Appendix B

DETAILED DESIGN

Design details for bioretention/bioswale

Figures 1 and 2 provide cross-sectional details of standard bioswales and bioretention installations used in design drawings. Table 1 provides guidance to the types of details of bioretention and bioswale designs to be included as part of the various design sheets.

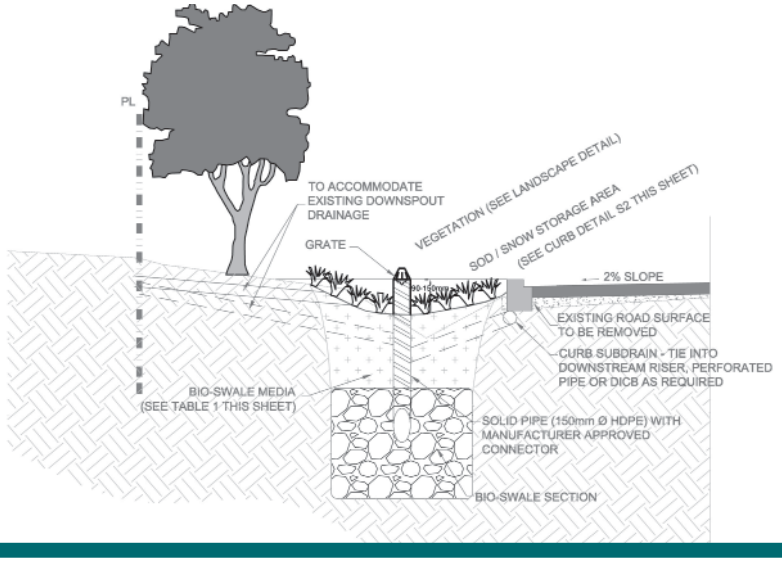

Figure 1: A cross-section detail from a bioretention area or a bioswale depending on the slope along the length of the facility. For detailed instructions, notes are provided to direct the contractor to separate detail sheets. (Source: Aquafor Beech)

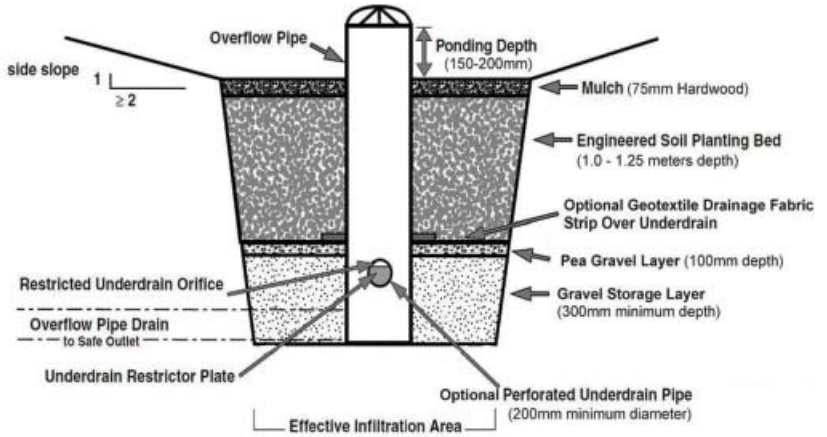

Figure 2: A cross-section of an overflow pipe. Note: Each material and depth of installation is specified. (Source: Aquafor Beech)

Table 1: Bioretention and bioswale design details

Parameter	Plan	Detail	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

Figures 3 and 4 provide construction details of standard permeable paver installations used for design drawings.

Similar design details can be applied to porous asphalt and pervious concrete installations. Differences to pervious concrete and porous asphalt design details compared to permeable paver design details are as follows:

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

Table 2 provides guidance for the types of details of permeable paver designs to be included as part of the various design sheets.

Detail drawings for permeable paver projects are available at the Interlocking Concrete Pavement Institute website at icpi.org.

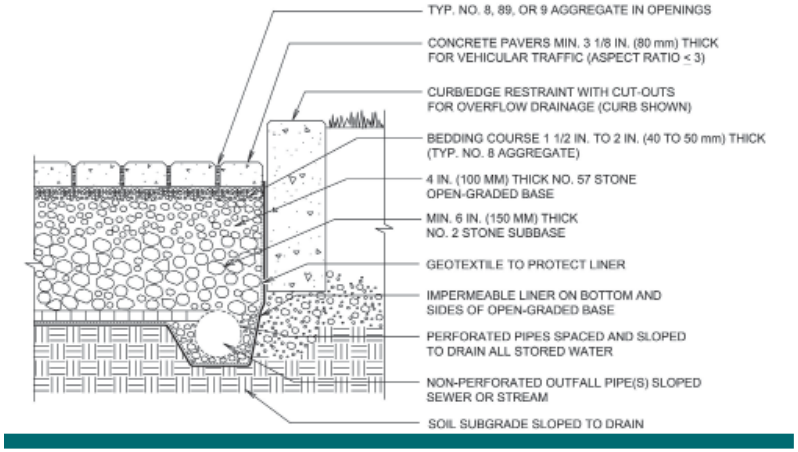

Figure 3: A cross-section detail from a permeable pavement system. This design includes an impermeable liner to prevent infiltration and a perforated pipe underdrain system for exfiltration. This is a common design feature where infiltration is not allowed. (Source: Aquafor Beech)

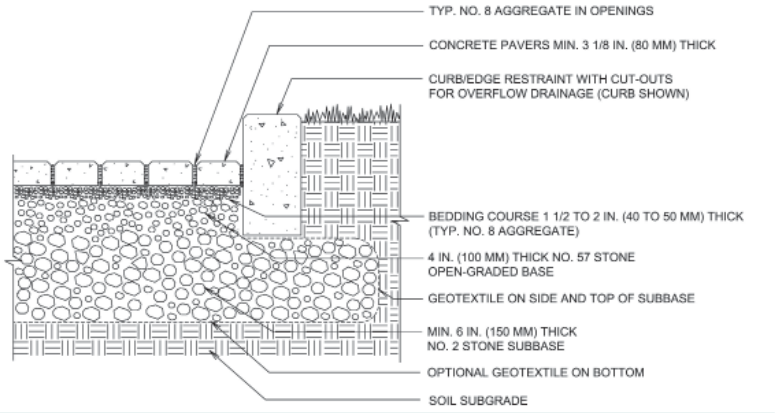

Figure 4: A cross-section detail from a permeable pavement system. This design allows for infiltration to the soil subgrade. (Source: Aquafor Beech)

Table 2: Permeable pavements design details

Parameter	Plan	Detail	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

Figure 5 provides a construction detail of standard perforated pipe installations used for design drawings. Table 3 provides guidance to the types of details of perforated pipe designs to be included as part of the various design sheets.

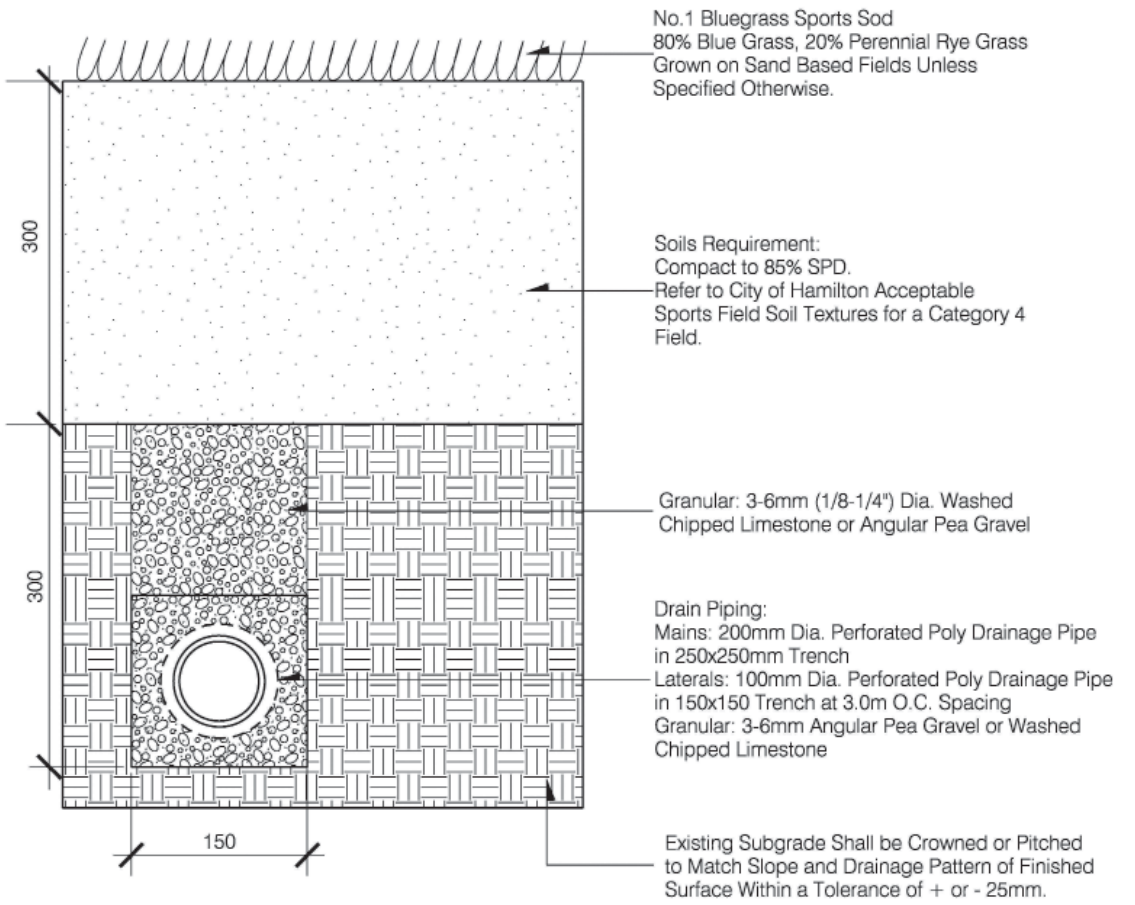

Figure 5: A cross-section detail of a perforated pipe system. (Source: Aquafor Beech)

Table 3: Perforated Pipe design details

Parameter	Plan	Detail	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
Perforate 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 infiltration chambers and soakaways

Figure 6 provides a construction detail of a typical soakaway installation used for design drawings. Table 4 provides guidance to the types of details of infiltration chambers and soakaway designs to be included as part of the various design sheets.

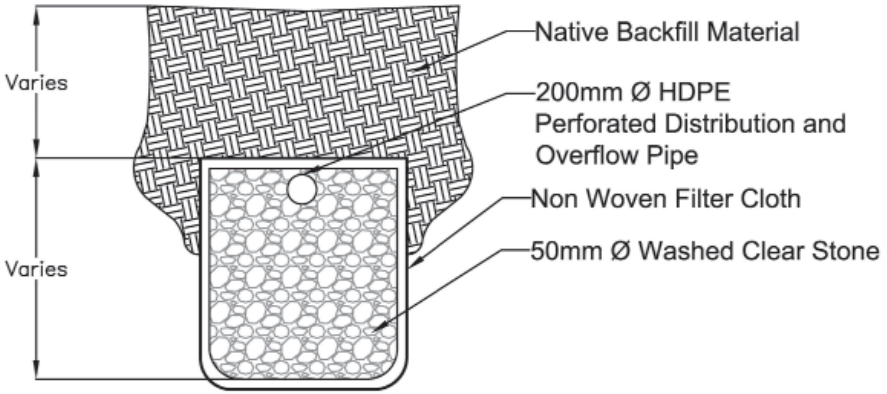

Figure 6: A cross-section detail of a soakaway. Note: Due to the relatively simple design, fewdetails are required. (Source: Aquafor Beech)

Table 4: Infiltration chamber and soakaway design details

Parameter	Plan	Detail	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
Perforate 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 proposed LID 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 rainwater harvesting and green roofs

Rainwater harvesting systems and green roofs require a multi-disciplinary design team and use a variety of proprietary components to create the overall system. Design details and shop drawings are generally produced by the manufacturer and individual design professions and integrated. Depending on the design constraints, systems components may require customization in order to fit your design. Figure 7 demonstrates the integration of a rainwater harvesting system within the paving structure implemented at the Brampton Flight Club in the Town of Caledon. This system used proprietary components integrated with the other LID practice on site. Table 5 provides guidance to the types of details of rainwater harvesting and green roof details to be included as part of the various design sheets.

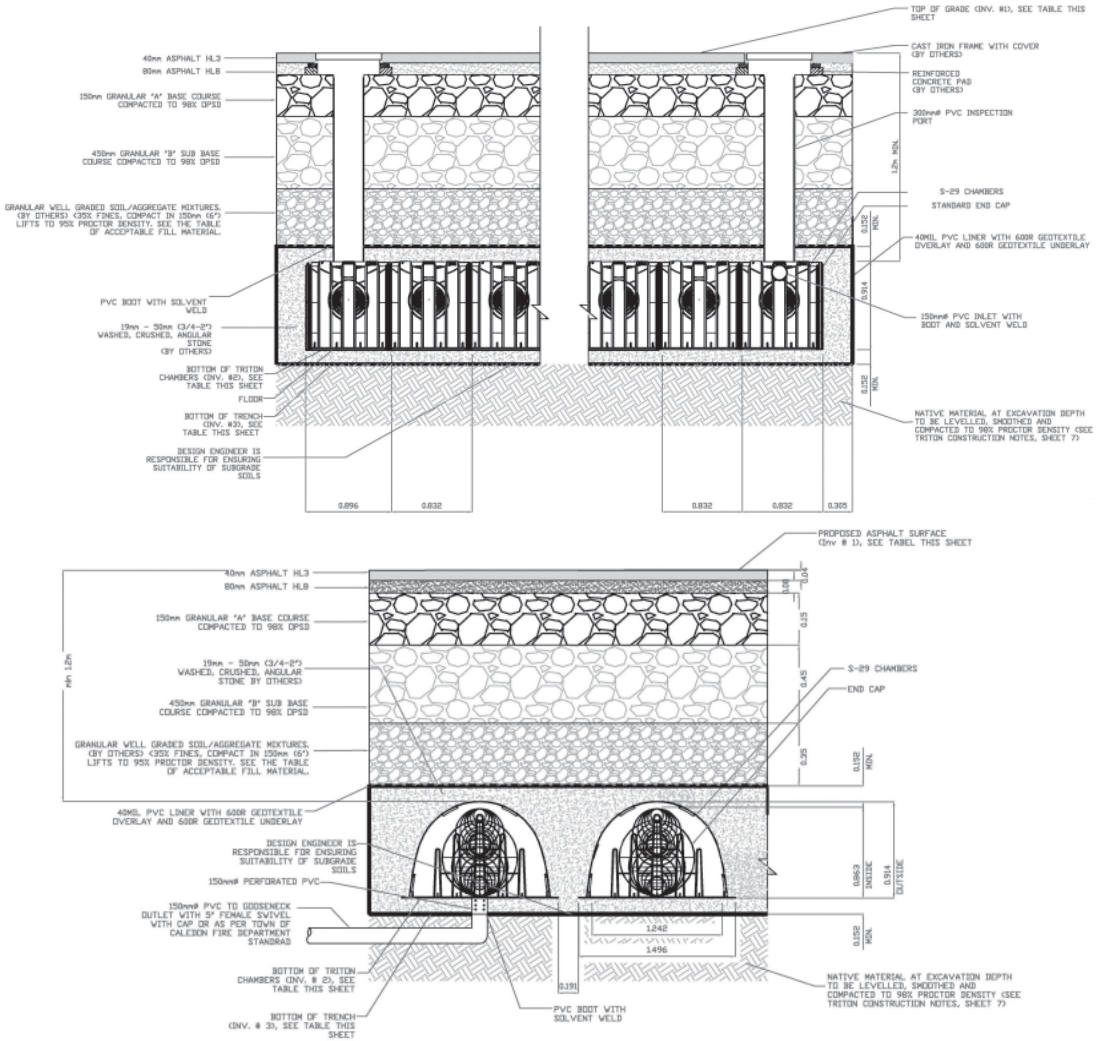

Figure 7: A cross-section detail of a proprietary rainwater harvesting unit installed at the Brampton Flight Centre (Source: Aquafor Beech & Terrafix)

Table 5: Rainwater harvesting and green roof design details

Parameter	Plan	Detail	Description
Location	•		Shown on plan view (driveways, building areas, roof top, parking stalls, pedestrian areas, emergency / access)
Surface area	•		Outlined on plan view drawings and stated in report
Piping Network	•	•	Pipe location, slope, size, and material type
Subsurface structures/ materials		•	Green roof layer order (membranes, reservoir, geotextile, planting materials, bedding materials, roof construction), reservoir tanks, utilities, and specifications (type, materials, gradation, hydraulic conductivity, void space, capacities, restrictions, limitations)
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
Building materials		•	Roof structure and build materials
Surface structures	•	•	Location shown on plan, Details provided on detail sheets. Includes roof structures – AC units, HVAC, utilities, green roof areas, reservoir tanks, signs, lighting poles, etc.
Outlet	•	•	Under-drain spec & slope, spill elevation, weir type and location, outlet control device details
Catchment	•		Delineated catchment area directed to proposed LID 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
Plantings	•	•	Landscape design (separate plan sheet) and planting types, size and densities
Erosion control	•	•	Located at inlet, outlet if overland spill

Design details prefabricated modules

Prefabricated modules are proprietary units supplied by the manufacturer. Design details and shop drawings are generally produced by the manufacturer and incorporated into design drawings unaltered. Systems that require customization should be coordinated with the product manufacturers. Customizing standard products generally requires custom shop drawings prepared prior to manufacturing. This can take several weeks to complete. Regardless, the designs of such systems do not require integration with the detailed design drawings. Typical details or shop drawings can be provided to the contractor separately.

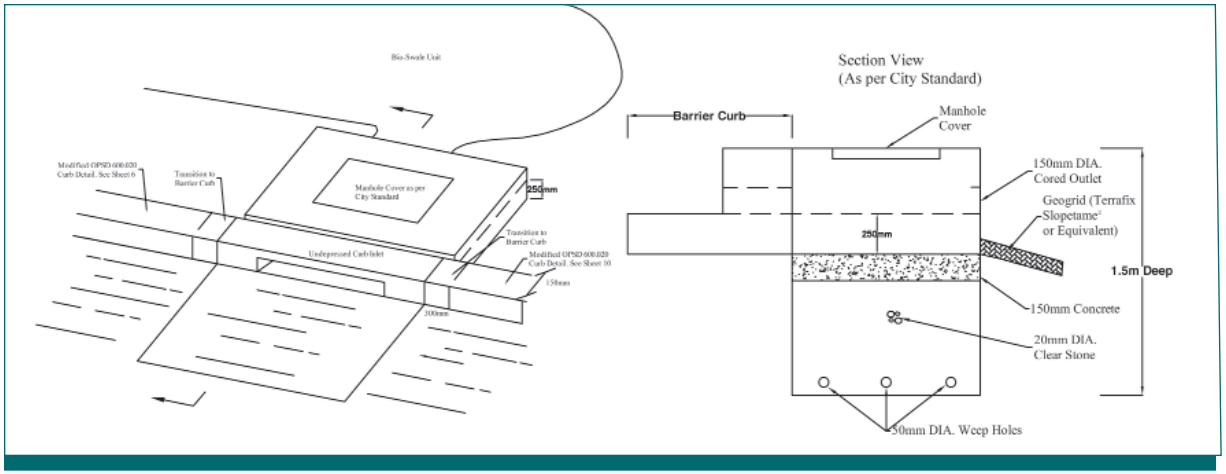

Figure 8: This figure details a modified bioswale inlet. This design includes a modified catch basin with a side inlet to convey flow from a road surface to a bioswale. (Source: Aquafor Beech)

Other design details

Additional design details which feature modifications to standard design elements, installation clarification, or other unique components should be included in design drawings to provide further clarity. Such details are generally used to demonstrate non-traditional design features. Figure 8 demonstrates design elements typically associated with LID practices that may require individual design details.

Shop drawings and custom products are associated with premiums and take longer to complete.

Special design amendments to standard structures, such as manholes, catch basins, or pre-treatment units, may be required. Figure 9 shows what was used during the design of a LID practice installed within a commercial area where a pipe offset was required to accommodate post-construction monitoring equipment.

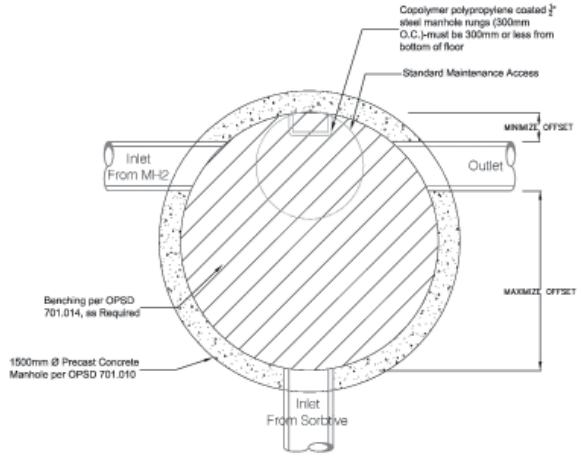

Figure 9: Include structure details like manholes and indicate. dimensions and OPSD numbers where available. (Source: Aquafor Beech)

Erosion and sedimentation measures

Figure 10 shows the placement of erosion and sedimentation controls to prevent surface runoff from contaminating infiltrating LID practices. Figure 11 shows these controls installed in the field.

Figure 11: Sediment logs used for erosion and sedimentation control at curb cut locations during construction. (Source: Aquafor Beech)

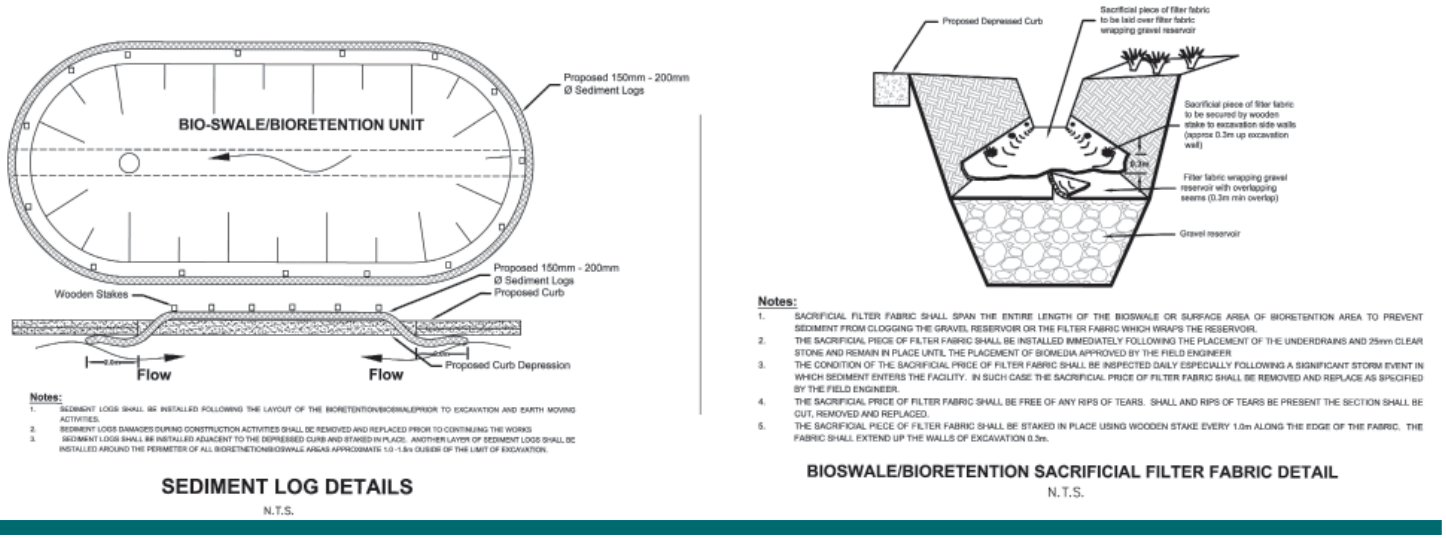

Figure 10: Sediment logs and sacrificial filter cloth used during construction to protect the integrity of infiltrating LID practices. (Source: Aquafor Beech)

Miscellaneous

Design accessories are generally simple design details that are not relevant to the overall function and performance of the design; however, details for their installation are still required.

Figure 12 demonstrates the notes and features of a covered inlet grate integrated into sidewalks at curb cut location to provide safe passage for pedestrians. The information included within the detail would have been necessary for the contractor to install the system properly.

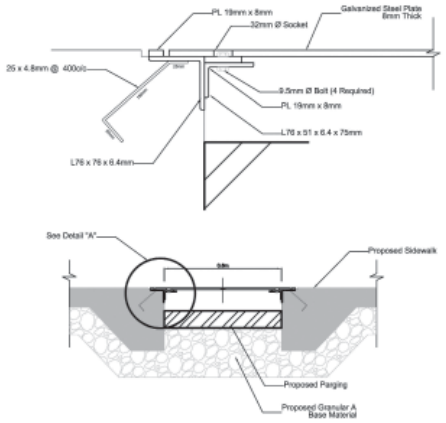

Figure 12: This figure illustrates how a covered inlet grate fits into the surrounding sidewalk to allow for pedestrian traffic over a bioswale inlet. (Source: Aquafor Beech)

Roadways

LID retrofits implemented on your site may include surface paving works, which need to include standards for asphalt paving. Details of the proposed asphalt and sub-base cross sections should be included as part of the design drawings. The Figure 13 provides a typical detail and relevant design notes to consider.

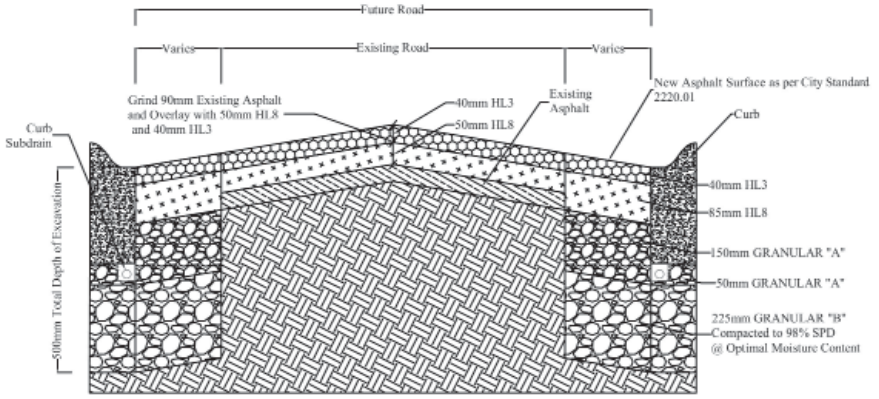

Figure 13: This figure illustrates a road cross-section used for standard asphalt paving. (Source: Aquafor Beech)

Design drawing notes

Design drawing notes are written details of key elements pertaining to installation requirements, materials or product specifications, testing requirements, and erosion and sedimentation control measures. This section provides examples of design drawing notes that may be incorporated into design drawings for various LID practices.

Tables 6 through 10 provide several examples and helpful resources to use when developing design details and corresponding construction notes for the LID practice. Several of the installation and product specification notes detailed in Table 6.5.7 for perforated pipes may be transferable to underdrains installed as part of other LID practices.

Manufacturers usually supply installation and product specifications for green roofs, prefabricated modules, and rainwater harvesting systems. These documents can be provided to contractor separately or appended to tender packages.

Table 6: Bioretention and bioswale design details

Note category	Reasoning	Examples	Resources
Media testing	Conditions and specifications of bioretention soil media are recommended to be included in the drawings to ensure that requirements are fully understood Include bioretention soil media specification table on drawings	• Vendor to provide testing results prior to installation. • Delivered media shall be tested and approved by field engineer prior to installation. • Media installed without field engineer clearance shall be removed at the contractor's expense if deemed necessary by the field engineer. • The contractor will be solely responsible for all required media testing expenses. • Media testing results can be expected approximately 2 - 3 weeks after submission to lab. • The contractor is responsible for any delays suffered as a result of testing. No compensation will be provided for delays due to media analysis.	CVC Low Impact Development Stormwater Management Planning and Design Guide
Product specification	Product specifications are recommended to be included. Most specification may be included on the plan and profiles sheets if brief. Detailed requirements may be included as notes	• Underdrain perforated pipe constructed in accordance with OPS 405. • Geotextile fabric must conform to OPSS 1860 for class II geotextile fabrics	OPSS or manufacturer specifications
Installation procedures	Details of installation procedures the contractor is to follow during construction. Notes may be as simple as referring the contractor to manufacturer installation guidelines.	• Geotextiles shall be placed on the (bottom and sides) of soil subbase. Secure in place to prevent wrinkling and overlap a minimum of 0.3m in the direction to drainage. • 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.	Manufacturer, municipality, or designer specifications.
Erosion and sedimentation control	Details of erosion and sedimentation control installation procedures the contractor is to follow during construction.	• All construction materials are to be stored down-gradient of excavated site whenever possible. • Materials stored up-gradient of the excavated site are to be enclosed by appropriate sediment control fencing. • Sediment control fencing to be installed 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 bio-swale.	Municipality, agency, or designer specifications.

Table 7: Permeable pavement design details notes

Note category	Reasoning	Examples	Resources
Product specification	Product specifications are recommended to be included. Most specification may be included on the plan and profiles sheets if brief. Detailed requirements may be included as notes Include base material gradations on drawings	• Aggregate materials used in the construction of permeable pavements shall be clean, have zero plasticity and contain no No. 200 sieve size materials. • Crushed stone shall be clean washed; no fines should be present in material (less than 1% passing 0.075mm sieve).	OPSS, manufacturer, ICPI or designer Specifications.
Installation procedures	Details of installation procedures the contractor is to follow during construction. Notes may be as simple as referring the contractor to manufacturer installation guidelines.	• 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 • Moisten spread and screed stone bedding material. • Do not subject screened bedding material to any pedestrian or vehicular traffic before paving unit installation begins. • Lay the paving units in the pattern(s) and joint widths shown on the drawings. • Fill the openings and joints with bedding stone. • Remove excess aggregate on the surface by sweeping pavers clean. • Compact and seat the pavers into the bedding material	OPSS, manufacturer, ICPI or designer specifications.
Erosion and sedimentation control	Details of erosion and sedimentation control installation procedures the contractor is to follow during construction.	• Sediment control fencing to be installed prior to the commencement of construction to prevent runoff from contaminating • Final grade of the permeable pavement subbase to be excavated immediately prior to backfilling with specified base course to avoid premature facility clogging. • All construction materials are to be stored down-gradient of excavated site whenever possible.	Municipality, agency, manufacturer or designer specifications.
QA/QC	Notes related to the quality assurance and control of the installation and product being installed	• After sweeping the surface clean, check final elevations for conformance to the drawings. • Lippage: No greater than 3 mm difference in height between adjacent pavers. • Contractor to remove and reinstall all cracked or fractured stone following compaction	Manufacturer, ICPI or designer specifications.

Table 8: Perforated pipe system design details notes

Note category	Reasoning	Examples	Resources
Product specification	Product specifications are recommended to be included. Most specification may be included on the plan and profiles sheets if brief. Detailed requirements may be included as notes	• Underdrain perforated pipe constructed in accordance with OPSS • Tubing must be uniform in colour and density and free from visible defects • Underdrain material should be resistant to the chemicals present in soils and groundwater and shall provide protection against degradation by ultra -violent light. • Aggregate materials used in the construction of permeable pavements shall be clean, have zero plasticity and contain no No. 200 sieve size materials. • Crushed stone shall be clean washed; no fines should be present in material (less than 1% passing 0.075mm sieve).	OPSS or manufacturer specifications
Installation procedures	Details of installation procedures the contractor is to follow during construction. Notes may be as simple as referring the contractor to manufacturer installation guidelines.	• Drainage pipes shall be installed with constant grades to drain, have smooth transitions. • Pipes should terminate 0.3m short of the ends of the excavated opening. ends to be capped • Cleanout risers shall be installed where junctions, grade or direction changes • Pipes shall be laid in a true line and gradient on a firm bed, free from loose material. Pipes • Underdrain pipes are to be joined using appropriate fittings as per pipe manufacture specifications. • Geotextiles shall be placed on the (bottom and sides) of soil subbase and secured in place to prevent wrinkling and overlap a minimum of 0.3m in the direction to drainage.	Manufacturer or designer specifications.
Erosion and sedimentation control	Details of erosion and sedimentation control installation procedures the contractor is to follow during construction.	• Same as bioretention/bioswales and permeable pavers • The inside of the underdrain shall be kept clean and free of debris during construction. • All debris should be removed before additional pipe is installed.	Municipality, agency, manufacturer or designer specifications.

Table 9: Soakaway design details notes

Note category	Reasoning	Examples	Resources
Product specification	Product specifications are recommended to be included. Most specification may be included on the plan and profiles sheets if brief. Detailed requirements may be included as notes	• Overflow perforated pipe constructed in accordance with OPSS • Tubing must be uniform in colour and density and free from visible defects • Overflow material should be resistant to the chemicals present in soils and groundwater and shall provide protection against degradation by ultra -violent light. • Aggregate materials used in the construction of permeable pavements shall be clean, have zero plasticity and contain no No. 200 sieve size materials. • Crushed stone shall be clean washed; no fines should be present in material (less than 1% passing 0.075mm sieve).	OPSS or manufacturer specifications
Installation procedures	Details of installation procedures the contractor is to follow during construction. Notes may be as simple as referring the contractor to manufacturer installation guidelines.	• Overflow pipes shall be installed with constant grades to drain, have smooth transitions. • Overflow pipes should terminate 0.3m short of the ends of the excavated opening. ends to be capped • Cleanout risers shall be installed where junctions, grade or direction changes • Overflow pipes are to be joined using appropriate fittings as per pipe manufacture specifications. • Geotextiles shall be placed on the (bottom and sides) of soil subbase and secured in place to prevent wrinkling and overlap a minimum of 0.3m in the direction to drainage.	Manufacturer or designer specifications.
Erosion and sedimentation control	Details of erosion and sedimentation control installation procedures the contractor is to follow during construction.	• Same as bioretention/bioswales and permeable pavers • The inside of the underdrain shall be kept clean and free of debris during construction. • All debris should be removed before additional pipe is installed.	Municipality, agency, manufacturer or designer specifications.

Table 10: Rainwater harvesting and green roof design details notes

Note category	Reasoning	Resources
Product specification	• Product specifications are recommended to be included. Most specification may be included on the plan and profiles sheets if brief. Detailed requirements may be included as notes • Examples will vary depending on installation situation (e.g. rainwater harvesting using subsurface or surface storage or grey water applications).	Building Codes, OPSS, manufacturer specifications, municipal standards.
Installation procedures	• Details of installation procedures the contractor is to follow during construction. Notes may be as simple as referring the contractor to manufacturer installation guidelines as required. • Similar to building home, the construction of green roofs and rainwater harvesting should have input for all disciplines involved. A coordinated effort shall ensure that all relevant installation procedure for mechanical, landscaping, structural, and electrical components are included.	Building Codes, OPSS, manufacturer specifications, municipal standards, designer specifications
Erosion and sedimentation control	• Details of erosion and sedimentation control installation procedures the contractor is to follow during construction. • Such notes will pertain mostly to subsurface rainwater harvesting practices as these application have the greatest impact on erosion and sedimentation control related concerns	Municipality, agency, manufacturer or designer specifications.
QA/QC	• Notes related to the quality assurance and control of the installation and product being installed.	Building Codes, OPSS, manufacturer specifications, municipal standards.