5.7 GREEN INFRASTRUCTURE AND INTEGRATED RAINWATER MANAGEMENT

5.7.1 INTRODUCTION

Green Rainwater Infrastructure (GI) refers to both a set of engineered systems and an approach to rainwater management, which uses both engineered and ecosystem-based practices to protect, restore and mimic the natural water cycle. GI systems may use soils, plants, trees and built structures to capture, store and clean rainwater before being absorbed in the ground or returning it to our waterways and atmosphere. The development of Green Rainwater Infrastructure is essential to meeting the goals and criteria outlined in several City of Vancouver documents: Rain City Strategy, Greenest City Action Plan, Climate Change Adaptation Strategy, and the Climate Emergency Action Plan.

This section provides technical guidance on how to design Green Infrastructure systems that meet the City of Vancouver's performance goals and provide the durability and resiliency expected of City of Vancouver infrastructure. The information in this section is intended for use on municipal right-of-ways but may be referenced for use in other areas. The content should not be considered exhaustive. Many other systems and methods may be approved if it can be demonstrated that the designs will meet the City of Vancouver design targets.

A brief description of each section is provided below:

- The *Introduction* section describes the primary motivations for GI implementation in the City of Vancouver and provides descriptions of some of the common GI system typologies.
- *Green Infrastructure Design Targets* outlines the performance goals for GI systems in the City of Vancouver.
- *Site Assessment and Design Considerations* provides an overview of the common design considerations for GI design, guidance on how these considerations may be addressed, and steps for successful GI implementation.

Refer to *Chapter 2: Design Process & Coordination* for specific submission requirements. Sizing and modelling information for Green Infrastructure systems may be found on the Green Infrastructure webpage. Construction Specifications and Standard Drawings for Green Infrastructure systems may also be found on the Green Infrastructure webpage. For more information on Green Infrastructure and Rainwater Management in the City of Vancouver, please refer to the Rain City Strategy.

5.7.1.1 MOTIVATIONS FOR GREEN INFRASTRUCTURE

GI is an emerging field and approach to rainwater management that uses both engineered and ecosystem-based practices to protect, restore and mimic the natural water cycle. It uses soils, plants, trees and built structures such as blue-green roofs, swales, rainwater tree trenches and rain gardens to capture, store and clean rainwater before being absorbed in the ground or returning it to our waterways and atmosphere. GI can also include the harvest and reuse of rainwater.

GI can be considered both a drainage infrastructure tool and an approach to water management and natural systems. GI systems are an essential component of resilient cities. They can reduce sewer flows, improve runoff water quality, mitigate urban heat islands, expand urban biodiversity, and benefit the physical and mental well-being of urban residents. Well-designed GI systems can provide all of these benefits. This document provides guidance on how GI systems can meet the targets adopted by the City of Vancouver and also contribute to the City's livability and resilience.

The design and placement of GI systems is also motivated by the City of Vancouver Equity Framework. High priority areas for new GI systems include historically under-serviced areas of the City such as those with low tree canopy, high urban heat, and a deficit of park space.

5.7.1.2 GREEN INFRASTRUCTURE TYPOLOGIES

This chapter provides design guidance on basic typologies of green infrastructure that may be used on City property. These include but are not limited to the following:

- **Bioretention** – Also known as rain gardens or bioswales, these systems may be designed for full infiltration, partial infiltration, and lined systems.
- **Rainwater Tree Trenches** – Tree trenches are a series of tree pits connected in the subsurface by perforated pipes, growing medium, structural soil, or soil cells and receive stormwater from surface inlets.
- **Subsurface Infiltration** – Subsurface infiltration practices can take many forms from linear gravel filled trenches to dry wells to chambers.
- **Permeable Pavement** – includes porous asphalt, pervious concrete, permeable concrete unit pavers, and grid pavers that may be filled with gravel or vegetation.

While these GI typologies utilize many common principles, materials, and performance mechanisms, they have unique design considerations and best practices. Additional information on the recommended design strategies and principles for these typologies may be found on the Green Infrastructure Website and in the Rain City Strategy.

5.7.2 GREEN INFRASTUCTURE DESIGN TARGETS

Green infrastructure is designed to manage small and frequent storms while allowing larger and extreme storms to safely bypass or be conveyed through the practice.

The City's Rain City Strategy and Integrated Rainwater Management Plan (IRMP) set design targets for green infrastructure for the majority of the City where stormwater is piped directly to either combined sewer, ocean or waterway outfalls. Outside of the IRMP study area, two watersheds in Vancouver have remaining surface streams: Still Creek and Musqueam Creek. The Still Creek Watershed Management Plan has goals, but does not set design targets, and the Musqueam Creek Watershed Management Plan has not been completed. In the absence of targets for those watersheds, the Citywide IRMP targets will apply and are summarized below.

Table 5-18: Green Infrastructure Design Targets

Volume Reduction	Retain 48 mm of rainfall during a 48 mm, 24hr storm (90% of the average annual rainfall volume). Infiltrate, evapotranspirate, and reuse rainwater to the greatest extent practicable.	See Section 5.7.2.2
Drawdown Time	Green infrastructure systems should be designed such that the above-ground ponded volume of the system can drain within 24 hours after the end of the rainfall event, and the soil media should drain within 72 hours after the end of the rain event.	See Section 5.7.2.3
Water Quality	Remove 80% of Total Suspended Solids (TSS) by mass for particles < 50μm during the first 48 mm of rainfall (event representing 90% of the average annual rainfall volume) and/or remove 80% of TSS according to results provided by Environmental Technology Verification (ETV) or Technology Assessment Protocol - Ecology (TAPE).	See Section 5.7.2.4
Urban Biodiversity	Prioritize the development of vegetated infrastructure systems that can support urban ecology.	See the Biodiversity Strategy, Urban Forest Strategy, and GI Planting Guide

5.7.2.1 DESIGN TARGET COMPLIANCE

Green infrastructure systems depend on environmental variables and space constraints that can vary significantly between sites. In areas with highly impermeable or contaminated soils, infiltration may be infeasible; a high groundwater table or bedrock may also limit surficial storage capacity.

An inability to meet design targets due to site constraints should not prevent the installation of green infrastructure systems. Design targets are to be implemented to the “greatest extent practicable” (GEP) to ensure that GI systems are utilized wherever possible. The GEP recognizes that the benefits of GI extend beyond traditional infrastructure servicing and that GI systems are a public good, regardless of whether or not they provide 48mm of volume retention.

If meeting any of the numerical design targets described in Section 5.7.2. is infeasible due to site constraints, the GEP expectation may be met by allocating a specific percentage of the site area or contributing drainage area to appropriately designed GI systems. For new roadway construction, a minimum of 4% of the contributing drainage area should consist of GI to comply with the GEP expectation. Roadways or developments containing less than this target may be approved at the discretion of Green Infrastructure Implementation branch staff.

5.7.2.2 VOLUME REDUCTION HIERARCHY

Rainfall runoff may be managed by GI systems through retention, detention, infiltration, evapotranspiration, or filtration. The prioritization of these pathways is referred to in this document as a ‘hierarchy’ of preferred strategies. Rainwater management on a site with a depleted groundwater table may prioritize infiltration, whereas a high-density residential site with highly impermeable soils may prioritize filtration and detention.

The top priority for 48mm management is full infiltration and evapotranspiration. If a stormwater management plan (SWMP) or geotechnical report for a given site demonstrates that full retention of the 48mm target is infeasible despite best efforts to accommodate the target, an allowance may be granted to provide 48mm of rainwater management through partial infiltration. Partially infiltrating green infrastructure systems have a perforated underdrain to discharge runoff to the sewer system after it is slowed and filtered through a green infrastructure system.

If the infiltration capacity is extremely low (<1 mm/hr) or other constraints (e.g. high groundwater, tree retention, contaminated soils) prohibit use of partially infiltrating GI, allowance may be granted for a combined grey-green system that discharges filtered runoff to detention storage and slow release.

The designer must prioritize methods of capture according to the categories below. Justification must be provided for using the priority 2 and 3 management options. Regardless of the criteria being met, the use of vegetation within stormwater management systems should be prioritized to meet the goals outlined in the City's biodiversity and urban forest strategy.

The priority tiers are as follows:

Priority 1: Full Infiltration

Priority 2: Partial Infiltration

Priority 3: Filtration and Detention

The City of Vancouver reserves the right to determine the water management priorities for a particular site depending on the context of the proposed area and the needs of the surrounding sewershed. For development areas, water re-use may be considered a Priority 1 management option. Criteria for using Priority 1 and 2 management systems are provided below.

Priority 1 Criteria:

- Sufficient setbacks from building foundations and utilities
- Downstream sewer inlets for accommodating overflow
- High infiltration capacity (e.g. greater than 15 mm/hr)
- Lack of contamination concerns
- Lack of slope stability concerns (as supported by a preliminary geotechnical study)

Priority 2 Criteria:

- Low infiltration capacity (e.g. less than 15 mm/hr, greater than 1 mm/hr);
- Limited available space for engineered infiltration systems due to onsite conditions, such as tree retention;
- Seasonally high groundwater table or bedrock more than 0.6 m from the bottom of the practice;
- Lack of contamination concerns

If the Priority 2 criteria are not met, Priority 3 alternatives should be considered.

5.7.2.3 DRAWDOWN TIME

Drawdown time is a measure of the time it takes for water to drain out of a GI system and is an important metric for green infrastructure performance. GI systems store runoff onsite and slows its flow into sewer systems, but they also must be designed to drain quickly enough that they can accommodate runoff from another storm event. Excessive waterlogging can also be detrimental to plant health and may be seen by residents as a nuisance. Section 5.4.4. states that ponding within City of Vancouver Streets is not acceptable because streets act as water conveyance systems. Green infrastructure is outside of the conveyance area of Streets, and so ponding is acceptable and often required in GI systems.

City of Vancouver GI systems should be designed to comply with two drawdown time performance targets.

- Maximum duration of ponded surface water: 24 hours
- Time required for excess water to drain from the systems soil (i.e. time until soils return to their field capacity): 72 hours

Drawdown times can be calculated using SWM modelling software or an approved design spreadsheet. Calculations should demonstrate that surface ponding in the system does not exceed 15cm during a 48 mm storm event. An allowance for additional ponding may be granted for green infrastructure systems with access prevention or systems that are not directly adjacent to pedestrian or roadway areas.

Additional information related to infiltration and exfiltration calculations is provided in the *GI Sizing and Modelling Guide* available on the Green Infrastructure webpage.

5.7.2.4 WATER QUALITY

The first 48 mm of rainfall from all pervious and impervious surfaces shall be treated to remove 80% Total Suspended Solids (TSS) by mass prior to discharge from the site. Treatment can be provided by either one green infrastructure practice or structural Best Management Practice (BMP) or by means of a treatment train comprised of multiple practices.

80% TSS removal by mass can be provided by designing and constructing a vegetated green infrastructure system to the standards outlined in this manual and any applicable construction specifications. A GI system that complies with the design requirements in this chapter, including having an appropriate ratio of *impervious* contributing drainage area to *pervious* GI area, referred to herein as the IP ratio, is assumed to meet the water quality requirements. Additional information on appropriate IP ratios is included in Section 5.7.3.3 and in the *GI Modelling Guide* on the Green Infrastructure webpage.

Compliance with the 80% TSS removal target may also be met using proprietary treatment devices. Proprietary treatment devices must be approved by City Staff and resources must be allocated for their continued maintenance. Proprietary treatment devices should demonstrate removal of 80% TSS removal for particles less than 50 microns and/or be certified by either the Washington State Department of Ecology's Technology Assessment Protocol –Ecology Program (TAPE) or Environmental Technology Verification (ETV) Canada. The applicant may propose other technologies but must provide supporting information that shows the technology meets the treatment standard.

Compliance with the 80% TSS removal target may also be met using proprietary treatment devices. Proprietary treatment devices should demonstrate removal of 80% TSS removal for particles less than 50 microns and be certified by either the Washington State Department of Ecology's Technology Assessment Protocol – Ecology Program (TAPE) or Environmental Technology Verification (ETV) Canada. The applicant may propose other technologies but must provide supporting information that shows the technology meets the treatment standard.

5.7.3 SITE ASSESSMENT AND DESIGN CONSIDERATIONS

Prior to the design of any GI system, the proposed site should be assessed for feasibility. The following guidance is intended to improve design times and ensure that GI systems appropriately consider site conditions, however the following sections are not a comprehensive list of the site-specific factors that should be considered in GI system design. ***Table 5-19***Table 5-7 ***p***rovides an overview of some of the more frequently encountered site considerations for GI systems. Additional information on these considerations is provided in the following sections.

Table 5-19: Considerations for GI Site Assessment

Required Information	Comments
Site Characterization	Designing GI systems requires an assessment of the proposed location and any site characteristics that impact the design. Existing trees, surrounding vegetation, road classification, and transportation needs should also be assessed, along with the presence of any City planning or construction initiatives in the surrounding area.
Geotechnical and Hydrogeological	A qualified geotechnical and hydrogeological consultant should assess the subsoil composition, infiltration rates, and underlying groundwater quality characteristics near the proposed GI system. See *Section 5.7.3.1*.

Services and Utilities	All services and utilities within 20 meters of the GI system should be identified prior to GI system design. Their approximate depths should be noted on a preliminary design drawing. See *Section 5.7.3.2*.
Contributing Drainage Area	Delineating and characterizing the contributing drainage area for the GI system is an essential component of GI sizing and determining future maintenance needs. See *Section 5.7.3.3*.
Topography and Grading	The slopes of the surrounding roadway, sidewalk, and boulevard will impact the grading of the GI system and the need for internal weirs and/or check dams. See *Section 5.7.3.4*.
Streets Features	The removal, replacement, or addition of streets features including but not limited to signage, litter cans, water fountains, benches, or planters should be coordinated with the relevant City branches during the site assessment phase. See *Section 5.7.3.5*.

5.7.3.1 GEOTECHNICAL AND HYDROGEOLOGICAL ASSESSMENT

Site specific geotechnical studies are recommended to support the design of surface-level green infrastructure systems and should include the following:

- An evaluation of the potential for and risks of onsite rainwater infiltration, such as slope stability, soil contamination, and nearby foundations and basements;
- Results of infiltration testing at likely locations for infiltration practices and a proposed design infiltration rate;
- Soil stratigraphy; and
- Depth to bedrock and seasonally high groundwater at likely locations for infiltration practices.

The design infiltration rate should be determined by borehole infiltration test (ASTM D6391), double ring infiltrometer or auger hole (i.e. Guelph) permeameter (as outlined in ASTM D5126) or an approved equivalent and should be conducted at the estimated depth of the GI system or a depth of 1.0 meter below surface level.

Boreholes for infiltration testing should be taken within the GI system area if possible, otherwise, they should be within 10 meters of the system footprint. Guidance for the number of test pits and/or soil borings for a given GI asset is included in the table below.

Table 5-20: Infiltration Testing Guidelines

Infiltration GI Surface Area (m2)	Number of Test Pits or Boreholes	# of Infiltration Tests per Pit or Borehole
<50	1	1-2
50 to 900	2	
>900	2 per $450m^2$	
Linear	1 per 100m	

Test locations should be spaced equidistant from one another. At least one infiltration test should be taken per borehole, though possibly more if infiltration rates during the test are inconsistent. The design infiltration rates should be calculated by dividing the measured infiltration rate by a safety factor of between 1 and 2, depending on the confidence on the infiltration rate test (high confidence, safety factor of 1, low confidence, safety factor of 2).

An additional round of tests should be conducted at 1.5 meters below the proposed bottom elevation of the system if there is significant variation in the initial results due to inconsistent geologic formation, soil texture or bulk density.

5.7.3.2 UTILITY SETBACKS AND PROTECTION

With protective measures and sufficient setbacks, GI systems can be successfully designed in proximity to most services and utilities. However, proximity to some utilities may lead to significant cost increases and introduce design complexities. The presence of the following services and utilities within the proposed work area for a green infrastructure system should be discussed with the project planning team at the earliest opportunity.

- Sanitary or combined sewers
- Water distribution systems
- Street lighting and traffic signals
- Above-ground BC Hydro lines
- High voltage BC Hydro ducts
- Third-party utilities (Fortis, Telus, etc.)
- Abandoned utilities

Utilities and services that pass under or adjacent to a GI system may require protective measures to ensure that construction and operation of the GI system does not negatively impact service provision. These setbacks and protective measures are specifically for utility coordination.

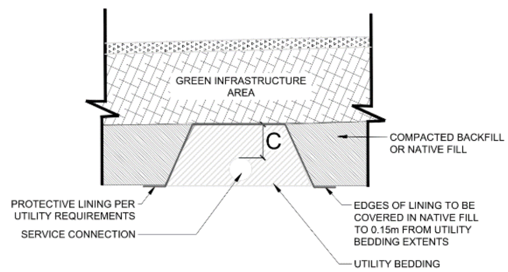
Unless otherwise noted, all clearances are measured from the outside edge of the service/utility to the nearest edge of the GI practice. Reference drawings are provided below outlining the separation distances relative to GI features. ***Table 5-21*** provides an overview of the required setbacks for services and utilities.

The setbacks and protective measures described in this section are preliminary and approximate. They are subject to change based on site-specific considerations and details related to the relevant on-site utilities. Utility coordination and protection measures on specific projects should always be confirmed with the appropriate City of Vancouver Engineering branches.

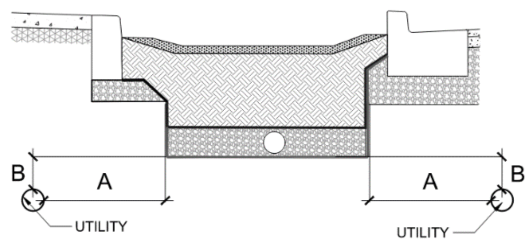
Wherever possible, utility bedding that passes through GI systems should be surrounded by compacted backfill such as drain rock or structural soil. For information related to the bedding requirement for individual utilities, refer to the appropriate utility construction specifications and the guidance in the relevant section of the Design Manual.

Figure 5-6: Reference Dimensions for GI Utility Separation

Service Lateral Crossing GI System



Service Parallel to GI System



The *Maximum Separation Distance Requiring Protective Measures* is the distance between a utility and a green infrastructure system at which protective measures for that utility are required, which are the **bold** numbers.

The *Minimum Separation Distance to Protective Measure* is the closest that a GI system boundary may be located to that utility even with protective measures in place, which are the numbers in parenthesis. If the separation distance is less than this value, the system boundaries must be adjusted to accommodate the setback.

Separation distances are to be measured from the outside of the utility to the nearest edge of the GI system as defined by the vegetated area, infiltration area, or perforated pipe.

Table 5-21: Recommended GI Separation from Utilities and Services

Service	**Maximum separation distance requiring protective measures** (minimum separation distance to protective measure). All units are in meters.			Protective measures required for service/utility when offset is not met.
	<A	<B	<C	
Parallel water distribution infrastructure	**3.0** (1.0)	**0.3** (0.3)	**0.3** (0.3)	Impermeable liner on the side of the GI trench nearest the water main
Storm sewer	**1.5** (0.0)	**0.3** (0.3)	**0.3** (0.3)	Non-woven geotextile
Sanitary sewer	**1.5** (0.3)	**0.3** (0.3)	**0.3** (0.3)	Impermeable liner
Telco	Refer to Chapter 7 for guidance on third-party utilities.			
Gas				
Street lighting				
BC Hydro (Subsurface)				
BC Hydro (Aboveground)				
Building foundations	**5.0** (1.0)	**N/A**	**N/A**	Impermeable liner
Retaining wall foundations	**3.0** (1.0)	**N/A**	**N/A**	N/A
District Energy Utilities	**1.2** (0.3)	**0.3** (0.3)	**0.3** (0.3)	Impermeable liner and non-woven geotextile

As shown in ***Figure 5-6,*** service laterals that cross GI systems should be surrounded by existing sub-base or the appropriate utility corridor aggregate and wrapped in the protective measure outlined in ***Table 5-21***. Further details for specific utilities are provided below.

For additional information regarding drawing requirements for services and utilities please refer to Chapter 2.

District Energy Utility Protection

GI systems must have a separation distance of 1.2m from District Energy Utility (DEU) transmission lines within the roadway to ensure sufficient space for excavation and repair of the DEU system. If a DEU joint is within the excavation area of a GI system, the joint should be wrapped and sealed with an impermeable liner. DEU sand bedding should be placed around the impermeable liner, and a non-woven geotextile should be wrapped around the sand bedding.

Wherever a DEU connection passes through a GI system, non-woven geotextile should be placed around the DEU bedding to prevent the sand bedding from migrating into the GI soil medium. Where Controlled Density Fill (CDF) is used for DEU connection bedding, a minimum of 0.30 m of soil should be placed above the CDF to allow for overlying plant growth.

Trees should not be planted near a DEU connection if the expected root zone may overlap with the DEU service.

Refer to Chapter 6 of the City of Vancouver design manual for further information.

Water Main Infrastructure

Protective measures must be considered for any water main infrastructure within 3 m horizontally from a GI system or 1.0 meter vertically. The proposed protective measures for a GI system within 3.0 meters of water service infrastructure must be reviewed and approved by CoV Waterworks Design. Where protective measures are required, a variance form may need to be submitted to CoV Waterworks Design for review. Waterworks Design will review the GI design and obtain approvals from VCH. For new water infrastructure near existing GI systems, proposed separation distances less than 3 meters will need to be reviewed concurrently with the proposed protective measures and approved by VCH.

Best practices for protection of water infrastructure near GI systems are evolving. Contact the Green Infrastructure Implementation Branch for clarification on current requirements and/or recommendations at raincity@vancouver.ca.

Sanitary and Storm Sewer Protection

Sanitary and combined sewer connections that pass through GI systems should be wrapped with an impermeable liner around the sewer bedding or the pipe joints should be wrapped with an approved waterproofing material. The sanitary or combined pipes may also be upgraded to a pressure rated pipe in lieu of an impermeable liner. Storm sewer connections do not require impermeable lining or joint wrapping. Bedding for sewer connections passing through GI systems should be wrapped with a geotextile to prevent fines migration between the connection bedding and the GI backfill. Sewer bedding should always be surrounded by backfill that can be compacted to 95% MPD or an approved equivalent, such as structural soil.

If a new sanitary main is installed less than 1.5 meters horizontally from a GI system and less than 0.3m beneath the bottom of the GI system, the portion of the sewer adjacent to the GI system should be wrapped with an impermeable liner (30mm LLDPE waterproof membrane or equivalent). If a GI system is installed less than 1.5 meters horizontally and less than 0.3 meters above a sanitary sewer, an impermeable liner should be installed on the side of the GI system nearest the sanitary sewer. Storm sewer mains adjacent to GI systems in the public ROW do not require protective measures.

Sewer bedding that is disturbed during GI construction should be reinstalled and recompacted wherever it was disturbed during.

GI systems should not be constructed within 0.3 m of a sanitary sewer main or a storm sewer main to allow for excavation of the utilities without disturbing the GI system. Refer to Chapters 4 and 5 for more details.

5.7.3.3 CONTRIBUTING DRAINAGE AREA

The contributing drainage area to GI assets should be characterized at the preliminary design stage. The contributing drainage area should be demarcated by land use such that the total contributing paved areas and the total contributing vegetated or sodded areas are recorded. This demarcation is important to calculating the effective contributing drainage area. For rational method assessments, the effective contributing drainage areas can be calculated with a composite runoff coefficient weighted by the portion of vegetated and paved areas in the contributing drainage area. For GI projects on City ROWs, the contributing drainage area should be delineated as the entirety of the ROW between the GI asset and the nearest upstream CB.

The composition of the contributing drainage area has important impacts on GI design and performance. The presence of active construction, high traffic loading, and deciduous trees may increase sedimentation and debris in the GI area and lead to greater maintenance needs. During the preliminary design stage, a description of the contributing drainage area should be recorded in project documentation.

Delineating the contributing drainage area is an essential step in sizing GI systems at the preliminary and detailed design stages. Preliminary GI sizing can be conducted using the Impervious-Pervious (IP) ratio, which compares the contributing *Impervious* catchment area to the *Pervious* GI system area.

> *Example: If the GI system consists of 10 m^2 of pervious area, and 300 m^2 of impervious roadway is directed to that system, the IP ratio is 30:1.*

The following table provides recommended and maximum IP ratios for functional GI sizing of different practices.

Table 5-22: GI Impervious to Pervious Ratios

GI System Type	Recommended IP	Maximum IP
Bioretention	20:1	35:1
Tree Trenches	20:1	30:1
Infiltration Systems	20:1	45:1

These ratios should only be used to identify the approximate footprint requirements of GI systems and may not represent the final sizing requirements once site-specific constraints are accounted for.

Permeable pavement systems should be designed so they do not accept any drainage from other areas and only manage the rainfall that falls on the permeable pavement surface.

5.7.3.4 TOPOGRAPHY AND GRADING

Prior to the design of any green infrastructure system, the topography of the proposed site and the contributing drainage area must be assessed and reflected on preliminary drawings. Preliminary drawings should include key grades and overland flow paths of the surrounding area. It must be technically feasible to direct runoff from the intended contributing drainage area into the green infrastructure system, which can be assessed with conventional grading design.

Site topography may impact system selection and design in a variety of ways, including but not limited to the following:

- Steep contributing drainage areas (>8%) may require additional erosion protection measures to reduce the impact of high-velocity runoff.
- GI systems on sites with a slope greater than 3% may require weirs or check dams to encourage ponding across the length of the system. Weirs and check dams may be constructed of natural or constructed materials.
- When a low-point (sag) is present within the area proposed for a GI system, an overflow inlet connected to the City sewer system should be designed with capacity to accommodate major storm events. Grading of surrounding features such as sidewalks, ramps, and curbs, may limit the available ponding depth in the system.

5.7.3.5 STREET FEATURES

If a proposed GI system is located on the boulevard or at an intersection, there may be existing street furniture installed within the design area. Street furniture includes but is not limited to benches, bike racks, bus shelters, waste bins, map stands, and advertising panels. During site assessment, any street furniture found within the design area should be flagged for further review by the Street Furniture Coordinator at street.furniture@vancouver.ca.

If any waste receptacles are found within the design area, Solid Waste Programs should be notified. If a proposed GI system is located on the boulevard or at a commercial intersection and there are no waste receptacles on site during site assessment, it could potentially be a site for planned waste receptacle installations and Solid Waste Programs should be notified.

Street furniture, including waste receptacles, needs to be anchored on a concrete pad. A hard surface may also be required for the space between the street furniture concrete pad and the curb, which may conflict with GI design.

5.7.3.6 SYSTEM CONSTRAINTS

The following design constraints should be considered for all vegetated GI systems.

Maximum Ponding Depth

GI systems should be designed to maximize the surface area of ponded water. The depth of ponded water, as defined by the elevation difference between the CB grate and the bottom of the vegetated area, should be no less than 10cm. The depth of this ponded water should be no greater than 15 cm where a GI system is immediately adjacent to a pedestrian area of roadway. Excessive water ponding in public areas can pose a risk to residents and may lead to difficulties ensuring the surface ponding drawdown time is less than 24 hours. Large GI systems may have ponding depths greater than 15 cm in areas of the system with more than two meters of separation from pedestrian areas or roadways. All GI systems in the right-of-way should be designed to overflow onto the roadway to ensure that any overflow is directed to a downstream catchbasin.

Maximum Step Height

Where a GI system is adjacent to a pedestrian area or a parking lane, the elevation difference between the surface of the GI system and surrounding hard surfaces should not exceed 17cm. Where a GI practice is adjacent to a public roadway that does not have street parking, the elevation difference between the roadway top of curb and the bottom of the GI system should not exceed 25cm. If street parking is present, a 17cm maximum may be enforced.

This elevation difference is referred to as the “step height” because it is the height that a pedestrian would have to step to enter the GI system from the adjacent hard surface.

Vegetated Slopes

The vegetated portions of GI systems should be flat wherever possible to encourage an even distribution of water for infiltration. However, a vegetated slope may be required due to grading constraints within a GI system, a maximum 2:1 slope should be used to ensure slope stability without requiring compaction. A 3:1 slope is preferred under all conditions.

5.7.3.7 RECOMMENDED STEPS FOR SUCCESSFUL DESIGN

The following steps provide an overview of the process for designing GI systems in the municipal ROW.

Step 1: Site Assessment

The first steps to designing a GI system are determining how much space is available for the system, and the boundaries of the contributing drainage area. Establishing site limitations and characteristics is a prerequisite for determining if a system meets the system design targets described in *Section 5.7.2*.

Step 2: Identify System Constraints

Once the boundaries of the system are determined, designers must identify the surrounding constraints, utilities, and required setbacks for the proposed area. Green Infrastructure systems have a variety of setback requirements from utilities, sewers, existing trees and vegetation and foundations. At the initial design stage, designers must identify any feature which may impact the location, depth, or footprint of a GI system. This information is critical to determining what type of system is more appropriate for the proposed area. More information is provided throughout *Section 5.7.3*.

Step 3: Establish the Infiltration Rate

The infiltration rate should be established using the standard methodology determined by the City of Vancouver as outlined in *Section 5.7.3.1*.

Step 4: Identify System Alternatives

Once the system constraints and performance targets are identified, designers should consider which GI systems are most likely to succeed on the proposed site and which system designs are best suited for the site context and any relevant City goals or targets for the proposed area.

Step 5: Calculate Proposed System Sizing

A preliminary sizing estimate is important to determine if the proposed GI system will have capacity for the contributing drainage area. At the preliminary design stage, GI systems should be assumed to have a ratio of contributing impervious drainage area to the GI system area consistent with those outlined in *Section 5.7.3.3*. Additional sizing guidance is provided in the *GI Sizing and Modelling Guide*, available on the Green Infrastructure webpage.

Step 6: Confirm System Performance

Once the system has been sized, it is important to verify system compliance with the relevant design targets as outlined in *Section 5.7.2*. Compliance should be assessed as a percentage completion of the relevant numerical targets.

Step 7: Re-assess and Optimize Design

If performance targets are not met initially, consider ways to optimize the performance of the system by increasing subsurface storage volume, increasing system surface area, providing more ponding volume, or adding additional systems. If necessary, return to Step 4 and re-consider other designs or typologies.

Step 8: Assemble Resources

Once a preliminary design has been finalized, the City of Vancouver GI Standard Drawings should be reviewed to confirm all relevant standards and determine what system components have already been drafted. Guidance on the content required in GI project drawings is included in Chapter 2.

The City of Vancouver Green Infrastructure Implementation branch has assembled a library of useful CAD resources that may be distributed to external designers. These are provided to simplify the process of adapting standard drawings to site-specific constraints. They have been drawn to scale and include adjustable dimensions where appropriate. These resources are to be used at the discretion of the designer and should always be adapted to site-specific constraints.