



# **The Use of Reed Beds for the Treatment of Sewage & Wastewater from Domestic Households**



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# TABLE OF CONTENTS

<b>1.0 On-Site Treatment of Domestic Wastewaters</b> .....	<b>1</b>
1.1 Regulatory Requirements for the Treatment and Disposal of On-Site Wastewater.....	1
1.2 The Treatment Train.....	1
<b>2.0 What is a Reed bed?</b> .....	<b>2</b>
2.1 How do Reed beds work? .....	2
2.2 Why Install a Reed bed?.....	3
<b>3.0 Sizing the Reed Bed</b> .....	<b>4</b>
3.1 Length to Width Ratio .....	5
<b>4.0 Construction Considerations</b> .....	<b>5</b>
4.1 Site Selection.....	5
4.2 Lining the Reed bed .....	5
4.3 Multiple Reed Beds - In Parallel or Series?.....	7
4.4 Inlet and Outlet Structures.....	7
4.4.1 T-Junction Inlet and Outlet Pipes.....	8
4.4.2 300mm Stormwater Inlet and Outlet Devices .....	8
4.4.3 Arch Trenching Inlet.....	9
4.5 Altering the height of Wastewater in the Reed Bed.....	10
4.6 What Size Gravel to Use? .....	10
4.7 Placing Gravel in the Reed Bed .....	11
4.8 What Macrophytes (Aquatic Plants) Can You Use? .....	11
4.9 Planting out the Reed Bed.....	11
4.10 Pump Well Capacity .....	11
<b>5.0 Maintenance Requirements</b> .....	<b>12</b>
5.1 Checking for Blockages in Inlet/Outlet Structures .....	12
5.2 Cleaning the Effluent Filter .....	12
5.3 Pumping out of Greywater or Septic Tanks.....	12
5.4 Altering the Water Height .....	12
5.5 Mini-Trenching or Sub-surface Irrigation Systems & Back-flushing the Lines .....	12
5.6 Harvesting.....	12
5.6.1 Phragmites, Typha (Bullrush) and Schoenoplectus and Bolboschoenus.....	13
5.6.2 Lomandra and Clumping Sedges .....	13
5.7 Holidays.....	13
5.8 Two or More Reed Beds.....	13
<b>6.0 After the Reed bed: Land Application (Disposal) Options</b> .....	<b>13</b>
6.1 Application Methods .....	13
6.1.1 Gravity feed to ETA beds.....	13
6.1.2 Small 1000Litre pump well, pump, pumped through indexing valve to a series of small trenches .....	13
6.1.3 Small 1000Litre pump well, pump, pumped to sub-surface irrigation system i.e. Wasteflow™or Netafim™ .....	14
6.2 What to plant in the Land Application Area .....	14
<b>Appendix 1: References</b> .....	<b>15</b>
<b>Appendix 2: On-site Sewage Management Information Sources</b> .....	<b>16</b>
<b>Appendix 3: Calculation of Residence Time</b> .....	<b>17</b>
<b>Appendix 4: Reed Collection from an Existing Reed bed and Planting Preparation</b> .....	<b>18</b>
<b>Appendix 5: Photos of Reed Beds</b> .....	<b>19</b>

## 1.0 ON-SITE TREATMENT OF DOMESTIC WASTEWATERS

Traditionally, all wastewater generated from an unsewered household was managed on-site by a septic tank and absorption trench. Recent audits across the State on the operating performance of on-site sewage management systems have revealed that a significant number of systems are failing to meet environmental standards and community expectations. In 2001 the failure rate for on-site sewage management systems (e.g. septic tanks) in the Lismore City Council (LCC) area was found to be 44%.

The high failure rate of these on-site systems has led to the implementation of more innovative solutions to the on-site treatment of wastewaters, such as composting toilets, sand filters, and reed beds. Many of these innovative systems split the wastewater stream into two categories:-

- Blackwater - wastewater from the toilet or bidet.
- Greywater - essentially the rest of the wastewater stream i.e. kitchen, laundry, bathroom.

An example of a split system involves a dry composting toilet for dealing with the human excreta, reducing the water use in the house by up to 35% and producing a useable compost material. The greywater can be collected and treated using a collection tank and reed bed. Any excess moisture (leachate) from the compost toilet is directed to the collection tank for treatment, with subsequent disposal/reuse of the reed bed effluent via sub-surface irrigation.

This document outlines the basic principles that should be adhered to by people looking to install a reed bed.

### 1.1 Regulatory Requirements for the Treatment and Disposal of On-Site Wastewater

Due to the high failure rate of sewage management systems, legislative reforms were introduced to the Local Government Act (1993) and companion legislation, re-establishing the performance standards and management responsibilities for on-site domestic wastewaters. In response to the reforms, Council was required to produce an "On-site Sewage and Wastewater Management Strategy" and introduce an audit program in order to minimise the threat failing systems may pose to public health and the environment. In July, 2003, Lismore City Council launched its "*Revised On-site Sewage & Wastewater Strategy, July 2003*" (Appendix 2).

### 1.2 The Treatment Train

The term 'treatment train' refers to the series of processes that wastewater undergoes from its generation in the household to its final disposal. There are three general stages in the treatment train: collection, treatment, and disposal/reuse.

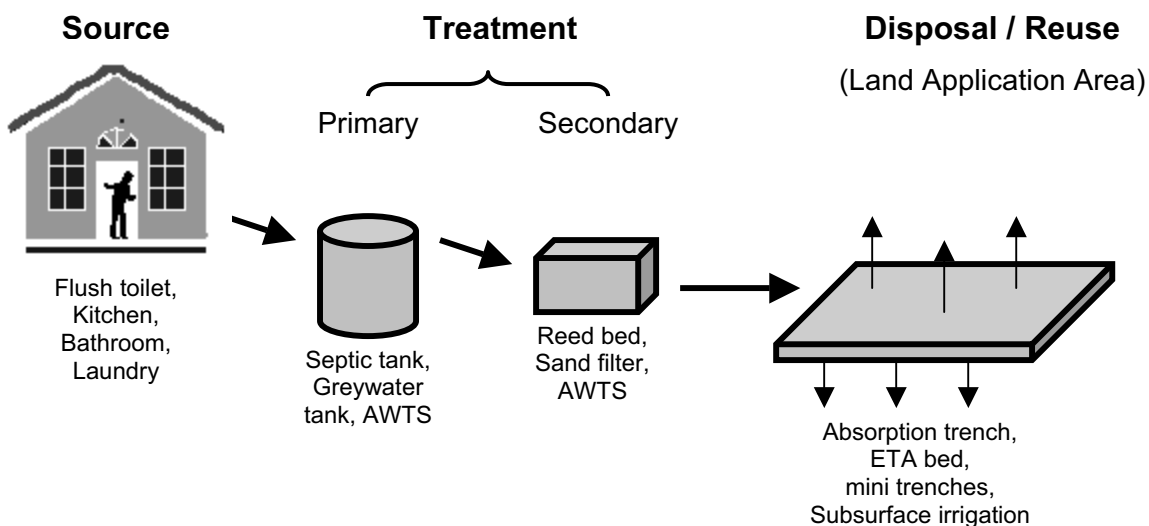
In the example shown in Figure 1, household wastewater is collected via a sanitary drainage system (i.e. pipes under the house) and discharged into a collection tank (greywater or septic tank) that acts as a primary treatment chamber for the settling of solids, flotation of oils and greases, and the anaerobic breakdown of pollutants. All collection tanks (greywater or septic) must be fitted with effluent filters (Section 5.2) to improve the quality of the effluent leaving the tank. Wastewater from the collection tank is either further treated to a secondary level or discharged directly to the land application area (disposal area) depending on site constraints and the preference of the home owner. In the LCC area, the size of the land application area is determined based on the area required to adequately deal with the hydraulic, nitrogen and phosphorus loads.

Treating the wastewater to a secondary level will increase the longevity of the land application area, whilst reducing the environmental and public health risks posed by the effluent. In order to qualify as a "secondary treated" effluent, the wastewater must contain no more than 20mg/L BOD and 30mg/L Total Suspended Solids. Aerated Wastewater Treatment Systems, reed beds and sand filters are examples of secondary treatment systems. Reed beds are also capable of removing nitrogen from the wastewater, which can

bring about a reduction in the size of the land application area that is required in some situations within the Lismore City Council area.

Different types of land application area are used, such as absorption trenches, evapotranspiration beds, sub-surface drip irrigation, drippers under mulch or spray irrigation (only disinfected effluent can be applied above the ground surface). Depending on the type of land application area, wastewater can be discharged under gravity or with the use of a pump or a passive dosing siphon. Please note manufacturers of sub-surface drip irrigation systems require that wastewater is treated to a secondary level.

The land application area can be planted with grass that is regularly mown in order to remove nutrients from the treatment train. Alternatively, Australian native plants suited to wet environments and local conditions can be planted between irrigation lines and along the boundary of the land application area.



**Figure 1: The On-site Wastewater Treatment Train**  
(AWTS = Aerated Wastewater Treatment System; ETA = Evapotranspiration-Absorption)

## 2.0 WHAT IS A REED BED?

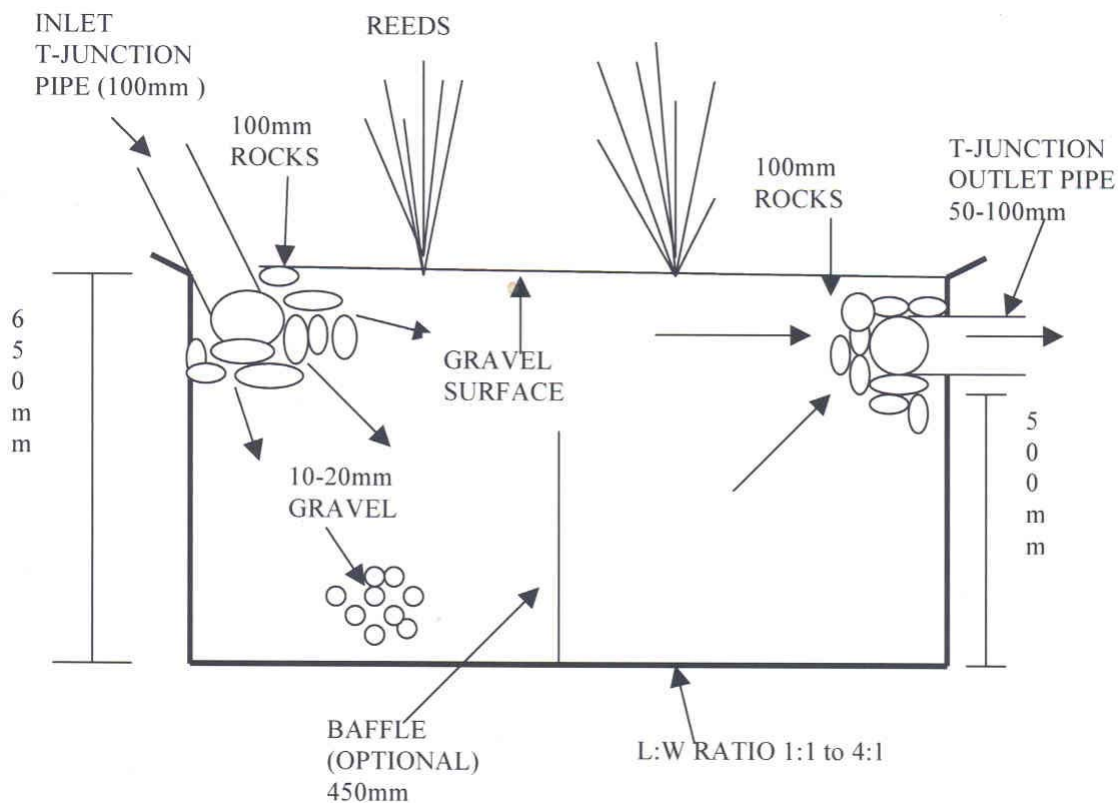
A reed bed is essentially a basin that is lined with an impermeable membrane, filled with gravel and planted with macrophytes such as reeds and rushes (Figure 2). Wastewater (black or grey) passes through the root zone of the reeds where it undergoes treatment via physical, chemical and biological interactions between the wastewater, plants, micro-organisms, gravel and atmosphere. Inlet and outlet pipes are positioned below the gravel surface, so that the water always remains below the surface, thus minimising the risk of human exposure to the wastewater, mosquito breeding and unpleasant odours.

### 2.1 How do Reed Beds Work?

Raw wastewater from the house flows into a collection tank for primary treatment to remove large solids, grease and oils. The partially clarified effluent from the collection tank passes through an effluent filter to trap any large solids that remain, and then flows into the reed bed. Once inside the reed bed, the wastewater undergoes a complex series of natural treatment processes as it moves laterally through the root zone from one end of the bed to the other. The wetland plants leak small amounts of oxygen out through their roots, creating small

oxygenated sites within an otherwise anaerobic environment. This mix of aerobic and anaerobic conditions creates an ideal environment for the growth of micro-organisms on the surface of the gravel and plant roots. These micro-organisms are largely responsible for the pollutant removal that occurs in a reed bed, as they feed on and breakdown organic matter and nutrients, and compete against pathogenic organisms. Earthworms have also been found to inhabit reed beds, and assist with the breakdown of organic matter and solids.

Most of the pollutant removal processes in reed beds are time dependent. Thus, the residence time (length of time water spends in the reed bed) is an important design parameter. Reed beds are generally designed to detain the wastewater for a period of 5 to 7 days in order to allow sufficient time for the settling and filtering of suspended solids, breakdown of organic matter, binding of some contaminants onto the gravel, and removal of nutrients by plants and micro-organisms.



**Figure 2: Basic Reed Bed Design (Lateral View)**

## 2.2 Why Install a Reed Bed?

There could be many reasons to install a reed bed. It may be a personal preference or it may be related to Local Government Policy or both. The use of a reed bed produces a secondary treated effluent that allows owners to better utilize (Section 6) their wastewater than if it were only primary treated. Reed bed effluent can percolate easier into the soil because it has reduced BOD and suspended solids. It also poses less of a risk to human health.

In regards to Local Government Policy, the Council may previously have given a house owner approval to install a septic tank and absorption trench within 100 metres of a waterway. However, due to changes in legislation and an increasing knowledge and understanding of the risks posed by on-site sewage systems, it may now be a requirement that the septic tank and absorption trench, if failing, treat the wastewater to an acceptable standard prior to land disposal. If the absorption trench is failing then the installation of a reed

bed will improve the quality of the septic tank effluent prior to land disposal, possibly alleviating the problem.

The size of land application areas in NSW are now based on both nutrient and hydraulic loads. The installation of a reed bed with a residence time greater than 7 days will approximately halve the nitrogen load in the wastewater and therefore greatly reduce the irrigation area required for nitrogen disposal. It will also significantly reduce faecal coliforms (a pathogen indicator).

Reed beds can be particularly useful for improving the quality of septic or greywater tank effluent prior to land application on sites constrained by soil type (e.g. sand, pugs, clays), steep slopes, or close proximity to a water body or adjoining property. If any of the following site constraints are found on a site, then the use of a reed bed to achieve secondary level treatment might be appropriate:-

- The land application area is within 100m's of a waterway i.e. river, creek
- The land application area is within 40m's of a dam or dry gully
- The soil type is medium to heavy clay (pug) or sand
- Shallow soil depth i.e. underlying rock layer
- High water table i.e. less than a metre below the proposed trench
- Steep site
- Small block

### **3.0 SIZING THE REED BED**

One of the most important design factors governing the level of treatment achieved by a reed bed is the residence time (the average length of time that wastewater spends in the reed bed). The residence time is determined by the water holding capacity of the reed bed, which is governed by the water depth, reed bed surface area and porosity of the gravel used. Residence times in the order of 5 to 7 days are commonly used, depending on the type of wastewater to be treated and the desired level of treatment to be achieved.

Lismore City Council requires a standard residence time of 7 days and a minimum nitrogen removal rate of 50%. Justification will be required for persons wishing to install a reed bed with a smaller residence time e.g. greywater reed beds or discharging to ETA beds and 50% nitrogen removal has been achieved. The sizing of all reed beds (Appendix 3) will need to be shown in documentation submitted to Council.

There are numerous approaches to sizing a reed bed, from simple rules-of-thumb to more complicated engineering models. Headley and Davison (2003) summarised the results of 28 different studies on 13 reed bed systems in north-east NSW and derived design models for BOD and nitrogen. These models have now been incorporated into Lismore City Council's on-site sewage management model (Daily Disposal Model), which should be used to provide accurate sizes for reed beds (available from LCC; Appendix 2). Although these design models are not discussed in any detail here, they have been used to derive a simpler rule-of-thumb approach that can be used to determine the size of your reed bed (Table 1).

This rule-of-thumb method is designed to give per person surface areas that will result in residence times of approximately 7 days, which should be adequate to ensure sufficient treatment in the majority of situations. Smaller surface areas are required for "greywater only" reed beds due to the decreased hydraulic and pollutant loads compared to combined black and grey water (septic tank effluent).

Although the standard reed bed water depth is 0.5 metres, if, for some reason, your reed bed is going to have a water depth other than the standard 0.5 metres, then different surface areas will be required to achieve the desired residence time of 7 days. Rule-of-thumb surface areas for a range of water depths are provided in Table 1.

**Table 1: Rule-of-thumb Sizing of a Reed Bed to achieve a Residence Time of 7 Days.**

Water Depth (m)	Surface Area/Person (m <sup>2</sup> ) (Combined black and greywater)*	Surface Area/Person (m <sup>2</sup> ) (Greywater only)#
0.30	6.5	5
0.40	5	4
0.50	4	3
0.75	3	2.5

\* Based on a wastewater generation rate of 115 L/person/day

# Based on a greywater generation rate of 90 L/person/day

### 3.1 Length to Width Ratio

Once the reed bed surface area has been determined, the length and width dimensions of the reed bed will need to be determined. As a guiding rule, reed beds should have a length to width ratio between 4:1 and 1:1. In practice, the dimensions of the reed bed will generally be governed by the length and width of the container used to line the reed bed (discussed in more detail in Sections 4.2 and 4.3). In the majority of situations, more than one container will be necessary in order to achieve the required reed bed surface area. In such cases, the individual containers can be linked together in parallel or series in order to achieve an overall length to width ratio between 4:1 and 1:1.

## 4.0 CONSTRUCTION CONSIDERATIONS

**Materials and methods used in the construction of a reed bed should be adequate to ensure the long-term durability of the reed bed.** The Local Government Act 1993 states that mechanical parts should last at least 5 years and non-mechanical parts 15 years. While reed beds can be viewed as a relatively inexpensive treatment alternative compared to other options, it is important to realise that they can be prone to failure if adequate time and money is not invested during the design, construction and installation stages to ensure the long-term durability and successful operation of the system.

### 4.1 Site Selection

The site for a reed bed should provide good sunlight for reed growth and be located down slope of the primary treatment unit to allow for gravity flow through the treatment train. Those sites on steep slopes may need a large length to width ratio, or be built as a series of terraced beds, as the reed bed will need to be on level ground and therefore follow the contour. Some house owners use their reed beds to define the border of their gardens to which the reed beds are incorporated.

### 4.2 Lining the Reed Bed

It is critically important that the reed bed be contained in a durable water-tight membrane in order to avoid leakage of poorly treated effluent into the environment and intrusion of groundwater into the reed bed. The membrane must be durable enough to resist being punctured by the gravel during installation, macrophyte rhizomes, and external tree roots and rocks. It must also be able to withstand sustained exposure to sunlight and potentially corrosive wastewater. Furthermore, in order to satisfy the Local Government Act (1993), the membrane must be expected to last at least 15 years.

Flexible liners provide possibly the least expensive option for lining a reed bed. However, after allowing the use of flexible liners on a trial basis in 2000, LCC identified a number of problems with the use of flexible liners, including the following:

- *Phragmites australis* was found to puncture liners (Canvacon 7000) due to its aggressive rhizome growth and people failing to protect the liners between two layers of geo-textile;
- Rats were found nesting under one liner and had chewed holes in the liner;

- Many liner reed beds used geotextile to protect the liner that was exposed to the sunlight. However, it was found that U.V. radiation soon breaks down the geotextile, leaving the liner exposed.
- Poor workmanship. Many plumbers left it up to the owners to finish off the reed bed with many reed beds not having sufficient lips to prevent stormwater or soil incursion. Many people did not use rocks or sleepers to support the lip, allowing the rain to erode the lip;
- It takes longer to install a flexible liner membrane reed bed than it does with other rigid membranes and a lot more can go wrong in the installation process i.e. puncturing of the liner, and;
- Perceived risk of root intrusion from nearby trees i.e. figs, mangoes.

Of the flexible-liner reed bed inspected by Lismore City Council, very few were expected to last the 15 years required by the Local Government Act (1993). Thus, **LCC no longer allows the use of flexible dam liners** for containment of reed beds, and requires the use of more rigid membranes. Suitable durable, rigid water-tight materials that can be used for the reed bed membrane include:-

- Polyethylene containers, e.g. 'Duraplas' reed bed mould, cattle troughs, water tanks cut in half.
- Concrete cattle troughs;
- Besser blocks with watertight cement rendering or other sealant; and

Where available, the polyethylene reed bed tubs (such as those manufactured by Duraplas; see Appendix 2) provide an excellent rigid membrane for containing a reed bed. The Duraplas tubs are available in two sizes: the standard depth tub (3.1m x 2m x 0.64m deep), and the deep tub (3.1m x 2m x 0.94m deep).

If a flexible liner is used as a membrane (**outside** the Lismore City Council Area), then one should consider the following points:-

- Do not use the common reed, *Phragmites australis*, as it may puncture the liner due to its aggressive growth.
- One should consider using a good quality, durable liner, such as HDPE, PVC or butyl rubber with a minimum thickness of 0.75mm, rather than the cheapest pond liner available.
- Care should be taken to ensure the hole you dig is free from tree roots or any sharp objects.
- The liner must be sandwiched between two protective layers (above and below the liner) of geo-textile or a similar product, such as old carpet, in order to protect the liner from puncturing.
- If the geotextile is exposed to sunlight and you are not going to cover it with railway sleepers or rocks, it should be protected, e.g. by weed matting.
- The lip of the reed bed should be well protected from UV radiation and accidental puncturing, i.e. use of railway sleepers, bricks and/or weed matting.
- The lip should be a minimum of 100mm above the ground surface to prevent overland flow into the reed bed.
- Care should be taken when placing the gravel into the reed bed so sharp points do not puncture the liner. Earth moving machinery should not be permitted to travel on the reed bed (for example, when inserting the gravel).
- Care should be taken when working around the reed bed with any tools or similar objects e.g. careful if using a whipper snipper, do not push a wheel barrow full of gravel over the liner when filling the reed bed.



### 4.3 Multiple Reed Beds - In Parallel or Series?

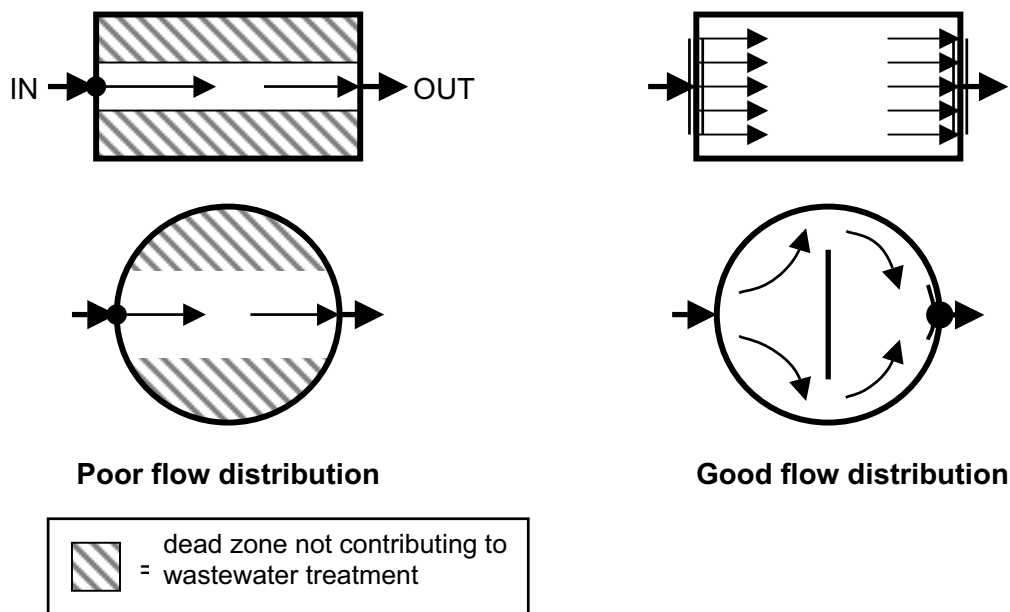
LCC recommends that reed beds are placed in series rather than in parallel, to avoid an unevenness of flow and thus a reduction in treatment performance that may occur if the reed beds are placed in parallel (see below).

If the reed beds are placed in series, there is a higher risk of the first reed bed clogging and therefore it is very important to ensure that the collection tank has an effluent filter installed and that the effluent filter is maintained regularly. Durable rubber grommets may be used to achieve a watertight seal around pipes when joining the beds together (costs approximately \$16-40).

If the reed beds are placed in parallel, there is a need to ensure that the effluent discharging to the reed beds is evenly split between the two or more parallel beds. The installation of a dosing siphon or tipping bucket can help to achieve an even split of flow. An uneven split of the wastewater can lead to treatment deficiencies in one or more of the reed beds, reducing the overall treatment performance of the reed bed system.

### 4.4 Inlet and Outlet Structures

One of the primary aims of the inlet and outlet structures is to minimise the risk of short-circuiting of flow through the reed bed by ensuring the even distribution of influent across the width of the bed, and the even collection of effluent across the width of the bed at the outlet end (Figure 3). In order to achieve this in a round reed bed, baffles should be installed at the inlet and outlet ends of the bed.



**Figure 3. Plan view of reed beds showing the effect of inlet and outlet structures on flow distribution and short-circuiting within reed beds.**

There have been many varieties of inlet and outlet structures used in reed beds. Traditionally the inlet and outlet structures consisted of perforated T-pipes (Section 4.41, Figure 4) or capped 300mm perforated stormwater pipe (Section 4.42, Figure 5). More recent designs have used two 150mm stormwater pipe "towers" connected together (Plate 5 in Appendix 4) or have used arched trenching (Plate 3 in Appendix 4). Essentially, whatever design is used for inlet and outlets they must be easily accessible for maintenance, whilst ensuring that wastewater is discharged below the gravel surface.

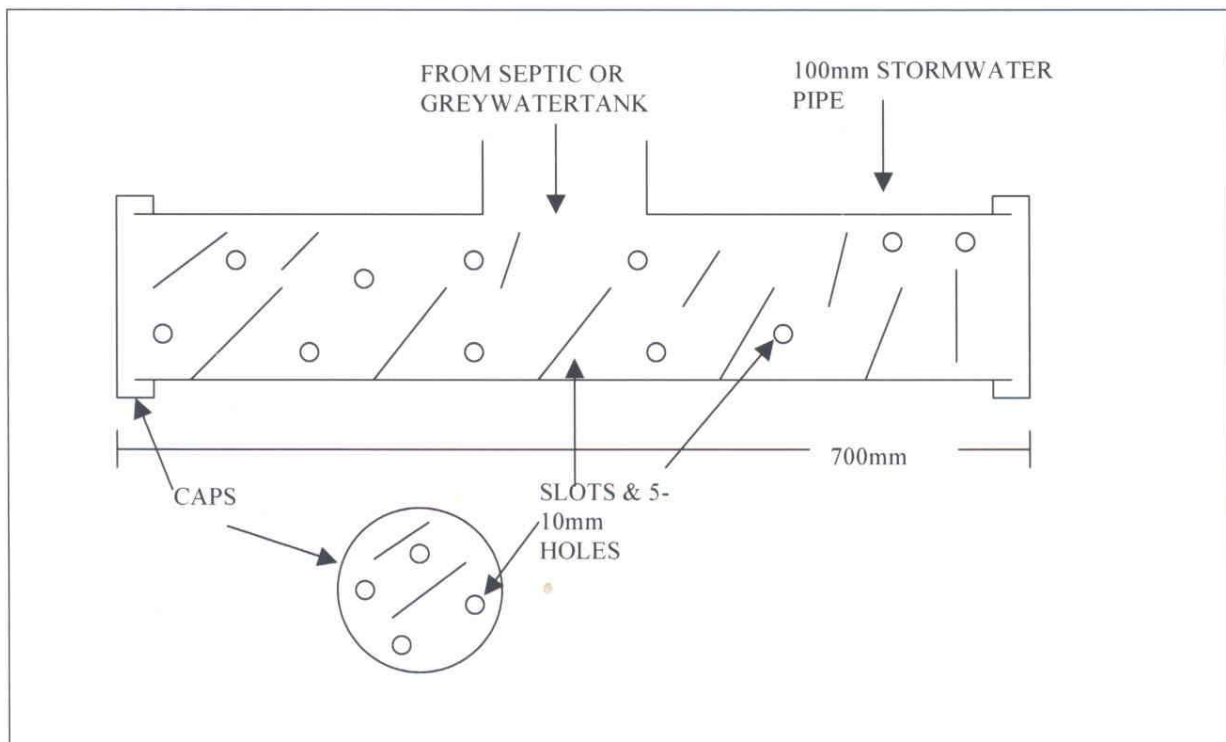
For reed beds in series it is recommended that a perforated T-junction is used as the inlet distribution for the first reed bed, and the design shown in Plate 5 is used for the outlet of the first reed bed and the inlet and outlet devices for following reed beds.

For reed beds in parallel, it is recommended that the inlet device consist of a perforated T-junction and the outlet device as shown in Plate 5.

#### 4.4.1 T-Junction Inlet and Outlet Pipes

A 100mm PVC sewer pipe can be used for inlet spreader and outlet collection pipes. A series of 5-10mm holes are drilled in the sewer pipe and a circular saw can be used to create a series of slots to allow for wastewater to discharge or enter the pipe. Ensure you drill enough holes to allow the wastewater to flow easily through the reed bed.

If using a T-junction outlet pipe, it is advisable that it be placed as close to the bottom as possible to allow complete drainage of the reed bed if major maintenance is required. The inlet pipe should be placed as close to the gravel surface as possible but remain covered by gravel. The gravel coverage is required to prevent vermin entering the inlet pipe and then entering the house, to avoid human contact and to prevent the escape of unpleasant odours.



**Figure 4: T-junction for Inlet and Outlets**

#### 4.4.2 300mm Stormwater Inlet and Outlet Devices

Many reed beds are now using this type of inlet or outlet device, or as mentioned above, use a smaller size pipe of 150mm. The 300mm pipe sits vertically in the gravel and has drilled holes greater than 5mm (Figure 5). The holes are located below the gravel surface. The cap can be removed to check for root intrusion.

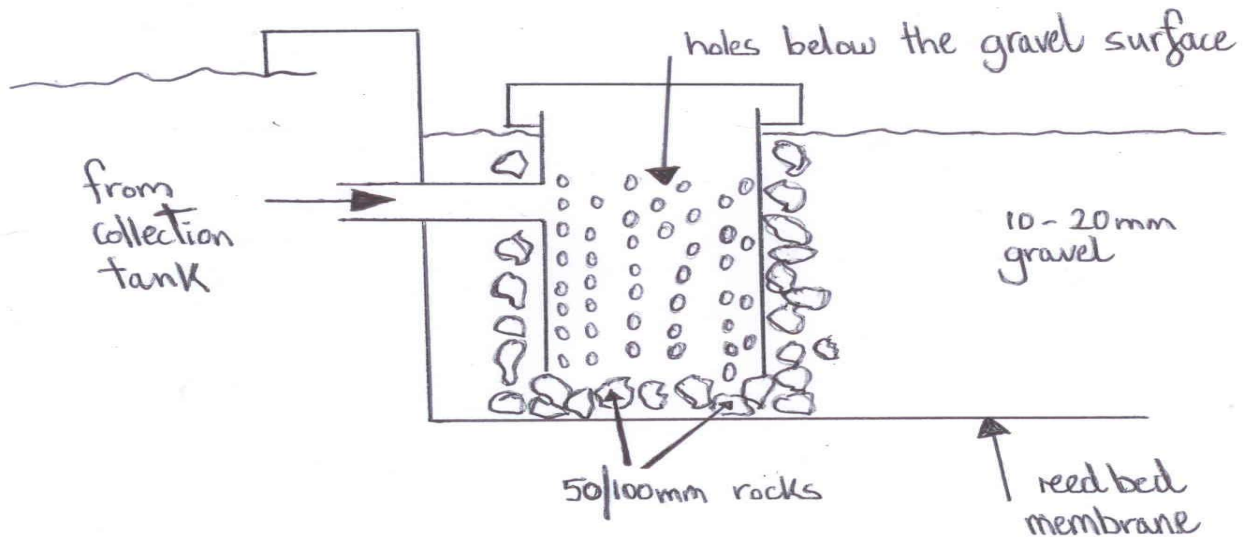


Figure 5: 300mm Stormwater Pipe with Cap

#### 4.4.3 Arch Trenching Inlet

A variation on the T-junction inlet is to use perforated plastic arch trenching to disperse the influent into the gravel, rather than the 100mm diameter pipe described in Section 4.4.1 (Plate 3 in Appendix 4). The arch trenching allows for any solids to build up in the void space without reducing the reed beds' ability to get the water away quickly from the inlet structure.

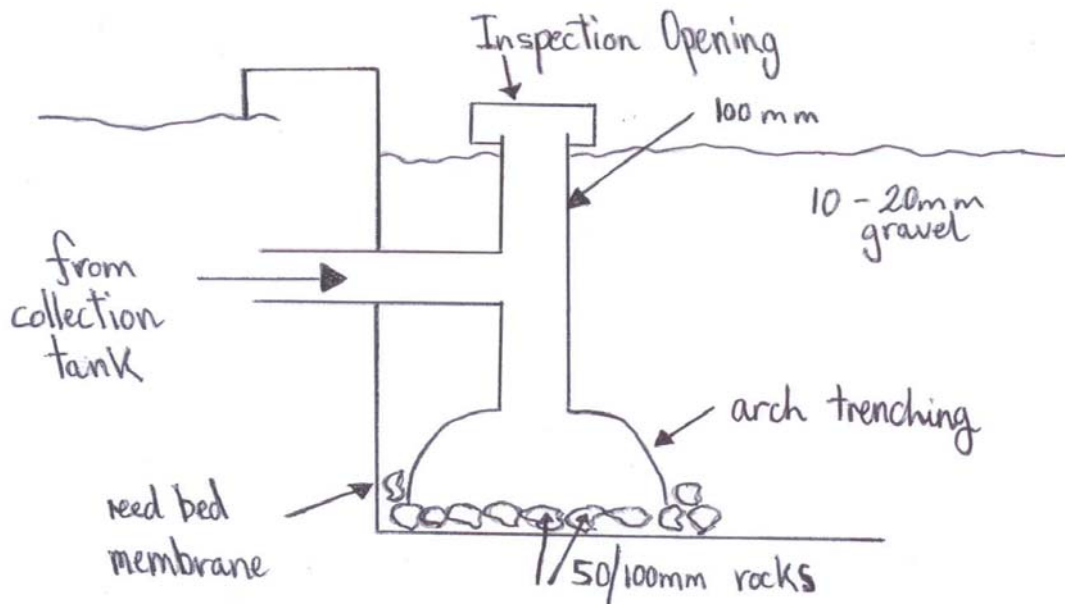


Figure 6: Diagram of Arch Trenching Inlet Design

#### 4.5 Altering the Height of Wastewater in a Reed Bed

Lismore City Council now requires a device to alter the water height in the reed bed. Reed beds can be designed with a water height control box or an internal chamber that allows the water height to be altered (Figure 7; Plate 6). Care must be taken to ensure that all fittings are water-tight and do not leak. Leaking fittings can cause the water level to drop substantially, leading to the death of the plants, whilst contaminating the surrounding soil and/or groundwater.

Lowering the height of water in a reed bed can stimulate root growth and aid in treatment performance by drying out the upper layer of gravel, oxygenating the exposed area and de-clogging the reed bed. Water height should be lower in summer when micro-organism activity is at its greatest and higher in winter when micro-organism growth slows down. A drop in water height of 200mm should be sufficient. The water level should be lowered for a period of two weeks or more.

It is also wise to make it possible to completely drain the reed bed, either through the water height controller or a drain plug, to allow for maintenance or repairs if required.

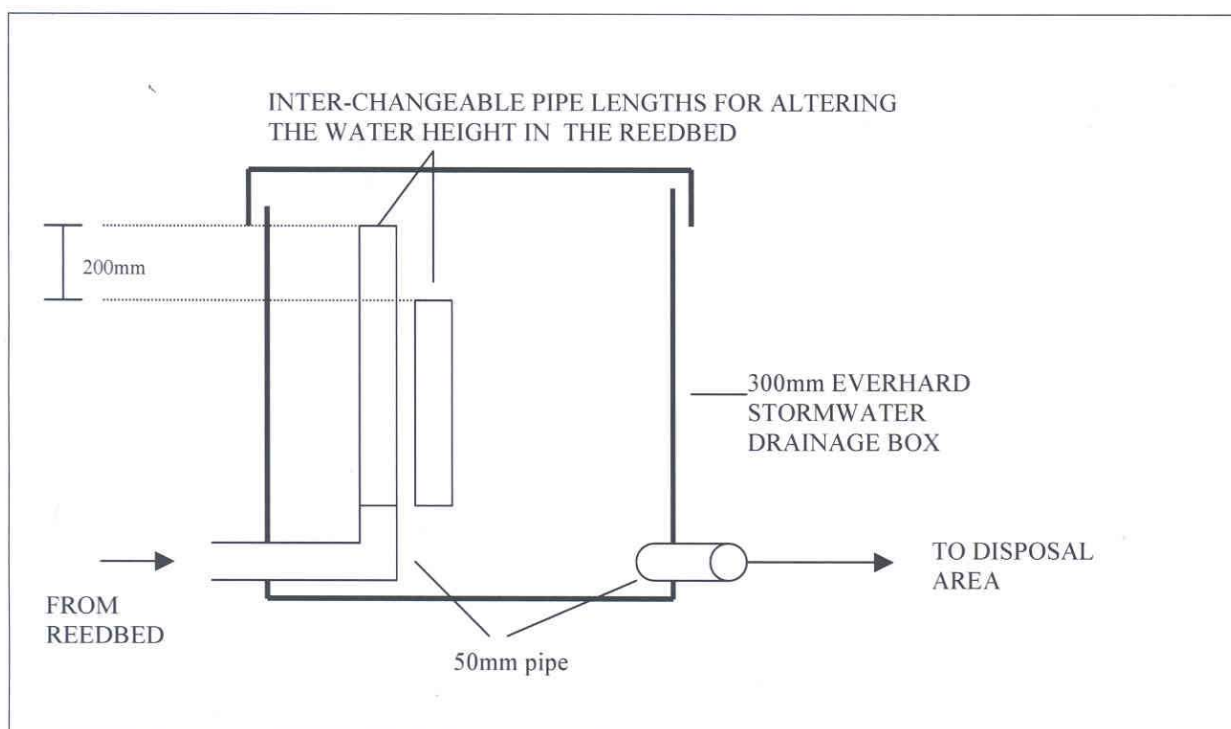


Figure 7: Water Height Control Box

It is advisable when installing the water height control box or a distribution box that a firm base is created by compacting a layer of cracker dust in the hole so that the water height control/distribution box does not move, resulting in an uneven distribution of effluent in the land application area (LAA). Some people are now installing dosing siphons or tipping buckets to provide a more even distribution of effluent in the LAA.

#### 4.6 What Size Gravel to Use?

The gravel used in the bulk of the reed bed should have a diameter of 10 – 20 mm. If the gravel used is too fine, there will be a high risk that it will clog with solids over time. However,

if the gravel is too coarse, plant growth will be very poor and it is likely that treatment performance will suffer.

Large rocks of approximately 50-100mm diameter or rail ballast should be placed at the entry and exits points of the reed bed to prevent the intrusion of reed roots, clogging, and to enhance the distribution of wastewater into the reed bed.

#### 4.7 Placing Gravel in the Reed Bed

If using a Duraplas mould for your reed bed, once your mould has been placed in the hole, you will need to ensure that when you are adding the gravel that the outside of the mould is supported/backfilled with gravel or soil. If this is not done, the mould will bow outwards and may cause problems in the future.

#### 4.8 What Macrophytes (Aquatic Plants) can you Use?

Macrophytes, i.e. sedges, reeds, and rushes, play an important role in the treatment of water within a reed bed. They directly take-up nutrients, pump oxygen into the substrate and provide a food source for the micro-organisms responsible for breaking down pollutants.

A range of native wetland plants can be used in reed beds, as shown in Table 2. Other species that don't mind having wet feet can also be used, such as *Lomandra hystrix* and *Carex spp.* Davison & Headley (2003) recommend that locally occurring native species that exhibit rapid and vigorous growth should be used. These species are generally found locally on the north coast of NSW and can be sourced either from existing treatment reed beds (see Appendix 4 ) or from local suppliers (see suppliers list in Appendix 2).

**Table 2. Macrophyte species suitable for use in reed beds and their maximum expected height.**

Species name	Common name	Height (m)
<i>Baumea articulata</i>	Jointed twigrush	2.5
<i>Baumea rubiginosa</i>	-	1
<i>Bolboschoenus fluviatilis</i>	marsh clubrush	2.5
<i>Eleocharis sphacelata</i>	Tall spikerush	2
<i>Lepironia articulata</i>	Grey rush	4
<i>Phragmites australis</i>	Common reed	4
<i>Schoenoplectus mucronatus</i>	Star clubrush	1
<i>Schoenoplectus validus</i>	River clubrush	3
<i>Typha orientalis</i>	Bullrush or cumbungi	4

Source: Dirou et al., 2003.

#### 4.9 Planting out the Reed Bed

Macrophytes can be planted as seedlings, rhizome cuttings, or mature clumps. Macrophytes should be planted at a density of at least 4 to 5 plants per square metre (approximately 30-40cm apart). Essentially, **the denser they are planted, the better!** Rhizome cuttings should be planted so that one end of the rhizome has access to water, whilst the other end protrudes above the gravel surface and has access to sunlight. If mature clumps are planted, all shoots/stems should be trimmed to a length of 20cm before placing the clump in the gravel (Appendix 3). Regardless of the planting material used, it is important to ensure that the plants do not dry out. However, plants should not be completely inundated, as unestablished plants will quickly rot away.

#### 4.10 Pump Well Capacity

Pump wells following a reed bed are to have a minimum capacity of 1000Litres or meet the requirements of the NSW Plumbing and Drainage Code of Practice.

## **5.0 MAINTENANCE REQUIREMENTS**

In a well-designed reed bed, the maintenance requirement should be minimal. Gloves should be worn when undertaking maintenance, and avoid contact with effluent if you are feeling unwell or have cuts on your hands.

### **5.1 Checking for Blockages in Inlet/Outlet Structures**

Blockages should be rare if large rocks are placed around the inlet and outlet structures. When the macrophytes are growing well it may be necessary to check that their roots are not blocking the inflow and exit pipes. Ponded effluent on the surface of the reed bed, or an overflowing septic or greywater tank, are good indicators that a blockage has occurred somewhere in the system.

### **5.2 Cleaning the Effluent Filter**

Effluent filters are required to be fitted to the outlet of septic and greywater tanks to reduce the concentration of suspended solids entering the reed bed. There are a number of manufactured effluent filters available, such as Biotube™, Taylex™, and Zoeller™ filters. These filters can be easily cleaned by the system owner. This should be checked periodically and cleaned when necessary.

### **5.3 Pumping out of Greywater or Septic Tanks**

It is important to have the greywater/septic tank periodically pumped (approximately 3-5 years) out to remove accumulated sludge and scum, in order to minimise the carry over of excess solids into the reed bed. The carry over of solids will potentially clog the gravel in the reed bed.

### **5.4 Altering the Water Height**

Water levels can be altered using the adjustable water height outlet device. Water levels can be low in summer and high in winter. This will dry out and de-clog the upper zone of the reed bed. Some reed bed operators lower their water level for 2 week periods in the summer months. The water level should only be lowered approximately 200mm and this should be done over the course of a few days to avoid a surge of wastewater exiting the reed bed.

Lowering of the water level in this way may assist in unblocking the gravel, should it become clogged, by drying out and oxidising the built up organic matter.

### **5.5 Mini-Trenching or Sub-surface Drip Irrigation Systems & Back-flushing the Lines**

If you have a mini-trench or sub-surface drip irrigation system (pressurised emitters) such as Wasteflow™ or Netafim™, then you will need to flush the lines every 6 to 12 months with chlorine to remove the build up of slime on the inside of the pipe work. Chlorine tablets can be dropped into the pump well before back flushing the lines.

### **5.6 Harvesting**

Harvesting is not entirely necessary and is primarily conducted for aesthetic purposes (to remove dead leaf/stem material and promote fresh regrowth). Although harvesting can remove some of the nutrients taken up by the plants, studies have shown that harvesting will remove no more than 10% of the overall nutrients removed by the reed bed.

Due to the variety of macrophytes being used in reed beds, there are several harvesting techniques that can be used. The harvested material can either be mulched onto the reed bed or removed. The majority of wetland plants undergo senescence during the winter months, when the plants stop growing and the above-ground stems die-back. Prior to senescence, the plants translocate nutrients from the leaves and stems to the rhizomes. Thus, in order to maximise the amount of nutrients removed via harvesting, the aboveground plant material should be removed before the bulk of nutrients have been redistributed to the below-gravel parts. Some experts recommend harvesting in late spring and then again in early to mid-autumn, prior to senescence. The rhizomes will send out new shoots after senescence, usually when the weather starts to get warmer.

Harvested vegetation can be used as mulch on the reed bed or composted. Mulch can be a valuable source of organic carbon to provide food for the bacteria that are responsible for nitrogen removal in the reed bed. If mulching the reed bed, you must ensure that the amount of mulched material placed on the reed bed does not prevent the re-growth of new shoots.

Council advises owners to use only 20% of the harvested material on the reed bed as a mulch, until such a time as the owner knows how much mulch can be used without limiting the growth of new shoots.

Recent studies have shown that mulching the reed bed helps attract garden/compost worms that help “transport” solids in the reed bed to the gravel surface that would otherwise clog the reed bed, thus having a positive effect on the treatment performance of the reed bed.

#### **5.6.1 Phragmites, Typha (Bullrush), Schoenoplectus and Bolboschoenus**

It will not be necessary to harvest the aboveground reed material in the first year, but after the first year (one growing season), the reeds can be harvested twice annually. This involves cutting back reeds to a height of 20cm above the gravel surface.

#### **5.6.2 Lomandra and Clumping Rushes**

These macrophytes grow in clumps and may need to be either thinned out periodically or trimmed as above in Section 5.6.1.

### **5.7 Holidays**

If all the occupants of the dwelling will be on holidays for an extended period (perhaps longer than 8 weeks) it will be necessary for the reed bed to receive water. A tap can either be left dripping or a friend can use the system. However, with the North Coast’s high rainfall conditions it is unlikely that this should be of concern during the wet season, as rainfall may provide adequate water during this time.

### **5.8 Two or More Reed beds in Parallel**

Where two or more reed beds exist in parallel, one can be decommissioned to allow maintenance to be undertaken.

## **6.0 AFTER THE REED BED: LAND APPLICATION (DISPOSAL) OPTIONS**

### **6.1 Application Methods**

The most common methods of land application in the LCC area are:-

1. Gravity fed to ETA beds;
2. Minimum 1000Litre pump well, pump/dosing siphon, through indexing valve to a series of mini trenches or ETA beds; and,
3. Minimum 1000Litre pump well, pump, pumped to pressurised sub-surface drip irrigation system (e.g. Wasteflow™ or Netafim™).

N:B. Pump wells will require an overflow trench or surface pipe and alarms for pump failure.

#### **6.1.1 Gravity Feed to ETA beds**

In most cases an owner will gravity feed to ETA beds if possible to reduce installation costs. A more effective way to apply the wastewater, whilst still using gravity, would be the use of a dosing siphon (usually 80-200Litres capacity) which will allow effluent to enter your ETA bed in doses, thus ensuring that the wastewater will make it to the end of you ETA bed and providing a more even distribution of effluent.

#### **6.1.2 Minimum 1000Litre pump well, pump, pumped through indexing valve to a series of small trenches**

Some owners install an indexing valve that allows up to six land application areas to be irrigated on an alternating basis. The indexing valve diverts wastewater to the land application areas alternatively, providing an even distribution of wastewater. Once the pump has finished pumping, it automatically switches to the next irrigation line, and so on. Floats in the pump well attached to the pump dictate how much wastewater is delivered per dose. These systems have been installed to irrigate rows of trees.

### **6.1.3 Minimum 1000Litre pump well, pump, pumped to sub-surface drip irrigation system (e.g. Wasteflow™ or Netafim™)**

Sub-surface drip irrigation systems are usually installed under garden lawns. Treated wastewater is pumped to the irrigation lines that contain pressurized drip emitters that cause a very even distribution of wastewater.

## **6.2 What to Plant in the Land Application Area**

It is important to note that the land application area is a managed area and thus whatever is planted there must be maintained. It is common practice to grass the top of evapotranspiration beds and keep the grass short to aid in evaporation. Suitable tree species can be planted around the border of the ETA beds or land application area. Melaleuca species are suitable for this. As with the grass, these plants will require pruning to remove nutrients from the system. Melaleucas can be cut in half when approximately 2 metres tall.

Shrubs should be thinned and lower branches removed to allow for air movement across the ground surface, aiding in evaporation. A vegetation list can be found in LCC's *Revised On-site Sewage & Wastewater Management Strategy, July 2003*.

Sub-surface drip irrigation systems are usually installed under garden lawns. Systems using an indexing valve have been planted with melaleucas, macadamias or act as regeneration areas. Grass between the trees is mown regularly. Areas to be used as regeneration areas must either be maintained or a new LAA established when the irrigation area fails.