ACHIEVING BEST PRACTICE IN SMALL FOOTPRINT ON-SITE WASTEWATER MANAGEMENT SYSTEMS

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ABSTRACT
Mound systems offer the smallest footprint combination of secondary treatment and land application. In addition mound systems offer a sustainable on-site wastewater management option for many constrained sites.

This paper reviews current practice in regulation, design and construction of mound systems in Australia for both domestic and commercial applications and reviews recent advances in comparable practice in the United States. A number of innovations with potential to enhance mound performance are described. These include refinements in wastewater application systems and modified construction for improved in-mound storage, evapotranspiration and nutrient removal. The paper concludes by providing some direction for regulatory reform to embrace best practice.

Keywords: enhanced performance, innovation, mound systems, regulatory reform, small footprint systems.

INTRODUCTION

Mound systems were originally developed in North Dakota, USA in the late 1940s and known as NODAK disposal systems (Witz, 1974). Modifications of the NODAK system by researchers at the University of Wisconsin – Madison in the early 1970s led to the mound design most commonly used today and these are most often referred to as Wisconsin mounds (USEPA, 1999). Many thousands of these mound systems are now installed across the USA (Converse & Tyler, 2000).

Mounds offer the smallest footprint combination of secondary on-site treatment and land application. Consequently they are often suited to small and constrained sites and in particular to sites with the following limitations:

- Slow or fast permeability soils;
- Shallow soils over creviced or porous bedrock; and
- Soils with high water tables (USEPA, 1999).

In recent years, in Australia, mound systems have become increasingly popular as an alternative for domestic on-site wastewater management; although only limited guidance on mounds is provided by the joint Australia/New Zealand Standard AS/NZS 1547:2000 (Standards Australia, 2000) and the various State on-site wastewater codes and guidelines. Relevant and detailed information is available in the literature, albeit that much of this is published in the United States, and consequently perhaps less readily accessed by practitioners in Australia. Useful guidance on Wisconsin mound siting, design and construction can be obtained from Converse and Tyler (2000). Many aspects of this available literature are reviewed and considered in the light of optimising mound designs in the Australian setting by Bishop & Whitehead (2007).

MOUNDS AS SMALL FOOTPRINT ON-SITE WASTEWATER MANAGEMENT OPTIONS

One significant advantage of a mound system over most other types of domestic on-site wastewater management systems is that it offers both treatment and land application on the same footprint. Hence when land availability is limited, mounds may provide both a high (secondary) level of treatment and permit relatively high loading rates for land application. On occasion, on constrained sites, mounds may be the only feasible servicing option.

Comparable land application rates as the Design Loading Rates (DLRs) for mounds and Design Irrigation Rates (DIRs) for surface or subsurface irrigation systems, as recommended by AS/NZS 1547:2000 (Standards Australia, 2000), for the various soil categories, are shown in Table 1. In the case of irrigation systems, wastewater treatment to secondary standard is generally by means of either an aerated wastewater treatment system (AWTS) or a sand filter. In the case of the mound, which acts as a bottomless sand filter, an equivalent secondary treatment standard is achieved by passage of effluent through the media in the mound.

Table 1: Comparable DLRs for mounds and DIRs for surface or subsurface irrigation systems.

Soil category	Soil Texture	DLR for mounds mm/day	DIRs for irrigation systems mm/day
1	Gravels and sands	32	7
2	Sandy loams	24	7
3	Loams	24-16	4
4	Clay loams	16-8	3.5
5	Light clays	8	3
6	Medium to heavy clays	-	2

AS/NZS 1547:2000

For a typical daily domestic wastewater load of 900 litres, generated by five persons in a three-bedroom household on reticulated water with standard fixtures, comparative land application areas (LAA), based on the loading rate approach of the Standard, for both mounds and irrigation systems are shown in Table 2.

Table 2: Land application areas required for mounds and irrigation systems for 900L daily load.

Soil category	Soil Texture	LAA for mounds m^2	LAA for irrigation systems m^2
1	Gravels and sands	28	129
2	Sandy loams	37.5	129
3	Loams	37.5-56.25	225
4	Clay loams	56.25-112.5	257
5	Light clays	112.5	300
6	Medium to heavy clays	-	450

Where appropriate sand media for mound construction are available within close proximity to the site, costs of the secondary treatment system plus an irrigation system are comparable to those of mound construction. Where transport of media is required, this can add significantly to mound costs, but nevertheless the significantly smaller land area required may prove attractive or indeed may offer the only feasible land application option if the site is small.

Current Practice In Regulation, Design And Construction Of Mounds In Australia

Sizing and design of mounds is addressed to only a limited degree by current Australian guidelines and Standards. None of the current State guidelines provide any design information. In Victoria, a Certificate of Approval has been issued by the EPA (EPA VIC, 2006), for a generic Mound System (CA 1.4/06) as shown in Figure 1. However, this offers little advice for design, no information on sizing and does not represent a best practice mound design. Despite stating that the system must be designed, installed and operated in accordance with AS/NZS 1547:2000, the design does not look anything like a true Wisconsin mound and appears more like raised absorption trenches or an inverted leach drain. The approval requires secondary level pre-treatment before the mound.

AS/NZS 1547:2000 provides information on Wisconsin mounds that is mostly consistent with best practice designs available in overseas guidelines. However, the Standard is limited in its scope and coverage of design and construction issues. Review of the 2008 consultation draft suggests that no major changes are proposed.

Recognising the need to provide higher level guidance on mound systems, the Northern Territory (NT) Government has commissioned detailed guidelines and a standard sizing methodology (Whitehead & Associates, 2005a & 2006) for the design, construction and operation of mound systems, with a focus on applicability to NT conditions. These are to be incorporated in the revised Northern Territory Code of Practice which is nearing completion and are to assist government staff, local installers and designers to incorporate best practice in NT mound design and construction. When published, these guidelines will offer far greater detail than is currently available in other State guidelines. Elsewhere, some councils have developed standard designs for on-site wastewater systems to address particular site constraints. Port Stephens Council, NSW, has had to address issues relating to failing on-site systems in high water table sites in close proximity to Tilligerry Creek. Studies of samples collected in the oyster leases in Tilligerry

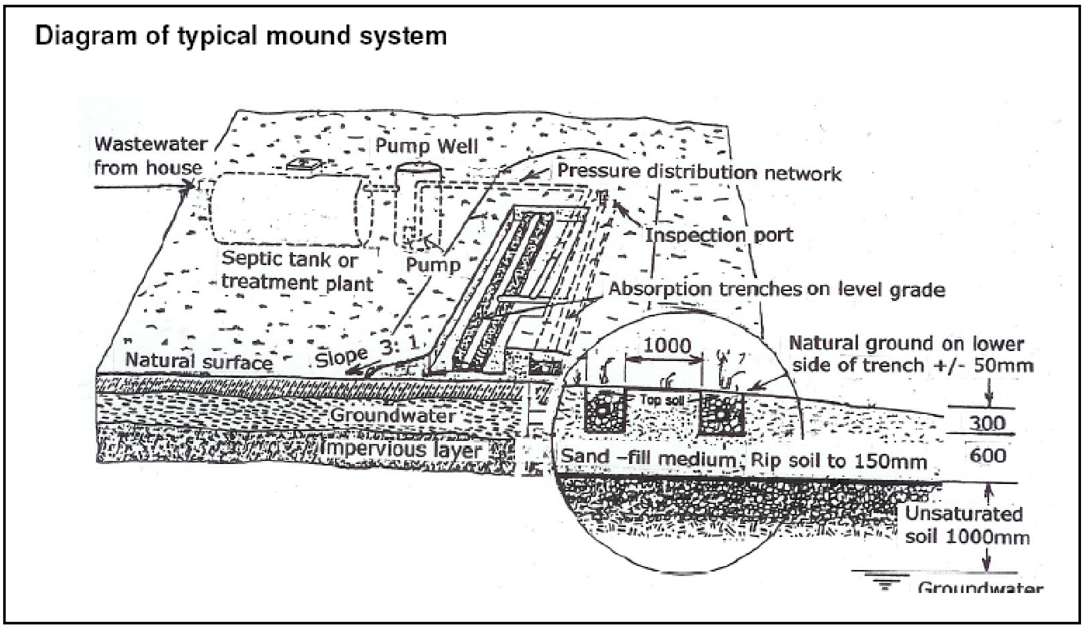

Figure 1: EPA Victoria type approval CA 1.4/06 (EPA VIC, 2006)

Creek demonstrated bacterial contamination from failing septic systems (Geary & Davies, 2003, Geary, 2005, Lucas *et al*., 2007). Council commissioned best practice standard designs (Whitehead & Associates, 2005b) for two land application options to address the high water tables experienced at the sites; raised beds with pressure compensating drip irrigation and Wisconsin mounds. Council has required upgrades of existing on-site systems to incorporate secondary treatment with land application in either raised beds or sand mounds, to both improve treatment and raise the level of application of treated effluent above the already high water table. In recognition of the cost to individual homeowners for site specific designs, Port Stephens Council has made the standard designs available to homeowners to reduce the overall cost of the necessary system upgrades (Port Stephens Council, 2005).

A recent study (Geary *et al*., 2008) which has investigated effluent quality within and beneath the mounds, has demonstrated that mounds constructed in accordance with the best practice designs are performing effectively as treatment systems and result in significantly reduced contaminant concentrations entering the shallow groundwater at less than one metre from the surface. The overall efficacy of the treatment systems is due to the increased vertical separation distance to the groundwater which is provided by the mounds and the unsaturated conditions which exist as a result of the periodic dose loading of effluent from the septic tank. Mounds represent a sound long-term wastewater servicing option with many mounds in the USA still performing well more than 25 years after construction.

Whilst the Standard and some codes and guidelines make relatively brief reference to mound systems and recognise their potential as a wastewater servicing option for constrained sites, there is little detail provided on design and, in particular, construction. It has been recognised that lack of trained professionals and/or unproven design modifications (Converse & Tyler, 2000) and lack of rigour in design, selection of appropriate materials and attention to detail in construction (Bishop & Whitehead, 2007) are major impediments to successful mound operation. By incorporating much more detail on design and construction, based on the sound research available elsewhere, the Australian Standard and State Government codes and guidelines, could help advance Australian mound practice significantly.

Mounds For Larger Than Domestic Settings

Given their capacity to provide a high level of treatment and their requirement for a relatively small land application area, mounds are being increasingly adopted in Australia as on-site wastewater servicing options, for premises of larger than domestic scale and commercial applications.

Many commercial operations such as caravan parks and camping grounds in coastal environments have to contend with either highly permeable sandy soils and/or shallow water tables. Older wastewater systems at such facilities were commonly designed and installed when regulatory requirements were more relaxed than they are today. Consequently, inspections and audits of wastewater systems often identify shortcomings in land application systems which in many cases fail to comply with current regulatory requirements. Lack of available land for expanded land application areas together with groundwater sensitivity or water table proximity issues may be suitably addressed by treatment in, and land application by, mounds. The mounds can often be incorporated as landscape features around the perimeter of the site, which is commonly the only remaining land available for extended wastewater application. In such cases the mounds might additionally offer useful visual screening or noise attenuation barriers as well as land application for wastewater. Other commercial operations where mounds might offer additional benefits as visual screens or sound barriers are recreational facilities and clubs which require noise attenuation to reduce impacts on neighbours, and roadhouses and motels located adjacent to highways where traffic noise would otherwise impact on patrons. In such locations consideration has to be given to both maintaining the integrity of the mounds by avoiding unnecessary trafficking by pedestrians or vehicles and, where several mounds are located in close proximity, careful attention has to be paid to issues of linear loading rate if mounds are arranged side by side.

Figure 2 illustrates a typical modern roadhouse site with fast food outlets, service station and motel, all constructed on a relatively small (approximately 30 hectare) site.

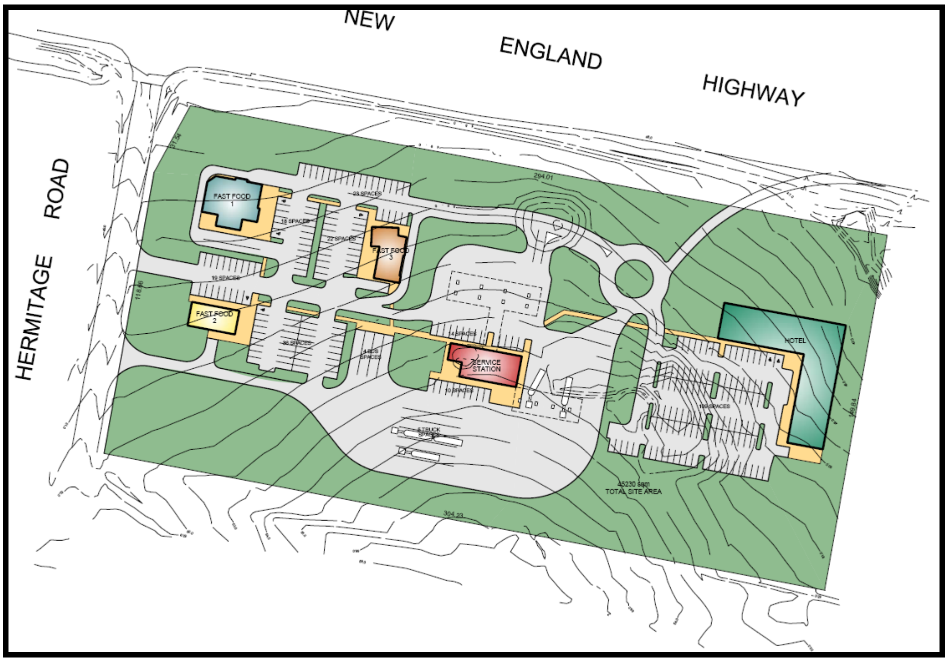

Figure 2: A schematic of a highway roadhouse and motel complex with potential area for mounds to address space limitations and afford visual and sound barriers.

Aside from the footprint of buildings, internal roads and carparks, the available landscape area with potential for wastewater application is approximately 17.5 hectares. The projected daily effluent load is in excess of 77,500 Litres. Such a site lends itself to multiple mounds which could be constructed along the highway frontage of the site or the rear boundary to afford visual screening and provide noise barriers in addition to land application. In this case, seven end to end mounds, each 42 metres x 10 metres in size and capable of accepting 1,750 Litres per day, could be accommodated along one of the longer property boundaries.

No Australian guidelines or codes offer advice on commercial scale mound design. As demand for and usage of mounds in commercial settings has increased, so regulatory agencies in the United States have developed more comprehensive guidance. The reader is directed to Iowa Department of Natural Resources, Sand Mound Technology Assessment and Design Guidance (Iowa Department of Natural Resources, 2007) for more recent and extensive coverage of the detail of mound design including larger scale commercial applications.

Recent Advances In Mound Practice In The USA

Mounds have now been widely used in many States in the United States and their design, construction, management and performance have been the subject of extensive and wide ranging research. Many publications exist in the formal literature, in conference proceedings and journals, and others are to be found as reports of various regulatory agencies. Many of these publications review advances as they have been made and identify the problems experienced and how these have been addressed. Individually and cumulatively, these documents identify many advances which have been brought into practice and from which mound designers, installers and regulators in Australia can learn.

Amongst those advances documented in the formal and informal literature are:

- Approaches to pressure dosing and the design of pressure distribution networks (Converse, 2000). Multiple distribution zones are used for larger mounds, with zones controlled by distribution valves and pressured by turbine pumps rather than centrifugal pumps, as these have been found to more readily keep distribution pipe orifices clear of blockages.
- Long and narrow mound designs are favoured and careful attention is given to linear loading rates (Converse & Tyler, 2000, Iowa DNR, 2007).
- Active resting and dosing of cells is practiced to eliminate clogging mat development, particularly where primary treated effluent is dosed to the mound. Higher loading rates and more continuous loading is practiced where secondary treated effluent is dosed to the mound. In these cases mounds with a primary disposal function are used on smaller and more constrained sites.
- Synthetic aggregates, including bundled polystyrene pellets, have been used where sand media is not so readily available, and leaching chambers have been used as an alternative to the conventional gravel distribution beds.
- Costing spreadsheets have been developed to assist with the costing of a complex array of materials and services used in mound construction and to better enable cost comparisons with other servicing options (Iowa DNR, 2007).
- Groundwater monitoring under mounds has enabled the groundwater mound that may form under a loaded mound to be better understood and sound methodologies for monitoring developed and documented (Poeter, McCray *et al*., 2005).
- Recent geophysical trials have been undertaken at the University of Wisconsin – Madison (UW-M) to define the groundwater mound beneath and to track the migration of effluent plumes away from an active mound by electromagnetic monitoring (Hart pers.comm., 2008). These trials have used a Geonics EM31 conductivity meter (Figure 3) which is based on not dissimilar technology to that described by Mitchell *et al*. (2005) in investigation of water flow around septic trenches. In the geophysical trials at UW-M, ground penetrating radar studies were undertaken on the same mound and offer some promise in further defining effluent plume movement beneath mounds, but this methodology requires further development.

Figure 3: Use of a Geonics EM31 conductivity meter to investigate the effluent plume beneath a Wisconsin mound at Lake Collins Campground, Wisconsin.

Many of these advances could and should be investigated by Australian mound designers and incorporated, where appropriate, into their designs.

INNOVATIONS
Other innovations in mound design under development or incorporated by the authors in designs for trials include:

- The use of irrigation systems for distribution of secondary treated effluent over mounds to improve mound surface vegetation growth and enhance evapotranspiration.
- The partial lining of the base of the mound to enable recirculation of treated effluent to a carbon source in the primary septic tank for enhanced nitrogen removal.
- The use of mounds on high water table floodplains for enhanced treatment, increased separation distance and continued operation for wastewater disposal by evapotranspiration during low level flood conditions.
- The design of disposal mounds, to optimise the potential for secondary treated effluent detention or storage within the mound by use of a capillary break beneath the mound media. This approach adopts a methodology proven to be successful in alternative landfill cover design which offers some promise for improved mound disposal by evapotranspiration (Albright *et al*., 2008).

REGULATORY REFORM
Unfortunately, Australian Standards and codes incorporate little of the available recent research on mound systems. Despite the fact that periodic revisions of Standards and codes are undertaken, there is little evidence that any significant effort is put into seeking out new ideas; testing and validating them and where appropriate incorporating them for the betterment of management practices in Australia. Consequently advances in wastewater servicing technology are only, at best, very slowly adopted. Their adoption is hampered by lack of guidance and lack of leadership from potentially important organisational drivers, the regulatory agencies themselves. Unfortunately, the historic devolution of much of the responsibility for on-site wastewater management to the lower levels of government and homeowners has not resulted in regulatory agencies in Australia championing research and development to further innovation in the field. It is evident that the regulatory agencies do not see themselves as defining the frontiers which might foster new solutions, so much as managing the limited range of existing solutions with which we have become familiar.

The limited exposure to new ideas presented by Standards and codes results in major challenges for resourceful, inventive and innovative designers, as designs with which regulators are unfamiliar rarely meet with enthusiastic regulatory acceptance. The Australian wastewater industry has many challenges to overcome and the potential to address these with innovation is currently hampered by the limited extent of regulatory reform. If those that guard our industry could be persuaded to more widely embrace the wealth of knowledge that is available, albeit for want of a bit of effort in accessing it, our regulatory guidelines could take a lead in ensuring that the small and decentralised wastewater systems industry in Australia moves forward at something more than its customary ambulatory pace.

ACKNOWLEDGEMENTS
Joe Whitehead acknowledges the support and funding of the University of Newcastle for a Special Studies Program including a three-month period spent at the University of Wisconsin – Madison. Prof Craig H. Benson, Wisconsin Distinguished Professor and Chairman, Geological Engineering at the University of Wisconsin – Madison is thanked for generously making departmental facilities available and Dr Dave Hart, Wisconsin Geological and Natural History Survey, University of Wisconsin – Extension is thanked for making available the opportunity to collaborate on geophysical field investigations.

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