding and control.

1. Centralised or "public" sewerage systems are constructed by Municipalities and Prefectures with aid from the Ministry of Construction.

2. "Community" Sewerage systems are constructed in areas with populations over 100 000 people by Municipalities with financial aid from the Ministry of Health and Welfare. In agricultural communities the sewerage systems are funded by the Ministry of Agriculture, Forestry and Fishery (sic).

   The Ministry of Health and Welfare and the Ministry of Construction set standards and guidelines for classifications 1 & 2.

3. Johkasou. Installation of the Tandoku Johkasou is funded privately but installation of the Gappei Johkasou can attract financial assistance from the Municipality funded by the Ministry of Health and Welfare. By 1991, local governments in Tokyo and 41 prefectures had subsidised the differential cost of 25 897 Gappei Johkasous (Watanabe et al. 1993: 56). This funding assistance is limited but as it is intended as an environmental protection incentive, it is hoped that more funds will become available. (Pers. comm. Watanabe T. May 1993). The Ministry of Health and Welfare and the Ministry of Construction sets codes and standards for the construction and maintenance of the Gappei Johkasou and the Ministry of Health and Welfare is responsible for supervising the Tandokou Johkasou.

4. Sedimentation tanks and other basic systems to treat grey water are funded and installed privately and there is no specific department regulating construction and maintenance.

5. Kumitori excrement is collected and transported by contract vacuum trucks to treatment plants constructed by the Municipality.

Financial assistance and codes and standards are provided by the Ministry of Health and Welfare.

6.2.1(ii) Administrative inequalities

The Ministry of Health and Welfare and the Ministry of Construction are both national Ministries but their budgets and influence differ greatly. Without examining in depth the complexities of Japanese politics, it is suffice to say that the Ministry of Construction is one of the most powerful and affluent of all the Ministries in Japan. According to Mr. Takahashi, Chief of International Affairs in the Japan Sewage Works Association, sewerage design and construction has "a very large budget" (Pers. comm. Takahashi May 1993), and the style in which the organisation conducts conferences and entertains foreign guests tends to confirm this statement (Pers. obs. March - June 1993).

At a discussion in Tokyo with Yakuro Inoue, Deputy Chief, Design Section, Planning Division of the Japan Sewage Works Association and other authorities it was stated that the Ministry of Construction would like to see all of Japan sewered, and if not possible then at least all sewage treatment matters under its control (Pers. comm. Inoue and Yamada May April 1993). Although it would probably simplify management, this view is not shared by Dr. Hideaki Ohmori, General Manager, Research and Investigation Division of Japan Education Centre of Environmental Sanitation. His department is within the Ministry of Health and Welfare and is responsible for research, education of sanitation officers and the public, and the publication of standards and guidelines, particularly relating to Johkasous.

6.2.1(iii) The role of the Johkasou and conflicting perceptions of its value

Dr. Ohmori sees the Johkasous as having an integral long term role in Japan's sewage management, especially outside the large metropolitan areas such as Osaka and Tokyo (Pers. comm. Ohmori April 1993). Even within Tokyo, there was still 20% of the population unsewered, (on-site treatment is facilitated in the Tokyo Wards or suburbs as buildings are predominantly low rise, due to the threat of earthquakes). However, in order to improve and thoroughly supervise on-site treatment which is serving 44% of the users of water borne sewage treatment in Japan, more equitable funding should be provided to the managers concerned (Watanabe et al. 1993: 52).

Japan has developed a broad range of on-site treatment systems capable of serving varying numbers of people. In 1986

> a look at the number of waste-water purifiers installed by size shows that of the approximately 5.8 million installed, 4.89 million (84%) are small scale purifiers for treating the waste water produced by fewer than 20 persons. 758 000 (3.1%) are purifiers for 21-100 persons, 142 000 (2.4%) are for 101-500 persons, and 13 000 (0.02%) for 501 persons or more (Waste Water Treatment System Association 1990: 6).

A number of useful Laws and Ordinances have incorporated the experience of regulators and the public in regard to on-site water-borne systems. These include:

- the 1983 Purifier Law (Law no 43) which provides detailed technological standards to ensure "purifiers" or Johkasous are correctly manufactured, constructed, installed, maintained, cleaned and inspected. The Law also establishes a system for determining the qualifications and obligations of all those involved in the installation and management of "Purifiers", including the householder.

- The Ministry of Construction Notification (Notification no. 1292) which stipulates the structure and capacity of "purifiers" was partially revised and the structure of Gappei Johkasous for servicing 5-50 people was added (Ministry of Construction Notification no. 342, March 8, 1988).

- The 1988 Estimation of Population for Waste-Water Purifiers of Buildings (JISA3302-1988) Notification revised estimations of toilet users which were adopted in 1960, and rationalised the estimation of populations for Gappei Johkasous (Waste Water Treatment System Association 1900: 5).

As of August 1989, there were 128 manufactures of Johkasous whose models had been authorised by the Ministry of Construction, and 2 490 models that had received authorisation (Waste Water Treatment System Association 1990: 23). It was not possible for the author to obtain more recent figures.

The advocates of Johkasous claim that they can be installed at lower cost than the cost of constructing public sewer facilities. They can be installed on demand in almost any location and allow for a choice of treatment process and scale in accordance with the size and purpose for which buildings are used (Waste Water Treatment System Association 1990: 32). In addition, significant environmental protection to receiving waters is provided immediately on installation (Pers. comm. Baba April 1993).

The difficulties and challenges of the Johkasou as seen by its advocates include:

- the inequity of users having to shoulder the cost of installation, (apart from the differential funding assistance that may be provided to Gappei users) management and maintenance, unlike those who have access to the centralised sewerage service;

- the need for improvement in the quality of final effluent with particular attention to the separation of solid and liquids, the removal of nitrogen and phosphorous and stabilising the uniformity and amount of influent;

- reduction in the amount of sludge by improving dewatering and anaerobic process;

- reduction of operating expenses including the amount of electricity consumed by improvement in aeration and anaerobic treatment performance and reducing need for maintenance;

- reduction of installation costs (Wastewater Treatment System Association 1992: 32).

Research is being encouraged by the Japan Education Center (sic) of Environmental Sanitation to improve technical performance, and lobbying aims at increasing subsidy (Pers. comm Watanabe T. May 1993). Some advances have been made stabilising the flowrate and characteristics of influent in Gappei Johkasou:

> It was decided to adopt the anaerobic and aerobic submerged biofilter for such treatment. As a result, 90% or higher BOD removal and 20 mg/l or lower effluent BOD have been attained by the domestic on-site facility, which is as good as municipal waste water treatment plants... Now a subsidy program has been issued by Japanese national and local governments for on-site domestic waste water treatment facilities (Watanabe, Kuniyasu & Ohmori 1993: 57).

Those that see the Johkasou as a limited auxiliary of centralised sewerage strategies argue that Johkasous are a more expensive option for treatment: 1.2 million yen for Johkasous and 2.6 million yen for sewerage to service an equivalent urban population; Johkasous last 15 years and sewers last 30 years after installation; sewers cost 10 000 yen maintenance per person per year, including stormwater drainage improvement, and Johkasous cost 50 000 yen per year operation and maintenance (2 000 yen for electricity, 10 000 yen for inspection, 10 000 yen for desludging, 5 000-10 000 yen for maintenance contractor) (Pers. comm. Inoue April 1993). However, calculations appear to reveal little difference in the overall cost.

A study had been conducted by the Ministry of Construction of 30 houses in 5 cities of an anaerobic/aerobic Gappei system (see Figure 6.2) because

> lack of adequate data is causing the overestimation of efficiency of the new systems resulting in the opinion that the new individual on-site treatment systems can take the place of

> public sewerage in controlling water pollution (Hasegawa & Nakamura 1991: 2).

The results indicated that widespread use of the Gappei would cause pollution downstream:

> Although the removal efficiency of total nitrogen is around 50% due to denitrification, ammonia remains in the final settling tank despite long retention time of the contact aeration tank. There is a leakage of ammonia from degraded sludge in the final settling tank...Based on the assumption of the log normal distribution of the effluent quality, 75% non-exceedence (sic) limit for BOD, COD, total nitrogen and total phosphorus are 44.2, 34.2, 32.7, and 3.85 mg/l, respectively (Hasegawa & Nakamura 1991: 6).

The effluent quality was said to have been affected by the inability of the system to handle the concentrated daily discharge (60%) of greywater between 7:00 am and 10:00 am and again in the evening. It is interesting to note that these results were presented as a vote of 'no confidence' in the Johkasou while similar difficulties in centralised treatment would have stimulated more funding for research (Pers. comm. Barnett July 1995). As previously mentioned, research by the Japan Education Centre of Environmental Sanitation has since provided solutions to the fluctuating characteristics and flow rate of the influent (Watanabe, Kuniyasu & Ohmori 1993 :56).

Critics of the Johkasou attribute widespread water pollution to its use:

> the untreated gray (sic) water which is the domestic effluent by-passing Johkasou is increasingly becoming acute in terms of ratio to the total pollution loads of all kinds...Household related sources account for nearly 70% of the total pollutant load in Tokyo Bay, including a content of untreated gray water of 42% (Fujiki 1992: 2).

This pollution is definitely an impact of the use of Tandoku Johkasou which is why subsidy of the Gappei Johkasou is so important. There is also room for further public education in domestic source control.

Advocates of centralised treatment argue that it is a waste of money to subsidise the Johkasou when sewerage installation will solve all problems (Pers. comm Ishida April 1993). Even if this were so, in many areas it will be some years before this service is supplied and most people want to install flush toilets as soon as possible. If people use the Kumitori their grey water also remains untreated. Johkasous that are not being maintained properly add to the pollution problem (Pers. comm. Yamada April 1993). Because the householder has to directly bear the cost of maintenance, there are naturally occasions when people do not want to spend the money on contractors, or the contractors fail to fulfil their obligations. Municipal inspections occur once or twice a year but this is insufficient if the householder or contractor is negligent.

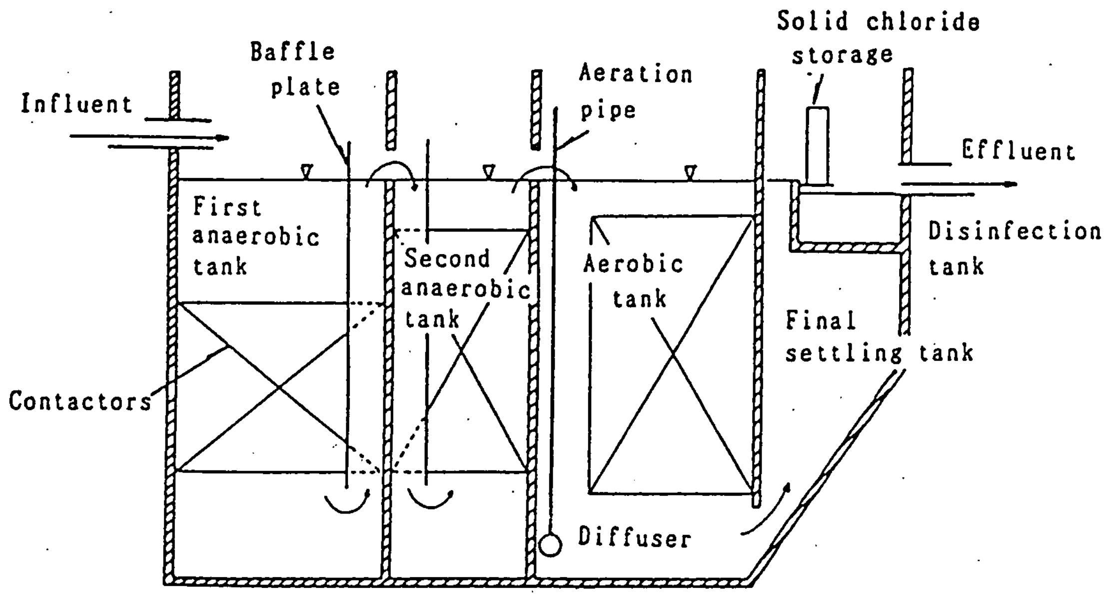


FIGURE 6.2

Structural View of Anaerobic/Aerobic System (Hasegawa & Nakumura 1991: 2).

6.2.1(iv) Citizen involvement and planning confusion

However most householders are very conscientious about the performance of their Johkasou (Pers. comm. Akiyama April 1993). The treated effluent drains into open gutters at the rear of residences and if a Johkasou is not properly maintained it is obvious to the neighbours (Pers. obs. March-June 1993). There are large numbers of Japanese women working in householder activist groups for a cleaner environment (Pers. comm. Inoue April 1993), which includes community vigilance of properly maintained Johkasous. To reduce grease in grey water, the Numazu City Hall Research Department uses cooking oil collected from housewives to make soap, and a Shizuoka womens' group recommends using coconut oil based detergent to reduce phosphates in grey water and because it is easier on their hands (Pers. comm. Akiyama April 1993). These initiatives are maintained on a voluntary basis to fill the gaps that inadequate funding cannot cover in the maintenance of on-site treatment.

It is the author's view that a positive outcome of this need for co-operation and a direct involvement in the treatment of their domestic 'waste' was a consciousness of water use, and environmental impact of that activity, among Japanese housewives that was less apparent or vocal among Australian householders at that time. Citizen action was sometimes supported by local government environmental education campaigns under the direction of the National Environment Agency (Pers. comm. Inoue April 1993).

One Tandoku Johkasou that was examined in Numazu had scraps of toilet paper at the outlet and the discharge was discoloured and odorous (Pers. obs. April 1993). Six people were using the system which was 11 years old and had not been desludged for nearly two years. The users' explanation was that soon they would be connected to the sewerage system being built at Hara. The connection fee to the sewerage is dependent on the area of land owned by the householder (200 yen per square meter) as it is considered that being connected to the sewer significantly raises the value of the property. The users of the faulty Johkasou, who owned a relatively large property did not want to spend money replacing or maintaining the Johkasou when they would soon be paying a high connection fee to the Hara sewerage plant (Pers. comm. Fukasawa April 1993).

Unfortunately, the Kanogawa Sewage Treatment Plant at Hara would not be completed for at least another three or four years. Sewers and mains are currently being constructed but may not be connected to the householders until 2003 (Pers. comm. Ishida April 1993). The plant is being built to treat the sewage from two cities and three towns. Sixty per cent of the population of Numazu, which is one of these cities, is currently serviced by Johkasous, predominantly of the Tandoku type, treating only black water. Because the region is "soon" to be sewered subsidies for Gappei Johkasous are unlikely to be requested or provided and so the ongoing resultant pollution from grey water will justify the sewerage treatment works. This kind of confusion among planners, managers and the public about the respective roles of on-site and centralised treatment needs to be resolved in an altruistic and non-competitive way. While the Ministry of Construction is politically indebted to major construction firms, unbiased re-assessment and integrated least cost planning may not always be possible (Pers. comm. Mori 1993).

6.2.1(v) The dominant paradigm

The construction of the Kanogawa sewerage system is typical of the considerable public works that are being undertaken outside the major metropolitan areas, to replace existing on-site treatment. The plant will include primary sedimentation tank, aeration tank, final sedimentation tank, sand filter, digesters, sludge dewatering machine, pumping station and offices. Effluent that passes through the sand filter will be re-used as cooling water in an aeration machine. Two large stormwater storage tanks are being installed on-site (to prevent flooding of open drains due to reduced absorbency resulting from concreted site), and two bores are being sunk below the water table to provide water for the plant.

The activated sludge treatment plant will handle domestic as well as some industrial effluent, i.e. from small factories that cannot afford their own pre-treatment. After some years of operation it will be necessary to build an incinerator to dispose of the sludge. While the local residents had reluctantly agreed to the plant because it would provide protection to the environment, they were not aware an incinerator would be a later addition (Pers. comm. Ishida May 19, 1993).

The 10 hectare construction site is located in the middle of paddy fields at the base of Mt Fuji, fed by a small spring of potable water still operating out of bamboo pipes (Pers. obs. April 1993). The Prefecture bought the site from the farmers. Farming land in Japan, particularly rice fields is extremely expensive and reluctantly relinquished. When it was suggested by the author that effluent from the treatment plant, (which does not include de-nitrification), be used in the paddy fields, Mr Ishida, Director of Shizuoka Construction Office for the Japan Sewage Works Agency who is in charge of the Kanogawa operation, explained that rice is the basic food of the Japanese and it would not be appreciated to flood the fields with treated effluent. It was pointed out by the author that excrement from the Kumitori treatment plants is used as fertiliser and this is a traditional practice in Japan. Mr Ishida replied that it is not necessary now as good chemical fertilisers are available, water is only necessary for two months in the paddy fields and too much nitrogen will stimulate green growth rather than the desired seed. The effluent from the plant will, therefore, be discharged directly into the open drain system and into the river or sea.

On the building site a Tandoku Johkasou had been installed at the construction office. It was designed to accommodate 10 people. Although it treats the effluent from his office toilet, Mr Ishida had not been aware of its existence until questioned as to current site sanitation methods. On inspection of the Johkasou, the sedimentation tank did not appear to be working and scum was floating to the top. The aeration tank which is operated by electricity was serving only to bubble the untreated brew. The disinfection container was empty, and the final separation tank did not appear to be working. The effluent discharged into a nearby open drain that passed through adjacent paddy fields (Pers. obs. April 19, 1993). An electrician who did not provide his name, reported to the author and Mr Ishida that the Johkasou had not been serviced for "over a year'. Mr. Ishida commented that Johkasous were "responsible for a large proportion of pollution" and although he used one in his own home, he did not approve of them (Pers. comm. Ishida April 19, 1993).

When asked what he considered was the biggest problem with sewerage treatment Mr. Ishida replied that there was lack of trained staff. Japan Sewage Works Agency train 1 100 men (there is a noticeable absence of women in the Japanese sewerage industry) every year but this was not sufficient because so much sewerage construction is needed. People were also moved on every few years from sewage to road work to buildings to dams or some other public works within the Ministry of Construction. Apart from this obstacle he saw no problems with the concept or impact of sewerage treatment (Pers. comm. Ishida April 19, 1993).

6.2.1(vi) Relevance to Australia

Centralised Sewerage Planners in Japan state that sewerage system maintenance is cheaper, and more consistent than on-site treatment and provides much improved environmental protection (Fujiki 1992: 2) and on the face of it, this may seem to be so. However, if both treatment systems were provided with funding, research and supportive institutional infrastructure equivalent to the population they serve, and then assessed for environmental impact, a more valid evaluation could be made. These principles could also be applied to the Australian context to enable a balanced investigation of the relative current and potential value of on-site and centralised reticulated treatment.

If the existing need for high standard on-site sanitation is to be recognised in Australia and appropriate institutional support for on-site sanitation is to be set in place, then it is important that certain matters are attended to from the outset, such as:

- administrative jurisdiction is clearly defined,
- inequitable or preferential funding strategies are avoided,
- the public and administrators are fully informed of the options,
- decentralised sanitation operators and regulators have a clear mandate for implementation.

6.2.2 Need for simplified administration of on-site sewage treatment

It is difficult to disentangle the issue of administration from the political and social forces in Japan that have been alluded to in the preceding paragraphs. The management of sewage and water in any country is inextricably linked with the values and power structure of its society, so to select one aspect and try to analyse its relevance independently of other factors is an artificial exercise which only partly assists clarification. However, this analysis will be attempted.

Although Japan is a far more densely populated country than Australia with a much greater population, the strong central government could provide more scope for a simplified approach to on-site treatment than may be possible, given the independence of the States in Australia. To some degree cohesive administration has been achieved in Japan under the umbrella of the Ministry of Health and Welfare for the privately used Johkasou but further development requires a resolution of the Gappei's uncertain status. This situation is even more highlighted in relation to the large scale 'community' Johkasou where there is considerable room for confusion.

> As it is usual for co-ordination to be made between projects, that is, public sewerage and community Johkasou only when they have reached the implementation stage, there is an increasing number of inefficient cases. For example, one situation where a public sewerage and community Johkasou were installed adjoining each other (Fujiki 1992: 7).

This lack of communication is partly due to the covertly competitive, and in some situations, mutually threatening positions of the Ministries, departments and related industries involved in sewage treatment.

> Also, it can be pointed out as a serious problem that the administrative procedures for co-ordinating projects require a long time mostly because of the adjustment between the department in charge of public sewerage and other concerned departments in local government (Fujiki 1992: 7).

For these reason, members of the Japan Sewage Works Association, under the Ministry of Construction, plan to absorb all organisations involved with sewage treatment into a single department under their control (Pers. comm. Yamada April 1993). However this plan is not likely to be accepted without resistance by the Ministry of Health and Welfare, or the Ministry of Agriculture, Forestry and Fishery and their umbrella organisations.

While a central authority and a simplified uniform code of management would certainly facilitate ecologically effective use of Johkasous, that central authority should be well informed as to the potential and benefits of on-site treatment and be given the necessary mandate and funding for effective implementation.

There are a number of private, semi-government, and government research and development organisations contributing to the body of knowledge relating to Johkasous. These include the Industrial Water Study Committee (Tsuchiya et al. 1980), the Japan Building Center (1980, 1981), the Studying Association on Rotary Disk Technique (1978), the Japan Education Centre of Environmental Sanitation (Baba et al. 1993), and the Johkasou Affairs Management Office (Sakurai et al. 1993) which are under the Ministry of Health and Welfare. There is also the Public Works Research Institute of the Ministry of Construction (Hasegawa and Nakamura 1991), the All Japan Private Sewerage

Treatment Association (Shibayama et al. 1993), and the many small businesses associated with the construction and maintenance of Johkasous.

A clear definition of the areas where on-site treatment will be installed and/or sustained is a prerequisite for effective implementation. To this end, Mr Fujiki, Assistant Director, Sewerage Planning Division, Sewerage and Sewage Purification Department of the Ministry of Construction presents an

> Outline of Prefectural Masterplan of Sewage Treatment. The content of this plan is 1) treatment zoning of public sewerage and individual/community Johkasou 2) schedule of implementation 3) sludge collection, treatment and disposal and 4) a facility maintenance and operation schedule (Fujiki 1992: 7).

Mr Fujiki states that this plan should be coordinated by

> public sewerage department to include close interaction with Johkasou and agriculture departments (Fujiki 1992: 8).

While the plan is a useful idea, the suggested co-ordinator once again assumes that the Ministry of Construction is the supreme authority in sewage treatment.

Another approach is provided by the Japan Education Centre of Environmental Sanitation where research is being conducted to establish guidelines for choosing what systems are most appropriate for an area by examining a wide range of economic, social and environmental considerations. These considerations include ease of management, lifetime of service, pollution during construction, availability of land, impact on living environment, and the effect of using a particular system on the consciousness of residents as to their understanding of the water cycle and their relationship to the wider human community (Baba et al. 1993: 762).

It is suggested that a co-ordinating body should be formed that includes representatives from all interested parties,

> establishing a consistent organisation, including government, local self-government, residents, services, education and research institutes (Sakurai 1993 et al. 1993: 767).

It is considered particularly important that uniform training is provided to the licensed technicians who are contracted to install, maintain and inspect

Johkasous. Currently there are a number of training institutions and different types of licences for the same duty classification. This can cause confusion with residents and between the respective administrations (Sakurai et al. 1993: 769).

Research has been conducted to establish guidelines as to which kind of Gappei Johkasou is suitable for particular applications (Shibayama et al. 1993: 771). Information such as this and all the other relevant research and experience would be most effectively utilised within an impartial central co-ordinating body. To realise this possibility certain political issues need to be resolved. Mr Mori from the Japan Environment Agency said that this would not happen "while Japan remained a one party government as it has been for the last 40 years, and that party is run by big business". He explained that local construction firms are dependent on subsidies from government especially the Ministry of Construction. Politicians will be on the Board of Directors of these firms when they retire so continue to support them by directing considerable funding into sewerage development (Pers. comm. Mori May 1993).

Mr. Mori regards Japan as remaining feudal in the sense that government and professional positions are passed down from father to son thus maintaining a self interested power block. Despite the rhetoric, environmental protection is a low priority. Mr Mori had recently spent many late nights in parliament while environmental legislation was watered down to suit the reigning party (Pers. comm. Mori 25/5/1993). Since that interview the Liberal Democratic Party was replaced by a Coalition Party in the July 1993 elections, which may indicate the potential for change in Japanese political power structures and priorities.

6.2.2 (i) Relevance to Australia

From the complexities described in this section, it appears that an infrastructure in support of decentralised sanitation requires an effective network of communication both internally and with traditional sewerage administration, a uniform code of management, clear definitions of where on-site sanitation is installed and will be sustained, and guidelines for choosing the appropriate technology based on economic, social and environmental considerations.

6.2.3 The problems of disposal of Kumitori and Johkasou sludge

Another challenge faced by Japanese managers of on-site treatment is the treatment and disposal of the solids from on-site treatment. This is, of course, a problem also faced by centralised sewerage treatment managers particularly in Japan where there is acute shortage of land for disposal (Oshima 1990: 48). Effective sludge or 'biosolids' disposal is a critical consideration when discussing the relative value and potential application of centralised and on-site sewage treatment.

Excrement from Kumitoris and Johkasou sludge is removed by vacuum trucks and transported to a municipal treatment plant (see Figure 6.3). The 'Eisei' plant is exclusively used for the treatment of Kumitori products and Johkasou sludge. Often it is located adjacent to the Municipal sewerage treatment plant.

FIGURE 6.3

Vacuum removal of Johkasou sludge

Information as to the ultimate disposal method of biosolids was often difficult to acquire. It was observed in some interviews with sewerage personnel, that staff were keen to reflect what is perceived as the views of the "Western observer". It often took some time to ascertain their genuine position on a sewage issue, either as individuals or when expressing department policy. This caution may be an outcome of the history of co-dependent and proscriptive relations that have existed between the United States and Japan (Pers. comm. Shiba M. May 1993). It may also be compounded by the exclusive view of sewage treatment options that the Western sewerage industry has presented to Japan. For example, sometimes it was reported that Eisei sludge was dumped until it was ascertained that the author was sympathetic to recycling, then they would 'admit' that it was used as fertiliser. On other occasions it was assumed the author favoured hi-tech solutions to pollution so the latest 'end of pipe' innovations would be proudly demonstrated.

6.2.3(i) Fujinomiya sewage treatment plants

The Hoshiyama Jouka Centre outside the city of Fujinomiya, at the base of Mt Fuji, is a sewerage treatment plant that has been designed to serve the population of this "small city" of 120 000 people. However only 30 000 residents were connected to the plant because of the cost and difficulty of laying sewers. Certain adjustments, such as a low volume chlorine pump were installed to attempt to accommodate the much reduced influent flow rate relative to design capabilities (Pers. obs. May 1991). According to the local government Sanitation Officer, Mr Takahide Watanabe, it may be 100 years until Fujinomiya is fully sewered. Approximately 141 km of pipe had been laid to date. In the meantime, 90 000 residents were using on-site treatment and 60% of those were using Johkasous, 800 of which were Gappei Johkasous which attracted a 2/3 subsidy from City Hall. Gappei Johkasous cost 700 000 yen. The Municipality can only afford 40 subsidies a year. Forty per cent of the 90 000 people not connected to the sewers use the Kumitori (Pers. comm. Watanabe T. May 1993).

The sewerage treatment plant was expensive to build and is costly to run. It consumes 1/3 of the Municipal budget. One of the high running costs is sludge disposal. Sludge cake is trucked 300 km to Gifu and dumped on the side of a mountain. It costs 47 million yen per year to transport the sludge cake, i.e. 15 000 yen per tonne. The construction of the sewerage treatment plant was 2/3 subsidised by the Ministry of Construction (Hamada 1990: 32).

It is this considerable subsidy which often influences Municipalities to choose sewerage treatment as a method of sanitation (Pers. comm. Fukasawa T. May 1993). The subsidy is paid to private construction companies to undertake the project.

The Eisei plant, adjacent to the sewerage treatment plant, was built by the Municipality with a relatively small subsidy from the Ministry of Health and Welfare. Running costs are covered entirely by the Municipality. The plant was originally designed to treat the Kumitori excrement, but with the increasing use of the flush toilets, the sludge emptied annually from the Johkasous was also treated there. This has created problems because

> the quality of Johkasou sludge is different from that of collected human excreta. If the proportion becomes higher in their combined treatment, care must be taken of it, and sometimes their separate treatment is necessary to meet the effluent quality regulations (Magara & Kunikane 1989: 373).

The strength of Johkasou sludge is weaker, the average concentration of suspended solids is about 30 to 60% that of human excreta, and BOD and nitrogen concentration is lower.

> Typical examples of adverse effects are as follows. Both the production rate and the energy potential of the digester gas are decreased and eventually auxiliary fuel is needed to keep the digester at an appropriate level. BOD concentration of the digester supernatant is decreased and the quality of the final effluent becomes worse due to underloading to activated sludge process. Biological denitrification process is also faced with a more serious adverse effect on the activities of nitrifying/denitrifying bacteria due to shift of the BOD/ nitrogen ratio of the influent from the design condition (Magara & Kunikane 1989: 381).

The installation of a storage tank in which the Johkasou sludge is gravity thickened for 3 days to a similar concentration as raw human excrement regulates flow and characteristics. This prevents the material disturbing the primary digestion process when mixed with Kumitori excrement. The slurry is also acceptable to the secondary activated sludge process. Adjustments in process have to be made according to the percentage of Johkasou sludge to Kumitori nightsoil (Magara & Kunikane 1989: 385). As flush toilets become the accepted norm, the input of sludge increases. The higher the percentage of sludge the more costly and complex the adjustment. The Eisei plant at Fujinomiya and more than 20 other Eisei plants in Japan have managed to make those adjustments but the manager, Mr. Mitutaka Watanabe, considers the plant too expensive to operate. He therefore prefers centralised sewerage treatment which is financed 28% by user rates, national government subsidy and City Hall. As previously mentioned sewerage treatment consumes 1/3 of the Municipality's annual budget (Pers. comm. Watanabe M. May 1993).

The annual maintenance cost for the sewerage treatment plant averaged over 1990-92 was 273 million yen (Jouka Centre Budget Report 1993). This plant serves 25% of the population. The users of Kumitori and Johkasous pay to have their systems emptied but this money goes to the contractors who transport the material to the plant. The Eisei plant is maintained by the Municipality from local taxes. The plant cost 147 million yen to operate in 1991 and 160 million yen to operate in 1992: 35 million yen to the seven staff; 35 million yen for chemicals; 30 million yen for electricity; 10 million for oil (fuel); and the remainder for maintenance (Eisei Plant Budget Report 1993). This plant serves 75% of the population.

Because the influent to the Eisei plant is relatively untainted by toxic material such as heavy metals, the end-product is an acceptable fertiliser for farmers. The sludge is dried at 85℃, and the plant pays for it to be delivered to the farmers free of charge. Approximately 120 tonnes per day of influent is treated at the plant. Five tonnes of rubbish per week is screened from the Kumitori 'nightsoil', trucked 13 kilometres to the City Hall Gomei plant, mixed with domestic rubbish, incinerated and buried. Two tonnes per day of sludge is delivered to farmers 239 days a year. The plant is operated by seven people during the day and automatically at night (Pers. comm. Watanabe M. May 31, 1993).

Further complications with treatment were arising with the use of the Gappei Johkasou. The presence of oil and other substances poured into sinks, showers, washing machines and baths will require more research to develop treatment for the Johkasou sludge. When asked would it not be simpler to treat the Kumitori night soil and the Johkasou sludge entirely separately, instead of compromising the treatment of the former with the addition of the latter, the Manager said construction of separate plants would be too expensive and that he looks forward to the day when Fujinomiya is sewered because that is the "perfect system" (Pers. comm. Watanabe M. May 31, 1993).

The treated effluent from both the Jouka Centre[1] and the Eisei Plant drains into a concrete lined creek that connects at the end of the valley with one of the rivers that flows from Mt. Fuji. The region is known for its "pure" rivers constantly fed by the melting snows from 3 740 m of magnificent mountain presence.

6.2.3(ii) Tondabayashi sewage treatment plants

Tondabayashi is another "small city" on the outskirts of Osaka, the second largest metropolitan area in Japan. The local sewerage treatment works serves 374 000 people. The adjacent Eisei plant serves 158 655 people, 35% of whom are using Kumitoris and 65% are using Johkasous.

The manager of the Eisei plant, Mr Rikuta Matsui, is proud of the fact that the Tondabayashi plant has the lowest running cost in Japan. The plant treats 272 kl of material per day. Methane gas from the plants' process provides all energy used in treatment. Magnesium ammonium phosphate extracted from the effluent by adding MgCl, is sold to fertiliser companies for 20 000 yen[2] per tonne. Approximately 20% of the sludge is composted and transported free of charge to public gardens and schools. The remainder of the sludge is supplied to farmers within 100 kilometres of the plant (see Figure 6.4). The running cost is 800 yen per cubic metre. Most Eisei plants run at 2 000-4 000 yen per cubic metre. The ratio of Johkasou sludge to "nightsoil" was being regulated by holding tanks and other innovations and did not seem to be causing any serious problems (Pers. comm. Matsui May 1993)

Users of Kumitoris paid 150 yen per person per month to have their vaults emptied, and Johkasous users paid 10 000 per year for emptying and cleaning their systems. These fees are paid to the contractors. The plant was operated from City taxes.

Despite the efficiency and environmentally sound performance of this plant, Mr Matsui informed the author that the extensions to the adjacent sewerage

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[1] Jouka Centre: treatment plant for sewage from a centralised sewerage system.

[2] At the time of the Japan field trip in 1993, one Japanese yen was equivalent to approximately seventy two Australian cents.

plant were being constructed to service the whole district and the Eisei plant would eventually be phased out. During a discussion preceding the inspection of the Jouka Centre and the Eisei plant, the former installation was presented by the Mayor as far more important than the Eisei plant with particular attention being drawn to the incinerator for burning sewage sludge (Pers. comm Uchida May 10, 1993).

the flow sheet of this night-soil treatment plant

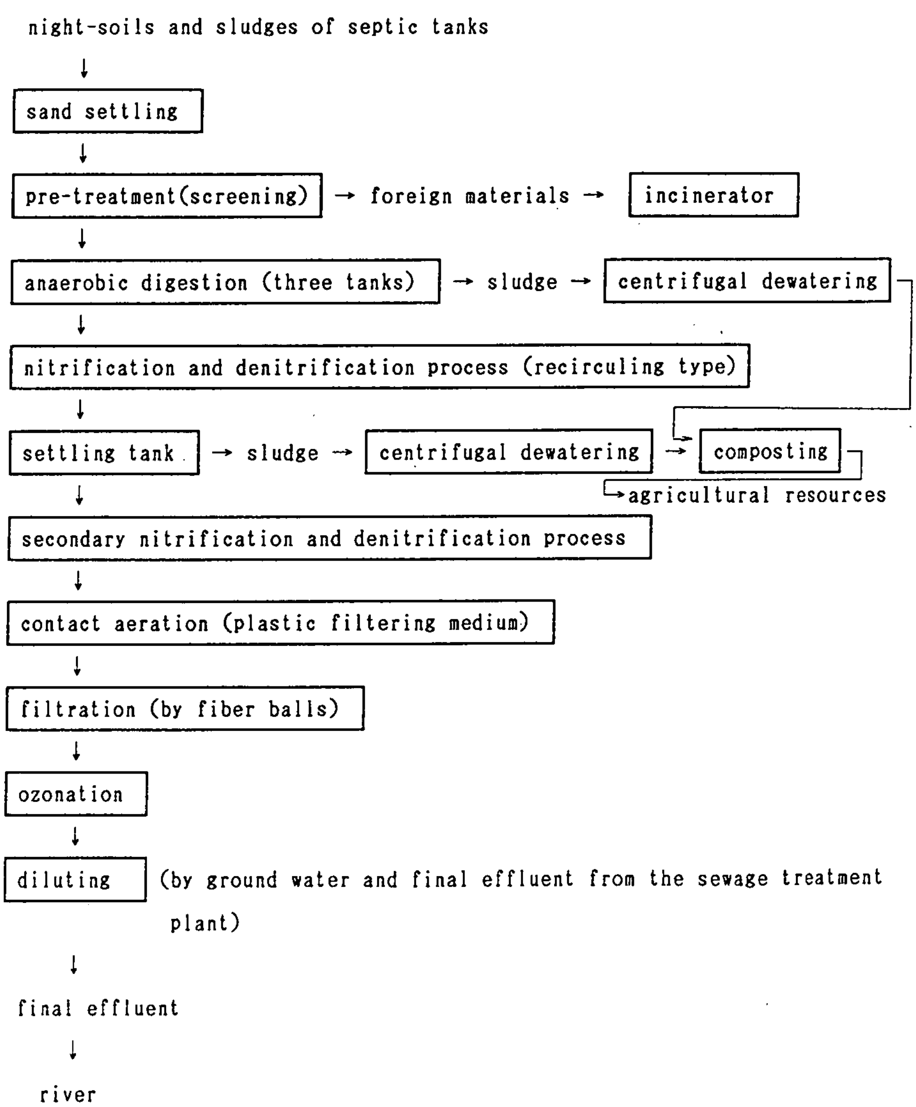

FIGURE 6.4

Night Soil Flow Chart (Pers. comm. Matsui May 1993).

Incinerators of the kind installed at Tondabayashi use about 2 000 kWh/day electricity and 123 000 Mcal/day fuel consumption although research is being conducted to supply some of this energy with gas from the sludge digestion process (Kanedo 1992: 43). Incinerators are increasingly a preferred option for sludge disposal in Japan for a variety of political, practical and economic reasons. While environmentalists could argue that Eisei plant sludge disposal completes a low impact method of sewage treatment beginning with inexpensive on-site treatment, and provides a safe method of recycling nutrients with all the attendant benefits, sewerage system advocates present incineration as a more economical long term solution to Japan's sludge disposal problems. In response to the criticism regarding the environmental impact of sewerage treatment, a number of composting units have been installed at Jouka Centres to treat and recycle sewerage sludge. However, in most cases their value is compared negatively with incineration.

For example, Masatoshi Yamada, Senior Environmental Engineer with the Japan Sewage Works Agency, explained that composting of sewage sludge from either Jouka Centres or Eisei plants has limited usefulness in Japan. He considers that there is no problem with the process technically but there is insufficient demand to justify the installations. Young people are moving to cities and old people remaining on the land find it difficult to use compost fertiliser. Mr Yamada suggests it is much more efficient for them to use chemical fertiliser. Although sludge and compost from Eisei plants is relatively free of toxins, Johkasous in the country are administered by the Ministry of Agriculture and Welfare and the Ministry is more likely to authorise the composting of farm manure and crop residues before sewage sludge. In addition, cost of labour is high in Japan and if 'middle men' are used to create a market then any profit from sale of the compost would be absorbed. It is therefore more profitable to sell directly to the farmer, but Mr. Yamada reports that not many farmers are interested. Deodorising the composting process is an expensive priority because of the close quarters of residents even in rural districts (Pers. comm Yamada April 1993). Composting installations in Japan are under cover in highly mechanised plants, unlike the composting of 1/5 of Sydney's sewerage sludge at Badgerys Creek which takes place in windrows exposed to all weather (Pers. obs. 1992-1993).

6.2.3(iii) Kofu sewage treatment plants

Another point of view was expressed by Satoru Hosaka, Water Quality Supervisor at the Kofu Jouka Centre and Sludge Composting Facility in the rural district of Yamanto Prefecture. The Kofu sewerage treatment plant receives 80 cubic meters of influent per day which generates 40 tonnes of sludge. Approximately 22 tonnes are incinerated and 18 tonnes are composted. Mr. Hosaka said that compost from their facility is in constant demand from farmers, orchardists and market gardeners. The area is famous for its grapes, peaches and strawberries and the proximity to Tokyo facilitates transport of produce (Pers. comm. Hosaka May 1993).

The compost is bought by growers from the Facility for 320 yen per 20 kilogram bag. It costs the plant 1 500 yen to produce and 300 yen to deodorise a 20 kilogram bag. The process uses 6.23 tonnes of sawdust per day which is mixed with 19.34 tonnes of sludge and 11.01 tonnes of 'seed sludge' to produce 400 twenty kilogram bags a day, 150 000 bags a year. The mix is treated in the first "reactor" for 14 days at 80-75°C, then for 60 days at 60°C. In the second reactor the compost is turned 2-3 times in 2 months. The Facility is entirely mechanised. When it was suggested that more be charged for the compost, it was pointed out that the duty of City Hall is to serve the people and it is an advantage to the Jouka Centre that the people take the residue away (Pers. comm. Amemiya May 1993).

Despite the constant demand for compost, the Municipal Office wishes to close down the Composting Facility because of high running costs. It is preferred that all sludge is incinerated. It cost 20 billion yen to build the incinerator. This was constructed through the Japan Sewage Works Agency with a subsidy from the Ministry of Construction. The incinerator can burn 50 tonnes of sludge a day operating continuously for 24 hours. The ash is then transported to neighbouring Shizuoka Prefecture to be dumped at 33 900 yen per tonne. When the incinerator is out of action for maintenance the sludge is dumped for 27 000 yen per tonne. The running costs of the incinerator are less than the Composting Facility (Kofu Jouka Centre Annual Report 1993: 2).

Mr Hosaka said that he would prefer not to see the nine year old Composting Facility close but,

> money talks in Japan and short term results are important. America forced us out of our old ways into economic boom. Some changes were good but we lost our traditional Japanese farming methods of recycling to the soil. Now it is obvious that environmentally there are many problems but Japan is twenty years behind in re-thinking (Pers. comm. Hosaka May 1993).

Mr. Yamaki, the General Manager of the Jouka Centre and Composting Facility stated that recycling is very important to him and his staff, "but there is a strong lobby to change to incinerating because running costs for City Hall would be less expensive". High operation costs include sawdust at 2 650 yen per cubic meter and operation of the scrubbers, packing machine and the blowers on the first reactor. He explained that the composting facility must be so highly mechanised because of limited land space, and the cost of labour (Pers. comm. Yamaki May 1993).

In Japan, 6 million tonnes of sludge are generated per year from sewerage treatment works, and some authorities consider incineration the best option given limitation of space for dumping the residue particularly as it is intended to sewer all urban environments in Japan as soon as possible (Uchiyama 1990: 62). Approximately 75% of the ash produced from incinerating sludge is used as landfill (International Committee 1991: 71), and 25% is combined with ash from incinerated Municipal garbage to "reclaim" land in water bodies such as Tokyo Bay (Pers. comm. Koubayashi June 1993). Examination of emission and ash analysis records from the Shizuoka incinerator indicate low residues of toxic substances (Suzuki 1993: 1-10). Incineration and dumping of ash is therefore considered the least polluting of sludge disposal methods (Pers. comm. Suzuki May 1993). Although emissions from incinerators are currently well within standards, air pollution laws will become more stringent in the next ten years and then incineration costs will escalate (Pers. comm. Ishida April 1993).

Mr Takashi Ishida, Director of the Shizuoka Construction Office of Japan Sewage Works Agency was trialing a sewerage treatment composting facility at Nazu, a hot springs resort town north of Tokyo. His project was much less mechanised than most composting systems and was enclosed in a glass house. It was costing considerably less than incineration and landfill. It did not use blowers and the blending machine only operated two hours per day, using wood shavings and saw dust (Ishida 1993:2). The volume of residuals was reduced by half and temperatures were registering in the 60s°C in the early stages. There should only be domestic sewage entering the Nazu sewerage plant, therefore the sludge would be suitable for fertiliser.

Mr. Ishida explained that <u>sale</u> of the compost is an extra benefit, the main goal being to provide inexpensive disposal of sludge. He had researched this issue for ten years and favours incinerators for large regional plants, and composting for plants that produce up to 10 000 cubic meters of sludge per day. Sludge production from small plants is intermittent, so use of large trucks is impractical and small trucks too costly, so composting would be good for these plants (Pers. comm. Ishida April 1993).

Mr Toshio Amemiya, Electrical Engineer at the Jouka Centre and Sludge Composting Facility at Kofu said there were problems of mercury, copper and zinc in stormwater occurring in the plant's sludge. Their presence in the compost was consequently increasing levels in the farmer's land. When it was suggested that composted sludge from the 40% of the Kofu population that use Johkasous and Kumitoris would be relatively free of heavy metals and therefore a reliable source of fertiliser, Mr. Amemiya agreed but said that City Hall could not afford to build a composting facility at the Eisei plant at the moment (Pers. comm. Amemiya May 1993).

6.2.3 (iv) Tokorozawa sewage treatment plants

The composting facility at Tokorozawa, which is an outer city of Tokyo, was built 10 years ago. The composting process was enclosed within a vertical or silo reactor, was entirely mechanised and produced 1.5 tonnes of compost per day after a 10 day fermentation period in the reactor. The facility composted 12% of the sludge produced by the adjacent Jouka Centre. (20% of the sludge was incinerated and the remainder was transported 120 km to a private composting company). One part sludge cake was mixed with two part 'seed' compost and 5% coarse wood chips. The wood chips were bought from a local agent for 7 000 yen per cubic meter. They were imported from Malaya and Australia. The compost was provided free of charge to organic farmers. There was no industry in the collection area, but there may be "minimal pollution from stormwater" in the sludge (Pers. comm. Nishitomi May 1993).

Mr. Mamoru Nishitomi, the Co-ordinator of the Operation and Maintenance Section of the city's Sewage Works Department, said, at first, that he thought it was not a good idea to compost sludge in a city area because the process was too expensive especially deodorising, and, therefore, incineration was preferable. City Hall was considering enlarging the incinerator and abandoning composting despite constant demand from the farmers for the compost. On suggestion that a simpler plant would be cheaper, he said that there was no room on the site to build a simpler horizontal plant. After further discussion Mr. Nishitomi acknowledged that from an environmental, and therefore long term economic, perspective composting the sludge was preferable and that there was plenty of room on site for expansion but that City Hall was reluctant to bear the cost of composting. He indicated that the original plan of the site anticipated expanding the composting facility, but that the current reactor, which had been commissioned by Japan Sewage Works Agency was too expensive and complicated to operate and maintain, and needed replacing with another design.

6.2.3(v) Yamata-Takada sewage treatment plants

Sewage from the semi-rural town of Yamata-Takada (sister city of Lismore in NSW, Australia) in Nara Prefecture is piped 15 km to the Upper Yamato River Basin Jouka Centre. Approximately 35% of the population of Yamata-Takada was sewered and the remaining 65% use Kumitori and Johkasou. The Jouka Centre was being expanded to eventually serve 1.5 million people over 4 000 hectares, which would include all of the population of Yamata Takada and a number of other towns. Seventy per cent of the sludge from the local Eisei plant was dumped into the sea and the remainder was transported to the Jouka Centre for incinerating. In reply to a suggestion that a composting facility at the Eisei plant could be useful to local farmers to provide minimally contaminated fertiliser, Mr. Hiroyasu Masada, Planning Officer from City Hall said that there would be no point in providing such a facility as it is planned that eventually most of the area will be sewered (Pers. comm. Masada May 1993).

6.2.3(vi) Relevance to Australia

Hi-tech responses to the biosolid disposal crisis in Japan predominate. However, independent research is being conducted in Japan to provide inexpensive biological treatment of Kumitori excrement and farmyard sewage (Pers. comm. Koiwai May 1993). Masaaki Koiwai, a microbiologist with Natural Agriculture Pty Ltd and co-researcher with Dr. Higa at the Ryukyu

University in Okinawa, described EM as an "effective microbe" compound which will reduce excrement to an effective fertiliser within a couple of weeks. Pathogens are said to be destroyed by lactic acid in the compound (Higa 1988: 3). The use of EM is being trialed on a farm on the North Coast of New Wales and was to be part of the dry conservancy trials in this PhD research. Due to lack of available time it will be a post doctorate project.

Australia does not have the critical shortage of land for biosolid disposal that plagues Japanese sanitation managers. However, sludge disposal is a serious area of concern as reflected in the activities of the Sydney Water Board division devoted exclusively to research in this field (Pers. comm. Fahy July 1994). The economic, environmental and social implications of biosolid disposal must be included in any comparative study of the relative merits of centralised and decentralised sanitation techniques.

6.2.4 The requirement to provide adequate treatment of grey water

The most convincing argument for the replacement of on-site sewage treatment with centralised sewerage treatment, in Japan, is the pollution caused by grey water. While installation of well maintained Gappei Johkasous can rectify this situation, the current cost of the Gappei and limited subsidy could cause planners and the public to choose sewerage installation despite the inevitable delay. This attitude also means it is inevitable that all Kumitoris must be replaced by water borne treatment. From a conservation point of view, this is not necessarily the most sound strategy.

Mr. Yakuro Inoue, Deputy Chief of the Design Section in the Planning Division of Japan Sewage Works Association defines the primary goal of sewerage treatment as "the improvement of water quality". When told that there was some movement in Australia toward on-site treatment as an environmentally protective alternative to sewerage systems his opinion was that secondary sewerage treatment was a preferable solution. Mr. Inoue said that primary treatment has been extended to secondary level in all Japan's sewerage systems and he was surprised that many Australian plants still had only primary treatment (Pers. comm. Inoue April 28, 1993).

Treatment of grey water to accompany the use of Tandoku Johkasous and Kumitori could be partly alleviated by source control. Environmental groups and 'Activist Housewife' groups in Japan certainly advocate conservation practices. These efforts are viewed sceptically by Mr. Inoue who says that education programs discouraging the use of phosphate based detergents have to be approved by all housewives, before implementation, or they have no impact. Companies are starting to make non-phosphate based detergents but "shampoo was still a problem" (Pers. comm. Inoue April 1993).

Children are taken to treatment plants for education regarding additives to domestic water, however the goal of government sponsored education programs is primarily to demonstrate the benefits of centralised sewerage treatment.

> The present status of sewage (sewerage) works in Japan as a whole is considerably backward compared with those in developed countries. One of the important steps to be taken for breaking through the present status will be to get the concept of sewage works correctly realised by the general public...people have tended to understand more about sewage works in recent years but not to such an extent as to thoroughly recognise their value and the role. For promoting such a recognition, it will be necessary to aggressively promote the popularisation and public education campaign (Takahashi 1992: 50).

A similar campaign regarding the benefits of on-site treatment could highlight the need for responsible source control. The use of coconut oil based detergents as advocated by the Shizuoka women's' group, grease traps, recycling systems and filters are some of the measures that could reduce pollution from grey water. Research is being conducted into other solutions (Pers. comm. Ohmori April 1993). On-site treatment always requires more active responsibility by the individual for environmental protection and necessitates an ecological awareness of the water cycle.

By the use of a common effluent drain (CED), it could be possible to provide drainage for grey water and run-off from Tandoku or Gappei Johkasous to flow through a regional nutrient removal plant. This would require minimum diameter pipes and minimum slope, due to reduced solids, and much less expensive treatment. Mr. Etsuji Sugano, Executive Planning Officer with the Sewage Works Bureau of Osaka Municipal Government argues that in high rainfall Japan stormwater has also to be controlled which necessitates a large pipe system. In that case he considers that it is more efficient to collect and centrally treat grey water, black water and storm water in a combined system (Pers. comm. Sugano May 10 1993). Combined sewer systems are advocated for the following reasons:

> The advantages are lower construction costs, shorter construction periods, greater flexibility in work execution beneath roads where other underground structures exist, and the capability of making use of existing pipes buried for flood control, etc. (Furasawa 1992: 18).

But the problems of untreated sewage discharged during high rainfall are causing some to advocate separate systems (Kato and Hara 1990: 71).

Another solution to the problems of combined sewerage systems is to install stormwater retention and to this end the city of Osaka is developing a massive stormwater drainage system.

> The plan includes the construction of 48 trunk sewer extensions, with a total length of 135km, and 24 pumping stations with a total drainage capacity of 744 m^3/s...The cost of the Project is estimated at approx. 910 billion yen...Among the facilities is the Naniwa Grand Floodway ...when completed will be one of the largest sewerage facilities in the city, with a maximum inner diameter of 6.5m, a total length of 12.8 km (trunk sewers only), a design stormwater run-off rate of 73 m^3/s, and having a cost of 98 billion yen (Yanagisako 1992: 18).

The Floodway is designed to directly drain stormwater into Osaka Bay, but will also be utilised as a retaining system to store and treat overflow from the combined sewer system (Pers. comm. Takasuke May 5 1993).

It is intended that

> the trunk sewers will be utilised in various ways, as for example, for the installation, inside the sewers, of pipes linking sewage treatment plants for transporting pressurised sludge for centralised treatment...According to the plan for improving the combined sewer system, it is necessary to prepare storage facilities with a total capacity of approx. 1 million m^3. When used as stormwater- retarding basins, trunk sewer extensions will have a storage capacity of approx. 450 000 m^3. In the Naniwa grand floodway, up to 150 000 m^3 (approx. 60% of the total storage capacity) of stormwater will be stored during small-scale rainfalls. The stormwater will subsequently be

treated and drained (Yanagisako 1992: 19).

The paradigm that created the Naniwa Grand Floodway is representative of one end of the continuum of sewage treatment in Japan (refer 6.3.1). Possibly the other extreme is the Kumitori. Both ends are quite defined, but the middle position is indistinct and confused. The application of a percentage of the innovation, funding and technology demonstrated in centralised treatment to on-site systems would surely consolidate a potentially sustainable strategy. Similarly, the individual responsibility engendered by on-site treatment, its relative simplicity of installation and management, potential for source control and comparatively low cost are all features that centralised treatment would benefit from absorbing.

The Floodway is an awesome venture economically, politically and from an engineering point of view. It makes the agonised deliberation of what to do with grey water and treated black water from houses using on-site treatment a trifling consideration. The Floodway is worth examining, at this point, along with a number of other examples of centralised sewerage system innovation in Japan, because it illustrates that where there is the will (with the necessary economic sustenance) almost anything is possible in the support of a particular paradigm.

6.2.4(i) Relevance to Australia

Recognition of the potential pollution levels of grey water and provision for adequate treatment is a pre-requisite for on-site sanitation research and development. It is particularly necessary when dry conservancy techniques such as the Kumitori or composting toilets are utilised. Composting toilets are often rejected by regulatory authorities, in Australia, because greywater treatment has not been accommodated. The Dowmus dry composting toilet was modified to become a 'wet' system to facilitate approval (Pers. comm. Cameron January 1994). The issues of nutrient removal and pathogen control must be addressed.

Despite some biological and technical complexities, improvement in technologies and strategies for treatment and source control of grey water is by no means an insurmountable problem and is already under way in the public and private sector (Pers. comm. Chiba October 1993), (ACTEW 1994: 120) (refer 5.8.4). Challenges such as appropriate grey water treatment can be overcome if the political will exists.

6.3 Innovation in support of the preferred paradigm

As has been discussed, centralised sewerage treatment appears to be the option favoured by the most powerful decision makers in Japan. And while evidence can be produced that sometimes suggests questionable motivations for exclusive promotion of this method of water cycle management, the advocates of sewerage treatment justify its application in similar terms as those used by the advocates of on-site treatment. For example Mr. Minoru Furusawa, Director General of the Sewerage Bureau in Kawasaki writes:

> Reportedly, when talking about global environmental problems, it is important to 'Think globally, Act locally'. Thus in order to hand over our only one Earth in good condition to the next generation, it is necessary for everybody everywhere to control on their own the influence which their living and production activities may exert on the environment...In terms of water environmental problems, the way to control the water environment is by people themselves through sewerage. Thus sewerage must not only be more widely spread and expanded as a water improvement measure, but also further improved qualitatively by positively attempting the introduction of advanced treatment and improving of combined sewer systems, so that the public can protect the surrounding environment by themselves (Furusawa 1992:26).

6.3.1 Naniwa Grand Floodway

One of these "improvements" would be the Naniwa Grand Floodway which was inspected by the author on May 5, 1993. It is one of the showpieces of the Municipality of Osaka, and the Ministry of Construction, through its contracting arm, the Japan Sewage Works Agency, and the Floodway's completion is intended to mark the 100 years Municipal Celebrations of the city (Yuki and Shimada n.d.: 9).

From 1979 to 1990, 78 floods have occurred, damaging 114 000 houses in every part of Osaka. The increasing incidence of flooding is due to rapid and extensive urbanisation since the mid-1960s, land subsidence, resulting from extraction of groundwater, and decreased drainage caused by deterioration of pumping facilities (Yanagisako 1992: 16). The Construction of the vertical shafts to the Floodway began in 1984 and the project should be completed by 1996 (Pers. comm. Miyazake May 1993).

The Floodway is large scale trunk sewer with a total length of 12.2 km and an inner diameter of 6.5 m at its widest point, constructed 30 m underground. As if these specifications were not challenging enough, the tunnel runs underneath the length of an urban expressway which carries 27 000 vehicles a day, 1 700 vehicles per hour in peak periods. Consequently the number of vertical shafts to the tunnel were limited to three, excavated to 33 m. In the vicinity of the shafts and tunnels are underground telephone and telegraph cables, two underground subway lines, three ground level train lines, and the foundations of two elevated train lines and one tram line (Yuki & Shimada n.d.: 10) (See Figure 6.5). The tunnel "passes through alluvial sand or sandy gravel, of which the N value exceeds 50 with groundwater pressure as high as 2.5kgf/cm^2" (Yuki & Shimada n.d.: 11). Seismic disturbance in the Osaka area are rare and minimal compared to other parts of Japan, so excavations of this magnitude are possible without the added complication of the threat of earthquakes (Pers. comm. Akio May 6, 1993).

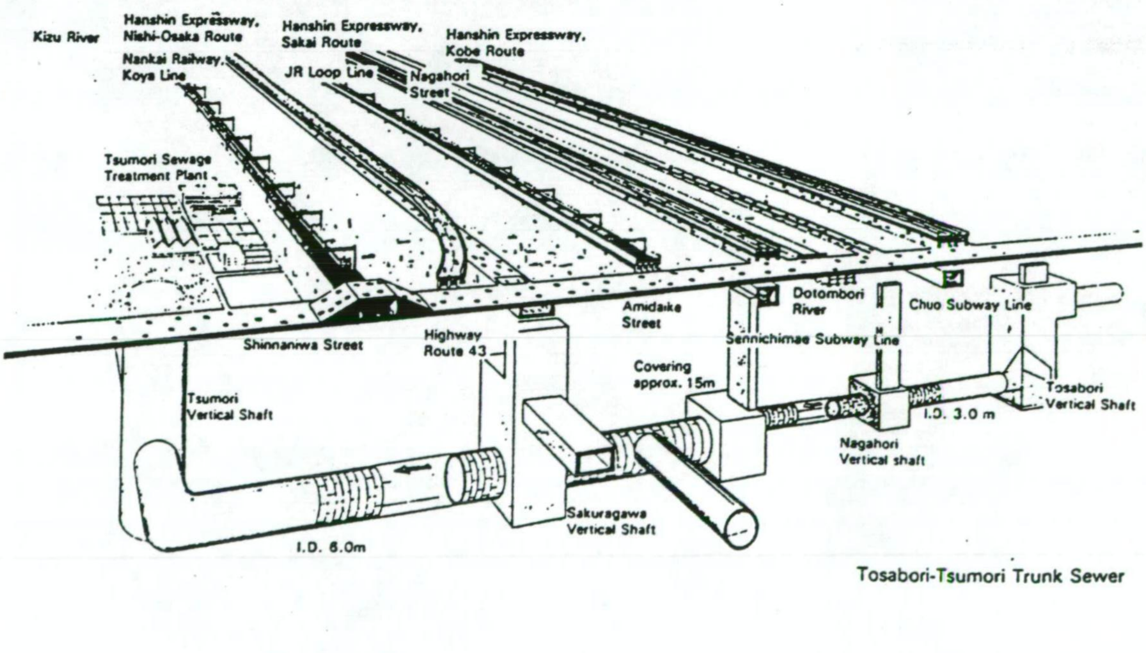

FIGURE 6.5

Naniwa Grand Floodway (Sewage Works Bureau 1990: 16).

At the time and place of inspection, the tunnel was being constructed using the "slurry type shield tunnelling machine" having an excavation diameter of 7 460 mm (Pers. comm. Miyazake May 6, 1933). The machine appeared to have many moving parts subject to wear and tear under very difficult maintenance conditions. However on inquiry, Mr. Masaji Tomihara, the Manager of Tunnel Construction for the Japan Sewage Works Agency replied that most parts are still in use after 2 years. Replacing the "cutter" is the most difficult maintenance procedure. This would require freezing the surrounding soil for a month, slurrying the soil out through the conveyer system that displaces the tunnel soil, and then replacing the cutter. Turning corners was the most difficult excavation. The machine is flexible so it bends to construct a corner (Pers. comm. Tomihara). At the monitor station above ground, staff observe, among other things, the impact of tunnelling on the foundations of a new rail station adjacent to the tunnel. At the same site displaced soil from the tunnel is dewatered and trucked to landfill (Pers. obs. May 6 1993). Where trunk lines intersect techniques such as "soil freezing" were used to facilitate connection:

> At one location, where shields of equal diameter (7.75 m outside diameter) met, the docking section of ground was frozen and the frozen ground between the two shield machines was excavated by manual labour.
>
> At the other docking location, where shields of unequal diameter met on the same axis, the shield of smaller diameter (4.44 m outside diameter) arrived first as a result of the schedule, and the shield of larger diameter (7.75 m) was driven up to it. The docking section of ground had been improved by jet and chemical grouting. After arrival of the larger shield, the intervening ground was excavated by manual labour and the two sections were connected using steel lining segments" (Miyasaki n.d.: 1).

The project is contracted to a number of joint construction companies such as 'Kajima, Hazama and Mitsui' by Japan Sewage Works Agency. Mr. Sugano said these companies "charge very big money" which is partly raised by the Municipality of Osaka through user pays charges (Pers. comm. Sugano May 25,1993). Although this technology is not unique to Japan, application to the local conditions is demanding and many complex adaptations and precautions have been undertaken (Pers. comm. Akio 25/5/1993) which are described in the references. Suffice to say that the venture reflects an extraordinary determination to provide a 'technological fix' to the inevitable problems created by developing dense urban infill on a flood plain.

Naniwa Grand Floodway is also seen by its instigators as "an epoch making point which entirely changes the concept of sewerage business carried out in the past" (Yuki and Shimada n.d.: 9). While Naniwa Grand Floodway is justifiably lauded as an example of engineering might, to view it as an indicator of sewerage technology potential further reinforces the notion of the superiority of that paradigm. In that milieu, the on-site management model with its emphasis on source control, localised treatment and personal responsibility, may be relegated to the status of a temporary and inadequate solution partly because the technology and practice is relatively simple and accessible (Bureau of Sewerage 1995: 2).

6.3.2 Multi-Story sewage treatment facilities

Another example of the political will, funding and innovation that supports "sewerage business" in Japan is the multi-story treatment facility (see Figure 6.6).

From the 1920s to the 1960s twelve treatment plants were built in Osaka City but planning did not anticipate the rapid urbanisation and rising land prices of the subsequent years. Consequently it was not feasible to buy more land to expand the plants to accommodate the increased sewage flow. Not to be deterred from the path of a centralised reticulated sewerage strategy the adaptation has been to augment the plants vertically:

> This effort commenced with the building of a two-story primary settling tank, followed by two-storey final settling tanks, aeration tanks vertically combined with final settling tanks and three-story final settling tanks. Together with the introduction of these multi-story facilities, efforts have also been made to further deepen the aeration tanks (Yuki et al. 1991: 1733).

Deepening the aeration tanks is technically and economically demanding both because of the depth of excavation required for the installation and the effect on the treatment process. However the success of the original concept of multi-story treatment has stimulated ongoing efforts and research to improve and streamline the system (Pers. comm. Sugano May 1993).

Tank depth has been increased gradually from the initial 4.5m to the present 10m, almost equal to the depth of three-story final settling tanks (Yuki et al. 1991: 1737).

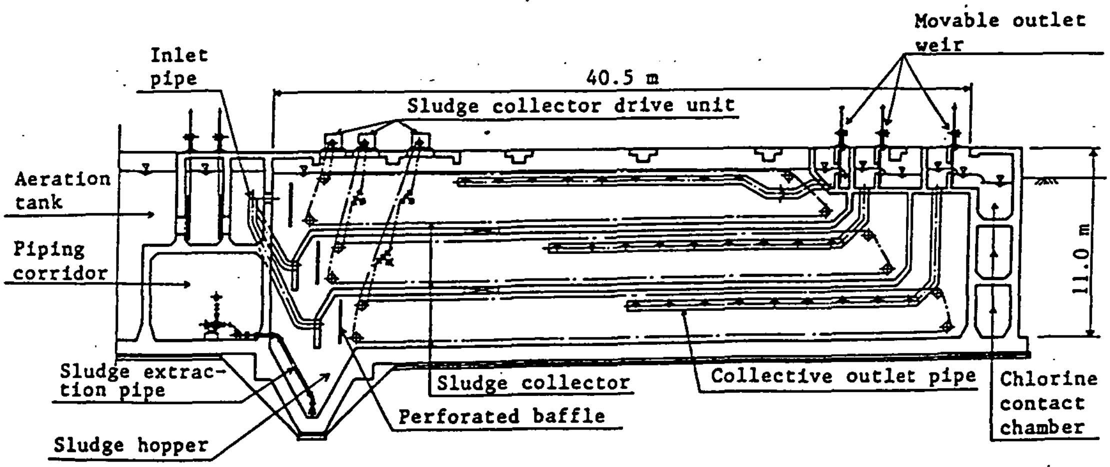

FIGURE 6.6

Three story final settling tank (Yuki et al. 1991: 1737).

The most expensive construction cost of multi-story facilities is the retaining walls and excavation which is three times that of a single-story facility. The high cost of the construction and technology of multi-story treatment facilities is favourably balanced against the cost of land acquisition for plant augmentation and the relative treatment capacities of multiple and single story installations. Mr. Enao Takayanagi, Manager of the Construction Division explained at a discussion with members of the Osaka Sewage Works Bureau that, therefore, there is no need to further promote alternatives such as on-site or demand management strategies to deal with the increased sewage flow (Per. comm. Takayanagi May 1993).

A conventional water treatment facilities comprising a single-story primary settling tank, a 4.5 m deep aeration tank and a single story final settling tank, require 164 m^2 of land area per thousand cubic metre of treatment capacity, while the combination of a two storey primary settling tank, a 10m aeration and a three story final settling tank, currently considered standard in Osaka city, requires only 76 m^2, or

> 46% of the conventional occupancy area (Yuki et al. 1991: 1741).

One of the innovations that has facilitated the development of multi-story facilities is the adaptation of outlet pipes to the particular demands of the various tank configurations, with special consideration given to maintaining regular flow. Water distribution to the upper and lower settling tanks is controlled on the outlet side rather than the inlet side.

> This is important because irregular flow, if present, causes an increase in the upflow rate in a portion of the tank and may result in suspended solids increase in effluent (Yuki 1990: 113).

Other adaptations such as collective outlet pipes have allowed vertical integration of the aeration tank, and construction of three-story final settling tanks (Pers. comm. Takayanagi May 1993).

6.3.3 ACE sludge treatment plants

As previously mentioned in 6.2.3, sludge disposal from whatever method of treatment is an escalating problem in Japan.

> The promotion of sewerage construction means increased output of sewage sludge and the total amount of sewage sludge in 1989 had expanded to approximately 244 million cubic meters. Yearly increase is expected and countermeasures must be established accordingly (Kanezashi and Murakami 1992: 33).

The "countermeasures" that have been promoted are the incineration (Ohama 1990: 106) and smelting of sludge to reduce volume for disposal (Masumoto & Furusawa 1990: 101). However these methods are expensive for construction and maintenance which burdens the Municipalities that adopt them. A solution provided by Japan Sewage Works Agency involved centralising sludge treatment from a number of different municipalities. This strategy is identified by the acronym ACE Plan (Agriculture re-use, Construction re-use and Energy re-use) and it is intended that it become the definitive or "ace" solution to sludge disposal (Pers. comm. Nakao May 1993).

The advantages of the ACE Plan are seen to be as follows:

> 1) More advanced sludge treatment technology can be used in a large scale treatment plant, as compared to that practised by single unit plants.
> 2) A stable supply of by-product is available, as it is possible to quantitatively accumulate treated sewage sludge as a resource.
> 3) The influent load of waste water treatment plants is reduced, thus enabling efficient treatment, as there are no sidestreams from the sludge treatment process.
> 4) Overall space conservation is possible (Kanezashi & Murakami 1992: 33).

and

> as the Japan Sewage Agency is undertaking the troublesome sludge treatment and disposal under the ACE plan, the local municipalities can merely concentrate their efforts on the construction and improvement of sanitary facilities other than sludge treatment plants...making it possible to build up and improve the sewer network in a streamlined manner (Japan Sewage Works Agency n.d.: 4).

National subsidies, treasury investments and loan funds covered construction costs. Loan redemption and maintenance costs were covered by the charges for sludge treatment collected from the participating municipalities. Trucks transported dewatered sludge to the ACE Centres but the plan to pump raw sludge at 1% concentration through pipes from municipal treatment plants to the ACE Centre was being implemented (Kanezashi & Murakami 1992: 35).

At the ACE Centre inspected on May 6, 1993, liquid sludge was thickened by gravity and centrifuge thickeners, dewatered by beltpress, dried, and then the cake was melted at 1500°C in a coke bed furnace (Pers. obs.). The emissions from the furnace were deodorised biologically and by activated carbon absorption. Monitoring and control of all mechanical equipment and processes was achieved through optical fibre (Pers. comm. Takamura May 1993). There was emphasis on re-use in the promotion of the ACE strategy. Some melted slag had been used for backfill and 10% granulated slag had been included in tile and paver manufacture trials (Kanezashi & Murakami 1992: 38). Although these developments were widely publicised, it appeared that the extent of this kind of re-use was very limited (Pers. comm. Takamura May 1993). Problems had occurred with the high concentration of non-biodegradable matter in the water generated by the thickening, dewatering and emission treatment processes, requiring further treatment (Kanezashi and Murakami 1992: 37).

6.3.4 The Water Recycling Centre

There is little reason to debate the utilisation of centralised reticulated sewerage systems in high rise inner city environments like Shinjuku in Tokyo. The paradigm is most suited to this application. However, once again centralised treatment fosters an innovation that makes the unresolved technical and management problems of on-site treatment seem inconsequential.

The innovation, in this case, is the Shinjuku Water Recycling Centre which recycles treated effluent from a nearby treatment plant to 19 skyscrapers accommodating approximately 60 000 office workers (Pers. comm Akira Mori May 1993). The Ochai sewerage treatment plant is 3 km from Shinjuku and after rapid sand filtration 3 700 tonnes of effluent are pumped to the Centre each day, chlorinated, and distributed to the surrounding skyscrapers, some of which are fifty stories high (Pers. comm. Takeuchi May 1993). Each skyscraper has its own basement pump to circulate the water to flush toilets after which it is returned to the Ochai treatment plant for retreatment (1% the total influent to the plant is reused).

Users of the treated effluent are charged less than users of fresh or 'raw' water even though supply costs more. The Centre will be tripled in capacity to service skyscrapers being built and existing buildings that are installing dual reticulation. The area of Shinjuku covered by the service will increase from 50 hectares to 80 hectares (Pers. comm. Tamura May 1993).

On display on the basement and ground floors of the Centre are detailed functioning life-like models of all aspects of sewerage treatment and its relation to urban living, including the recycling of treated water (Pers. obs. May 1993). Recycled water is also used to wash Shinkansen ('bullet trains') and recycled to industry. It is intended that it will be used for inner city fountains and other "urban beautification". Research is being conducted into the possible environmental impacts of effluent re-use (Takeuchi 1991: 2).

6.3.5 Environmental Pollution Monitoring and Control Centre

Monitoring systems appear to be a speciality of Japanese water and sewage management. All the sewerage treatment works inspected had extensive computerised monitoring systems and control rooms, some more advanced than others depending on the Municipal budget priority. The most impressive of these installations was the Yokohama Environmental Pollution Monitoring and Control Centre, which was a local government department devoted entirely to monitoring of effluent and emissions of major industry and sewerage treatment in the Yokohama district. The Centre has one of the largest budgets of all the local government divisions, due to the very high cost of installing, replacing and maintaining the monitoring technology (Pers. comm. Ohka June 1993).

At any time, the current pollutant content of effluent from any of the monitored factories or sewerage treatment plants can be displayed on one of the many screens in the Centre. However, the Centre does not have authority to act if pollutants exceed standards. They can telephone the factory and inform them of the problem, but usually they report to another division which may or may not act on the advice (Pers. comm. Mitsuya June 1993).

6.3.6 Relevance to Australia

Although the technological innovations in Australia in support of the dominant sanitation paradigm are not as extensive or spectacular as those inspected in Japan, and described in this section, Australian sewerage managers have been substantially funded to produce a 'hi-tech fix' for the myriad of problems created by centralised reticulated technology (Beder 1989). These solutions have not always been in the best interest of the environment or the community and sometimes have to be reversed, but the basic premise on which they are founded continues to be politically and ecumenically supported, while alternatives have been explored on an ad hoc basis.

6.4 On-site treatment used within the centralised system

In the preceding investigation of sewage treatment in Japan, a clear distinction has been drawn between the politics and technology of the two available options of on-site or centralised reticulated treatment. In fact, there is overlap as on-site treatment is used in industrial pollution control which indicates that an integration of the two systems is both conceptually and technically possible.

6.4.1 Muruoh Paper Co. Ltd

The city of Fuji in Shizuoka Prefecture was the location of hand made paper factories in the last century and now hosts 150 small and large modern paper production companies including Daishowa. The area was chosen because of the plentiful supply of water from the melting snows of nearby Mt. Fuji and the close proximity of the sea for discharge of the large quantities of water used and generated by the process (Pers. comm. Ishida May 1993).

The Muruoh Paper Factory is a relatively small company which produces recycled paper for comics. The paper is recycled up to 40 times until the length of the fibre is too short and matting does not take place. The bulky comics are published weekly and are available at all bookstores and small supermarkets (Pers. obs. March-June 1993). The raw material is made up from the unprinted edges of magazines, a percentage of newspaper bulk, and previously recycled comics collected from designated sites throughout the Municipality. Glue is chemically dissolved from the magazine edges, and ink is chemically separated from the paper. Colours are added to the paper as the comics have beige, pink and green pages interspersed throughout (Pers. comm. Watanabe A. April 1993).

The effluent is first treated through a rotational chemical flotation tank where the ink and the solids are creamed off and the liquid is then passed into a rotational sedimentation tank and pumped to a centralised Municipal industrial reservoir. The reservoir pumps the collective effluent into the sea. It was not possible to ascertain whether further treatment took place at the reservoir but the use of this system illustrates the potential for an on-site domestic equivalent for collecting and monitoring the effluent from Johkasous. The scum from the flotation tank is dewatered by a belt press and the sludge is collected by a contractor for incineration.

Thirty years ago the sludge was dumped around Mt Fuji and the effluent pumped directly into the sea. Each year pre-treatment requirements increase. Currently, a monitoring laboratory conducts daily tests to ensure that the effluent from the plant achieves the standards of COD <90, SS <10 and pH 8. Records are kept for inspection and spot checks of the effluent are conducted by city authorities two to three times a year. The plant is warned if there is a breach on the first occasion and the second time machines may be stopped for rectification. The President of the company, Mr. Watanabe, did not know what happens on the occasion of a third breach because as far as he knew all companies comply and the relationship with City Hall is a co-operative one (Pers. comm. Watanabe A. April 1993). However, it has been suggested that compliance by big companies such as Daishowa is not enforced due to family influence at City Hall (Pers. comm. Ishida April 1993). Monitoring is only effective if is politically supported.

To generate 4 000 tonnes of paper per month, the plant uses 6 000 tonnes of used paper. Eighty tonnes of paper is produced a day generating 13 tonnes a day of sludge and 3 500 tonnes per day of effluent. Sludge costs 5 000 yen per tonne to be burnt. It costs 5 million yen a month to run the plant including labour and the annual gross income is 7.5 billion yen. Capital cost of the plant is 1.5 billion yen, renewal costs 100 000 000 yen per year and 2 000 0000 yen is paid for chemicals per year. The purification tanks cost 200 000 000 yen. Mr Watanabe considers that pre-treatment accounts for a disproportionably large percentage of his capital and running costs but acknowledges that it is necessary because paper production had previously made Fuji a very polluted city. He believes that individual pre-treatment is the most suitable system to accommodate the quantity and quality of effluent produced (Pers. comm. Watanabe A. April 1993).

6.4.2 The Fuku-Ura Industrial Pre-treatment Plant

As part of an effort to improve the urban environment

> Yokohama City has instituted a plan to create reclaimed land on the coast of Kanagawa, relocate factories that have been sited at diverse locations across the city there, promote the modernisation of these factories upon location, and at the same time implement effective solutions for industrial waste water and other causes of pollution associated with such factories (Kameyama 1991: 31).

The solution in this case was a collective pre-treatment plant to treat the effluent of small factories capitalised at less than 100 million yen and employing less than 100 people, i.e. too small to be able to afford their own pre-treatment. This is an expanded application of the on-site concept or a contracted application of the centralised treatment potentially utilising the benefits of both systems. The effluent from 34 factories, (most of which have less than 50 employees) consisting of 13 plating factories, 13 pickling factories and 8 printing and dyeing factories is collectively treated in the pre-treatment plant (Pers. comm. Suzuki June 1993).

In principle the pre-treatment plant is a progressive development, and has been widely publicised in Japanese and international sewerage circles attracting regular tours of inspections in its early years of operation.

> The plant constitutes both progressive and permanent countermeasures for industrial waste water including future treatment requirements. This is a feature that sets it apart from conventional industrial waste water measures, which merely responds to problems after the fact. Today almost ten years since it went into operation in June 1982, the plant continues to operate smoothly and achieve the desired results with respect to combating industrial waste water (Kameyama 1991: 36).

However, in long term practice there have been some administrative and technical problems (Pers. comm. Koubayashi June 1993).

Large companies provide their own pre-treatment or pay the Municipality for treatment. The Fuku-ura pre-treatment plant was built by the Municipality but is managed and maintained by charges from the connected factories. The average payment is 60 million yen per year. Often the factories have not paid the charges necessary for maintenance because of purported financial difficulties, and since the Municipality does not want to cover the shortfall, the plant has deteriorated (Pers. comm. Suzuki June 1993).

The Fuku-ura pre-treatment plant was constructed in 1982 with Japan Environmental Pollution Control Service Corporation funding at the cost of 26 million US dollars. Five "lines" treat the effluent from the factories: a high concentration cyanide line: a low concentration cyanide line; an acid/alkali line; and a printing/dyeing line (see Figure 6.7). One of the earliest technical problems that occurred was damage to the monitoring system on the third floor from hydrogen sulphide gas seeping up from the basement. The system had been out of order for many years with no available funds to repair it, and make the necessary alterations to ensure leakage would not happen again (Pers comm. Suzuki June 1993).

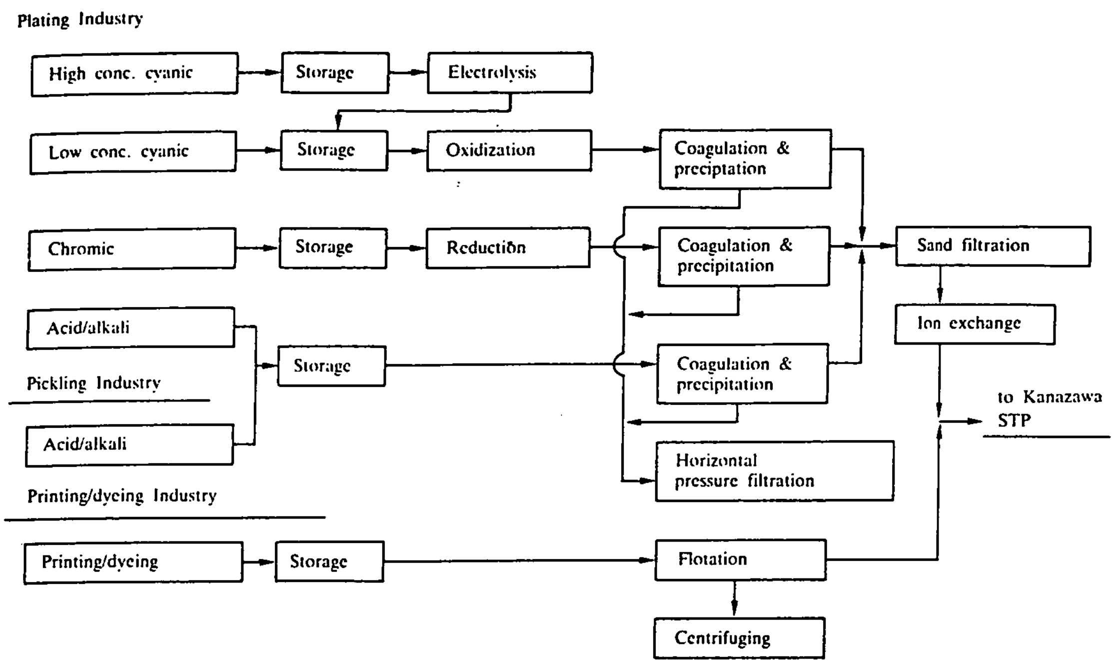

FIGURE 6.7

Treatment Flow (Kameyama 1991: 34).

The moving parts in the flotation tank on the dyeing/printing 'line' had become rusted, so that line was decommissioned and the effluent was diluted and piped directly to the nearby Kanazawa Sewerage Treatment Plant. The Kanazwa plant normally receives the treated effluent from the pre-treatment plant, domestic sewerage, and low pollutant effluent from small factories in the district. The Sewerage Treatment Plant is monitored by the Pollution Monitoring Control Centre near Kenmai Station (Pers. comm. Terada June 1993).

Many other parts of the pre-treatment plant appeared rusted and the site was covered with long weeds, an unusual circumstance on Japanese public works installations which are usually very presentable (Pers. obs. June 1993). Mr Akira Kohara, Deputy Chief of Research and Development Section who had just returned from 3 years secondment to Japan Sewage Works Agency in Tokyo was shocked at the condition of the plant on our inspection. He said there was another pre-treatment plant in the area, built and maintained by the Municipality. This plant did not treat toxic pollutants like cyanide but it had more effective and enforceable funding system and was functioning well (Pers. comm. Kohara June 1993).

Mr Mitsuya Ishihara, an industrial chemist and water quality surveyor had recently been appointed as the Municipal Chief of the pre-treatment plant by the Yokohama government. A manager representing the private companies supervised the plant but Mr. Ishihara was appointed to rectify deterioration. He said that the plant had originally been designed and built to treat a much increased capacity so it needs to be scaled down to the current influent in order to reduce costs. In addition, he intended to try and raise money from the user factories for repairs. Mr Ishihara said that there were delicate political issues involved (Pers. comm. Ishihara June 1993).

One criticism of collective pre-treatment systems has been the reduced responsibility of individual factories to ensure that their process complies with guidelines, especially where a fixed charged is involved. To avoid this possibility, a separate contract with each factory imposed the following:

Limitations:
a. Limitations on the maximum waste water volume per day and maximum concentrations of pollutants.
b. Limitations on the chemicals used in factory process.

Prohibitions:
a. Prohibition on the discharge of substances that cannot be treated at the collective pre-treatment plant.
b. Prohibition on the discharge of waste water that could damage the collective pre-treatment plant facilities.

Obligations:
a. Obligation to install, maintain, and manage flow meters to measure the volume of waste water discharged from each factory.
b. Obligation to install, maintain and manage monitoring pits for sampling industrial waste water.
c. Obligation to measure the quality of the waste water discharged from each factory (Kameyama 1991: 35).

6.4.3 Relevance to Australia

While certain management problems have arisen in the Fuku-ura experiment, there is much to be learnt from its successes and failures in this ongoing examination of sewage treatment and the relative value of the policies that determine its implementation. On-site factory pre-treatment is common in Australia and one of the main stimulants for research and development in the private sector (Pers. comm. Chiba March 1994).

If decentralised sanitation strategies were given appropriate recognition and support, there is a potential for increased environmental protection and community benefit. Centralised and decentralised strategies can be implemented in the application to which each is most suited and they can serve an integrated as well as a complimentary purpose.

6.5 Global implications of Japanese sewage treatment policy and practice

In the introduction to this Chapter, Japanese experience with on-site sewage treatment and its relationship to centralised treatment was presented as a useful framework within which to examine similar issues in Australia. As has already been discussed, on-site sanitation is at an embryonic stage administratively in Australia, but there is considerable public interest in the concept for a variety of reasons. However, the direction it takes in Australia will have limited implications domestically as most of the urban areas are sewered and will probably remain that way, unless there is a considerable shift in vision and technology. The consideration of on-site treatment is currently most relevant for public land application, new developments, or the upgrading of sewage treatment in semi-rural and rural areas.

What is more significant is the impact Japanese sewage treatment policy and practice is having on the global environment, particularly in the so called developing world. Third world (or 'two-third' world as is a more correct and preferred description) countries seek advice from Japan on a wide range of management and technical issues as they undertake the process of 'modernisation'. Whatever antagonism or prejudices may exist toward Japanese people, Japan is seen as a non-Caucasian country that triumphed over the devastation and humiliation of World War II to become one of the world's richest nations. Therefore Japan is a desirable model to recently developing countries, including those emerging from the disintegration of the Soviet Union, such as Mongolia, who have sent many delegations to Tokyo for advice (Pers. comm. Takahashi June 1993).

6.5.1 "Technical Assistance/Co-operation" Programs

This desire to imitate extends to sewage treatment and it is encouraged by the Japanese sewerage industry through offers of loans, training and active promotion of consultancy.

> In recent years, requests to Japan for technical and/or financial assistance from developing countries are increasingly occurring in the field of sewage works. In order to respond to these requests, the Ministry of Construction has positively advanced overseas assistance such as technical co-operation...which is broadly divided into group training of foreign engineers and overseas dispatch of Japanese engineers (Japan Sewage Works Association 1991: 60).

Since 1973, 235 trainees have attended the Ministry of Construction sewerage treatment courses from 45 countries in Africa, Asia, South America and the Middle East. Countries that have special resource trade agreements with Japan such as Brazil, Saudi Arabia and Iran have been invited to send the highest number of trainees from non-Asian regions.

> The Japan International Cooperation Association (JICA) performs group training for developing countries. It provides 230 courses and admits more than 4 000 trainees every year. A group training course concerning sewerage systems is included in these courses. Under the full cooperation of Japan Sewage Works Agency, some dozen trainees are admitted each year. The course is held for 3 months...and consists of lectures, practical training, field trips etc. Its purpose is to impact general knowledge concerning sewerage systems...Almost all these trainees hold important posts in developing countries, and thus a favourable secondary effect of the training on sewerage systems is to expose foreign peoples to knowledge about Japan (Ueda 1990: 152).

Japanese engineers are sent to developing countries to provide technical assistance for planning and installation of sewerage treatment works. For example, in 1989, 38 sewerage treatment engineers worked on such projects in 12 different countries. In addition, engineers are sent to assess the potential of sewerage projects. More than thirty projects in 20 countries have hosted

Japanese 'investigation commissions'.

Consultancy is provided as part of an aid or loan package involving the public and private sector of the Japanese sewerage industry.

> Requests for the dispatch of specialists has tended to increase recently. According to the contents of a request, positive reaction to them are necessary with the cooperation of engineers of local public bodies and private parties in Japan. Investigation commissions are dispatched for a development investigation to determine the possibility of realising development planning as well as to make a proposal for such realisation, and includes a basic design investigation to confirm financial cooperation without reimbursement. In the case of advanced investigation, the investigating commission consists of members from JICA and the official staff of the concerned ministries (Ministry of Foreign Affairs and Ministry of Construction). The main investigation is performed by members including consultants contracted to perform investigating work for JICA. One project generally requires dispatching of investigating commission 3-4 times (Ueda 1990: 152).

Mr Haruki Takahashi, Chief of International Affairs in the Engineering Division of Japan Sewage Works Association, has participated in these international consultancies. He worked for three years in Bangkok on storm water drainage during which time he "sowed seeds" for future consultancy, and as a result has been back 10 times in the last 5 years to advise on further work for Japan Sewage Works Agency. In 1992 he was selected to go to India for three weeks to develop a sewerage scheme for Delhi and adjoining cities, which included 10 sewage treatment plants for 10 cities along the connecting river. He said he thought he was picked for the Indian consultancy because he "had experience and understanding of third word people"(Pers. comm. Takahashi May 1993).

While the provision of reticulated centralised sewerage treatment has certainly played a part in the elimination of the diseases that ravaged the Western world in the nineteenth century, the technology that was introduced then is 100 years old now, and much has been learnt about its benefits and disadvantages. If introduced now to 'developed' countries, it may not be considered the most appropriate means to manage sewage treatment and water usage, given the many environmental, economic and social factors that have changed since that time. This is even more so in 'developing' countries where population density, degraded environments and impoverished economies could mean that the introduction of traditional sewerage treatment would be disastrous.

In addition to the sewerage system and the treatment plants, centralised reticulated treatment generates further major public works such as the building of dams. These potential developments have to be researched with the real needs and priorities of the local people in mind. The investigators should be without vested interest and have social analysis as well as technical skills. The Japanese Ministry of Construction does not have a good reputation for responsive practice in relation to public opinion in its own country, so how can it be expected to always act in the best interest of a foreign people.

One of several areas of public conflict with the Ministry of Construction has been on the issue of dam construction. In Japan all the rivers have been dammed except the Nagara, but this river is scheduled for the same fate despite widespread protest:

> ...calls for a halt to the construction of the dam while an open and independent review of the project are falling on deaf ears. Yamasaki Taku, Minister of Construction, refused to fulfil his promise to talk with opponents before resuming construction this fall...The dam is to be completed by March 1995...Originally designed 30 years ago to meet anticipated demand for industrial and local water supply in Nagoya City and Mie and Aichi Prefectures, the Ministry of Construction has changed its rationale for the dam now that water resources are clearly sufficient to meet current demand. Presently Nagoya uses only three percent of its water supply and Iwaya dam supplies more than the present water consumption needs in the Kiso Three Rivers Basin Area. The Ministry of Construction currently emphasises that the dam is needed for flood control and preventing salt water intrusion (Griesbach 1992: 4).

Mr. Tatsuhiro Ueda, Chief of Planning and Coordination in the Sewerage Department of the Ministry of Construction acknowledges that on some occasions centralised sewerage systems are not appropriate in developing countries, despite the efforts of the 'technical cooperation' program:

> There are also some cases that the techniques impacted do not take root in a developing country and thus result in

> unsuccessful development of techniques concerning sewerage systems (Ueda 1990: 155).

Within the sewerage treatment industry not all participants are unquestioning advocates of the paradigm. Mr. Tetsu Fukasawa, Water Quality Control Officer at the Fujinomiya Jouka Centre said he had

> always questioned the basic premise of mixing waste with water, piping the mixture great distances and then incurring much expense trying to separate them (Pers. comm. Fukusawa T. May 1993).

It is essential that developing countries are given an informed choice of the sewage treatment technology and management practices that are utilised in developed countries, and a clear picture of environmental impact and long term costs. To ensure this will happen the developed counties should give equal importance to the range of options within their own sanitation administration and management. On-site sewage treatment managers in Japan do give advice to developing countries on sanitation issues. For example, Dr Hideaki Ohmori, General Manager of Research and Investigation Division in the Japan Education Centre of Environmental Sanitation visited Beijing in April 1993 for a week as part of a consultancy to Chinese authorities on the potential use of the Johkasous in China (Pers. comm. Ohmori April 1993). However, these consultations do not have the political and financial backing that the Ministries of Construction and Foreign Affairs give to the "technical co-operation" sewerage system schemes.

It is necessary that sewage treatment is seen in a realistic economic context. Japan is currently a very affluent country with an excess of internal revenue due to its trading surplus. Funds are available for public works and ongoing maintenance that may not be available in a developing country. Loans or aid packages may lock sewage management into a technology it cannot sustain. This could also be the case in Japan if its external resource dependent economy faltered.

6.5.1(i) Relevance to Australia

Australia is also involved in technology transfer to developing countries in the form of aid packages and commodities promotion, and our traditional sewerage and on-site sanitation strategies have been exported, sometimes inappropriately, with serious consequences for the recipient nation. Australian sanitation managers have a global as well as a local responsibility to research and develop appropriate sewage treatment options for all required applications.

A constructive outcome of recent innovations in dry conservancy techniques has been the cultural and technical trial of composting toilets in the Central Pacific. This project and its implications for decentralised treatment will be examined in Chapter Seven.

6.5.2 China's choice of sewage treatment

China is the most populated country currently engaged in a rapid process of "modernisation". Foreign investment and loans toward this process are being solicited by the Chinese Government even from countries with which it has a history of hostilities, or perhaps as a subtle face-saving form of extracting reparations in some cases (Pers comm. Donghing June 1993):

> The Japanese Government has offered more than $10 billion in loans to China which puts Japan at the top of the list of countries that provide China with governmental loans (China Daily, Beijing, 23/7/93)

As a result of this "open China" policy, development is taking place at a rate that could have critical implications for the environment particularly in the Special Economic Zones.

> The '93 Zheijiang Investment Fair opened here yesterday...more than 460 business people from 22 countries and regions have come to participate. Some 1 900 projects will be available for bid, requiring a total investment of $24.2 billion, of which $12 billion will be sought from overseas...Investment projects include an expressway, an international airport, a nuclear power station and therm-power station...Other projects are in the sectors of machinery, light industry, textiles, medicines, raw materials, agriculture, real estate, forestry, fishery and tourism (Zai 1993: 2).

During a discussion at the Beijing Municipal Engineering Design and Research Institute, Ms. Chen Xiaojun, a process engineer, said that the first stage of the sewering of Beijing, currently under construction, was being financed by Japan with a 30 year loan at low interest. The only condition of the loan was that no technology or consultancy be bought from Communist/Socialist countries. Many of their staff were trained in Japan. She had been trained in England (Pers. comm. Xiaojun June 1993).

The first stage,"the largest sewage treatment plant in Asia" would serve 40% of Beijing and 40% of that area is industrial. On inquiring what methods of sludge disposal would be used, Ms. Qu Sha said they would dewater the sludge and use it on agriculture (Pers. comm. Qu Sha June 1993). The industries to be served by the plant include manufacturers of pharmaceuticals, textiles and chemicals. When asked whether they had considered the levels of pollutant that might be in the sludge, Mr. Zhao Jie responded that perhaps it should instead be disposed by landfill (Pers. comm. Jie June 1993). It appeared that the issues of sludge disposal had not been resolved and Mr. Zhao Ru Qiao asked what method of disposal the author thought was most appropriate! (Pers. comm. Ru Qiao June 1993).

The second stage was to be financed by Sweden and the condition of that loan was that 80% of the technology and expertise was to be from the Swedish sewerage industry. The second stage would consist of 15 smaller sewerage treatment plants that would be built in time for the anticipated Beijing Olympic Games in 2 000, which Ms Lui Sha said was the reason for undertaking the sewering of Beijing at this time, although they had been planning for this for twenty years (Pers. comm. Lui Sha June, 1993).

Asked whether they thought this sewerage development would necessitate the building of more dams, Ms. Chen Yi said that it was likely, but it will be difficult technically and economically as Beijing is in a dry flat region (Pers. comm. Yi June 1993). In addition

> Beijing's water table, which in the 1950s was about 16 feet below the surface, is now down as far as 150 feet, a fact which has led Chinese scientists to go as far as to question Beijing's long term viability as a capital (Link 1993: 6).

At the time of visiting in 1993, there were more than 10 million people living in Beijing and if they all had flush toilets and reticulated water to 'modern' bathrooms and kitchen facilities, the water consumption could be impossible to sustain. Ms. Yi said it was hoped that domestic and industrial user charges would reduce consumption. However "it would not be like Britain where the people have to pay for everything"(Pers. comm. Yi June 1993). Asked how the construction loans will be repaid, and maintenance of the sewerage system financed, Mr. Ru Qiao replied "that is the government's problem, the government pays for everything" (Pers. comm. Ru Qiao June 1993).

Currently, most Beijing people use public toilets that consist of a long open trench in an enclosed building on each street block (Pers. obs. June 1993). Excrement is vacuumed out of the trench, and usually taken to the country where it is applied directly to agricultural land, or composted and then applied as fertiliser (Pers. comm. Gui Hua June 1993). There is often a common tap shared by surrounding houses in the traditional areas. Hotels and apartment blocks have flush toilets and reticulated water. Effluent is untreated and drains into local canals that pass through the city. The canals also receive untreated effluent from industry.

There is definitely an urgent need for management and treatment of waterborne sewage especially as the traditional one-storey housing is rapidly being bulldozed and replaced by apartment blocks and hotels with flush toilets (Pers. comm. Shenghong June 1993). However, perhaps centralised reticulated treatment is not necessarily the most appropriate system for this vast city. There should at least be an informed choice of options.

The personnel at the Beijing Municipal Engineering Design and Research Institute, who are responsible for directing the sewering of the city, were interested in designs of composting toilets being trialed in Australia. They were particularly curious about, and affirming of, the Wheelibatch for urban use (refer Chapter Five). They were astonished that people in developed countries would even consider such techniques of sewage disposal. It appeared that there were some doubts about the enormity and complexity of the sewerage project they had embarked upon. In a culture that is accustomed to basic management of excrement and direct reuse, a simpler, less expensive strategy than centralised sewerage treatment seemed attractive. Questions were asked whether possible environmental problems could arise from the use of sewerage systems, and had they occurred in Australia? (Pers. comm. Ru Qiao June 1993).

In an interview with Ms. Xu Gui Hua, the Hygienic Doctor in Charge of the Office of the National Patriotic Health Campaign Committee, she said that she thought on-site treatment will remain the preferred strategy in country areas, mainly because of the expense of sewerage systems. Water borne and improved dry conservancy methods were being considered for rural cities. The latter was preferred in some areas due to water shortages. A number of dry conservancy methods were being used in the Provinces incorporating the production of biogas for lighting and cooking. Ms. Gui Hua expressed interest in the Wheelibatch trials particularly in the cold climate of Hobart, Tasmania. She said the design could have application in the cold north regions of China. She too was surprised that people in sewered countries like Australia would be interested in alternatives (Pers. comm. Gui Hua June 1993).

There are approximately 1.2 billion people in China. The choices made for sewage treatment and water management in China during the coming years of 'modernisation' are likely to have worldwide implications.

6.6 Conclusion

In this chapter, on-site and centralised sewage treatment in Japan has been broadly introduced and examined as it is considered that the strategies and technology implemented in that country offer much useful information and experience for Australian sewage and water management. In addition Japan's practice has global implications, and suggests a positive role Australia could play in water quality protection and resource conservation, if sanitation managers were to develop a viable alternative to centralised sewerage systems in situations where it is obviously preferable.

Japan took its direction in centralised treatment from the West, under some political pressure at times, particularly from the United States (Pers. comm. Motichi Shiba March 1993).

> With internationalisation proceeding rapidly in Japan, appropriate response in the area of sewerage systems is also required much more than before...Practical international activities are roughly divided into technical exchanges and technical assistance/cooperation. The former is represented by technical exchanges between Japan and the United States or Japan and West Germany. Also on the occasion of international conferences or during exchanges of engineers, information and opinions relating to techniques, systems, etc. are exchanged (Ueda 1990: 147).

These 'technical exchanges' in sewerage treatment, have been conducted for many years and have included Japanese engineers being trained in the US, Europe and England, and engineers from those countries visiting Japan to supervise and inspect projects (Pers. comm. Ishida April 1993).

Initially, the flow of information was from the West to Japan, but now due to the stimulation of specific local requirements and considerable government funding, sewerage innovation in Japan is increasing. For example, Mr. Akira Kohara, Deputy Chief of the Research and Development Section in Yokohama's Sewerage Bureau, reported that since England's sewerage managers are required to cease dumping sludge in the sea, they are looking to incinerate as there is land shortage for disposal. Many delegations have come from England to inspect Japan's advanced incineration technology (Pers. comm Kohara June 1993).

On the other hand, Japanese on-site treatment and management has predominantly originated in Japan for the reasons already discussed. It is to their credit that this strategy emerged with very little example from the West, and developed and developing countries can learn from that experience. If it had been the case that on-site treatment had a viable reputation in the West over the period of Japan's adoption of centralised treatment, perhaps the Kumitori would have been improved rather than discarded, and a more varied approach to sewage treatment consolidated by government. It is the author's opinion that Western sewage managers have a responsibility to the Japanese on-site sanitation industry and to Japan's environment to support their efforts in this direction by making our own significant contribution to on-site research and development. For the the countries that imitate Japanese sewage management practice, there is a responsibility to provide a more environmentally sound range of options.

Japan has paid a price for its material affluence, both environmentally and spiritually (Pers. comm. Shiba March 1993). Apart from its impact on the environment of its trading partners, Japan itself is a profoundly polluted country. If it were not for high rainfall, fast flowing rivers and the airflow typical of an island country, its environmental condition would be critical. The water table is far more seriously contaminated than is acknowledged, and soil toxicity is high (Pers. comm. Mori May 1993). Hopefully, the developing countries (and some Australian economists, business people and politicians) that covert Japan's wealth and power, will come to understand that there is no such thing as a free lunch.

There is also a direct relationship between Japan's ecological health and Australia's that is worth contemplating from a mercenary point of view: Japanese tourism exists in Australia because it is seen as a "clean" country, a welcome escape from a polluted homeland (Pers. comm. Chiba October 1993). If Australia continues to allow its waterways and beaches to be contaminated by sewerage and industrial effluent, and agricultural run-off, the economic benefits from Japanese tourism will be significantly reduced.

The next Chapter describes sanitation technology transfer in the Pacific region and reflects the positive international ramifications of improved research and development in Australia. The project emphasises the importance of social and cultural considerations in sanitation application, and again illustrates the limitations of inadequate supportive infrastructure and remote site development.

CHAPTER SEVEN

TECHNOLOGY TRANSFER AND CULTURAL ADJUSTMENT

Having examined the limitations and potential for on-site sewage development in Australia in Chapters One to Five, Chapter Six explored Japanese management in this field and the relationship between on-site and centralised treatment in Japan. The study suggests that there are lessons that Australian sanitation managers may learn from the Japanese experience, and by referring to emerging Chinese sewerage practice, indicates the global responsibility of addressing these issues appropriately.

Chapter Seven further examines the theme of global responsibility for appropriate sanitation development, and describes sanitation technology transfer in the Central Pacific region which reflects the positive international ramifications of improved research and development in Australia. This Chapter emphasises the importance of social and cultural considerations in sanitation application and also illustrates the recurring limitations of inadequate infrastructure and remote site evaluation. Although the Pacific location is 'remote' in a different sense to that described in Chapter Three, there are similarities in the challenges of undertaking research and development in that context.

Composting toilets are almost always utilised as a last resort in sanitation applications. The first choice, if it is at all practical or affordable, is centralised reticulated waterborne treatment. If this is not possible then waterborne on-site treatment such a septic tanks or more recently AWTS are the next choice so that the flush toilet can be used and blackwater and greywater water can be treated in the same system. This configuration is a mini Sewage Treatment Plant and provides a service that resembles, as closely as possible, the often preferred centralised sewerage technology.

Apart from the concerned citizen who chooses the composting toilet because of a conviction that it protects the environment from sewerage pollution and conserves resources, most dry conservancy facilities are installed when all else is impractical to utilise, or has failed. Often this involves remote and extreme conditions, such as those described in Chapter Three, or where development may be precluded because of the cost and impact of expanded waterborne sewage treatment such as the Fitzroy Falls project described in Chapter Four.

The events described in this Chapter took place in a context where the traditional centralised and on-site sanitation systems had been tried with many related problems (AIDAB 1990: 22), and where the extreme nature of the environment precluded more sophisticated reticulated technology. If composting toilets had been a familiar and accepted technology among sanitation managers in developed countries such as Australia, then perhaps it would not have taken more than 20 years of costly and environmentally damaging sanitation transfer to aid recipient countries before this more appropriate option was offered (Ministry of Works and Engineering 1994: 49).

One of the constructive outcomes of the investigations described in preceding Chapters is that the study has provided the opportunity to improvise technology and acquire experience that could facilitate the transfer of an environmentally benign sanitation system to a developing country. If this has been possible after only three and a half years of research in often stringent and constrained circumstances, how much more could Australian sanitation managers offer in this field if on-site sewage treatment was given the necessary status and latitude to evolve to its full potential?

7.1 The project

In March, 1994, a tender was submitted by the author and Dr. Stuart White to Snowy Mountains Engineering Corporation Ltd (hereafter referred to as SMEC), commodities contracting agent for the Australian International Development Bureau (hereafter referred to as AusAID) to supply composting toilets for trial on the island of Kiritimati in the Republic of Kiribati in the Central Pacific. The tender was ultimately accepted after some negotiation.

Kiribati is a small island nation of 33 coral atolls dispersed along the Equator in the Central Pacific. There are three groups of islands and atolls, and Kiritimati is the southern most atoll in a chain of islands known as the Northern Line Islands (see Figure 7.1). Kiritimati is the largest coral atoll in the world in terms of land area (320 km²). The total area is 640 km² and includes a central lagoon, and many other lagoons, most of which are landlocked and hypersaline (Cholerton 1988: iii) (see Figure 7.2).

THE REPUBLIC OF KIRIBATI

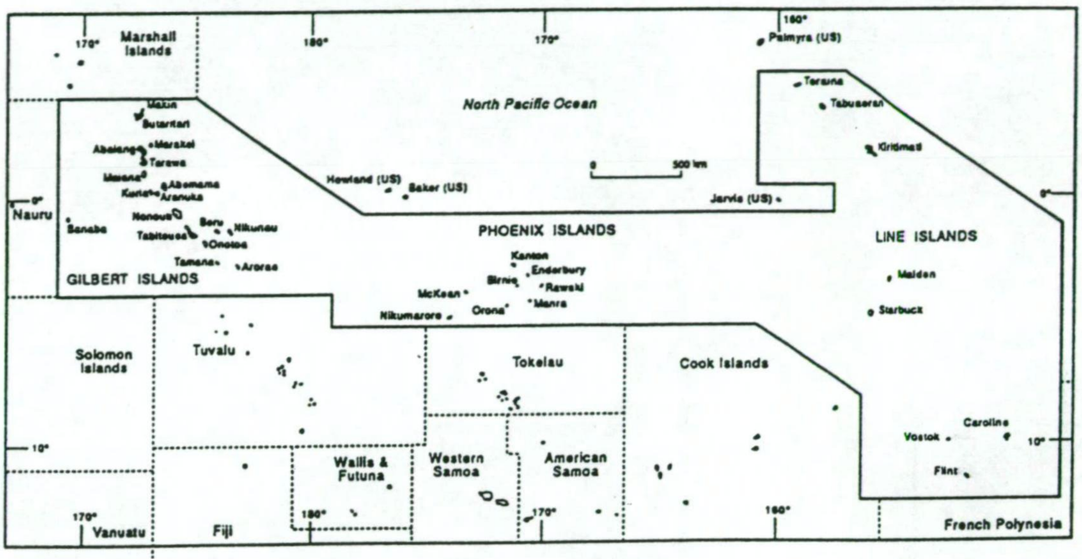

FIGURE 7.1

Republic of Kiribati (Van Trease 1993: xix).

The present population of approximately 3 000 people is located in five villages: Banana, London, Tabakea, Poland and Main Camp. Water supply is provided from roof catchments or ground water from fresh water lenses. The limited number of rainwater tanks rely on erratic rainfall and the island can suffer long periods of drought. Ground water is pumped from infiltration galleries constructed over the lenses. Deterioration in the quality of the ground water has occurred through localised over pumping of the lenses causing 'upconing' of the underlying transition zone and sea water, especially during periods of average or lower rainfall (Falkland 1983: 1). The ground water is also affected by bacteriological and chemical pollution from human activities (Falkland

1990: 19). Groundwater can be polluted from sources such as domestic animals particularly pigs and dogs, latrines and septic tanks, greywater soaks, fuel storage, agricultural activities, and open rubbish and Babai (taro) pits (see Figure 7.3).

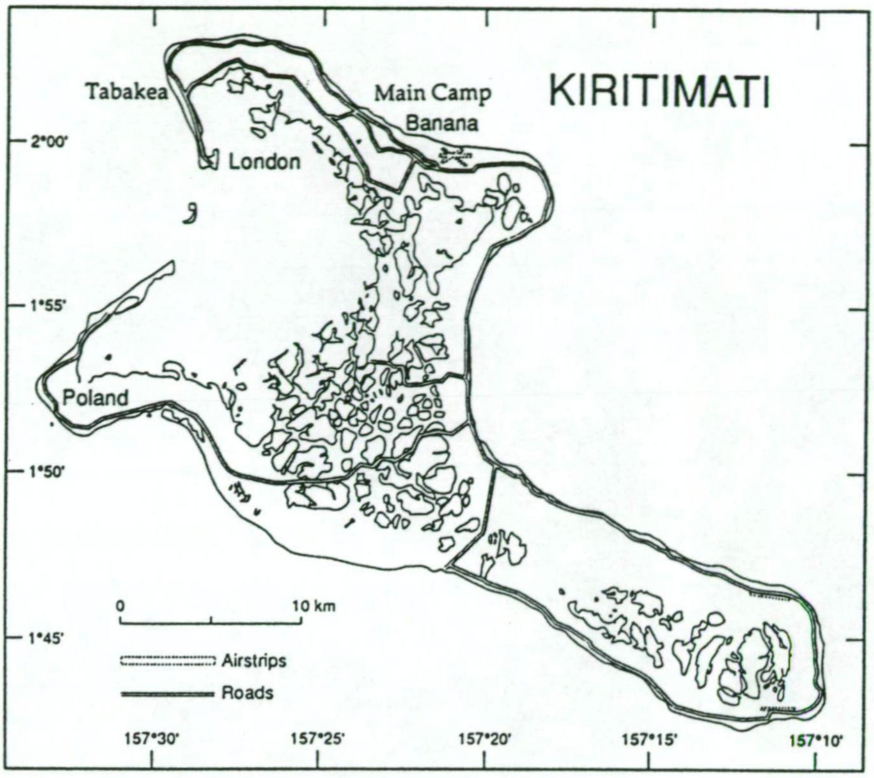

FIGURE 7.2

Map of the island of Kiritimati (Van Trease 1993: 201).

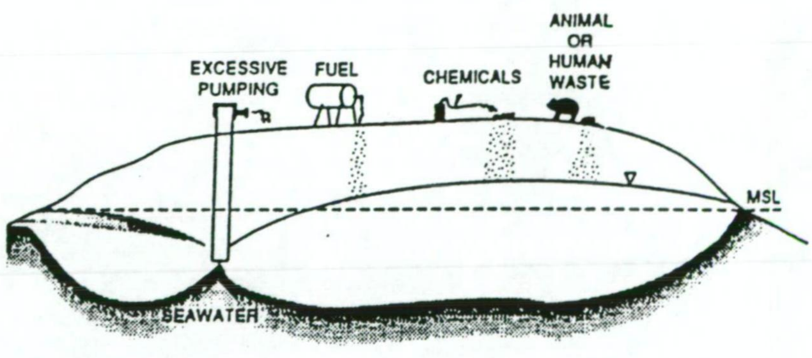

FIGURE 7.3

Impact on lenses from human activities (Falkland 1995: 21).

In 1982, the Government of Kiribati requested assistance from the Australian government to improve and protect the Kiritimati water supply. A succession of studies and design missions to the island over the last 13 years have attempted to define the problems and propose solutions. Recent awareness throughout the Pacific of the impact of inadequate or inappropriate sanitation prompted AusAID to expand the proposed Kiritimati water supply project to include a sanitation component (Henry and Drew 1993: v). The composting toilet trial which began in June 1994 with a reconnaissance visit by the author to Kiritimati, was the outcome of that proposal.

7.1.1 Designs proposed

The composting toilet designs suggested for the trial were the Wheelibatch discussed in Chapter Five and the Cage Batch discussed in Chapter Three. Early in the negotiations with SMEC, the choice of designs had to be justified, particularly as they were not approved designs in NSW, had no official history of usage, and because the contract was challenged by commercial composting toilet companies (Pers. comm. Wildermuth April 1994).

The need to justify the design choice arose out of the tenuous status of composting toilets in Australia that has been described in this thesis. Because of the lack of institutional support for composting toilet research, development and usage there are few approved design options available and those options may not be the most appropriate for the Kiritimati context. In addition the commercial interests that have negotiated the regulatory obstacles and gained official approval are anxious to protect their turf. As discussed in Chapter Five, there are owner built or custom designs that have had successful usage for decades in Australia and other developed countries, but these have not yet gained approval, although progress in that direction is occurring (Norris 1994: 18). The Wheelibatch and Cage Batch designs are derived from the positive experience with the owner-built or site-built batch systems, but the history of their usage is short, with no record outside Australia and particularly in the coral atoll application. In that sense the Kiritimati project is a further field trial of the Cage Batch and the Wheelibatch, in addition to being a cultural and technical trial of composting toilets per se in the developing country context.

The contracting officer at SMEC acknowledged that he had originally been primarily focused on procuring the technology (Pers. comm. John Wildermuth

March 1994). The author's submission emphasised the importance of communication with the local people both in a formal and informal context, and in particular, consultation with, and involvement of the I-Kiribati women.

In response to SMEC's concerns regarding lack of approval for the designs in NSW, it was explained that the guiding principles for proposing these batch designs are based on social and environmental rather than technological considerations. The users and those responsible for maintenance are the most critical components of a composting toilet system. As discussed in Chapter Two, there have been extensive maintenance difficulties with existing approved commercial units that have resulted in non-composting of the pile and health hazards to staff, partly due to design limitations and partly due to insufficient pre-sales consultation, inappropriate application and inadequate after sales support.

The tender was for cultural and technical monitoring of a trial, not merely for supply and installation of composting toilets. The trial design and monitoring are as important as the actual toilet design used.

The tender did not specify that the toilets had to be commercially available units with approval in Australian states. It is reasonable for AusAID to expect that the units to be trialed on Kiritimati should be 'tried and true'. The challenge with composting toilets is that the usual measures of 'tried and true' are not sufficient, and indeed may not be sufficient in any context. In addition, the guidelines for approval of composting toilets vary greatly from State to State and are still undergoing development. In response to this Doctorate study, and as little other sustained research in the field has been undertaken recently, the author has been asked to advise on the development of approval guidelines in a number of Australian States, (Pers. comm. Gould June 1992) (Pers. comm. Cowie June 1995), and for the National Parks Service in the United States (Pers. comm. Collins September 1994), and for participation in the formulation of an Australian Standard (Pers. comm. Walsh October 1994). Comprehensive and uniform guidelines for composting toilet design, maintenance and usage are currently in an embryonic stage of evolution.

The central question is not: "how can we be sure that this particular toilet (using a modified mobile garbage bin or a cage module) will work, since it does not have approval in one or all of the Australian States?" but rather "what is the cumulative experience with the use of domestic batch composting toilets which work on identical principles, and how acceptable will these designs be to the residents of Kiritimati?"

Provided that certain fundamental design principles are observed, such as suitable sizing, aeration, ease of emptying, strength of construction, liquid drainage, the success of a composting toilet trial depends to a much greater extent on other issues, such as community education, consultation and acceptance, environmental impact, usage patterns, available bulking agents, liquid treatment, post installation support and other issues which have less to do with the physical toilet. This is all in addition to the need for appropriate institutional support to conduct the trial itself.

The design which incorporates modified mobile garbage bins was initially selected over other possible domestic batch composting toilet designs, as it is easily constructed and shipped, being lightweight and modular. Being an off-the-shelf mass produced item, the mobile garbage bin is low cost and of proven quality. After an initial briefing with AusAID, it was decided to include the Cage Batch in the domestic section of the trial as it was thought the maintenance requirements of that design may be more acceptable to the I-Kiribati.

The Cage Batch was planned to be used for two communal or public toilets, so the design was already part of the trial. A smaller adapted version of the public toilet would now be used in two domestic locations. It was considered necessary to have at least two units of the altered design to conduct a valid comparative study. The Cage Batch does not have the flexibility of the mobile batch in that its capacity is predetermined. In addition, manual emptying of the compost is required using a shovel and wheelbarrow, rather than wheeling the fallow mobile bin to the disposal site, and tipping out the pile. However, the advantage of the Cage Batch is that the bins do not require manual change-over during use, and the cage bins are fixed, which prevents the bins being used for some other purpose. The trial would determine which combination of design features are the most culturally and practically acceptable to the I-Kiribati. Both cage and mobile batch composting toilets are adaptable to local architecture.

Once these explanations were processed, the tender was accepted with the

Once these explanations were processed, the tender was accepted with the author as project director and Dr Stuart White as technical manager and co-designer of the trial. An architecture firm were sub-contracted to design and fabricate the outhouses for the 12 imported trial toilets. As the project was conducted under a commodities program all materials had to be shipped from Australia to Kiritimati, and the toilet buildings were geared to be light, easily assembled module installations, while attending to cyclone proof specifications. It was later discovered that there was no history of cyclones on Kiritimati, and that there were aspects of these buildings that were unsuitable to Kiritimati conditions.

In other research projects described in this thesis, introduction of on-site sanitation to national parks' rangers, local government staff and domestic users has been conducted by the author, as a component of the study, but it was considered that this project required extra assistance and experience to attend to the cultural challenges anticipated in the introduction of alternative technologies. A Community Health Education Specialist was sub-contracted to assist with this task.

7.1.2 Initial consultation with Australian authorities

On May 13, 1994, the author and Community Education Specialist met at AusAID offices in Canberra, Australia with the Country Program Manager for Vanuatu and Kiribati, representatives from Women in Development, and SMEC personnel for a brief introduction to the project and at the end of June, departed for Kiritimati on a reconnaissance visit.

Conflicting information emerged at the AusAID briefing regarding attitudes and conditions on Kiritimati which indicated the complexity of the issues involved and the difficulty of choosing appropriate toilet designs and buildings without on-site experience or contact. However, because the project had already suffered lengthy delays, it was required that all materials had to be pre-fabricated and ready for shipment immediately prior to the project personnel returning from the reconnaissance visit.

This first journey set the stage for what was going to be another composting toilet research project conducted in a remote and unpredictable circumstance. At 157°30'W 2°N, Kiritimati is, in fact, one of the most remote places on Earth in terms of distance from a large land mass or continent. Its traditional

Kiribati name is *Abakiroroa,* the faraway island, as Kiritimati is 3 300 km from the capital of Kiribati, Tarawa and the other 'home' islands. The nearest substantially inhabited islands are Hawaii, 2151 km to the north and Tahiti, 2467 km to the south. It is serviced by erratic air and ship transport services (Langston 1993: 201).

Due to mechanical failure, the Air Nauru flight was delayed en route to Tarawa for ten days. The plane delays significantly shortened the planned three week reconnaissance visit to Kiritimati, but the time spent in Tarawa was worthwhile, and in retrospect, provided necessary background to the project for the Australian team, and an opportunity to discuss the trial with local officials and community leaders.

7.1.3 Community consultation on Tarawa

Most interviews lasted a couple of hours, and a second visit to allow further discussion was requested in some cases. Prepared illustrations, photographs and diagrams of composting toilets were explained. Additional materials on composting systems and integrated water supply were often requested to be sent from Australia when the project team returned home. Prior understanding of composting processes ranged from comprehensive understanding to unfamiliarity. People were shown photographs of Australian women and children accessing and maintaining their composting toilets. A sample of toilet compost from Australia was examined incredulously, and sniffed most reluctantly. Related issues such as the effect of constructed causeways on lagoon flushing, septic tanks, sewerage systems and pollution of the reef and the lagoon were discussed (see Coleman 1989: 55; AIDAB 1990: 22).

All the I-Kiribati present at these interviews appeared interested in the project and once the situation relaxed, there were many questions and suggestions. The most common initial response, was to query why the trial was not being conducted on Tarawa where the sanitation conditions are critical. Some observations were made in confidence, and often similar comments were made by a variety of people.

Observations, queries and opinions covered the following issues:

- it would be the women's responsibility to take care of the composting toilets, but if removal of compost required 'heavy work' then the men

- it was necessary to involve the men in the project because they would be using the toilet and as 'head of the house' their approval and co-operation would be supportive (Pers. comm. Karoua July 1994);

- health authorities queried why had composting toilets not been offered as an alternative previously, either in direct capital aid, or through sanitation training that I-Kiribati had undertaken in Australia, and other developed countries? They were interested to know to what extent and under what conditions composting toilets are used in developed countries and stated that if the system was as effective as it appeared then it should have been offered as an option many years ago (Pers. comm. Rui July 1995);

- there would be some reluctance to change the bins in the mobile batch system. It was suggested by some community leaders that the trial participants' pride should be challenged by pointing out that Kiritimati was specially selected, and that the success or failure of the trial would affect all I-Kiribati, and this may engender a sense of responsibility (Pers. comm. Consiliato July 1994);

- the public composting toilets will have the least likelihood of being properly maintained as there will be reluctance for any one person to take responsibility for them. While people may accept maintaining their own family toilet, contact with the containers of faeces of non-family members would be culturally unacceptable for reasons to do with sorcery and other matters (Pers. comm. Iabeta July 1994);

- the toilets should be outside the houses, or even at a distance from the house to avoid the sound of 'toilet noises' and because they were sure there would be a smell (Pers. comm. Ruta July 1995);

- some people want the toilet inside because it is more convenient especially for women and old people at night, and/or because I-Matang (Caucasians) have their toilets inside (Pers. comm. Metutira July 1994);

- when showed the two designs that would be used in the trial, most people favoured the Cage Batch because it required the least contact until after the composting process was complete. Some people preferred the mobile bins because the capacity could be increased according to need, and the bins were easy to empty without contact with the compost;

- there are no acceptable or efficient sanitation solutions currently available on Tarawa, but "the I-Kiribati would be very happy with the composting toilets <u>if they didn't smell"</u> because the systems did not need water, the people could use leaves for anal cleansing, and they could sit or squat according to preference (Pers. comm. Erdei July 1994);

- there is shame associated with carrying faeces. When a can toilet system was introduced on Tarawa, prisoners were forced to empty the cans and these people were ridiculed (Pers. comm. Stackpole July 1994);

- people were not likely to 'steal' the bins because traditionally the I-Kiribati carried goods and chattels rather than pushed or pulled containers of materials so the bins would not be so attractive for that purpose (Pers. comm. Russell July 1994);

- concern that the composting systems were unsustainable, and would require ongoing aid to purchase the bins if the design was to be used extensively (Pers. comm. Barao July 1994);

- vandalism to reticulated sewerage or septic flush toilet systems was partly due to the peoples' frustration with the requirement for manufactured toilet paper, which was beyond their means, and inconvenient (Pers. comm. Timon July 1994);

- concern that the dual reticulated sewerage system being used in Tarawa will leak salt water into the lens and salinate the supply (Pers. comm. Iosua July 1994);

- an I-Kiribati reported that she had heard of the trial from the I-Matang (Caucasian) with whom she worked, and that they predicted its failure because "the composting toilets were as big as the I-Kiribati's houses and the people would not handle the compost". When questioned as to the relevance of I-Matang opinion, she suggested it would have a significant impact as most uneducated local people assumed that the

I-Matang knew what they were talking about;

- the trial would be less successful and conclusive on Kiritimati because the residents were temporary, and did not own their land. They would not take a personal pride in an efficient composting system and would not establish gardens to use the compost (Pers. comm. Abete July 1994);

- the General Secretary for the Kiribati Protestant Church queried the necessity of a trial as he was convinced the composting system would work and was the most appropriate sewage treatment for Kiribati, and particularly Tarawa. He had a thorough understanding of composting principles and currently composts pig manure and organic matter for the fruit trees and gardens of the Protestant Compound. He suggested constructing a composting toilet in the compound as a demonstration and educative model. He was convinced that acceptance was only dependent on appropriate education. To this end, he wrote a letter to the High Commissioner which he requested be delivered. He also said that he would circulate news of the system and the trial through the Church newsletter (Pers. comm. Iosua July 1994);

- most people expressed appreciation that some form of community consultation was taking place regarding the trial. They claimed that they had not been fully informed and consulted prior to the introduction of the reticulated sewerage system or septic tanks. There was general acknowledgment that it was a positive model for the community that a woman was the project director and a designer of the composting systems, although some male technicians were politely sceptical;

- the Catholic Sisters were very interested in the composting systems for developments planned on the outer islands (Pers comm. Baljak July 1994).

Representatives from a number of NGOs and government aid organisations approached the author with consultancy proposals to design a composting system to be trialed on Tarawa either as a stand-alone project or as a component of a range of projects such as housing development (Pers. comm. Pablito July 1994), (Pers. comm. Wilson July 1994). This was not permitted by AusAID for a number of reasons, including the fact that the Tarawa sewerage scheme which had encountered many problems had been funded by the Australian government, and AusAID did not want be associated with an untrialed sanitation system being used in overcrowded South Tarawa (Pers. comm. Kuipers July 1994).

The Catholic Marist Brothers compound was also visited informally, and the Brothers were particularly interested in integrated composting toilet and grey water sanitation as they are keen gardeners.

It was noted that all flush toilets at government offices in Tarawa used by team members were either blocked or the cistern was leaking continuously. The toilets were locked and the key kept by a senior member of staff. The toilet paper was also locked in a cupboard in an adjoining office. The flush toilets at the Otientai Tourist Hotel and at the Australian High Commission offices functioned normally.

From the Tarawa visit it appeared that sanitation systems transferred from developed countries at great expense were not appropriate to the Kiribati context and may have created more problems than they had solved. This impression was reinforced when the project team finally arrived on Kiritimati. It was also apparent that some I-Kiribati were keen to investigate alternatives once they had been made aware that they existed.

7.1.4 Community consultation on Kiritimati

On arrival on Kiritimati, a meeting took place at the Ministry of Line and Phoenix Development[1] office in the village of London with the First Secretary the Kiribati Health Education Officer, and the Construction Superintendent. The designs and the proposed trial were explained and regrets expressed for the abbreviated visit. The Ministry has administrative control of Kiritimati, although there are representatives on the island from other departments located in Tarawa, such as the Health Department.

The meeting with Ministry staff and subsequent informal conversations revealed a pre-existing set of circumstances of which the Australian team were unaware, prior to arriving on Kiritimati. Some of the content of these revelations is described here to establish the political and social context in

[1] The Ministry of Line and Phoenix Development is the government body responsible for the administation of the Line and Phoenix groups of islands, which includes Kiritimati, Washington and Fanning islands in the Line group.

which the trial has been conducted.

Although there was general polite interest in the compost toilets and a positive response to the compost sample, and potential for water quality protection, the First Secretary expressed concern for the following reasons:

- alarm that the strategy for the sanitation and water project had changed, and that the water supply would not be improved until the sanitation issue was resolved;

- they had been waiting for a long time for the toilets and expected that there would be more than 10 domestic toilets for the trial: there are 89 government houses on Kiritimati without toilets and they had suspended installation of septic tanks in the hope that the composting toilets would be more appropriate;

- there was considerable pressure on him to provide toilets and he had thought that the project would have commenced no later than March 1994, with provision of at least 20 composting toilets;

- choosing who would have toilets installed at their house would be a very difficult process, particularly at short notice. Suggestions by the author that the toilets should be the responsibility of those willing and able to participate in the trial were disregarded. It would have to be decided by lottery or there would be jealousy and resentment (Pers. comm. Yeeting July 1994).

The First Secretary suggested that the public toilets should be installed at the airport and the wharf "for convenience of the foreigners". It was pointed out by the author that this would not be a trial of I-Kiribati acceptance, and it would also be difficult to monitor usage and other factors in these locations.

Ministry staff expressed a general concern that the composting systems would create an import market in Kiribati that could not be provided for locally and so would maintain dependence on aid. They were reassured to know that batch composting toilet designs can be adapted to locally available materials and that this practice is common among owner-builders in Australia. It was stressed, however, that the concept needed to be thoroughly trailed first and an appropriate design and integrated water/sanitation management strategy be developed from the results of that trial.

The use of anal cleansers was discussed, and a preference by the I-Kiribati for leaves was indicated. Stones were strongly discouraged because they would fill the bin and make emptying difficult, although they would not seriously affect the biological process. When the men had left the room, menstrual protection was queried and it was explained that 'rags' could be added to the pile, and that the use of rags or scraps of cloth was prevalent in Australia prior to the introduction of tampons and pads, and as the cloth does not contain bleach, it is more likely to decompose than the commercial products. In many instances, it was observed by the author that habits and English expressions that were common in Australia in the 1940s and 1950s are extant in Kiribati. This could be due to the influence of the local Christian Churches which appear to be fixed, in some respects, in approximately that period of religious history and values (Pers. obs. June 1994 - June 1995).

The First Secretary suggested that prisoners could be used to empty the bins. It was pointed out that this would give a negative image to the composting toilets, and that if the process is working well, then emptying the bins should not be unpleasant and the system, including the production of fertiliser could be seen positively. Ministry staff queried whether it was safe to dispose of the compost in the lagoon. This was discouraged as it would be a high nutrient product, and also a waste of fertiliser in an environment with such poor soil.

Ministry staff asked if it were possible to operate the toilets without the solar powered fans. They suggested that the fans would not be maintained and the panels would probably be used for some other purpose. They also said that the monitoring of temperature was too complicated and there were already enough associated chores to perform in maintaining the toilets. In response it was decided that all toilets would be trialed with passive ventilation and temperatures would be measured during site visits by Australian team personnel.

Issues of privacy were discussed. Although the traditional practice of defecating on the beach or in the bush was conducted in public and could even be a social occasion, especially for women, people would not wish to be even be a social occasion, especially for women, people would not wish to be at all visible using their own toilets. There may even be objections to windows in the outhouses. This information was faxed to Australia so modifications to the out-house designs could be considered.

It was generally agreed that providing bulking agent from Australia would create an unsustainable habit and the people would be unlikely to want to collect their own supply when the rice husks were depleted. Also, it would not be testing the capability of the people and the environment to import this essential ingredient.

The project team were informed that the households would be chosen as soon as possible to allow time for site assessments before the Australian team's departure from Kiritimati. The Ministry appeared to be preoccupied with preparations for Independence Day, and with the extended presence of the Chief Justice and the Secretaries of the Ministries from Tarawa, whose departure from Kiritimati had been postponed by the Air Nauru flight delays.

It was apparent to the author that relevant Line and Phoenix Ministry staff had been very disturbed by the project team's arrival. Their expectations were based on what had been said by AusAID personnel during a visit in October 1993 (they appeared to remember conversations in precise detail), and the subsequent Project Design Document submitted for the Water and Sanitation Project in November, 1993 (Henry and Drew 1993).

Based on these communications, Ministry staff anticipated, at the time of the Australian team's arrival:

- that the Australian Community Health Educator, would remain on Kiritimati for 3 months;

- that an I-Kiribati Curriculum Development Officer from Tarawa would be funded to work with the Australian Community Health Educator (this person was waiting to be transferred to Kiritimati);

- that $50 000 would be provided to begin a national education program about water/composting toilets immediately, including the purchase of video equipment and televisions;

- that the toilet trial would be complete by the end of 1994;

- that water supply augmentation would be concurrent;

- that funding of additional technical staff and their training would begin immediately;

- that the Australian team were arriving with the toilets and outhouses;

- that the AusAID representatives who visited Kiritimati in October 1993 would be implementing the project;

- and that the composting toilets would be Clivus Multrums which they understood was the generic name for composting toilets. The Ministry staff claimed they were told these toilets would not need any maintenance and would produce minimal end-product which could be scattered around the toilet site. For these reasons they wondered if they were being provided with a inferior product because the systems proposed by the current Australian team obviously required householder participation and maintenance.

The staff also queried:

- why was the author's system more appropriate than Clivus Multrums if it required more work? Why had AusAID chosen the author's team and equipment? (They were unaware of the involvement of SMEC, and it was too difficult to explain the bureaucratic chain of command that resulted in the team's arrival. As far as they were concerned the Australian personnel were representatives of AusAID);

- if the Clivus Multrums were not being supplied why were they recommended in the first place? Was it because Clivus had a relative in the Australian government who had arranged to secure a market (Pers. comm. Karawaiti, Awira July 1994).

Later conversations revealed that the Community Health Educator, Marutaake Karawaiti had recently been recalled to Tarawa, but had decided to remain on Kiritimati because she felt that the sanitation project was very important for her people nationally, and she had established trust with the Kiritimati residents which she felt would ensure that the trial would be as effective as possible. She confided that her intended replacement was a man and it would not be as acceptable for him to visit the women in their homes, particularly to discuss sanitation issues. She had not seen her children for over a year so the decision to remain on Kiritimati was personally difficult, and she was concerned when she heard that the composting toilet trial would not be completed for another 12 months. Ms. Karawaiti emphasised the need for continuity of key personnel, both Australian and I-Kiribati during the Water and Sanitation project .

The Resource Economist, Ms. Miire Awira also expressed disappointment for personal as well as professional reasons that the water/sanitation strategy had changed and intended to write to AusAID in Tarawa requesting that $50 000 for the education program be advanced so that material could begin to be prepared for the National strategy. She stated that she too was due to leave Kiritimati when the trial was complete. Ms. Awira expressed her difficulty at adjusting to new personnel and a new agenda, which felt to her as though "the whole project was starting all over again". They alleged that they had not been notified of any of these changes and developments, and had not received any communications since October 1993, except to be told our names in June, 1994 when it was queried whether they would be present on Kiritimati at the time of our intended visit. Ms. Awira inquired whether the full water and sanitation project was still to be funded.

Repeated questions were asked concerning these issues when team personnel were working together or separately, as though the information that had been provided needed to be cross checked. It was not easy to provide complete or authoritative answers since the Australian team had received minimal official briefing by SMEC/AusAID as to the background or future intentions with regard to Kiritimati Water and Sanitation project. The team's credibility was significantly tested in this context.

The circumstances surrounding the commencement of the composting toilet trial were partially aspects of a remote and extreme environment, partially due to bureaucratic ineptitude and partially ramifications of the immature status of composting toilets in developed countries like Australia. Kiritimati is in an isolated place where communication even within their own county is erratic and where aid projects, such as the water and sanitation strategy have a significant effect on people's lives, not only in terms of providing much needed services, but also in providing direct and indirect employment, infrastructure, luxury items, status and for some individuals a reason for being sent to Kiritimati from distant homes and family.

For thirteen years the administrators and residents had been waiting for a water supply system and now it was dependent upon the trial of unfamiliar toilet technology. In addition both the toilet and the project team were not what they had been expecting for the proceeding six months. There were also expectations that provision of the toilet would fill a supply quota for government houses. All these circumstances, created an attitude of disappointment and mistrust which had to be overcome to allow an objective cultural and technical appraisal of the toilet to be conducted on Kiritimati.

On the positive side, it was apparent that the composting toilet had certain features that were appealing to the I-Kiribati. Unlike previously introduced sanitation technology, the composting toilet did not rely on scarce water supplies for flushing, traditional means of cleansing such as leaves, coconut fibre and rags could be used without clogging up the toilet or incurring expense, the toilet could in the long term be built from locally available materials, and compost from the toilet could be utilised to improve the deficient coral soil. However people were sceptical that the toilet could turn faeces into compost and many were doubtful that I-Kiribati faeces would produce as inoffensive compost as the I-Matang sample. Anxiety was expressed as to who would take care of the toilet due to the taboo against having anything to do with other people's excreta (Scott 1952: 27).

Communications with the Construction Superintendent revealed a further significant advantage to the usage of composting toilets on Kiritimati. To date trenches from the septic tanks, or pour flush latrines, have been dug vertically into the lenses to prevent seepage to the surface from a horizontal trench. The superintendent reported that he had never done percolation tests prior to constructing trenches because of this more direct practice and that sometimes, when the lens was too far below the surface they "would stop digging and rely on the run-off to seep to the lens". At the time of the first site visit to Kiritimati, there were 170 septic tanks installed in government houses on the island and 65 of these were over fresh water lenses, 97 over a houses on the island and 65 of these were over fresh water lenses, 97 over a brackish lens, and 8 toilets approximately 200 m from the fresh water supply. In the non-government houses there were at least 30 septic tanks installed over the fresh water lenses. Pit latrines and greywater soaks were also dug into the lens.

The World Health Organisation had designed and funded many of these sanitation installations (Wagner and Lanoix 1958:87; Public Works Division 1989: 2) (Pers. comm. Iotia July 1994). The practice of installing latrines into ground water sources was based on information from studies in European countries that pathogens (indicators) only travel up to a distance of 30 m before "filtration and die-off" causes them to disappear. Therefore, it was considered safe to install latrines more than 30 m from drinking water wells (Wagner and Lanoix 1958:29). This advice was followed closely on Kiritimati, and many domestic wells were installed approximately 30 m from the pour flush latrine.

7.1.5 Preparation for toilet installations

The provision of education concerning the need to protect the quality of the water lens became a priority (see Figure 7.4). Other matters attended to in preparation for the commencement of the trial included, organising local labour, soil percolation tests and ground water level assessment at trial sites to design trenches for the liquid run-off from the composting toilet, checking weather patterns for possible impact on composting process, and meeting with trial participants for initial education sessions. These meetings revealed that some houses had up to 20 residents which was more than anticipated and would have warranted the use of the Cage Batch in domestic locations had the project team been forewarned. The household numbers include grandparents and married siblings and their spouses and children, many of whom are at home all day. This load was not indicated. It was thought to be unlikely that the pile in the Wheelibatch fallow bins would compost as fast as the bins in use would fill up. If the bins fill more rapidly than they can be emptied then it is possible that the people would resume their practice of defecating on the beach or in the bush. It remained to be seen how the usage and biological function worked in practice.

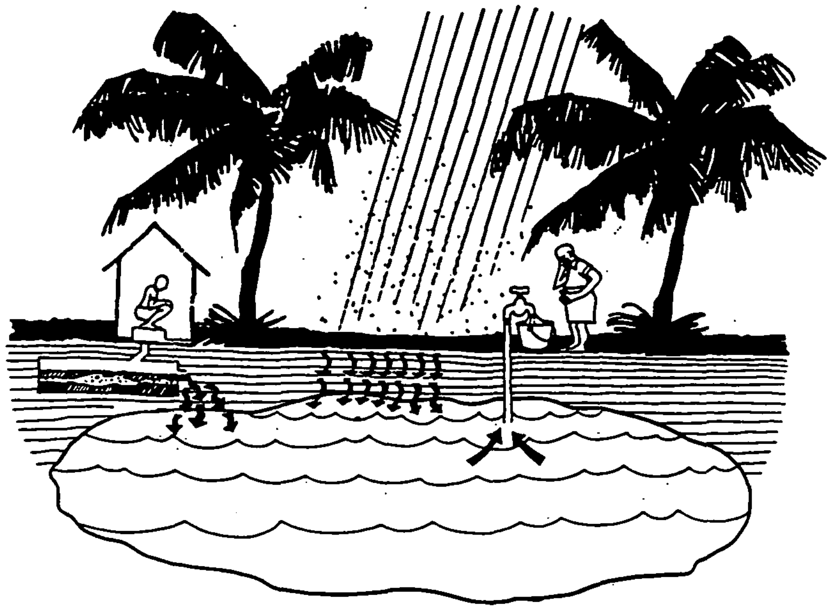

FIGURE 7.4

Education material: lens pollution from septic tanks.

Apart from a community funded clinic all sites were initially selected to be in government premises due to the requirement to fill supply quotas. This imbalance in the trial was later corrected to include non government residences (refer 7.2.3 and 7.4.2). Residents of government house are usually transient whereas non-government residents are long term in the sense that their leases are for 10 years, renewable, they are not transferred every three years as are the residents of the government houses, and they appear to take pride in their makeshift homes. For these reasons, it was thought that they may take more interest in the trial because the composting toilets would be more permanently theirs. In addition, there was evidence of cultivation of fruit trees in the non-government village of Tabakea that was not so apparent in London and Banana. In many ways Tabakea was more representative of a typical Kiribati village than the government villages.

The people of Tabakea had taken the initiative to fund and build basic septic tanks using stones. Unfortunately, the runoff is piped directly into the lens. The lens water is said to be brackish at those sites, but this was not confirmed.

Normally, the announcement regarding the locations for the composting toilets would have been communicated through the maneabas (community meeting house) with explanations as to the decision making process or perhaps a debate to decide how the choice should be made. The requirement that the locations be selected prior to the departure of the Australian team so that, at least, site assessments could be conducted was unfortunate, but the Ministry staff seemed confident that any confusion or resentment could be sorted out after the team's departure.

The trial participants gathered in one of the houses for a brief overview of water and sanitation problems on the island, an illustrated explanation of the workings of the toilet, and their required participation in the trial. Strong emphasis was placed on their control of the trial, the need for them to be honest in their criticisms and suggestions regarding use of the systems, and the importance the trial had for all I-Kiribati. Translation was required. A lively discussion followed. Some of the questions were:

- Will the buildings be secure for keeping the bins safe from children and dogs?
- Will there be locks for the bins?
- Is there any smell?
- Where does the urine go? Does the trench smell?
- Will others have the right to use their toilet because it is a trial?

One woman expressed concern and distaste regarding changing the bins. In general the group seemed enthusiastic about the trial, very pleased to have been selected, and keen to talk about related domestic issues. The group consisted of women and children and one man. The household representatives were asked to pass on what they had learnt to their families, and if it was too difficult to monitor the trial as required, then they should inform the Community Educator and another household would be selected.

It was emphasised at both domestic education sessions that the people did not have to remember all the details, and that the instructions would be repeated during the next visit to Kiritimati by the Australian team which would be the installation visit. This discussion was to let them know what the trial would involve so they could be prepared and could decide whether or not they wished to participate. It later became apparent that very little information was absorbed in these initial meetings, nor was it passed on to absent family members possibly because until the toilets arrived the project was too abstract.

Despite the similar general appearance of the soil on Kiritimati the percolation rates varied significantly between sites. The most alarming results occurred in some areas of Banana where the lens is less than a meter from the surface. As this lens is the main source of drinking water for Banana, London and Tabakea the proximity of housing, greywater soakaways and makeshift wells are a sure source of contamination. There were also 53 government houses with septic tanks in Banana. Even if they were replaced by composting toilets there would still be the likelihood of contamination from the other sources.

As a result of these assessments, maximum protection absorption trenches for composting toilet run-off would be installed, but with the high water table and the flash floods that occur during the rainy season in low lying housing area, there is the possibility of occasional panning, and leaching to the lens. However, the composting toilet and combination drainage system was thought to be the best possible protection that could be offered in those circumstances. There was more area available for trenches in Banana than in London where the houses were built close together, but each site had sufficient area for the required trench and the use of the run-off for growing bananas and paw paw (refer 7.2.4).

A large Cage Batch was to be installed at the government schools at Tennessee and Banana. A presentation regarding the trial was given to the teachers at each school. The Head Mistress of Tennessee school was very enthusiastic about the trial. She reported that when the school was built by the Americans, they refused to supply her with water tanks to collect drinking water off the corrugated iron roofs because they informed her it was unsafe to drink rainwater as it was polluted. The roof run-off was piped into the lens. After their departure she connected a tank to one of the roofs. She stated that she and the other teachers, two of whom were men, were very pleased to have a woman Project Director. One of the male teachers was from a London household that had been selected to have a domestic toilet and he stated that he was interested in gardening and compost use.

7.1.6 Consultation with Australian authorities after the first site visit

On return to Australia, the project team had a number of recommendations to make to AusAID. These communications were required to be passed through SMEC. One of the bureaucratic difficulties of organising the trial began at this time. Because the project was facilitated under a commodities program for administrative expediency, all consultation with AusAID was conducted through the procurement officer at SMEC. His job was normally to process the purchase and transport of commodities, not to deal with the complex cultural political and logistical problems that the trial entailed. Consequently consultation was often delayed, diluted or confused. Seven months into the trial, the author requested a meeting with AusAID, and this direct discussion significantly improved communication, temporarily (refer 7.2.9).

It was recommended that at some stage in the trial, possibly at the end of the installation visit or the first re-education visit that an adviser in organic agriculture join the Australian team to assess the most acceptable and efficient use of the compost on Kiritimati. Although there is an aid funded agricultural project established a few kilometres from Banana, it is not integrated with the village, and given the critical difficulty of transport on the island it appears that very few I-Kiribati visit the compound. Some households, particularly in Tabakea have started small gardens but they required advice and assistance to make the most of the poor soil conditions and limited water. It was considered necessary to start preparing trial participants for the use of the toilet compost, and to anticipate any related cultural or practical obstacles to utilisation.

Introduction of a sanitation strategy in any society is a complex and delicate undertaking as it touches people's lives in the most basic and personal manner, and has a myriad of social, economic and environmental ramifications. Where the technology transfer is cross cultural, the undertaking is even more complex, particularly if it involves the symbiotic relationships associated with aid. For the above reasons, it was strongly recommended to AusAID that personnel responsible for carrying out this task are readily and thoroughly briefed as to pre-existing conditions and possible future intentions before being sent to the location. The obligation to source relevant instruction and information should not be the responsibility of the implementing team, unless otherwise advised. When AusAID Kiribati Program personnel were requested for at least some background information, a very abbreviated version of the draft of the Design Document for the Water and Sanitation Project was informally provided. Without this limited briefing, the team would have been entirely unprepared for the response from the Ministry of Line and Phoenix Development that occurred during the first visit to Kiritimati.

In addition to erratic flight schedules, the ship scheduled to transport the toilet equipment to Kiritimati ran aground. These mishaps and delays are common in the developing world and it was suggested that a project of this kind in the Pacific should allow for considerable stand-by time, and appropriate remuneration. The expectation that the project team would adjust other commitments to the constantly changing transport schedules of the Pacific added extra stress to the trial process, particularly in the early stages.

From the outset it was suggested to AusAID that it could be useful to design an alternating batch composter to be constructed out of locally produced concrete blocks and trial at least two of these systems concurrently with the mobile and Cage Batch toilets. Ministry staff had asked if this would be possible. This would provide additional information as to what was the most appropriate long term strategy. Ultimately, sanitation technology would need to be considered in relation to integrated planning of housing design and village settlements. The author observed that most of the government housing, which was constructed from materials left by the British after the 1950s nuclear tests on Kiritimati, was dilapidated, inappropriate and unnecessarily crowded. The I-Kiribati Construction Superintendent advised that it was due to be replaced or renovated so this would provide the opportunity for integrated design, if the concept of composting toilets proved culturally acceptable (Pers. comm. Iotia June 1994).

7.2 The second site visit: toilet installations

The toilet outhouses and composting systems were shipped from Brisbane, Australia on August 16, 1994. On advice as to probable shipment time, the installation visit was scheduled September 19 - October 19, 1994. Due to shipping delays, the equipment did not arrive on Kiritimati until October 21. At that time regular Air Nauru flights to Kiritimati from Tarawa were indefinitely cancelled, and although some flights continued it was not possible to make bookings for these flights in Australia. It appeared that the installation visit would have to be postponed, and suspending the project altogether was discussed. Eventually it was possible to join a chartered flight to Kiritimati via Honolulu but this arrangement was temporary and was only confirmed from week to week.

Due to the unreliable project schedule, and the lack of bureaucratic support and associated difficulties, the Australian Community Education Specialist resigned, and ongoing education was undertaken by the author with the assistance of Dr Stuart White. During this period of adjustment communications with AusAID were significantly strained by the necessity to negotiate through the contracting agent, SMEC.

7.2.1 Unloading equipment

The Ministry of Line and Phoenix staff claimed not to have received prior instructions as to handling of the shipment, or the exact date of the Australian project team's arrival, and had proceeded to unload two of the three containers containing the toilet equipment. Two of the containers were then loaded with copra in preparation for the return trip to Tarawa. At that point, Ms Karawaiti contacted the Australian High Commission in Tarawa to seek storage advice and was informed that the containers should not be unloaded until the Australian project personnel arrived and the containers were to remain on Kiritimati. The copra was removed from the containers and the equipment stored in a warehouse. During this process one of the containers and some of the equipment were damaged.

Removal of the large Cage Batch toilets from one of the containers required the assistance of a forklift truck which was assumed to be available on the island, but this was not the case. In the first couple of days, a variety of vehicles were hired in an attempt to remove the equipment, and the units were finally hauled out by crane and personpower. As there were only three weeks to complete the installation of twelve toilets and conduct an education program, this delay in unloading reduced available project time.

7.2.2 Labour

At most times during installation four or five unskilled and semi-skilled I-Kiribati assisted with construction. As there was minimum shared language between the Australian project team and the I-Kiribati construction crew, communication depended largely upon mime and intuition. None of the labourers had any prior experience of composting toilets, or working with I-Matang.

7.2.3 Installation

The 12 composting toilets were successfully installed in the locations and conditions summarised in Table 7.1

TABLE 7.1
Location and characteristics of trial toilets at second site visit.

Toilet No.	Name	House-hold size	Location	Type	Comments
1	Bosco	15	Banana	Small cage	installed 40 m from bathhouse
2	Bokatu	19	Banana	W'batch	installed 100 m from house
3	Ereataake	7	Banana	W'batch	installed 20 m from house
4	Kabunare	6	Banana	W'batch	installed 20 m from house
5	Arawatau	5	Banana	W'batch	installed near bathhouse
6	Kononos	9	Tabakea	W'batch	installed beside existing septic tank toilet 100 m from house
7	Community clinic	2 staff plus clinic patients	Tabakea	Small cage	installed near proposed maternity hut
8	Banana (Government) School	200 pupils	Banana	Large cage	installed near teachers' office
9	Tennessee School	480 pupils	Between London and Tabakea	Large cage	installed on exposed sandhill near existing septic tank toilet
10	Taukaban	6	London	W'batch	installed beside bathhouse
11	Titana	2	London	W'batch	installed beside bathhouse. Neighbours objected to promimity
12	Temakau (Bitati)	7	London	W'batch	installed beside outside kitchen area

Three Wheelibatch domestic toilets were installed adjacent to the bathrooms at London government houses. If housing had not been crowded, residents would have requested that the toilets be installed as far away from the house as possible as they were convinced that they would smell. When the fourth Wheelibatch was about to be installed, the author was informed that a neighbour had complained to the Ministry about the proximity of the proposed toilet to his house and the toilet should be relocated.

The author strongly recommended that this toilet should be relocated to a

Tabakea domestic site. To create a fair evaluation of usage in Kiribati conditions, it seemed desirable to also trial the composting toilets at non-government houses. The proposal was discussed by I-Kiribati project personnel and then submitted to the Tabakea Housing Committee for selection. The decision was difficult, partly because it had to be made within 24 hours, and the Chairman of the Committee was selected. He and his family were most helpful during construction and showed initiative in dealing with potential security problems by offering to build a fence from local materials around the toilet building.

Four Wheelibatch toilets were installed in government houses in Banana. As a result of the neighbours' complaints in London, the domestic toilets at Banana were installed at the back of the house blocks at some considerable distance from the house. The Health Department staff discussed the proposed toilet with the neighbours, in each case, before installation, to ensure there would be no objections.

7.2.4 Liquid drainage system

Excess urine drained to an evapotranspiration trench (see Figure 7.5), which was designed to minimise the percolation of liquid down to the ground water by:

- minimising the likelihood of runoff entering the trench by mounding the soil above the trench;

- maximising the opportunity for evapotranspiration through grass and other high evapotranspiration plants on the mounded area above and adjacent to the trench;

- maximising the path length for any excess liquid which may build up from time to time due to periods of low evapotranspiration or higher loading rates.

The trenches were dug to a depth of approximately 500 mm, with a width of 600 mm and a length ranging from 1 m to 2 m depending on the expected loading rates.

These trenches would be handling considerably lower volumes of liquid than the septic tank absorption trenches or greywater soaks that were currently in use at many Kiritimati houses. It was anticipated that the accumulation of liquid should be slow and would allow ample time for the growth of high evapotranspiration species on these mounds.

The urine loading of the toilets units would be determined as the trial proceeded, since it depended on a number of factors, including the frequency of urination, the volume of urine and evaporation rates. Following discussions, it was clear that many men and boys were unlikely to use the toilets for urination and would continue to urinate outside, other than when defecating. Some of the units might, therefore, have very little or even zero excess urine accumulation.

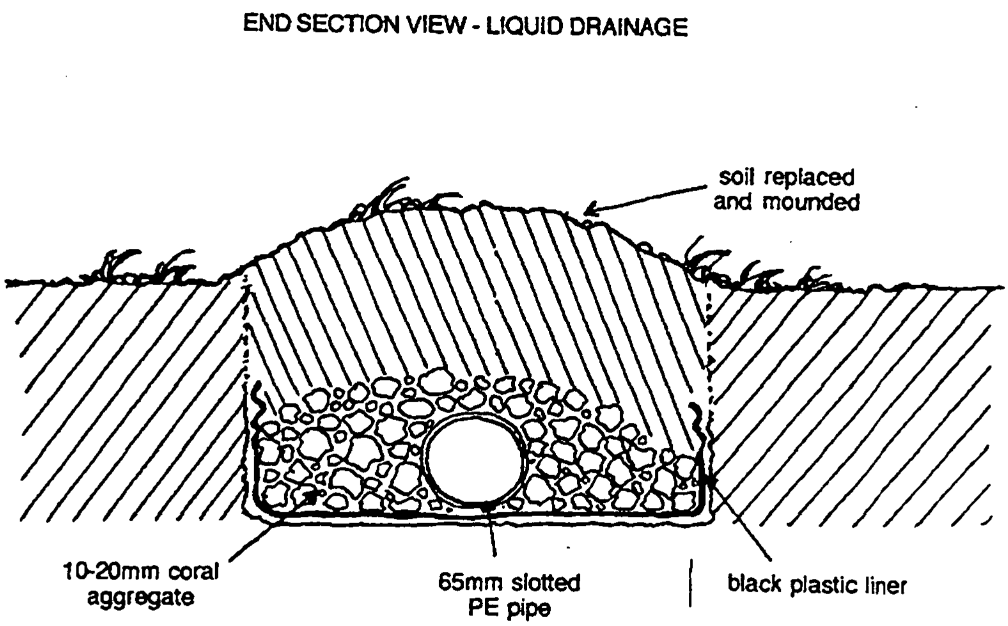

FIGURE 7.5

Section of evapotranspiration trench.

7.2.5 Outhouse design

The buildings were prefabricated in Australia, and designed for easy transportation and assembly. Due to the rushed timetable of the project, they were designed and almost built before the first reconnaissance visit was completed, and some features proved impractical in Kiritimati conditions.

Access doors were made of canvass flaps that could be secured from both the outside and inside, and the windows were covered with shade cloth. This was to allow maximum ventilation and light and minimum maintenance.

The toilet rooms were elevated to allow the compost bins to be above ground level, which was to ensure non-contamination of the ground water by sewage material. This was particularly important where villages were sited over the lenses as was the case in most of the villages. Because the buildings were tall and narrow, resistance to strong winds was built into the design. The buildings were often the highest construction in an area. The obvious nature of the buildings was increased at sites where the unit was installed at some distance from the house.

7.2.6 Community feedback

As previously mentioned, residents in London village objected to the proximity of their neighbour's composting toilet to their house. During the reconnaissance visits potential locations had been investigated and the toilet sited on the bathroom side of the user's house (refer 7.1.5). However in one case, the site was adjacent to the neighbours' kitchen area, which had been extended since the reconnaissance visit. To help alleviate this problem the bin was carefully concealed with canvas, and later a fence was built between the two houses.

Some I-Kiribati considered the height of the toilet building peculiar, if not objectionable. Some householders suggested growing trees around the building to make it less obvious. Monitoring the trial would produce data that would indicate usage relative to capacity and so may allow design adjustments. However, the guiding principle of ground water protection necessitates the bins being above ground and so the composting toilet building will always be higher than other toilet facilities, particularly in a flat landscape. Housing design and the use of tree cover could alleviate this discontinuity, but otherwise acceptance of building height was a focus for education.

Most householders and the school staff were concerned that the toilets could not be padlocked. During the reconnaissance visit it was requested that the bins could be locked to prevent access by children or theft, and this protection was provided. But it was not mentioned that the buildings should be lockable. To rectify this situation it was suggested, by the author, that light timber frames be built and the canvass doors attached so that the doors could be padlocked. A satisfactory prototype was constructed and installed before the Australian project team's departure, and funds were requested by the Construction Superintendent to construct similar lockable doors for the other eleven toilet buildings.

Some apprehension was again expressed regarding the changing of the Wheelibins, because of certain cultural implications. It was requested that if a government householder moves to another residence, they should change the Wheelibin in use before moving, even if it was not full, and leave a clean empty bin for the next resident to use, to avoid cultural aversion.

Australian project team personnel were guests of honour at a celebration presented by the staff and school committee of the Tennessee School. Ministry and Health Department staff were invited. The function included presentation of gifts, singing, speeches and a feast, to mark the opening of the school's composting toilet. The I-Kiribati particularly appreciated the efforts of a volunteer from Australia in his late sixties who joined the project team to assist with the construction of the toilets. A copy of the speech, which indicates a solid grasp of the principles involved in the trial is attached in Appendix C. At the function senior ministerial staff became inebriated and criticised the Australian team for forcing a culturally unacceptable toilet upon the Kiribati people. This caused considerable embarrassment to other guests, but was usefully revealing to the Australian team. Often more authentic responses were forthcoming from people whose strict code of politeness was diminished by excessive alcohol consumption

The staff of the community funded clinic at Tabakea prepared lunch for Australian and I-Kiribati personnel on the two installation days at that location, and were generally very appreciative to have been selected for the composting toilet trial.

7.2.7 Education during the second site visit

The education component for the installation visit was conducted by the author, in co-operation with the Community Health Educator, Marutaake Karawaiti and the Health Inspector, Ms. Beia Tim. Beia Tim was transferred in August 1994 from Tarawa to supervise the composting toilet project and attend to other duties. Due to insufficient housing on Kiritimati, she had been temporarily transferred to Fanning, (or Tabuaeran) Island (refer Figure

7.1) Funding was requested and provided by the author for her return airfare to Kiritimati during the installation visit. Funding was also provided to assist with her family's transfer from Fanning to Kiritimati by the next available ship. Adequate housing for Kiribati project staff remained a problem throughout the trial.

7.2.7(i) Instruction and training

Individual instruction and training was provided, at each site, to the nine households, clinic staff, and staff from the two schools on the following:

- use of the toilet, for example, recommended bulking agent and anal cleansing material, keeping the lid closed to ensure correct ventilation flow, and to exclude insects.
- cleaning the toilet facility
- monitoring usage and composting process.
- changing the bins.
- starting the composting process.
- emptying the bins, and potential uses for compost.

Laminated signs, in Kiribati, describing toilet usage, monitoring and maintenance, were pre-prepared by project personnel in Australia, and fixed in each toilet room. Most of these signs were damaged or removed within a couple of months, and the maintenance directions required regular reinforcement.

7.2.7(ii) Community discussions and information

1. Community group discussions on the use of the toilets and importance of the trial were conducted in London and Tabakea by Health Department staff, and were extended to Banana in the coming months as part of general community health instruction.

2. A meeting was held with the nurses and nurses-aids from all the villages including Poland, and hospital staff, to explain the composting toilet technology, health benefits and the trial program.

3. A full briefing on trial progress was provided to senior staff from the

Ministry of Line and Phoenix, the Health Department, and the Education Department.

4. Public notices were prepared in Kiribati describing the technology, usage, and the importance of the trial and placed at shops, public facilities and meeting places in London, Banana and Tabakea.

5. Although there was no radio station on Kiritimati, local I-Kiribati had erratic access to Tarawa radio so a program was prepared on the installation of the toilets and the significance of the trial, and released by Tarawa radio station for the information of the people on Kiritimati, and I-Kiribati throughout the country.

7.2.7(iii) Water quality demonstration

A portable water quality testing laboratory was transported to Kiritimati by the Australian project team to begin to establish base-line data, and as an educational tool, to substantiate the level of faecal contamination in the lens, and to demonstrate this pollution problem to the I-Kiribati. The Ministry and Health Department staff were impressed and concerned at the results, and asked for their staff to be trained to use the equipment. Basic training of Health Department and Public Utilities staff was commenced, involving the foreman of the PUD, and the Health Inspector. The Ministry wished to purchase the equipment so monitoring could be continued, and requested a components list. As the kit was equipment privately owned by the Australian project team and used regularly, it was not advised to leave the equipment with the Ministry without confirmed funding, although the Ministry requested this. A letter from the second Secretary, Francis Ngulu, requesting funding for the equipment was sent to AusAID.

7.2.8 Continuing unfulfilled expectations

On arrival on Kiritimati for the installation visit, the author was questioned again as to why they had not brought a video camera and video player to make an educational film about the toilets and the trial (refer 7.1.4) As previously mentioned this assumption was based on the original October 1993 Project Proposal which included funds and equipment for an educational film. As queries raised in the author's reconnaissance visit report, regarding the funding parameters of the composting toilet trial, had not be clarified by

AusAID, it was still assumed by Ministry staff that funds were available to carry out the education program proposed for the wider Kiritimati Water and Sanitation Project. Health Department and Ministry staff strongly expressed the opinion it was necessary to produce a video to provide adequate education.

In response to the urgent requests, and as resistance to the trial was inflamed by these unfulfilled expectations, permission was requested by fax to AusAID/SMEC to order a video camera through the Kiribati Honorary Consul in Honolulu, William Paupe. Mr. Paupe delivered a video camera to Kiritimati on the next charter flight as requested. Negotiations around this sensitive transaction were again complicated and impeded by the indirect consultation procedures required, and the erratic telecommunications service on Kiritimati.

It later became apparent that filming and editing skills were not available among the I-Kiribati Ministry staff, and that the video camera was partly required for events unrelated to the composting toilet trial (Pers. comm. Karawaiti November 1994). Coincidentally, the author had previous experience directing and editing documentaries in Australia, so an attempt was made in the limited time available, to shoot installation footage and to develop a simple educational script using key I-Kiribati project personnel as 'talking heads'. However, film making was not part of the project brief or schedule, and funds were not included in the composting toilet trial budget to create an appropriate educational film.

As there was no editing equipment available on Kiritimati, the footage was brought to Australia. However, as it was shot on an American NTSC system it required several generations of transfer to enable it to be edited in the Australian PAL system and returned to NTSC, and the quality, particularly of the sound, would seriously deteriorate during this translation. It seemed that the camera had been purchased without purpose, and although the I-Kiribati were somewhat placated, relations with AusAID and SMEC had further deteriorated in the process.

7.2.9 Observations after the second site visit

Official clarification of the funding and scope of the composting trial in relation to the overall Kiritimati Water and Sanitation Project should have been conveyed to the Ministry of Line and Phoenix Development to avoid unfulfilled expectations and dissatisfaction, particularly as this was requested by the author after the reconnaissance visit. The Australian team were required to deal with the complaints and resistance from the I-Kiribati without any pre-briefing or support from the funding or contracting agency. There had been no response to the first report or recommendations or any direct consultation with AusAID for six months. The Australian project team were inexperienced in dealing with inter-government aid politics.

The unpredictable Air Nauru and Air Marshall Islands flight schedules made it very difficult for Australian project personnel to plan visits, or co-ordinate the composting toilet project with other commitments. Flight cancellations had also prevented the scheduled visits of the AusAID Country Program Manager, Greg Brooke and the AusAID Tarawa representative, Leo Kuipers. Their attendance on the island would have allowed many of the misunderstandings among the I-Kiribati and between the Australian project team and AusAID to be clarified. The uncertain flight schedules reduced the potential for constructive input, and therefore threatened to affect the success of the trial.

The primary purpose of this project was to trial all aspects of the installation of composting toilets in coral atoll conditions. This included administrative, social, cultural, technical, environmental and maintenance considerations. For this reason, all feedback from the Kiritimati community, users/householders and the Australian and I-Kiribati team personnel, whether negative or positive, was important.

However, there was an inclination for SMEC to screen out 'negative' responses in any reports to AusAID. Conducting a thorough trial of a small number of toilet installations is potentially a constructive and efficient strategy that should indicate what is realistically workable, and what is impractical, before extensive implementation is undertaken, but the feedback should be realistic and authentic. In addition, the treatment of sewage should not be planned in isolation. Integration with on-site and reticulated water supply, and small scale agriculture is a characteristic and beneficial feature of composting toilet usage, and these issues required thorough discussion and review. As this was a complex project culturally, geographically and environmentally, the project would be significantly facilitated by reliable transfer of information and feedback.

The Ministry staff also requested prior notice of arrival of equipment and directions for handling, arrival dates of Australian team personnel and copies of progress reports. AusAID personnel claimed that all this information had been provided to the Kiribati government in Tarawa (Pers. comm. Brooke January 1995).

The difficulties experienced in the first nine months of the trial related to the communication and transport problems associated with a remote site, the convoluted chain of command that controlled the administration and funding of the project, the symbiotic complexities of aid donor/recipient relations and the lack of adequate comprehension on the part of project administrators of the implications of cross cultural sanitation technology transfer.

As the misunderstandings increased, the author disregarded instructions not to make direct contact with AusAID and appealed for assistance through Women in Development personnel. In response a meeting was held in January 1995 at the University of Tasmania in Hobart between the AusAID Country Program Manager, an AusAID social impact adviser, the commodities manager from SMEC and the project team. This face to face encounter clarified many issues and allowed discussion and agreement concerning the next stage of the trial which would provide limited funding to make an educational video using a PAL system camera, the installation of three more toilets in the non-government village of Tabakea and the inclusion of a sustainable agriculture adviser in the project team to address the issue of the use of toilet compost in cultivation. In addition, AusAID undertook to fully inform the Ministry of Line and Phoenix on the parameters of the trial (Pers. comm. Brooke, Luscombe, Ranck January 1995).

7.3 The third site visit: cultural and technical monitoring

In February 1995, the Australian team visited Kiritimati for the third time, for a duration of two weeks to continue the education program associated with the trial of composting toilets on the island. The toilets had been installed in November 1994, and this visit was the first opportunity for the Australian team to observe the toilets and assess their performance. The toilets were performing satisfactorily overall, and the problems that were observed were able to be remedied during the visit. These problems included undermining of some bins by chickens, pigs and crabs, use of inappropriate bulking agent, concern about privacy relating to the design of the door and toilet seats being left up by school pupils and non-participants less familiar with the requirements of the toilets.

During the February 1995 visit, action was taken to remedy these problems and to further the aims of the trial. This included the construction of concrete slabs under the eight wheelibatch toilets to provide a more secure surface for the bin, more detailed instruction for participants in the use of bulking agent, the installation of new doors on the toilets with padlocks and assisting with the development of a mimed song about the trial to help spread the message amongst the school pupils and their parents. Table 7.2 summarises these investigations and remedies.

Other educational activities included shooting video footage for the educational video on the trial and two short training videos on water testing and the procedure for changing the bins. A poster was developed in conjunction with the Government of Kiribati counterparts.

A specialist in sustainable agriculture, Mr. Greg Berry, joined the project team on the February 1995 visit. The purpose of his participation was to assess the potential for the use of the composted material and the attitude of householders to that possibility. These investigations indicated that successful production of good quality compost and its demonstrated use in cultivation would be conducive to the acceptance of the toilets. There were a number of I-Kiribati who expressed willingness to use the compost on their gardens.

Following the decision to construct three additional toilets as part of the trial, planning and organisation of these additions was undertaken in anticipation of supervising the construction during the next visit. The sites were chosen by the Tabakea Housing Committee and surveyed, and arrangements made for the labour and materials for their construction. The outhouse component of the toilets was designed in discussion with the Tabakea village participants. In a meeting with the Tabakean villagers, the Mayor of the village requested that the Australian team provide him with fittings that could not be purchased on Kiritimati and he would build a composting toilet at his own expense. He understood how the use of composting toilets would protect the lenses from faecal contamination and stated that he intended to remove his septic tank flush toilets. In a society dependent on aid, this offer from a community leader to undertake his own toilet construction was a very significant gesture in support of the trial. The fact that the mayor had recently resigned from a long career in sanitation and water supply as the foreman of the Public Utilities Division, made his participation even more eloquent.

TABLE 7.2
Location and characteristics of existing trial toilets assessed during the February 1995 visit. See Appendix D for assessment by Kiribati counterparts up to 10 January 1995.

Toilet No.	Name	Household size	Location	Type	Comments
1	Bosco	15	Banana	Small cage	At least 10 adults every day; also performed well after large gathering in late January 1995; slight ammonia smell; well maintained with leaves and flowers; advised occasional use of coconut fibre; flies seen in liquid drain area.
2	Bokatu	19	Banana	W'batch	Bin changed 7/1/95 despite being half full; advised to tamp pile to maximise bin capacity; gap between chute and pedestal caused by undermining by pigs and crabs; bulking agent pandanus and breadfruit leaves; no smell observed; large increase in household size; feast under way 21/2; slab installed 14/2.
3	Ereataake	7	Banana	W'batch	Gap between chute and pedestal caused by undermining by pigs and hens; fly larvae observed in bin 10/2/95; no flies observed; no smell observed; bulking agent coconut fibre; slab installed 14/2/95; bin near full 21/2.
4	Kabunare	6	Banana	W'batch	Gap between chute and pedestal caused by undermining by pigs and crabs; flies observed in bin 10/2/95; no fly larvae observed; no smell observed; bulking agent included whole coconut husks; concrete slab installed 14/2/95; bin nearly full 21/2/95.
5	Arawatau	5	Banana	W'batch	Gap between chute and pedestal caused by pigs and crabs; fly larvae observed in bin 10/2/95; no flies observed; no smell detected; bulking agent mostly leaves; excess of leaves used; concrete slab installed 14/2/95

Table 7.2 continued

Table 7.2 continued

Toilet No.	Name	Household size	Location	Type	Comments
6	Kononos	9	Tabakea	W'batch	Slight gap between chute and pedestal caused by undermining by hens; participant erected fence for security; no smell detected; bulking agent mostly leaves; slab installed 14/2/95.
7	Community clinic	2 staff plus clinic patients	Tabakea	Small cage	Some smell reported on weekends; no smell detected on inspection; bulking agent mostly leaves.
8	Banana (Government) School	200 pupils	Banana	Large cage	Nearby residents used toilet during weekends and vacation; seat left open; slight smell detected; inadequate bulking agent; flies observed in liquid drainage area.
9	Tennessee School	480 pupils	Between London and Tabakea	Large cage	Slight urine odour from under toilet during cross wind; seat left open; high urine load suspected.
10	Taukaban	6	London	W'batch	Gap between chute and pedestal caused by undermining by pigs and crabs; fly larvae observed in bin 10/2/95; no flies observed; bulking agent included pandanus; slab installed 14/2/95.
11	Titana	2	London	W'batch	Treated pine shavings being used as bulking agent despite instructions to the contrary; no smell detected; concrete slab installed 14/2/95.
12	Temakau (Bitati)	7	London	W'batch	Gap between chute and pedestal caused by hens; liquid drainage pipe blocked as a result of slippage; fly larvae observed in bin 10/2/95; contents very moist from heavy urine load; no smell detected; bulking agent leaves; bin changed 16/2; slab installed 14/2.

The Government of Kiribati counterparts, in particular Ms. Beia Tim and Ms. Marutaake Karawaiti, were conducting the trial between the Australian team's visits. Through further contact and shared work with these personnel, the Australian Team continued to establish constructive working relationships. However, the level of resourcing for these two personnel was inadequate, particularly in terms of access to transport and work space. This lack of support was partly due to lack of consultation between AusAID and the Ministry of Line and Phoenix, and partly due to the Ministry's apparent resistance to the introduction of composting toilets.

During the February 1995 visit the AusAID representative from the Australian High Commission in Tarawa, and the AusAID social impact adviser visited Kiritimati in the company of an engineer from SMEC. The presence of these representatives improved their understanding of the complexity of the trial, but due to the absence of senior Ministry of Line and Phoenix officials at the time, inter-government consultation did not appear to achieve the clarification that may have otherwise been possible. Despite being informed that these representatives were travelling considerable distance to Kiritimati to discuss the water and sanitation project, the I-Kiribati First Secretary left the island on the plane on which they arrived.

Communications had also been obstructed between the Australian project team and their I-Kiribati counterparts despite good working relations. From the outset of the trial, the Australian and Kiribati counterparts had acknowledged the need for ongoing communication between visits regarding trial progress, to provide feedback and advice. The Health Inspector, Ms. Tim, reported receiving fax communications from the Australian team and, as agreed, she had prepared a comprehensive progress report for the author and passed it on to Ministry of Line and Phoenix staff to be forwarded. A copy was sent to the Tarawa Health Department but not to the Australian project team. Had the Australian team received the report prior to departing Australia they would have been more prepared to deal with the maintenance issues that had arisen between visits.

It was decided to open a fax account for the Kiribati counterparts to send and receive faxes to Australia as required. This would eliminate the need for co-operation by the Ministry staff, but it did not address the issues that were at the core of some government officials' resistance to the project. To deal with these issues the author suggested that representatives of the Government of Kiribati Health Department and the Ministry of Line and Phoenix and AusAID meet to discuss and determine respective commitments, contributions, and responsibilities with regard to the composting toilet trial and its relationship to the water supply project. This would probably have to take place in Tarawa at some future date.

In the meantime, AusAID agreed to provide Ms. Beia Tim and Ms. Marutaake

Karawaiti with a motor scooter to facilitate their monitoring and educational responsibilities in relation to the composting toilet trial. It was expected that the Ministry would at least provide work space for the Kiribati counterparts. At the time of writing this still had not occurred.

7.3.1 Additional trial toilets

At the January 1995 meeting attended by representatives of SMEC, AusAID and project team, the Country Program Manager requested three additional toilets to be installed in Tabakea and it was agreed that a Cage Batch type would be trialed and that final decisions regarding the installations would be made after the February 1995 visit.

The need for these additional toilets was discussed at the official Ministry meeting on arrival on Kiritimati followed by a meeting between the project team and the PWD Construction Superintendent, Mr. Tuen Iotia to discuss the technical and logistical issues involved. During the reconnaissance visit, senior Ministry staff had expressed their concern that maintenance of the imported toilets would not be sustainable and requested that composting toilets from locally available materials also be trialed (refer 7.1.4).

The feasibility of building the additional toilets out of local materials was canvassed. It was established that cement, concrete blocks and treated pine timber for framing could all be purchased from the Government Supply Division. The project team were advised by Mr. Iotia that the materials should be ordered and paid for before departure. This was due to the fact that there had been a recent shipment from Tarawa and by May 1995 when the next visit was planned, supplies would have dwindled if another shipment had not arrived.

The design provided for a treated pine framing for the toilet outhouse on which a range of cladding could be used. Fibro, Colourbond corrugated iron and local thatching were discussed. Mr. Iotia expressed the opinion that if the trial was successful and this design extended to the rest of the island then a low maintenance 'permanent' cladding would be required, particularly for government built houses. However, for the trial it was decided to give the Tabakea residents the choice of cladding.

As there was need to include the three extra toilets in the trial as soon as possible, the author discussed this issue with the AusAID representative on his arrival on Kiritimati. Mr. Kuipers approved of the proposal to fabricate the toilets with locally procured materials (Pers. comm. Kuipers May 1995).

The Australian team decided that the bulk of the timber for framing and the cement for the slabs should be purchased and stored, and that the required concrete blocks should be ordered before leaving Kiritimati, to ensure availability of materials for the next installation visit.

The design to be used for the additional toilets in Tabakea is similar to the Cage Batch system, in that it has two fixed bins and false floor, but the pile is not suspended in an expanded metal cage. The design is based on the basic Farallones batch and it had been used by the Australian team for owner-built installations (refer 1.3.2). The chambers can be constructed from either concrete blocks or mud bricks (see Figure 7.6).

The advantages of the additional composting toilets being built from locally acquired materials, at that stage of the trial, were:

- increased local participation in, and ownership of the project;

- increased familiarity with the concept and principles of composting toilets through owner-building;

- increased likelihood of sustainable maintenance due to the use of locally available materials;

- delay and expense avoided through bulk shipment of items such as timber and cement from Australia; and

- provided an opportunity for comparison of performance, and attitudes to, locally-built and fully imported units.

It was planned that on Kiritimati locally made concrete blocks would be used for the chambers and treated pine will be used for the false floor in the bin and the frame of the toilet outhouse. The participants would supply coconut thatch for the roof and coconut sticks for the walls. The roof pitch was set to ensure that thatch could be used.

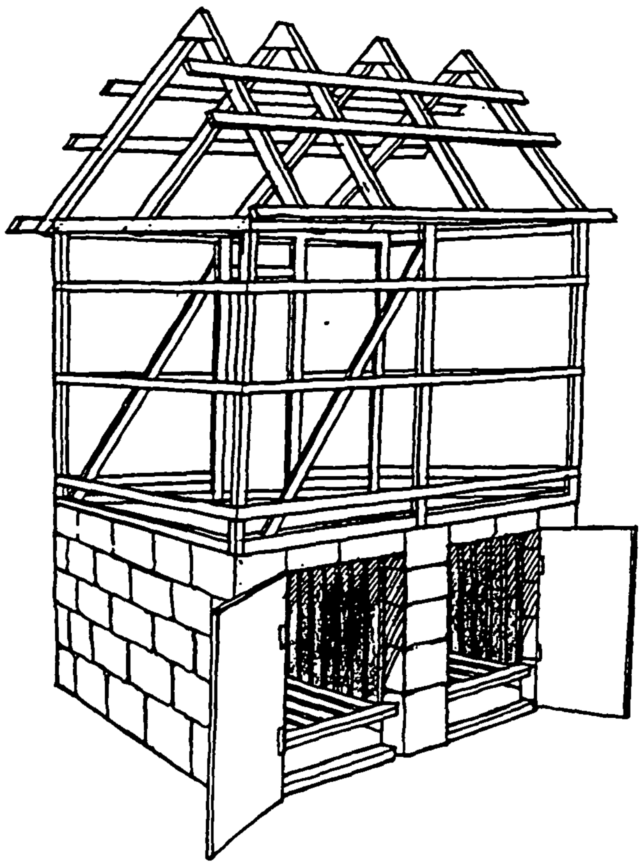

FIGURE 7.6

Batch toilet using locally available materials.

Mr. Kuipers expressed concern that if the locally built design was successful there would not be enough pandanus thatch to provide for all the toilets. He was informed of Mr. Iotia's preference for manufactured cladding for government house toilets and also that coconut thatching could be used, if desired, although it has to be replaced every two years.

On the project team's return to Australia, it was considered that these decisions had not been thoroughly discussed with SMEC and AusAID. As the composting toilet trial had been implemented under a commodities program to avoid bureaucratic delay, it was required that there be a maximum Australian content in the goods and services provided in the aid package. Although it was informally acknowledged that trialing the locally constructed toilet was appropriate, officially the Australian team were reprimanded for this undertaking (Pers. comm. Luscombe March 1995).

7.3.2 The Tabakea participants

The Tabakea Housing Committee met to decide who would have the extra three toilets. The trial participants were chosen from the list of people who had previously applied for composting toilets, with consideration given to two families with elderly long term residents of Tabakea who had difficulty walking to the beach due to physical disability. This was a gesture of respect within the village council rather that a practical decision as to who would be most appropriate as a trial participant. It was unlikely that the older family members would use the toilet due to the height of the building and the stairs.

The principles and practicalities of the composting toilet were carefully explained using the Tabakea clinic Cage Batch as a model. It was explained that the prefabricated bins could be replaced by concrete block chambers. A choice of cladding for the outhouse was offered. The trial participants chose local thatching. The availability of skilled labour in Tabakea was discussed and the three families decided to pool their skills and build each of the toilets together. They requested the assistance and supervision of the Australian team on-site, which was assured. They were also told that fittings that could not be purchased on Kiritimati would be brought from Australia.

7.3.3 Education during the third site visit

The education program for the composting toilet trial was the most important aspect of the trial, given the social and cultural barriers that needed to be overcome for the success of the project. The education program contained many components, and some of these have been developed in response to discussion with the Kiribati counterparts and to respond to changing circumstances and understanding of the problems as they arose. The components of the education program are described in more detail in the following sections.

7.3.3(i) Household trial participants

Each household participating in the trial was visited by the Australian team and the Kiribati counterparts on several occasions to discuss usage and maintenance of the toilets and potential use of compost. Some of the comments and observations are recorded in Table 7.3 which can be cross-referenced to Tables 7.1 and 7.2 Analysis and discussion of the attitudes to compost use are included in Table 7.4 of this Chapter.

7.3.3(ii) School education

The schools were regarded as having an extremely important role in the education program, due to the community focus that schools represent and also the didactic role that pupils have for their parents. Consequently, it was planned that as much effort as possible within time constraints be put into working with the teachers. However, during the period of this study educating the teachers to use the toilet was somewhat ineffectual and therefore the children were also deterred, despite both teachers and children displaying an interest in the project when the Australian team visited the schools.

<u>The compost toilet song "Kanoana te Kainakotari"</u>

Ms. Karawaiti, Ms. Tim and the Head Teacher at Tennessee Primary School composed a song about the need for toilets, the problems of waterborne disease, maintenance of the composting toilet and the protection of the water lens. The song was taught to the Tennessee primary school children and the teachers from that school put the song to mime and dance and performed it for the Australian team at a celebratory evening meal at the school. The performance was recorded and was featured in the educational video. Figure 7.7 shows a performance of the song at Tennessee Primary School near the large Cage Batch toilet.

It was intended that the compost toilet song be taught to the teachers and children of Banana Primary School and a competition would be held between the teachers of the two schools to develop the best accompanying dance and mime. The competition would be judged by the Australian Team and Kiribati counterparts at the May 1995 visit. Due to lack of time this performance did not occur.

TABLE 7.3

Comments and observations on the use of existing trial toilets assessed during the February 1995 visit.

Toilet no.	Name	House-hold size	Location	Type	Comments by trial participants
1	Bosco	15	Banana (govt)	Small cage	"Good for Kiritimati as it protects the lens; the toilets should be away from the house for cultural reasons"
2	Bokatu	19	Banana (govt)	W'batch	One teenage boy initially reluctant to use the toilet, now prepared to use it.
3	Ereataake	7	Banana (govt)	W'batch	Two teenage boys won't use the toilet, they don't want to be seen i.e. embarrassed by public nature of toilet.
4	Kabunare	6	Banana (govt)	W'batch	Temporary residents with little interest displayed in toilet; man using the toilet and woman not so keen; neighbours possibly using the toilet.
5	Arawatau	5	Banana (govt)	W'batch	Toilet had been closed to prevent children playing with record sheet; now in use following installation of lockable doors.
6	Kononos	9	Tabakea (non-govt)	W'batch	Prepared to use compost on garden; liked the fact that he didn't have to use water or toilet paper; has removed existing water seal latrine.
7	Community clinic	2 staff plus clinic patients	Tabakea (non-govt)	Small cage	Some neighbouring households may have been using toilet; nurse awaiting construction of house and compound to start garden for compost.
8	Banana (Govern-ment school	200 pupils	Banana	Large cage	Some neighbouring households using toilet; seat left open; song being taught to pupils; at meeting of 20/2/95 it was resolved to open toilet use from years 6-8 to whole school.
9	Tennessee School	480 pupils	Between London and Tabakea	Large cage	Some reluctance on pupils part to use toilet due to embarrassment of exposure; teachers use school water toilets; resident teachers use own water toilets; song being taught to pupils with mime composed by teachers.
10	Taukaban	6	London (govt)	W'batch	Woman more enthusiastic than man; woman using pandanus mat offcuts in toilet and was advised to change to leaves and coconut fibre.
11	Titana	2	London (govt)	W'batch	Previously complained about height of building, doors and windows; is now pleased with the toilet; mainly uses toilet at workplace.
12	Temakau (Bitati)	7	London (govt)	W'batch	Enthusiastic participants; no complaints despite technical difficulties.

FIGURE 7.7

The Tennessee Primary School teachers perform the compost toilet song "Kanoana te Kainakotari" in front of the large Cage Batch toilet.

Follow-up demonstrations at the schools

In the following months it was intended that the Kiribati counterparts would be concentrating on the teachers and students at the schools to ensure that the need for, and the principles of the composting toilets were understood and that the children and teachers were clearly shown, again, exactly how the toilets are used, maintained and what personal cleansing and bulking agents can be readily collected. It was acknowledged that these details need constant repetition since the concept was new and change is difficult to assimilate, particularly where there are cultural obstacles. As it happened only one visit to the schools occurred between the February and May visits. Consequently very little progress was made in the school trials during that period. For consistent education, it seemed that the presence on Kiritimati of Australian project personnel would be required over a three or four month period.

Toilet usage

Both schools had restricted the use of the toilets to the older children in order to control the monitoring process, and in case the children damaged the toilets. However it was decided at the February meetings that the toilet would be opened to the whole school and careful note taken of the children's reactions and comments. If the record keeping proved an obstacle to the use of the toilet, then the usage monitoring was to be abandoned. It was believed that the song would help with education, as would the educational video when it became available. Some smaller children had independently commented to the Australian team that they were disappointed that they had not been allowed to use the composting toilet (Pers. comm. Bryden February 1995).

At both schools the bush was still the preferred place of defecation for the older girls because of the difficulty of not being able to lock the door and secure privacy. It was hoped that this situation would now be improved with the installation of lockable doors.

7.3.3(iii) Poster

During the February 1995 visit a poster illustrating the relevance of the composting toilet to community health and water quality was developed by the Kiribati counterparts, the Australian Team and the Kiritimati Police Superintendent, who is a traditional composer of Kiribati poetry and song. The ideas were later incorporated into a design by an Australian artist (who had assisted with educational material throughout the project), and faxed back to Kiritimati for approval and pre-testing, before being printed (Pers. comm. Slapp March 1994/95). The development of the poster was a mutually informative process, as it clarified the different perspectives from which the Kiribati and Australian teams viewed the project (refer 7.4.4(ii)).

7.3.3(iv) Water test training

As mentioned in 7.2.7(iii), the Australian team transported a water test kit to Kiritimati on the second site visit in November 1994 and, in addition to undertaking a number of water tests, also conducted training sessions with the health inspector and the foreman of the Public Utilities Board

(Mara 1974: 70). Following the decision to bring forward the purchase of a water quality test kit for the Kiribati counterparts, the Australian team transported another kit to Kiritimati on the February 1995 visit, continued training and undertook several tests on groundwater samples from Decca, Poland, Banana and Main Camp which further demonstrated the high faecal contamination of the freshwater lenses (see Table 7.4).

TABLE 7.4
Water test results from February 1995.

Test date	Sample location	Result (faecal coliform per 100 ml)	Comment
19/2/95	Poland Gallery	60	Average of two results
19/2/95	Tabakea (Ambo well)	700	
21/2/95	Banana Gallery - near Banana Primary School	600	
21/2/95	Main Camp	70	Captain Cook Hotel

During the February 1995 visit the Australian team also recorded video footage of the full water test procedure. This footage was later edited and converted to NTSC format and a copy left on Kiritimati for the Kiribati counterparts to refer to in conjunction with the written instructions.

7.3.3(v) Educational Video

On instruction from AusAID an educational video was produced for the purpose of extending the impact and reach of the education program. Although there is no radio, TV or newspaper on Kiritimati, about 300 video machines have been imported to the island, and videos are supplied from the United States (Pers. comm. Bryden February 1995). It was hoped the educational video might give some status to the trial, and improve cross cultural communication.

During the February 1995 visit, the Australian team and Kiribati counterparts developed a film script dealing with pollutants to the lens, community health, the principles and practicalities of composting toilets, community responses to the toilets, use of toilet compost as a fertiliser, Australian water quality problems and Australian installations. The Kiribati counterparts wrote the speeches of Ministry and Health Department personnel and assisted with direction of community participation. As many technical and educational issues had to be dealt with in the two week February 1995 visit, time available for script development and shooting was limited. Script development, direction and shooting of the Australian segment continued when the project team returned to Australia, followed by editing of the complete video. Only the editing and printing costs for the production of the video were funded by AusAID.

7.4 The fourth site visit: additional toilet installations and monitoring

The Australian project team made a three week visit to Kiritimati in May 1995. The tasks were to inspect and review the operation of the existing toilets, to continue the education program including the cultivation and compost usage training and to construct three additional toilets in Tabakea village. These tasks were all completed, although once again time constraints only allowed minimum attention to each component.

A trial of composting toilets is a challenging task in any context. There is a large range of variables such as usage rate, balance between faeces and urine, micro-organism and invertebrate activity, pile and ambient temperature, pile size, and bulking agent composition and consistency of application. In the Kiritimati context it is even more rigorous, due to the history of sanitation, the cultural taboos and the lack of a common tradition of cultivation.

Therefore it was recognised that a trial period of nine months from installation to assessment is a limited evaluation period. This is particularly so on Kiritimati where there is no mass communication system such as radio or newspaper and where the traditional Maneaba (village meeting house) system of networking is breaking down and has not been replaced. Kiritimati also has many residents who have grown up or lived for years without using a toilet of any kind, much less an unfamiliar system which contravenes certain cultural taboos, and where people are now being asked to abandon a system (the pour flush or water treatment toilet) that has been strongly advocated for decades (Scott 1952: 27). If there were not justifiable pressures on the Australian government from the Kiribati government and community to proceed with implementation of the water and sanitation project as soon as possible, the

Australian team would have recommended that cultural and technical monitoring of the sanitation project be extended for at least another 12 months.

7.4.1 Existing toilets

A number of issues were common to all twelve original toilets and are worth noting, because they illustrate the cultural barriers in technology transfer of this nature. Firstly, the basic information such as household size, the number of people in a household who actually use the toilet and the frequency and type of usage is very difficult to establish. This is partly a result of a traditional lack of directness, particularly in regard to 'negative' responses, on the part of the I-Kiribati householders, which means that an extended period of quality time must be spent talking with individuals or groups before it is possible to obtain direct answers that can be regarded as accurate. For candid feedback it is also necessary that such an interview be undertaken by people familiar to the householder, a status that the Australian team were slowly achieving. Within these limitations it was established that usage pattern varied considerably as did household size, even within the one household.

It also became apparent that there was a fear of using the toilet in case the user would "do something wrong" which would jeopardise the trial which is regarded as important by a number of people, and upon which the water supply project is partially predicated. For example, many of the Banana Primary School teachers did not use the toilet despite the lack of a satisfactory alternative, and it was revealed only after much discussion that some teachers were concerned that the seat would not be able to take the weight of some of the heavier teachers. The teachers were reassured that the fibreglass pedestals, including the seats, are certainly strong enough to cope with all likely users (refer 5.8.1).

The initial observations are recorded in Table 7.5.

TABLE 7.5
Observations of trial toilets during the May 1995 visit.

Toilet No.	Name	House-hold size May 95	Location	Type	Comments
1	Bosco	6	Banana	Small cage	Well maintained with leaves and flowers; no smell observed; changed cage 13/5/95
2	Bokatu	15	Banana	W'batch	Active pile firm, moist and full, no smell observed; bulking agent too rough (pandanus and coconut shell observed); bin changed 14/5/95; material in first fallow bin (changed 8/1/95) dark, no odour, no sign of faecal material; sample taken
3	Ereataake	8	Banana	W'batch	Active pile no smell observed; fly larvae observed under leaves; bin changed 16/4/95; bin changed 13/5/95; crab holes under slab; 3 week old fallow pile had dropped to half volume and was partly decomposed, contained dark matted leaves, light faeces smell.
4	Kabunare	6	Banana	W'batch	Active pile no smell observed; fly larvae observed; dried salt bush bulking agent well mixed; bin 2/3 full on 13/5/95
5	Arawatau	5	Banana	W'batch	Active pile no smell observed; bin 2/3 full on 13/5/95
6	Kononos	8	Tabakea	W'batch	Active pile solid; compacted matted leaves; gap between bin and flange corrected with clips; fly larvae observed under leaves; no smell observed; 3/4 full bin changed 13/5/95
7	Community clinic	2 staff	Tabakea	Small cage	Active pile slight urine smell; bin 1/3 full
8	Banana (Government School	200 pupils	Banana	Large cage	Slight smell observed in cubicle; decomposition already occurring in active pile; pile levelled on 13/5/95
9	Tennessee School	480 pupils	Between London and Tabakea	Large cage	No smell observed; active pile small; pile levelled on 13/5/95

Table 7.5 continued

Table 7.5 continued

Toilet No.	Name	House-hold size May 95	Location	Type	Comments
10	Taukaban	6.	London	W'batch	Whole household using toilet; active pile is solid and has high moisture level; fly larvae observed; no smell observed 10/5/95 and 13/5/95; changed 3/4 full bin 13/5/95
11	Titana	2	London	W'batch	No smell or flies observed 13/5/95; active pile is dry, leafy, unable to be further compacted; changed full bin 13/5/95
12	Temakau (Bitati)	7	London	W'batch	Active pile very moist; wet brown leaves; firm but springy pile; little smell observed; fly larvae observed; changed 3/4 full bin 13/5/95; first fallow bin (changed 16/2/95) visibly changed and no odour observed.

7.4.1(i) Bulking agent

Various bulking agents were being used, and it was noted that most households had taken note of the advice offered during the February 1995 visit and were using appropriate materials, and with appropriate frequency. It was observed however, that even amongst the suitable materials added to the pile, there was a large variation in absorbency and size, with differences between salt bush leaves, breadfruit leaves, coconut fibre and whether or not the material was dried or freshly cut. These differences add to the number of variables that can influence the performance of the toilets. In ideal circumstances, the type and amount of bulking agent would be more standardised, but in the context of this trial, the overriding requirement was to find a bulking agent that the householders are able to collect with minimum effort. In one household it was reported that some children were not using the toilet because of the unwillingness to gather bulking agent, despite its close proximity.

7.4.1(ii) Active pile temperature

No consistent monitoring of pile temperatures was undertaken during this component of the study, but on one occasion during the May 1995 visit, the temperature of a number of piles was measured using a thermocouple probe, in each case inserted approximately 30 cm from the top of the pile. The results are shown in Table 7.6. As discussed in Chapter One, the temperature of a compost pile of this type is dependent on a number of variables, such as the moisture content, the carbon-nitrogen ratio, the aeration and most importantly the stage at which that part of the pile is in the composting process. This means that for 'snapshot' measurements, such as are being presented here, there is a range of temperatures giving a simple indication of likely microbial activity.

The results for no. 1 and no. 2 toilets indicate that, at the position of the thermocouple probe at that time, there was microbial activity which resulted in pile temperatures 10°C to 15°C above ambient. Thorough monitoring of temperatures in the piles would provide a useful comparison with the Australian domestic trials (refer 5.8).

TABLE 7.6

The results of temperature measurement of a sample of toilets. Note (a) indicates a reading error in the ambient temperature, the correct value can be assumed as an average 30 °C.

Toilet	Ambient temperature	Active pile	First fallow bin
1. Bosco	31.2°C	46.1°C	
3. Ereataake	29°C	40.4°C	31.3°C
6. Kononos	30.4°C	33.8°C	
8. Banana School	29.8°C	29.7°C	
10. Taukaban	29°C	31°C	
11. Titana	35.8°Ca	32.7°C	
12. Temakau (Bitati)	27.7°C	34.7°C	31°C

7.4.1(iii) Liquid trenches

As discussed at 7.2.4, the liquid trenches were designed to capture and allow treatment of any urine that drained through the active pile. It was of interest to know how much liquid was being drained from the toilets, so holes were dug in a number of the liquid trenches to determine the amount of moisture that has accumulated since the toilets were installed. The results of this investigation are presented in Table 7.7. In summary, the amount of liquid being drained into the trenches was less than expected, and was likely to be readily taken up through evapotranspiration by the existing and recently planted trees. This indicates that the liquid from the trenches was being prevented from reaching the ground water, due to the plastic lined trenches.

It was noted that the liquid was more concentrated and sometimes more odorous than that which had been observed in composting toilets being trialed in Australia. This was probably due to the increased likelihood of faecal matter being carried through with the urine, which was in turn due to the use of coarse bulking agent in the initial starter layer and the chronic diarrhoea suffered by people on Kiritimati (Pers. comm. Tim 1994/1995). This was only likely to cause a problem if blockages occurred in the drainage system, and could be remedied by ensuring that the first layer of bulking agent is suitably thick and contains finer fibrous material. Ensuring that the drainage pipes are large enough to accommodate solids would also help to ensure that blockages do not occur. It should be emphasised that with the small volume of liquid that was draining to the trenches, the plastic lining and the potential for evapotranspiration by nearby plants, there was a minimal risk of this liquid contributing to a public health risk. A concern in this regard had been expressed by a number of AusAID officials (Pers. comm. Ranck April 1995).

TABLE 7.7
Observations of liquid in drainage trenches.

Toilet	Depth of liquid
6. Kononos	slight moisture
8. Tennessee School	50 mm
10. Taukaban	minimal moisture
11. Titana	no moisture observed
12. Temakau (Bitati)	60 mm

7.4.1(iv) Establishment of gardens and trees

During the May 1995 visit, gardens were established at each composting toilet site and a number of improvements were made to existing gardens of participating households and the two schools. The objectives were to prepare areas for productive use of the compost when it became available and to ensure maximum likelihood of evapotranspiration of any liquid from the toilets that drained to the trenches. The households were assisted and advised by the Australian agricultural adviser, and it became clear that a major benefit of the cultivation education was the support it was able to generate for the trial and the toilets. Many households which had appeared indifferent to the toilets displayed enthusiasm following the garden augmentation process. The cultivation project is discussed in more detail in 7.4.3.

7.4.1(v) Composted material

A number of the bins and cages had material that had been deposited for some time. In the case of the Bokatu household in Banana village, the first bin had been changed on January 8, 1995 by the Kiribati team, despite being far from full. Nevertheless, this provided a good opportunity for the Australian team and the Kiribati counterparts to observe and test some material that had been lying fallow for just under four months. As described in Table 7.5, the remaining material was mostly bulking agent, in this case leaves, with no sign of faecal matter and no smell of faeces or urine. This material was analysed using the water test equipment on Kiritimati and found to contain no Faecal Coliform bacteria. A sample was further tested for this and other indicators (Faecal Streptococci and Salmonella) in Australia and no pathogen indicators were detected, but non viable whipworm eggs were observed. It is not known if the sample was adversely affected by temperature changes in transit from Kiritimati to Australia.

Other toilet piles showed signs of rapid decomposition, e.g at the Banana School the large Cage Batch showed evidence of composting at the base of the active pile. Also the toilet piles at the Temakau (Bitati, Temakau's wife has been the primary contact) and Taukaban households, which had been fallow since February, were obviously decomposing, having no offensive odour and the material was visibly altered and drying out.

One bin at the Kabunare household had only been changed three weeks previously and yet there had been significant decomposition and the volume had reduced in the bin substantially. This is quite common where the right combination of bulking agent and temperature means that the water content can be reduced and the pile shrinks (refer 3.2.6).

7.4.1(vi) Interviews with trial participants

The Australian team and the I-Kiribati counterparts met with all the participants. Many issues were discussed too lengthy to detail in this thesis. However, the constantly changing conditions under which the toilets were being trialed were a consistent theme. For example, the Principal of Banana School was newly arrived on Kiritimati since the February visit and was therefore unacquainted with the composting toilet, or the significance of the trial. It was reported that only two teachers used the toilet and that only 10 children on average per day used the toilet, and this was probably a generous estimate. Despite instructions to the contrary, the toilet door was left locked all day and children had to ask the Principal for the key. The author recommended to the teachers that the toilet be left open so that the children did not have to ask for the key, and that teachers or senior students be asked to check the toilet periodically to see that bulking agent had been added and that the lid was down.

Apart from the composting toilet, there was no functioning toilet at this school, so teachers used the toilets attached to nearby staff residences, or the bush. Most of the students used the bush, which was very near to the Banana water supply gallery.

There was no tap for the students to wash their hands after they had defecated, whether they used the composting toilet or the bush. As a result of the emphasis in the video on the need to wash hands after toilet use, the Public Utilities personnel undertook to install a tap at the compost toilet site, at both schools. At the time of writing the author does not know whether this has been done.

Despite all these obstacles, the base of the active pile in the school Cage Batch toilet was observed to be decomposing, and the pile did not have an offensive odour.

At the Tennessee school, the doors of this toilet were left unlocked during the day and teachers claimed that students were using the toilet, although the size of the pile suggested that this toilet had been receiving even less use than Banana School toilet. The teachers used the existing flush toilets or the nearby teachers residence, and most students continued to use the bush or the nearby lagoon beach.

7.4.2 New toilets

It was agreed during the February 1995 visit that the recipients of the new toilets would form a team and build each of the three toilets in turn (refer 7.3.2). This plan was abandoned because family members were engaged in other work at the time of the May 1995 visit. It was difficult to find skilled labour on Kiritimati as many people were preparing for the regional Small Island States Presidents meeting on Kiritimati, which was subsequently cancelled. Members of the household of the Tabakean mayor, Mr. Ambo Keeba, were employed to build all three toilets. This was advantageous as these men should then know how to build Mr. Keeba's toilet.

It was also agreed at the February 1995 Tabakea meeting that the three toilets would be assigned to those who had requested composting toilets. However, as previously mentioned, at least two of the toilets were allocated to households that were headed by elderly disabled men "as a sign of respect". Some objection was expressed by villagers who had requested the toilets and specifically wanted to use the compost for their gardens. Although this would have been preferable, the allocation that eventuated has meant that the toilets have been trialed in a variety of circumstance and with a variety of levels of enthusiasm. One of the households had a pour flush toilet and appeared to be not particularly interested in replacing it with a composting toilet. Recent fax correspondence from Kiritimati indicates that this household have removed their pour flush toilet and are using the compost toilet (Pers. comm. Teema June 1994).

Members of each household receiving a new toilet were given a comprehensive education session by Ms. Beia Tim and the author as to the principles of composting, the usage and maintenance of the toilet and the purpose of the trial. The participants were encouraged to discuss difficulties with the Kiribati team, including any reluctance to use the toilet. Ms. Tim reported that when she used the toilet, she experienced anxiety that she may be defecating on some one below her. This is one of the difficulties associated with the height of the building. For many people who have never or rarely used a toilet, just being inside a building to defecate feels like an unclean, or at least unfamiliar act.

The details of the households where the new toilets were installed are provided in Table 7.8.

The process of collecting, preparing and attaching the thatch roof and sticks for cladding was significant in terms of the overall objectives of the trial for several reasons. Firstly, most of the members of the families who were receiving a toilet had been reluctant to get involved in the building process, out of shyness or disinterest. The process of thatching required everyone to work together and appeared to 'break the ice' toward building a better relationship. The girls and women wove the thatch and then the boys and men attached it to the treated pine timber frame (see Figures 7.8 and 7.9). It took some persuasion by the Health Inspector to mobilise the families to contribute to the roofing and cladding of the toilets, despite earlier expressed enthusiasm for the locally constructed toilet (refer 7.3.2).

TABLE 7.8

Location and characteristics of new trial toilets constructed during the May 1995 visit. Note that the no 14 household have an alternative residence in Banana village and a large extended family which accounts for variations in the number of persons resident in the Tabakea house.

Toilet No.	Name	House-hold size May	Comments
13	Iaokiri Etera	7 adults 4 children	Male head of household limited mobility
14	Taabwi Teatata	7 adults 2 children	Household size varies considerably (0 to 30)
15	Bataua Tawaia	2 adults 3 children	
16	Ambo Keeba	8 adults 1 child	Toilet to be constructed by household using low cost adaptation of design

FIGURE 7.8

Weaving the coconut thatch for the roof.

FIGURE 7.9

Attaching the coconut thatch to the roof frame.

Secondly, despite reservations that some people had expressed about the disadvantages of the traditional materials in terms of their shorter life, after they were applied, the view was expressed that the toilets appeared more attractive than their houses and was an inspiration to improve their buildings generally. Many people also commented that the thatch and stick cladding made the toilet more inconspicuous and appealing to use than the imported prefabricated toilets installed in November 1994. It was made clear to the householders that the thatch and sticks could be replaced by permanent materials such as fibro and corrugated iron, and that the frame was designed to accommodate these materials.

7.4.3 Cultivation development

During the May 1995 visit to Kiritimati all the toilet trial participants were introduced to the fundamentals of basic gardening in preparation for the safe disposal of composted toilet waste into the soil as a fertiliser. Because there is no universal gardening tradition in Kiribati, the most simple tasks required to establish and maintain a successful garden needed to be explained, reiterated and reinforced. Essential tasks included regular watering of seeds and seedlings and exclusion of animals from the garden area.

It was decided to keep all operations as simple as possible and garden areas small and concentrated to maximise the chances of the program succeeding and to minimise watering requirements. Banana and papaya trees were established adjacent to all liquid drainage trenches. Where possible, plants used for the liquid trenches could serve a dual function as compost recipients. The aim was to ensure that trenches were planted out, and that there was a fenced or contained garden area planted with trees ready for the disposal of compost (see Table 7.9). Non hybrid seeds were provided by the Australian agricultural adviser and the potential for collection of seeds was explained. These procedures would require demonstration when the seeds were ready for collection.

Papaya and banana were chosen for the drainage trench planting because they are quick growing and the fruit is in high demand and short supply. Other local plants such as *te bero* or *te non* could just as readily be used and would be worth trialing. Most of the banana and papaya seedlings came from the Agricultural Station and the mayor of Tabakea. It was queried by AusAID personnel (Pers. comm. Ranck June 1995) whether the fruits of these plants could be contaminated from effluent in the trenches, and it was explained that in the process of evapotranspiration of the effluent from the drainage trenches, it is not possible for bacteria, protozoa or viruses to be transferred to the fruit from the roots through the millions of sieve tubes within the plants. In addition, plants are only infected by plant viruses, not by organisms that infect warm blooded animals (Pers. comm. Grohmann June 1995).

7.4.4 Education during the fourth site visit

The primary methods of ongoing education during the May 1995 visit were meetings with trial participants (refer 7.4.1(vi)), screenings of the video followed by discussion, the sale and distribution of the colour poster, development of cultivation at the sites of the composting toilets to treat and utilise liquid effluent and to prepare for use of compost (refer 7.4.3), and demonstrated use of a temporary composting toilet at the hotel. The video and cultivation education programs proved to be effective communication tools, mainly due to their interactive nature.

7.4.4(i) Video screenings

Between the February and May 1995 visits to Kiritimati, a 42 minute documentary/educational video on the compost toilet project was produced by the Australian team as part of the education program of the trial. Two copies of the video were brought to Kiritimati and shown extensively during the May 1995 visit.

The Australian and Kiribati project personnel all appear in the educational video and so the video screenings served to clearly identify them to the community. This resulted in increased spontaneous communication and queries from village residents concerning the composting toilets, and appeared to give more credibility to the trial. It was clear from the audience response that many people had been unaware of the purpose and technicalities of the composting toilet trial despite previous programs designed to spread the message.

TABLE 7.9

Details of liquid trench planting and garden construction at toilet trial sites (Pers. comm. Berry May 1995)

	Household	Drainage trench	Preparation for compost	Comments
1.	Bosco	Papaya planted in prepared soil next to trench. Area fenced with roofing iron.	Fenced area directly adjacent to toilet and very suitable for compost use. for further planting.	Residents prepared to use compost when instructed. First batch is now fallow.
2.	Bokatu	Large rusty metal containers were installed beside trench in which papaya & banana were planted & mulched in soil.	Trees on liquid trench also suitable for compost use. Vegetable garden established by request to encourage a gardening consciousness.	Surprising keenness to establish & learn gardening from all Banana trial participants. Likelihood of correct utilisation of compost is very with instruction. Testing of partly composted material from this toilet showed no pathogen indicators.
3.	Ereataake	Garden area fenced with thatch adjacent to toilet. Banana & papaya planted next to trench.	Vegetable garden also established within fenced area; compost to be incorporated around fruit	An enthusiastic participant prepared to use compost in area; crabs could be a problem
4.	Kabunare	Garden area fenced with roofing iron adjacent to toilet, banana & papaya planted near trench, nasturtium on	Separate garden prepared within fenced area for vegetables to provide incentive to care for garden area. will be used for fruit trees and flowers within	Householder is still unsure about compost because she hasn't seen it. But was reassured when told she would be shown how to use it when it is ready.
5.	Arawatau	Toilet is very close to a large breadfruit so nasturtium seedlings are planted directly on trench in prepared bed; small fence constructed around bed.	There are established papaya & breadfruit trees adequately fenced ready for compost	Householder became enthusiastic when his neighbours Kabunare & Ereataake arrived to watch proceedings & discuss their gardens; he is very willing to use compost & resolved to establish a joint garden with his
6.	Kononos	Banana was planted beside, and nasturtium on top of trench in prepared	Fenced area around toilet containing a breadfruit tree and the banana & flowers; ideal place to use compost	Willing to use the compost in the area when it is ready; very positive response to the project and interested in the
7.	Tabakea Communit Clinic	Banana and papaya planted in prepared soil in old tyres beside trench.	Flower gardens established and fruit trees planted between clinic and Birthing Centre as part of beautification project. Suitable for compost use.	The nurses at the clinic seemed inspired by garden & tree planting & conscientiously watered garden. Most seedlings appeared in 3 or 4 days.

Table 7.9 continued

Table 7.9 continued

	Household	Drainage trench	Preparation for compost	Comments
8.	Banana School	Banana planted beside trench in prepared soil & garden prepared on trench for flowers but not planted because of school holidays & time constraints.	If fenced, the banana tree will provide a suitable site for compost. Rehabilitation & fencing of a disused garden trench near the headmaster's office would also benefit from compost applications.	More work required at the school during the term on next visit including education on gardening, the use of compost & construction of secure fences around new garden sites. The pile in the first bin is composting well.
9.	Tennessee School	Banana & papaya planted in prepared soil beside trench. Very exposed site, coconut husks used as mulch.	Flower garden prepared and covered with shadecloth and chicken wire to exclude chickens.	Principal very keen. More work required during school term. Potential exists to develop beds begun by Ag. Officer & one teacher.
10.	Taukaban	Ground prepared & banana planted beside trench. Fence erected. No liquid in trench.	Two additional fenced areas are suitable for compost use, one growing food trees including breadfruit and papaya.	Enthusiastic and prepared to involve themselves in the project. Willing to use compost. Will be instructed in compost use next visit.
11.	Titana	Banana planted in prepared soil next to trench. Trench dry. Roots of nearby papaya in trench.	Fenced garden area suitable for compost use. Additional well fenced banana tree ready for compost.	Householder is more supportive than previous visit and will use compost when team says its OK. Neighbours now want toilet.
12.	Temakau (Bitati)	Banana, papaya & tapioca planted in fenced area near toilet. Nasturtium planted on trench inside tyre & drum for protection.	Inside the same fenced area around fruit trees.	Mother & young son keen to help and learn gardening. Willing to use toilet compost and will be instructed next visit. Trench inspected had 6cm liquid in bottom of trench. Need to inspect next visit.

Formal screenings of the educational video were held for a large number of community groups, with the three Australian team members and usually two Kiribati team personnel present for questions and discussion. On each occasion the video player was provided by the church minister, teacher or a local community member. Attendance and attention varied with each meeting.

Informal screenings were held in the homes of village residents and were usually attended by neighbours and one Kiribati and one Australian team member. Both NTSC copies of the videos were on loan each night during the visit by request from the householders who then organised screenings.

The English spoken/Australian segment of the video was translated by one of the Kiribati team personnel at each screening. Some I-Kiribati understood the English voice-over, but most of the audience required explanation and/or translation. These translations usually stimulated further discussion. However, with an increased budget, it would be useful to have Kiribatese subtitles for the English voice-over. It was considered that the Australian voice was quite effective for those who could follow the English as it gave authenticity to those sections of the video. Feedback from the video screenings is detailed in Appendix E. It indicates the effectiveness of the video as an educational tool in cross cultural communication, and the range of responses to and comprehension of the composting toilet trial.

The Kiribati project team, who pre-viewed the video, considered that the content and presentation of the video were appropriate and useful. Despite the video being edited in Australia without the assistance of an I-Kiribati translator, there were only a couple of minor points of style that would merit alteration if the video was to be re-cut, refined or updated for the larger project. Future video productions would benefit from the presence of an I-Kiribati community educator in Australia to assist with editing.

The video was generally received favourably by the Kiritimati community and some people requested second screenings, particularly if they or their relatives appeared in the video. As the children were on school holidays during most of the May 1995 visit, school screenings were not possible, but many children attended the community screenings and their attention was sometimes maintained throughout the video despite the length and serious content. Many of the same issues were raised in discussion at each screening, although in some cases the points were particularly related to the interests and occupations of the audience members. The I-Kiribati on Kiritimati rarely see themselves or hear their language on video, so this probably stimulated extra interest in the composting toilet trial video production.

7.4.4(ii) Poster - Naakuu Ee!

As mentioned at 7.3.3(iii), a four colour A2 poster, (see Appendix F) featuring the composting toilets as contributing to the cycle of clean water, health, hygiene and productive gardens was produced by the Australian team in conjunction with the Kiribati counterparts. The poster used the colours of the Kiribati flag. The Australian team brought 500 copies of the poster to Kiritimati during the May 1995 visit and presented them to the Kiribati counterparts for distribution and sale as they saw fit. Following discussions with the Australian team, the Kiribati team decided to sell the posters and to put the money towards a video player for showing the educational video about the trial and other health education videos. The Australian team also prepared a notice and information sheet for the tourists who stay at the only tourist hotel on the island advertising the poster for sale at an appropriately higher price. At the end of the May visit, several dozen posters had been sold to I-Kiribati and several to tourists. It is not known whether any further sales continued after the project team left the island. It has been apparent that I-Kiribati enthusiasm for such activities wanes between the Australian project team's visits.

7.4.4(iii) T-shirts

At the time of writing T-shirts are being produced using the graphics of the poster in Kiribatese and English. The T-shirts will also be sold by Kiribati counterparts to raise funds for health education strategies.

7.4.4(iv) Temporary composting toilet at hotel

The Australian team set up a makeshift composting toilet to demonstrate that I-Matang will use this dry conservancy technique, even when a flush toilet is available, and to observe how fast it would become full. The Kiribati team members were impressed with this commitment, and the Health Inspector requested that the system be transferred to her home when the Australians left the island. During this mini trial the Wheelibatch bin was invaded by housefly larvae.

7.4.5 Emptying the fallow bins

Between the May 1995 visit and the proposed assessment visit in September 1995, some of the households are likely to fill all their Wheelibatch bins and need to empty the fallow bin, so that it can be restarted as an active bin. If this were a controlled trial, or even a trial conducted in the somewhat less extreme circumstances such as the projects described in the rest of the thesis, it would be possible for the author and colleagues to be on-site when the fallow bin needs to be emptied to inspect the compost, and if there is no odour and the texture is like humus, to then conduct pathogen tests. As this was also a cultural trial of the toilets it would be useful to observe the response of the trial participants to the toilet end-product and the manner in which they choose to use or dispose of the material.

However, it is the nature of a trial conducted in remote conditions such as Kiritimati, that the length and regularity of site visits are constrained by economic, administrative and political considerations rather than being determined by significant stages of the composting process.

To deal with these conflicting requirements, and to anticipate the need to empty the fallow bins before the Australian team's return, a meeting was held with the head of the Kiribati Health Department. It was decided in discussion with Dr. Tawata that if all bins were used and a fallow bin required emptying prior to the September 1995 visit, a sample would be saved for inspection and testing by the Australian team and the oldest fallow pile would be emptied into the garden beds which have been prepared by the agricultural adviser with the trial participants. The compost would be dug into the bed and covered with mulch as directed.

As some bins had not been changed by May 1995 and there are 3 bins available to each household, disposal of compost is only likely to be required for a few of the toilets prior to September, 1995. However as a result of the ongoing education programs, toilet usage may increase and the bins would then fill up more rapidly than has occurred to date.

Dr. Tawata did not want the householders to be asked to stop using the toilets if all the bins were filled before the September 1995 visit. He felt this would affect the momentum of the trial and negate all the effort that had been put into persuading the householders to use the toilets, preparing the gardens and educating the participants in applying compost and mulch for improved cultivation. He was confident that the compost disposal would be handled hygienically and he stated that he would supervise that stage of the process (Pers. comm. Tawata May 1995).

Dr Tawata suggested it would also provide useful cultural data to observe how people dealt with the disposal of compost without the direct supervision of the Australian team. The Kiribati team would keep a record of all reactions and responses.

7.4.6 Project consultation

In June 1995, a second meeting was held at the University of Tasmania in Hobart with representatives of AusAID, SMEC and the Australian project team. Once again this direct consultation clarified any misunderstandings and was mutually informative. AusAID expressed satisfaction with the progress of the trial, and announced that an international conference would be held after the September 1995 appraisal visit to publicise the trial and promote the use of environmentally benign accessible sanitation technology in developing countries, and in Australia. Funding for virus and parasite testing of the compost would be provided and it was requested that the author and the agricultural adviser spend an extra week on Kiritimati to allow more time for assessment (Pers. comm. Brooke, Gallagher, Ranck, Wildermuth June 1995).

7.5 Directions and implications from the Kiritimati trial

It is not the domain of this component of the study to address the general issue of international aid or to refer to the large body of literature that critiques aid culture and practice. The composting toilet project on Kiritimati is evaluated in relation to the thesis proposition that on-site sanitation merits appropriate institutional support.

The experience and technology which evolved out of the research projects described in Chapters Three to Six of this thesis contributed to the on-site sanitation and education strategies applied in the Kiritimati composting toilet trial. The Kiritimati trial has in itself further contributed to the development of appropriate on-site sanitation application particularly for tropical conditions with limited and sensitive water resources.

The project was initially impeded by unsatisfactory communication and lack of co-operation between the Australian implementing team and its funding agency at home, and between the Australian team and the Kiribati aid recipients. One of the most significant factors contributing to the facilitation of this project has been the gradual improvement in communication among all the players. This has partly been a matter of time and of increasing familiarity with the different cultures, bureaucracies and personalities involved. Familiarity has been enhanced by consistency of personnel undertaking visits to the island, and the efforts made by the author and colleagues to clearly articulate difficulties as they arose, however unacceptable that may have been at the time. This experience has confirmed the author's view that technology transfer is largely dependent on attention to social and cultural matters on both a micro and macro level. In this regard, the evolution of the project has been a learning experience for all concerned (Pers. comm. Brooke June 1995).

At the time of writing, many issues remain unresolved but the process of implementing and evaluating sanitation technology for a coral atoll context has already provided useful information and directions which will be pursued in future study. It remains to be seen whether the I-Kiribati will accept the composting toilet, but progress has been achieved firstly by giving the people some educated choice and input into the matter unlike previous sanitation technology application, and by providing a system which even in a malfunctioning condition can do little to pollute or deplete water resources (Pers. comm. Yeeting May 1995). At worst the Batch systems will provide sealed above-ground holding tanks for sewage that can be easily emptied, without the need for vehicles or machinery. At best, simple effective sewage treatment will be provided that also produces an hygienic soil improver.

Despite the trial not yet being completed, the authorities responsible for funding sanitation projects in developing countries are anticipating extending the developments on Kiritimati to other parts of the Pacific, the Indian Ocean, and Africa (Pers. comm. Brooke June 1995) (Pers. comm. Depledge June 1995). While these suggestions certainly do not constitute a definite outcome, they do indicate the insufficiency of sanitation options that have existed in the past and the aspiration that environmentally benign, culturally acceptable and accessible possibilities might be forthcoming.

At the same time as offering possible alternatives to traditional sanitation practice and technology transfer, this trial has been constrained by the historical, political, social and geographical context in which it was conducted.

The composting toilet was a last resort after sewerage systems, septic tanks, pits, and pour flush latrines had been installed in Kiribati and had encountered environmental, economic and maintenance problems. The I-Kiribati on Kiritimati who use, or aspire to use, flush toilets have learned over more than 20 years that water borne treatment is the 'civilised' choice of citizens of powerful developed countries. Some people are suspicious and query why they are now being persuaded to adopt what appears to be a primitive and experimental alternative, and ask who uses these toilets in developed countries? In response one explains that it is not suggested that composting toilets should be used in all situations, for example, in high rise metropolitan areas it would be impractical, but rather that water-borne treatment is not appropriate in many situations in Australia as for Kiritimati. On the other hand, I-Kiribati who understand the value of composting toilets in the coral atoll context query why this alternative was not offered many years previously.

As the sanitation system would be paid for by a donor country, a certain apathetic attitude existed among the I-Kiribati toward the technology. It was thought that if it fails and has to be removed then there is no real loss to the community because they have not had to bear the financial burden (Pers. comm. Yeeting May 1995). Related to this perspective is the predominant interest in the goods that may be supplied for facilitation of the project such as cameras, video machines, vehicles, rather than in the sanitation technology itself. These benefits are often expected and if they are not supplied then resentment can be an obstruction to the success of the project.

There is additional pressure on the toilet trial because the Kiritimati sanitation project is tied to a water reticulation program that has been planned since 1982. While it is progressive for funding agencies to link water and sanitation in development, the requirement that environmentally benign sanitation is accepted prior to agreement to provide reticulated water is likely to inhibit candid response to the toilets. The desire to appear as though the toilets are acceptable in order to have the water provided may preclude further appropriate adaptation of the design to Kiritimati requirements.

In addition, there is pressure to facilitate the water and sanitation program because of overpopulation of other Kiribati islands especially Tarawa, and plans to develop and move people to the less crowded islands like Kiritimati. These issues create political forces beyond the scope of this thesis to examine. However, the political pressures have combined with other factors such as the prevailing attitudes common to an aid dependent society, cultural and language barriers, inadequate consultation procedures, unreliable transport and telecommunications, the transient Kiribati government population and infrequent and brief presence on the island of the research team, to create the rigorous circumstances under which the Kiritimati composting toilet trial has been conducted. Yet, like the other sanitation trials described in this thesis, constructive results have been achieved despite these impediments.

Significant achievements, at the time of writing, include the construction of toilets from locally available materials, the expressed willingness of a senior citizen to build his own composting toilet and dismantle his flush toilets, the integration of the sanitation project with a cultivation program, and the request by previously hostile neighbours to be supplied with a dry conservancy toilet rather than a waterborne system. In addition, some of the toilets have shown signs of producing a composted pile within an appropriate time frame.

The Kiritimati compost toilet trial indicates potential for further progress if on-site sanitation research and implementation was undertaken in a pro-active fashion in developed countries, and technology transfer to developing countries was conducted through properly facilitated comprehensive strategies which included environmental impact assessment, community consultation and education, and sustainable practice.

CHAPTER EIGHT

DOES WET AND DRY CONSERVANCY HAVE THE CUTTING EDGE?

This study included four practical projects in Australia and the Central Pacific, and field surveys of aspects of on-site sanitation practice in Australia, Japan and to a lesser extent China and the United States. As stated in Chapter One, these investigations sought to establish: whether there is a practical requirement for on-site sanitation that is not being adequately satisfied; what is practically achievable to meet that demand; and what are the ramifications of, and potential for, ensuring that appropriate on-site sanitation is provided where necessary.

The results of the field surveys in Chapter Two and the sanitation trials described in Chapters Three and Four indicate that institutions that manage public land such as national parks, forestry reserves, water catchments and defence reserves require on-site technology to provide sanitation facilities where reticulated sewerage treatment is not available, and not feasible. In some of these locations, on-site water borne treatment, pits, chemical toilets, vault or haul-out systems are precluded or inadvisable for practical, economic, and environmental reasons so that dry conservancy treatment is the only remaining option. Chapter Five addressed domestic situations where on-site treatment was required because of distance from sewerage scavenging areas and where on-site water borne treatment has also proved problematic. The domestic composting toilet research was supported by municipal councils, the least funded tier of government. Chapter Seven explored technology transfer in a context where traditional centralised and decentralised options have previously been applied as aid packages. These applications (which have been plagued by maintenance difficulties), have apparently caused faecal pollution of ground water. The sewage pollution of the freshwater lenses on

Kiritimati, despite the contrary intentions of the aid donors, may be contributing to the persistent ill health of the population.

In all the situations referred to above available sanitation options were very limited and therefore provided an opportunity for experimentation to fulfil requirements. This raises the question: why are institutions whose responsibility it is to manage national parks, local government, or overseas aid compelled to research and develop sanitation technology? If it could be argued that these institutions should be responsible for such development, then why do they not have trained personnel and infrastructure to support this process? And why are community members inclined to fund experimentation with sewage treatment technology in their own homes such as is described in Chapter Five? Do these circumstances suggest that an essential service is not being provided by those charged with responsibility to do so? The thesis proposes that this may be the case, and in Chapter Six, draws upon the Japanese experience in this field to illustrate the inequitable relationship that exists between centralised and decentralised sanitation that can contribute to the inadequate provision of on-site options. Japan is chosen for this purpose because it is a densely populated developed country and more than half the urban population is serviced by on-site treatment. As it is demonstrated in Japan that on-site treatment has, for decades, provided a sanitation service with certain economic and environmental advantages to many millions of people, it counters the argument that it is a secondary and temporary alternative to centralised systems and therefore does not merit equivalent institutional support.

In response to the question whether on-site systems can provide adequate sewage treatment, the compost toilet trials described in Chapters Three, Five and Seven have established that a humus material can be produced from dry conservancy on-site technology. This humus material has an acceptable odour and appearance, has significantly reduced in volume, and has a low or nil pathogen indicator count. In addition the technology is simple to install and maintain, is resource efficient and has relatively minor environmental impact. Consequently, dry conservancy on-site technology could be considered an effective method of sewage treatment, and its development in the cases detailed has been achieved despite research being restricted by certain combinations of unfavourable logistic, political, cultural and budgetary circumstances.

It is suggested, therefore, that given the necessary funding, trained personnel, administrative backing, community education, informed regulation and mandate for implementation, decentralised sanitation could offer a cost effective, environmentally benign, socially responsible method of sewage management, and at the very least should be given the opportunity to prove whether or not this is possible. Chapter Six examines ways in which this opportunity may be provided by examining how on-site sanitation is managed in Japan and what the obstacles and advantages are within that system. It is recognised that this is a complicated subject and the economic and political issues involved are merely referred to as an overview in Chapter Six. On-site sanitation management is not a new subject and although there was much discussion in the United States in the early 1980s about potential structures, and some experimentation with implementation, many of the funding and management problems encountered at that time continue to exist today (Adamkus 1982; Mancl et al. 1982: 236; Paalsgaard 1982: 223; Barror et al. 1982: 6; Flowers 1982: 240; Envirosciences 1991: 68; Crennan 1992: 82).

The current status of on-site sanitation at the time of this study, does not reflect the optimistic words of the administrator of the United States Environmental Protection Agency in 1981:

> No matter what the federal government does, the 1980s will be the most important and productive decade in the history of on-site treatment. The times when the first, or only way to solve a water quality problem was by constructing a sewer are dead. Government on any level does not have a single dollar to waste. Individuals, towns, counties and states will need to use efficient, lower-cost on-site treatment to the fullest if we are even going to come near meeting all of our water quality needs (Adamkus 1982: 1).

The field survey in China and sanitation aid packages referred to in Chapter Six and the composting toilet trial described in Chapter Seven indicate the seriousness of this lack of substantial progress in on-site sanitation management in developed countries. While it has been established that there is a legitimate demand for on-site innovation and implementation by public land managers, defence services, local government and the community in developed countries, none of these requirements could be considered a matter of life and death urgency at this stage. However, in developing countries such as Kiribati, the promotion of inappropriate sanitation technology may have had significant negative environmental and public health impact, and in countries like China with very high populations and limited resources, the long term effects of current implementation could be catastrophic. It is not just sewerage development itself, it is also the industries and life style it generates that have long term and widespread impact. For example, related infrastructure projects such as dam building are being aggressively promoted in countries in Asia, and in some cases by Australian organisations which have had a questionable record of appropriate development in this country (Corben 1995: 69). This is at a time when countries such as Australia are beginning to employ demand management initiatives rather than being driven by supply side solutions to water usage (ACTEW 1994: 5).

On a more positive note, the technical and management experience gained during this multi-faceted study has enabled the author and colleagues to effectively initiate sanitation technology transfer to a developing country, as summarised in Chapter Seven, in a manner which includes environmental, cultural and socio-economic considerations. This means that the chance for long term assimilation of the technology is increased and the likelihood of unpredictable negative impact on any level is decreased. If progress of this nature can be achieved as a result of this brief study and the related efforts of a small group of people operating in largely unsupported conditions, then it is indicated that the potential for constructive implementation of appropriate sanitation technology in developing countries would be greatly enhanced by integrated institutional involvement in this field.

This multi-disciplinary approach needs to be maintained in any infrastructure that may be established to implement on-site treatment, and this is probably the main obstacle to progress. Centralised sewerage treatment has been promoted as a relatively simple mono-disciplinary solution to sewage disposal that can be installed anywhere. It accepts all waste streams regardless of strength and volume, it transports the influent to a central treatment location which is under the control of a specialist agency and then discharges the effluent to an environment in which there is minimum immediate effect on those who originally generated the 'waste'. On the other hand, on-site treatment requires a multi-skilled approach to select the appropriate technology for a particular location and usage, and to ensure that users and those responsible for maintenance understand the system, and act accordingly. However, in practice, centralised sewerage treatment also requires a multi-disciplinary approach in order to anticipate the technical, environmental, cultural and socio-economic impact that its implementation involves, both at source and 'downstream'.

8.1 Observations from the trials

Out of the practical projects described in Chapters Three, Four, Five and Seven, certain factors have become apparent.

A visual and odour test of compost end-product is a useful start to assessment. If the material is passable then pathogen indicator, or specific pathogen, tests can be conducted.

An acceptable humus end-product, which is primarily bulking agent, with no unpleasant odour, no apparent faecal material and having low or nil pathogen indicator count can be produced from the batch compost toilet after three to five months 'fallow' period (refer 5.8.1; 5.8.4; 7.4.1.v). In 5.8.1 and 5.8.4 mesophilic temperatures had been recorded during much of the active batch cycle. Virus and parasite tests of the end-product need to be undertaken from a fresh sample to establish whether complete sterilisation has taken place (Feacham et al. 1983: 74), even though this standard is not yet demanded of water borne treatment. If the compost is buried around fruit trees or is even placed on the soil, within weeks it is barely discernible.

Piles in compost toilets that are not turned or mechanically aerated can maintain mesophilic temperatures for many weeks, even when ambient temperatures fluctuate to below 10°C (refer 3.2.3).

Liquid run-off from composting toilets can contain high concentrations of pathogens and should be treated as any other sewage effluent except that it is much reduced in volume, BOD and suspended solids (refer 3.2.6; 5.8.1; 5.8.4) (Barshied 1991: 45).

Invertebrates are extremely difficult to exclude from a domestic or public composting toilet pile. As they perform a vital and constructive role in decomposition it would be expedient to educate the user as to the advantage of their presence, while ensuring that species that act as vectors of disease are minimised (Dindal 1979: 165).

Composting toilets can work effectively without assisted ventilation from electric fans, in warmer climates (refer 7.2 and 5.8.1) including providing adequate ventilation for odour control. Passive ventilation can also be utilised in cold climates but reverse venting may sometimes occur in very low temperatures (refer 3.3.7 and 5.8.5).

It is important to ensure that all trial participants understand the fundamentals of composting, composting toilets and the nature and purpose of a trial. Although it was an aspiration of the trials to test the systems in realistic circumstances, this does not include the householder arbitrarily changing the process or adding some material to the pile because someone told them it would "make the thing compost" (Pers. comm. Abbot July 1995). Any experimentation needs to be conducted systematically and be carefully monitored.

The disadvantage of conducting the research in-situ, and outside the researcher's control, is that information may be withheld or altered because the users or maintenance personnel want the toilets to work successfully for practical or personal reasons unrelated to the study. These motivations could include; the householder's building permit being dependent on having an approved sanitation system; the owner-builder had designed the house around the composting toilet; construction budgets would be slashed or the public would complain if the toilet malfunctioned; or in the case of Kiritimati, the aid donor would withhold a water supply project if the composting toilets are not accepted. This is also an aspect of conducting a study in circumstances where research is crisis driven and is therefore secondary to the necessary service that the object of the research provides.

8.2 Inadequate research

At the outset of this study, the developments that have taken place could not have been anticipated and, although events have had a certain logic and contributed to the evolution of a sound case for institutional support for on-site sanitation, there are obvious gaps in the process from a research point of view. The limitations are due to insufficient time and resources to thoroughly conduct such a study and, of course, it has been argued that these limitations apply to research and development of on-site sanitation in general. It could be said that the study took on too much and therefore was 'spread too thin' and to some extent this is a valid criticism, as the number of projects undertaken precluded thorough investigation of any one in particular. Apart from the number of practical projects undertaken their geographical distance from one another, the remote location of two of them (Tasmanian World Heritage Area and Kiritimati) further stretched resources and available time.

It took some discipline not to include other sites and applications as there was persistent pressure to do so. In addition, some aspects of the initial study such as trialing the use of 'EM' (effective microbes) to speed up decomposition in the piles, and monitoring user response to the composting toilets had to be postponed until after completion of the PhD.

Analysis of the extensive temperature and usage records kept by the householders using the Wheelibatch toilets will be the subject of future papers and a stimulus for trialing further maintenance procedures. Seeding the piles with viruses (e.g. polio vaccine) will also be trialed to ascertain a more accurate assessment of potential for pathogen kill. There are many loose ends, and much work to be done, and this reinforces the argument that it is not the responsibility of one or even half a dozen scattered research projects to undertake that work. As it has been established that on-site sanitation and, in particular, dry conservancy technology has a significant role to play in environmental and human health, then future research and development should be conducted comprehensively and pro-actively by those institutions funded by public money to provide sanitation services.

8.3 Further developments

In the last 15 months, there has been increased interest in on-site treatment and composting toilets in the public sector in Australia. For example, in 1994, a Parliamentary Committee investigating the Sydney Water Board included the following recommendations that:

> 36. The Board should trial compost toilets in urban areas of Sydney and provide financial incentives or rebates to encourage the acceptance and management of such facilities, subject to the agreement of the department of health, particularly where their use will be cost effective and avoid the provision of additional or augmented sewage pipes...

> 39. Tenders by government departments and public agencies should include design specifications for on-site retention, rainwater tanks, porous paving, compost toilets, water re-use and other water efficient appliances in new development and in refitting existing development (Joint Select Committee upon the Sydney Water Board 1994: 147).

The Report included justification for decentralised sanitation[1], and proposals for regulation and management, (some of which could admittedly be regarded as light weight). In response members of the government, who saw the report as a criticism of its Clean Waterways Program, focused on the recommendations regarding composting toilets and ridiculed them as "totally bizarre, extreme, potential bureaucratic nightmares...and a risk to public health" (Parliament of New South Wales 19/4/95).

The dissenting government members on the Committee opposed the endorsement of composting toilets

> due to (i) their cost; (ii) their likely ability to satisfy health standards in dense urban areas; (iii) odour problems when not properly used, poorly maintained or with excessive use; (iv) the need to rake and stir faeces; (v) environmental impacts from nutrient loads when the residue is used as compost; and (vi) the associated problem of disposing of grey water (Joint Select Committee upon the Sydney Water Board 1994: 148).

Apart from the politics behind this heated debate, personal concerns could also contribute to the negative response to the recommendations. For example, decision makers who have flush toilets may fear that if they legislate that people who use composting toilets and grey water systems are rewarded for lessening their burden on water and sewerage utilities that they (the legislator and her/his constituents) will have to pay more to have a toilet that is connected to the sewer.

A representative of the Water Board contacted the author requesting 'any information' on composting toilet research, and a response to the Parliamentary Committee's recommendations, "but would not expect (the author) to prepare

[1] Some of the material in Reference g., and Appendix H of the Parliamentary Report, is an uncited reference to the author's 1992 publication Waste in Troubled Waters (Crennan 1992: 89).

reports especially for the Board" (Pers. comm. Maher May 2, 1994). Similar requests for gratuitous information are regularly received from government and non government organisations and members of the public. The New South Wales Health Department is currently conducting a 'Chapter on Composting Toilets' to update policy and determine performance criteria. In requesting information, and references, the Policy Adviser complained of the dearth of reliable data on composting toilets and queried whether the author's research could be made available prior to completion of the study (Pers. comm. Cowie June 8, 1994). If these institutions require such information then perhaps they should initiate and support the necessary research in the same way that they internally finance specific divisions or hire consultants to advise on the myriad of issues relating to centralised sewerage treatment.

A more pro-active approach has been taken by ACT Electricity and Water (ACTEW). On June 29, 1995, the author was invited to present a one day seminar on the current status of composting toilets, findings from this research, and potential for use in an urban environment. The seminar was attended by sewerage engineers and other interested personnel. On the following day, on-site water borne sanitation trials being conducted by ACTEW in Canberra were inspected. The ACT Future Water Supply Strategy includes a recommendation to

> develop a research program with ACT architects and ACT Health, including the installation of trial composting toilets for public and residential purposes in the ACT...and...develop composting toilet policy for the ACT by 2002 (ACT Electricity and Water 1994: 25).

ACTEW personnel are engaged in designing their own prototype, and have since approached the author with a proposal to trial the Wheelibatch in a 30 house estate, and generally market the design (Pers. comm. Szlapinski July 9, 1995). Whatever the outcome of such a proposal, this active interest by a public utility in dry conservancy, and their own water borne trials, are significant constructive steps toward the institutional support and involvement that may give on-site sanitation an equitable status in sewage management.

Other developments in which the author is involved reflect the range of organisations interested in decentralised sewage treatment, but still indicate that the approach is piecemeal and activity is being conducted by institutions not necessarily mandated to research and develop sanitation. These projects include a grant by the national Department of Tourism to develop 'Ecological Sanitation Strategies' for Australian eco-tourism, and an aid project in the Pacific country of Tonga to assist the Tonga Water Board to "research institute and implement appropriate work practices and procedures to ensure that the TWB achieves best practice in technical and engineering activities" in sanitation and water supply (Falkland 1995: 1). There has also been a request to advise on a trial of 30 commercial composting toilets in the Torres Strait Islands which has been conducted without any community consultation or education programs and is showing signs of failing (Pers. comm. Henderson July 1995).

8.4 In conclusion

It is the personal view of the author that, in Australia, in the last 10 years, aspects of what was rejected as 'fringe' politics in the 1960s and early 1970s have become 'mainstream'. The politics, economics and lifestyle of the dominant majority have, in varying degrees, absorbed such concerns as: environmental protection; gender and race equity; a desire for a 'natural' healthy appearance due to physical exercise and a fresh food diet; energy efficient housing; recycling and resource conservation; so called alternative medicine e.g. acupuncture, herbalism and massage; enjoyment of 'wild nature' as a recreational pastime; Eastern or native religions and meditation as alternatives to church going Christianity; and communication and relationship skills are now considered a prerequisite for 'good business'. These phenomena are to be observed in minor and major aspects of public and private life. For example, Sydney apparently won the Olympic games for the year 2000 on its 'green' bid, however genuine that may have been.

These attitudes may be the domain of educated middle class affluence and could be a phase in a cycle of fashion, or they may reflect a more profound shift in values. Water quality as a priority is a current value (Alexandra and Eyre 1993: 86). It is now a sign of status and wealth to own property adjacent to a clean water body, and people will trustingly buy bottled water from a far-off 'pristine' source rather than risk drinking from their neighbourhood watercourses or municipal water supply. Holiday packages promote the opportunity to swim in 'sparkling clean' rivers, lakes and beaches. And there is public outcry when tankers leak oil into the ocean, or rivers turn green with algal growth. The Australian Prime Minister recently commented to a group of school children involved in remediation of a sewage polluted lagoon:

> it is great for Australia that its young people have such a good understanding of the quality of our nature and our inheritance...cleaning up the lagoon is in harmony with nature...it is a path breaker in the treatment of effluent that will have to be followed by other major cities (The Mercury, 16/6/1995).

The current resurgence of interest in composting toilets, and decentralised sanitation in general, is a 'hands on' expression of water quality consciousness, and may be a reflection of the desire to take preventative action and some personal responsibility for our impact on the world around us. It remains to be seen whether it is just a fashionable interest, something that will return to the fringe, or whether on-site sanitation will be incorporated into the management of twenty-first century life with the status and support it needs to reach its full potential. The question remains whether market forces will favour the steps that need to be taken to break the pattern that influences administrators to prefer traditional treatment. Even where an alternative strategy is an obvious choice, centralised reticulated treatment is often preferred because it is fully supported, and does not require negotiating the regulatory minefield that surrounds decentralised treatment.

While advocating due consideration of on-site sanitation, it is not the intention of this study to imply that centralised reticulated sewerage systems do not have a valid role. It is rather to suggest that, in any country, the most appropriate technology should be applied in each location, and that the selection from a range of equally accessible technical options should be based on a thorough appraisal of the cultural, socio-economic and ecological context to be serviced.

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APPENDIX A

Agenda and attendees at Yosemite Composting Toilet Conference

(refer Chapter Two)

BACKCOUNTRY HUMAN WASTE MANAGEMENT,
A COMPOSTING APPLICATION WORKSHOP
Yosemite National Park
September 12 - 16, 1994

ITINERARY - BACKCOUNTRY
MONDAY, SEPTEMBER 12
THROUGH
WEDNESDAY, SEPTEMBER 14, 1994

September 12	08:00am - 10:00am	Arrival at Camp 6, Yosemite Valley: Registration, Parking, Luggage Storage, Introduction to Workshop
	10:00am - 12:00pm	Bus travel to Sunrise Trailhead
	12:00pm - 04:00pm	Hike to Sunrise Camp
	04:00pm - 05:00pm	Discussion: "Clivis", graywater (C. English)
	05:00pm - 06:00pm	Discussion: "Phoenix" (A. Palisca, K. Kirk)
	06:00pm - 07:00pm	Dinner
	07:00pm - 07:45pm	Discussion: Resources Mgmt. (L. Acree, V. Goldman)
September 13	07:00am - 08:00am	Breakfast
	08:00am - 02:00pm	Hike to Little Yosemite Valley
	02:00pm - 03:30pm	Discussion: LYV composter (A. Palisca)
	03:30pm - 05:00pm	Discussion: Passive Composters (D. Mann)
	06:00pm - 07:00pm	Dinner
	07:00pm - 07:45pm	Discussion: Wilderness Management (Wild. Ranger Div.)
September 14	07:00am - 08:00am	Breakfast
	08:00am - 10:00am	Discussion: Engineering (B. Rust, C. English)
	10:00am - 11:00am	Hike to Emerald Pool
	11:00am - 12:00pm	Discussion: Overuse (J. Clark)
	12:00pm - 01:00pm	Lunch
	01:00pm - 03:00pm	Hike to Valley; shuttle bus back to Camp 6
	03:00pm - 05:00pm	Discussion at Camp 6: synopsis of tour (E. Walls)

ITINERARY - LECTURES AND WORKSHOP
THURSDAY, SEPTEMBER 15, 1994

Meeting Place: Cliff Room, Yosemite Lodge
Emcee: Edward Walls, Facility Manager, Utility Branch of Maintenance Division, NPS, Yosemite

07:30 - 08:00am	**Introduction** Kevin Cann, Chief of Maintenance, NPS, Yosemite
08:00 - 08:30am	**Incineration** John Collins, P.E., Environmental Sanitation Consultant, USPHS/NPS/RMR
08:30 - 09:00am	**Guidance** Brenda Land, Sanitary Engineer, USFS, San Dimas, CA
09:00 - 09:30am	**Photovoltaics** Representative, Sandia Labs
09:30 - 10:00am	**BREAK**
10:00 - 10:30am	**Sanitary Survey** Dr. Rhea Williamson, Civil Engineer, Assoc. Professor, Dept. of Civil Engineering, San Jose State University
10:30 - 11:00am	**Regulatory** Cindy Forbes, District Engineer, State of California, Department of Health Services
11:00 - 11:30am	**Regulatory** Mark Butler, Physical Science Specialist, Resource Management Division, NPS, Yosemite
11:30 - 12:30pm	**LUNCH**
12:30 - 01:00pm	**Data Collection, 503 Regulations** Chris English, Civil Engineer, Professional Services Division, NPS, Yosemite
01:00 - 01:30pm	**Resource Management, Wilderness** Steve Thomas, Wildlife Biologist Resources Division, NPS, Yosemite
01:30 - 02:00pm	**International Applications** George Savage, Executive Vice-President, California Recovery Inc.

02:00 - 02:30pm	**BREAK**
02:30 - 03:00pm	**International Participants - Introduction**
03:00 - 03:30pm	**Yosemite Operations** Korwin Kirk, Supervisor, Backcountry Utilities, NPS, Yosemite; Alan Palisca, USRO Leader, Backcountry Utilities, NPS, Yosemite
03:30 - 04:30pm	**Form Work Groups** 1. Operations Facilitator, Korwin Kirk 2. Design/Engineering Facilitators, Chris English and Bill Rust, Professional Services Division, NPS, Yosemite 3. Compliance Facilitators, Mark Butler and John Clark, Facility Management Specialist, Utility Branch, NPS, Yosemite 4. Construction Facilitator, Alan Palisca

ITINERARY - WORKSHOPS, PANEL DISCUSSION
FRIDAY, SEPTEMBER 16, 1994

Meeting Place: Cliff Room, Yosemite Lodge
Emcee, Edward Walls

08:00 - 08:45am	**Operations** Facilitator, Korwin Kirk
08:45 - 09:30am	**Design/Engineering** Facilitators, Chris English and Bill Rust
09:30 - 10:15am	**Compliance** Facilitators, Mark Butler and John Clark
10:15 - 11:00am	**Construction** Facilitator, Alan Palisca
11:00 - 12:00pm	**Conclusion** Edward Walls

LIST OF PARTICIPANTS

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A COMPOSTING APPLICATION WORKSHOP
Yosemite National Park
September 12 - 16, 1994**

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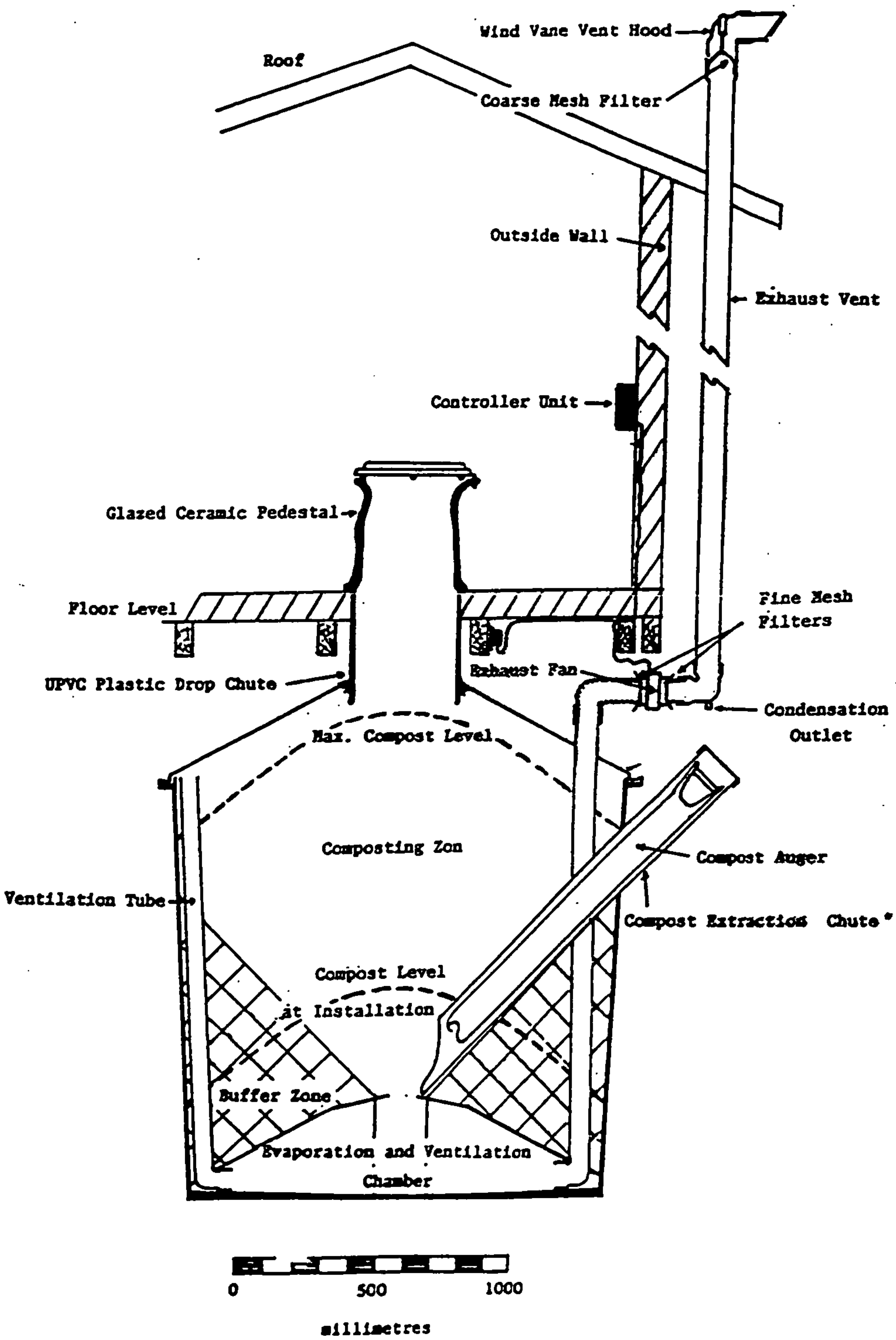
APPENDIX B

Dowmus Composting Toilet
(refer Chapter Four)



* Angle of Extraction Chute varies with ground level

APPENDIX C

Speech by Head Mistress of Tennessee School
(refer Chapter Seven)

Master of Ceremony, Invited Guests, Fellow Teachers, Ladies and Gentleman. Kam na bane ni mauri.

It's a privilege for me to speak on behalf of Tennessee Primary School and it's committee, to say a few words that relates to today's event.

Ladies and Gentleman, Tennessee Primary School as we all know is one of the oldest primary school in the Line Islands that have been operated without a proper adequate toilet facility to cater for the need of it's increasing number of students. Fortunately, the school have been chosen as one of the trial venue for this composting toilet project and for this we are grateful and also thankful to the project committee who is not only knowledgeable but also sympathetic with our case. Moreover, we understand that the toilet itself not only serves our needs but is also friendly to our environment since it does not contaminate our fresh water lens. It's in this respect that I would like to thank the Sanitation Project Coordinator, Ms Leonie Crennan for her great initiative and for the Australian Government for allowing this type of toilet to be implemented here in Kiritimati. Also I would like to express the school's sincere word of thanks to Ms Crennan colleagues for their tiresome effort to build this toilet under our very hot climate. For all the effort that have been rendered to the construction of this composite toilet we are proud and honored to invite all the school committee members, my fellow teachers and all of you who are here not only to witness the completion of such a toilet but to bear in mind as an history of the school the first friendly Environmentally and Ecological toilet ever built in our school.

Ladies and Gentleman before I conclude, I would like to give my school's assurance to the project team, that what ever expected to be carried out as part of the trial requirement will be fulfilled in every aspect and for no doubt that the toilet will enhance not only our sewage and sanitation system but also improve our health standards.

Lets all hope and work for a successful trial.

Kam raba.

APPENDIX D
I-Kiribati January 1995 Report on Composting Toilets

(refer Chapter Seven)

GOVERNMENT OF KIRIBATI

MINISTRY OF LINE & PHOENIX DEVELOPMENT

KIRITIMATI
REPUBLIC OF KIRIBATI
CENTRAL PACIFIC

Telegrams: LINNIX XMAS
Fax: 81278

Ref: Lac

Date: 10th January, 1995

To: Leonie Crennan
Project Director
Centre for Environmental Studies
University of Tasmania.

Madame,

Ref: General Report on Composting Toilet on Christmas Island

Below is my report on composting toilets

	Name	No. of H/Hold mem.	Location	Situation	Comments
1.	Bosco	15	Banana	In use began to experience smell	During the 1st and 2nd week of trial, wife comments, everything went on well. In the third week & fourth, they began to experience smell like stale water.
2.	Bokatu	19	Banana	First Bin was changed on 7/1/95	Like the system very much
3.	Ereataake	7	Banana	Toilet in use ¾ full	Like the system very much except 2 men still using the bush. Have not been used to this system.
4.	Kabunare	6	Banana	¼ full - OK. No smell	No comment, they are away most of the time, they sleep in the maneaba, but still use toilet. No smell.
5.	Arawatau	5	Banana	Toilet half full	No comment, toilet Request padlock.
6.	Konono	9	Tabakea	2 days in use No comments	No comment.
7.	Tabakea Clinic	2 staff	Tabakea	In use. No problem except a little bit smell.	Nurse complaints that it smells over the weekend.

8.	Banana Primary School	50 upper class	Banana	It also smells like stale water. Same as Tennessee Primary School.	Teacher comments that there is a smell, flies roaming around the toilet.
9.	Tennessee Pri. School	480	Between London and Tabwakea	In use, there is odour (like stale water or smell like effluent from septic tank). Around building air vented netting where tray is, flies in numbers could be seen outside netting.	Teacher comments that there is a smell and flies roaming around the toilet.
10.	Taukaban	6	London	Rarely use toilet (Husband). Complain of strench smell.	Odourous, still have to get use to toilet.
11.	Tietana	2	London	In use no complain	No smell, no flies no complain.
12.	Temakau	7	London	In use. No complain. Recording have been done properly.	OK. except fowls dug under bin so that it slipped and tipped at an angle giving.

It is very pleasing to note that the people using toilet are using it properly and in the right manner. Note that there is very little complaint from the people. Most of the toilet owners like it and said it is a lot better than the waterseal type.

Also note that the first full up bin was changed on the 7/01/95, and that was Bokatu's bin. "It was very easy work," Bokatu said. He is very much enjoyed changing his first bin.

Thank you.

Yours sincerely,

D/AHI BEIA TIH
for Secretary for Line & Phoenix Developments

cc Senior Health Inspector
T. C. H., Naverane.
DMO, Ronton, Kiritimati
> Secretary
Ronton
Kiritimati

10th January, 1995

To: Senior Health Inspector
T.C.H., Nawerewere
Bikenibeu, Tarawa

cc: District Medical Officer
Ronton, Kiritimati

> Secretary
Line & Phoenix Developments
Ronton, Kiritimati

MINISTRY OF LINE & PHOENIX DEVELOPMENT
LONDON KIRITIMATI
RECEIVED
13 JAN 1995
SGD ....

Sir,

Ref: GENERAL REPORT ON COMPOSTING TRAIL TOILET

I would like to inform you that twelve (12) composting trail toilets had been constructed on Kiritimati Island. Five (5) toilets were built in Banana village, three (3) in Ronton, two (2) at Tabakea, one (1) at Tennessee Primary School and one (1) at Banana Primary School.

It is interesting to note that there are three types or forms of toilets. These are (1) the bin types; we have nine of these in use at Banana and Ronton villages. (2) The gauze or chamber type used by the two primary schools and one at Tabakea clinic. (3) One small gauze or chamber type, a small version of those at the primary schools and at the clinic. This small gauze type is used by a family in Banana.

How Toilet is used

Each time you use the toilet, you can use papers, dead leaves or green leaves, etc, or anything that decomposes. After you finish, a handful of bulk or dead leaves is dropped into the bin over your waste, and then close the lid.

Organic waste and human waste is used in this process of decomposition.

Description or Operation of the Compost Toilet

The toilet is built above the ground. The chambers or bins that stores human waste is also placed off ground. There is an outlet or pipe that drains out urine or effluent from human waste to a dug out pit that was properly lined with plastic and gravel so that no effluent can go down to the water lens. This pit was covered with earth and can be used as a bed for gardening. The toilet is vented to take up smell of human waste.

Sir, note that this type of toilet is unlike our waterseal latrine where human waste is dumped into the ground and probably pollute our water lens.

Water, any chemical and constant urination into the system is not allowed. Those can disturb the biological decomposting process. This is known as the dry system.

Each time the bin is full, it is removed, closed and locked and a fresh bin is used in place. The idea is that when the first binfull decomposes it is emptied out as fertiliser and the bin is ready to be used again.

This also is applied to the chamber type of toilet. When the first chamber in use is full, it is closed off for decomposition process and the second chamber is used. It rotates that way like the bin type.

For composting process, it is based on aerobic decomposition of organic and human waste which are left undisturbed during a period of maybe two or three months (depending on the climate) to ensure destruction of pathogens and ova helminths.

It is very rich fertile, good for gardening.

Progress of trail on Compost Toilet

I am pleased to report that the people with these toilets are using it properly and in the right manner. With the support they received from time to time by the health staff and other government officers, the people are getting used to this type of toilet.

During the first week of trail, I noticed that maybe only 1 or 2 members in the family use the toilet and the rest of the family continue the original practice of defaecating anywhere. Now, there is hope of the success of the trial. People using the toilets are more confident and more enthutiastic.

It is also encouraging to say the first bin was full and had been changed, the rest of the bins are not far behind. Meaning, maybe the people are beginning to be aware of the dangers of defeccating indiscriminately and or maybe are getting use to the idea.

I found the trips from Fanning to Kiritimati to monitor this project, worthwhile and rewarding.

Thanks alot to all the people involved in the project, health staff and government workers and officers and individuals for their untiring efforts and cooperation.

Thank you very much.

Yours faithfully,

Beia Tim
D/AHI Line and Phoenix Development

APPENDIX E

Responses to video:
(refer Chapter Seven)

Many questions and issues arose as a result of the video showing. A selection of those that were recorded during the May 1995 visit to Kiritimati are listed below, with response from the Australian project team and I-Kiribati counterparts.

Question:	How long have composting toilets been used in Australia?
Response:	Since the early 1970s composting toilets have been used in countries like Australia and America. In Scandinavia they have been used for more than 30 years
Question:	Why are the Australian toilets mostly inside the house, and Kiritimati toilets are free standing at some distance from the house?
Response:	I-Kiribati had requested the buildings be installed away from the house because they could not believe it would not smell, and also Kiritimati houses are not raised high off the ground like some Australian houses shown in the video.
Comment:	The school teachers reported that the video would be a useful educational tool for the children and most of them would have no trouble understanding the content. They commented that the "the content and actors are very good". They intended to show the video to each class group when the school term resumed.
Question:	One teacher asked whether the pedestals are strong enough for large I-Kiribati to sit on, and can they be used for squatting?
Response:	The pedestals are very strong and can also be squatted upon if balance is comfortable and aim is careful.
Question:	Is the faeces really good for the garden?
Response:	Once the faeces has been mixed with carbonaceous matter and has turned to compost it is a safe and beneficial soil additive.
Question:	What happens to the urine/liquid in the trench?
Response:	It is used up through evapotranspiration using appropriate plants.
Question:	How long does it take for the faeces to turn to compost in Australia?
Response:	In areas like Tasmania where the composting toilet is used in mountainous snow country, it takes 6-12 months to produce fine compost. In warm coastal areas like Lismore it takes 3-4

months.

Question: How long will it take on Kiritimati for the faeces to turn to compost?

Response: This is something that will be established during the trial. In one Wheelie-batch bin that has been changed, composting is advanced after only 3 weeks fallow (refer to Section 2.1). The under section of the active piles in the cage batch at the schools is already composting before the bins have been changed. Other bins have been changed since February and the process is slower. It depends on the bulking agent used and how much urine is going in to the pile. We are still finding out what works best.

Question: Can water be used for anal cleansing?

Response: Yes, water can be used, but not over the pedestal. A bowl of water could be taken into the toilet room, or a person could wash in the bathroom, or behind a nearby bush. Water should not be poured into the composting toilet because it will flood the pile and drown the organisms that do the composting work. A small amount of water can be added to a dry pile.

Question: If people have very bad diarrhoea and the inside of the pedestal becomes soiled, how can it be cleaned?

Response: The pedestal is tapered outwards at the base to avoid skid marks. However, if it needs cleaning, then a piece of coconut fibre or old rag soaked in water can be used to clean the inside of the pedestal and then dropped in the toilet. You should wash your hands afterwards the same as you would if you cleaned any toilet.

Question: Where do the germs go in the compost and the liquid run-off?

Response: The bacteria, viruses and parasites in the compost are destroyed by the combination of time, temperature, drying and the actions of other bacteria. In the liquid runoff, the liquid is absorbed by the soil and coral aggregate in the trench and soil bacteria break it down, and the roots of plants and trees reduce it through evapotranspiration.

Question: Will the roots of the trees and plants puncture the plastic?

Response: The roots will find a good source of nutrients above the plastic and will not be likely to penetrate easily. We will monitor the plastic over the time of the trial to see what is happening with the liquid and the plastic lining.

Comment: The composting toilet is not good for old or disabled people as they need to climb steps to use the toilet. The flush toilet is not a problem in that way.

Response: Yes, the steps could present a problem for old people. However, solutions may include building ramps instead of steps and/or to design the toilets into the house so that the climb up the toilet is not so great. It may also be possible to have a leaf lined bowl for the disabled to defecate into, and then a family member could empty this into the composting toilet. Several women in the audience agreed that this may be possible as old people often use a container in the house if it is difficult for them to go outside. The question of universal accessibility requires attention.

Note: Criticisms of the toilet usually only came from drunken members of the audience. Attempts were made by other I-Kiribati to censor what was seen as impolite behaviour, but the Unitas Team encouraged discussion of the issues raised to emphasise that criticism was useful and constructive in the context of the trial.

Question: What is the cost of each the different designs being trialed on Kiritimati?

Response: This is still being refined as the trial progresses and the final figures will also depend on the scale of production. Figures will be provided at the end of the trial.

Question: Can we have one of these toilets now or when you next visit in September?

Response: There will be no more toilets installed as part of the trial, but if the trial is considered successful by the Governments of Kiribati and Australia then everyone may be able to have a composting toilet.

Note: More than 30 households requested their name be recorded to receive a composting toilet. Some of these households were currently using pour flush latrines, and some did not have a toilet installed at their house. Some of these requests also came from community leaders.

Question: If the trial is successful will the water treatment toilets be replaced by composting toilets?

Response: This is likely to be recommended in order to ensure all the water supply lenses are protected and management is uniform, but nothing has been decided yet.

Note: Mr. Ambo Keeba, the Chairman of the Tabakea Housing Committee, retired Head of the Public Utilities Division on Kiritimati and a local magistrate, intends to remove his 2 septic tank flush toilets when his compost toilet is built. He is reputed to have one of the best flush systems on the island, due to his many years experience working in sanitation.

Note: The Minister for Line and Phoenix Development commented that "these toilets would be very useful in Tarawa".

Comments: The First Secretary of the Ministry for Line and Phoenix Development, Mr. David Yeeting made the following comments on the video:

- The English voice over should be translated as the messages contained therein are important.
- There is not enough emphasis on the fact that water is not used in the composting toilet
- The video does not say how long the faeces will take to turn to compost.
- The gloves suggest the changing of the bins is messy and it would be impractical to issue everyone with gloves as they would get lost.
- Everyone in the video should formally introduce themselves at the beginning of their speech.
- The speeches of the old men are repetitive.

Response: The Community Health Educator replied that although there is some repetition, each speech covers different issues.

Comment: The Third Secretary of Linnix, Mr. Tarataake Teannaki, commented that the video promotes the composting toilet but does not detail its failures and problems.

Response: The problems encountered on Kiritimati are covered in the images and English voice-over and referred to in the video by Ms. Marutaake Karawaiti. Translation would make this coverage clearer. It is also stated that if the toilets are not maintained according to directions they will not produce compost.

Comment: The director of the medical staff commented that the video effectively got the health message across.

APPENDIX F
Education poster: Naakuu EE!
(refer Chapter Seven)