## Improving On-site Wastewater Management Systems and Factors Influencing Option Selection



## Introduction

- Some definitions.
  - Rectification: repair or extension of an existing component (e.g. no change of function).
  - Retrofit: addition of components to an existing system to improve performance.
- System improvement can comprise one or both of these two actions.



## Pre-treatment Options

- There are three main improvement options available prior to treatment. They can all be highly cost effective.
  - Water conservation measures.
  - Reduction in mass pollutant load.
  - Flow balancing or equalisation.



## Water Conservation Measures

- Common sense but crucial to sustainable on-site wastewater management.
- Typical water saving devices include:
  - AAA fittings (shower heads, taps);
  - Reduced / dual flush toilets;
  - Water efficient appliances.
- Water use behaviour is just as important as fitting the appropriate devices.



## Water Conservation Measures

- Large shock loads produced by spa baths and dishwashers will interrupt most treatment processes.
- Constrained sites may have limited available land to accept the higher load.
- Limiting the use of water hungry devices may save the owner thousands of dollars in the long-term.



## Mass Pollutant Reduction

- Also one of the most influential factors in determining system performance.
- The particular pollutant(s) of concern will depend on the observed problem:
  - sensitive receiving environment;
  - site and soil limitations;
  - capacity of treatment components; or
  - sustaining biological processes.

## Mass Pollutant Reduction

- Sodium (soil permeability / sodicity).
- Phosphorus (poor retention capacity / sensitive receiving environment).
- Organic load (treatment capacity / soil loading rate).
- Chemical and antibiotic load (limiting biological activity).



## Mass Pollutant Reduction

- Selection of cleaning products with lower concentrations of pollutants or reduced disinfection efficiency.
- Use of products sparingly at low concentrations.
- Beware of 'safe for septics' labelling. This does not mean that it is safe for processes essential to effective operation.



## Hydraulic / Pollutant Load Reduction

- Simple, proactive and effective way to improve performance.
- Applicable to any system type with no need to modify the system.
- But will only delay system failure if the land application area has already blocked up.
- It can be hard to enforce conservation / reduction practices over long periods (e.g. change of owner).



## Flow Balancing / Equalisation

- Flow balancing can be installed at a number of locations in a system.
- Flow balancing prior to any treatment is one option.
- Requires a grinder pump to be installed rather than a lift pump.

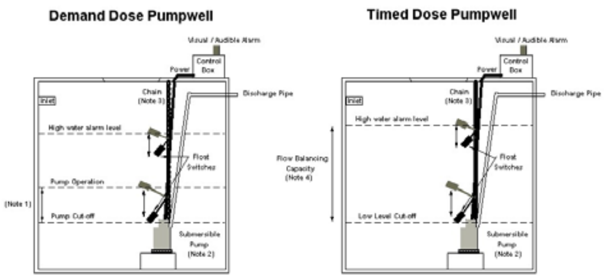


## Flow Balancing / Equalisation

- Flow balancing typically involves,
  - a pump well sized to buffer peak hydraulic loads;
  - a lift or grinder pump;
  - a timer controlled switch to deliver a set volume of wastewater in a set period; and
  - a low level cut-off switch and high level alarm.



## Flow Balancing / Equalisation



## Flow Balancing / Equalisation

- Useful for sites with an undersized or overloaded treatment system (hydraulic or pollutant loads).
- Or sites subject to shock or highly intermittent loads (e.g. community facilities).
- Can be used for any system but will require careful design.
- Indicative capital costs of approximately $3,000 - $5,000.



## Treatment Options

- Improving effluent quality can help overcome limitations such as;
  - limited available land application area;
  - limited capacity to assimilate pollutants;
  - public health risks;
  - highly permeable or impermeable soil;
  - shallow depth to a limiting layer.



## Increased Primary Treatment

- A well designed and operated septic tank should not be considered substandard.
- Increasing the capacity of primary treatment components will result in improved effluent quality.
- Can increase volume, flow path and / or number of chambers (Indicative capital costs of ~$3,000 - $5,000).
- Should incorporate an outlet filter where possible.



## Septic Tank Outlet Filters

- Usually cylindrical design to fit into the outlet square of a septic tank.
- Acts as a physical screen and provides surface area for biofilm development.
- Can significantly reduce suspended solids carryover and organic loads to land application systems or other treatment components.
- Cost between $100 - $250, a cost effective improvement option!



## Septic Tank Outlet Filters



## Secondary / Advanced Secondary Treatment

- Enhanced reduction of pollutants through secondary to advanced treatment will;
  - increase land application / reuse options;
  - sometimes reduce the required size of land application areas;
  - sometimes rejuvenate failing trenches and beds;
  - reduce the pollutant load to sensitive receptors in areas with high potential for off-site impacts.

## Mechanical Treatment Plants

- Can be added to an existing septic tank system.
- Proper operation and maintenance is essential.
- Sensitive to variations in hydraulic and pollutant loads.
- Typically involve multiple pumps and significant componentry.

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## Mechanical Treatment Plants

- Many systems do not consistently treat effluent to secondary standards.

*Performance Assessment of On-site Aerated Wastewater Treatment Systems 1995 – 1998*

Queensland Department of Natural Resources and Mines 2001

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## Sand / Media Filters

- Proven track record of producing advanced secondary quality effluent.
- However they do need to be designed and installed correctly.
- Relatively little maintenance required.
- Alternative media can be used for specific pollutant reduction.

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## Peat Filters

- Peat filters can also be used to provide secondary to advanced secondary quality effluent.
- Particularly effective in reducing organic loads and faecal coliforms.
- Peat will settle over time and the filter will require augmenting with new peat.

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## Reed Beds

- A relatively passive option for secondary treatment.
- Can be an effective system for nitrogen reduction when effluent is recirculated or the reed bed is fed with highly aerated effluent.
- Careful design is important including selection of plant species.

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## Secondary / Advanced Secondary Treatment

- There are other proprietary units on the market that are available or will become available over time.
- Manufacturers need to demonstrate to regulators and designers that their system can perform adequately.
- All of the secondary to advanced secondary treatment systems described will cost ~$8,000 – $13,000 depending on the size and quality of effluent required.

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## Secondary / Advanced Secondary Treatment

Source: Orenco Systems

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## Conclusions

- Options to reduce the hydraulic and pollutant inputs to a system will always be the most effective way to improve a treatment system.
- Installing a secondary / advanced secondary treatment system will not help if poor effluent quality is not the problem.
- However, it will be highly beneficial in areas where cumulative off-site impacts are observed or likely.

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## Land Application System Options

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## Introduction

- Modifying the configuration and dosing method used in a land application area can significantly improve performance.
- Simple measures such as stormwater diversion or vegetation planting can also be effective.
- Technological improvement options (e.g. subsurface irrigation or mounds) also available.

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## Stormwater Diversion

- Normally consists of an upslope swale / earth bank drain.
- Can include subsoil drainage where this is a problem.
- Stormwater run-on is a common contributor to failure of land application areas.
- Should also be considered for treatment components.

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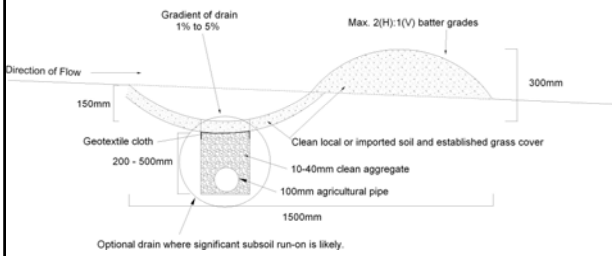
## Stormwater Diversion

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## Stormwater Diversion

- Be mindful of the fact that the diverted stormwater flow will now concentrate at the discharge point of the drain.
- This flow needs to be managed appropriately to prevent erosion.
- Swale and earth bank should be grassed as soon as possible.

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## Vegetation Planting

- Simple way to increase the assimilative capacity of a land application area.
- Selection of appropriate species is important.
- Need species that are manageable and won't damage the area / system.
- Need moisture tolerant species that can survive in eutrophic environments.

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## Vegetation Planting

- Typical grasses such as kikuyu are highly effective species for uptake of both water and nutrients.
- Regular harvesting essential to remove nutrients from the system.
- Downslope vegetation buffers are an option on suitable sites.
- Before planting additional species make sure the land application area is supplying enough water and nutrients to sustain them!

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## Flow Balancing / Regulation

- This system operates in the same way as a flow balancing tank for a treatment component.
- The maximum load to the land application area can be set to prevent overloading.
- The balancing tank must be big enough to provide the buffer capacity for peak loads.

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## Flow Balancing / Regulation

- Any disinfection unit will need to be modified to treat effluent after storage.
- Aeration sometimes required to prevent effluent going septic.
- For these reasons flow balancing is usually best placed within the treatment process when disinfection is required.

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## Enlarging an Existing Land Application Area

- May involve;
  - increasing the dimensions of an existing trench, bed, mound or irrigation area; or
  - constructing a new component that is linked to an existing land application area.
- The repair of existing beds and trenches is usually not possible.

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## Enlarging an Existing Land Application Area

- This is an option easily understood by owners and installers.
- But it is only relevant where insufficient area is the problem.
- Will not help if the existing method of land application is not suitable for the site.

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## Alternating Land Application Areas

- Periodic resting of all land application areas can help restore hydraulic capacity.
- Restores aerobic conditions and allows the biomat to be consumed by soil organisms.
- Alternating doses between two smaller areas is much more effective than constantly loading a single larger area.
- Can be alternated by manual valve or automatic indexing valve.

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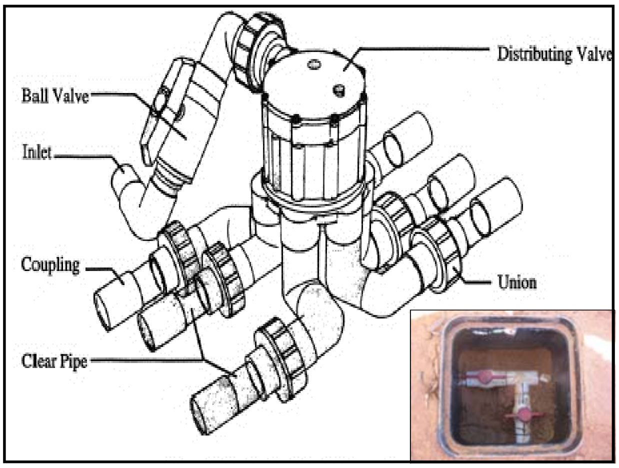


## Alternating Land Application Areas

- Manual valves - need to ensure that each land application component is sized to adequately cope with the daily hydraulic load.
- Automatic indexing valves – can split the total required area between alternating sections.
- Also applicable to irrigation systems.
- Can be used to dose numerous landscaped garden beds.

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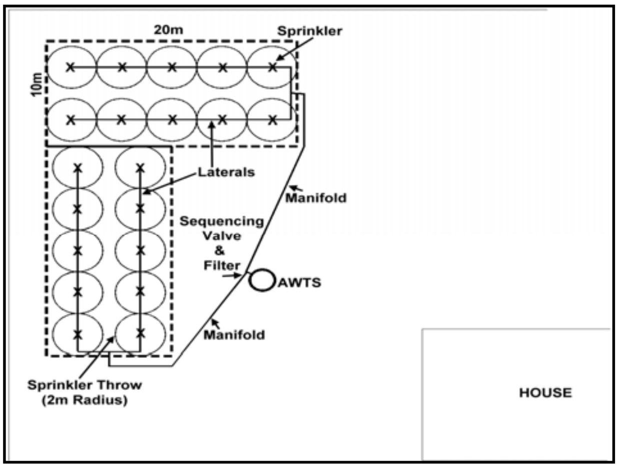

## Pressure Dosed Land Application

- Ensures even, intermittent distribution of effluent over the whole area.
- Will reduce the rate of soil clogging and maintain unsaturated conditions in the soil.
- It has been shown that pressure dosing results in improved effluent acceptance and treatment in the soil.
- Prevents flooding and minimises localised failure of the area due to uneven distribution.

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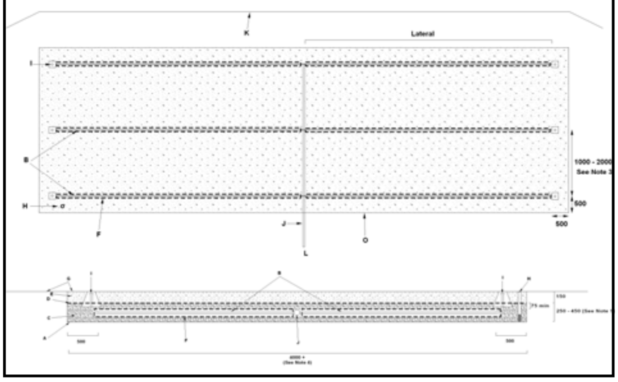
## Pressure Dosed Land Application



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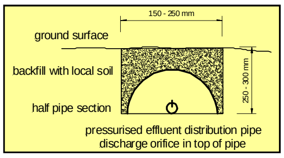
## Pressure Dosed Land Application

- Pressure dosed shallow absorption system

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## Pressure Dosed Land Application

- Effective option for highly permeable or impermeable soils.
- Raised beds in areas with shallow limiting layers should be pressure dosed.
- When combined with flow balancing and alternating areas, pressure dosing will substantially improve the performance of trenches and beds when compared to traditional designs.

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## Evapo-Transpiration / Absorption Beds

- A simple, passive option for low permeability soils.
- ETA beds will work if they are designed correctly but not suitable for all sites.
- Optimum performance when installed as two alternately pressure dosed beds.
- Can also use a splitter box to evenly distribute gravity doses to separate beds.

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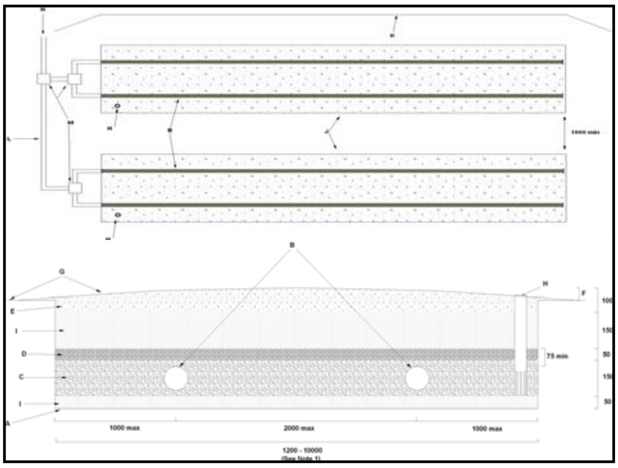

## Evapo-Transpiration / Absorption Beds

- Suitable for use with any treatment system.
- Minimal maintenance, especially if gravity dosed.
- Requires a relatively flat site (<5% slope).
- Will require less land area than an irrigation system but not always feasible.
- Indicative capital costs of $5,000 - $8,000.

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## Subsurface Irrigation

- Significant development in subsurface drip technology for effluent irrigation.
- Involves pressure dosing of 13mm pipe fitted with turbulent flow or pressure compensating emitters.
- Built-in protection against root intrusion and biofilm development.

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## Subsurface Irrigation

- Places effluent directly in root zone and prevents surface runoff during rainfall.
- Allows more use and ease of maintenance for an irrigation area.
- Careful design still essential (effluent filtration, line flushing, vacuum release valves, correct spacing of laterals/emitters).

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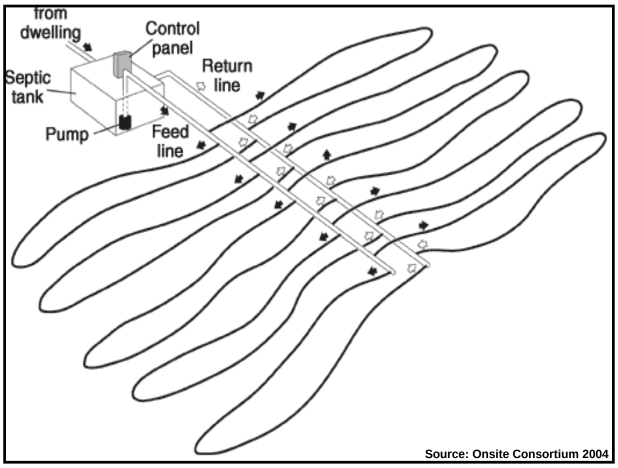


Source: Onsite Consortium 2004

## Subsurface Irrigation

- Good for sites where public access is likely.
- A need to maintain the filtration and flushing system.
- Requires secondary treated effluent and (arguably) disinfection.
- Indicative capital costs of $6-$10/m$^2$.



## Mound Systems

- Wisconsin mounds (mounds) have been operating successfully in the U.S.A. for fifty years.
- Provide a viable option for sites with a shallow limiting layer.
- Can be installed on sites with sands to clays and slopes up to 15%.
- Provide secondary treatment or polishing of effluent as well as land application.



## Mound Systems

- Careful design and construction is absolutely crucial to effective operation.
- *AS/NZS 1547:2012* provides some guidance but should be used with caution.
- Converse and Tyler (2000) *Wisconsin Mound Siting, Design and Construction Manual* is a good reference.



## Mound Systems

Monitoring results for a mound system in Port Stephens.

Results are the average of seven monitoring events over six months (Port Stephens Council, 2004).

| Parameter | Average Result P7 (Tank Effluent) | Average Result P2 (Within Graded Sand) | % Reduction P7 → P2 | Average Result P3 (Below Graded Sand) | % Reduction P7 → P3 |
|---|---|---|---|---|---|
| Electrical Conductivity | 1334 | 751 | **44** | 461 | **65** |
| Total Oxidised Nitrogen (mg N/L) | 0.013 | 11 | **-84600** | 0.049 | **-376** |
| Total Kjeldahl Nitrogen | 68 | 6.5 | **90** | 6.4 | **96** |
| Total Phosphorus | 13 | 7.5 | **44** | 0.75 | **94** |
| Thermotolerant Coliforms | 54400 | 41 | **>99** | 474 | **>99** |



## Mound Systems

- Mounds must be pressure dosed to work.
- Sides need to have a gradient no steeper than 3:1 (horizontal:vertical) to allow mowing.
- Indicative costs of ~$15,000 - $20,000 for typical domestic sites.

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## Factors Affecting Improvement Option Selection

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## Introduction

- Selection of appropriate options often requires a balance between;
  - risk management (improved performance);
  - cost effectiveness and affordability; and
  - capacity of the owner to operate and maintain the system.

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## Compliance or Improvement?

- Who is driving the process?
- Who is paying the bill?
- Balancing best practice against what is practically achievable.
- Political influences (e.g. previous Council planning / management decisions).

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## Cost Effectiveness

- Consider the outcomes.
- Are there physical site limitations that cannot be overcome by retrofitting and rectification work?
- Does the risk justify the expenditure or increased management?
- Do the site’s physical characteristics lend it to that particular solution?

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## Regulatory Framework

- Regulations governing on-site sewage management allow for some variation from guidelines and standards.
- Onus is on Councils to assess the risk and decide if that risk is acceptable.
- This creates an opportunity for regulators to vary from standards and guidelines in the operation and management of on-site systems *if it is backed up by good science*.

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## Discussion

- What do you think are the key factors that influence the selection of improvement options?
- Do you have any examples of situations where an improvement option has varied from standards and guidelines and proven effective?
- What about situations where options have been unsuccessful?

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