# 3. Selection and design of stormwater devices

In this section:



Where this guideline recommends a procedure, the following format is used:

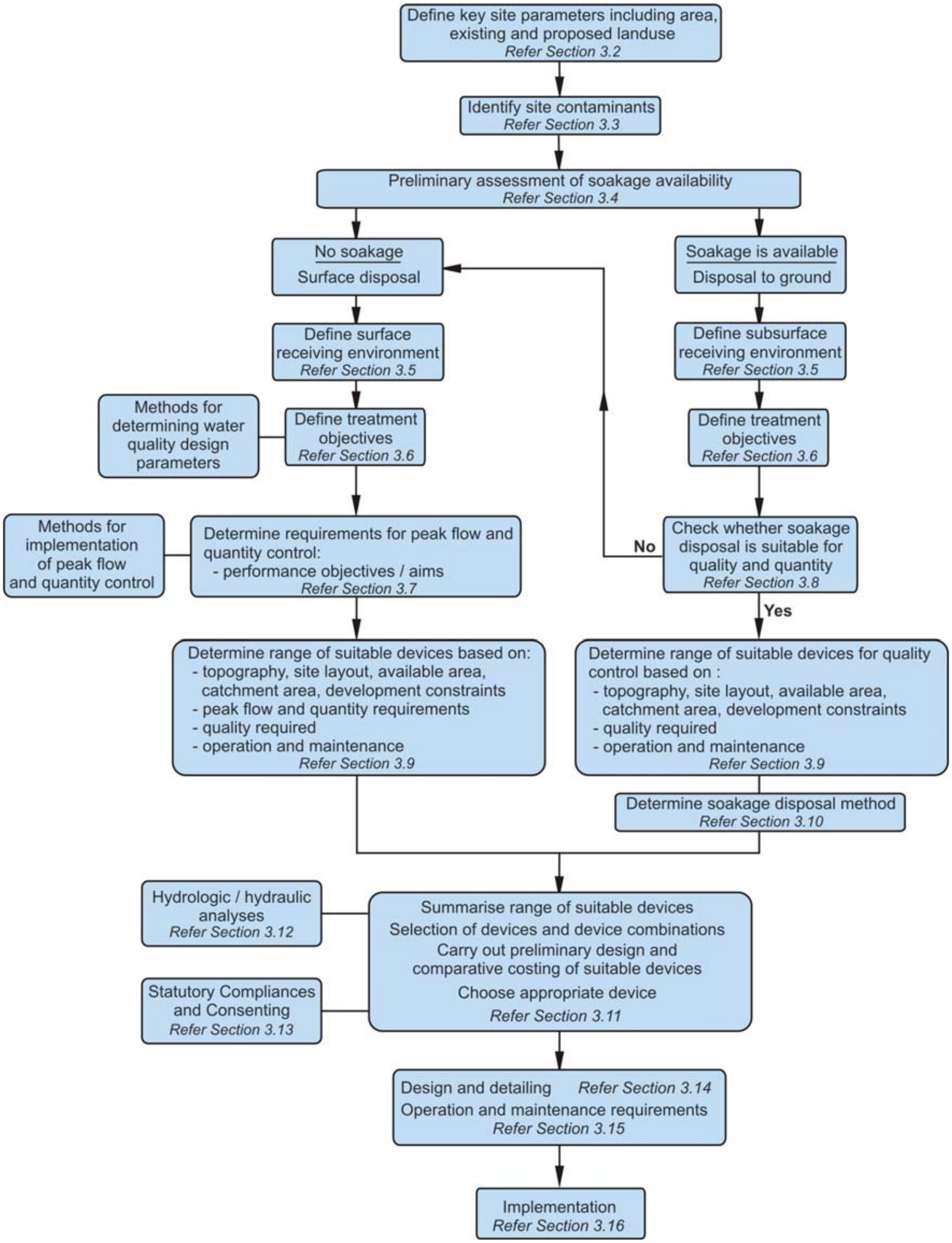
RECOMMENDATIONS

**Relevant steps in bold font**

Where particular caution needs to be exercised, the following format is used:

Cautionary advice is given in a box next to a red flag.

# Figure 3.1 Selecting and designing on-site stormwater management devices



## 3.1 Overview of this section

The primary focus of these guidelines is on stormwater management devices to provide:

- water quality treatment with final disposal to surface water or to ground soakage or infiltration
- peak flow and quantity reduction for sites where final disposal is to surface water

There will be some situations where primary disposal is to ground soakage and secondary or larger flows disposed to surface water.

The structure of this section reflects the separate ground or ground soakage disposal options by:

- describing the treatment performance of stormwater quality treatment devices where final disposal may be to surface water or ground soakage, depending on the site conditions, as addressed in this section
- a separate discussion of devices that dispose stormwater to ground soakage

Before or during the processes in this section, it is necessary to assess whether on-site stormwater management is appropriate for a particular site, in comparison, for example, with catchment or neighbourhood based management approaches or devices (refer Sections 1.6 and 1.8).

The generic process for selection and design of on-site stormwater treatment devices is shown in Figure 3.1, on the previous page. The process follows a logical progression:

- site description: defining key parameters
- identifying site contaminants
- preliminary assessment of soakage availability
- defining the receiving environment
- determining stormwater quality objectives
- confirming the suitability of soakage and describing soakage disposal methods
- determining requirements for peak flow and/or quantity control
- identifying a range of suitable devices
- developing options using a variety of devices
- preliminary design of and comparative costing of suitable devices
- selecting appropriate devices
- detailed design of devices and operation and maintenance (O&M) requirements

> The selection process includes a decision step early in the process to address whether or not on-site soakage is a viable disposal option. This is important because although ground disposal can potentially avoid the many design steps needed to prevent adverse effects of stormwater on surface receiving environments, ground disposal systems do not suit many soils, geological and topographical conditions.

The detailed procedures in each step in the decision process are described next.

## 3.2 Define key site parameters

In this subsection:
- site area
- land use
- slopes
- soil type
- natural site features
    - streams
    - bush
    - heritage

### 3.2.1 Area and land use

Site parameters that determine the stormwater characteristics of stormwater runoff from the site include:

- total site area
- impervious site area (roof and on-ground)
- pervious area and cover type (for use in later run-off calculations)
- land use

Land use categories with impervious areas include:

- urban (high density) residential, commercial and industrial sites
- suburban (low density) residential, commercial and industrial sites
- rural residential, commercial and industrial sites
- subsections of the above including:
    - car parks
    - access drives
    - roads
    - storage or loading areas – specify the type of operation and types of materials handled or stored, e.g. fuel dispensing facilities, above-ground storage of liquid materials, solid waste storage areas, containers, compactors, storage of compost or fertiliser, storage of treated timber. This information will indicate expected contaminants in stormwater

### 3.2.2 Site slopes

Determine the slope of the catchment areas that contribute to proposed on-site devices. This is used to calculate the time of concentration used in calculation of runoff flow rates.

Determine the slope of land at the likely device location. This may affect the types of devices that can be used or to slope stability issues that might affect the disposal method.

### 3.2.3 Soil type

Determine the type of soil in the catchment areas that contribute to proposed on-site devices. This is used to assess appropriate factors used in calculation of runoff flow rates. Soil type generally will not have major relevance to assessment of treatment requirements, as this guideline assumes site stabilisation has been completed and sediment from bare soil will not provide major inputs to treatment devices.

Determine the type of soil at the likely device location. This may be relevant to the types of devices that can be used or to slope stability issues that might affect the disposal method and to assist with assessment of soakage availability for disposal.

The type and design of the mechanism for final disposal of site stormwater to surface water should take into account soil type and prevention of erosion. This aspect is beyond the scope of this guideline.

### 3.2.4 Natural site features

Important natural site features should be noted and marked on a site plan. These will include but not necessarily be limited to:

- streams
- bush areas
- heritage such as areas of archaeological significance

The development of stormwater management options for a site should include consideration of the natural site features and protection and enhancement of them if practicable.

## 3.3 Identify contaminants in stormwater from the site

In this subsection:

- a general guide to contaminants in stormwater from various site land uses
- a guide to contaminants in stormwater from specific industry types

The nature and form of contaminants in stormwater runoff from urbanised or developed sites is complex. These guidelines do not provide a detailed description of contaminants. The user is referred to other references for a detailed description, including:

- Williamson, 1986, *Urban Runoff Data Book: a Manual for the Preliminary Evaluation of Urban Stormwater impacts on Water Quality*, NIWA Water Quality Centre Publication No. 20
- Auckland Regional Council, 2003, *Stormwater Treatment Devices: Design Guideline Manual*, ARC Technical Publication No. 10 (ARC TP10)
- Auckland Regional Council, 1995, *The Environmental Impacts of Stormwater Runoff*, ARC Technical Publication No. 53 (ARC TP53)
- Christchurch City Council, 2003, *Waterways, Wetlands and Drainage Guide*, (CCC 2003)
- Transfund New Zealand Research Report No. 228 (2002), *see references*

Table 3.1 is a general guide to contaminants in stormwater from various site land uses.

Table 3.2 is a guide to contaminants in stormwater from specific industry types. It lists industries where typical practices include activities on uncovered areas that can lead to contaminants being entrained in stormwater. The list is not exhaustive and may not include some industries where stormwater contamination may regularly occur. On some industrial sites potential accidental spillage of product could lead to stormwater contamination. The list contains some activities for which the water discharges are more properly described as wastewater, for example car washing, steam cleaning and water blasting. Such discharges may require appropriate separate treatment or discharge to a sewer, subject to the appropriate approvals.

At this stage of the site stormwater management selection process it is important to investigate possible **source control** measures that can be carried out to reduce or prevent contaminants entering stormwater. If this can be achieved it removes the need to provide treatment for those contaminants.

Common examples where source control is likely to be a more appropriate option than providing treatment of stormwater practice are:

- painting galvanised iron roofs to prevent zinc entering stormwater
- avoiding the use of copper roofing and guttering materials and those incorporating permanently exposed zinc coated surfaces
- covering stockpiles of soil or waste products on industrial sites
- directing wash water to the sanitary sewer
- covering dirty work areas such as truck washes

# Table 3.1 General guide to contaminants in stormwater

Source: ARC TP10

| Land use | Contaminant (refer key below for abbreviations) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **pH** | **SS** | **HC** | **ME** | **OD** | **NU** | **PA** | **TO** | **LI** |
| Residential roofs | ✓ | ? | | ✓? | ✓? | ✓? | ? | | |
| Residential: paved, parking driveways | | ✓ | ✓ | ✓ | ✓? | ✓ | ✓ | | ✓ |
| Residential grassed areas | | ✓? | | | ✓ | ✓ | ✓ | | ✓ |
| Roads and road berms | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Commercial: roofs | ✓ | ? | | ✓? | ? | ? | ? | | |
| Commercial: paved, parking, driveways, yards | | ✓ | ✓ | ✓ | ✓? | ? | ✓ | ? | ✓ |
| Commercial landscaped, grassed areas | | ✓? | | | ✓? | ✓ | ✓ | | ✓ |
| Industrial: roofs | ✓ | | | ✓? | ? | ? | ? | | |
| Industrial: paved, parking driveways, yards | ? | ✓ | ✓ | ✓ | ✓? | ? | ? | ? | ✓ |
| Water blasting | | ✓ | | ✓? | ✓? | | | | |
| House painting | | ✓ | | | ✓? | | | | |

Key to abbreviations of contaminants:

pH power of hydrogen
SS suspended solids
HC hydrocarbons, including TPH and PAHs
ME heavy metals (lead, zinc and copper)
OD oxygen demanding substances (generally particulate organic matter)
NU nutrients (nitrogen and phosphorus)
PA pathogens including bacteria
TO toxic organics, including for example antisapstain chemicals on timber treatment sites, chlorinated hydrocarbons and other toxic chemicals used on industrial sites
LI litter
? uncertain, dependant on land use activities, e.g. type of industrial activities and material e.g. type of roof material

Note that for residential roofs the contaminants of concern can generally be addressed by source control measures, for example avoiding bare zinc or copper surfaces and regular cleaning of gutters to prevent accumulation of organic material. Such source control practices can avoid the need for treatment. Similar source control measures may be appropriate for roofs in or near industrial and commercial sites. However accumulation of atmospheric emissions from industry need to be considered when addressing potential contaminants in roof water.

It is important to determine whether the following contaminants in stormwater are attached to sediment, i.e. are in particulate or soluble form, as this will influence the selection of the appropriate treatment device and / or treatment media:

- hydrocarbons
- metals
- toxic organics

## Table 3.2 Industry activity and associated contaminants

Sources: ARC TP10; Environment Waikato Proposed Regional Plan, Appeals version 2002

| **Industry / activity** | **Contaminant (refer key below for abbreviations)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **pH** | **SS** | **HC** | **ME** | **OD** | **NU** | **PA** | **TO** | **LI** |
| Mechanical workshops, service stations, refuelling areas | | ✓ | ✓ | ✓ | | | | ? | |
| Spray painting facilities spray drift | | | | | | | | ✓ | |
| Wood preserving outside storage of timber | | ✓ | ✓ | ✓ | ✓ | | | ? | |
| Agricultural chemicals, fertilisers-outside storage | | ✓ | | ✓ | ✓ | ✓ | | ? | |
| Asphalt, paving and roofing materials | | ✓ | ✓ | ✓ | ✓ | | | ? | |
| Concrete products yard activities | ✓ | ✓ | | ✓ | ✓ | | | | |
| Iron steel lead foundries yard areas | ✓ | ✓ | | ✓ | ✓ | | | | |
| Waste management sites transfer stations, landfills, composting | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Automobile dismantler yards-yard | | ✓ | ✓ | ✓ | | | | ? | ✓ |
| Scrap recycling yards | | ✓ | | ✓ | ✓ | | | ? | ✓ |
| Bakeries with outside washing of trays etc. | | | | ✓ | ✓ | ✓ | ✓ | | |
| Furniture / wood manufacturing and refinishing – outside activities sawdust | ✓ | ✓ | | | ✓ | | | | |
| Car wash and valet | | ✓ | ✓ | ✓ | ✓ | | | | |
| Steam cleaning | | ✓ | ✓ | | ✓ | | | | |
| Stock sale yards | | ✓ | | | ✓ | ✓ | ✓ | ✓ | |

Key to abbreviations of contaminants:

pH power of hydrogen
SS suspended solids
HC hydrocarbons, including TPH and PAHs
ME heavy metals (lead, zinc and copper)
OD oxygen demanding substances (generally particulate organic matter)
NU nutrients (nitrogen and phosphorus)
PA pathogens including bacteria
TO toxic organics, including for example antisapstain chemicals on timber treatment sites, chlorinated hydrocarbons and other toxic chemicals used on industrial sites
LI litter
? uncertain, dependant on land use activities, e.g. type of industrial activities and material e.g. type of roof material

# 3.4 Preliminary assessment of soakage availability

In this subsection:

- assessing geological conditions
- identifying suitable subsurface materials
- preliminary assessment of slope stability considerations

A preliminary assessment determines whether disposal of stormwater by soakage is likely to be possible. This procedure is relevant for sites where preliminary analysis indicates that all or a significant proportion of site stormwater can be disposed to ground soakage via specially designed devices. It does not assess the viability of utilising existing vegetation or the potential for planting additional vegetation to counteract the effects of increased impervious areas on other parts of a site (low impact development principles). Soakage disposal via on-site devices can be used in conjunction with vegetation retention or augmentation if conditions are suitable.

## 3.4.1 Assess hydrogeological conditions

A depth of at least 3 metres of permeable subsurface material is required for good long term soakage. Suitable permeable material may be at some depth below shallow impermeable material. This assessment can be based on the following sources:

- local knowledge of subsurface conditions and performance of existing stormwater soakage systems, for example from adjacent landowners, drainage contractors, builders, well drillers
- geological maps
- information held by territorial councils and available from LIMs
- information held by regional or unitary councils
- land use capability information held by other organisations such as Landcare Research
- preliminary field investigation such as boreholes or excavated pits

Suitable subsurface material for ground disposal of stormwater by soakage is likely to be one or a mix of the following:

- sand (some clay, silt or loam content may be acceptable)
- gravel
- fractured rock for example basalt
- scoriaceous material
- pumice
- limestone - sink holes, karst terrain (care needed to use these for disposal, consult with the regional council)

The base of soakage devices should be a minimum of 600 mm above the seasonal high water table (Georgia Stormwater, 2001).

- soakage disposal may be viable in permeable soils that are overlain by surface soils that are of low permeability
- soakage disposal should not be used at sites that are known or suspected to be contaminated and there is a risk of such contamination entering stormwater or leaching to groundwater
- soakage disposal should not be to areas of fill material unless sufficient investigation has been carried out to determine that long term disposal by soakage is viable and effects on land stability have been addressed
- valley floors or other areas that may have significant groundwater inflows should not be used for soakage disposal
- the presence of a water supply or high quality underlying aquifer may affect suitability , or influence the design details, particularly for industrial sites (see below)

### 3.4.2 Preliminary assessment of site stability

Slopes and soils are the key indicators of likely stability:

- ARC TP10 recommends that infiltration practices shall not be constructed on slopes exceeding 15%
- University of Technology Sydney SWITCH design (2001) states:
  - stormwater infiltration is a type of on-site retention (OSR)
  - British practice places a limit of 5% on the land-slope where water retention is recommended. This is less slope-dependant and more related to the soil/rock conditions likely to be encountered in steep terrain
  - a simple guideline is that a depth of suitable soil of at least 3m should be available throughout a downslope developed hillside before on-site retention should be contemplated

RECOMMENDATION

**This guideline recommends that infiltration or soakage practices should not be considered on or adjacent to slopes steeper than 5%, without detailed geotechnical investigations that establish their viability.**

### 3.4.3 Summary of preliminary assessment of soakage availability

The main preliminary assessment criteria are:

- local experience - is it successfully carried out nearby and under similar conditions?
- subsurface soils of sufficient permeability
- sufficient depth to water table
- no risk of slope instability due to infiltration of stormwater
- risk of subsurface contamination: for commercial or industrial sites where soakage disposal would be to an aquifer of high quality groundwater, soakage disposal may not be desirable due to risks of contamination from contaminated runoff or spills of toxic substances

Stormwater soakage disposal has been used in various areas of New Zealand in silt or clay subsoils, despite the fact that their limited permeability generally allows only partial disposal of site stormwater. Although such disposal may be of limited environmental benefit for groundwater recharge, for the purposes of this guideline stormwater disposal to silt or clay soils is not considered viable for long term disposal of site stormwater.

## 3.5 Define receiving environment and determine sensitivity to contaminants

In this subsection:

- assessing receiving environment sensitivity to contaminants in stormwater:
  - contaminants of concern for surface water
  - sensitivity of types of groundwater to contaminants
- determining the water quality objectives for stormwater quality management (or the degree of treatment required for site stormwater)

The first step in assessing the sensitivity of the receiving environment to contaminants is to clearly define the receiving environment, including:

- surface waters:
  - immediate receiving environment: watercourse, channel or stream immediately below the site
  - ultimate receiving environment: estuary, lake or coastal marine area the site discharges will eventually enter
- reticulated outfall point: where site stormwater discharges to a reticulated system, the receiving environment will be:
  - where the pipe reticulation discharges and
  - downstream of that point
- ground soakage: the aquifer or subsurface material

Check the site land use and site areas determined in section 3.1 against the following documents for any specific comments about the sensitivity of the receiving environment in relation to physical location and land use:

- regional policy statement
- regional plan
- district plan
- any relevant catchment management plans or structure plans
- relevant reports on the receiving environment (ARC TP10 and TP53 are good references on the environmental effects of urban stormwater runoff)
- national or other strategies for example the low impact urban design guidelines

Also check with appropriate regional council staff, unitary council staff or territorial authority staff and pipe network utility operator where relevant, about the particular aspects of the receiving environment and any requirements for stormwater quality control.

### 3.5.1 Surface water sensitivity

It is important to identify the key contaminant/s of concern so as to ensure use of the appropriate devices. These vary widely, for example (Greg Paterson, pers. comm. May 2004):

- nutrients affecting eelgrass beds off the Florida coast
- hypodermic syringes on Sydney beaches
- zinc in Auckland

The contaminants of concern in stormwater for surface water receiving environments are listed in Table 3.3.

## Table 3.3 Indicative stormwater contaminants of concern for surface water

| Description of receiving environment / values | | | | | |
|---|---|---|---|---|---|
| **Stream, river, or lake used for water supply** | **Stream, river or lake used for fishing** | **Stream, river, lake: potential nutrient enrichment concern** | **Estuary: Sediment accumulation and shellfish** | **Used for contact recreation** | **Visual and other amenity values** |
| pH | pH | | pH | | |
| SS | SS | SS | SS | SS | SS |
| HC | HC | HC | HC | HC | HC |
| ME | ME | ME | ME | ME | |
| OD | OD | | | OD | OD |
| NU | | NU | | | |
| PA | PA | | PA | PA | |
| TO | TO | TO | TO | TO | |
| | | | | LI | LI |

Key to abbreviations of contaminants:

pH power of hydrogen
SS suspended solids
HC hydrocarbons, including TPH and PAHs
ME heavy metals (lead, zinc and copper)
OD oxygen demanding substances (generally particulate organic matter)
NU nutrients (nitrogen and phosphorus)
PA pathogens including bacteria
TO toxic organics, including for example antisapstain chemicals on timber treatment sites, chlorinated hydrocarbons and other toxic chemicals used on industrial sites
LI litter

### 3.5.2 Sensitivity of types of groundwater to contaminants

For the purposes of these guidelines the following categories of groundwater are considered to be sensitive to contamination from stormwater (others may also do so, depending on the local situation):

- currently or potentially used for water supply
- shallow groundwater discharging to a surface water body used for water supply
- shallow groundwater discharging to a river, lake or stream where there is concern about nutrient enrichment

## Table 3.4 Indicative stormwater contaminants of concern for groundwater

Note: it is assumed that all stormwater discharged to groundwater has been treated to reduce suspended solids to low levels to avoid clogging of the disposal system. The suspended solid constituent in itself is thus not a contaminant of concern to the receiving environment.

Identification of the contaminants of concern has been made from general literature reviews and these sources have not been specifically referenced (see list of references).

| **Description of groundwater** | | | |
|---|---|---|---|
| **Currently or potentially used for water supply** | **Shallow groundwater discharging to a surface water body used for water supply** | **Shallow groundwater discharging to a river, lake or stream where there is concern about aquatic health** | **Shallow groundwater discharging to a river, lake or stream where there is concern about nutrient enrichment** |
| pH | pH | pH | |
| HC | HC | HC | |
| ME | ME | ME | |
| OD? | | OD | |
| | | NU | NU |
| PA | PA | PA | |
| TO | TO | TO | |

Key to abbreviations of contaminants:

| | |
|---|---|
| pH | power of hydrogen |
| SS | suspended solids |
| HC | hydrocarbons, including TPH and PAHs |
| ME | heavy metals (lead, zinc and copper) |
| OD | oxygen demanding substances (generally particulate organic matter) |
| NU | nutrients (nitrogen and phosphorus) |
| PA | pathogens including bacteria |
| TO | toxic organics, including for example antisapstain chemicals on timber treatment sites, chlorinated hydrocarbons and other toxic chemicals used on industrial sites |
| LI | litter |

## 3.6 Determine water quality objectives for stormwater quality management

In this subsection:

- setting allowable discharge concentrations
- best practical option (BPO) or best management practice (BMP)
- BPO design approaches
  - description of stormwater quality volume
  - removal of a specific proportion of the total suspended solids on a long-term basis
  - calculation of water quality design storm and water quality volume
  - capture and treatment of the first flush
  - recommendations for using a water quality volume approach
- recommended procedure to determine stormwater quality design flows
  - device assessment and sizing for water quality treatment
  - summary of recommended BPO / BMP approach for water quality design parameters for these guidelines

**Water quality objectives determine the degree of stormwater treatment required.** There are two alternative generic approaches to determining the water quality objectives for stormwater quality management:

- setting allowable discharge concentrations
- best practical option (BPO) or best management practice (BMP)

In stormwater management the instantaneous discharge quality can be important, together with the cumulative effects of discharges of contaminants where contaminants accumulate at particular locations.

### 3.6.1 Setting allowable discharge concentrations

Allowable concentrations in stormwater of contaminants of concern are typically based on:

- available water quality guidelines
- regional plan rules
- detailed site specific assessment
- resource consent conditions

Setting discharge concentrations for stormwater is often not appropriate because of:

- lack of information on allowable concentrations
- the difficulty of setting appropriate allowable concentrations due to variations in receiving environments and the need to address cumulative effects
- the difficulty of representative sampling of runoff events to ensure compliance with concentration limits

Environmental exposure limits (EELs) have been established under the Hazardous Substances and New Organisms Act 1996 (HSNO) for a number of hazardous substances. They establish a conservative environmental guideline for the receiving environment after mixing and are available from http://www.ermanz.govt.nz/hs/hs-comp-eels.asp .

The use and adoption of EELs under the RMA is currently under review by the Environmental Risk Management Authority (ERMA) and the Ministry for the Environment. For industrial and commercial sites where toxic organic or other substances for which EELs have been established under HSNO may enter stormwater, setting of an allowable discharge concentrations in stormwater discharges may be appropriate.

### 3.6.2 Best practical option or best management practice

The definition of best practical option (BPO) in the RMA for discharge of contaminants is the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to:

- the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and
- the financial implications, and the effects on the environment, of that option when compared with other options; and
- the current state of technical knowledge and the likelihood that the option can be successfully applied

The BPO approach is generally considered appropriate for treatment of stormwater discharges because of the:

- impracticality and expense of carrying out detailed site specific assessments to set allowable concentrations for site stormwater discharges
- difficulty of representative sampling of runoff events to ensure compliance with concentration limits
- it provides greater certainty of treatment requirements for consent applications and of outcomes for environmental regulators

#### 3.6.2.1 BPO approach for water quality

The BPO approach can be either regional or site specific:

- regional or city-wide
    - a region wide study is carried out to determine appropriate sizing of various devices relative to performance, rainfall characteristics, soils etc. and the regulator then sets regional standards and requires these to be met. For example water quality volume (WQV)
    - the stormwater practitioner/designer uses regional standards to calculate water quality volume and size and design the device
- site specific (where there is no regional or city-wide guideline)

The stormwater practitioner / designer:

- assesses a range of device sizes using local rainfall data and soil / contaminant characteristics
- selects a suitable size of device based on balancing cost versus performance
- the ideal analysis method is continuous series analysis and accumulated volumes of contaminants removed and discharged

### 3.6.2.2 Auckland Regional Council approach

The ARC approach is to capture 75% of total suspended sediment on a long term average basis. This is the water quality objective of ARC TP 10 and is also the treatment objective of a number of overseas agencies (Seyb, 2001, *A revised stormwater treatment design methodology for the new TP10*, 2nd South Pacific Stormwater Conference 2001**).**

The water quality design storm for the ARC method has been developed from detailed analysis of long term rainfall records at one rain gauge, which yielded a water quality design storm depth of 25 mm, equivalent to one third of the 2 year ARI daily rainfall at this location. The ARC method provides for the water quality design storm to be calculated for any location in the region by dividing the 2 year ARI daily rainfall at that location by a factor of 3. For the Auckland region the water quality design storm depths are:

- range over the Auckland region: from 16.7mm to 43.3 mm
- most of the urbanised area: 26.7 mm

The ARC method provides for using the water quality design storm together with catchment physical characteristics to calculate a 'water quality volume' for the catchment area contributing to a device. This method is calculated in TP108 (Auckland Regional Council, 1999, *Guidelines for stormwater runoff modelling in the Auckland region*, ARC Technical Publication No. 108) using the US Soil Conservation Service rainfall-runoff model, based largely on its Technical Release No. 55 (SCS 1986). The model takes into account rainfall losses based on ground cover and soil type. It also allows calculation of peak flows taking into account rainfall temporal pattern. Peak flows associated with the water quality design storm can be calculated for use in design of devices such as swales.

ARC TP10 then stipulates in its design methodology for different devices:

- the proportion of the WQV to be captured for ponds, wetlands, filters, rain gardens
- a nominated hydraulic retention time for the water quality flow rate for swales

### 3.6.2.3 Christchurch City Council approach

CCC (2003) states that:

- the principle of first flush capture should be used to treat stormwater from hard standing areas
- care should be exercised in considering stormwater runoff that has high concentrations of dissolved metals
- any dissolved contaminants that have particulate forms (e.g. metals), don't always show a first flush effect because their concentrations usually depend simply on the presence, not the amount, of their particulate forms
- for particulate contaminants in small stormwater catchments, the first flush effect will usually be pronounced
- if a treatment system can be constructed close to a stormwater source , only the first flush need be captured and treated
- the critical component of the first flush system is the bypass for stormwater in excess of the first flush volume

Environment Canterbury consent CR C000315 (granted to the Christchurch City Council for green fields development in the Upper Heathcote / Wigram area) requires capture and treatment of the first 12.5 mm of all rainfall events prior to discharge to ground. This first flush interception will achieve treatment of 58% of the Christchurch average annual rainfall depth falling on the recipient catchment.
A suggested requirement within Environment Canterbury's Draft Canterbury Natural Resources Regional Plan (2002) is for first flush to be considered as the first 15 mm of all rainfall events

followed by 72 hours detention prior to discharge to surface water. Christchurch City Council recommends as best practice the capture of runoff from the first 25 mm of storm rainfall depth, but not less than 15 mm. average detention time prior to discharge to surface waters should be at least 24 hours. To be effective in treating dissolved pollutants, detention time in wetlands and wet ponds should be longer.

The CCC (2003) method uses average effective impervious area percentages based on land use zonings to calculate first flush volumes. The CCC (2003) first flush method is limited to the design of ponds and wetlands. For design of swales it refers to ARC TP10.

#### 3.6.2.4 Review of water quality volume and first flush approaches and applicability New Zealand wide

The ARC and Christchurch City Council (CCC 2003) approaches of water quality design storm and first flush rainfall are similar to each other and comparable with many overseas stormwater quality best management approaches.

As detailed modeling to assess water quality rainfalls and appropriate proportions of the water quality volume to be captured for various devices has not been carried out regionally in all areas of New Zealand a simplistic approach has been taken to determine approximate water quality rainfalls throughout New Zealand.

This has comprised a review of the 2 year ARI daily rainfalls for representative areas throughout New Zealand using HIRDS.

The results are in Table 3.5 and show that for the locations listed in Table 3.5, the New Zealand-wide range is reasonably similar to the range within the Auckland area. The Christchurch City value of 18.8 mm for the one third of the 2 year daily rainfall depth is above the minimum depth of 15 mm, but less than the best practice value of 25 mm of the Christchurch City Council’s recommended method for runoff capture (CCC, 2003).

## Table 3.5 Summary of one third of 2 year 24 hour rainfalls at selected locations

| **Location** | **One third of 2 year 24 hour rainfall (Calculated from HIRDS) (mm)** |
|---|---|
| Kaitaia | 28.9 |
| Whangarei | 37.4 |
| Auckland region | Range: 16.7mm to 43.3 mm<br>Most of urbanised area: 26.7 |
| Hamilton | 20.8 |
| Tauranga | 33.4 |
| Taupo | 24.3 |
| Gisborne | 32.6 |
| Napier | 25.3 |
| New Plymouth | 30.8 |
| Palmerston North | 17.2 |
| Wellington | 24.4 |
| Nelson City | 23.8 |
| Westport | 33.7 |
| Blenheim township | 20.3 |
| Hokitika | 42.1 |
| Christchurch City | 18.8 |
| Queenstown | 19.3 |
| Dunedin | 20.7 |
| Invercargill | 15.0 |

These values are indicative only, for the purposes of a general review of variation throughout New Zealand. There can be considerable local variation in rainfall. Use of HIRDS or equivalent or other relevant locally derived data is recommended to establish site specific values.

### 3.6.3 Recommendations for using a BPO approach for determining water quality volume

Water quality volume determination requires assessment of a water quality design storm followed by determination of the water quality volume.

RECOMMENDATIONS

**For these guidelines it is recommended that in the absence of detailed local or regional analyses to determine water quality design storms the approximate water quality design storm be assessed by dividing the 2 year ARI 24 hour rainfall by a factor of 3. The 2 year ARI 24 hour rainfall data can be derived from analysis of local rainfall data or using HIRDS. This approach is relatively simplistic and must be used with caution. In particular:**

- **it should be used only for devices serving small catchments so that any inaccuracies in rainfall depths and associated water quality volumes does not have a significant impact on sizing and device cost**
- **for larger catchments or for individual devices with significant capital cost, more detailed analyses of rainfall records and device performance are likely to be appropriate**

**It is recommended that territorial local authorities, unitary councils and regional councils arrange for analysis of local rainfall records and other aspects of treatment devices to arrive at accurate local or regional quality design storms. Local rainfall data may be available from a regional council, the Meteorological Service or NIWA.**

The methods currently recommended in other New Zealand guidelines for determining the water quality volume, i.e. runoff to a device from a water quality rainstorm, are:

- ARC TP10: rainfall-runoff curves, with curve numbers determined by soil types. This is based on the US Department of Agriculture, Soil Conservation Service publication, Urban hydrology for small watersheds, Technical Release No.55 (SCS 1986). This method is described for use in the Auckland region in ARC TP 108, Guidelines for stormwater runoff modeling in the Auckland region
- a simplified method such as in Christchurch City Council (CCC 2003) in which catchment percent effective impervious areas are estimated from land use and runoff is assumed to be generated only from impervious areas

RECOMMENDATIONS

**For this guideline, for areas outside the Auckland Regional Council and Christchurch City areas, the following method is recommended:**

1. **Determine impervious and pervious contributing areas draining to a device. Note that for device water quality design purposes, the amount of pervious area contributing to the device often is relatively small or zero. This will not be the case where there are specific concerns about the effect of contaminants from pervious areas e.g. nutrients and treatment of runoff from pervious areas is required.**
2. **For impervious areas: runoff depth = water quality design storm depth less an allowance for depression storage: an allowance of 2 mm is recommended, unless site conditions give reason to allow a different amount.**
3. **For pervious areas: runoff depth = water quality design storm depth less an allowance for depression storage and infiltration into the ground:**
    - **the allowance for depression storage and infiltration into the ground will depend mainly on the subsoil drainage**
    - **for poorly drained subsoils: for example sandstone, siltstone, other fine grained slowly draining soils: an allowance for depression storage and infiltration into the**

**ground of 15 mm is recommended unless site conditions and / or local knowledge give reason to allow a different amount**

- **for well drained soils, for example pervious volcanic ash soils, the user is advised to carefully evaluate likely depression storage and infiltration based on the site conditions (topography and soil infiltration) as well as the amount of pervious area contributing to a device and whether all the design rainfall could be stored or would infiltrate. The allowance for depression storage and infiltration is recommended to be between 15 mm and the water quality design depth, based on the site assessment. Note that for sites where there are small amounts of contributing pervious area compared with impervious areas, the accuracy of the allowance for likely depression storage and infiltration will not be important**

### 3.6.4 Recommendations for using a BPO approach for determining stormwater quality design flows

Some devices such as swales and filter strips require calculation of a water quality design flow. ARC TP10 recommends that water quality design flows are calculated using the method of ARC TP108. For Christchurch City, CCC (2003) recommends the method of ARC TP10 also. This method uses rainfall data and other hydrological relationships and can be used anywhere, subject to parameter calibration for that region. For the Auckland region, swale and filter strip design assumes the time of concentration is 10 minutes. The design rainfall intensity is obtained by multiplying the water quality storm depth (mm) by a factor of 0.675 to obtain the relevant rainfall intensity (for a time of concentration of 10 minutes) in mm per hour.

RECOMMENDATIONS

**For this guideline it is recommended that, for areas outside Auckland where the method of ARC TP108 has not been calibrated for local conditions, water quality design flows be calculated using standard hydrological methods such as the rational method, using the local rainfall intensity for one third of the 2 year 10 minute rainfall.**

### 3.6.5 Summary of recommended procedure to determine water quality treatment objectives and water quality design parameters

RECOMMENDATIONS

1. **Identify site contaminants from Section 3.3, noting that this assessment should include incorporation of source control where appropriate**
2. **Define receiving environment and contaminants of concern, refer section 3.5**
3. **Compare contaminants of concern with the contaminants from the site and determine list of contaminants that require treatment**
4. **Decide on appropriate water quality objective procedure for each contaminant of concern. This could be one or more or a combination of the following:**
    - **determine allowable concentrations, if feasible and practical. This is generally unlikely to be practical for small sites or for general urban areas but may be appropriate for large (over 1 ha) commercial sites or for industrial sites that discharge to a sensitive environment**
    - **BPO / BMP approach. This is likely to be the preferred approach at present for most situations in New Zealand**
5. **Tabulate the contaminants that require treatment and the treatment aim, taking into account potential upper limit treatment efficiencies to be achieved by BPO/BMP devices (refer Table 3.6)**

**6. Calculate water quality volumes using section 3.6.3**

**7. Calculate water quality peak flows using Section 3.6.4**

## Table 3.6 Potential upper limit treatment efficiencies

Source: ARC TP10; Christchurch City Council (2003)

Note: These are likely upper limit efficiencies that can be provided by treatment devices assuming a BPO water quality approach. Detailed discussions of the contaminant removal efficiency of treatment devices are in ARC TP10 and CCC (2003)

| Contaminant | | Removal efficiency | Comment |
|---|---|---|---|
| pH | | Not applicable | |
| SS | suspended solids | max 80% | |
| HC | hydrocarbons, totals | max 80% | most reported data is for removal achieved where the contaminant is predominantly in the particulate form |
| HC | hydrocarbons, soluble | | little data |
| ME | trace metals, totals | max 80% | most reported data is for removal achieved where the contaminant is predominantly in the particulate form |
| ME | trace metals, soluble | | little data |
| OD | oxygen demanding | max 60% | |
| NU | nutrients (nitrogen ) | max 60% | |
| NU | phosphorus | max 80% | |
| PA | pathogens including bacteria | max 100% | For bacteria, little data on other pathogens |
| TC | toxic chemicals | | extremely variable, depending on the contaminant, little data available |
| LI | litter | not applicable | |

At this stage, if contaminants of concern cannot be reduced to concentrations to be acceptable for the receiving environment, a BMP may not be suitable and other practices may be required.

Example: an industrial site with organic toxics from stockpiles of raw materials or product. If final discharge is to a groundwater system used nearby for drinking water or stock water use care needs to be taken. A management option would be to cover stockpiles to prevent contaminants reaching stormwater (source control). If the stockpile is not covered, treatment devices based on a BPO approach may not provide enough treatment. A concentration based water quality objective may then be needed, or it may be decided that final disposal to groundwater is not appropriate.

For sites where there may be spillage of toxic organic substances that could reach the stormwater disposal system, disposal to groundwater may not be appropriate.

For hydrocarbons, trace metals and toxic chemicals, it is necessary to determine whether they are in the particulate or dissolved form, as this will affect the choice of an appropriate device for treatment. Particulates mean that contaminants are attached to suspended solids and can be removed by devices that remove suspended solids, while dissolved means that contaminants are in the soluble form and require specific treatment such as bioretention.

### 3.6.6 Device assessment and sizing for water quality treatment

The assessment of suitable devices for achievement of water quality objectives is presented in section 3.9. Procedures for designing and sizing a range of commonly devices to meet water quality objectives are presented in section 4 on a device by device basis. Guideline notes with references to suitable design methods for devices not covered in detail in Section 4 are presented in section 5.

## 3.7 Requirements for peak flow and quantity control and performance requirements / aims

In this subsection:

- flood protection
- stream channel protection
- recommended procedure for determining the need for and type of stream channel protection measures

### 3.7.1 General

For the purposes of this guideline, flow and quantity control by devices may be required where either flood control or stream channel protection is needed downstream.

This section does not address disposal of stormwater by infiltration, which is covered in sections 3.8 and 3.10. It also does not address low stream flow augmentation in detail although some devices used for quantity control will provide this.

Two terms for flood probability are used in this guideline; average recurrence interval (ARI) and annual exceedence probability (AEP). ARI is the average period between exceedences of a given discharge and is generally used in this guideline for discussion of larger flood events such as 10 or 100 year events. AEP is the probability of exceedence of a given discharge within a period of one year and is generally used in this guideline as a percentage. The relationship between AEP and ARI is illustrated by the following examples:

- 1 % AEP = 100 year ARI
- 10% AEP = 10 year ARI
- 50% AEP = 2 year ARI

### 3.7.2 Flood protection

Flood protection is needed where the increase in peak flood flows and levels downstream of the site that have arisen or can be expected to arise from increases in impermeable areas on the site are reduced or controlled by an on-site device. The usual average flood recurrence intervals are:

- 2 year - relatively frequent
- 10 year – this is the flood for which stormwater reticulation is usually sized
- 50 or 100 year - this is the flood relevant for assessment of flood hazard and protection of habitable floor levels against flooding. The Building Act uses a 50 year recurrence interval, while most TLAs adopt a 100 year interval)

The ARC requirement for control of peak flows for flood protection purposes is that post-development peak discharges for the 2 and 10 year storm events shall not exceed pre-development peaks for these discharges. If there are existing flooding problems downstream, the 100 year post development peak discharge must be be limited to the pre-development peak. This approach appears to be generally applicable with the proviso that control of the 2 and 10 year flows would not be required in the following situations:

- where site stormwater discharges directly to the marine environment where no adverse effects, including scour or erosion, can be shown to result from the stormwater discharge
- other situations where no adverse effects on channels would occur

### 3.7.3 Stream channel protection

Site development that results in an increase in impermeable areas within a catchment has the effect of increasing the frequency and magnitude of floods, particularly during frequent storm events. The total volume of stormwater runoff also increases significantly. As a consequence streams can suffer an increase in erosion, as they enlarge to cope with larger flows and more prolonged flood flows. North American research has demonstrated that impairment of the quality of streams and lakes due to impervious cover occurs at levels as low as 5 to 15 % impervious cover (Schueler et al., 1999, *Better site design as a stormwater management practice*, Comprehensive stormwater and aquatic ecosystem management: First South Pacific Conference 1999).

The objectives for stream channel protection are to:

- maintain or improve the in-stream channel stability to protect ecological values of the stream and reduce sedimentation downstream
- prevent or minimise erosion of stream bed and banks to minimise requirements and costs for engineering solutions for stream erosion

The on-site stormwater management objectives to achieve the above stream channel protection objectives when site development is considered are to:

- not increase total volumes of stormwater runoff from the existing or greenfield conditions
- control the peak flows for frequent runoff events such that they are not more than existing or greenfield conditions (where total volumes of runoff increase significantly, peak flows will need to be significantly lower than existing to compensate for increased frequency and duration of runoff)

For sites with significant impervious cover and no significant disposal by soakage, achieving no increase in total volumes of runoff is not achievable.

For this reason selecting appropriate on-site stormwater management measures for stream channel protection usually requires consideration of a range of management measures and selection of those that can be implemented on the site.

Stormwater management options available for preventing stream channel erosion due to increases in stormwater volumes arising from site development include:

- limiting total impervious catchment area contributing to a stream to less than a nominated fraction of the stream catchment area. This fraction may range from 5% to 15%, depending on rainfall, stream morphology and other factors. This approach generally also requires implementation of other catchment wide practices to limit the effect of discharges from impermeable areas, such as for example limiting the use of piped discharges of stormwater to streams. Rigorous use of this option for stormwater management for individual sites would thus require investigation of the whole catchment contributing to a stream and use of appropriate catchment-wide criteria.
- on-site reduction of effects of increased runoff volumes by some or a combination of:
  - limiting impervious area
  - bush planting to counteract the effects of impervious areas
  - re-use of stormwater from roof storage tanks
  - discharge of stormwater to ground by soakage/infiltration. For the purposes of this guideline for areas where disposal by soakage is not considered viable, this will not be an option. Where disposal to soakage is viable, runoff to streams is unlikely or infrequent
  - controlling peak flows for more frequent flows, up to 2 year ARI
  - extended detention, that is, temporarily storing runoff on-site and discharging it slowly over a long period (at least 24 hours)

A generic guideline for stream channel protection needs to address:

- whether stream channel protection measures are needed
- if they are needed, what practices are appropriate and how are they designed and implemented

Note that stream channel protection measures referred to in this section of the guideline are for mitigating the effects of stormwater runoff from the site for the stream including the full length of stream downstream of the discharge. They do not apply to any erosion protection measures at any outfall to protect against local erosion due to the velocity of the stormwater discharge from the outlet itself.

#### 3.7.3.1 Recommended procedure for determining whether stream channel protection measures are required

RECOMMENDATIONS

**In order to assess whether stream channel protection measures are needed:**

1. **Determine whether stormwater runoff from the site discharges to a stream – note that this discharge may not be within or immediately downstream of the site, but at the point where any piped or other reticulation serving the site discharges to surface water**
2. **If stormwater does discharge to a stream, contact the TLA, unitary council (UC) or regional council to determine whether stream channel protection measure are required to mitigate stormwater runoff effects for sites where new development is proposed. This would include review of any relevant catchment management or structure plans**
3. **If the TLA, UC or regional council is uncertain or requires individual site owners to make their own assessment, an assessment can be carried out as follows:**
    - **if the discharge location is to a stream or other natural channel that is within the coastal marine area or is within an area that has significant tidal influence, and the site area is small in comparison with the stream catchment area, stream channel protection measures are unlikely to be required**
    - **if the discharge is from a site near the lower end of a stream and the site area is small in comparison with the stream catchment area, stream channel protection measures are unlikely to be required**
    - **assess the future percentage impervious area within the contributing catchment permitted by the district plan, or likely to occur within say 20 years. This can be assessed assuming maximum impermeable areas as permitted by district plan rules or assessed from typical maximum impermeable areas for the permitted or expected land use. This can be carried out using GIS data bases, air photos or 1:50,000 scale topographical maps and district plan maps. For small sites in rural areas, this exercise may be straight forward. For sites in urban or urbanising areas it may be onerous.**
    - **if the assessed future percentage impervious area within the contributing catchment is less than 5%, stream channel protection measures are unlikely to be required**
    - **if the assessed future percentage impervious area within the contributing catchment is greater than 5%, stream channel protection measures are likely to be required**

#### 3.7.3.2 Recommended procedures for selecting and designing stream channel protection measures

Some methodologies that are currently used for selecting and designing on-site devices or practices for stream channel protection are described below.

Waitakere City Council's *Countryside and foothills stormwater management code of practice* (2002) is suitable for use for lots of area greater than or equal to 1 ha. It provides design methodology for selection of on-site management options to provide stream channel protection including the use of bush planting, rain tanks, rain gardens, permeable pavements. It aims to protect stream channels by mitigating the effects of additional impermeable area by maintaining the existing hydrologic regime for flows up to the 50% AEP event and not piping discharges to streams.

Waitakere City Council's *Countryside and foothills stormwater management code of practice* (2002) gives the following detailed methodology:

- table relating area of bush required in relation to impermeable area to be mitigated
- table relating required detention storage and outlet orifice diameters in relation to impermeable area to be mitigated.
- design method for sizing rain gardens based on catchment area and per cent impervious
- a chart providing a reduction factor to apply to pervious paving depending on the percentage pervious area of the pavement - this allows calculation of the remaining equivalent pervious area of the permeable pavement which will need to be mitigated by other methods

The Code of Practice does not spell out the assumptions or approaches used to develop the detailed design methodology. It can thus not be easily adapted or used for areas outside Waitakere City.

Kettle and Heijs (2003) have developed a suggested methodology based on incorporating a limit of 15% effective imperviousness to protect stream health for Long Bay in North Shore City. This is recommended for suburban and urban lots of 200 to 1000 $m^2$ in area. The paper provides an example calculation in which a rain tank together with permeable pavement is used to reduce the effective site imperviousness to 15%. The paper does not describe how to size a tank for mitigation and appears to assume that areas of permeable paving provide full mitigation for the area of permeable paving installed. This is different from Waitakere City Council's (2002) approach, which allows only a portion of the permeable paving for mitigation. The Kettle and Heijs (2003) method also refers to the use of green roofs and revegetation to reduce the effective impermeable area.

The Auckland Regional Council in ARC TP10 requires that where discharges enter a perennial natural stream, its channel will need to be protected and the runoff from a rainfall event of 34.5 mm shall be stored and released over 24 hour period (extended detention). This has been developed for the Auckland area where most of the streams are suffering from some degree of frittering of banks, landslides, bank collapse or stream bed undermining. Similar approaches and rainfall detention requirements are used in some areas in the USA (McCuen et al, 1987, *Policy guidelines for controlling stream channel erosion with detention basins*, Department of Civil Engineering, University of Maryland).

The ARC also allows for mitigation of runoff from impervious areas by bush planting. This mitigation can be assessed by calculating average annual runoff for pre-development and post development conditions using the method in Chapter 2 of *Urban hydrology for small watersheds*, Technical Release No. 55, US Department of Agriculture, Soil Conservation Service, 1986. (SCS, 1986).

Using this method an area-weighted curve number (CN) for a contributing catchment based on cover type, hydrologic condition and hydrologic soil group is determined. Average annual runoff can then be estimated using rainfall data. The additional runoff due to development can then be calculated.

If site area is available for bush planting, the effect of this on runoff can be calculated. If the site is large enough, it may be possible to achieve sufficient reduction in runoff through bush planting to counteract the effect of impervious area from proposed low intensity development.

RECOMMENDATIONS

1. **Where stream channel protection measures are needed, consider the following options:**
   - **minimising impervious areas**
   - **planting bush to counteract the effects of impervious areas**
   - **re-using stormwater from roof storage tanks (note that in some situations this may reduce stream base flows with adverse ecological effects)**
   - **discharging stormwater to ground by infiltration**
   - **controlling peak flows for more frequent flows, say up to year ARI**
   - **temporarily storing runoff onsite and discharging it slowly over a long period (at least 24 hours)**
2. **Assess how bush planting, if practical, can reduce total runoff using the method of SCS (1986)**
3. **Assess any reduction of runoff due to re-use of water from roof tanks.**
4. **Assess the amount of disposal by soakage/infiltration devices, if they are practical on the site (refer to sections 3.8 and 3.10)**
5. **Use the method of SCS (1986) to determine the net area of the site that requires mitigation after implementation of any bush planting, water re-use and infiltration disposal**
6. **Provide for mitigation of remaining site areas by:**
   - **controlling peak flows for more frequent flows, say up to 2 year ARI**
   - **providing extended detention storage by temporarily storing runoff from half the 2 year 24 hour storm on-site and discharging it slowly over at least 24 hours**
   - **controlling peak flows and providing extended detention can potentially be achieved by devices such as:**
     - **rainwater tanks**
     - **wetlands**
     - **ponds**
     - **detention tanks**
     - **rain gardens, roof gutters**
     - **depression storage**
     - **stormwater planters**
     - **permeable paving in conjunction with underlying storage within the pavement foundation**
     - **treatment trench/rock filter**
7. **Size the devices for peak flow reduction and extended detention as per the methodology described in Appendix C**
8. **Choose an appropriate device, depending on the device size required to achieve the stream channel protection objective, the associated cost and treatment train considerations; for example, based on whether the device meet water quality requirements**

# 3.8 Procedure to confirm that stormwater disposal by soakage is suitable - site characteristics and quantity

In this subsection:

- physical location criteria for groundwater soakage devices
- groundwater system characterization
- allowable infiltration rates for stormwater soakage systems

If the preliminary assessment of section 3.3 indicates suitable subsurface material of sufficient depth and extent, and the assessment of the receiving environment and definition of treatment objectives in sections 3.5 and 3.6 shows soakage to ground to be viable, then the following need to be determined:

- physical location criteria for groundwater soakage devices
- groundwater system characterisation

## 3.8.1 Physical location criteria for groundwater soakage devices

When locating devices:

- avoid former landfill sites or other sites which may be contaminated
- avoid the 10 year ARI flood area
- avoid valley floors or other areas that may have groundwater inflows
- allow ongoing access for maintenance
- allow clearance from existing or proposed buildings: minimum of between 1 and 3 metres, depending on type of soakage device used
- allow clearance from sewers and other services: minimum 2 metres
- slope stability considerations;
    - not on the uphill side of retaining walls unless there is appropriate clearance as per design guidelines
    - for slopes less than 5% (3°) slope stability is very unlikely to be an issue
    - for slopes between 5% and 15% (3° and 8.5°), obtain specialist geotechnical input to determine whether disposal of stormwater to ground is acceptable in terms of slope stability
    - for slopes over 15% (8.5°), disposal by soakage is not recommended unless approved by and subject to specific geotechnical investigation and reporting

## 3.8.2 Groundwater system characterisation

To characterise the groundwater system:

- perform permeability testing or assess permeability from knowledge of subsurface material properties to confirm that subsurface conditions are suitable for disposal of stormwater by soakage; permeability values are also required for soakage disposal device sizing. Other guidelines specify minimum and sometimes maximum allowable infiltration rates and these are summarised in Table 3.7 from four other guidelines

- determine likely depth of permeable materials and presence and extent of any impervious materials (e.g. lenses) and depth to any impervious layer
- determine the winter water table level. This must be at least 1 m deep and preferably more than 3 metres deep; the seasonally high water table must be at least 600 mm below the base of the disposal device (Georgia Stormwater, 2001)
- assess likely water table rise, both short term and long term, resulting from the proposed disposal of stormwater (both on the site and uphill of it) and check that this will not have an adverse effect on the stormwater treatment and soakage disposal devices or on adjacent structures or facilities (this may require hydrogeological analysis)

If this characterisation indicates that the groundwater system is suitable for disposal of stormwater from capacity and hydrogeological and groundwater level considerations, then further steps in designing disposal systems should be carried out.

**Note**
In good soakage conditions, soakage disposal capacity may be high enough to cater for the 10 year storm. However, soakage may be an appropriate solution even if this capacity is not able to be met, if a suitable secondary flow path can be provided.

## Table 3.7 Allowable infiltration rates for stormwater soakage systems

| **Guideline** | **Minimum infiltration / percolation rate (mm/hr)** | **Maximum infiltration / percolation rate (mm/hr)** | **Comment** |
|---|---|---|---|
| ARC TP 10 | 3 | | Guideline covers shallow disposal only, not in fractured rock |
| Christchurch City Council (2003) | 1 | 50 (for infiltration basins for protection of groundwater quality) | Relevant for Christchurch conditions, i.e. free draining alluvial soils. |
| Auckland City Council *Soakage Design Manual* (2003) | 30 | | Relevant for areas of fractured basalt and associated highly permeable soils |
| University of Technology, Sydney (2001) | Generally greater than 3.6 mm/hour, can be as low as 0.8 to 1.3 | | |

## 3.9 Determine range of suitable devices for treatment, peak flow and quantity objectives

In this subsection:

- screening information to allow identification of the range of devices that meet the treatment, peak flow and quantity objectives that have been determined for the site
- a series of tables for selection of suitable devices based on various site and treatment/flow objectives and operation and maintenance requirements
- examples of how a number of devices could be used on-site in a treatment train

The type of device or devices that are suitable will depend on:

- site constraints
  - topography
  - site layout, including building location
  - available area
  - soil type, geology
  - catchment area
  - development constraints
  - benefits such as water re-use
  - natural features
- treatment objectives
- peak flow / quantity objectives
- operation and maintenance requirements

For any site a range of separate devices may be required to meet the quality, peak flow/ volume objectives. This may include a number of different devices in series, referred to as a treatment train, or separate devices in parallel.

The suitability of different devices in relation to the following site constraints is in Table 3.8. Site constraints include topography, site layout, available area, catchment area, development constraints and benefits such as water re-use. Potential constraints additional to those in Table 3.8 include soils and geology, for example:

- shallow water table which may preclude devices requiring excavation
- permeable soils which may preclude wetlands or ponds unless liners are used

This subsection includes the two generic options for final disposal of stormwater, to:

- surface water
- soakage

**The range of separate devices suitable for meeting quality objectives is in Table 3.9.**

The range of separate devices that meet the peak flow/ volume objectives for sites (where final discharge is to surface water, not to the subsurface) is in Table 3.10.

Operation and maintenance (O&M) considerations for selecting devices are in Table 3.11. There is more detail on (O&M) for each device in sections 4 and 5 and Appendix D.

# Table 3.8 Suitability of devices in relation to site constraints

**Source:** ARC TP10 and others

| Device | Land use [1] | *Slope* | | | | | *Catchment area* Min. (m²) | Max. (m²) | Development Constraints / Benefits |
|---|---|---|---|---|---|---|---|---|---|
| | | Moderately steep >20% | Rolling 15-20% | Moderate 10-15% | Gentle 5-10% | Flat <5% | | | |
| Filter | C, I [2] | ✓ | ✓ | ✓ | ✓ | ✓ | 100 | 40000 | |
| Infiltration trench | C, IR, GR I [2] | x | ? (3) | ✓ | ✓ | ✓ | 100 | 2500? | small footprint |
| Rain garden | All | ✓? | ✓ | ✓ | ✓ | ✓ | 100 | 1000 | aesthetic benefit |
| Stormwater planter | Roof only | ✓ | ✓ | ✓ | ✓ | ✓ | 100 | 1000 | aesthetic benefit |
| Rain tank | All | ✓ | ✓ | ✓ | ✓ | ✓ | NA | 500? | water re-use benefit |
| Swale/ grass filter | All | | | | ✓? | ✓ | 300 | 40,000 | min length 30m required<br>aesthetic benefit |
| Wetland | GR, C, I | | | ? | ✓ | ✓ | 10,000 [4] | NA | aesthetic benefit |
| Detention tank | All | | ✓ | ✓ | ✓ | ✓ | NA | 2500 | small footprint |
| Pond | GR, C, I | | | ? | ✓ | ✓ | 20,000[4] | NA | aesthetic benefit |
| Roof garden | All | ✓ | ✓ | ✓ | ✓ | ✓ | not applicable | | dependent on house/building design |
| Roof gutters | All | ✓ | ✓ | ✓ | ✓ | ✓ | not applicable | | dependent on house/building design |
| Depression storage | All | | | ? | ✓ | ✓ | NA | 5000 | possible constraint on use of area |
| Permeable pavement | IR, C | | | ? | ✓ | ✓ | not applicable | | |
| Catchpit insert | C, I | ✓ | ✓ | ✓ | ✓ | ✓ | NA | 1000 | |
| Treatment trench/ rock filter | I,IR,GR, C | | | | ✓ | ✓ | 100 | 20000? | |
| Gross pollutant trap | C, I | ✓ | ✓ | ✓ | ✓ | ✓ | dependant on device | | |
| Oil and water separators | C, I | | ✓ | ✓ | ✓ | ✓ | | | |

Notes

1 IR Individual residential; I Industrial; GR Group residential; C Commercial; ? Uncertain; NA not applicable

2 Generally for hardstand only – industrial/commercial/roads

3 Subject to geotech evaluation of slope stability

4 For little or no summer baseflow

## Table 3.9 Range of devices and their ability to remove contaminants from stormwater

Source: ARC TP10

| Device | Contaminant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | SS | HC | ME | OD | NU | PA | TO | LI |
| Filter | ✓ | ✓ | ✓? | ✓ | | | | ✓ |
| Trench | ✓ | ✓ | | ✓ | | | | |
| Rain garden | ✓ | ✓ | ✓ | ✓ | | | | ✓ |
| Stormwater planter | | | | | | | | |
| Rain tank | | | | | | | | |
| Swale/filter strip | ✓ | | ✓ | ✓ | | | | |
| Wetland | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Detention tank | ✓ | | | | | | | |
| Pond | ✓ | ✓ | ✓ | ✓ | | | | ? |
| Roof garden | | | | | | | | |
| Roof gutters | | | | | | | | |
| Depression storage | ✓ | | | | | | | |
| Permeable pavement | ✓ | ✓ | ✓ | ?✓ | | | | |
| Catchpit insert | ✓ | ✓ | ✓? | ✓? | | | | ✓ |
| Gross pollutant trap | ✓ | | | ✓ | | | | ✓ |
| Litter trap | | | | | | | | ✓ |
| Hydrodynamic separator | ✓ | ? | | ✓ | | | | ✓ |
| Separators | | ✓ | | | | | | |

Key to abbreviations of contaminants:

pH power of hydrogen
NU nutrients (nitrogen and phosphorus)
ME metals (lead, zinc and copper)
HC hydrocarbons, including TPH and PAHs
OD oxygen demanding substances (generally particulate organic matter)
TO toxic organics, including for example antisapstain chemicals on timber treatment sites, chlorinated hydrocarbons and other toxic chemicals used on industrial sites
? uncertain, depends on design of device or nature of contaminants
SS suspended solids
PA pathogens including bacteria
LI litter

## Table 3.10 Range of separate devices that meet the peak flow / volume objectives

**Source:** ARC TP10, various

| Device | Peak discharge control ARI (years) | | | Volume control<br>Includes reduction of runoff due to re-use (RU) and the use of extended detention (ED) for stream channel protection |
|---|---|---|---|---|
| | Up to 2 | 5-10 | 50-100 | |
| Filter | ✓? | | | |
| Rain garden | ✓ | | | ED |
| Rain tanks | ✓ | ✓ | | ED,RU |
| Swales/grass filter [1] | ? | | | |
| Wetland | ✓ | ✓ | ✓ | ED |
| Detention tank | ✓ | ✓ | ✓ | |
| Pond | ✓ | ✓ | ✓ | ED |
| Roof garden | ✓ | ? | ? | ? |
| Roof gutters | ✓ | ? | | |
| Depression storage | ✓ | ✓? | | |
| Permeable pavement | ✓? | ? | | ? |
| Treatment trench / rock filter | ✓? | | | ED |
| Gross pollutant trap | | | | |
| Oil and water separators | | | | |

Notes
(1) some guidelines refer to use of swales for detention
? uncertain

## Table 3.11 Indicative operation and maintenance considerations for devices

| Device | Summary of operation and maintenance issues |
|---|---|
| Filter | Requires regular maintenance, preferably by contractor |
| Infiltration trench | May require removal of gravel media, need to ensure suspended solids loads will not result in rapid clogging |
| Rain garden | Maintenance can be done by home owner |
| Stormwater planter | Maintenance can be done by home owner |
| Rain tank | Maintenance can be done by home owner |
| Swale / filter strip | Maintenance can be done by home owner |
| Wetland | Ongoing specialist maintenance required |
| Detention tank | Ongoing specialist maintenance required, concern about maintaining long term integrity/performance |
| Pond | Maintenance needs to be done by contractor, relatively onerous due to potentially large amount of potentially contaminated material requiring removal and appropriate disposal |
| Roof garden | Ongoing maintenance, cutting and removal vegetation |
| Roof gutters | Maintenance can be done by homeowner |
| Depression storage | Need to allow for removal of deposited sediment |
| Permeable pavement | Ongoing cleaning of pavement is required to avoid clogging. This may preclude their use as a robust system. Some regulators express reservations about their long term viability. |
| Treatment trench / rock filter | May require flushing to remove sediment and slime, may be onerous, need to ensure suspended solids loads will not result in rapid clogging |
| Catchpit insert | Maintenance preferably done by contractor, relatively onerous due to large amount of material collected |
| Gross pollutant trap | Specialist maintenance required; can be onerous |
| Oil and water separators | Ongoing specialist maintenance required |

# 3.10 Selection and design of soakage disposal devices

In this subsection:

- the types of devices and mechanisms used for disposal of stormwater to ground soakage
  - mechanisms incorporated within treatment devices
  - stand alone disposal devices
- references for design methods

Some guidelines refer to disposal to ground soakage as infiltration practices. For the purposes of this guideline the terms soakage and infiltration refer to the same thing, namely the final disposal of stormwater to ground including by soakage and/or infiltration.

In this guideline, for the purposes of facilitating device selection and design, soakage methods or categories fall into two main categories:

- those that use infiltration into the soil directly from a treatment device
- stand alone disposal devices

## 3.10.1 Infiltration into soil directly from treatment devices

Devices such as those below can provide treatment via a constructed medium associated with the device. In some cases additional treatment is provided by insitu soils below the device:

- infiltration trenches
- rain gardens
- swales and filter strips
- permeable paving
- soakage basins

## 3.10.2 Stand alone devices

Stand alone disposal devices provide disposal only (any treatment of stormwater is provided beforehand). Examples include:

- trenches (where trenches used only for disposal, not treatment), chambers and pits
- infiltration galleries
- dry wells
- disposal bores, including rock bore soakholes

## 3.10.3 Interaction between design of treatment devices and ground disposal

For treatment devices that dispose stormwater directly to groundwater, the disposal rate of soakage or infiltration from the base and possibly the sides of the device can have a significant effect on the design size of the device. It is thus necessary to establish appropriate design soakage or infiltration rates before designing such treatment devices. If the insitu soil is relied upon to provide treatment of contaminants, then careful assessment of the receiving environment and the potential effect on it from discharge of stormwater is required. Refer to sections 3.5 and 3.8.

### 3.10.4 Design methodologies for soakage or infiltration disposal

This guideline does not provide detailed methods for design of stormwater soakage or infiltration practices or devices. There a number of design methodologies in other guidelines. Comment on four such guidelines with respect to their detailed stormwater soakage or design methods is in Table 3.12.

## Table 3.12 Comments on guidelines that provide design methodologies for stormwater soakage disposal

| Guideline | Comment |
|---|---|
| ARC TP10 | Design procedure is for disposal of the water quality storm; presumably this procedure would be relevant for larger storms, ie. to provide full disposal |
| Christchurch City Council (2003) | This provides for water quality aspects and flood protection, developed for Christchurch conditions, namely free draining alluvial soils. Expected to be relevant for other locations with free draining soils. |
| Auckland City Council (ACC 2002) | Relevant for areas of fractured basalt and associated highly permeable soils. Includes details on percolation testing. Uses design charts specifically prepared for Auckland city rainfall. |
| Approved Document for New Zealand Building code Surface Water Clause E1 (BIA, 2003) | Design procedure for disposal of stormwater from individual buildings, including procedures for field testing of soakage and soak pit design methodology |
| University of Technology, Sydney (2001) | Method not reviewed |

RECOMMENDATIONS

**It is recommended that relevant design procedures from the above guidelines or other suitable guidelines be used for:**

- **development of soakage and infiltration rates for infiltration into the soil directly from a treatment device**
- **development of soakage and infiltration rates and detailed design and operation and maintenance requirements for stand alone disposal devices. Pretreatment requirements for these devices may be able to be designed in accordance with the relevant parts of this guideline**

Care needs to be taken with procedures for field testing of soakage and use of field test results for soakage design, in particular:

- test holes in sands may collapse, affecting the geometry of the test hole and interpretation of the test results
- borehole size tests are subject to local variations in ground conditions, for example if they intercept a crack, results may indicate high soakage but may not be representative of the wider area. Multiple tests over the proposed disposal area may be required for accurate result

# 3.11 Selecting suitable devices and device combinations, treatment train

In this subsection:
- general considerations
- process for selecting site device or devices

## 3.11.1 General

On site stormwater management is often best done using a treatment train or a variety of devices on one site because:

- one device may not be able to meet a range of different objectives, for example all of the needs for water quality, peak flow and quantity control
- an appropriate combination of devices can often provide the most cost-effective approach

## 3.11.2 Process for selecting site device or devices

To select appropriate devices for a site:

- identify the range of separate devices that are suitable based on site constraints, quality, peak and quantity requirements and consideration of operation and maintenance requirements, determined according to the methods above
- develop a range of options of a treatment train or collection of above determined suitable devices that meet the overall site stormwater management requirements
- carry out preliminary design, sizing and costing of the devices considered
- compare the costs and sizes for each option
- choose appropriate train or collection of suitable devices based on cost and any other relevant consideration such as benefits e.g. water re-use, aesthetic benefit, site area requirements, operation and maintenance requirements, the number of devices required

Examples of common treatment trains used for residential sites and commercial / industrial sites are shown in Figures 3.2 and 3.3. Note that rain tanks provide only flow control, filters swales and grass filter strip provide only treatment, while rain gardens and wetlands can provide a combination of flow control and treatment.

An example of a summary of options considered is in Table 3.13.

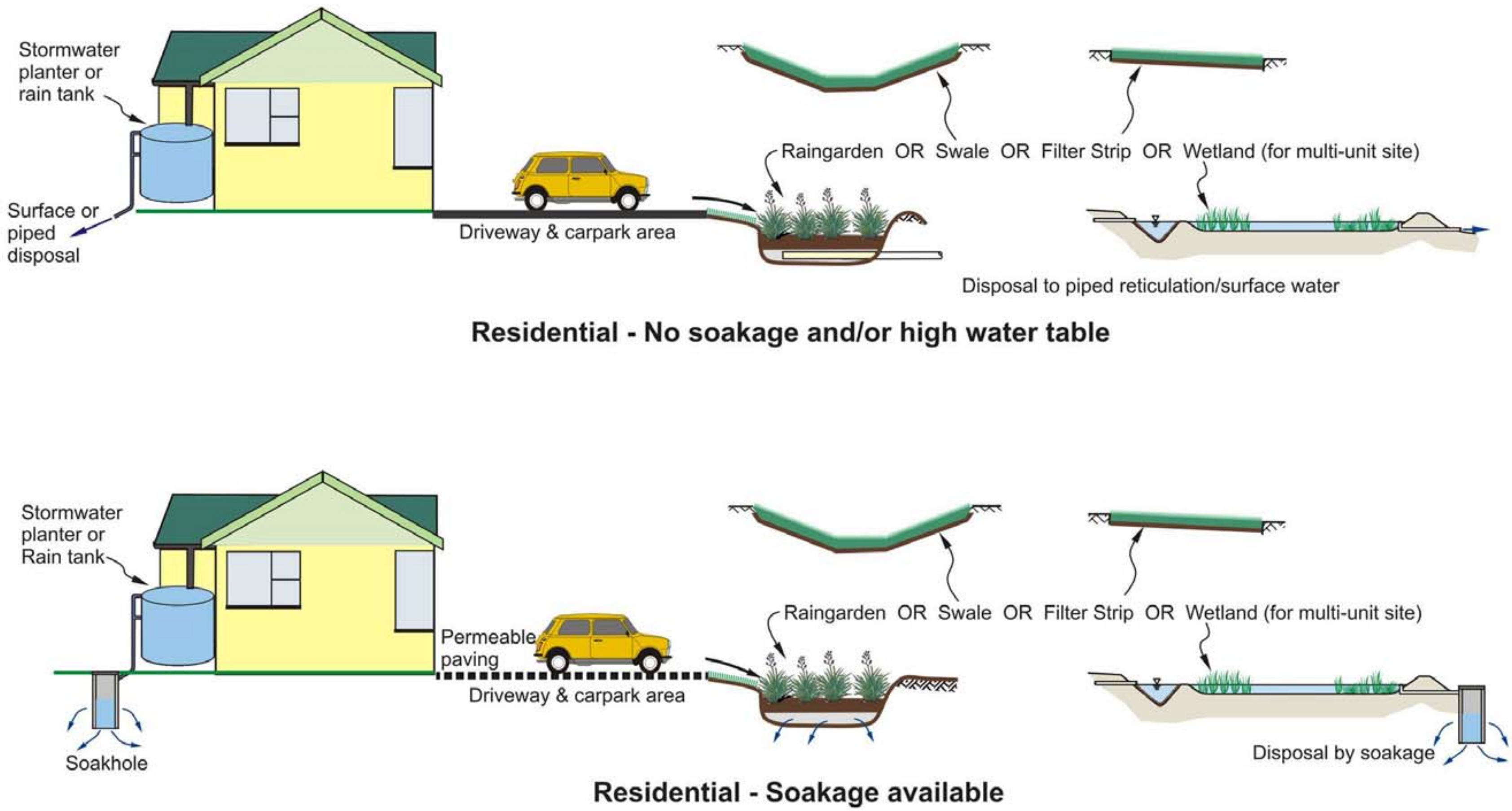
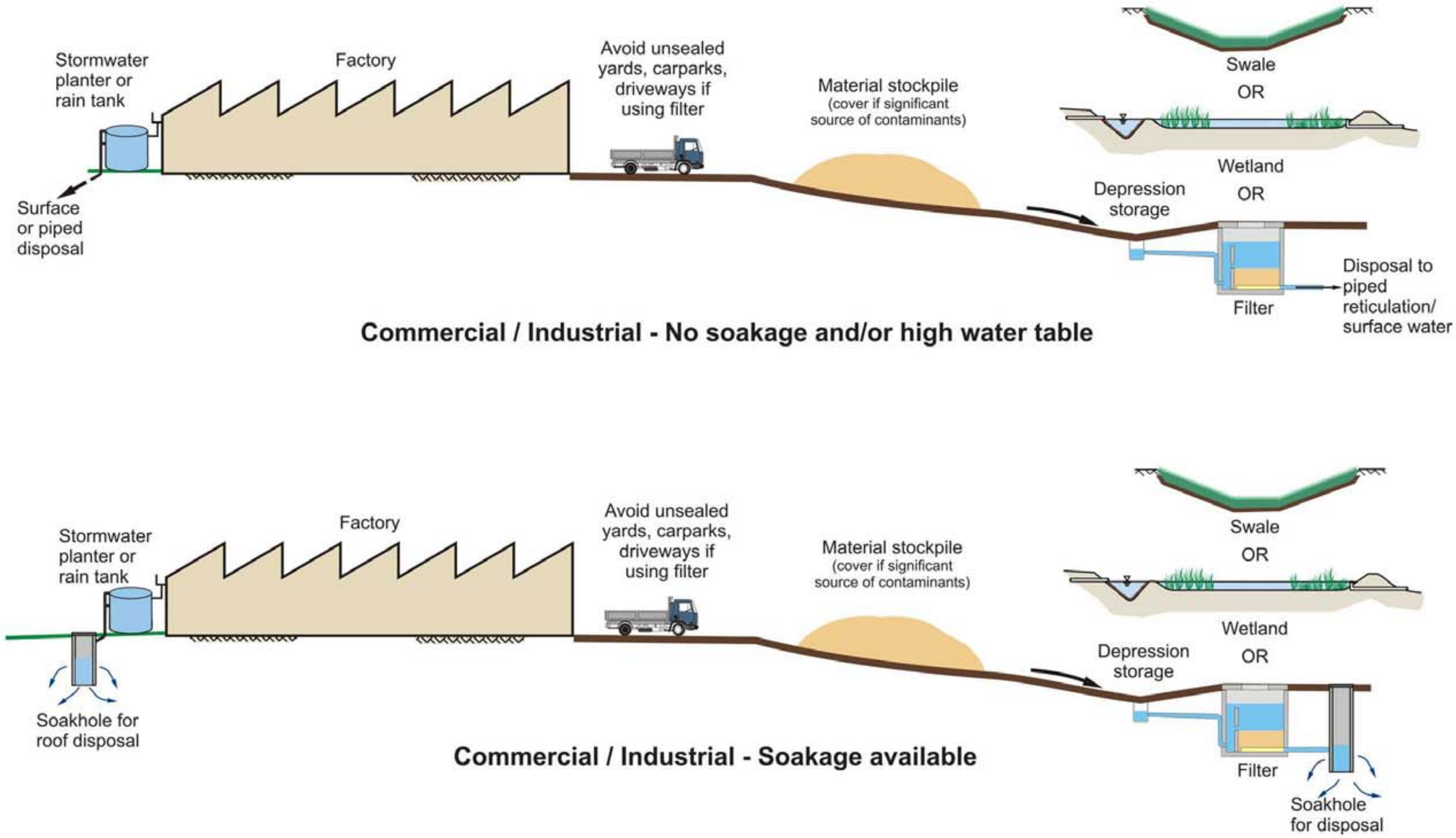



Figure 3.2 Treatment train example for typical residential site




## Figure 3.3 Treatment train example for typical commercial/industrial site

# Table 3.13 Example of results of comparing site stormwater options

Hypothetical example for illustrative purposes

| **Option / Description** | **Satisfies objectives of:** | | | **Capital cost** | **O&M** | **Comment** |
|---|---|---|---|---|---|---|
| | **water quality** | **peak flow** | **Volume** | | | |
| **Example 1: Require peak flow and quality control from a 20000 m$^2$ ( 2ha) industrial site** | | | | | | |
| ***Option1*** | | | | | | |
| Pond for peak flow control and settling coarse solids | Some | ✓ | ✓ | M | M | Would require sufficient site area for pond |
| and | | | | | | Decision between wetland and filter will most likely depend on land availability and cost. Note that wetland can provide some peak flow control, which would require a smaller pond. Need to assess and compare efficiency of each treatment device for removal of contaminants expected in site runoff |
| Filter / rain garden | ✓ | ✓ | ✓ | H / M | H / M | |
| OR | | | | | | |
| Wetland for treatment | ✓ | ✓ | | M | M | |
| ***Option 2*** | | | | | | |
| Depression storage using car park and /or detention tanks. May require gross pollutant trap (GPT) | Some | ✓ | ✓ | M to H | M to H | Using car park could be cost effective if depression storage is not possible, detention tanks could be used.<br>GPT may be necessary to reduce maintenance costs for detention tank |
| Filter / rain garden / wetland for treatment | As for option 1 | As for option 1 | As for option 1 | As for option 1 | As for option 1 | As for option 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Example 2  Residential site: requiring quality treatment for driveways and extended detention flow control for stream channel protection, no soakage available** | | | | | | |
| ***Option 1*** | | | | | | |
| Rain tank for flow control<br>and<br>Swales for quality | <br><br>✓ | ✓ | ✓ | M<br><br>L | L to M<br><br>L to M | Benefit for water re-use<br><br>Swales require large amount of land |
| ***Option 2*** | | | | | | |
| Rain garden providing flow and quality control | ✓ | ✓ | ✓ | L to M | L to M | Carefully designed rain garden may be able to provide flow control and water quality treatment |
| ***Option 3*** | | | | | | |
| Roof gutter<br>Depression storage<br>Permeable pavement | <br><br>✓? | ✓<br>✓<br>✓ | ✓<br><br>✓ | M<br>L<br>M to H | L<br>L<br>H | Viability of depression storage depends on topography<br>Long term performance of permeable pavement is uncertain |

Notes

O & M   is operation and maintenance

L= low   M= medium   H = high

# 3.12 Hydrologic / hydraulic analysis

In this subsection:

- hydrograph generation
- routing computations
- hydraulic computations

Hydrologic/hydraulic analysis will often be required as part of the design of an on-site device, especially the flow attenuation component. This typically involves:

- hydrograph derivation, manually, or by modelling. For an example of a rainfall analysis to feed into such modelling, see the Auckland Regional Council's TP108
- routing computations: routing the inflow hydrograph through the device to establish the outflow hydrograph
- hydraulic computations to size pipes, orifices, weirs and other components

These are discussed below.

Appendix C provides more guidance on these topics, with the brief notes below clarifying the general approach. The following aspects also require consideration, but are covered elsewhere in the guide:

- design storm magnitude: refer section 3.7
- flow attenuation performance and extended detention requirements: refer Section 3.7
- rainfall temporal and spatial patterns (and time of concentration, Tc): refer Appendix C
- computer modelling:
    - this guide focuses on manual or spreadsheet-oriented analysis methods, but commercial models area available to simulate the performance of on-site devices and establish device sizings
    - such models typically generate hydrographs based on rainfall data from single-storm events or long-term pluviographic records
    - Appendix C comments on modelling approaches, noting that these methods are very powerful and their use is recommended for users planning to specialise in preparing on-site device designs

## 3.12.1 Hydrograph generation

Typical methods include:

- the rational method, for example as used in BIA (2003) typically expressed as Q = C x I x A / 360, where:

  Q = peak flow ($m^3/s$)
  C = runoff coefficient (refer below for details)
  I = rainfall intensity (mm/hr), for the applicable duration (Tc) and design storm magnitude
  A = catchment area (ha)

- TM61 Method for estimating design peak discharge (MWD, 1980)
- US Soil Conservation Service Method (USSCS, 1986, for example as applied in ARC TP108 (Guidelines for Stormwater Runoff Modelling in the Auckland Region)

Some considerations and sources of the data required to apply these methods include:

- location-specific rainfall depth-duration-frequency data:
    - NZ Meteorological Service ('Metservice') publications (eg Coulter & Hessell 1980)
    - NIWA's HIRDS software; URL: www.niwa.cri.nz/ncc/tools/hirds
- time of concentration: typically short for on-site devices (e.g. 5 – 15 minutes), but see Appendix C for a commentary on the broader issues to be considered in this context
- runoff coefficient 'C':
    - for impervious areas, the coefficient will be 0.9
    - however, where the device is to be designed to match, for example, the greenfield discharge standard, more attention needs to be devoted to selecting the appropriate C factor(s). For values, refer to chart in Appendix C, or the table in BIA (2003)
- hydrograph shape: the rational method or TM61 methods produce peak discharge figures, but a hydrograph is needed for use in the routing analysis. A suitable triangular hydrograph can be prepared by (refer Appendix C for further details on hydrograph derivation, including the approach applicable to longer-duration storms where the hydrograph shape is trapezoidal in form):
    - rising limb: linear rise to reach the peak at time Tc
    - falling limb: linear fall back to zero, over a time period Tc

### 3.12.2 Routing computations

Routing involves quantifying the way the storage provided in the on-site device modifies the inflow hydrograph. Typically, a spreadsheet will be used to perform the routing calculations, applying the following general relationships:

- outflow = inflow – change in storage
- outflow = function of the applied head on the outlet flow control device (eg orifice, weir)

The layout of a typical spreadsheet used to perform the routing calculation, is shown in section 4.5.6 and in Appendix C. It should be noted that cell arithmetic will vary depending on the device type, especially the type, number and size of outlet(s).

To size an on-site device, use a trial and error approach to using the routing computation spreadsheet as follows:

- define the device performance target, eg: site runoff peak to match the greenfield case in the 10% AEP storm
- derive the peak flows and hydrographs for the following cases (note that worked examples are given in Appendix C – Section C3.5):
    - for the target performance standard case, as above
    - inflow to the on-site device, for the post-development case
    - rest-of-site runoff, for the post-development case (ie to add to the device outflow hydrograph, to establish the post-development with-device outflow)
- select the trial device size characteristics, for example for a detention tank:
    - plan area of tank
    - top outlet pipe diameter and height above tank base
    - outlet orifice diameter and height
- run the spreadsheet (refer examples in Section 4.5.10) and:
    - identify the peak site outflow rate
    - compare this to the target peak site outflow (eg greenfield, as above)
- select new trial device sizing parameters (eg smaller/larger tank, smaller/larger orifice) and re-run the spreadsheet until the required device performance standard is met
- in practice, as explained in Appendix C - Section C2.2, spreadsheet runs will be required to cover a series of storm durations, to identify the critical case

### 3.12.3 Hydraulic computations

The user is referred to the following documents and standard hydraulics textbooks for the various formulae to size pipes, orifices, weirs and so on:

Building Industry Authority. *Building Code Clause E1– Verification Method E1/VM1: Surface Water.* New Zealand, Effective September 2003 (BIA, 2003)

Brater, E.F., King, H.W., Lindell J.E., & Wei, C.Y. (1986). *Handbook of hydraulics*. New York: McGraw Hill.

Streeter, V.L. (1985). *Fluid mechanics*. Tokyo: McGraw Hill.

Department of Environment and Natural Heritage. (1992). *National strategy for ecologically sustainable development*. Department of Environment and Natural Heritage, ACT, Australia. (NSESD 1992). http://www.deh.gov.au/esd/national/nsesd/index.html.

Check that nominated coefficients in formulae apply to the metric case; especially in material of American origin, where imperial units are used. Also check units e.g. U.S. versus British gallons

### 3.12.4 References

Auckland Regional Council. (2003). *Stormwater treatment devices: design guideline manual*. ARC Technical Publication No. 10 (ARC TP10). From http://www.arc.govt.nz/arc/index.cfm?34C9C2A8-1BCF-4AA1-91AF-CC49CFE4A80C.

BIA (Building Industry Authority). (2003). *Building Code Clause E1– Verification method E1/VM1: Surface water*. (BIA 2003)

Brater, E.F., King, H.W., Lindell J.E., & Wei, C.Y. (1986). *Handbook of hydraulics*. New York: McGraw Hill.

Coulter, J.D., & Hessell, J.W.D. (1980). *The frequency of high intensity rainfalls in New Zealand, Part 2 - Point estimates*. Miscellaneous Publication 162, New Zealand, Meteorological Service, Wellington

Drainage & Irrigation Dept, Malaysia: *Draft stormwater management manual*. From http://agrolink.moa.my/did/river/stormwater/toc.htm

Ministry of Works and Development. (1980). *A method for estimating design peak discharge*. Technical Memorandum No 61, Planning and Technical Services, Water and Soil Division.

New Zealand Meteorological Service. (1983). *Rainfall normals for New Zealand* 1951-1980. New Zealand Meteorological Service Miscellaneous Publication 185. (NZMS 1983)

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## 3.13 Statutory compliances and consenting

When planning to use an on-site device, apply sound stormwater planning principles in the context of the relevant statutory requirements. Aspects such as those listed below will need to be drawn together and documented in a consent application (also discussed later in this sub-section). The issues discussed below should be addressed at an early stage in planning for an on-site device.

1. Identify if the site is susceptible to existing or potential future flooding by checking to see if any stormwater issues are identified in the following documents, which are available from the territorial local authority:
    - PIM (project information memorandum)
    - LIM (Land Information Memorandum)
    - any catchment management plan and/or flood hazard maps
    - if these are not available, consider the capacity of both public and private drainage
    - undertake a site visit to see that planning information matches the on-the-ground situation

2. Structures must comply with both council and central government policy on flood hazards if building consents are to be issued. In general, it is convenient to consider these polices at the same time that the stormwater system is designed, and for this reason the policies are summarised below. Relevant policy documents include, but may not be limited to:
    - Building Act (Section 36)
    - Building Code (Approved Documents E1 and E2)
    - District Plan
    - Regional and District/City Council Bylaw and Engineering Standards on Stormwater Management (if applicable)
    - Resource Management Act (Section 76)

3. For all properties, all structures (including decks, fences, etc) must be designed so there is no obstruction of overland flow paths

4. For land that may be subject to flooding, the following policies apply:
    - all building work and land on the property must be adequately protected from flooding, in accordance with s36 of the Building Act and the relevant parts of the District Plan
    - at a minimum, flood protection for building work is required to prevent floodwaters from a 2% AEP flood entering houses, communal residential buildings and communal non-residential buildings, in accordance with Approved Document E1 of the Building Code
    - note, however, that council will consider each case individually and may decline a building consent if they do not consider that s36 of the Building Act and the relevant requirements of the District Plan have been adequately complied with
    - Building consents may also be issued subject to s36(2) of the Building Act, which will mean that a note will be placed on the title of the land indicating that the land is subject to flooding
    - the development must not increase the extent of flooding on any other property, either upstream or downstream (ie as broadly required by sections 36 of the Building Act and 76 of the RMA, as amplified by provisions in Regional/District Plans)

5. Confirm with the consenting authority the precise consent application requirements so as to take account of these in developing the on-site device designs and details. Consenting processes will vary around the country, but the following general guidance may help when implementing an on-site device:
    - depending on the provisions of the relevant district plan, implementation of an on-site device may require a resource consent. If so, seek advice from the consenting authority as to what details must be included in the consent application
    - even if it does not require a resource consent, an on-site device will generally require a building consent

6. Although requirements will vary, consent applications will typically need to include:

- details of the proposed type(s) of on-site device(s), together with evidence as to the suitability of the proposed on-site device(s) to the site/development, for example, availability of a connection to a formal stormwater system such as a pipe or watercourse
- a site plan to scale showing proposed layout and key elevations, covering:
  - site development plan, including buildings, paving, etc
  - details of the proposed on-site device(s), specifically:
    - location(s) of the device(s)
    - delineation of the impervious area connected to each on-site device
    - arrangements as to the ownership of each on-site device and corresponding responsibilities for operation and maintenance (if applicable)
    - the route(s) of the connecting pipes or channels between the impervious area and the device and, if applicable, the device outlet and the receiving system
- design calculations for the on-site device(s), covering:
  - structural elements
  - analyses/sizing
  - performance in accordance with appropriate guidelines
- technical specifications, including construction materials details
- producer statements for any proprietary equipment
- as well as standard provisions, consent conditions may also cover:
  - O&M provisions (obligatory or recommended)
  - prohibition on modifying/dismantling/removing the device, except with the written permission of the local authority

# 3.14 Design and detailing

The step-by-step design procedures in section 4 give device-specific guidance for sizing and design detailing, so only general comment is given here. Examples of design and detailing issues to account for include:

- conservatism: be conservative at all stages in the design of on-site devices, recognising for example that O&M practices will often be less than ideal
- non-standard applications: although this guideline provides for a wide variety of site conditions and device applications, there will be instances where further guidance is required. In such cases it is suggested that the user:
  - refer to the references listed in section 4 for each device and/or to Appendix B
  - seek the advice of experienced New Zealand on-site device designers (NZWWA and any of the councils may be able to suggest suitably experienced practitioners)
- detailing principles: attention to well thought-out and accurate detailing is essential if the device is to give long-term effective service. Issues to consider include:
  - construction practicality
  - ease of O&M and adequate access for maintenance
  - building in measures which will limit damage if the device blocks or otherwise fails, such as directing spills to a defined overland flow path
- detailing practices: examples of areas where attention to detail is especially important include:
  - device siting, such as considering aesthetics, ease of maintenance
  - setting key elevations, for example to ensure adequate fall to the outlet receiving system
  - appropriate selection of materials, such as rain tank material, concrete or timber walling for stormwater planter, soil/gravel specifications
  - screening of outlets to avoid blockage and provision of inspection covers for screen cleaning

> It is especially important to ensure good erosion protection of all sources draining to the inlet of devices such as surface of rain gardens and stormwater planters, to avoid clogging up the media with eroded sediment.

# 3.15 Operation and maintenance (O&M)

In order to meet water quantity and/or quality targets, the long-term effective operation of on-site devices depends not only on sound design and construction, but also on applying routine operation and maintenance practices. These 'O&M' practices are typically not onerous in terms of either effort or frequency. Further, the costs are modest – and are typically less than neglect causing devices to fall into disrepair and need major overhaul.

It is generally the responsibility of the on-site device owner to carry out appropriate O&M, unless the local authority agrees to take-over responsibility. Ideally, requirements should be scheduled in the appropriate consent. O&M practices will typically involve:

- frequently: check for and rectify any problems evident during/after heavy rain
- regularly, about every 2 – 3 months: check state of repair of the OSM device and remove growths, repair leaks, clear blockages, etc
- periodically (eg once or twice a year): inspect pipes, remove sediment, repair any defects

O&M requirements are specific to each on-site device, but will typically cover (refer Appendix D for full details):

- soils in stormwater planters, rain gardens, roof gardens
- vegetation management
- sediment management/pollutant control
- insect/vector control
- access and safety
- a monitoring and inspection programme detailing the above

> Sediment accumulated in treatment devices may be contaminated, in particular with hydrocarbons and metals. Appropriate disposal of such sediment is essential to avoid adverse effects.

Table 3.14 is a typical O&M checklist for an on-site device.

## Table 3.14 Operation and maintenance checklist - grass swale

| Frequency | | | Action |
|---|---|---|---|
| **As required** | **Quarterly** | **Annually** | |
| | ✓ | ✓ | **General**<br>Remove any debris accumulation / waste vegetation |
| | | ✓ | **Inlets and outlets**<br>Remove sediment |
| ✓ | ✓ | ✓ | **Grass**<br>Mow (with catcher) to maintain the grass length at 50 – 150 mm |
| | ✓ | ✓ | **Grass**<br>• remove nuisance weeds<br>• fertilise or treat to maintain vigorous growth, as required<br>• fill any erosion holes and re-seed |
| | ✓ | ✓ | **Pipework:**<br>Check for debris/blockages/leaks & rectify |

The consenting authority typically sets the O&M obligations and the corresponding enforcement regime. O&M delivery models include (see Appendix D for more detail):

- traditional: voluntary regime, with guidance given and backed by random inspections
- obligatory:
  - owner responsibility: owners are required to have their on-site device serviced at designated intervals, with certification by an independent person as to the servicing submitted to the controlling authority (eg as in Auckland City)
  - contracted out responsibility: in installing an on-site device, the owner agrees to contract-out maintenance to the controlling authority, which equips the serviceperson with a notebook computer that has the site and device details. On completing the service, details are logged in and downloaded to the controlling authority's database (for example as in the City of Orlando, Florida, USA)

# 3.16 Implementation

Following the receipt of the consent (refer Section 3.15), steps are:

- construction: requires close attention to ensuring that the following are met:
  - o design details (refer Section 3.13)
  - o materials specifications, especially the grading of the materials in the planting medium
  - o specifications
- commissioning:
  - o once constructed, the device will need to be commissioned and tested
  - o in the event that the device is commissioned during a dry spell, in some cases it may be appropriate to test the device using a high-capacity hose (eg from hydrant or tanker, feeding water to the roof or site impervious area)
  - o checks need to be made for flaws such as leaks, blockages, evidence of scour etc
- certification: once commissioned and operating satisfactorily, the device will need to be certified under the provisions of the Building and/or Resource Consent – ARC TP10 provides examples of the checklists used by certification authorities
- O&M (ongoing): the routine maintenance provisions set out in Section 3.15 will need to be undertaken, in accordance with either (as applicable):
  - o the provisions of the consent (where nominated), or
  - o a voluntary, non-enforced basis (albeit recognising that the local authority generally has the power, under either its bylaw or the Local Government Act, to require repairs where the device is causing flooding on a neighbouring property)

# 3.17 References

Notes:

1. Internet references are accurate at the time of publication
2. Short references are given in brackets at the end of key documents that are used throughout the text for ease of use, for example (ARC TP10, or CCC, 2003)

## Publications


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Auckland City Council. (2002). *On-site stormwater management programme*. (ACC 2002)

Auckland Regional Council. (2003). *Stormwater treatment devices: design guideline manual*. ARC Technical Publication No. 10 (ARC TP10). From http://www.arc.govt.nz/arc/index.cfm?34C9C2A8-1BCF-4AA1-91AF-CC49CFE4A80C

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US Soil Conservation Service. (1986). *Urban hydrology for small watersheds*. US Department of Agriculture, Soil Conservation Service Technical Release No. 55. (SCS 1986). From http://www.mi.nrcs.usda.gov/technical/engineering/neh.html

Waitakere City Council. (2002). *Countryside and foothills stormwater management code of practice*.

Williamson, R.B. (1986). *Urban runoff data book: manual for the preliminary evaluation of urban stormwater impacts on water quality*. NIWA Water Quality Centre Publication No. 20.

## Web-based resources

Environmental Risk Management Authority. (1996). Environmental exposure limits (EELs) established under the Hazardous Substances and New Organisms Act 1996 (HSNO), for a number of hazardous substances are available from http://www.erma.govt.nz/hs/hs-comp-eels.asp