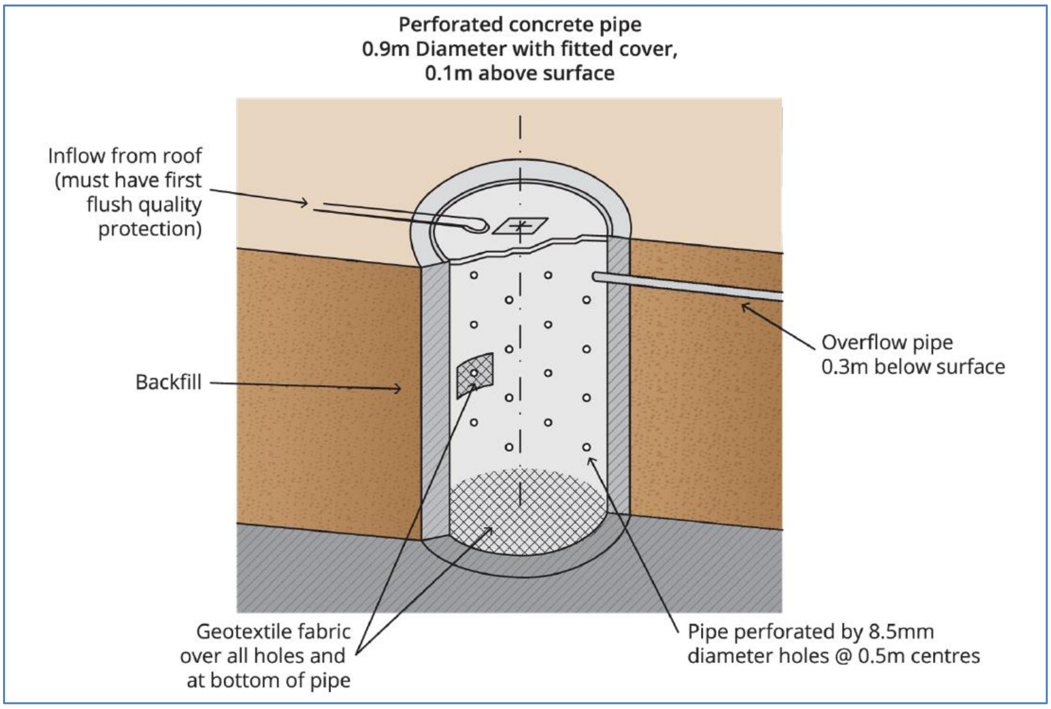

Figure 3. Leaky well infiltration system.

Performance efficiency

Data on the performance efficiency of infiltration systems is presented in the Performance Efficiency section and Table 1 of the Infiltration Basins and Trenches BMP, based on Fletcher et al. (2004).

Cost^

The cost for soakwell systems can vary considerably according to the type of soakwell to be installed, site-specific conditions (including soil type), configuration, location, storage volumes, and landscaping and restoration requirements.

See Chapter 6: Retrofitting, Case Study 7.1 'Town of Mosman Park – Total Water Cycle Project' for further information on the costs of a catchment-wide infiltration project. An example of the techniques used in the Town of Mosman Park to maximise infiltration in the catchment is the installation of combination gully/soakwells, as shown in Figure 2. The cost of installation and materials for each 2.4 m deep soakwell was approximately $1,300 per unit (note : 2004/05 prices) (Glover, M. 2007, pers. comm.[2]).

Installation and other associated works are a significant proportion of the cost of these systems. Soakwells are a relatively cheap stormwater management measure for lot-scale application.

^The costs quoted in this section are from around 2000 to 2007 and have not been adjusted for inflation or potential cost changes due to technological advances which may have occurred since this chapter was published in 2007. Therefore, it should be considered indicative only and users of the manual are encouraged to seek further specific industry advice on the current costs as appropriate.

[2] Personal communication with Martyn Glover, City of Bayswater, 2007.

Design considerations

Design considerations for soakwells are similar to those for other infiltration systems.

Soil type and stability, topography, separation to groundwater, setback to buildings and pre-treatment to remove sediment, litter and other pollutants must all be considered. These issues are discussed in the Design Considerations section of the Infiltration Basins and Trenches BMP.

Design guidelines

The calculations contained in this section for sizing the storage volume of soakwells and determining emptying time are based on Engineers Australia (2006) and Argue (2004). The calculations should be applied with caution to the sizing of infiltration systems where shallow groundwater is present. This approach does not consider the impacts of shallow groundwater in its calculation, which may reduce infiltration capacity. Detailed modelling of shallow groundwater table situations is recommended. Designers should take into account the maximum groundwater level, and hence the minimum infiltration potential, in determining their flood detention design. However, designers should also consider maximum infiltration opportunities to achieve aquifer recharge when the groundwater table is below its maximum level (refer to the Design Considerations section of the Infiltration Basins and Trenches BMP for further discussion).

Inflow volume

The required storage volume is defined by the difference in inflow and outflow volumes for the duration of a storm. The inflow volume is a product of the rainfall, runoff coefficient and contributing area connected to the infiltration system, i.e.:

$$Flow\ Volume = \frac{CiAD}{1000}$$

Where:

$C = runoff\ coefficient$

$i = probabilistic\ rainfall\ intensity\ (mm/hr)$

$A = contributing\ area\ connected\ to\ the\ infiltration\ system\ (m^2)$

$D = storm\ duration\ (hours)$

Soakwell sizing

Note that the following equation is based on an approximation where d ≈ H and may not be valid for other design situations.

Argue (2004) provides the following formula for sizing of a soakwell:

$$d = \sqrt{\frac{\forall}{\frac{\pi}{4}(H + 120k_h tU}}$$

(refer to Argue 2004 for derivation)

Where:

$d\ =\ well\ diameter\ (m)$

$\forall =\ Inflow\ volume\ (m^3)$

$H\ =\ well\ height\ (m)$

$$k_h = soil\ saturated\ hydraulic\ conductivity\ (ms^{-1})$$

$$\tau = time\ base\ of\ the\ design\ storm\ runoff\ hydrograph\ (min)$$

$$U = soil\ moderation\ factor\ (Table\ 3\ in\ the\ Infiltration\ Basins\ and\ Trenches\ BMP)$$

The above equation assumes the device is empty at the commencement of flow. Application of this equation must be followed by a check on the emptying time of the system's storage.

Emptying time

Emptying time is defined as the time taken to completely empty a storage associated with an infiltration system following the cessation of rainfall. This is an important design consideration as the computation procedures previously described assume that the storage is empty prior to the commencement of the design storm event.

Argue (2004) provides the following formula for calculating the emptying time for soakwells:

$$T = -\left(\frac{4.6d}{4k_h}\right) log_{10}\left(\frac{\frac{d}{4}}{H + \left(\frac{d}{4}\right)}\right)$$

(refer to Argue 2004 for derivation)

$$T = emptying\ time\ (s)$$

$$d = well\ diameter\ (m)$$

$$H = well\ height\ (m)$$

$$k_h = soil\ saturated\ hydraulic\ conductivity\ (ms^{-1})$$

Further discussion regarding emptying times is contained in the Design Guidelines section of the Infiltration Basins and Trenches BMP.

Maintenance

Soakwells require maintenance for efficient operation and to reduce the risk of mosquito breeding, including regular inspection and cleaning to prevent clogging by sediments and litter. Pre-treatment BMPs can significantly reduce the maintenance requirements by preventing sediments and litter from entering the system. To prevent road/carpark soakwells from being clogged with sediment/litter during road and housing/building construction (see Figure 4), temporary bunding or sediment controls need to be installed (see Figure 5 for an example of a sediment fence). See section 2.1.1 'Land development and construction sites' of Chapter 7 for information about site management practices.

A maintenance plan for infiltration systems is described in the Maintenance section of the Infiltration Basins and Trenches BMP.

Figure 4. Soil entering a side entry pit that has a soakwell at the base; located within a pipeless subdivision within the City of Mandurah, WA. (Photograph: Department of Water 2007.)

Figure 5. Silt fence for controlling sediment during land development. (Photograph: André Taylor, Ecological Engineering Pty Ltd.)

Worked example

Caution: The following worked examples use Rational Method as per the Australian Rainfall and Runoff (ARR) Book VIII (Institution of Engineers, Australia 2001). However, as per the updated ARR Book 9 'Runoff in Urban Areas', the Rational Method is only suitable for lot-scale scale catchments or simplistic small catchments where flood routing is not critical. This method is not suitable for a 'precinct' scale estimation of peak flows as it has 'limited' runoff generation and surface routing capabilities. If runoff volume management infrastructure forms part of a solution, or if an understanding of potential impacts on downstream flooding are required, then a 'strong' hydrologic estimation method such as a runoff-routing model should be used (ARR 2019). For further information on the limitations of Rational Method, please refer to Book 9 'Runoff in Urban Areas' of ARR 2019.

The following worked example is based on a WSUD Workshop held by John Argue in Perth, November 2005.

An onsite stormwater retention system is to be designed for runoff from a roof located in Perth. The site is located in an elevated area with good clearance to groundwater, hence application of the formulae contained in the design guideline for this BMP is considered appropriate.

The design parameters are listed below:

$$Roof\ area, A\ =\ 400\ m^2$$

$$Soil\ saturated\ hydraulic\ conductivity, k_h\ =\ 1.6\ \times\ 10-4\ ms^{-1}\ (sandy)$$

$$Standard\ soakwell\ effective\ height, H\ =\ 2.30\ m$$

Based on spreadsheet analysis, for a required design average recurrence interval (ARI) of two years (or 0.5 EY), refer Engineers Australia (2006) for methods of 't' calculation:

$$site\ t_c\ =\ 15\ minutes\ (calculated\ site\ time\ of\ concentration)$$

$$site\ t\ =\ 30\ minutes\ (calculated\ site\ time\ of\ concentration)$$

$$\tau = 15 + 30$$
$$= 45\ minutes\ (time\ base\ of\ the\ design\ storm\ runoff\ hydrograph\ in\ Figure\ 3)$$

Based on the above, the design rainfall intensity i_2 = 31.7 mm/hr (refer to Rainfall Intensity–Frequency–Duration curves for Perth, available from Bureau of Meteorology).

Runoff volume

$$Inflow\ Volume\ \forall = \frac{CiAD}{1000}$$

From ARR Book VIII (Institution of Engineers Australia 2001):

$$C_y = F_y . C_{10}$$

Where:

$$C_y = runoff\ coefficient\ for\ a\ 'Y'\ year\ ARI\ (currently\ termed\ as\ EY\ or\ AEP)$$

$$F_y = frequency\ factor\ for\ rational\ method\ runoff\ coefficients$$

$$C_{10} = 10\ year\ ARI\ (or\ 10\%\ AEP)\ runoff\ coefficient\ (0.9\ where\ the\ fraction\ impervious\ is\ 1)$$

Therefore, for ARI = 2 years or (0.5 EY):

$$C_2 = F_2 . C_{10}$$

$$C_2 = 0.85 * 0.90$$

$$C_2 = 0.765$$

$$Inflow\ Volume\ \forall = 0.765 * \frac{31.7}{1000}(mhr^{-1}) * 400(m^2) * \frac{30}{60(hr)}$$

$$\forall = 4.85\ (m^3)$$

Soakwell sizing

Argue (2004) provides the following formula for sizing of a soakwell:

$$d = \sqrt{\frac{\forall}{\frac{\pi}{4}(H + 120k_h tU}}$$

(refer to Argue 2004 for derivation)

Where:

$$d = well\ diameter\ (m)$$

$$\forall = Inflow\ volume\ (m^3)$$

$$H = well\ height\ (m)$$

$$k_h = soil\ saturated\ hydraulic\ conductivity\ (ms^{-1})$$

$$\tau = time\ base\ of\ the\ design\ storm\ runoff\ hydrograph\ (min)$$

$$U = soil\ moderation\ factor\ (Table\ 3\ in\ the\ Infiltration\ Basins\ and\ Trenches\ BMP)$$

Where U = 0.5 for sandy soils.

$$d = \sqrt{\frac{4.85}{\frac{\pi}{4}(2.3 + 120 * 1.6 * 10^{-4} * 45 * 0.5)}}$$

$d = 1.50\, m$

Emptying time

Determine the emptying time (T):

$$T = -\left(\frac{4.6d}{4k_h}\right) log_{10}\left(\frac{\frac{d}{4}}{H + \left(\frac{d}{4}\right)}\right)$$

$$T = -10781 * -0.8533$$

$$T = 9199\ seconds$$

$$T = 2\ hours\ 33\ minutes$$

The acceptable maximum emptying time for a two year ARI event (0.5 EY event) is one day (Table 5) of the Infiltration Basins and Trenches BMP), therefore the soakwell design is suitable.

References and further reading

Argue, J. R. (Editor) 2004, *Water Sensitive Urban Design*: *basic procedures for 'source control' of stormwater – a handbook for Australian practice*, Urban Water Resources Centre, University of South Australia, Adelaide, South Australia, in collaboration with Stormwater Industry Association and Australian Water Association.

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