Bioretention Practice Note for Nelson and Tasman Councils

1. Introduction

Table 1: abbreviations used

LDM	Land Development Manual (jointly owned by Tasman and Nelson councils)
ESCP	Erosion and Sediment Control Plan.
ARI	Annual Return Interval
LID	Low Impact Design
TRMP	Tasman Resource Management Plan
NRMP	Nelson Resource Management Plan

Purpose

This practice note is intended to support the design and delivery of (public) bioretention devices. It also supports the process to obtain consents and engineering approvals. The applicant needs to ensure that requirements in the local Resource Management Plan and Engineering Standards are also complied with.

To the reader

This practice note is one of several practice notes developed specifically for stormwater management with an emphasis on environmental protection and the mitigation of development related impacts on flooding and surface waterways, including reducing peak flows, reducing spills and reducing water pollution.

The practice notes will be updated as technology and research progresses.

Currently Tasman District Council and Nelson City Council are preparing changes in the RMA plans and are developing a new joined "Land Development Manual" (LDM) replacing the existing engineering standards. It is the intention that these practice notes will be updated to show how to comply with these new requirements once they are operative,

The digital version of the practice note has hyperlinks to enable easy navigation and access more information.

2. Description

Bioretention devices (also called rain gardens) are engineered vegetated systems designed to treat stormwater using the natural physical, chemical and biological processes shown in Fig. 1. Bioretention devices can be designed to: reduce peak flows for a range of storm sizes (through temporary storage); reduce stormwater volumes discharged (through storage, exfiltration and evapotranspiration); and, reduce pollutants (though filtration, sedimentation, absorption and microbial processing). Bioretention is an efficient and highly effective stormwater management practice when key design steps are adhered to.

Bioretention devices are typically designed to capture stormwater from small storms and the initial (first flush) runoff from larger storms. Excess runoff during these larger storms should bypass the bioretention devices and discharge directly to detention basins and/or surface waters via either the piped (reticulated) network or overland flow. Stormwater that enters a bioretention device will either infiltrate into the surrounding soils (where appropriate) or flow via underdrains and outlet works to the piped network and/or devices such as detention basins or wetlands.

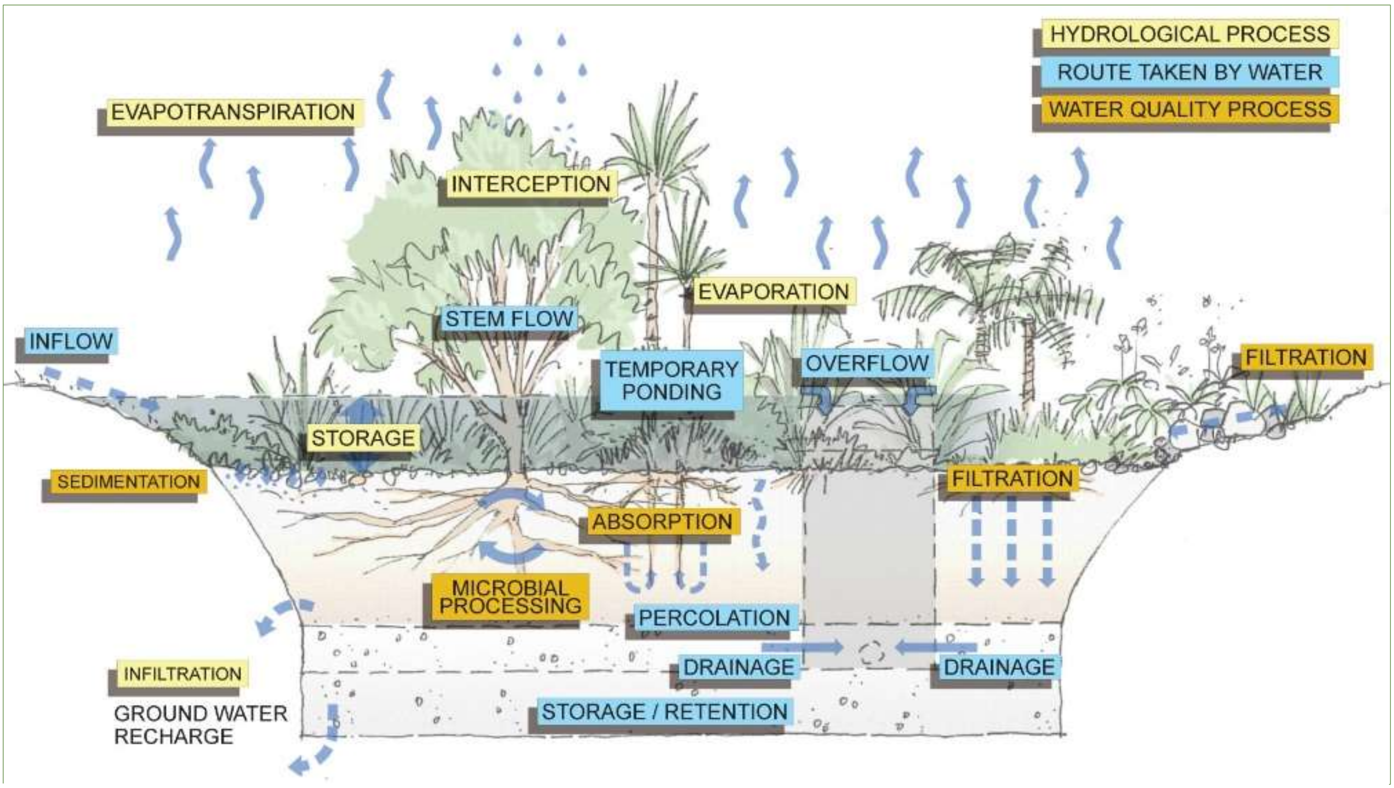
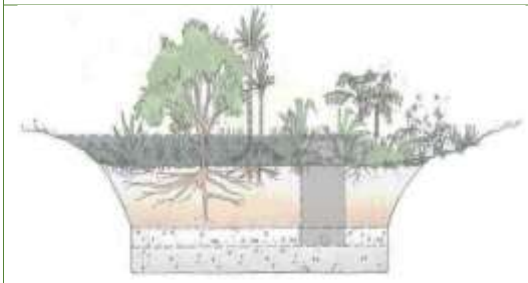


Figure 1: processes in a typical bioretention device

There are a range of applications which are commonly referred to as bioretention devices which are suited to use in the public realm. The most common ones are shown below.

A *raingarden* is a planted filter in which water ponds during rainfall before percolating through the filter media. Raingardens have a specific filter media, storage volume, hydraulic controls (inlets and underdrainage), and specially selected plants to support stormwater treatment. Raingardens must have shapes and inlets that avoid scour and ensure even stormwater loading.	A *bioretention swale* is a linear system, typically used along roads that moves stormwater. Swales have specific filter media in the base and must meet stringent hydraulic controls and plant cover types to avoid scour from high velocity flows. Swales help reduce peak flows by slowing water, but provide limited volume reduction and contaminant removal, however they are effective at reducing impacts of 'spills' and car washing.	*Stormwater planters* are an alternative to a raingarden that is a wholly or partly above ground; almost a 'living water tank'. Planters are large container/confined areas that receive and detain stormwater direct from downpipes. They are suited to treatment of roof runoff in areas where exfiltration is not wanted, such as near buildings. The raised edges can provide separation, security and seating.
		

3. Benefits

Bioretention is one of the preferred methods for stormwater management because they:

- Remove particulate and dissolved contaminants (including sediments, metals, nutrients and hydrocarbons). Bioretention swales are often used alongside roads because of their function and shape, replacing traditional kerb-and-channel design and because runoff from roads is a major contributor to pollution.
- Mitigate the increase in runoff of frequent (small) rainfall events from increased imperviousness. Depending on the design, bioretention can allow runoff to mimic the pre-developed hydrology through detention, infiltration and/or evapotranspiration, therefore reducing scour and erosion in streams and reducing stream animal stress. Bioretention is very effective at intercepting small spills (and detergent/car wash) that can otherwise kill stream life and discolour streams
- Suit inclusion of additional attenuation storage to reduce peak flow rates from larger infrequent events to reduce the risk of downstream flooding and/or to respond to downstream capacity limitations within the primary system.
- Are readily maintainable, so contaminants can be removed, rather than washed into the environment.
- Reduce the temperature of stormwater runoff prior to discharge; this is important for roads and carparks near streams.
- Provide amenity and increased plant cover that contributes to ecological, social, cultural and health benefits.
- Often use the same space as standard landscaping, berms or verges, but are self-watering and self-fertilising (from stormwater), so supports more resilient plant growth.

4. Rules and requirements

In addition to this Practice Note the user/applicant needs to also ensure that any requirements in the operative Resource Management Plans and Engineering requirements are met.

5. Design requirements

The following is intended to guide a design that reflects best practice, will work and is cost-effective to maintain.

This does not include meeting any other requirements; final discretion is with the Council consenting department.

Bioretention devices have a number of key parts as described below; design should be done or peer reviewed by an experienced practitioner.

a. Bioretention operating layers

The design of bioretention systems requires the design to incorporate specific layers which are fundamental to its performance. These are shown in Fig 2.and discussed in the following sections.

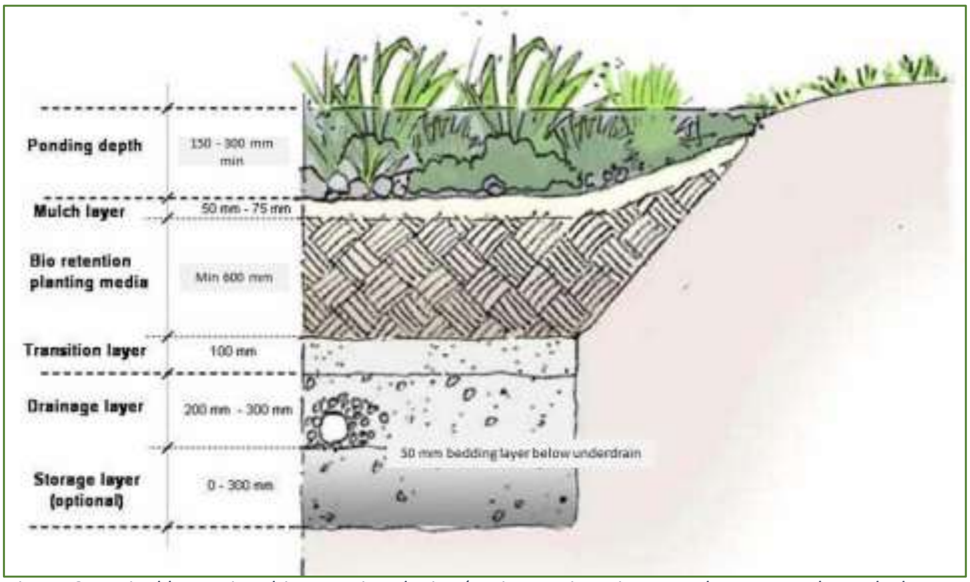


Figure 2: typical layers in a bioretention device (an inspection pipe, not show, goes through the layers and connects into the underdrain)

b. Shape

Whilst the shape of bioretention systems is flexible, it is important to consider the effect on performance. The shape and inlet location shall ensure the full surface of the filter media is covered with stormwater at the design ponding depth and to ensure that inlet velocities and flow routes into the system do not cause surface scour. The shape should protect plants from traffic damage (i.e. minimum 1.5 m width adjacent to parking areas), reduce maintenance (have more 'core' relative to edge), maximise other benefits such as amenity, and provide for cost effective maintenance.

c. Location

Water runs downhill. The device should be located so stormwater from the contributing catchments can enter under gravity. The location should avoid underground and above-ground services where practicable. Where this is unavoidable, the design should reduce the risk of damage to the device during maintenance of the other services (signage, use of conduits, etc.). Avoid putting lighting (especially uplighting), signs and rubbish bins in these devices. Raingardens on street corners add to road safety by preventing parking, creating a physical buffer for pedestrians and narrowing road crossings while also capturing the most contaminated runoff (generated at places where cars turn and brake).

Devices should be least 3 meters from building foundations unless an impermeable layer is used to protect the building, or a stormwater planter is used. Devices must be set back from existing retaining walls a distance equal to 1.5 x the height of the wall unless specific geotechnical design certification is provided. Devices which are adjacent to roads and/or public pathways must consider safety in design, account for surcharge loading from the roadway, and manage the step down to the filter surface through appropriate edge treatments. Access for maintenance is required, in particular the inlet and outlet structures, so setting them at least 1 m back from the edge of active traffic lanes improves safety and can dramatically decrease maintenance costs. Plants require adequate natural light. Raingarden function is enhanced if roots of adjacent evergreen trees can access the devices; large-leafed deciduous trees have potential to block inlets and smother groundcovers at leaf-fall.

d. Road runoff

The grade of the road will affect the design solutions that can be used.

~ Bio-retention, is suitable treatment options for shallow grades (<5%) parallel to the roadway. Sometimes it is cost efficient to use swales (horizontal flow only) to convey stormwater to a bioretention device. Swales (and filter strips) only provide for some water quality treatment and cannot be used to reduce volume or flows. Raingardens can be combined seamlessly with swales on shallow grades by varying excavation depth.

~ For grades between 5% and 8% check dams and other flow control measures will be needed. Catchment data should be used for site-specific design.

~ For grades greater than 8% it is recommended that treatment is offline. This should involve diverting 'first flush' and low flows for treatment using solutions such as stepped rain gardens. Options require detailed site-specific design.

~ Minimising impervious areas. Pervious materials may be suitable for drives and light-vehicle parking areas and can reduce the size and cost of a bioretention device.

~ Roads are often used as overland flow paths. Some of these might only be used in large storms that exceed the design capacity of the primary system. Location of flow paths should be avoid scouring of bioretention device(s).

e. Size

The size of bioretention systems needs to be proportional to the contributing catchment. This can range from 2 m^2 up to 1,000 m^2 where inflows are from the piped network, appropriate inlet design ensures even distribution across the device. Locally specific analysis to define the preferred sizing method shall also be consistent with the local requirements. Where bioretention systems are provided for water quality only, a minimum filter media footprint equal to 2% of the contributing catchment shall be adopted. Bioretention need to be a minimum width to minimise plant stress and edge maintenance (depending on plant size). Minimum bioretention volume is needed to support trees; large trees may require 10 to 30 m^3, so consider how soils outside the devices can also support tree growth.

Bioretention systems complement detention storage designed to mitigate flooding, downstream erosion or address network capacity constraints. Any such temporary detention storage must be above the top of the normal operating water level (top of operating detention storage) and must only be engaged in events greater than the post developed 2 year ARI event. If this is applied then the hydraulic design needs to show that flood flows do not compromise the working of the bioretention devices. Required volumes for such attenuation must be calculated in accordance with the local requirements.

f. Inlet design

Effective inlet design is essential for a bioretention device to function and be maintainable. Flows can be either concentrated surface flow (i.e. direct from a minimum of two kerb openings/cuts), distributed surface flow (i.e. multiple kerb inlets or sheet flow) or via the pipe network (with inlet diversion structure for large catchments). Bubble ups are not acceptable as they have a high risk of blockage. Up The inlet must be designed to facilitate the managed deposition of coarse sediment and the cleanout of the sediment. This is typically achieved by ensuring a minimum 200 mm wide (a standard shovel width) with 100 mm step down at the inlet to the bioretention surface and a defined sediment deposition zone such as a concrete apron, or (for large systems) a forebay. Bioretention systems shall not be subject to continuous baseflows from catchments with constant flows from contributing streams or groundwater ingress. If possible, high flows should bypass the device. The levels should allow for increasing soil level over time (due to deposition). As inlet design is a common problem, a number of good/bad practice examples are included in section 9.2.

g. Operating detention depth

The operating detention depth is used to increase the efficiency of the bioretention system (through attenuating flows from the first flush and treating through the media) and enable the flows to engage the full filter surface area. The operating detention depth shall be 300mm (excluding mulch) unless there are identified public safety risks or functional constraints which cannot be designed for. In these instances a minimum of 150 mm must be achieved. Note that edges may be battered / sloped to reduce risks of vertical drops. The maximum ponding shall be 350 mm depth. The operating detention depth is controlled by the hydraulic structures (either the crest of overflow manhole or kerb invert to support bypass of peak flows).

h. Mulch layer

Mulches are a 50 to 75 mm deep layer of non-floating organic placed over the surface before or after planting. Inorganic mulches must be washed, i.e. contain no silt or clay. An adequate depth of suitable mulch helps plant establishment by supressing weeds and reducing drought stress. Suitable organic mulches will reduce risk of crusting/sealing and erosion, reduce compaction during planting and reduce surface temperature. The depth of mulch shall be allowed for when setting the overflow level. Mulch must enable new shoots to establish through it. Bark nuggets float and are not suitable. Do not use weed mat or filter fabric under the much layer as they have a high risk of blocking with sediment.

i. Bioretention filter media

Filter medium and drainage specification is fundamental to the performance of bioretention. Filter media must support plant growth (i.e. provide initial nutrients, plant-available water and air) whilst also meeting a prescribed hydraulic conductivity to support the filtration of particulates. This is typically achieved with a sandy loam soil mix. Filter media must be <u>from an approved commercial source</u> and meet the following criteria:

~ Hydraulic conductivity of 100-300 mm/hr.
~ Sandy loam with clay content of 3–5%
~ Organic content of 2-5% (by weight) if no organic mulch or surface amendment used, 1-3% if organic mulch or 50 to 75 mm depth of weed-free compost amendment to the upper 200 to 250 mm of media is used
~ pH 5.5 to 7.5, Total Copper <80 mg/kg, total Zn <200 mg/kg
~ No added inorganic fertilisers, free of plant pests and diseases, free of building materials.

Media should not generate contaminants and not structurally collapse. The optimal media depth is 600mm. When trees are planted, the depth this should be either increased to 1m or minimum 5m^3 volume provided, or trees specifically enabled to exploit favourable adjacent soils outside the bioretention area (for example, plant trees on the edge of swales, never in the centre). The media surface shall be approximately level (+/-30 mm) to avoid localised blinding, excluding batters. For bioretention swales the surface should be gently sloping with a maximum grade of 2%. Filter media shall be lightly compacted only (single pass of hand roller or saturation and drawdown) with any natural differential settling requiring top up during establishment. Install media in 300mm layers and ensure that the finished surface is completely level prior to planting.

j. Transition layer / bridging layer

A transition layer is required between the filter media and the drainage layer to prevent migration of fines into the drainage layer. A geofabric must **not be used** under any circumstance. The filter zone should consist of 100mm of washed coarse sand (i.e. 5mm washed sand).

k. Drainage layer and under drain

A minimum 200 mm thick layer of clean, washed fine gravel (i.e. washed driveway chip) shall be installed beneath the transition layer to surround the perforated underdrain pipes and provide additional storage zone where included. A minimum 50mm bedding layer beneath the pipe shall be provided. The size of the drainage gravel should be determined by the size of the perforations of the under drain pipe, i.e. d_{85} > 1 x size of the perforation.

Underdrains shall be provided in all bioretention systems even when ground infiltration is used. The under drain should be a slotted PVC pipe with a minimum diameter of 100mm and should have a minimum slope of 0.5%. For filter areas up to 10m^2 a single 100mm diameter pipe will suffice, for areas between 10m^2 and 20m^2 a single 150mm or two 100mm diameter pipes will suffice. For areas larger than 20m^2 a site specific design is required. Under drains should be evenly spaced (1.5 m spacing) along the length of the device and connect to the outlet pipe via a solid pvc collector pipe. The invert level of the outlet pipes will determine the standing water level between events and can be designed to support a storage reservoir within the drainage layer. The standing water level must not extend above the base of the transition layer. Such reservoirs are particularly valuable to reduce drought stress and maximise evapotranspiration for deep rooted plants such as trees.

Where ground exfiltration is desired, ensure the base of the device is roughened with a toothed bucket prior to installation of drainage layer. This helps remove compaction and smearing that otherwise limits exfiltration.

l. Liner

An impervious liner is required when bio-retention is used in geotechnical unstable or steep sites greater than 1V:5H. Systems may also be lined to support a permanent saturated storage zone at the base of the bioretention to enhance nutrient removal (through anoxic conditions) and provide a water source during prolonged dry spells. Liners can be compacted clay (either imported or in-situ), synthetic clay liners (GCL) or polyethylene (HDPE or heavy duty PE sheets).

A permeable geotextile liner must be included where bioretentions are constructed on dispersive clay soils to prevent migration into the drainage layer.

m. Root barrier

Where trees are included in bioretention systems, consider species tolerance of significant root disruption during replacement of filter media. A root barrier should be used to identify extent of media removal but should not surround the tree (i.e., allow root movement to adjacent suitable soils). The use of a perimeter root barrier can be used to protect sewers, or foundations which are likely to be at risk from root penetration. The root barrier should only be placed adjacent to the services which require protection and not around the whole device. A better approach is to place services in conduits at the time of construction.

n. Plants

Bioretention devices rely on very high plant cover between 200 to 600 mm height to protect the surface (maintain infiltration rates), support bio-chemical treatment of contaminants, prevent weed growth and keep people/traffic out of the device. Plants must be able to tolerate short periods of inundation with silty water and saturated soils along with longer dry periods. Bioretention plants should be perennial, evergreen and live at least ten years, although up to 10% other species is permissible (for colour and seasonal interest). Most suburban raingardens have low contaminant loading and are likely to last at least 50 years before renewal, so consider landscape succession. Using a variety plant species in a device increases resilience and probably enhances performance. The majority of groundcover plants should have deep, fibrous root systems and spreading or creeping growth form with many anchoring points, rather than clumped growth forms. Sightlines, operations and maintenance consequences should be considered, particularly for plants along road or footpath edges. Native plants are preferred but not essential. A high density of planting with small to medium grades of groundcover (e.g. 5 to 9 root trainers/m^2, or 3 to 5, 1 litre pots/m^2) will be most resilient to drought and weeds. Large grades of plants are vulnerable to poor weather during establishment.

A separate comprehensive planting list is attached which has species, key attributes, operation and maintenance implications, etc. If plants are chosen from this list then approval from council can be assumed although alternatives can be proposed (discretion of council). Case studies from Nelson Tasman should be visited to assess plant aesthetics and maintenance; see http://nelson.govt.nz/assets/Environment/Downloads/Water/freshwater-working-groups/Applying-Low-Impact-Designs-in-Nelson-Tasman-Landcare-Report-August-2016.pdf

o. Flushing/inspection riser

A solid drainage pipe extends to the surface with an inspection opening which also allows flushing of sediment from the under-drain. Inspection risers in mown grass areas need to be physically protected from mowers and weed whackers (e.g. with rocks/concrete nib), or placed flush with ground surface with a curb-marker (stamp) identifying its location.

p. Infiltration and geotech

The infiltration of treated stormwater into the surrounding soils is supported where the underlying soils are suited to infiltration to support stream base flows and will not adversely impact on adjacent properties or land. An impermeable liner is required to avoid infiltration in locations where slopes are greater than 1:5 (20%) or geotechnical unstable layers exist. In situations where nitrogen loads are expected to adversely impact on the receiving environment the use of an impermeable liner beneath the bioretention will support anoxic conditions and improved treatment performance through enhanced denitrification. This is referred to as a saturated zone bioretention. In such cases a wood chip amendment to substrate also enhances performance

q. Overflow

Even where a bioretention is configured to be off line, overflow must be allowed for (to address long duration and very intense events). Ideally high flows should be by-passed to a discharge point located outside the bioretention device (such as standard sump downstream of the inlet). Overflows located within the bioretention can comprise a raised manhole which connects into the underdrains or an overflow weir which connects back to the surface network at the downstream end of the system. As outlet design is a common problem, a number of good/bad practice examples are included in in section 9.2.

r. Maintenance Access

Suitable, safe access needs to be provided for routine maintenance appropriate to the size. Consider safety in design, including parking, pedestrian and vehicle sight lines and CPTED. Maintenance is more efficient if inlets and overflows are readily visible from a distance and at least 1 m from active road edges on corner bioretention. Inlets should be have a flat base at least a shovel width across 200 mm).

s. Protection

The design (shape) and planting plan must prevent vehicles driving through or parking on the bioretention devices and/or pedestrians walking through to avoid compaction and damage to plants and soil. Create raised crossings along pedestrian 'desire lines', for example adjacent to shop entrances or adjacent gates.

6. Construction

Although bioretention devices should not be fully built until the rest of the site has been constructed and the site stabilised (about 80% build-out), this rarely happens in large subdivisions. During the bulk earthworks and initial building phase the footprint should be excavated and can be configured as sediment control/capture devices as part of the Erosion and Sediment Control Plan (ESCP). The ESCP must consider the sensitivity of the receiving environment and ensure that protection is provided during the building and establishment phase. If the bioretention device is constructed before the rest of the site is stabilised then cover the substrate with a geotextile and rolled turf. Trees can be planted at this stage if they are physically protected. Once buildout is achieved the turf and geotextile is removed and planting completed. Filter socks are to be used across all inlets during these construction activities.

7. Handover

Plant establishment is critical for a bioretention device to perform. Plants shall be maintained by the developer/contractor for 24 months from the time of practical completion (establishment phase). This shall include weed control, replacement of unhealthy plants and rectification of any construction flaws. At the time that bioretention device is vested to Council all plants must have been growing for at least 3 months and be in good condition as per the design intent and/or a defect liability and bond details where applicable.

Checking is required at several stages during the construction to ensure the bioretention devices is constructed to specifications. At the hand-over stage particular attention is required to ensure the establishment phase is managed (e.g. by taking a bond) and that plant health is satisfactory.

8. Responsibility and maintenance

This practice note only covers publically vested bioretention devices or bioretention devices jointly owned and managed through a body corporate or institution that can be expected to be able to operate and maintain the device (council discretion).

One of the important considerations with bio-retention devices is long-term maintenance. A bio-retention device is a garden and not just a drainage system – they are generally low maintenance, not NO maintenance. They need water when it doesn't rain until the plants are established. During dry periods the under drain in the bio-retention devices may cause the planting soil to dry out. Watering the vegetation on an as needed basis helps ensure a healthy condition and appearance. Maintenance will include:

- Weed regularly (particularly during establishment) to maintain amenity, prevent weeds flowering or seeding (build-up of a seed bank), and to ensure rapid establishment of dense cover of desirable plants. Weeds tend to establish at inlets due to seed loads in sediment in bright light (not shaded by desirable plants).
- Ensure that inlets are clear of accumulated sediment and/or plant growth or leaves (especially in autumn)
- Ensure the outlet is not blocked. If underdrains become blocked, use the inspection pipe to clean with water jets or rodding.
- If water ponds on the surface for more than 24 hours, check for a crust formed by fine sediments or concrete wash accumulating on the surface; these can be raked (to break any crust) or scraped off where deeper.

- Don't park or drive on the device as this causes compaction and leaves ruts. If the device is mown, compaction is likely under wet conditions – ensure the grass is at least 80 mm height and dense (do not spray broadleaf weeds – hand weed)
- Plant health is an indicator of system effectiveness. Plants along edges are likely to require trimming; trees are likely to require removal of staking, pruning (particularly crown lifting to maintain sightlines) or thinning from time to time.
- Do not fertilise or add pesticides such as slug bait.
- Strong water flows may cause erosion, particularly at inlets. Erosion will need to be repaired and measures put in place to prevent recurrence (for example, removing inlet constraints, creating wider inlet or adding rip rap).
- Remove rubbish, litter and debris, however, dead plant leaves can be retained, tucked out of sight where they contribute to stormwater attenuation.

9. Attachments

9.1. Plants for Nelson/Tasman stormwater bioretention

NOTES:

Match plant size to location within the bioretention device as shown above. The width and height of plants along edges with roads or foot paths has a huge impact on maintenance costs. Upright and shorter plants require less trimming. The photos above show key plant selection zones: road 'edge', wet or dry swale 'base' or bed through which water flows (requiring dense ground covers that filter water and avoid deflecting or concentrating water flows), a 'CIPTED' bed that allows open views across the devices (and can include trees or shrubs that are narrow or have trunks with clear 2 to 2.5 m trunks to maintain views and light levels to ground cover plants) and 'vegetation edge' that abuts taller landscaping elements (allowing plants that 'flop', or are bulkier).

Match plant species to site conditions. The species below have been selected based on performance in silt loam and sandy soils in Nelson/Tasman, however the level of drought stress varies across devices with changes in soil depth, organic content and temperature. Salt wind and frosts are also site specific.

Most groundcover plants listed below are at least 400 mm tall, but less than 1 to 1.3 m at maturity, and form dense cover that is able to supress weeds that require light to grow. Smaller groundcovers can be used where a higher level of maintenance is agreed: these include smaller sedges such as *Carex comans*, *C. buchananii* , *C. flagellifera* and *C. petriei* , rasp fern, and many creeping herbs: *Acaena species (bidibid), Dichondra repens, Centella uniflora, Cotulas, Leptinellas, Lobelia angulate, Mazus radicans, Muehlenbeckia axillaris, Sellieria radicans* In sandy coastal carparks in Nelson, *Euphorbia glauca* has been used as an attractive component with the tree *ngaio (Myporum laetum)*. Grasses that may be mistaken for weeds, such as *Poa imbecilla, Hierochloe redolens, Lachnogrostis, Microlaena stipoides* and *Rytidosperma*, have not been included.

Links for further information, including sourcing, planting timing and methods are given below. However, note that planting in all bioretention devices should be staggered, in clusters to specifically **avoiding lines** as these may concentrate water flow and lead to erosion. High plant density at inlets helps reduce erosion risk. Where pukekos are present larger plant sizes and specific planting methods may need to be used to prevent plant removal.

~ Nelson Living Heritage plant guide: http://nelson.govhttp://nelson.govt.nz/assets/Environment/Downloads/living-heritage-nelson-native-plants.pdf
~ Back yard biodiversity in Canterbury http://www.lincolnenvirotown.org.nz/assets/Uploads/docs/BackyardBiodiversityBookletWEBMarch2011.pdf
~ Landscape and ecology values within stormwater management http://www.aucklandcity.govt.nz/council/documents/technicalpublications/TR2009083.pdf
~ How to put nature into our neighbourhoods http://www.mwpress.co.nz/__data/assets/pdf_file/0015/70503/LRSS_35_nature_neighbourhoods.pdf
~ Nga Tipu Aotearoa – New Zealand Plants http://www.landcareresearch.co.nz/resources/data/nzplants

*Table 2: Planting list for stormwater bioretention. **Bold plants indicate suggested use as dominant components**, (N) indicates plant recommended in Nelson's Living Heritage Guide.*

Groundcover plants	*Anemanthele lessoniania*	bamboo grass (N)	0.9 m with taller flower spikes best planted in raingardens with better soils and fertility (less stressful)
	Apodasmia similis	jointed rush (N)	0.5 to 1.3 m rush, very weed resistant once established and tolerant of a wide range of conditions but naturally found in saline environments; select upright and shorter forms available in Nelson. Will smother other plants in tough sites.
	Astelia fragrans	astelia, kahaka (N)	1.5 m spreading 1.5 m lilly, highly aesthetic, berries, use as minor component in moist sites (not very sandy media), establishes slowly; *Astelia grandis* is suitable for very moist sites
	Austroderia richardii	South Island toetoe (N)	2 m spreading 2 m tussock was *Cortaderia.* very sensitive to glyphosate, too large for bioretention less than 3 m width or adjacent to road sight lines. Use as scattered plants within shrubs.
	Austrostipa stipoides	Estuary needle grass (N)	0.7 M, grass with very sharp tips, hard to weed but useful to exclude people
	Blechnum novae zelandiae	kiokio (N)	1.5 m fern, new foliage is attractive red, use as minor component in larger, moist or shaded raingardens as tends to establish slowly
	Carex geminata	cutty grass, rautahi	0.8 m tussock with sharp edges helps keep people out of swales
	Carex lessoniana	rautahi	1.0 m green tussock-sedge
	Carex secta	purei, makura (N)	2m green tussock-sedge when mature, not suitable for swales as forms a trunk, too large for bioretention cells less than 2.5 m width; check sight lines
	Carex testaceae	speckled sedge	0.5 to 0.7 m, moderate drought and waterlogging tolerance so for sites with richer soils, edge plant where no glyphosate is used
	Carex virgata	purei, makura (N)	1m sharp-edged sedge, often used in swales, grows fast and will smother other plants in high fertility conditions
	Coprosma acerosa	sand coprosma	0.2 to 1.2 m depending on cultivar – a wide variety of leaf colours available as with other ground-cover coprosmas, and nearly all have performed well in Nelson / Tasman (see photos)

	Coprosma repens	taupata (N)	Prostrate forms have been successful in Nelson coastal raingardens where there is no frost, but are not local, otherwise use *C. acerosa*
	Chinochloa rubra	red tussock	1.2 m tussock suits frosty sites with moderate to high moisture (not droughts or salt). Highly attractive, long lived tussock.
	Cyperus ustulatus	umbrella sedge, upoko tangata (N)	0.8 to 1.5 m, very sharp-edged sedge, deciduous so can look messy, minor and tough to weed amongst
	Dianella nigra	**turutu, NZ blueberry**	0.5 to 0.8 m lily with blue berries, a useful and widely used edge plant
	Eleocharis acuta	spike sedge	0.5 m suits base of wet, narrow swales as has low drought tolerance
	Ficinia nodosa	**knobby clubrush (N)**	0.6 to 1 m green-orange sedge (edge) with high drought and salt wind tolerance, unsuitable for base of wet swales
	Hebe species	koromiko	Variety of heights to 3 m depending on species and cultivar that require well-drained raingardens, not suitable for swales
	Juncus australis	rush (N)	0.6 to 1.2 m hardy rush for swales may be seen as weed by farmers, will invade swales near pasture with seed sources
	Juncus edgariae	wiwi, common rush (N)	1.5 m spreading 1 m for swales
	Lepidosperma australe	four square sedge	0.6 m upright sedge with high drought tolerance for swales
	Libertia peregrinans *L.grandiflora/L. ixioides (N)*	NZ iris	0.5 to 0.7 m tussocks with white flowers and attractive short seed heads; an edge plant that spreads by seeds and rhizomes. Plant with scrambling 'gap fillers'; not suitable with deciduous trees as hard to remove weeds/rubbish without pulling out clumps
	Phormium cookianum	whārariki, coastal flax (N)	1 to 1.5 m but size varies with cultivar; consider length of flower spikes where adjacent to paths or roads (1.5 to 2 m); remove larger plants at 12 months
Shrubs and Trees for larger bioretention areas, particularly along edges and adjacent areas where roots can enter bioretention to enhance recovery	*Coprosma propinqua*	Mingimingi (N)	6 m narrow, small-leafed shrub with berries and high tolerance of drought, moisture, salt and wind. Space out to maintain sight lines
	Carpodetus serratus	putaputaweta (N)	Small tree to 10 m can be covered in small white flowers attractive to insects, mainly better draining but moist soils
	Coprosma tenuicaulis	Swamp coprosma, hukihuki	3 m tangled but upright shrub with black berries for wetter swales provides interest and diversity in wetter swales
	Cordyline australis	ti kouka, cabbage tree (N)	Narrow, architectural tree to 12 m tolerant of wind, provides fragrant flowers and fruit for birds and insects but little shade. Plant at least 3 m from any mown areas as leaves damage mowers

of stormwater detention volumes	*Dacrycarpus dacrydioides*	kahikatea, white pine (N)	Noble, slow-growing, tall tree (20-30m), plant where weeds can be maintained for at least 3 years
	Hebe stricta var, atkinsonii	n/a (N)	Fast-growing shrub with large ‘bottle brushes’ of white flowers; other hebes are also used in Nelson; select cultivars with heights that will maintain required sight lines or confirm maintenance allows trimming (e.g. hedge)
	Hoheria angustifolia	houhere, narrow-leafed lacebark (N)	Small tree to 10 m with tangled juvenile form
	Kunzea ericoides	kanuka (N)	Small tree to 10 m for drier raingardens with abundant, small white flowers
	Leptosopermum scoparium	manuka, teatree (N)	Small tree to 8 m with abundant white flowers (or pink to red if cultivars are used) produced over a long period, tolerant of compaction and full sun
	Phormium tenax	harakeke, flax (N)	2 to 2.5 m monocot clump; plant at least 3 m from paths or roads, do not use in swales, too large for bioretention less than 4 m width or adjacent to road sight lines
	Plagianthus regius	manatu, lowland ribbonwood (N)	Small tree to 15 m
	Sophora microphylla	Kowhai (N)	Small tree to 10 m, attractive to tui, bellbird (nectar) and keruru (leaves) but needs reasonably free drainage, not ponded water

1. .

Bio retention checklist

9.2. Good and bad practise examples

	Good example Large bioretention retrofitted into heritage landscape feature. Bioretention utilises existing formed edges to create ponding with dense plant cover
	Bad example Raingarden undersized for its catchment and landuse (high traffic road with increased loads). Lack of surface vegetation and maintenance results in reduced infiltration rates and surface ponding. Poor landscape outcomes
	Bad example Levels of raingarden not able to receive inflows from kerb resulting in excessively dry media and poor plant health. Contaminants (and flow) bypass system.
	Bad example Use of gabion at inlet results in blockage which is difficult to rectify. Ultimately inlet is restricting inflows into system. Worsened by significant deciduous trees in immediate catchment and lack of sediment control in development building phase

Bio retention checklist

	Bad example Sloped raingarden surface prevents engagement of full filter media area and reduces the detention storage volume. Raingarden effectively overflows from lower corner with uncontrolled flow across footpath.
	Bad example Stormwater catch pit located immediately upstream of raingarden. Flows unable to enter raingarden resulting in negligible treatment and poor plant growth.
	Bad example Small raingarden inlets prone to rapid blockage and difficult to maintain. Ultimately prevents flow entering system and therefore prevents treatment.
	Bad example Small raingarden inlets prone to rapid blockage and difficult to maintain. Ultimately prevents flow entering system and therefore prevents treatment.
	Bad example Lack of detention depth and step down from road surface results in plants blocking inflows

	Bad example Small raingarden inlets prone to rapid blockage and difficult to maintain. Ultimately prevents flow entering system and therefore prevents treatment. Worsened by position on busy arterial road preventing easy maintenance.

Bio retention checklist

The most common bioretention devices: raingardens, bioretention swales and stormwater planters.

Wooden stormwater planter showing key features from left to right: Outlet of underdrain (to rock-mulched surface swale); a PVC pipe with perforations spreads stormwater evenly, avoids erosion, and is detachable for cleaning; the overflow and black plastic-lining that is waterproof with swale in the background; the wooden box integrated into decking with white inlet downpipe. The plants are oioi (*Apodasmia similis, left*), *Sellieria radicans* (centre), and a perennial, non-native lilly (right).

Stormwater planters and planter-possibilities: left – downpipe scuppers discharge onto rock-rip rap which removes energy from stormwater before it flows into planted bed; metal lining creates a hard-wearing edge against the building. Centre – This Nelson pool has planter boxes that could be easily re-purposed as planter boxes to capture runoff from the white downpipe. Right – Runoff from this Nelson carpark could be treated in the planter given suitable inlets and sub-drainage.

Bio retention checklist

Bioretention swale about six months after planting and after about three years; plants on the well-drained edges are prostrate Coprosmas, prostrate manuka, mountain flax and scrambling pohuehue, with oioi in the wet base of the swale.

Raingarden treating parking lot runoff shortly after planting, showing the overflow, and after about three years; a diverse range of native groundcovers is used including coprosmas, shrubby pohuehue, sedges and Astelia, with lancewood providing interest.

Bioretention can be located to provide multiple benefits: these three locations protect pedestrians from traffic, maintain clear views of intersections by preventing parking, and also receive the dirtiest runoff (corners are where brakes and tyres are worn, and spills are most likely to occur). Left – bump out in Nelson city could be converted to a raingarden; centre – bump out raingarden protects a bus stop and pedestrian crossing (Portland, Oregon, before planting); right – turn around raingarden with edges protected by boulders (North Harbour residential development).

Bio retention checklist

Effective placement of bioretention. Left – bioretention in a public through fare separates cycle parking from pedestrians ; Centre and right – bioretention set back from the road edge allows people to get out of cars and reduces need for traffic controls when trimming vegetation / removing litter (Portland, Oregon and New Lynn Auckland)

Edge details are important. Left – raised edges with colour differentiation from the pavement reduce risk of pram and pedestrian entry in this public space (Adelaide Zoo); centre – tall concrete edge creates car and cyclist hazard, and high-maintenance grass strip between footpath and device (Auckland); right – sharp drop, colour contrast and bollards along edge of large raingarden that receives runoff from downpipe (with boulders to dissipate energy)

Narrow bioretention and small cell on corners with no protective edges are highly vulnerable to traffic damage

Bio retention checklist

TREE PLACEMENT

Left – placing trees between raingardens helps anchor trees and reduces damage to trees if raingardens are rejuvenated; the sloping sides at this site allow concrete retaining to be reduced. Right – bioretention swale showing underdrain and clean gravel drainage layer during construction. Deeper areas (foreground) support trees with 1000 mm media; between the trees the depth is 600 mm (photo by Chris Stumbles). Right – existing trees are incorporated into raingardens with a temporary cover of coir matting preventing weed establishment until planting.

INLETS

Inlets must be large to avoid being blocked by litter (fast food outlet in left photo) or leaves, especially if deciduous trees are nearby. Plane trees have large leaves and meant the inlets in the centre photo needed at least weekly maintenance. Inlets can be created by having gaps between bricks, but in this case the gap is too narrow (right)

These inlets are too narrow. Centre – an innovative cap allows for stencilling stormwater information but increases risk of blockage. Right – placement of stones reduces potential scour at the bioretention side of the inlet.

A 50 to 100 mm drop over concrete allows sheet flow into these swales planted with scrambling pohuehue and pohutukawa trees (left, Auckland), low sedges and taller rushes with kōwhai and ribbonwood trees (centre, Lincoln, Canterbury) and mountain flax and pohutukawa (right, Waitakere).

In the absence of a vertical 50 to 100 mm drop into a swale, physical barriers are usually important to exclude vehicles. Left – boulders used (Nelson); centre – bollards used (Melbourne); right – a clever use of curbs around trees (Nelson)

Physical protection and effective drop into a grass swale planted with totara (Manukau), trees should be planted on the sides of a swale as shown in Saxton Fields (centre). Trees should not be planted in the centre of swales as 1) the surface rises with tree age 2) bare sprayed areas around tree bases should not be in the main flow path (right, Stoke).

Bio retention checklist



Non-floating mulches include shell (left, Nelson port) and composted, stringy bark (centre, Stoke). Bark nuggets (right) should never be used where water will float or pond as they are prone to floating.



Common faults. Inadequate planting density in swale base and rock mulch that is too big to allow rushes to spread (Left), planting in rows that leave the vital central area bare (centre) and using plants that flop over areas that require clear passage (right). These plants need cutting 2 to 4 times a year so are expensive to maintain.

NELSON PHOTOS



Left – Nelson has a range of upright, smaller stature oioi that create a weed-resistant cover with reduced trimming requirement (left, Mitre 10 Nelson). Centre – placement of seating over the garden edge protects the garden from damage and creates a sense of enclosure (Stoke, not bioretention, but could easily be). Right – small sedges (*Carex testaceae*) form a shorter, low maintenance edge to a pathway. The sedges are protected from invasion from adjacent oioi by a concrete nib (Stoke).

Bio retention checklist


Attractive plantings in dry detention basins / overland flow paths, Stoke using mainly flax and sedges with cabbage trees. The drier 'riparian' areas include colourful flowering hebes and manuka with kowhai and ribbonwood trees.



Nelson/Tasman Bioswale plantings. Left – stakes are used to allow fast identification for efficient weed control during establishment of this swale. Centre – a low-maintenance edge of gravel-mulched, short turutu (Dianella nigra) and taller oioi and knobby clubrush (Ficnia nodosa) in the centre. Right – *Cyperus ustulatus* in the centre of this raingarden is considered 'messy' by some people and may require removal of seed-heads to achieve suitable aesthetic outcomes in some localities.


Plant species used in drier bioswales and raingardens include shrubby pohehue (*Meuhlenbeckia astonii*) and Libertia species (here at Tahuna), although Libertia can be difficult to weed (left), small sedges and oioi (centre, Stoke). Right – some Hebe species and cultivars can be used to form short, fast-growing hedges with abundant flowers

Prostrate, dense Coprosma species and cultivars are useful plants for bioretention: left – Coprosma acerosa, centre – Coprosma acerosa 'Hawera', right - Coprosma repens 'Poor Knights' has glossy, bright-green leaves (Nelson Port), a taller olive-brown Coprosma lies behing.

Avoid planting lowland flax within 2.5 to 3 m of paths (Stoke cycleway

9.3. Acknowledgements and source references

The Practice notes were developed by Morphum Environmental with input from Robyn Simcock from Landcare related to planting specifications and overall peer review.

These practice notes including graphic are largely based on information from the North Shore City Council Bioretention guidelines (2008), the Long Bay Practice Notes developed for North Shore city Council by D & B Kettle Consulting Ltd (2011) and the Bioretention Practices Notes for Hamilton City Council (2016).

9.4. Version, version control and change comments

The Practice notes were developed by Morphum Environmental with input from Robyn Simcock from Landcare related to planting specifications and overall peer review.

Summary of changes

Version	Date	comments
0.1	24 January 2017	First draft for comment from the Industry
0.2	12 June 2017	Second draft including planting requirements
1.0	16 June 2017	Immediate Release version, showing good practice, independent of local requirements

9.5. Want to know more?

There is a lot of information available related to Low Impact Design (LID, or Waster Sensitive Urban Design (wsud). Underneath are few references. It should be noted that all info in these documents is not necessarily agreed, up to date and/or applicable in the Nelson/Tasman area and that the application of LID is evolving over time.

Landcare / Morphum Ltd: "Applying Low Impact (Water Sensitive) Design in Nelson Tasman", June 2016. A review of LID practices in Tasman and Nelson and issues experienced by council and the industry. Includes description of many different LID devices and recommendations for improvement.

All Hamilton practice notes can be found on the Hamilton Council website

Auckland council "Water Sensitive Design Guide GD04". An online resource, including background and wider design approach.

CRC for Water Sensitive Cities: "Adoption guidelines for stormwater biofiltration systems – Summary report"