

## 4.6 Vegetated Filter Strips

### 4.6.1 Overview

#### Description

Vegetated filter strips (a.k.a. buffer strips and grassed filter strips) are gently sloping, densely vegetated areas that treat runoff as sheet flow from adjacent impervious areas (Figure 4.6.1). They function by slowing runoff velocity and filtering out suspended sediment and associated pollutants, and by providing some infiltration into underlying soils. Originally used as an agricultural treatment practice, filter strips have evolved into an urban SWM practice. Vegetation may be comprised of a variety of trees, shrubs and native plants to add aesthetic value as well as water quality benefits (see Appendix B for guidance on plant species selection). With proper design and maintenance, filter strips can provide relatively high pollutant removal. Maintaining sheet flow into the filter strip through the use of a level spreading device (e.g., pea gravel diaphragm) is essential.

Using vegetated filter strips as pretreatment practices to other best management practices is highly recommended. They also provide a convenient area for snow storage and treatment, and are particularly valuable due to their capacity for snowmelt infiltration (Figure 4.6.2). If used for snow storage, the area should be planted with salt-tolerant, non-woody plant species. Because of the simplicity of filter strip designs, physical changes to the practice are not needed for winter operation.

Filter strips are included in Section 4.5.12 of the OMOE 2003 *Stormwater Management Planning and Design Manual*. The guidance in this guide is intended to supplement that resource.

**Figure 4.6.1 Filter strips along a residential road and as pretreatment to a dry swale**



Source: Trinkaus Engineering (left), Seattle Public Utilities (right)

**Figure 4.6.2 Snow storage on a filter strip in Markham, Ontario**



### Common Concerns

There are some common concerns associated with vegetated filter strips:

- **Risk of Groundwater Contamination:** Most pollutants in urban runoff are well retained by infiltration practices and soils and therefore, have a low to moderate potential for groundwater contamination (Pitt *et al.*, 1999). Chloride and sodium from de-icing salts applied to roads and parking areas during winter are not well attenuated in soil and can easily travel to shallow groundwater. Infiltration of de-icing salt constituents is also known to increase the mobility of certain heavy metals in soil (*e.g.*, lead, copper and cadmium), thereby raising the potential for elevated concentrations in underlying groundwater (Amrhein *et al.*, 1992; Bauske and Goetz, 1993). However, very few studies that have sampled groundwater below infiltration facilities or roadside ditches receiving de-icing salt laden runoff have found concentrations of heavy metals that exceed drinking water standards (*e.g.*, Howard and Beck, 1993; Granato *et al.*, 1995). To minimize risk of groundwater contamination the following management approaches are recommended (Pitt *et al.*, 1999; TRCA, 2009b):
  - stormwater infiltration practices should not receive runoff from high traffic areas where large amounts of de-icing salts are applied (*e.g.*, busy highways), nor from pollution hot spots (*e.g.*, source areas where land uses or activities have the potential to generate highly contaminated runoff such as vehicle fuelling, servicing or demolition areas, outdoor storage or handling areas for hazardous materials and some heavy industry sites);
  - prioritize infiltration of runoff from source areas that are comparatively less contaminated such as roofs, low traffic roads and parking areas; and,
  - apply sedimentation pretreatment practices (*e.g.*, oil and grit separators) before infiltration of road or parking area runoff.
- **Risk of Soil Contamination:** Available evidence from monitoring studies indicates that small distributed stormwater infiltration practices do not contaminate underlying soils, even after more than 10 years of operation (TRCA, 2008).

- *Maintenance*: Requirements are greatest during the first two years, when vegetation is becoming established and involve regular inspection, replacing dead or invasive vegetation and possibly watering. Once vegetation is established, maintenance is limited to periodic mowing, pruning, aeration and removal of trash, debris and accumulated sediment from pretreatment devices and the filter strip.
- *Erosion*: Limits on the allowable slope of the filter strips and use of level spreaders should prevent erosion.
- *On Private Property*: If vegetated filter strips are installed on private lots, property owners or managers will need to be educated on their routine maintenance needs, understand the long-term maintenance plan, and may be subject to a legally binding maintenance agreement. An incentive program such as a storm sewer user fee based on the area of impervious cover on a property that is directly connected to a storm sewer (*i.e.*, does not first drain to a pervious area or LID practice) could be used to encourage property owners or managers to maintain existing practices.
- *Standing Water and Mosquitoes*: On properly designed filter strips, standing water should not occur. If pools of standing water are observed along the slope, regrading and revegetation may be required.
- *Winter Performance and Operation*: When immediately next to roads or parking lots, filter strips can act as a permeable snow storage area. Extra maintenance may be needed to remove accumulated sand following the spring melt event or to replace vegetation damaged by road de-icing salt constituents.

### **Physical Suitability and Constraints**

Vegetated filter strips can be used in a variety of situations however there are several constraints to their use:

- *Available Space*: The flow path length across the vegetated filter strip should be at least 5 metres to provide substantial water quality benefits (Barrett *et al.*, 2004). Vegetated filter strips incorporated as pretreatment to another water quality best management practice may be designed with shorter flow path lengths.
- *Site Topography*: Filter strips are best used to treat runoff from ground-level impervious surfaces that generate sheet flow (*e.g.*, roads and parking areas). The recommended filter strip slope is between 1% to 5%. Though steeper slopes increase the likelihood of erosion, incorporation of multiple level spreaders in series or terraces can counteract this.
- *Water Table*: Filter strips should only be used where depth to the seasonally high

water table is at least one (1) metre below the surface.

- *Soils*: Filter strips are a suitable practice on all soil types. If soils are highly compacted, or of such low fertility that vegetation cannot become established, they should be tilled to a depth of 300 mm and amended with compost to achieve an organic content of 8 to 15% by weight or 30 to 40% by volume.
- *Flow Path Length Across Impermeable Surface*: A limiting design factor is that the maximum flow path length across the impermeable surface should be less than 25 metres. This is because runoff flowing as sheet flow over an impermeable surface tends to concentrate after 25 metres (Clayton and Schueler, 1996). Once runoff from an impervious surface becomes concentrated, a swale design should be used instead of a vegetated filter strip (Barrett *et al.*, 2004).
- *Pollution Hot Spot Runoff*: To protect groundwater from possible contamination, source areas where land uses or human activities have the potential to generate highly contaminated runoff (e.g., vehicle fueling, servicing and demolition areas, outdoor storage and handling areas for hazardous materials and some heavy industry sites) should not be treated by vegetated filter strips.

### Typical Performance

Vegetated filter strips are primarily a practice used to achieve water quality improvements although some infiltration can occur, depending on the soil type and infiltration rate. The ability of filter strips to help meet stormwater management objectives is summarized in Table 4.6.1.

**Table 4.6.1 Ability of vegetated filter strips to meet SWM objectives**

BMP	Water Balance Benefit	Water Quality Improvement	Stream Channel Erosion Control Benefit
Vegetated Filter Strips	Partial - depends on soil infiltration rate	Partial – depends on soil infiltration rate and length of flow path over the pervious area	Partial - depends on soil infiltration rate

### Water Balance

Research indicates that runoff reduction from vegetated filter strips is a function of soil type, slope, vegetative cover and flow path length across the pervious surface. Table 4.6.2 summarizes available research regarding runoff reduction rates.

A conservative runoff reduction rate for vegetated filter strips is 25% for HSG C and D soils and 50% for HSG A and B soils. These values apply to filter strips that meet the design criteria outlined in this section.

**Table 4.6.2 Volumetric runoff reduction achieved by vegetated filter strips**

LID Practice	Location	Runoff Reduction	Reference
Filter Strip	Guelph, Ontario	20 to 62% <sup>1</sup>	Abu-Zreig et al (2004)
Filter Strip	California	40 to 70% <sup>1</sup>	Barrett (2003)
<b>Runoff Reduction Estimate:</b>		<b>50% on HSG A and B soils; 25% on HSG C and D soils</b>	

Notes:

1. Where a range is given, the first number is for a flow path length of 2 to 5 metres and the second is from 8 to 15 metres.
2. This estimate is provided only for the purpose of initial screening of LID practices suitable for achieving stormwater management objectives and targets. Performance of individual facilities will vary depending on site specific contexts and facility design parameters and should be estimated as part of the design process and submitted with other documentation for review by the approval authority.

### **Water Quality**

Vegetated filter strips can provide moderate pollutant removal from runoff. Research suggests that runoff pollutant concentrations and loads decrease when treated with filter strips and that steady state pollutant levels are typically achieved within five (5) metres of the pavement edge (Barrett *et al.*, 2004).

Based on a synthesis of performance monitoring studies as of 2000, it was reported that pollutant removal efficiencies of vegetated filter strips are highly variable (Table 4.6.3). For this reason, filter strips should be used in conjunction with other water quality best management practices (*e.g.*, as pretreatment).

**Table 4.6.3 Pollutant removal efficiencies of vegetated filter strips**

Pollutant	Removal Efficiency <sup>1</sup>
Total Suspended Solids (TSS)	20 to 80%
Total Nitrogen	20 to 60%
Total Phosphorus	20 to 60%
Total Heavy Metals	20 to 80%

Source: ASCE, 2000

Notes:

1. Removal efficiencies are based on differences between event mean concentrations of pollutants in runoff from vegetated filter strips relative to an untreated impervious surface.

Performance of filter strips has also been evaluated based on the Roadside Vegetated Treatment Sites Study (Barrett, 2003) and the BMP Retrofit Pilot Study (Caltrans, 2004). These studies concluded that concentration reductions consistently occur for TSS and total heavy metals and frequently for dissolved metals. Nutrient concentrations remained generally unchanged. When vegetation cover on the filter strip is below 80% water quality performance declines.



## 4.6.2 Design Template

### Applications

Filter strips are best suited for pretreatment of runoff from roads and parking lots prior to it being treated by other best management practices (e.g., Figure 4.6.3). They are also an ideal practice within stream or wetland buffer zones. Filter strips can be used as part of a treatment train approach (Figure 4.6.4). Filter strips may also be applied at roof leaders, outfalls, or large parking lots if level spreaders are used to create sheet flow. They are often impractical in densely developed urban areas because they consume a large amount of space.

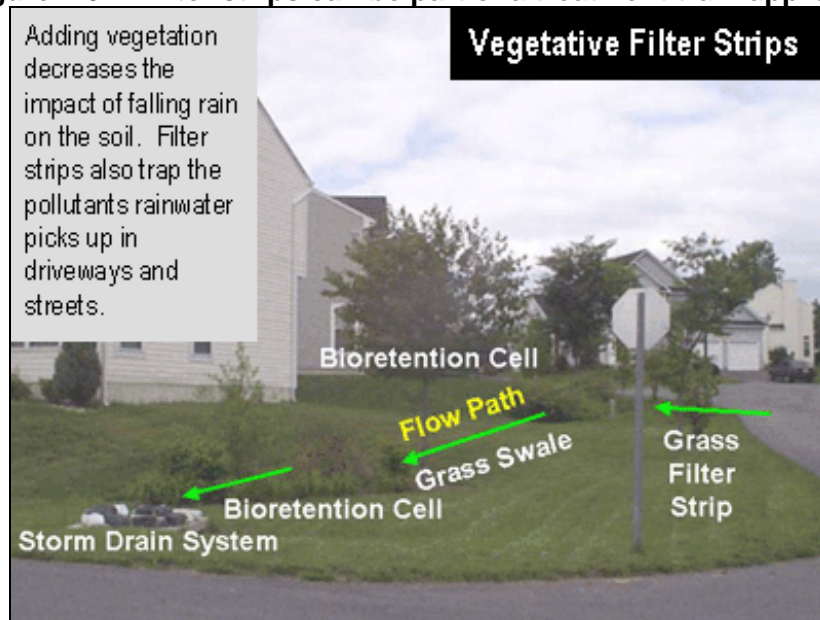
Properly functioning filter strips should not pond water on the surface and do not contribute to stream warming. Thus, filter strips are a good stormwater treatment option for cold water streams that support species sensitive to changes in stream temperature.

**Figure 4.6.3 Filter strips providing pretreatment of parking lot runoff**



Source: CWP (left), Aquafor Beech (right)

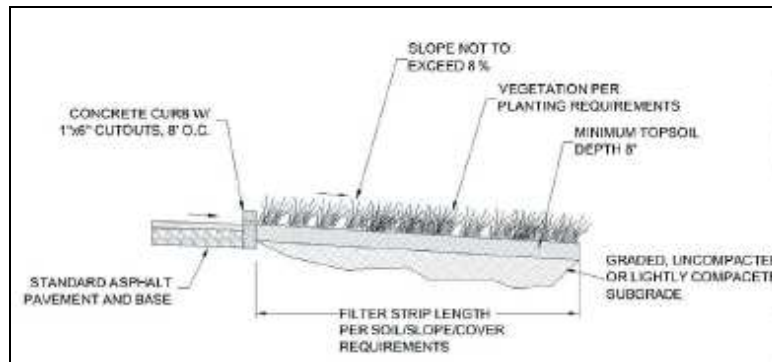
**Figure 4.6.4 Filter strips can be part of a treatment train approach**



Source: U.S. EPA

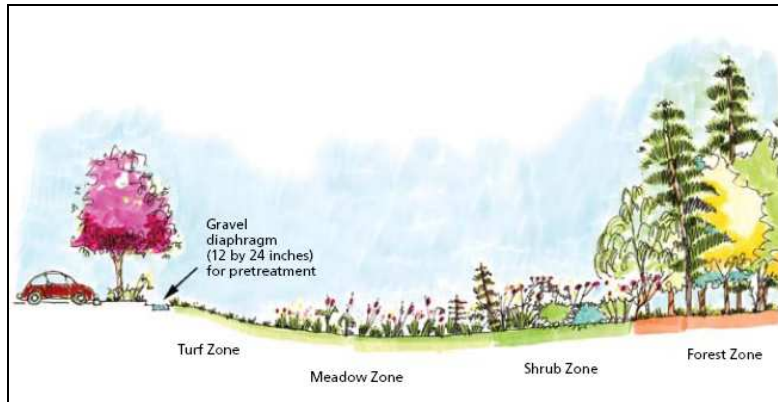
## Typical Details

**Figure 4.6.5 Filter strip with curb cut-outs**



Source: GVRD, 2005

**Figure 4.6.6 Multi-zone filter strip profile**



Source: Cappiella *et al.*, 2006

See also Figure 4.16 in the OMOE *Stormwater Management Planning and Design Manual* (OMOE, 2003).

### Design Guidance

While filter strips are a simple technology, proper design requires attention to detail because small problems, such as concentration of inflowing runoff or improper grading, can decrease effectiveness and create nuisance soil erosion or ponding of water conditions.

#### **Geometry and Site Layout**

The maximum contributing flow path length across adjacent impervious surfaces should not exceed 25 metres. The impervious surfaces draining to a filter strip should not have slopes greater than 3%.

The flow path length across the vegetated filter strip should exceed the maximum flow path length across the impervious surface draining to it.

The filter strip should have a flow path length of at least five (5) metres to provide substantial water quality benefits; however, some pollutant removal benefits are realized with three (3) metres of flow path length.

### ***Pretreatment***

A pea gravel diaphragm at the top of the slope is recommended. The pea gravel diaphragm (a small, gravel filled trench running along the top of the filter strip) serves two purposes. First, it acts as a pretreatment device, settling out coarse particles before they reach the practice. Second, it acts as a level spreader, maintaining sheet flow as runoff flows over the filter strip. If the contributing drainage area is steep, then larger stone should be used in the diaphragm.

### ***Conveyance and Overflow***

Level spreaders are recommended to ensure runoff draining into the filter strip does so as sheet flow (e.g., pea gravel diaphragms, concrete curbs with cutouts). When filter strip slopes are greater than 5%, a series of level spreaders should be used to help maintain sheet flow. Some common type of level spreader devices are pea gravel diaphragms, concrete curbs with cutouts or earthen berms.

The filter strip should drain continuously as sheet flow until reaching a swale, other LID practice or a storm sewer inlet. When designed as a stand alone water quality BMP (*i.e.*, not pretreatment to another BMP) the vegetated filter strip should be designed with a pervious berm of sand and gravel at the toe of the slope for shallow ponding of runoff. The berm should be 150 to 300 millimetres in height above the bottom of the depression and should contain a perforated pipe underdrain connected to the storm sewer (Cappiella *et al.*, 2006). Runoff ponds behind the berm and gradually flows through it, into the perforated pipe underdrain connected to the storm sewer system. The volume ponded behind the berm should be equal to the water quality storage requirement. During larger storms, runoff will overtop the berm and flow directly into a storm sewer inlet (Cappiella *et al.*, 2006). This berm is not needed when filter strips are used as pretreatment to another stormwater best management practice.

### ***Soil Amendments***

If soils on the filter strip site are highly compacted, or of such low fertility that vegetation cannot become established, they should be tilled to a depth of 300 mm and amended with compost to achieve an organic content of 8 to 15% by weight or 30 to 40% by volume.

### ***Landscaping***

Filter strip vegetation can consist of turf grasses, meadow grasses, wildflowers and herbs, shrubs, and trees. Designers should choose vegetation that stabilizes the soil and is salt tolerant where the filter strip will be used for snow storage or to treat road runoff. Filter strips used for snow storage and treatment should be planted with non-woody vegetation. Vegetation at the toe of the slope, where ponding will occur, should be able to withstand both wet and dry soil conditions. The planting areas can be divided into zones to account for differences in moisture conditions and slope.



Traditional filter strips are grass slopes that treat sheet flow from adjacent impervious areas. An alternative design is a forested filter strip. In a forested filter strip, the entire filter strip is planted with trees and shrubs. Another design is the multi-zone filter strip, which features several vegetation zones that provide a gradual transition from turf to meadow to shrub and forest. The multi-zone filter strip design can be effective as a buffer zone to an existing natural heritage feature.

Trees and shrubs with deep rooting capabilities are recommended for planting to maximize soil infiltration capacity (PWD, 2007). Appendix B provides guidance regarding planting and selection of suitable species.

### ***Maintenance Agreement***

The filter strip should be protected by a perpetual easement or deed restriction that assigns the responsible party to ensure no future development, disturbance or clearing can occur within the area.

### ***Other Design Resources***

Stormwater resources that provide useful guidance for filter strips are:

North Carolina State University Level Spreader Design Worksheet  
[http://www.bae.ncsu.edu/cont\\_ed/main/handouts/lsworksheet.pdf](http://www.bae.ncsu.edu/cont_ed/main/handouts/lsworksheet.pdf)

Philadelphia Stormwater Management Guidance Manual  
<http://www.phillyriverinfo.org/Programs/SubprogramMain.aspx?Id=StormwaterManual>

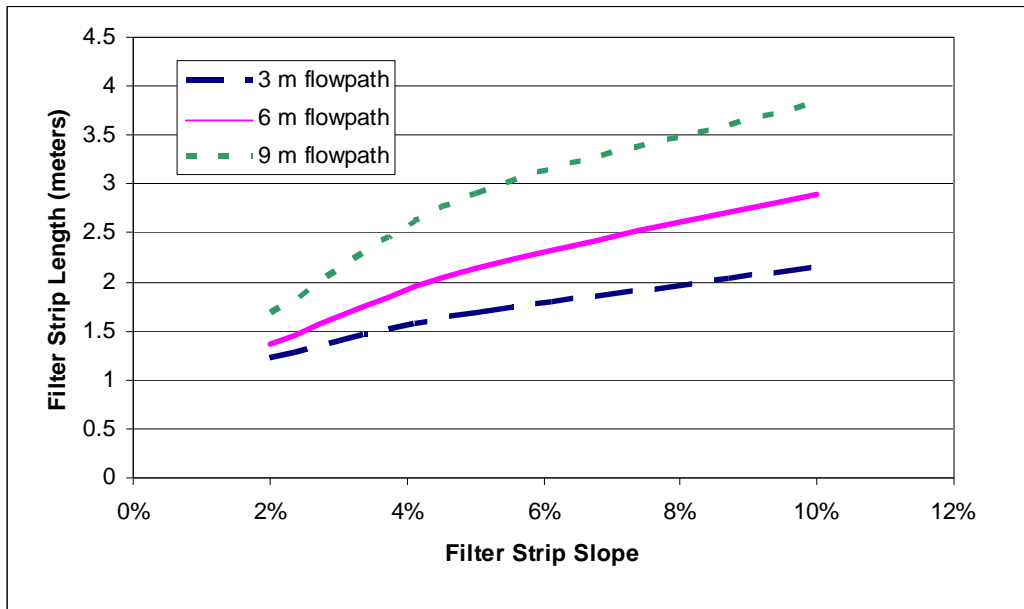
2004 Portland Stormwater Management Manual  
<http://www.portlandonline.com/bes/index.cfm?c=dfbbh>

### **BMP Sizing**

Water quality benefits can be achieved when vegetated filter strips are designed as follows:

- 1) Where the contributing flow path length (across the impermeable surface) is 9 metres or less, filter strip length and slope should be designed based on the relationship shown in Figure 4.6.7.
- 2) Where the contributing flow path length is greater than 9 metres and less than 25 metres, filter strips should be designed with a maximum velocity of 0.5 metres/second and a length that is greater than the contributing flow path length.

**Figure 4.6.7 Filter strip length sizing based on slope and contributing flow path**



Source: adapted from PWD, 2007

For further guidance regarding BMP sizing, refer to the OMOE *Stormwater Management Planning and Design Manual* (OMOE, 2003)

**Design Specifications**

Table 4.6.4 below gives the specifications for pretreatment to filter strips.

**Table 4.6.4 Filter strip pretreatment specifications**

Material	Specification	Quantity
Pea Gravel Diaphragm	Washed aggregate that is 3 to 10 mm in diameter	Diaphragm should be a minimum of 300 mm wide and 600 mm deep (MDE, 2000)
Gravel or Earthen Berm	Berm should be composed of sand (35 to 60%), silt (30 to 55%), and gravel (10 to 25%) (MDE, 2000) Gravel should be 15 to 25 mm in diameter	Based on width of the filter strip

**Construction Considerations**

The following should be considered during the construction of filter strips:

- *Soil Disturbance and Compaction:* The limits of disturbance should be clearly shown on all construction drawings. Before site work begins, areas for filter strips should be clearly marked and protected by acceptable signage and silt fencing. Only vehicular traffic used for construction should be allowed within three metres of the filter strip (City of Portland, 2004). Micro-grading is critical to ensure sheet flow.

- *Erosion and Sediment Control:* Construction runoff should be directed away from the proposed filter strip site. If used for sediment control during construction, it should be regraded and revegetated after construction is finished.
- *Vegetation:* If necessary, filter strips should be regularly inspected between April and September of the first two years and watered when necessary to establish healthy vegetation. Ideally, filter strips should be planted in the spring, when vegetation can become established with minimal irrigation (Barrett *et al.*, 2004).

### 4.6.3 Maintenance and Construction Costs

#### Maintenance

Maintenance requirements for vegetated filter strips are similar to enhanced grass swales and typically involve a low level of activity after vegetation becomes established. Routine inspection is important to ensure that dense vegetation cover is maintained and inflowing runoff does not become concentrated and short circuit the practice. Vehicles should not be parked or driven on filter strips. For routine mowing of grassed filter strips, the lightest possible mowing equipment should be used to prevent soil compaction. The activities outlined in Table 4.6.5 should be incorporated into the maintenance plan.

**Table 4.6.5 Typical maintenance activities for vegetated filter strips**

Activity	Schedule
<ul style="list-style-type: none"> <li>▪ Inspect for vegetation density (at least 80% coverage), damage by foot or vehicular traffic, channelization, accumulation of debris, trash and sediment, and structural damage to pretreatment and level spreader devices.</li> </ul>	<p>After every major storm event (&gt;25 mm), quarterly for the first two years, and twice annually thereafter.</p>
<ul style="list-style-type: none"> <li>▪ Regular watering may be required during the first two years while vegetation is becoming established;</li> <li>▪ Mow grass to maintain height between 50 to 150 mm;</li> <li>▪ Remove trash and debris from level spreaders, pretreatment devices and the filter strip surface..</li> </ul>	<p>At least twice annually. More frequently if desired for aesthetic reasons.</p>
<ul style="list-style-type: none"> <li>▪ Remove accumulated sediment from pretreatment and level spreader devices;</li> <li>▪ Replace mulch in spring;</li> <li>▪ Trim trees and shrubs;</li> <li>▪ Replace dead vegetation, remove invasive growth, dethatch, remove thatching and aerate (PDEP, 2006);</li> <li>▪ Repair eroded or sparsely vegetated areas;</li> <li>▪ Remove accumulated sediment on the filter strip or bottom of the slope when dry and exceeds 25 mm depth (PDEP, 2006);</li> <li>▪ If pools of standing water are observed along the slope, regrading and revegetating may be required.</li> </ul>	<p>Annually or as needed</p>

### **Installation and Operation Costs**

Little data are available on the actual construction costs of vegetated filter strips. One rough estimate can be the cost of seed or sod, which is approximately \$3.50 per square metre for seed or \$9 per square metre for sod.

#### **4.6.4 References**

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