Appendix B

GRI Typologies

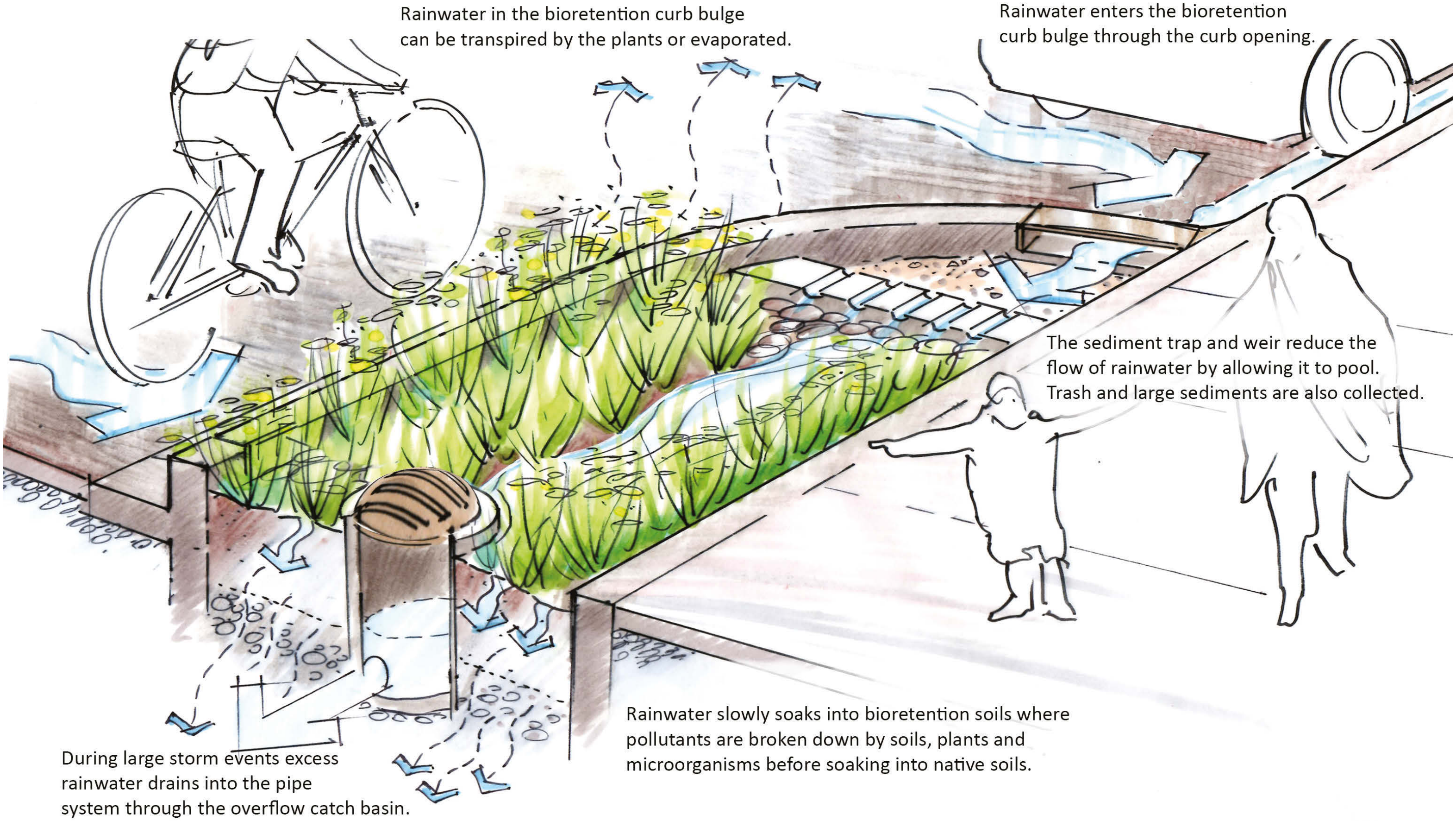
There are several typologies of green rainwater infrastructure. The following appendix provides illustrations and descriptions of the typologies at our disposal along with typical applications and examples in Vancouver and other parts of the world.

BIORETENTION PRACTICES

Bioswales, bioretention bulges and cells, rain gardens

What are bioretention practices?

Bioretention practices are engineered landscapes designed to infiltrate and filter urban rainwater runoff. They can be designed as rain gardens, bioswales, bioretention cells, bioretention planters and bioretention corner bulges. This common practice typically consists of a shallow depression or basin that features layers of rock, engineered soils, and resilient vegetation that can tolerate extreme rain and drought events. During a rainfall event, rainwater is directed into the practice, where water pools temporarily before soaking into the soil layer. Harmful pollutants are either broken down or captured in the soils and plant roots. Once cleaned, water is taken up by plants and released as water vapour, infiltrated into the ground, or carried away by a drainage pipe into our aquatic ecosystems.



Example: 63rd at Yukon

The enhanced public space at West 63rd Avenue and Yukon Street in Vancouver uses bioretention practices to manage rainwater runoff from adjacent streets. The location was highlighted for intervention in the Marpole Community Plan. The plaza includes 102 m^2 of bioretention systems—a rain garden and a bioswale—which capture, retain and treat urban rainwater runoff from more than 1,170 m^2 of adjacent roads and sidewalks. Together, these systems capture 90% of average annual rainfall that falls within the 1,170 m^2 drainage area, resulting in 2,200m^3 of rainwater diverted from the sewer system in a typical rainfall year. The plaza also includes seating areas, a drinking water fountain, and public art installations. This project was designed by the City's Green Infrastructure Implementation Branch and built by City crews.


63rd Avenue at Yukon Rain Garden and Bioswale

Typical applications

- Traffic calming bulges
- Greenways
- Bikeways
- School crossings
- Local streets
- Park connector streets
- Pollinator highways
- Yards
- Parks
- Plazas


Rain Garden, Tupper Greenway


Bioretention Bulge, River District (EFL)

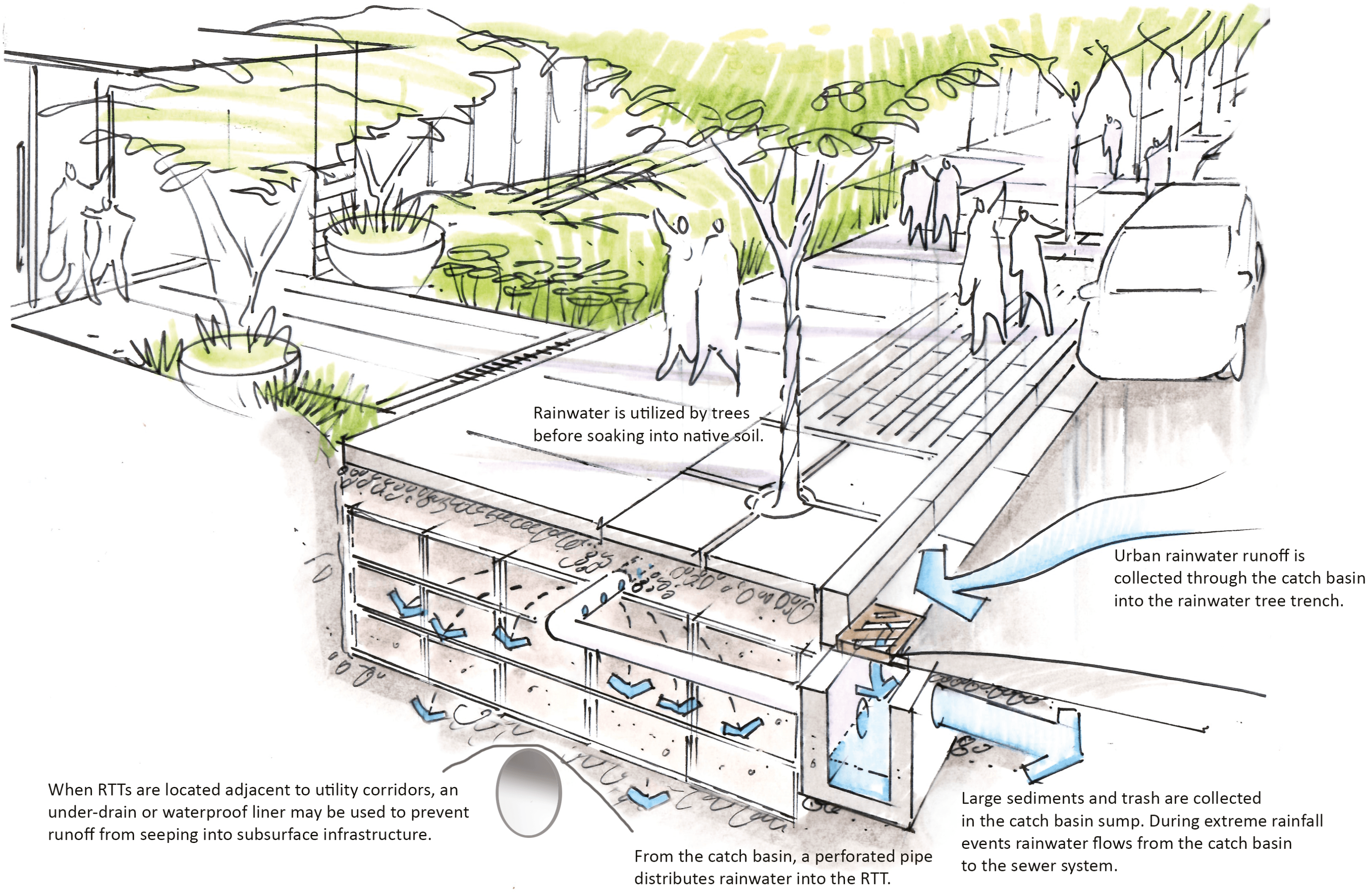
RAINWATER TREE TRENCH

Soil cells, structural soil

What are rainwater tree trenches?

Rainwater Tree Trenches (RTTs) are multifunctional GRI practices that provide both storage for rainwater and support to street trees. This type of GRI practice, typically located in dense urban environments, directs urban rainwater runoff from adjacent impermeable areas such as streets, parking lots, sidewalks, plazas and rooftops into underground trenches for treatment and then infiltration or uptake by street trees.

There are two types of RTTs in the City of Vancouver: structural soil and soil cells. Soil cells consists of plastic frames that are strong enough to bear the weight of surfaces like sidewalks. Soil fills the void left in the plastic frame, leaving space for tree roots. Structural soil uses a mix of large crushed stone and soil. The stone bears the weight of the surface while the soil and the space between the stone allows tree root growth.



Example: Quebec and 1st Avenue

Underneath the new separated bike lane in Quebec & East 1st Avenue, a RTT was installed as part of the precinct upgrades. This RTT installation will be monitored for performance to better understand the benefits of the system and improve on the design for future projects. The RTT has been monitored continuously since September 2018 and has performed similarly in terms of rainwater treatment and capture as the more common bioretention systems. Altogether, this project was a collaborative effort between the Green Infrastructure Implementation Branch and the Transportation and Street Divisions.

Rainwater Tree Trench, Quebec and E 1st Ave. Vancouver BC

Typical applications

- Streets
- Greenways
- Bike lanes
- Laneways


Seaside Greenway, Olympic Village, Vancouver


Rainwater tree trenches, 10th Avenue Bikeway

RESILIENT ROOFS

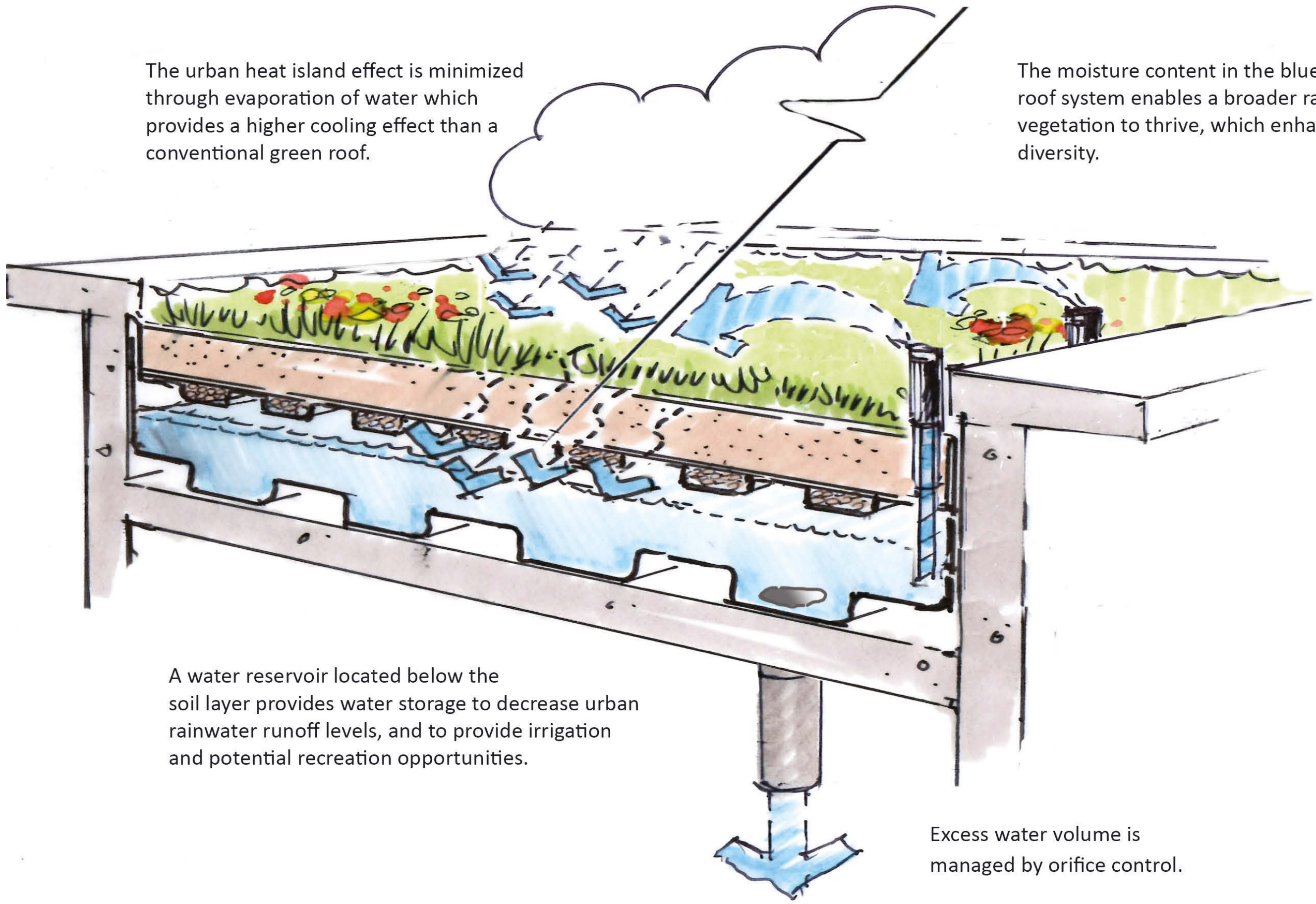
Green roofs (extensive and intensive), blue roofs, blue-green roofs, white roofs

What are resilient roofs?

Resilient roofs are roofs that can be designed to manage rainwater and support plant growth. Examples of resilient roofs include green roofs (extensive or intensive), blue roofs, blue-green roofs and white roofs. While white roofs are included in this group and serve to mitigate the urban heat island effect by reflecting sunlight, because they lack a rainwater management component they are not further discussed in this section.

Green roofs use vegetation and soils to absorb rainwater, to provide insulation for buildings, and to improve biodiversity. Intensive green roofs support larger plants with a thick layer of soil (up to 730 kg/m^2 of vegetation) and are typically accessible to building users, whereas extensive green roofs support smaller plants with a thin layer of soil (up to 120 kg/m^2 of vegetation) and are generally not accessible.

Blue roofs are designed to temporarily store rainwater before releasing it into the sewer system. They can be combined with other measures to improve water quality and reduce the volume of water entering pipes to reduce combined sewer overflow (CSO) volume. They can also be designed to allow evaporation of stored rainwater. When blue roofs are designed with vegetation, they are called Blue-green roofs. Blue-green roofs help keep plants watered even during hot summer season while reducing flows to the sewer system and improving water quality.



Example: Blue-green roof retrofit

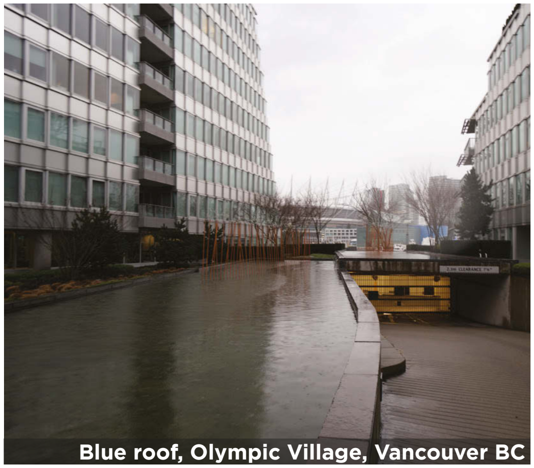
The roof of Building 002 at the former Navy Yard in Amsterdam has been retrofitted with a blue-green roof system that captures and stores rainwater. The roof system consists of an 85 mm thick hollow drainage layer located directly under the planted soil layer that provides rainwater storage. This hollow drainage layer is comprised of lightweight recycled plastic drainage units called permavoid units that are fitted with special fibre cylinders. The fibre cylinders utilize capillary action to transport water to the upper soil layer to naturally irrigate the plants without the use of pumps, hoses, valves or energy.


Building 002 Blue-Green Roof, Amsterdam, Netherlands

Typical applications

- Multi-unit residential buildings
- Commercial and office buildings
- University buildings
- Civic buildings
- Community centers
- Hospitals
- Libraries


Green roof, VanDusen Botanical Garden

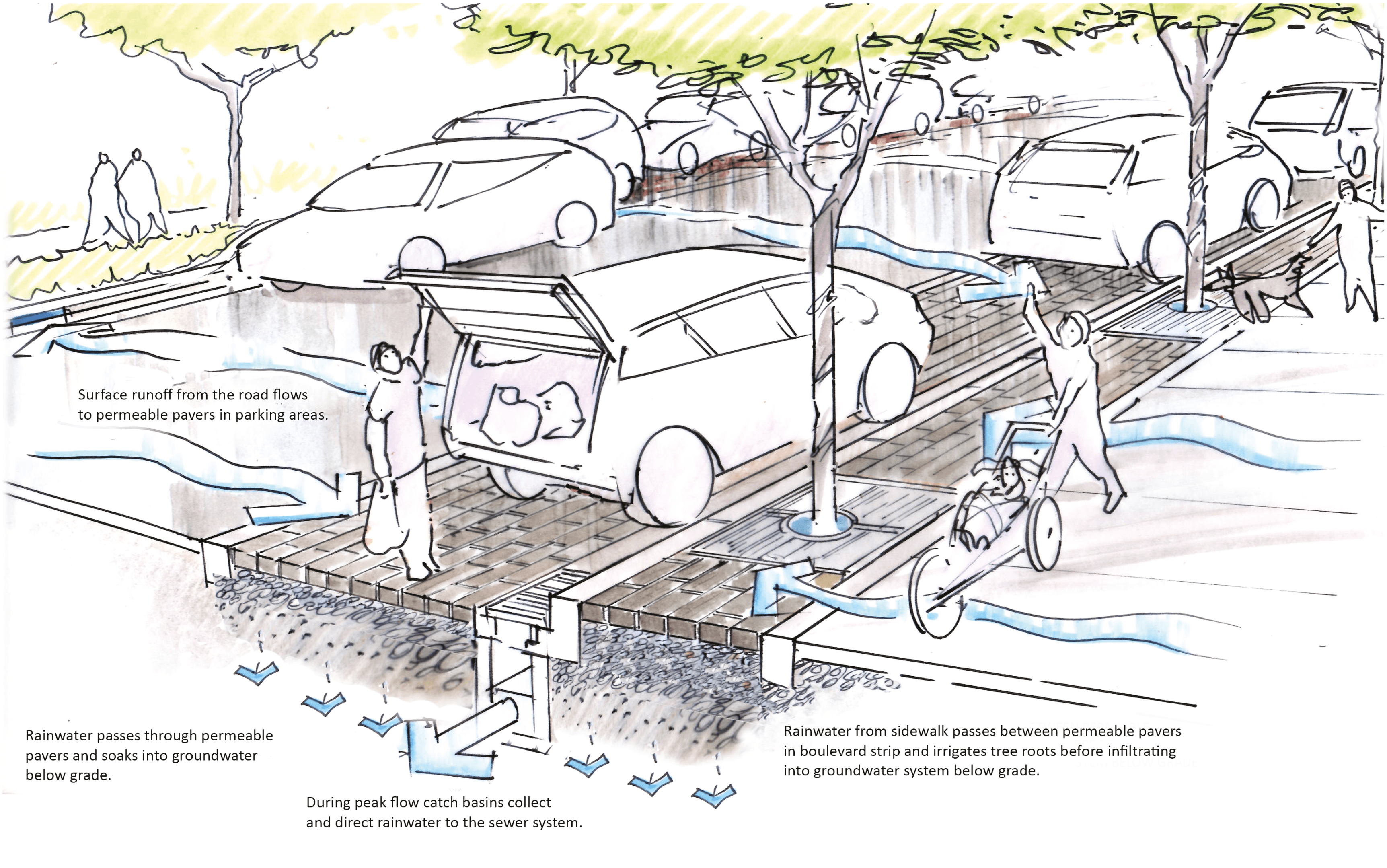

Blue roof, Olympic Village, Vancouver BC

PERMEABLE PAVEMENT

Permeable concrete pavers, pervious concrete, porous asphalt, grass grid pavers/country lane, porous rubber, permeable epoxied gravel

What is permeable pavement?

Permeable pavement comes in a variety of forms similar to the various types of conventional paving materials. All permeable pavement types allow rainfall to soak into an underlying reservoir base where it is either infiltrated to the ground or removed by a subsurface drain. Rainwater is filtered and cleaned through the different aggregate layers and the underlying subsoil layer. Permeable pavement provides a hard, usable surface, whether by cars, bikes, or pedestrians, while reducing runoff volume and improving water quality.



Example: Permeable Parking in Olympic Village

The on-street parking spots along Athletes Way and Columbia Street in Olympic Village are paved with permeable interlocking concrete pavers. These pavers allow rainwater to pass through the paving and infiltrate into the soils below. Permeable pavement projects can be designed to collect and infiltrate rainwater from the surrounding street surfaces; however, this particular application was not designed for this purpose.


Permeable Interlocking Concrete Pavers, Olympic Village, Vancouver BC

Typical applications

- Bike lanes
- Laneways
- Plazas
- Sidewalks
- Parking lots
- Parking lanes
- Low traffic streets


Pervious concrete plaza, Vancouver


Porous Rubber, 10th Avenue Bikeway

LARGE SCALE PRACTICES

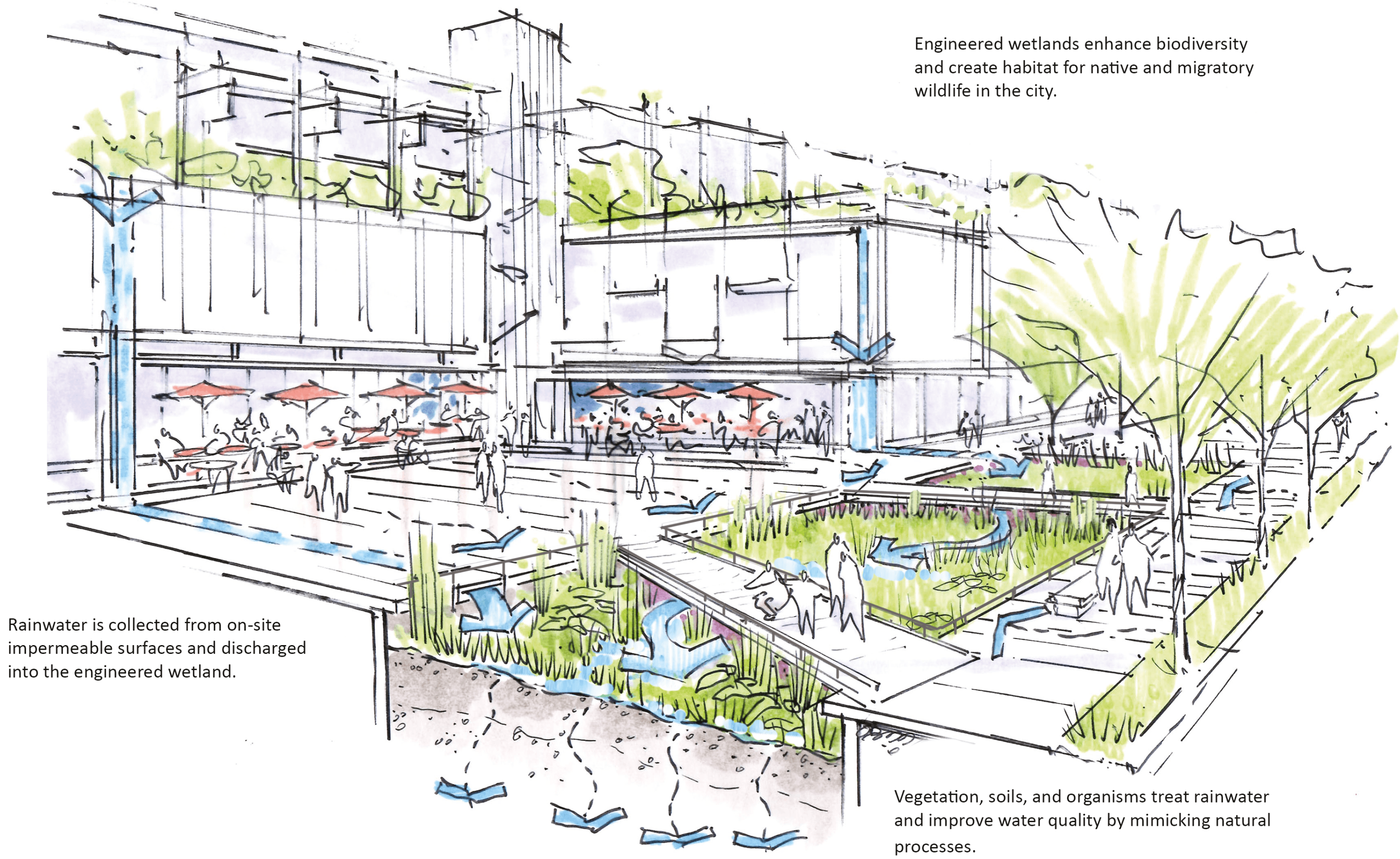
Engineered wetlands, floodable spaces, stream daylighting

What are large scale practices?

This category of GRI practices includes a variety of tools that collect and manage large volumes of surface water. Large scale practices include engineered wetlands, floodable spaces or stream daylighting. Engineered wetlands are designed to use the same processes that natural wetlands use to clean and absorb rainwater runoff.

Floodable spaces include plazas and parks designed with a depression that will fill in with water during heavy rain events and will drain out slowly through an outlet. The space can be multifunctional; designed to be used for recreation during dry weather and flood in wet weather; or be more static in design, retaining visible water features year-round.

Stream daylighting is the practice of recreating or uncovering natural waterways buried as a result of urbanization. Stream daylighting is most beneficial if the restoration includes streamside vegetation and upstream watershed improvements. Opportunities for more projects of this GRI type are being assessed as part of many upcoming projects including the Cambie Corridor and Broadway Area plans and other major projects working to address sea level rise.



Example : Hinge Park Wetland

Hinge Park in Olympic Village includes an engineered wetland which collects and manages two thirds of the rainwater that runs off of roadways, plazas and other public spaces in Olympic Village. The wetland uses native plants and naturally occurring microorganisms to filter water, removing pollutants before the water enters False Creek. The wetland also provides an important habitat for wildlife.

Hinge Park Wetland, Vancouver BC

Typical applications

- Park amenity spaces
- Skate parks and sport courts
- Greenways
- Reconfigured streets
- Plazas

Tanner Springs Park, Portland OR

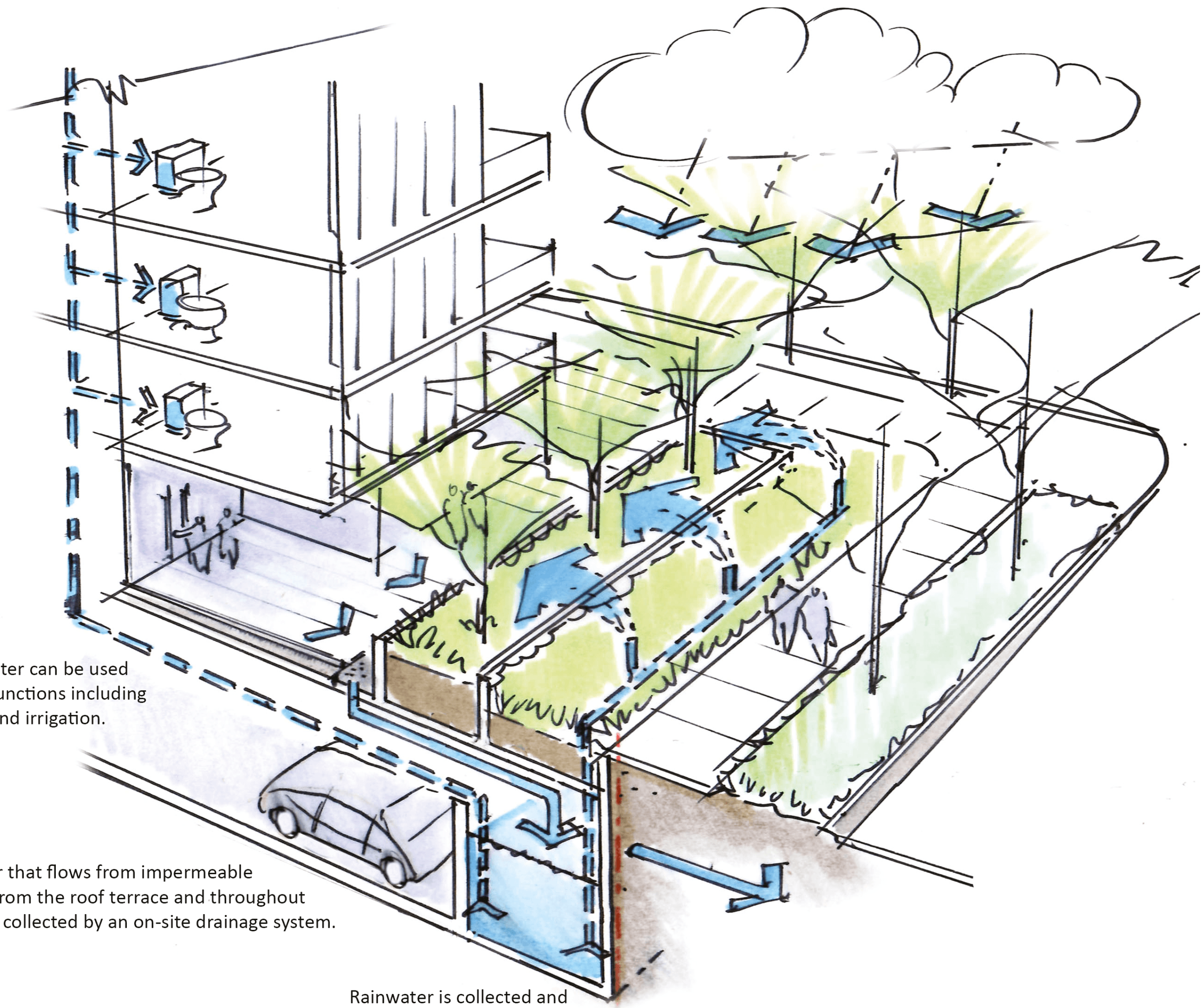
Creekway Park, Creek daylighting, Vancouver

NON-POTABLE SYSTEMS

Water harvest, re-use, and treatment

What are non-potable water systems?

Non-potable water systems aim to collect, store, treat and supply non-potable water in buildings and facilities. Non-potable water is not safe for drinking but can still be used for other applications such as toilet flushing and irrigation. Sources of non-potable water include rainwater, groundwater, greywater and/or blackwater for which strict regulations and guidelines may apply. Greywater refers to wastewater from less intensive uses like showering, hand and dish washing and laundry whereas blackwater refers to wastewater from intensive uses like flushing toilets, and is also referred to as sanitary sewage. Greywater requires less intensive treatment than blackwater before it can be discharged or reused. However, the current regulation for collection and treatment in Vancouver does not differentiate between these two types of wastewater.



Collected rainwater can be used for a variety of functions including flushing toilets and irrigation.

Rainwater that flows from impermeable surfaces from the roof terrace and throughout the site is collected by an on-site drainage system.

Rainwater is collected and stored in storage tanks.

Example: Vancouver Convention Centre

The Vancouver Convention Centre reduces its wastewater discharge to the sewer and its potable water demand through the use of an on-site wastewater (blackwater) treatment plant and distribution system. The use of water efficient fixtures and the blackwater system reduces water use by 38% annually, the equivalent of 300,000 toilet flushes per year.

Vancouver Convention Centre, Vancouver BC

Photo: Courtesy Vancouver Convention Centre

Typical applications

- Multi-unit residential buildings
- Single-family homes
- Townhouses
- Commercial/office buildings
- City works yards
- Schools
- Community Centers
- Golf courses

District Blackwater Treatment, Portland OR

MEC Head Office, Vancouver BC

Photo: Ed White

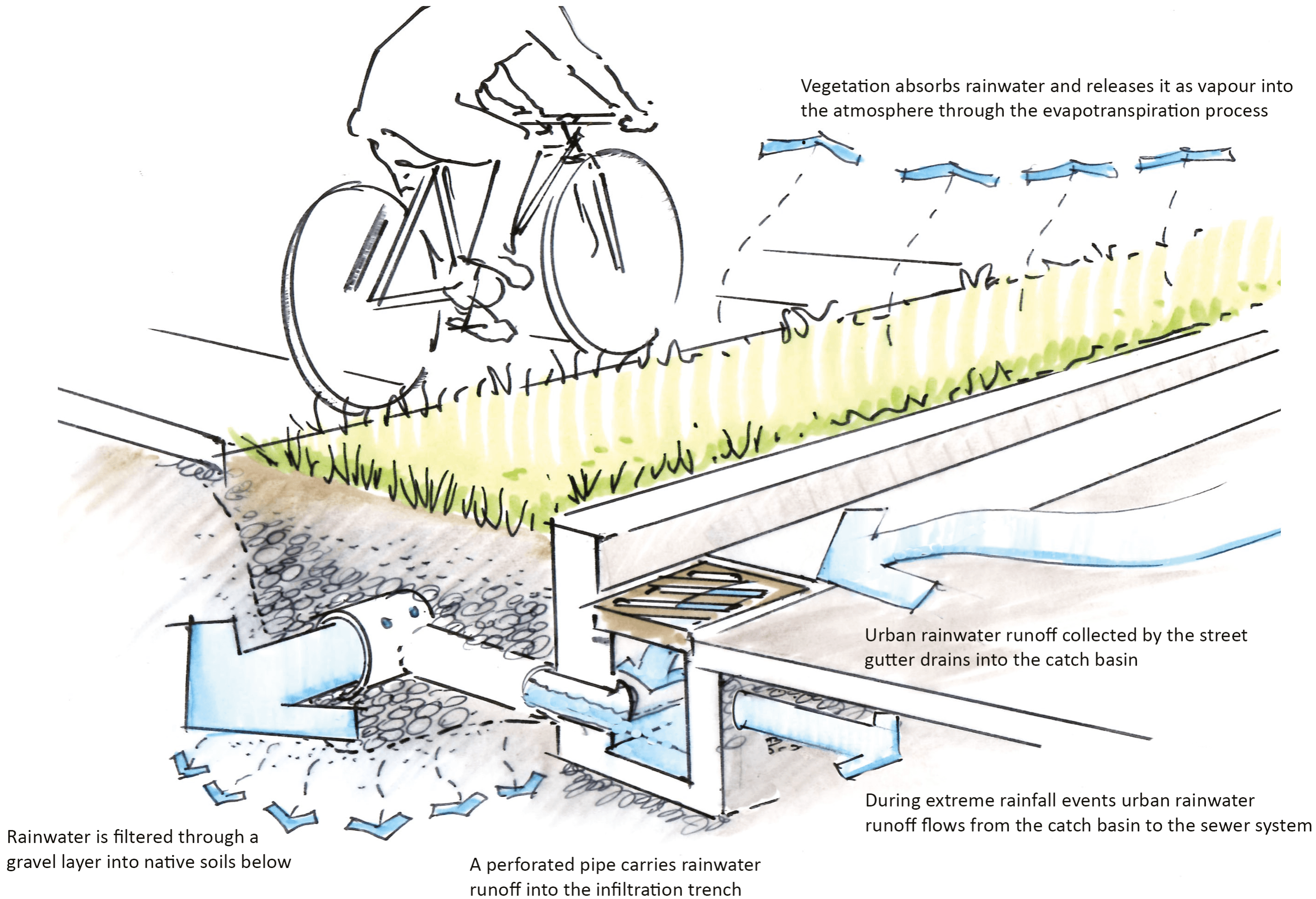
SUBSURFACE INFILTRATION

Infiltration trenches, dry wells, soakways, chambers, arches, modular systems

What are subsurface infiltration practices?

Subsurface infiltration practices use conventional grey rainwater infrastructure to collect and convey rainwater to areas where it can be stored and infiltrated. Large aggregate materials with void spaces and/or modular crates and arches are used to create storage space below the ground's surface. Rainwater is temporarily stored in these practices, giving it a chance to soak back into the ground. Subsurface infiltration practices include infiltration trenches, dry wells, soakways, chambers, arches and modular systems.

Infiltration trenches are typically used to collect and infiltrate rainwater from large areas such as streets, bike lanes, sidewalks and laneways. Dry wells are similar to manholes with perforations that infiltrate rainwater, and can be constructed in series with catchbasins. Soakways, chambers, arches and modular systems can be sized to infiltrate runoff from small or large areas and can be incorporated beneath plazas, natural and artificial turf fields and other locations where sufficient space is available. To date, Vancouver has built 48 subsurface trenches and chambers.



Example: Burrard and Cornwall infiltration trench

Infiltration trenches have been built underneath the existing grass boulevard at the intersection of Burrard Street and Cornwall Avenue in the Kitsilano neighbourhood. The surface runoff is collected by conventional street catch basins and then conveyed into the gravel trench where the water can soak into the soils below. City staff have been monitoring the performance of the infiltration trench since February 2018 and found the trenches are capable of capturing more than 24 mm of rainfall within 24 hours.

Infiltration trench under construction, Burrard at Cornwall, Vancouver BC

Typical applications

- Bike lanes
- Laneways
- Sidewalks
- Underneath plazas
- Natural and artificial turf fields

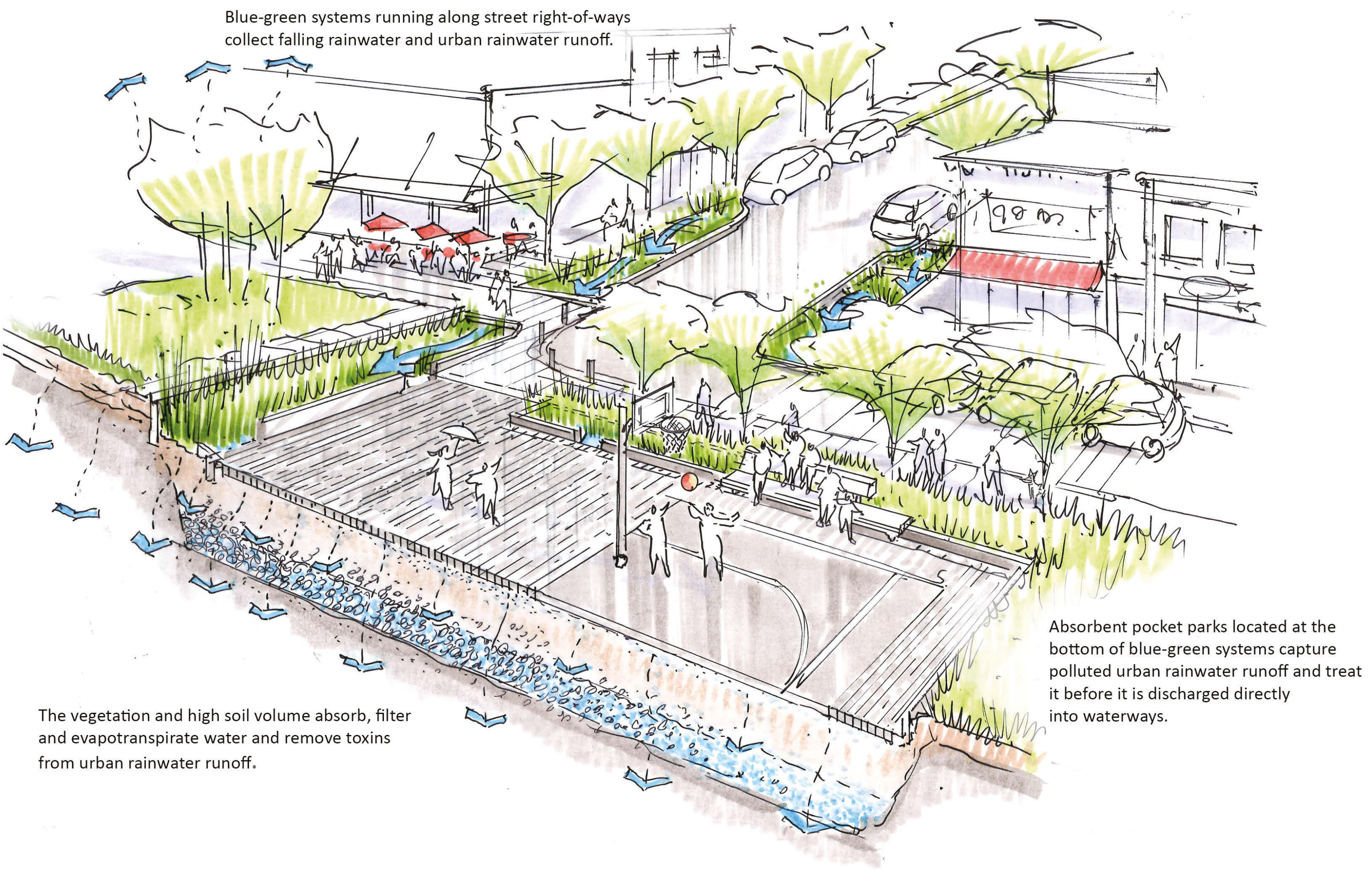
Dry Well

Infiltration Chambers

ABSORBENT LANDSCAPES

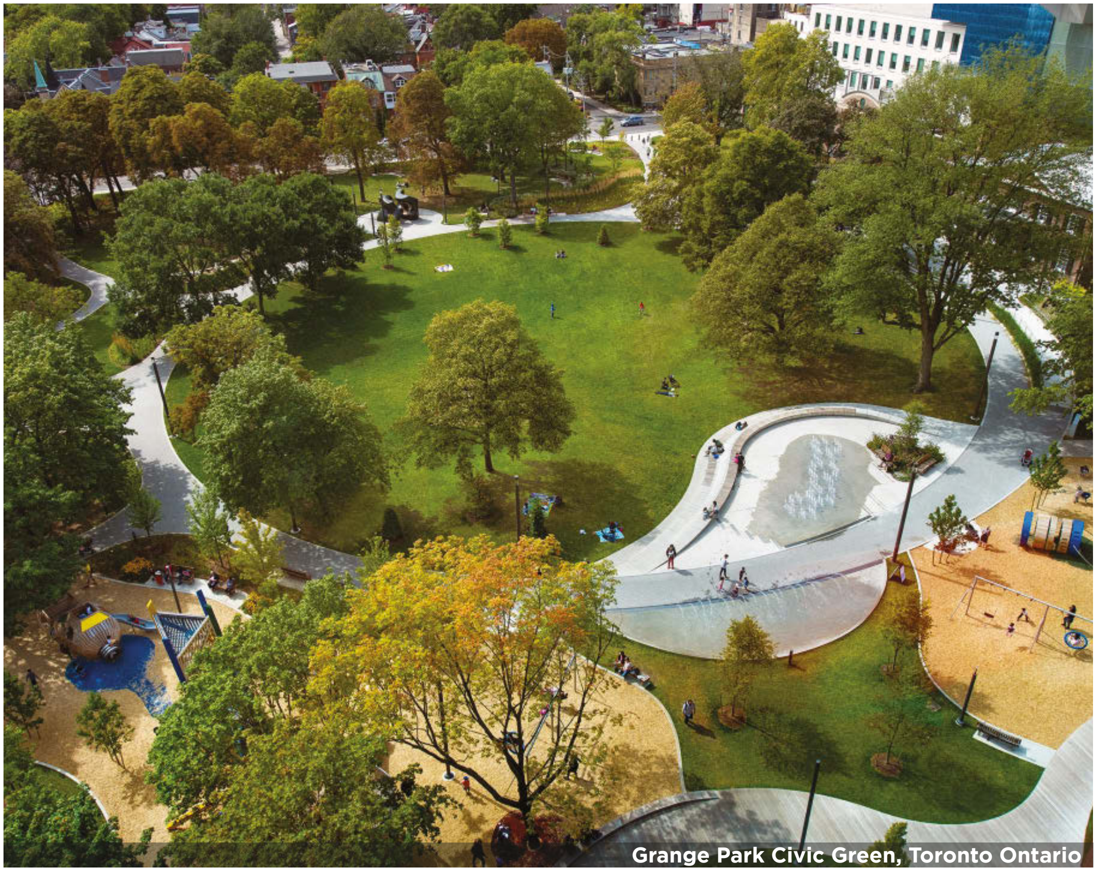
What are absorbent landscapes?

Absorbent landscapes are vegetated areas designed to absorb and retain larger amounts of rainfall than conventional compacted landscapes without ponding. The practice can be as simple as providing an increased uncompacted topsoil depth or including other design features that can capture and retain water. Examples include large evergreen trees to intercept rainwater in their upper branches; plentiful surface vegetation to absorb water, prevent erosion and encourage evapotranspiration; and healthy soil with the right sand and organic matter content, which offers the right balance of permeability and water holding capacity. Absorbent landscapes can improve water quality, reduce runoff and increase biodiversity while creating aesthetic appeal.



Example: Grange Park

The new and revitalized Grange Park in Toronto re-opened in 2017. The design is anchored by a large civic green defined by a circular promenade. The bowl-shaped civic green is designed to collect runoff from the entire lawn and recharge the water table. The park has a zone of historic trees called the 'Grove' on the west side of the park that incorporates intimate gathering spaces that also allow for absorbent landscaping. In addition, many of the large trees planted onsite account for increased evapotranspiration, further reducing the volume of rainwater to be managed. Tree species include American Elm, Horse Chestnut, Beech and Oak and others.



Grange Park Civic Green, Toronto Ontario

Photo: PFS Studio

Typical applications

- Residential front yards
- City boulevards
- Park amenity spaces

Absorbent Landscape, residential

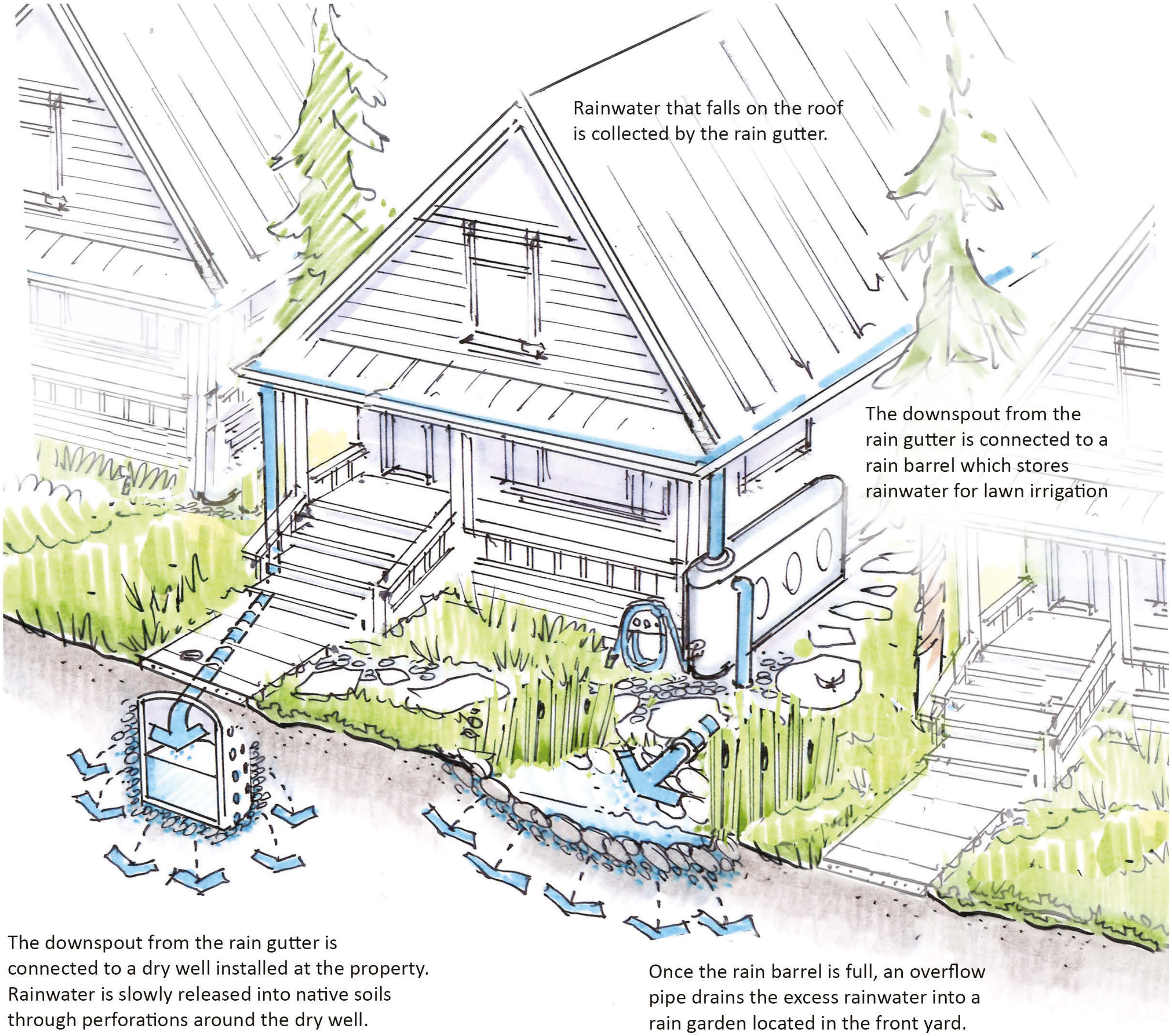
Photo: KWL

Absorbent lawn, public park

DOWNSPOUT DISCONNECTION

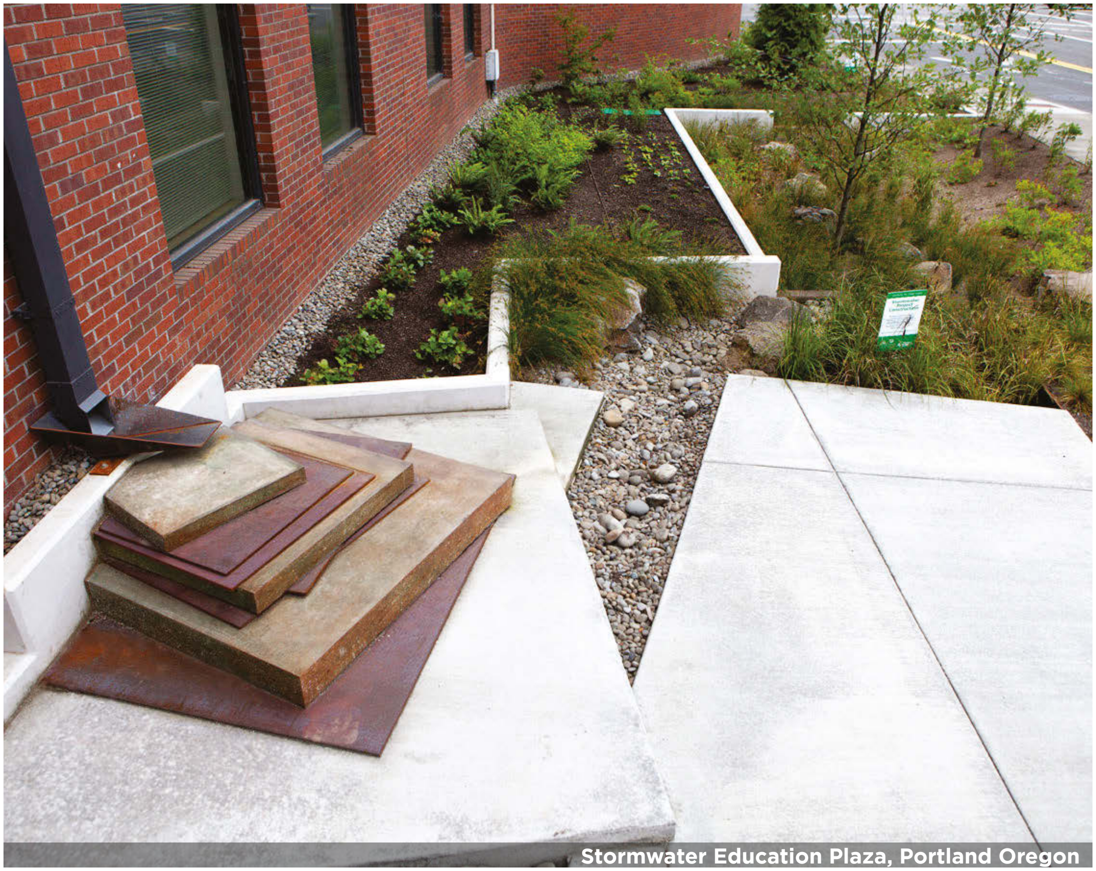
What is downspout disconnection?

Downspout disconnection is the process of redirecting rainwater flowing from downspouts away from the sewer system to complementary rainwater management practices designed to use or absorb rainwater. These practices can include rain gardens and other types of bioretention, rainwater harvest and reuse, absorbent landscapes and subsurface infiltration. When combined with these complementary practices, downspout disconnection reduces the volume of rainwater entering local water bodies through the sewer system thereby reducing CSO volumes.



Example: Stormwater Education Plaza

The City of Portland Environmental Services has collaborated with Portland Community College (PCC) to create the Stormwater Education Plaza at the CLIMB Center on PCC's Central Campus. The disconnected downspout at this location allows rainwater runoff from the Centre's 5,200 ft^2 roof to flow over a concrete and steel slab waterfall into a rain garden. Water that enters the rain garden soaks into the ground. This practice transports rainwater from a 5,200 ft2 (483 m^2) roof space and feeds into a rain garden. The raingarden also captures 3,000 ft (915 m) surface runoff from the adjacent street. In an extreme rain event, the water flows back into an outlet to a catch basin.



Stormwater Education Plaza, Portland Oregon

Photo: City of Portland

Typical applications

- Single-family homes
- Townhouses
- Multi-unit residential buildings
- Large public buildings
- Commercial/office buildings
- Underpass drainage for bridges

Downspout disconnection, Portland OR

Downspout disconnection, Portland OR