This WaterSmart Practice Note explains how to design and configure stormwater infiltration devices.

**Infiltration Devices**

**Practice Note 5**

Infiltration basin under normal conditions (left), and during heavy rain (above).

**In this practice note:**
- Infiltration system overview
- Infiltration retention systems
- Infiltration materials & devices
- Design issues
- Costs

WaterSmart development involves simple design and management practices that take advantage of natural site features and minimise impacts on the water cycle. It is part of the contemporary trend towards more ‘sustainable’ solutions that protect the environment and cost less.

**Introduction**

This Practice Note describes how to design and construct various types of stormwater infiltration devices for dwellings and other similar-scale development. There is growing interest in infiltration as an alternative or supplement to conventional drainage techniques due to its many environmental and economic benefits. These benefits include reduced peak stormwater flows, reduced downstream flooding, reduced stormwater drainage capital costs, improved groundwater recharge and improved stormwater quality.

Conventional stormwater practice typically involves discharging stormwater from residential properties to a constructed street drainage system. Such systems are highly effective for removing stormwater from the site, but can also contribute to flooding risk, erosion and sedimentation and water quality decline in downstream catchments. Prior to the construction of urban drainage systems in the late 19th Century, one of the most common methods for managing stormwater was on-site gravel infiltration pits. These provided temporary storage, and allowed stormwater to percolate to the surrounding soil at a rate limited by the soil’s hydraulic conductivity.

Modern infiltration devices are much more efficient than their traditional counterparts. They are constructed so as to minimise clogging by silt material, and can be designed to overflow to landscaped areas or the street drainage system when their storage capacity is exceeded during major storms. A number of pollutant removal mechanisms operate within infiltration devices, including adsorption, straining, microbial decomposition in the gravel layer and trapping of sediment in the pre-treatment areas. If correctly designed, an infiltration device can remove approximately 90% of sediment, 60% of phosphorus and 60% of nitrogen from stormwater.

This Practice Note draws upon the latest design and performance results for Australian conditions. Research undertaken at the University of Newcastle (Coombes et al. 1999, Coombes 2002) and the University of South Australia (Allen and Argue 1992, Argue et al. 1998, Argue 2002) shows that infiltration is a very practical option for managing stormwater provided that site conditions such as slope, soil permeability and reactivity to water are correctly taken into account.
Infiltration devices can be used as a sole approach or in unison with rainwater tanks, porous paving and landscape measures (see Practice Notes 4, 6 and 7 respectively) to manage stormwater. An infiltration device collects the rain that falls on site, stores it temporarily and then releases it slowly into the ground. There are three parts of an infiltration device:

1. **Site drainage system**

The site drainage system e.g. roof gutters, downpipes, paths and driveways which collect and deliver stormwater to the infiltration device.

2. **Pre-treatment system**

The pre-treatment system receives water runoff prior to entering an infiltration device to remove gross pollutants, particulate matter and soluble pollutants. Pretreatment protects and maximises the life of the infiltration device and improves the quality of water entering the environment. Table 1, outlines the types of pollutants found in different water sources and mechanisms used to protect the infiltration device and/or improve water quality.

3. **Infiltration retention system**

The retention system stores roof water and stormwater until it can percolate into the surrounding soil (Fig 1). There are a number of options for using stormwater infiltration on residential properties. The most commonly used systems are:

- leaky wells
- retention trenches
- infiltration basins.

### Table 1: Types of pollutants and mechanisms to protect infiltration devices

<table>
<thead>
<tr>
<th>Type of pollutants</th>
<th>Roof water</th>
<th>Stormwater</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>System Protection</td>
<td>Environment Protection</td>
</tr>
<tr>
<td>Gross</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soluble</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protection mechanisms</th>
<th>Top</th>
<th>Middle</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Leaf guards</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- First flush device</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>- Leaf screen</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>- Sediment trap</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Contour banks</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>- Vegetation</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Grass swales</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Biofiltration strips</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Wetlands</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 1: A typical infiltration strategy

### Types of Systems

1. **Leaky wells**

A leaky well consists of a vertical perforated pipe with a lid at the ground surface and an open bottom. Stormwater enters via an inlet pipe at the top and an overflow pipe caters for excess stormwater. The holes in the walls and the open bottom are covered with geotextile fabric to cleanse stormwater as it percolates into the surrounding soil (see Figure 2).

Leaky wells store stormwater until it can percolate to the surrounding soil. Before entering the device, all stormwater should be filtered by a sediment trap to remove sediment, leaves and debris. An advantage of the leaky well is that the accessible chamber allows sediment to be readily removed. Consequently it is more resistant to failure due to clogging. Note that the dimensions shown in Figure 2 are nominal.
2. Retention trenches

A retention trench consists of a trench lined with geotextile fabric and filled with coarse gravel, and placed under a 300 mm layer of sand or loam. Stormwater is conveyed to the trench via an inflow pipe after passing through a sediment trap. A perforated distribution pipe allows stormwater to percolate to the gravel. An overflow pipe directs excess flow during very heavy rain to the street drainage system (see Figure 3).

The sediment trap prevents clogging of the trench with sediment, leaves and debris, whilst the geotextile fabric cleanses the stormwater as it percolates from the trench to the surrounding soil. The detailed design for a retention trench can vary provided it includes the basic elements referred to above. Note that the dimensions shown in Figure 3 are nominal.

3. Infiltration basins

An infiltration basin collects and stores stormwater runoff until it infiltrates to the surrounding soil and evaporates to the atmosphere. By removing a portion of stormwater runoff, infiltration basins reduce stormwater peak discharges and volumes to downstream catchments. They also improve the quality of stormwater discharged to the receiving environment.

An infiltration basin is designed as a depression with good grass coverage over a layer of coarse gravel surrounded by geotextile fabric. A 300 mm layer of topsoil is usually placed between the gravel layer and the grassed surface. Stormwater entering the basin is filtered to remove sediment, leaves and debris by sediment traps, vegetated areas or specially designed gutter systems. Stormwater fills the basin and the gravel layer, percolates to the soil and overflows to the street drainage system when the basin fills.

A schematic diagram for an infiltration basin is shown in Figure 4. Infiltration basins are more suitable for larger lots where there is plenty of space. Their design should be well-integrated with landscape measures (see Practice Note No. 7).
WATER SMART Practice Note 5

INFILTRATION DEVICES

1. Void Materials
Void materials such as gravel, crushed concrete, sand, infiltration cells (similar to a plastic milk crate), tyres filled with gravel and enviromedia (a mix of sand/gravel and organic material) fill infiltration devices. Void materials contain spaces that store and filter water before it percolates into the surrounding soil. Sand, gravel, crushed concrete, infiltration cells and tyres, are inert media capable of removing particulate-bound matter largely through physical filtration. Enviromedia is a reactive media that removes both particulate-bound and soluble material. The table below provides a general indication of the performance (most to least) of each material relative to its water storage capacity, weight bearing capacity, pollutant removal ability, and typical proportion of recycled materials.

<table>
<thead>
<tr>
<th>Void space</th>
<th>Weight support</th>
<th>Pollutant removal ability</th>
<th>Recycled material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration cells</td>
<td>Gravel/Crush concrete</td>
<td>Enviromedia</td>
<td>Tyres/Crush concrete</td>
</tr>
<tr>
<td>Tyres</td>
<td>Sand</td>
<td>Sand</td>
<td>Infiltration cells/Enviromedia</td>
</tr>
<tr>
<td>Gravel/Crush concrete</td>
<td>Enviromedia</td>
<td>Gravel/Crush concrete</td>
<td>Gravel</td>
</tr>
<tr>
<td>Enviromedia</td>
<td>Tyres</td>
<td>Tyres/Infiltration cells</td>
<td>Sand</td>
</tr>
<tr>
<td>Sand</td>
<td>Infiltration cells</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Geotextile fabric
Geotextile is a synthetic engineered fabric used in in-line infiltration devices to cleanse water percolating into the soil and to prevent erosion during construction.

3. Seepage or agricultural pipes
A seepage pipe is a pipe with pervious walls, formed by punched or moulded holes, that allows stormwater to percolate into the surrounding soil. Seepage pipes are installed in a similar fashion to retention trenches. The pipe is surrounded by sand or gravel in a trench and covered with sand or loam to a thickness of 300 mm (see Figure 5).

Fig 4: Design for an infiltration basin

Fig 5: Seepage pipe installation
DESIGN ISSUES

1. Clearance from buildings
Soils can shrink or swell depending on their clay and water content, presenting potential problems for building foundations. However, research shows that only minimum soil movement is associated with the intermittent release of stormwater from infiltration devices. The possibility of an infiltration device impacting on the structural integrity of a building can be eliminated by observing minimum clearances.

The recommended minimum separation between an infiltration device and a building for various soil types is shown in the following table. Check with your local council for any local requirements that they may have.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Hydraulic Conductivity</th>
<th>Minimum Building Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>&gt;180 mm/hr</td>
<td>1 m</td>
</tr>
<tr>
<td>Sandy clay</td>
<td>180 – 36 mm/hr</td>
<td>2 m</td>
</tr>
<tr>
<td>Medium clay</td>
<td>36 – 3.6 mm/hr</td>
<td>4 m</td>
</tr>
<tr>
<td>Reactive clay</td>
<td>3.6 – 0.036 mm/hr</td>
<td>5 m</td>
</tr>
</tbody>
</table>

2. Unsuitable soils
Infiltration devices should not be installed in:
- saline, sodic or very shallow soils
- wind blown or loose sands
- clay soils that collapse in contact with water or have high shrink/swell characteristics
- soils with a hydraulic conductivity of less than 0.36 mm/hr.

Soil assessment and permeability testing must be undertaken as part of the design process for infiltration devices.

3. Slope
Infiltration devices should not be installed on steep slopes. Installation of infiltration devices on slopes greater than 5% is not recommended unless a detailed engineering analysis is undertaken at the design stage.

4. Rock & shale
Infiltration devices should not be placed in rock that has little or no permeability. Studies have shown that infiltration is possible in severely weathered or fractured rock (for example, sandstone). Engineering testing is essential in these circumstances to ensure that the rock will accept infiltration. In the case of shallow soil cover, testing is required to ensure that seepage does not cause hazard or nuisance to downstream sites.

5. Water tables
The presence of a high water table can limit the potential effectiveness of infiltration devices. Infiltration devices can be successful in areas with high water tables if the water table is stable. Infiltration is not recommended for areas where the water table is rising or the salinity of ground water is increasing.

6. Sediment
Sediment can be deposited on roofs from the atmosphere at approximately 2 kg per 100 square metres of roof area per annum. It can also be deposited from runoff on other surfaces in established suburbs at about 0.7 tonnes per allotment per year. The management of sediment is therefore a very important issue in the design and construction of infiltration devices. Sediment generation during construction must be prevented from overloading any installed infiltration devices.

Special measures must be implemented to provide pre-treatment for stormwater containing sediment, leaves or other debris before it enters an infiltration device. For example, runoff from roof downpipes should be directed to an effective sediment trap. Runoff from impervious surfaces such as paved areas, courtyards, walkways and driveways should be directed to grassed surfaces, vegetated areas or a sand-loam layer that is at least 200 mm thick. The only direct input to an infiltration device should be overflow from a roofwater tank, since the tank serves to remove sediment and other matter (see Practice Note 4: Rainwater Tanks).
Sizing infiltration devices
Many councils require infiltration devices to be designed with sufficient capacity to store the inflow for a one-in-three months average recurrence interval design storm, with an emptying time of less than 24 hours.

In order to satisfy this design criteria in the Newcastle area, an infiltration device filled with gravel (30 mm nominal particle size) and a catchment roof area of 150 square metres will need to have the following volumes:

- 2.5 cubic metres in a sandy soil

In medium clay soils a low-level overflow pipe may need to be installed to ensure an emptying time of 24 hours. This is illustrated in Figure 6.

**COSTS**

The cost to install a retention trench can vary considerably. However, an indicative cost is about $80 per cubic metre. This includes gravel and backfilling ($30 per cubic metre), excavation ($30 per cubic metre) and geotextile fabric and plumbing ($20 per cubic metre).

**USEFUL WEBSITES**


University of South Australia: [www.unisa.edu.au](http://www.unisa.edu.au)

Centre for Organic and Resource Enterprises: [www.corebusinessnet.com](http://www.corebusinessnet.com)

**PRODUCT SUPPLIERS**

Some suppliers in Hunter-Central Coast region of NSW are:

- Geotextile fabric, slotted pipes and plumbing fittings: Saddingtons, tel. 02 4969 6222
- Gravel and sand: Specialised Gravel Services, tel. 02 4930 3166
- Gravel: Rock-Inn, tel. 02 4968 2541
- Infiltration cells: Atlantis, tel. 02 9419 6710
- Seepage pipes: HydroCon, tel. 0411 644 463

Additional suppliers can be found in the yellow pages, by searching the internet.
REFERENCES


OTHER PRACTICE NOTES

Other WaterSmart Practice Notes are available in this series:

No. 1 The WaterSmart Home  
No.2 Site Planning  
No.3 Drainage Design  
No.4 Rainwater Tanks  
No.5 Infiltration Devices  
No. 6 Paving  
No.7 Landscape Stormwater Measures  
No.8 Water Efficient Landscape Practices  
No.9 Wastewater Reuse  
No.10 Groundwater  
No.11 Site Discharge Index

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