

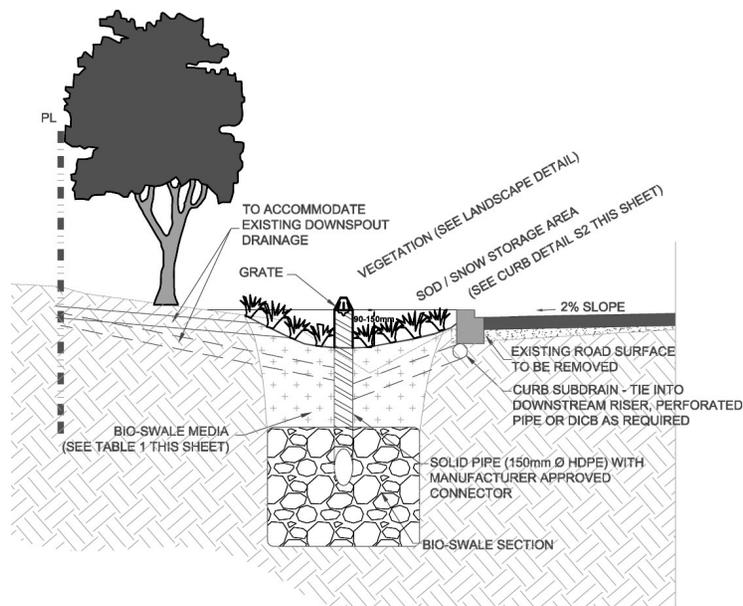
# Appendix G

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Detailed Design

## G1: Construction details

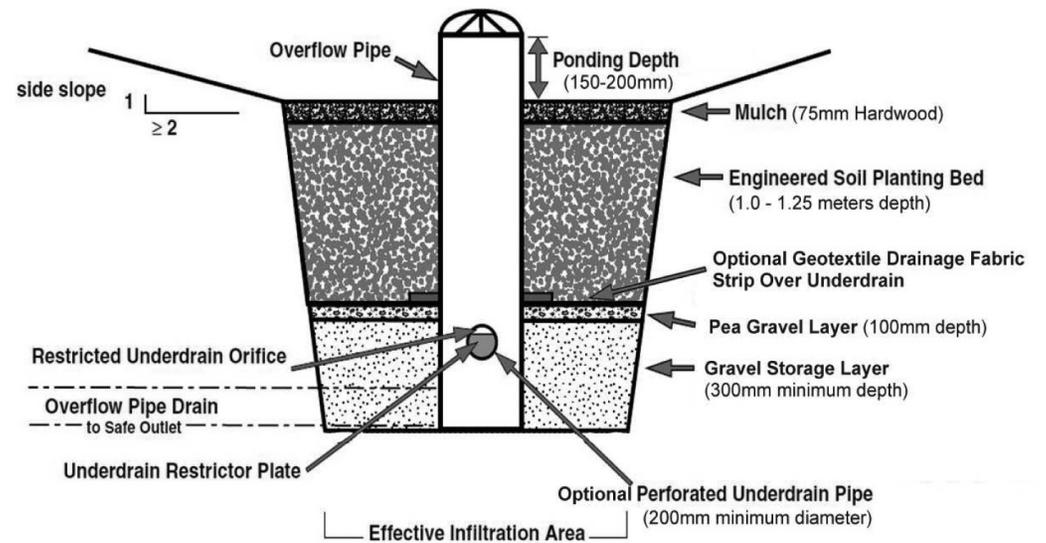
Construction detail drawings usually include important details and specifications for required project design elements. This section provides information and examples of the types of design details that might be included as part of design drawings for LID projects within municipal ROWs.



**Figure G1.1:** Construction details show the location of important design elements. The above detail is from a bioswale. Note important information such as the property line, pipe size, and references to design sheets. (Source: Aquafor Beech)

## Design details for bioswales and bioretention

The following figures are construction details for bioswales and bioretention practices. Table G1.1 provides guidance for what to include on construction detail drawings when implementing bioswales or bioretention.



**Figure G1.2:** Construction details should be provided for all design elements. These include inlets, outlets, manholes, and pipe connections. The above construction detail illustrates an overflow pipe and includes specified materials and depths of all subsurface components. (Source: CVC)

**Table G1.1:** Bioretention and bioswale design details.

Parameter	Plan	Detail	Profile	Description
Location	●			Area extent shown on plan view (bump-outs, municipal reserves, private lots, parks)
Surface area	●			Outlined on plan view drawings and stated in report
Inlet	●	●		Shown on plan view and typical detail provided (curb cut, flow spreader, ribbon curb)
Materials		●		Material specs (soil, drainage layer), depth, hydraulic conductivity, porosity
Vegetation	●	●		Planting plan and vegetation details (species, mature density, succession plan)
Outlet	●	●	●	Under-drain spec & slope, spill elevation, catch basin type and grate, weir type and location, inlet control device details
Catchment	●			Delineated catchment area directed to bioretention facility
Subsurface materials		●		Layer order (filter, reservoir, geotextile) and specifications (gradation, hydraulic conductivity, void space)
Depth		●	●	Depth of each layer, reservoir retention depth (if applicable), surface ponding depth (if applicable)
Slope		●	●	Sub-base slope and surface slope
Flow arrows		●		From contributing area and overflow route
Water depth		●		Ponding depth and water surface elevation during design storm and maximum prior to spill
Inundation		●		Extent of inundation during design storms
Erosion control	●	●		Located at inlet, outlet if overland spill

## Design details for permeable pavements

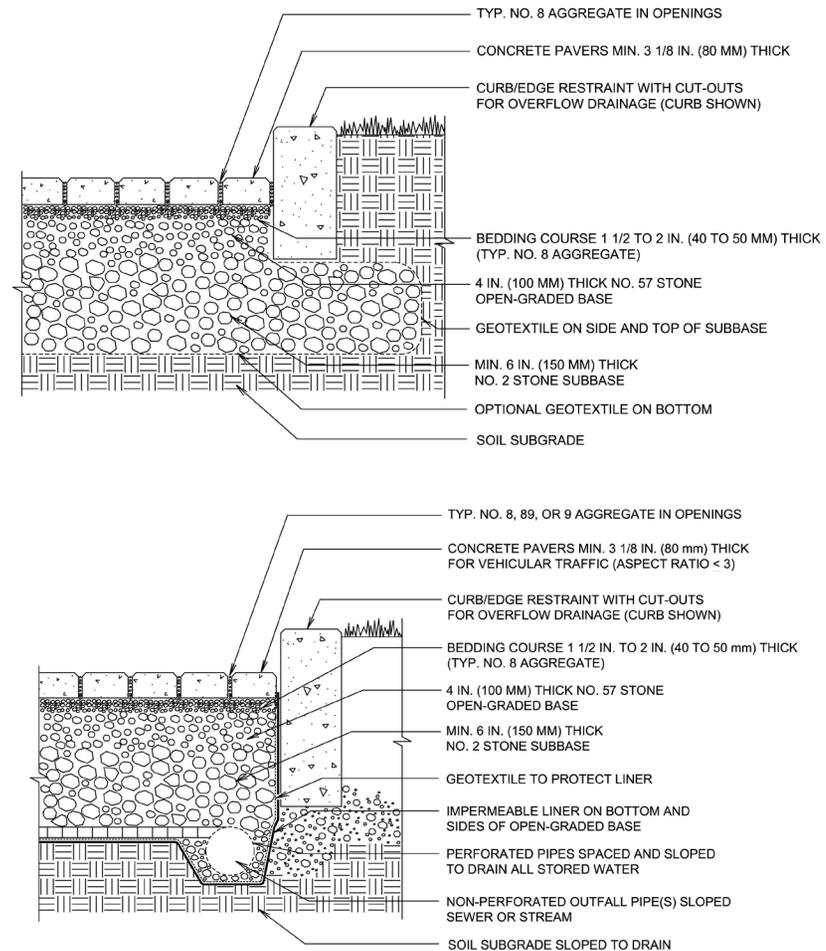
These figures provide cross-sectional details used for design drawings for standard permeable paver installations.

Similar design details can be applied to pervious asphalt and concrete installations. The differences between design details for pervious concrete and asphalt compared to permeable paver are as follows:

- Bedding course layer not required for pervious concrete or asphalt
- Compaction specifications required for pervious asphalt
- Thickness and porosity specification required for both pervious concrete and asphalt

Table G1.2 provides guidance for what to include on construction detail drawings when implementing permeable pavement designs.

*Detail drawing for permeable paver projects are available at the Interlocking Concrete Pavement Institute website at [www.icpi.org](http://www.icpi.org) for a variety of different design scenarios*



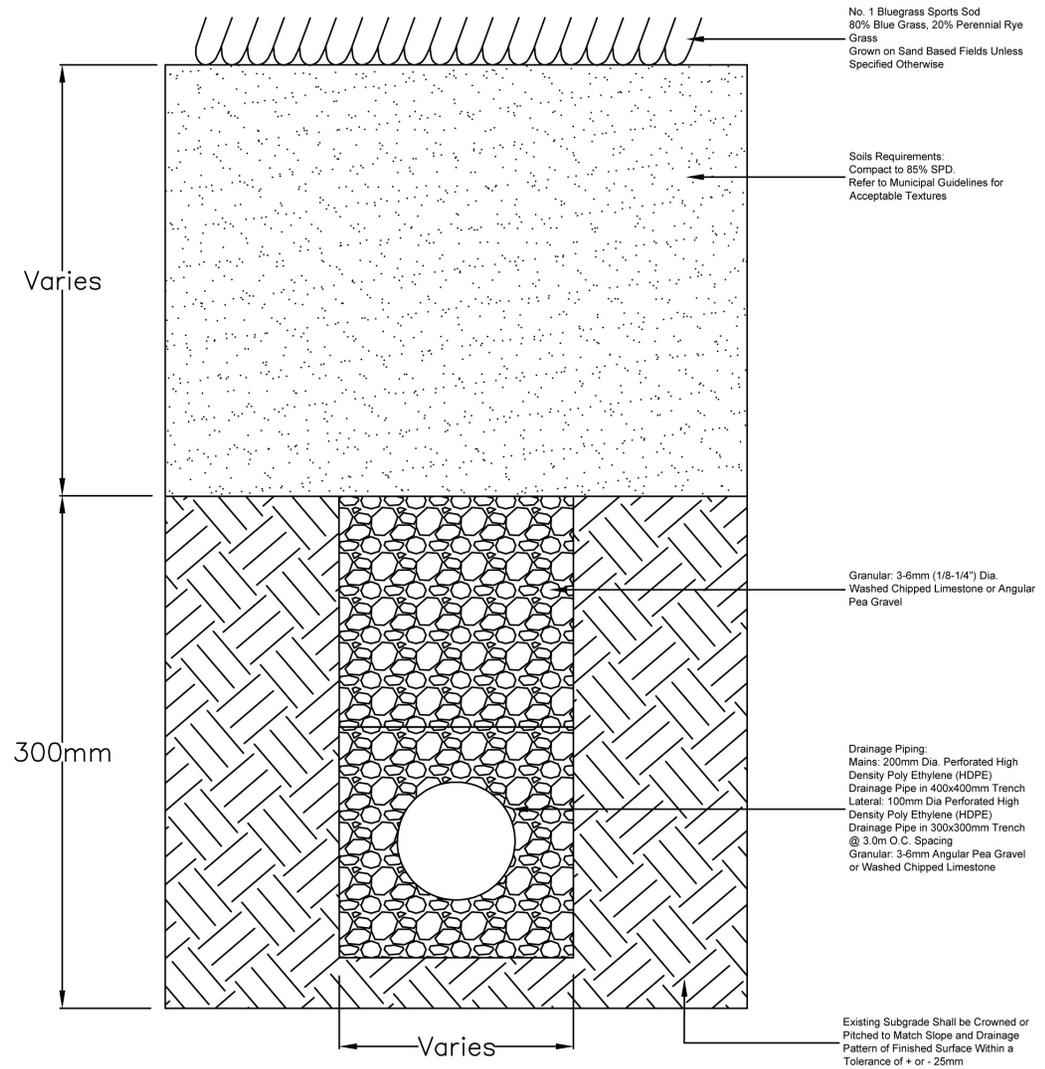
**Figure G1.3:** Note the subtle differences between a permeable pavement system designed for infiltration (above) and a permeable pavement system designed for detention (below). (Source: ICPI, 2012)

**Table G1.2:** Permeable pavements design details.

Parameter	Plan	Detail	Profile	Description
Location	●			Shown on plan view (driveways, parking stalls, pedestrian areas, emergency / delivery vehicle access)
Surface area	●			Outlined on plan view drawings and stated in report
Permeable Pavement	●	●	●	Permeable surface (pavers, asphalt, concrete) with porosity and mix specifications
Subsurface materials		●	●	Layer order (filter, reservoir, geotextile) and specifications (gradation, hydraulic conductivity, void space)
Depth		●	●	Depth of each layer, reservoir retention depth (if applicable), surface ponding depth (if applicable)
Slope		●	●	Sub-base slope and surface slope
Inlet	●	●		Shown on plan view, detail (if applicable), and in report
Native materials		●	●	Material specs (soil, drainage layer), depth, hydraulic conductivity, porosity
Outlet	●	●	●	Under-drain spec & slope, spill elevation, catch basin type and grate, weir type and location, inlet control device details
Catchment	●			Delineated catchment area directed to permeable paver facility
Flow arrows		●		From contributing area, within pavement structure and overflow route
Water Depth		●		Ponding depth and water surface elevation during design storm and maximum prior to spill
Inundation		●		Extent of inundation during design storms
Erosion control	●	●		Located at inlet, outlet if overland spill

## Design details for perforated pipe

This figure provides cross-sectional details for design drawings for standard perforated pipe installations. Table G1.3 provides guidance for the types of details to be included as part of the various design sheets.



**Figure G1.4:** This standard construction detail for a perforated pipe shows material specification and dimensions needed for construction. (Source: Aquafor Beech)

**Table G1.3:** Perforated pipe design details.

Parameter	Plan	Detail	Profile	Description
Location	●			Shown on plan view (driveways, parking stalls, pedestrian areas, emergency / delivery vehicle access)
Surface area	●			Outlined on plan view drawings and stated in report
Perforated pipe	●	●	●	Pipe location, slope, size, and material type
Subsurface materials		●	●	Layer order (filter, reservoir, geotextile) and specifications (gradation, hydraulic conductivity, void space)
Depth		●	●	Depth of each layer, reservoir retention depth (if applicable), surface ponding depth (if applicable)
Slope		●	●	Sub-base slope and surface slope
Inlet	●	●		Shown on plan view, detail (if applicable), and in report
Native materials		●	●	Material specs (soil, drainage layer), depth, hydraulic conductivity, porosity
Outlet	●	●	●	Under-drain spec & slope, spill elevation, catch basin type and grate, weir type and location, inlet control device details
Catchment	●			Delineated catchment area directed to perforate pipe facility
Flow arrows		●		From contributing area, within pavement structure and overflow route
Water depth		●		Ponding depth and water surface elevation during design storm and maximum prior to spill
Inundation		●		Extent of inundation during design storms
Erosion control	●	●		Located at inlet, outlet if overland spill

## Design details for prefabricated modules

Prefabricated modules are standard products supplied by a manufacturer. If desired, product manufacturers can provide typical design details which can be incorporated into design drawings. For customized modules, it's best to coordinate with product manufacturers, since that process can require preparing shop drawings in advance of manufacturing. Either way, prefabricated module designs do not need to be integrated with the detailed design drawings. Typical details or shop drawings can be provided to the contractor separately.

## Other design details to consider

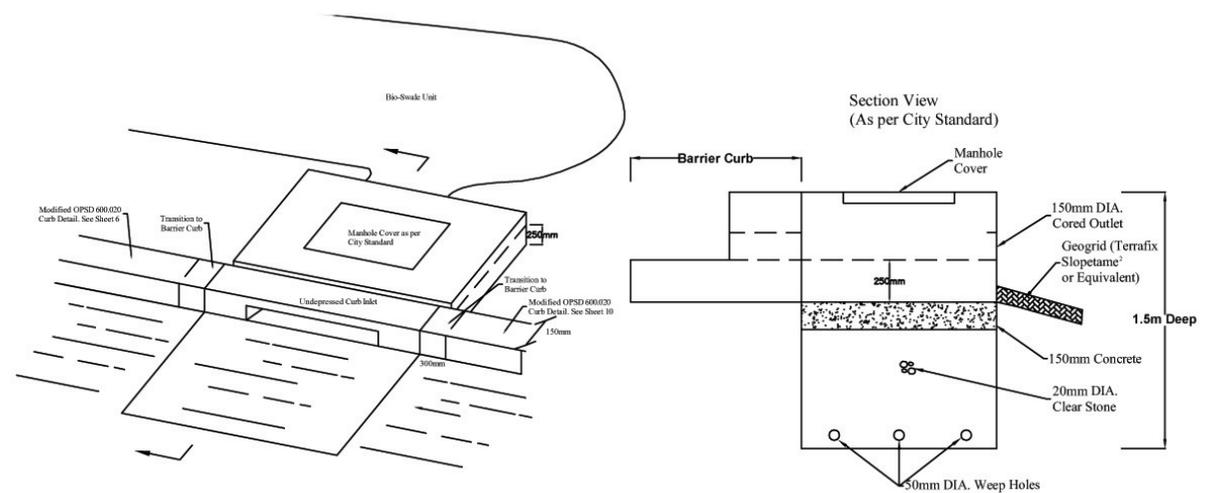
Include additional design details that feature modifications to standard design elements, installation clarification, or other unique components in design drawings to provide further clarity. Among other things, these details can be used to demonstrate non-traditional design features. These examples demonstrate design elements typically associated with LID techniques that might require individual design details.

### Curb cut/overflows

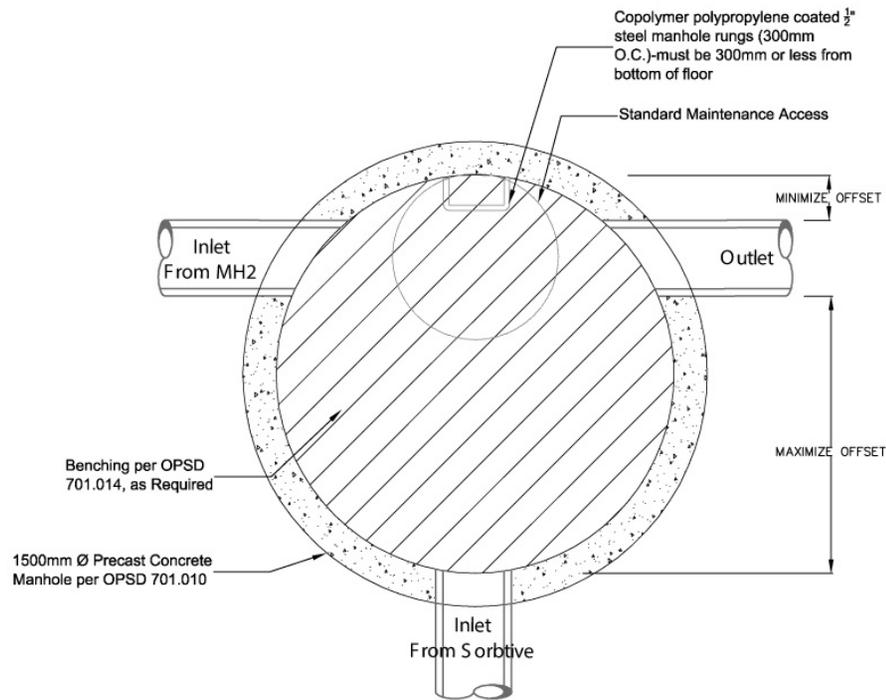
This figure demonstrates a side inlet catch basin design used during the Lakeview Project. This design amended the typical installation and function of a catch basin to fulfill the requirements of the LID design.

## Structures

Special design amendments or features added to standard structures such as manholes, catch basins, or pretreatment units must be shown in construction details. The adjacent manhole figure demonstrates a detail used during the IMAX Project where a pipe offset was required to accommodate monitoring equipment.



**Figure G1.5:** Due to the unique side inlet catch basin design used in the Lakeview Project, construction details were necessary to provide contractors with sufficient design information. (Source: Aquafor Beech)



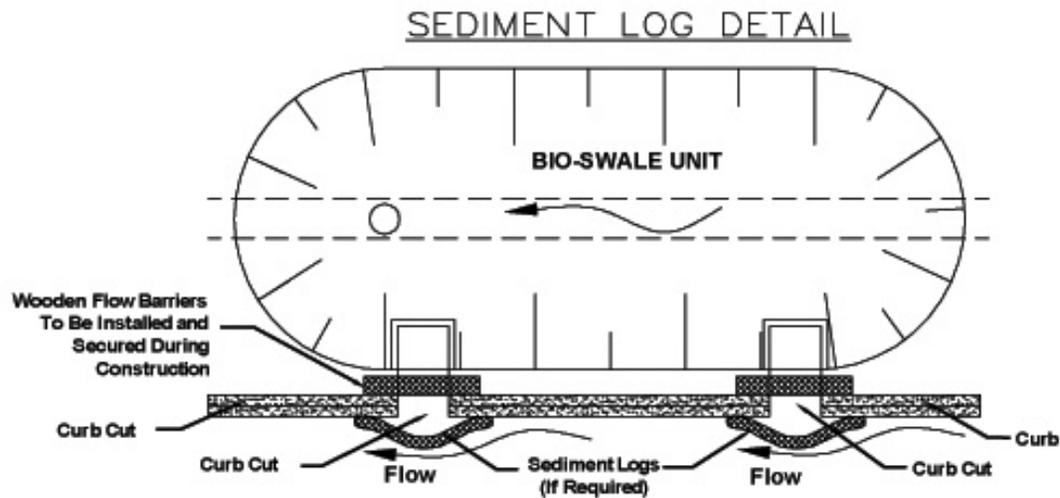
**Figure G1.6:** Inlet and outlet sizes, inverts and hydraulic controls will differ between manholes within a given project. Details on each should be provided to contractors. (Source: Aquafor Beech)

## Erosion and sedimentation measures

This figure demonstrates the correct placement and installation of erosion and sedimentation measures acting as barriers at bioretention inlets to protect against sediment contamination at curb cut locations.



**Figure G1.7:** Properly installed and maintained erosion and sediment control features can mean the difference between a successful LID project and a failure. A bag of mulch (sediment log) blocking the inlet of a bioretention facility is a simple yet effective sediment control practice. (Source: CVC)



**Figure G1.8:** Details of erosion and sediment control plans should be developed and provided to contractors. These plans will change with dynamic site conditions. Modifications should be noted on the construction details. (Source: Aquafor Beech)

## Miscellaneous

LID practices may have unique design elements that site contractors are familiar installing. It is vital to include these in construction detail packages. This figure demonstrates the notes and features of a grated covered, integrated into sidewalks at curb cut location in order to provide safe passage for pedestrians. The detail was necessary for the contractor to install the system properly.

## Roadways

LID retrofits implemented within the ROW are generally associated the road works including utility replacements or surface rehabilitation. Include details of the proposed road cross-section as part of road expansion, reduction, or total reconstruction activities.

## Additional information

Properly positioning LID practices within municipal right of ways is critical. Give contractors additional information related to the layout and positioning of LID features to assist with the correct placement of features. Offsets from key elements, required elevations, lengths and slopes are critical pieces of information that the contractor will need. The provided bioswale details demonstrate the important information that can be provided to the contractor.



## G2: Design drawing notes

Design drawing notes should provide written details of key elements pertaining to installation requirements, materials or product specifications, testing requirements, and erosion and sediment control measures.

Tables G2.1 and G2.2 provide several examples and helpful resources to use when developing design details and corresponding construction notes for bioretention/bioswales, permeable pavers, and perforated pipe systems. Several of the installation and product specification notes detailed in Table G2.3 for perforated pipes are transferable to underdrains installed as part of bioretention/bioswale and permeable paver design.

Usually, manufacturers supply installation and product specifications for prefabricated modules. Supply these documents to the contractor separately or append them to tender packages.

**TABLE 1 BIO-SWALE DETAILS**

FIRST STREET							
Bio-Swale ID	Length (m)	Start Station	Start Elevation	Stop Station	Stop Elevation	Overflow Station	Overflow Elevation
BSF-1	6.3	0+035.0	86.2	0+028.7	86.2	0+030.6	86.29
BSF-2	18.3	0+047.2	86.2	0+028.9	86.2	0+030.9	86.29
BSF-3	20.0	0+064.0	86.7	0+044.0	86.4	0+045.9	86.51
BSF-4	7.5	0+063.0	86.6	0+055.5	86.6	0+057.4	86.78
BSF-5	8.2	0+077.8	86.9	0+069.6	86.9	0+071.4	87.00
BSF-6	14.6	0+088.8	86.9	0+074.2	86.9	0+076.0	87.03
BSF-7	14.0	0+102.0	87.0	0+088.0	87.0	0+090.0	87.11
BSF-8	21.4	0+132.8	87.2	0+111.4	87.2	0+113.3	87.24
BSF-9	9.0	0+131.0	87.2	0+122.0	87.2	0+124.0	87.31
BSF-10	21.0	0+158.0	87.1	0+137.0	87.1	0+139.2	87.33
BSF-11	18.9	0+158.6	87.2	0+139.7	87.2	0+141.6	87.33

**START ELEVATION =** CORRESPONDS TO UPSTREAM EXTENT OF FINISHED GRADE OF BIOSWALE INVERT

**STOP ELEVATION =** CORRESPONDS TO DOWNSTREAM EXTENT OF FINISHED GRADE OF BIOSWALE INVERT



**Figure G1.11:** Note the installation specifications included in these drawings. Additional notes would be included on the design sheet. (Source: Aquafor Beech)

**Table G2.1: Bioretention/bioswale design details notes.**

Note category	Reasoning	Examples	Resources
Media testing	<p>Include conditions and specifications of bioretention soil media in the drawings to ensure that requirements are fully understood.</p> <p>Include bioretention soil media specification table on drawings.</p>	<ul style="list-style-type: none"> <li>• Vendor to provide testing results prior to installation.</li> <li>• Delivered media shall be tested and approved by field engineer prior to installation.</li> <li>• Media installed without field engineer clearance shall be removed at the contractor's expense if deemed necessary by the field engineer.</li> <li>• The contractor will be solely responsible for all required media testing expenses.</li> <li>• Media testing results can be expected approximately 2 - 3 weeks after submission to lab.</li> <li>• The contractor is responsible for any delays suffered as a result of testing. No compensation will be provided for delays due to media analysis.</li> </ul>	CVC Low Impact Development Stormwater Management Planning and Design Guide
Product specification	<p>Include product specifications. If brief, most specifications can be included on the plan and profiles sheets. Detailed requirements can be included as notes.</p>	<ul style="list-style-type: none"> <li>• Underdrain perforated pipe constructed in accordance with OPS 405.</li> <li>• Geotextile fabric must conform to OPSS 1860 for class II geotextile fabrics</li> </ul>	OPSS or manufacturer specifications
Installation procedures	<p>Details of installation procedures the contractor is to follow during construction are provided to avoid confusion and mistakes. Notes can be as simple as referring the contractor to manufacturer installation guidelines.</p>	<ul style="list-style-type: none"> <li>• Place geotextiles on the (bottom and sides of the) soil sub-base. Secure in place to prevent wrinkling and overlap a minimum of 0.3m in the direction to drainage.</li> <li>• Apply bioswale media in 300mm lifts until desired elevation is achieved. Thoroughly wet each lift before adding next lift. Allow water to fully percolate through the soil before adding each course.</li> </ul>	Manufacturer, municipality, or designer specifications
Erosion and sedimentation control	<p>Details of erosion and sedimentation control installation procedures the contractor is to follow during construction to avoid clogging of infiltration practices and impacts to adjacent land uses.</p>	<ul style="list-style-type: none"> <li>• Store all construction materials down-gradient of excavated site whenever possible.</li> <li>• Enclose materials stored up-gradient of the excavated site within the appropriate sediment control fencing.</li> <li>• Install sediment control fencing prior to the commencement of construction to prevent runoff from contaminating excavated surface of the native soils and or the aggregate base courses and of the bioswale.</li> </ul>	Municipality, agency, or designer specifications

**Table G2.2:** Permeable pavement design details notes.

Note category	Reasoning	Examples	Resources
Product specification	<p>Include product specifications. Most specification can be included on the plan and profiles sheets if brief. Include detailed requirements as notes.</p> <p>Include base material gradations on drawings.</p>	<ul style="list-style-type: none"> <li>Aggregate materials used in the construction of permeable pavements shall be clean, have zero plasticity, and contain no No. 200 sieve size materials.</li> <li>Crushed stone shall be clean washed; no fines should be present in material (less than 1% passing 0.075mm sieve).</li> </ul>	OPSS, manufacturer, ICPI, or designer specifications
Installation procedures	<p>Details of installation procedures the contractor is to follow during construction are provided to avoid confusion and mistakes. Notes may be as simple as referring the contractor to manufacturer installation guidelines.</p>	<ul style="list-style-type: none"> <li>Moisten, spread and compact base layer in one 100 mm thick lift and compact using vibratory and static mode with a minimum 10 t (10 T) vibratory roller until there is no visible movement</li> <li>Moisten, spread and screed stone bedding material.</li> <li>Do not subject screeded bedding material to any pedestrian or vehicular traffic before paving unit installation begins.</li> <li>Lay the paving units in the pattern(s) and joint widths shown on the drawings. Fill the openings and joints with bedding stone.</li> <li>Remove excess aggregate on the surface by sweeping pavers clean.</li> <li>Compact and seat the pavers into the bedding material</li> </ul>	OPSS, manufacturer, ICPI, or designer specifications
Erosion and sedimentation control	<p>Details of erosion and sedimentation control installation procedures the contractor is to follow during construction to avoid clogging of infiltration practices and impacts to adjacent land uses.</p>	<ul style="list-style-type: none"> <li>Install sediment control fencing prior to the commencement of construction to prevent runoff from contaminating</li> <li>Excavate the final grade of the permeable pavement sub-base immediately prior to backfilling with specified base course to avoid premature facility clogging.</li> <li>Store all construction materials down-gradient of excavated site whenever possible.</li> </ul>	Municipality, agency, manufacturer, or designer specifications.
QA/AC	<p>Notes related to the quality assurance and control of the installation and product being installed should be provided to ensure all materials used are as specified, will function as intended, and will meet any certification.</p>	<ul style="list-style-type: none"> <li>After sweeping the surface clean, check final elevations for conformance to the drawings.</li> <li>Lippage: No greater than 3 mm difference in height between adjacent pavers.</li> <li>Contractor to remove and reinstall all cracked or fractured stone following compaction</li> </ul>	Manufacturer, ICPI, or designer specifications.

**Table G2.3:** Perforated pipe system design details notes.

Note category	Reasoning	Examples	Resources
Product specification	<p>Include product specifications. Most specification can be included on the plan and profiles sheets if brief. Include detailed requirements as notes.</p>	<ul style="list-style-type: none"> <li>• Construct underdrain perforated pipe in accordance with OPSS.</li> <li>• Tubing must be uniform in colour and density and free from visible defects</li> <li>• Underdrain material should be resistant to the chemicals present in soils and groundwater and shall provide protection against degradation by ultraviolet light.</li> </ul>	<p>OPSS or manufacturer specifications</p>
Installation procedures	<p>Details of installation procedures the contractor is to follow during construction are provided to avoid confusion and mistakes. Notes can be as simple as referring the contractor to manufacturer installation guidelines.</p>	<ul style="list-style-type: none"> <li>• Install drainage pipes with constant grades to drain, have smooth transitions.</li> <li>• Pipes should terminate 0.3m short of the ends of the excavated opening. ends to be capped</li> <li>• Install cleanout risers where junctions, grade or direction changes</li> <li>• Pipes shall be laid in a true line and gradient on a firm bed, free from loose material. Pipes</li> <li>• Join underdrain pipes using appropriate fittings as per pipe manufacture specifications.</li> <li>• Place geotextiles on the (bottom and sides of the) soil sub-base. Secure in place to prevent wrinkling and overlap a minimum of 0.3m in the direction to drainage.</li> </ul>	<p>Manufacturer or designer Specifications.</p>
Erosion and sedimentation control	<p>Details of erosion and sedimentation control installation procedures the contractor is to follow during construction to avoid clogging of infiltration practices and impacts to adjacent land uses.</p>	<ul style="list-style-type: none"> <li>• Same as bioretention/bioswales and permeable pavers.</li> <li>• Keep the inside of the underdrain clean and free of debris during construction.</li> <li>• Remove all debris before additional pipe is installed.</li> </ul>	<p>Municipality, agency, manufacturer, or designer specifications.</p>