Green Stormwater Infrastructure Planning & Guidance Document

Prepared for the City of Somerville

Stantec

Purpose

This document provides guidelines for retrofitting green stormwater infrastructure practices into existing sidewalks, streets, and on public properties in the City of Somerville. Each green stormwater infrastructure practice is listed with a brief description, design and siting guidelines, and associated benefits. This information should be used to guide initial planning and design efforts within the City.

Definition

Green stormwater infrastructure provides a resilient approach to managing stormwater runoff. It aims to protect, restore, and mimic the natural water cycle by managing stormwater runoff where it falls with methods that would occur naturally. Green stormwater infrastructure places an emphasis on low-impact development with nature-based practices to increase infiltration, evapotranspiration, and transpiration, and to enhance water quality.

Green stormwater infrastructure includes a range of practices including pavement and rooftop disconnections, rainwater harvesting, rain gardens, planter boxes, bioswales, subsurface trenches, bumpouts, planters, permeable pavement, green roofs, wetlands, and living shorelines. Green stormwater infrastructure can also refer to conservation measures, such as the protection of underutilized space, environmentally sensitive areas, and forests. In addition to stormwater management, these practices provide additional benefits, such as recreation, wildlife habitat creation, carbon sequestration, and pedestrian safety improvements.

Green stormwater infrastructure can be used to reduce the effects of excessive heat and the urban heat island effect, improve air quality and habitats, improve climate resiliency, and restore ecosystems. In addition, green stormwater infrastructure can be used to reduce operational costs for storm sewers, increase property values, and create jobs within the local economy.

Green stormwater infrastructure is flexible in design and can be modified to meet a variety of site conditions. Where feasible, green stormwater infrastructure is designed to allow stormwater runoff to infiltrate into the ground to recharge aquifers and to restore base flows to local waterways, effectively removing stormwater runoff from the storm sewer system during minor storm events. However, in a dense, highly urbanized environment with utility conflicts and uncertain soil conditions, it is not always feasible or safe to infiltrate stormwater runoff. In some cases, green stormwater infrastructure is designed to detain and slowly release stormwater runoff back into the storm sewer after a storm's peak, when the storm sewer has flow has tapered. Infiltration and detention/slow-release techniques are both effective techniques for the management of stormwater runoff during wet weather events.

General Design Considerations

The following is a list of general design considerations that apply to all green stormwater infrastructure practices.

Cost Considerations

When considering cost for a green stormwater infrastructure design, the designer should consider the following:

- What are the stormwater management and programming goals of the project and how does that impact the design?
- Where is the practice located (e.g., sidewalk, roadway, park, building, etc.) and what will need to be replaced or restored as a result of the project?
- Will existing infrastructure need to be modified to accommodate the design, such as new catch basins or connections to the storm sewers?
- Are there utility conflicts that will need to be considered and addressed?
- Are there any other agencies that should be included in the planning and design stages? If so, what are their review policies?
- Are there any partners or stakeholders that should be included in the planning and design stages? If so, is there a potential for cost-sharing?
- Will the practice have a surface expression or will everything be located below-grade?
- Are there special considerations for the maintenance and control of traffic during construction?

- What type of equipment is necessary to install and maintain the practice, and who will perform the work?
- When a right-of-way is disturbed, will everything be restored “in-kind”, or will upgrades be necessary to conform to regulations or ADA requirements?
- Which plants can survive in this area (micro-climate, soils, etc.)?

Technical Terms & Considerations

Design Storm

While green stormwater infrastructure is typically used to manage smaller, more frequent precipitation events, it can be used in combination with gray infrastructure (e.g., underground storage) as a flood control technique to manage larger storm events as well. As a conservative measure, green stormwater infrastructure practices should be designed to manage at least 1-inch of stormwater runoff, as this amount of runoff correlates to the “first flush” of pollutants.

Drain-down Time

Green stormwater infrastructure practices should be designed to accommodate a drain-down time between 24 to 72 hours. This helps to ensure that the stormwater runoff has time to properly filter though the practice, that volume is available for the next storm event, and also helps to reduce public health concerns associated with standing water.

Energy Dissipation

Green stormwater infrastructure practices that intercept flow along a gutter or discharge from a pipe should be designed to include energy dissipaters - such as a stone or rock apron - to reduce the flow speed and resulting erosion at entrances to the green stormwater infrastructure practice.

Infiltration Rate

Infiltration rate is defined as the speed or time for water to flow through a soil profile and is the measure of permeability of a soil. Infiltration rate is measured as depth of the water layer that can absorb into the soil over a given time, usually represented as inches per hour. Many factors can effect infiltration rates, including the soil type (e.g., clay, sand, silt, etc.), texture, and porosity. As a conservative measure, an underdrain should be considered for practices with a tested infiltration rate of less than 0.50 inches per hour, or as directed by a qualified geotechnical engineer.

Loading Ratio

Loading ratio is defined as the area of contributing impervious drainage area compared to the bed bottom area of a green stormwater infrastructure practice. The loading ratio is an important design consideration, as practices with higher loading ratios tend to fail at a higher rate than practices with a lower loading ratio due to the anticipated sediment loading to the practice.

Loading ratio is calculated as follows:

$$\textit{Loading Ratio} = \frac{\textit{Contributing Impervious Drainage Area}}{\textit{Bed Bottom Area of Green Stormwater Infrastructure Practice}}$$

As a conservative measure, a loading ratio of up to 10:1 should be considered for subsurface green stormwater infrastructure practices and a loading ratio of up to 25:1 should be considered for surface green stormwater infrastructure practices. To reduce the impervious drainage area that is directed to a green stormwater infrastructure practice, a new catch basin may be considered upstream of the practice.

Pre-treatment

Pre-treatment of trash, debris, and suspended solids in stormwater runoff should be considered to extend the life of a system. Pre-treatment techniques could include sediment filter bags within catch basins, forebays, grass filter strips, and sumped catch basins.

Proximity to Adjacent Structures

Green stormwater infrastructure designs should consider the proximity to adjacent structures and foundations. Specifically, the design should consider the structural integrity of the building and should account for proper horizontal offsets or setbacks to ensure that the practice is not placed within the structural bearing plane of the foundation. Additionally, the design should also consider waterproofing measures where appropriate. As a conservative measure, practices should be placed at a horizontal distance of at least 5-feet from all building foundations, and should include waterproofing measures when placed within a horizontal distance of 10-feet or within a 1:1 zone of influence of building foundations. The zone of influence for infiltration is determined by taking the lowest point of the foundation and projecting a 1:1 line up and away from the structure. All green stormwater infrastructure practices that are placed within this zone of influence line should include an impermeable liner.

Proximity to Adjacent Utilities

Green stormwater infrastructure designs should consider the proximity to adjacent utilities. As a conservative measure, practices and associated piping should be designed to provide at least 6-inches of vertical clearance and at least 3-feet of horizontal clearance from all impacted utilities. Early coordination with impacted utilities is recommended to determine if any additional requirements are necessary in the design.

Proximity to Limiting Zones

A limiting zone is defined as the upper limit of any zone that prevents water from infiltrating into the ground below this elevation. Green stormwater infrastructure practices should consider the proximity to limiting zones, such as shallow bedrock or a high seasonal groundwater table. As a conservative measure, infiltrating green stormwater infrastructure practices should allow for at least 2-feet of vertical clearance from a limiting zone, or as directed by a qualified geotechnical engineer.

Site Context

Green stormwater infrastructure designs should consider existing and proposed site context, such as proximity to schools, parks, or other areas that can be leveraged to derive additional benefits. Where possible, green stormwater infrastructure should be designed to provide a multi-purpose solution such as creating learning opportunities, recreation areas, wildlife habitat, carbon sequestration, and pedestrian safety improvements.

Soil

A soil depth of at least 2-feet should be provided for all vegetated practices. Where trees are present, a soil depth of at least 3-feet should be provided. Soil amendments should be considered to improve water quality and to provide for sufficient infiltration rates for all vegetated practices.

Soil or Groundwater Contamination

If a site is known to have soil or groundwater contamination, the green stormwater infrastructure design should consider proper impermeable liners or other separation mechanisms to prevent further contamination based on the site specific issues in consultation with a qualified environmental engineer.

Vegetation

Vegetation placed within green stormwater infrastructure practices should consider plant species, lines of sight, climate, hydrologic zone elevation, maintenance, salinity tolerance, winter storm tolerance, light requirements, bloom time and color, rodent management, and drought tolerance among others. Where possible, native plant species should be selected.

Water Quality Management

Green stormwater infrastructure practices can be used to improve water quality and to reduce the impact of pathogens, nutrients, sediment, and heavy metals on receiving water bodies by retaining and managing stormwater runoff where it falls. Pollutant removal occurs through a variety of physical and chemical processes including filtration, sedimentation, adsorption, and plant uptake among others. Green stormwater infrastructure practices that use vegetation or have the ability to infiltrate play an important role in water quality management. On practices where infiltration is not feasible, design amendments such as an enhanced sand filter can be included to provide additional water quality management.

Next Steps

The following items are identified as next steps for the City:

- Use results of the 2019 Stantec Municipal Vulnerability Preparedness (MVP) Study to inform green stormwater infrastructure locations during City project planning
- Confirm catch basin locations (as not all catch basins were available on the City's GIS database)
- Confirm drainage areas to each green stormwater infrastructure practice
- Perform public outreach activities to include a review of community and neighborhood development plans
- Perform a site walk to identify any constraints that were not identified in GIS analysis
- Conduct a search of land use history, specifically for off-street properties, to identify any potential environmental concerns
- Perform a topographic and utility study to confirm site features, topography, and subsurface utilities
- Perform a geotechnical investigation within the footprint of the green stormwater infrastructure practices to identify limiting zones and potential for infiltration

Siting

The chart below provides general siting guidelines for green stormwater infrastructure that is placed within the public right-of-way and on off-street properties. The recommended practices and related siting guidance consider typical urban strategies and design constraints.

Practice Type	GSI Practice Placement										
	Public Right-of-Way		Public Parking Lots				Public Parks and Recreation Centers			Public Buildings	
	Sidewalk	Roadway	Parking Stalls	Sidewalk	Driving Aisle	Underutilized Space	Sidewalk	Building	Underutilized Space	Building	Underutilized Space
Bumpout		●									
Subsurface Trench	●	●	●	●	●	●	●		●		●
Planter	●			●		●	●		●		●
Rain Garden						●			●		●
Bioswale						●			●		●
Permeable Pavement	●	●	●	●	●		●				
Green Roof								●		●	

Bumpout

Description

Bumpouts are contained landscaped practices that extend into the street and are designed to collect, treat, and temporarily store stormwater runoff. Bumpouts are generally placed within a parking lane or roadway shoulder. They can be located at a corner or mid-block, depending on the site-specific configuration. Stormwater runoff is directed to the surface of the bumpout through curb cuts, subsurface trench drains, overland flow, or catch basins. Once collected, water slowly infiltrates through vegetation and an engineered soil media, providing water quality treatment and volume reduction or attenuation. Where infiltration is possible, the practice is designed to allow the stored water to seep into the underlying soils. Where infiltration is not possible, an underdrain is placed at the bottom of the practice to capture and slowly-release the collected stormwater runoff into the existing storm sewer. When the capacity of the bumpout is exceeded, stormwater runoff can flow through the bumpout to a downstream catch basin or could be piped to the existing storm sewer with an overflow structure within the bumpout.

Siting Guidelines

- In a parking lane or roadway shoulder (for 2-way streets installed street width should be a minimum of 18-feet to allow for emergency vehicle access)
- On the right side of the departing vehicular travel lane (as opposed to the right side of the receiving travel lane) where feasible to facilitate turning maneuvers
- Upstream of an existing catch basin

Example Locations within Somerville

Bumpouts are a viable option in many locations throughout the City, such as the following two intersections:

- Northeast corner of Skehan Street and Hanson Street (Corner Bumpout)
- East side of Holland Street, between Gorham Street and Jay Street (Mid-block Bumpout)

Benefits

- Stormwater runoff is filtered through vegetation and an engineered soil media, providing water quality benefits regardless of subsurface soil conditions
- Physically reduces the width of the roadway, contributing to slower vehicle speeds and a reduced pedestrian crossing distance at intersections
- Does not require encroachment into the sidewalk
- Provides aesthetic improvements to the streetscape
- Provides a physical barrier between pedestrians and vehicles
- Provides habitat for wildlife
- Sequesters carbon and reduces urban heat island effect

Design Considerations

- Design should consider street width, on-street parking, drainage, bicycle lanes, bus routes, ADA accessibility, and vehicular turning maneuvers

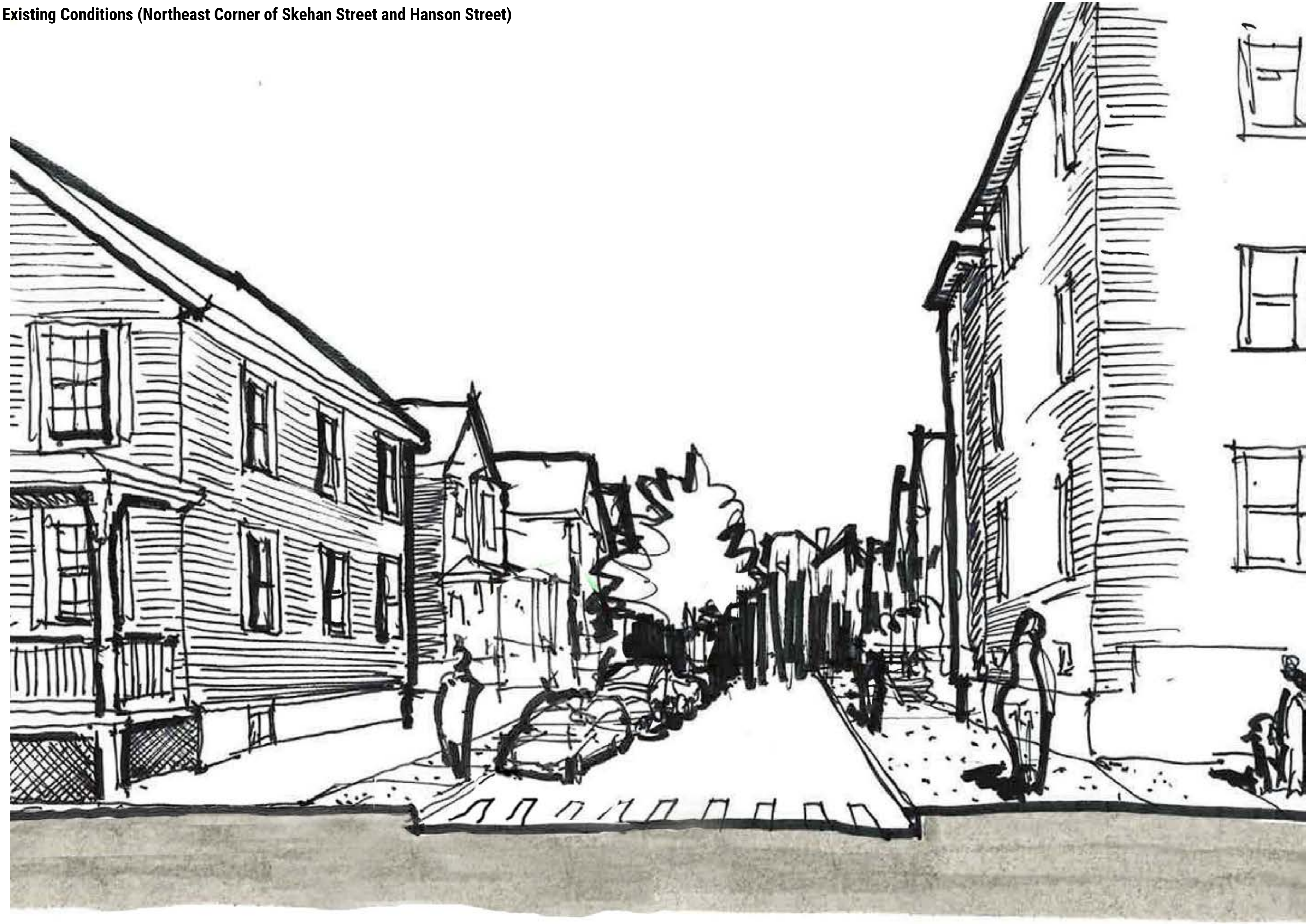
- A terraced practice may be required for steep streets
- Landscape design should consider vehicular sight distances at intersections and driveway locations, plant species, climate, hydrologic zone elevation, maintenance, salinity tolerance, winter storm tolerance, light requirements, bloom time and color, rodent control, and drought tolerance
- Design should consider surface ponding depths and should include safety measures such as traffic delineators, fencing, and a raised curb
- Design may require replacement of existing catch basins and modifications to the drainage patterns along the roadway
- Design should consider proximity to adjacent buildings and structures and should include waterproofing where necessary

Installation and Cost Considerations

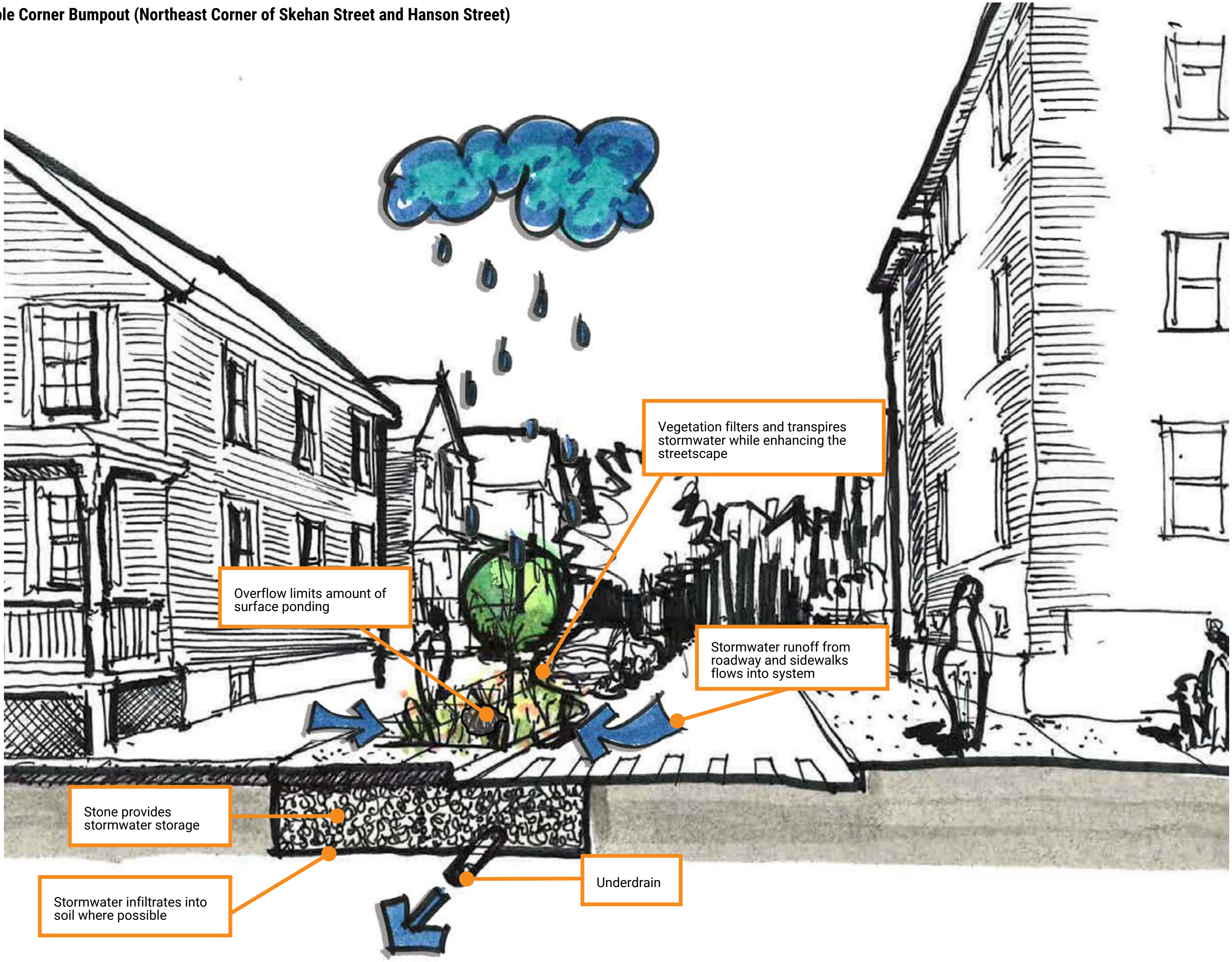
Bumpouts tend to be one of the more expensive green stormwater infrastructure practices due to the following items:

- Existing catch basins and associated storm lateral may need to be relocated
- Existing ADA ramps may need to be reconstructed
- Maintenance of traffic considerations due to location within right-of-way
- Cost for materials (e.g., vegetation, soil, stone, piping, curbing, curb cuts, wheel guards, energy dissipaters, overflow structure, etc.)

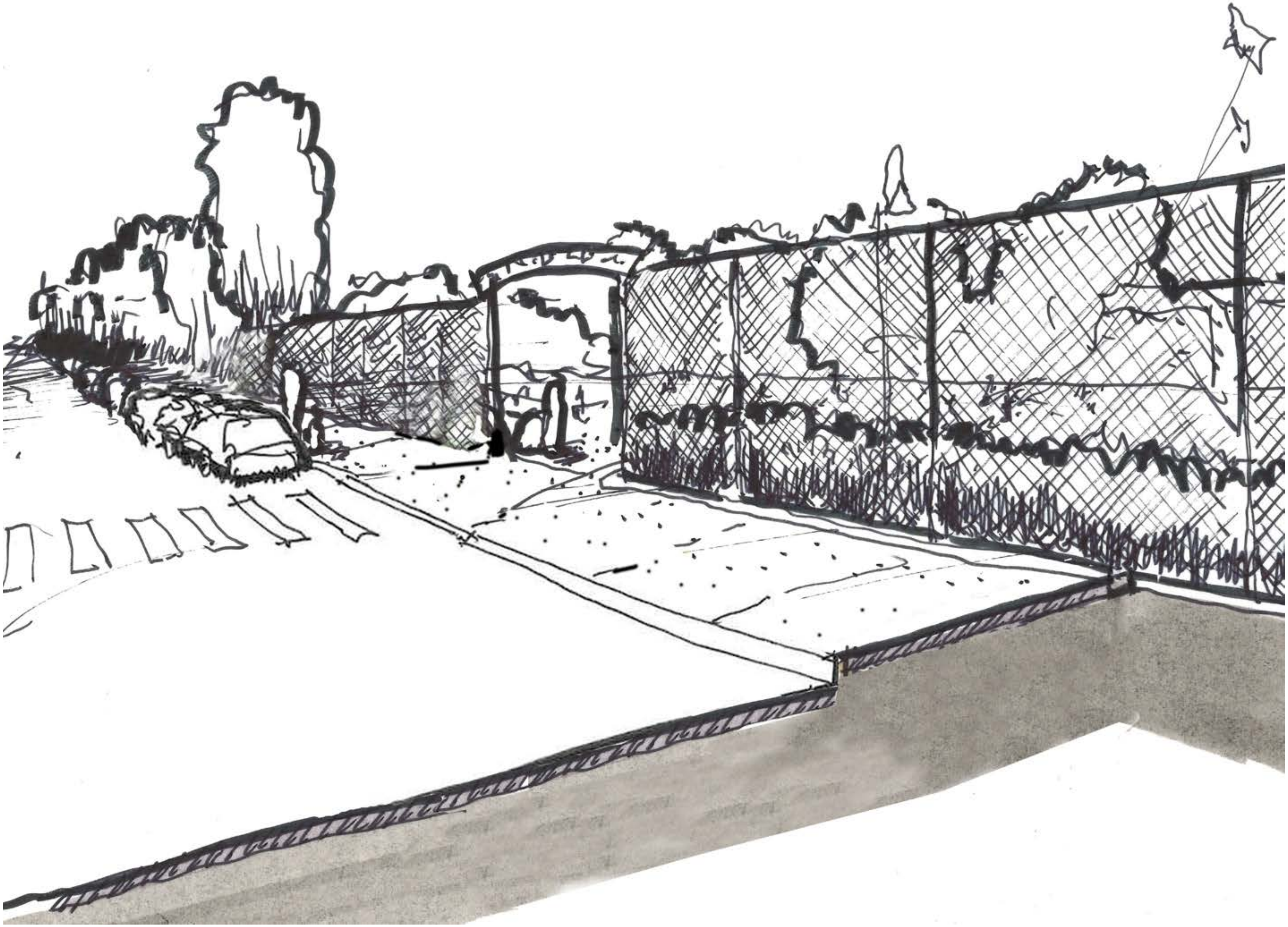
Existing Conditions (Northeast Corner of Skehan Street and Hanson Street)



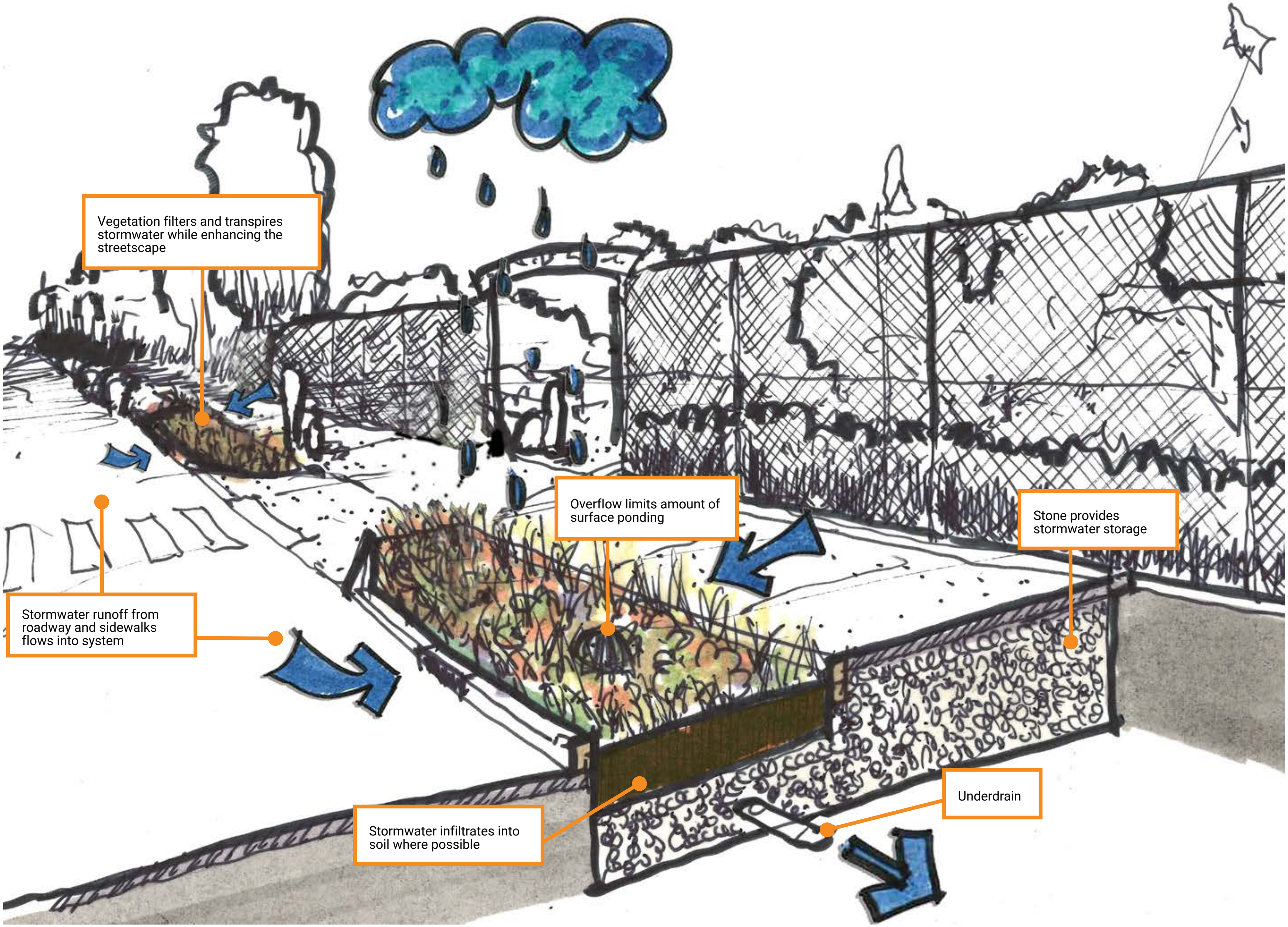
Example Corner Bumpout (Northeast Corner of Skehan Street and Hanson Street)



Existing Conditions (Hodgkins - Curtin Park)



Example Mid-block Bumpout (Hodgkins - Curtin Park)



Subsurface Trench

Description

Subsurface trenches are below-grade stone storage practices designed to collect, treat, and temporarily store stormwater runoff. Stormwater runoff is directed to the practice through a new catch basin placed directly upstream of an existing catch basin. Once inside the practice, water is detained and either infiltrated or slowly-released back into the existing storm sewer after the peak of the storm has passed. Where feasible, tree pits can be embedded within or adjacent to the subsurface trench to provide a surface expression and opportunity for evapotranspiration. When the capacity of the practice is exceeded, stormwater runoff can bypass the practice to a downstream catch basin.

Siting Guidelines

- Below any surface, including sidewalks, roadways, parking lots, or landscaped areas with consideration for subsurface utilities
- Upstream of an existing catch basin

Example Locations within Somerville

Stormwater trenches are a viable option in many locations throughout the City, including the following example:

- Northeast corner of Hillsdale Road and Sunset Road
- Northeast corner of Flint Street and Rush Street

Benefits

- Provides a large storage volume in a tight space
- Practice is below-grade and does not impact the primary use of the space above

Design Considerations

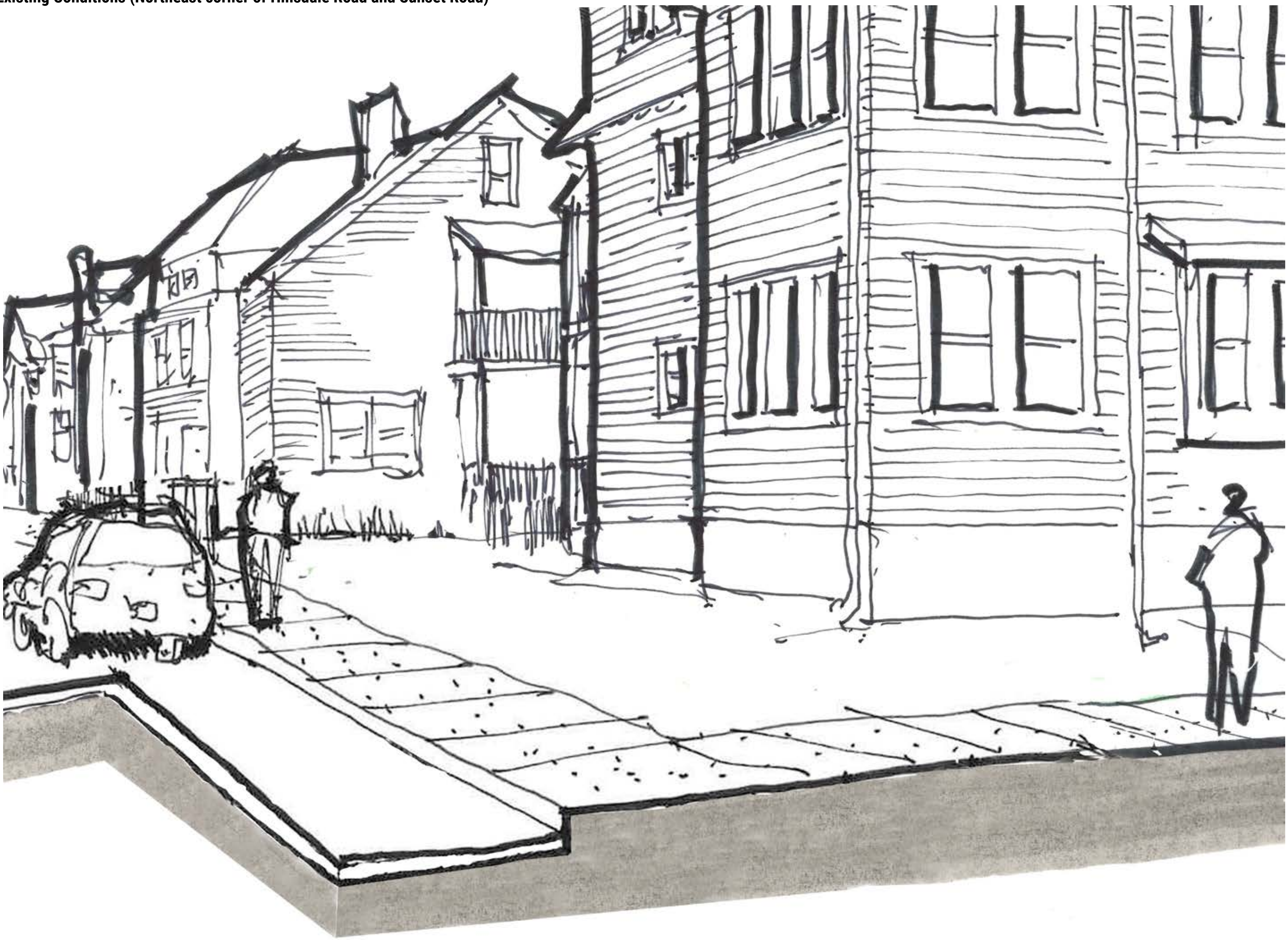
- Design should consider proximity to adjacent buildings and structures and should include waterproofing where necessary
- Landscape design should consider vehicular sight distances at intersections and driveway locations when trees are included in design
- If infiltration is not feasible, a mixed soil/stone media can be considered within the subsurface trench for water quality management
- Design should consider pretreatment at catch basins

Installation and Cost Considerations

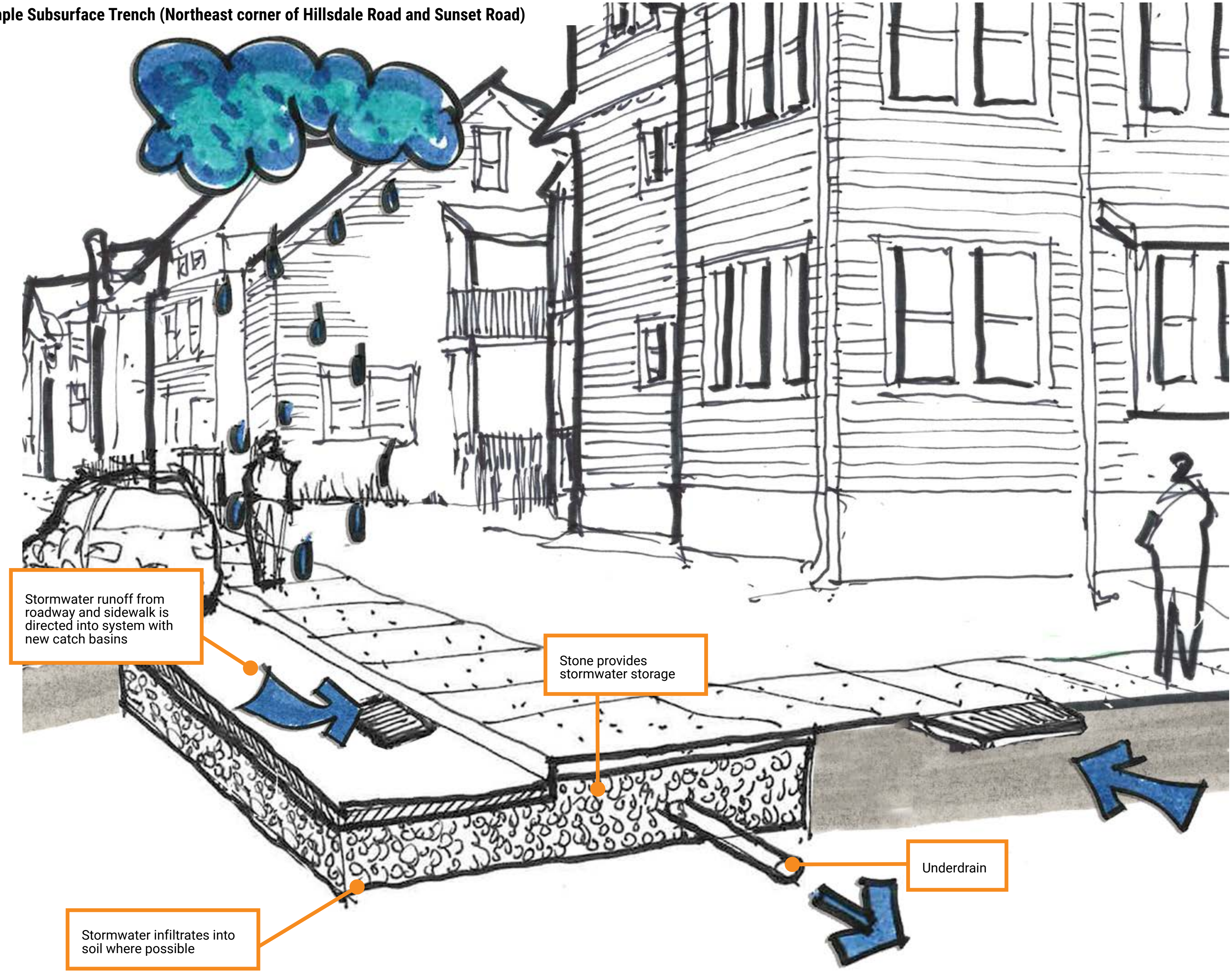
When constructing subsurface trenches, the designer should consider the following:

- Existing catch basins and associated storm lateral may need to be replaced
- Existing ADA ramps may need to be reconstructed
- Maintenance of traffic considerations if located within the right-of-way
- Cost for materials (e.g., stone, piping, curbing, new catch basin, etc.)
- Cost for surface restoration (e.g., roadway, sidewalk, etc.)

Existing Conditions (Northeast corner of Hillsdale Road and Sunset Road)



Example Subsurface Trench (Northeast corner of Hillsdale Road and Sunset Road)



Planter

Description

Planters are contained landscaped practices that are designed to collect, treat, and temporarily store stormwater runoff. Stormwater runoff is directed to the surface of the planter through trench drains, catch basins, overland flow, or external roof drains. Once inside the practice, water slowly infiltrates through vegetation and an engineered soil media, providing water quality treatment and volume reduction or attenuation. When the capacity of the planter is exceeded, stormwater runoff can flow through the practice to a downstream catch basin or could be piped to the existing storm sewer with an overflow structure within the planter.

Siting Guidelines

- Within the sidewalk
  - Installed sidewalk width should be a minimum of 6-feet to allow for ADA access
- Within underutilized space or adjacent to building structures
- Upstream of an existing catch basin

Example Locations within Somerville

Planters have a limited application within Somerville given the narrow street widths. Planters may be applicable on commercial corridors such as:

- East Side of Holland Street at Elmwood Street

Benefits

- Stormwater runoff is filtered through an engineered soil media providing water quality benefits regardless of subsurface soil conditions
- Provides aesthetic improvements to the streetscape
- Provides a physical barrier between pedestrians and vehicles
- Provides habitat for wildlife
- Sequesters carbon and reduces urban heat island effect

Design Considerations

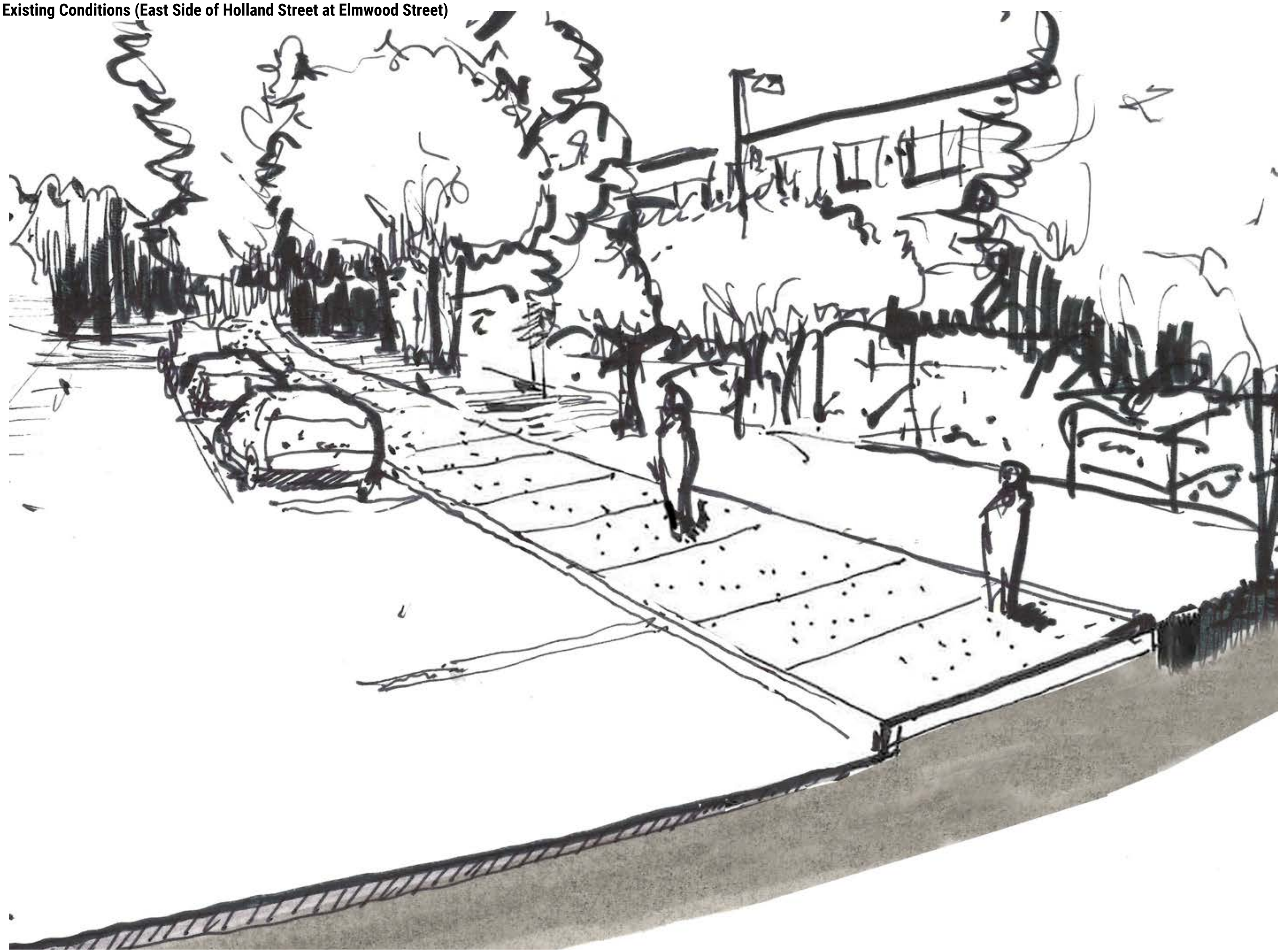
- Design should consider sidewalk width, drainage, bus routes, lines of sight, and ADA accessibility
- Landscape design should consider vehicular sight distances at intersections and driveway locations, plant species, climate, hydrologic zone elevation, maintenance, salinity tolerance, winter storm tolerance, light requirements, bloom time and color, rodent control, and drought tolerance
- Design should consider surface ponding depths and should include safety measures such as traffic delineators, fencing, and a raised curb
- Design should consider proximity to adjacent buildings and structures and should include waterproofing where necessary
- Design should consider step-out areas when placed adjacent to on-street parking

Installation and Cost Considerations

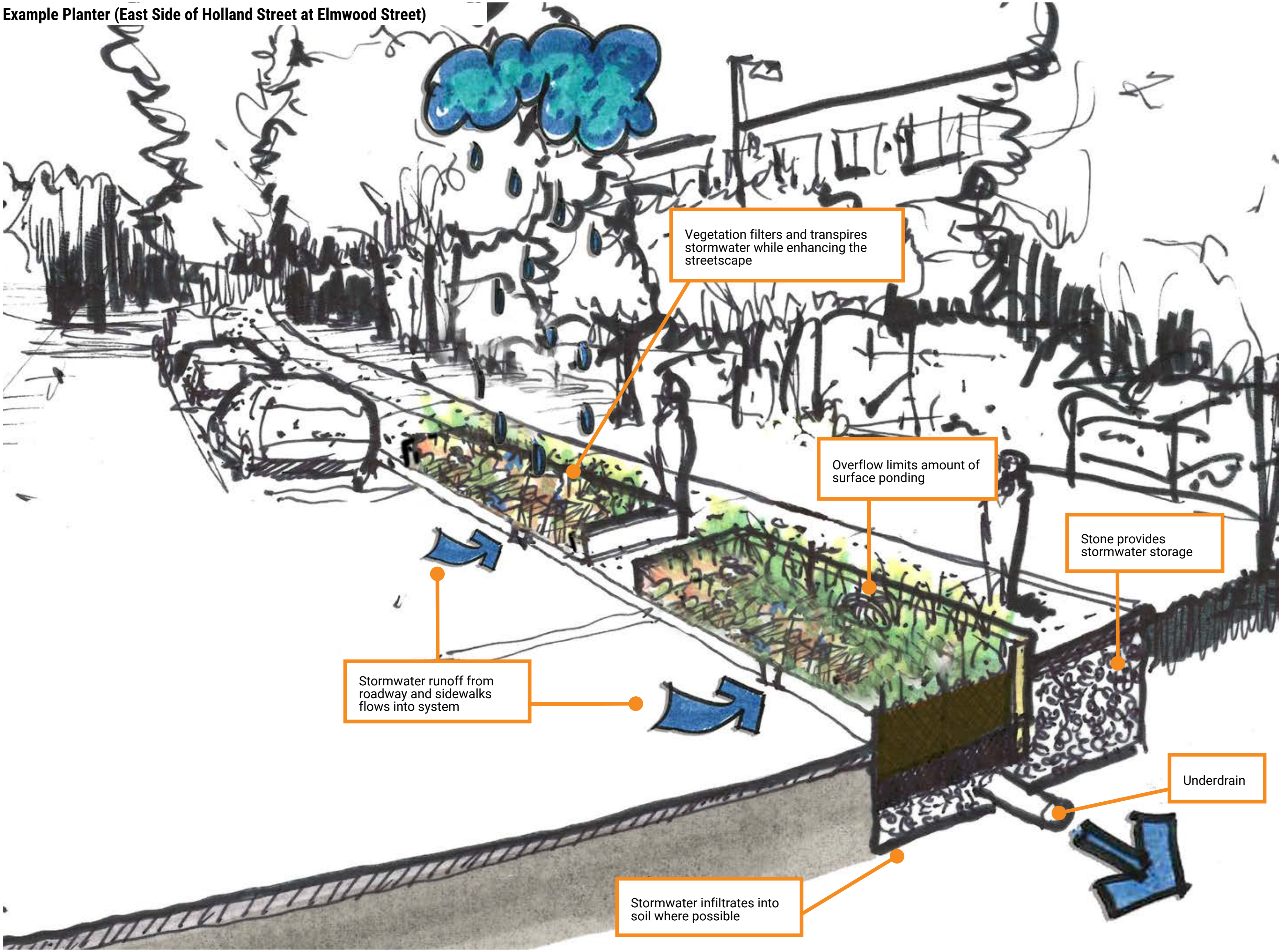
Planters tend to be one of the more expensive green stormwater infrastructure practices due to the following items:

- Existing catch basins and associated storm lateral may need to be replaced
- Existing ADA ramps may need to be reconstructed
- Maintenance of traffic considerations due to location within right-of-way
- Cost for materials (e.g., vegetation, soil, stone, piping, curbing, curb cuts, wheel guards, energy dissipaters, overflow structure, etc.)

Existing Conditions (East Side of Holland Street at Elmwood Street)



Example Planter (East Side of Holland Street at Elmwood Street)



Rain Garden

Description

Rain gardens are depressed, landscaped practices that are situated in low-lying, open areas to collect, treat, and temporarily store stormwater runoff. Rain gardens can be configured in any shape to respond to the surrounding environment. Stormwater runoff is directed to the surface of the rain garden through curb cuts, trench drains, catch basins, and overland flow. Once inside the practice, water slowly infiltrates through vegetation and an engineered soil media, providing water quality treatment and volume reduction or attenuation. When the capacity of the practice is exceeded, stormwater runoff is hard-piped to the existing storm sewer with an overflow structure within the rain garden.

Siting Guidelines

- Within underutilized space in parks, parking lots, or around public buildings

Example Locations within Somerville

Rain gardens can be a great option for parks or within underutilized space of parking lots. If the Herbert Street lot were reconfigured with one-way driving aisles this would allow for a large rain garden in the center of the lot.

- Herbert Street Parking Lot

Benefits

- Stormwater runoff is filtered through an engineered soil media providing water quality benefits regardless of subsurface soil conditions
- Provides aesthetic improvements
- Provides habitat for wildlife
- Sequesters carbon and reduces urban heat island effect

Design Considerations

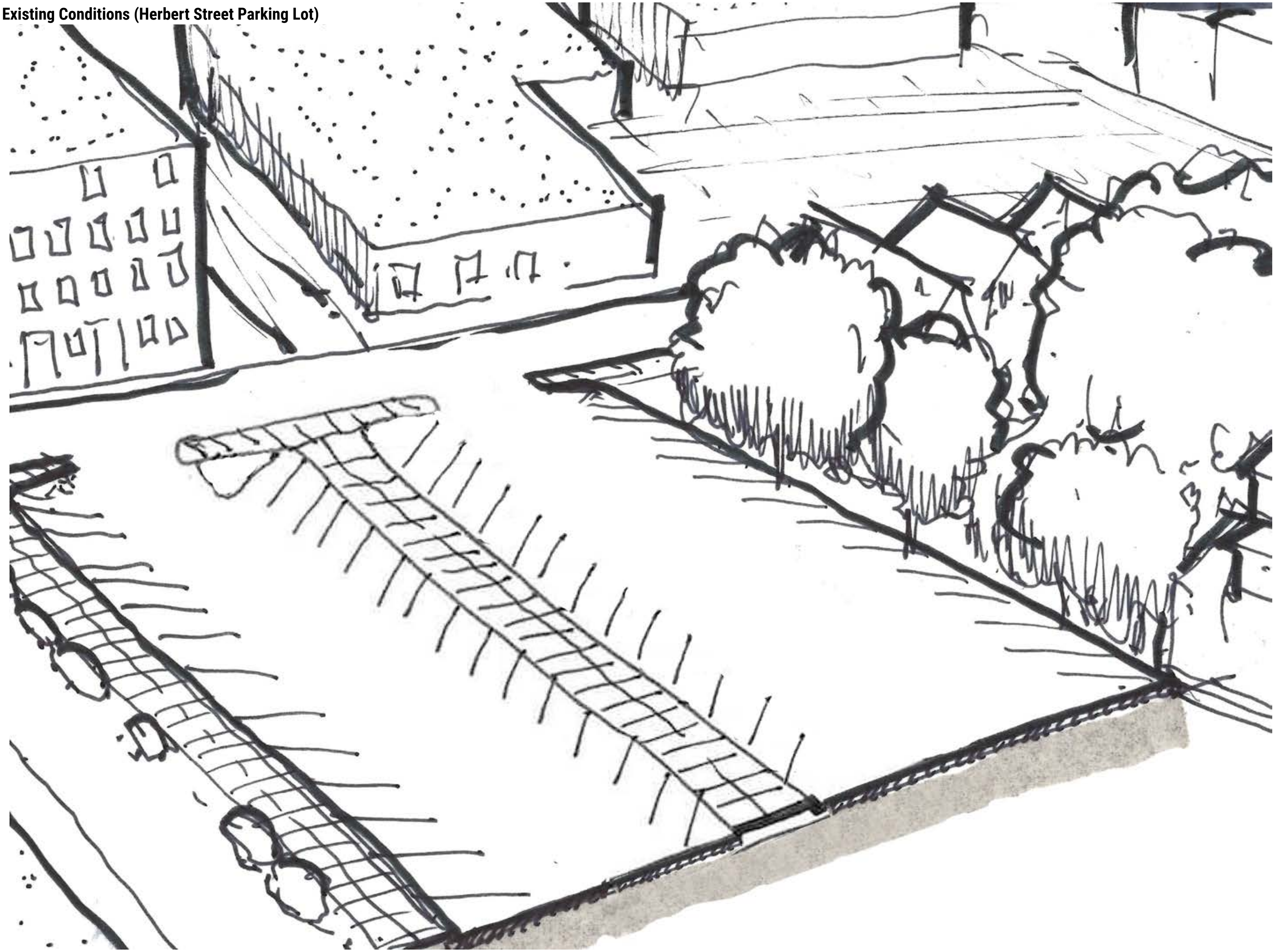
- Design should consider proximity to adjacent buildings and structures and should include waterproofing where necessary
- Design should consider side slopes, ponding depth, and drainage
- Design can be modified to accept stormwater runoff from the public right-of-way and off-street areas
- Landscape design should consider plant species, lines of sight, climate, hydrologic zone elevation, maintenance, salinity tolerance, winter storm tolerance, light requirements, bloom time and color, rodent control, and drought tolerance

Installation and Cost Considerations

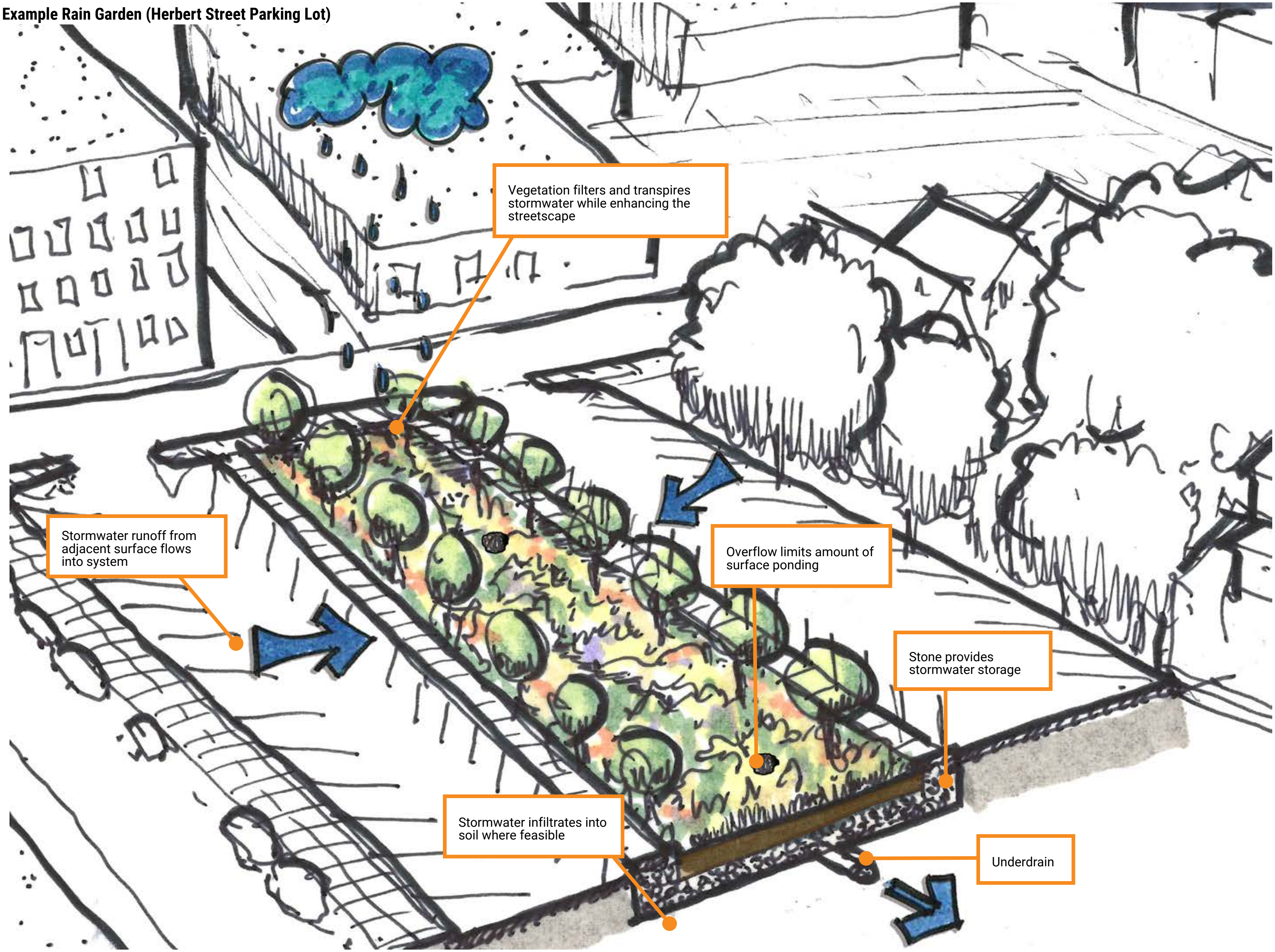
Rain gardens can be a cost-effective solution given their ability to manage a large volume of stormwater runoff, provided there is sufficient underutilized space. When constructing rain gardens, the designer should consider the following:

- Cost for materials (e.g., vegetation, mulch, soil, stone, piping, inlets, energy dissipaters, overflow structure, etc.)

Existing Conditions (Herbert Street Parking Lot)



Example Rain Garden (Herbert Street Parking Lot)



Bioswale

Description

Bioswales are landscaped practices that are narrow and linear in shape and are used to direct water at shallow grades from a receiving point upstream to a discharge point at its furthest downstream end. Check dams can be installed within the bioswale to encourage infiltration along the length of the practice. Stormwater runoff is directed to the surface of the bioswale through curb cuts, trench drains, catch basins, or overland flow. Once inside the practice, water slowly infiltrates through vegetation and an engineered soil media, providing water quality treatment and volume reduction and attenuation.

Siting Guidelines

- Within underutilized space, around parking lot areas, or within traffic islands, placed adjacent to an impervious surface

Example Locations within Somerville

Bioswales may have a limited application in Somerville given the number and proximity of large trees adjacent to walkways within park areas.

Benefits

- Stormwater runoff is filtered through an engineered soil media providing water quality benefits regardless of subsurface soil conditions
- Provides aesthetic improvements
- Provides habitat for wildlife
- Sequesters carbon and reduces urban heat island effect

Design Considerations

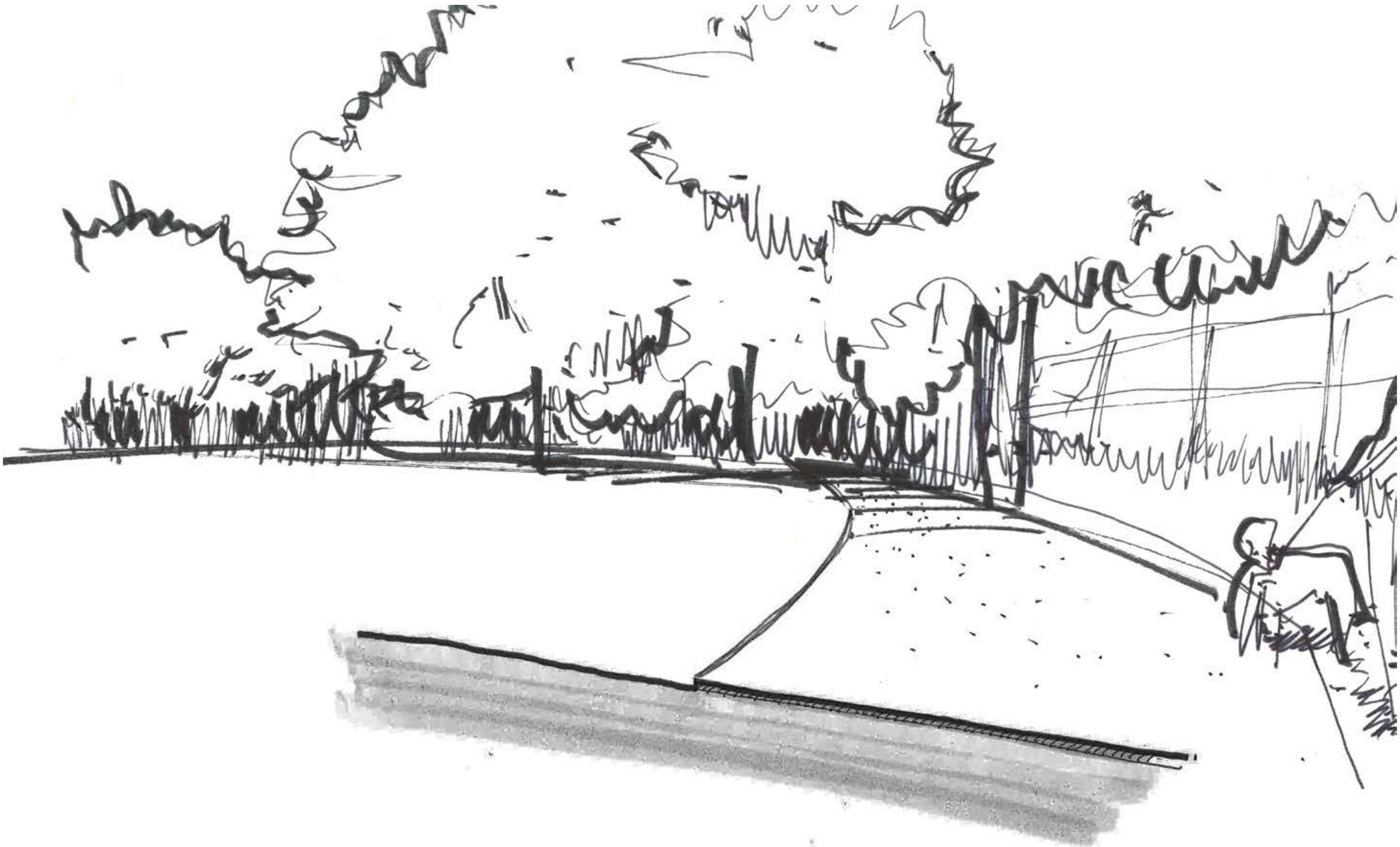
- Design should consider proximity to adjacent buildings and structures and should include waterproofing where necessary
- Design should consider side slopes, ponding depth, and drainage
- Landscape design should consider plant species, lines of sight, climate, hydrologic zone elevation, maintenance, salinity tolerance, winter storm tolerance, light requirements, bloom time and color, and drought tolerance

Installation and Cost Considerations

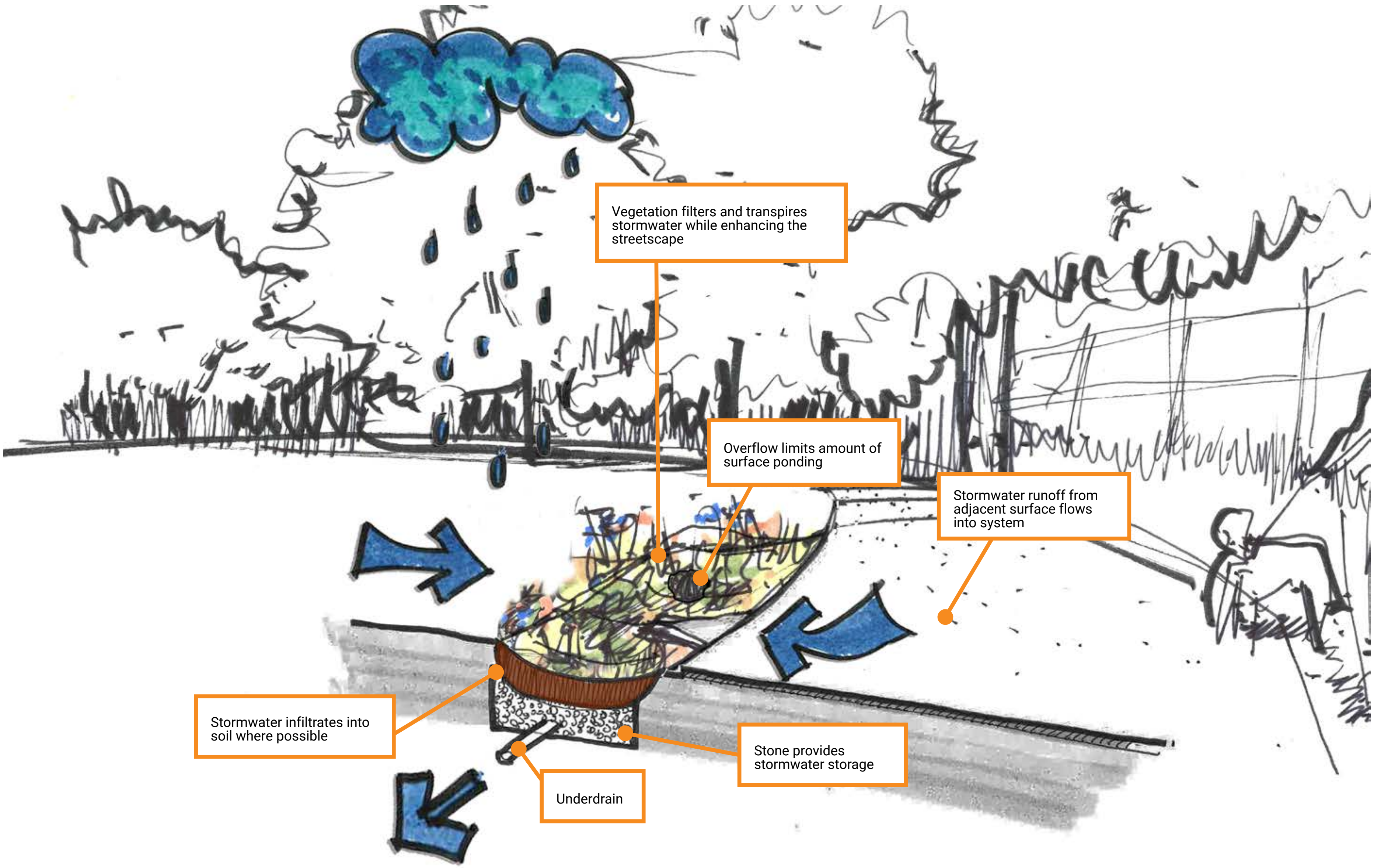
Bioswales can be a cost-effective solution given their ability to manage a large volume of stormwater runoff, provided there is sufficient underutilized space. When constructing bioswales, the designer should consider the following:

- Cost for materials (e.g., vegetation, mulch, soil, stone, piping, inlets, energy dissipaters, overflow structure, etc.)

Existing Conditions



Example Bioswale



Permeable Pavement

Description

Permeable pavements are paving systems that provide the structural support of conventional pavements but are designed to collect, treat, convey, and temporarily store stormwater runoff. Permeable pavements consist of a porous surface material over a bed of clean-washed stone. Permeable pavement comes in a variety of materials, including paver blocks, concrete, rubberized play surface, or asphalt.

Siting Guidelines

- At any paved surface, including sidewalks, roadways, play surfaces, or parking lots

Example Locations within Somerville

Permeable pavement is a great option for parking lots that will be reconstructed in the near future. An example from the MVP Study GIS analysis is:

- Fountain Avenue and Glen Street Parking Lot

Benefits

- Permeable pavement materials have been shown to have secondary benefits ranging from reduced snow collection to reduced noise on basketball courts
- Practice is below-grade and does not impact the primary use of the space

Design Considerations

- Design should consider proximity to adjacent structures
- Design should consider existing and proposed uses when selecting paving materials
- Design should consider contributing drainage area and should aim for a 1:1 loading ratio (e.g., divert contributing drainage areas away from porous pavement areas)
- Design should consider maintenance requirements and salt application

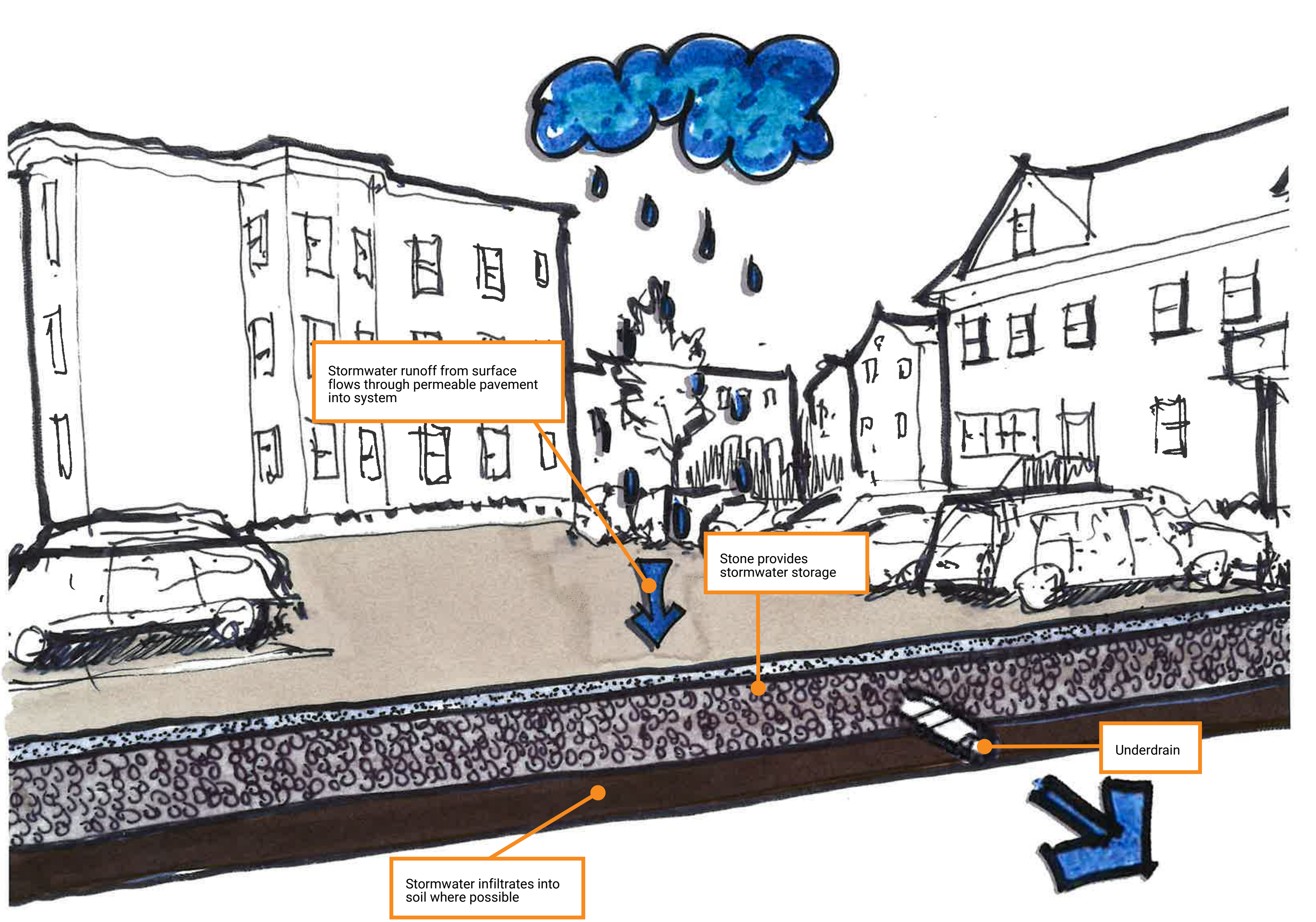
Installation and Cost Considerations

Permeable pavements can be a cost-effective solution when a paving surface is slated to be upgraded or replaced. Proper maintenance is critical for ensuring the success of these systems. When constructing permeable pavement systems, the designer should consider the following:

- Maintenance of traffic considerations if located within the right-of-way

Existing Conditions (Fountain Avenue and Glen Street Parking Lot)

Example Permeable Pavement (Fountain Avenue and Glen Street Parking Lot)



Green Roof

Description

Green roofs are vegetated stormwater management practices placed over a conventional roof surface to collect, treat, and temporarily store stormwater runoff. A green roof may include waterproofing membranes, root barriers, drainage and irrigation practices, light-weight growing medium, and plants. Green roofs can be assembled on site where each layer of the practice is installed individually or installed as modular units where all layers are included in movable pieces that can be assembled on the roof.

Siting Guidelines

- On new buildings or buildings that are slated for major renovations (to include any necessary structural improvements to the roof practice)

Example Locations within Somerville

Green roofs are most likely cost-prohibitive unless the building is slated for major structural improvements, or new construction. An example from the MVP Study GIS analysis is:

- City Traffic and Parking Department Building at 133 Holland Street

Benefits

- Conserves energy and reduces building operation costs
- Reduces noise and air pollution
- Provides habitat for wildlife
- Sequesters carbon and reduces urban heat island effect
- Increases the longevity of roofing membranes
- Does not rely on sub-surface soil conditions

Design Considerations

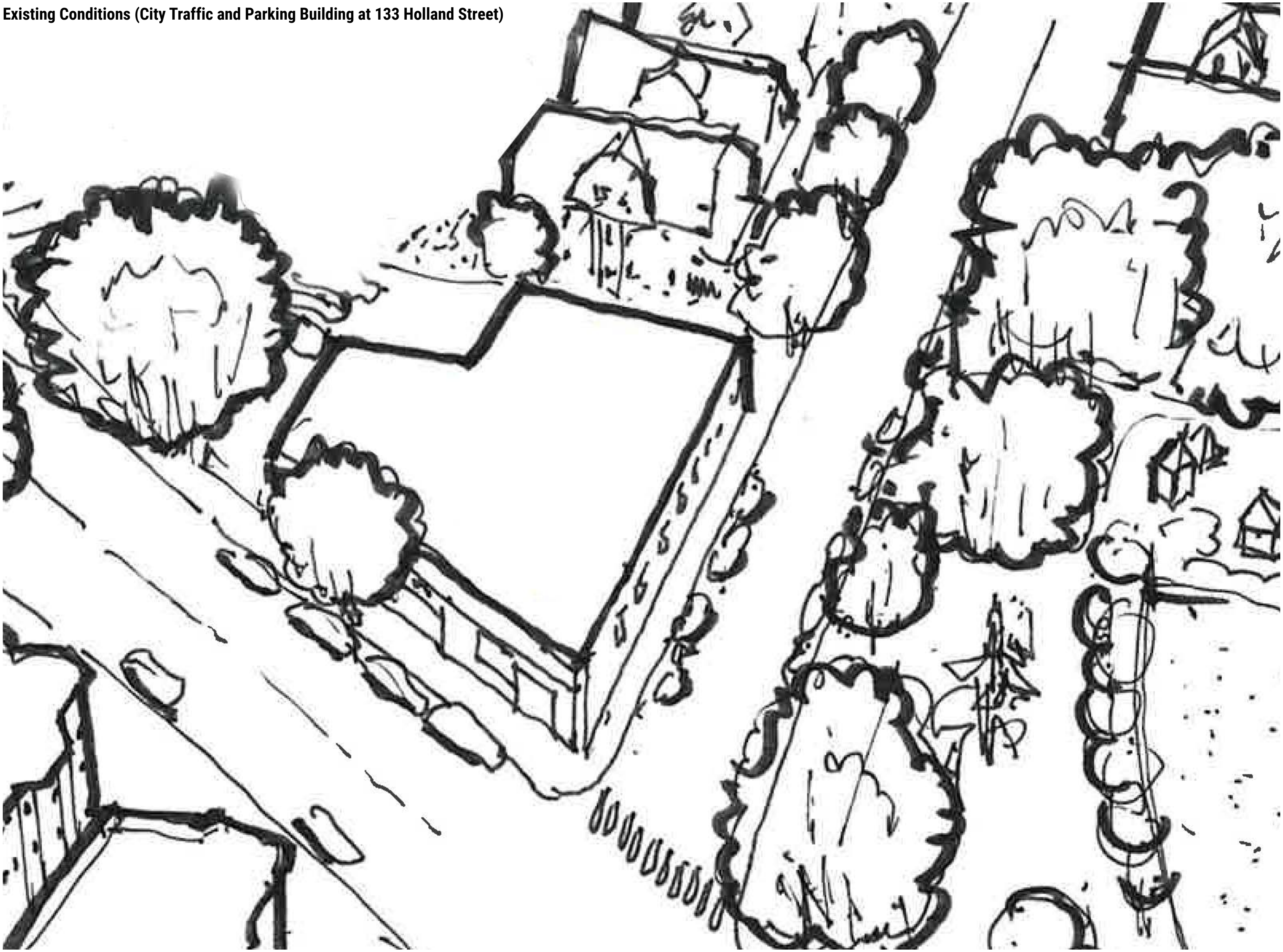
- A detailed structural analysis should be performed to ensure that the building structure can support the additional load from a green roof
- Design should consider roof slope, placement of mechanical equipment and vents, wind loads, vegetation and growing medium depth, drainage and overflow practices
- Design may require irrigation for maintenance of vegetation

Installation and Cost Considerations

When constructing green roof systems, the designer should consider the following:

- Green roofs have slightly higher cost than conventional roofs when installed on new buildings. Retrofit green roofs can be costly if structural members of the building need to be modified
- How to get material to the roof area

Existing Conditions (City Traffic and Parking Building at 133 Holland Street)



Example Green Roof (City Traffic and Parking Building at 133 Holland Street)

Glossary

Adsorption
Chemical process in which pollutants bind to the surface of a soil particle at a molecular level.

Aquifer
An underground water supply that can be found in a porous rock, gravel, or sand layer.

Bioswale
Depressed, landscaped practices that are situated in low-lying, open areas to collect, treat, convey, and temporarily store stormwater runoff.

Bumpout
Contained landscaped practices that extend into the street and are designed to collect, treat, and temporarily store stormwater runoff.

Carbon Sequestration
The uptake and storage of carbon dioxide by vegetation through photosynthesis. This long-term storage of carbon dioxide helps to mitigate the impacts of global warming.

Catch Basin
An opening or pipe to allow water into a stormwater management practice or storm sewer system.

Curb Cuts
A drainage opening within a roadway curb. Curb cuts are typically 2 feet wide and include a wheel guard to protect the curb opening.

Design Storm
A rainfall event of a specified size and return frequency used for stormwater management design.

Detention/Slow-Release
Temporary storage of stormwater runoff during a rainfall event with a controlled release rate.

Drain-down Time
The amount of time that it takes for a volume of water to be emptied from a stormwater management practice.

Ecosystem
A community of living organisms.

Energy Dissipation
A system that is used to reduce the flow speed

Engineered Soil Media
A soil that has sand or compost added to increase the infiltration capacity and water retention capabilities.

Evapotranspiration
The movement of water into the air from evaporation (from land) and transpiration (from vegetation).

Filtration
Straining and retention of suspended particles as a result of water passing through a granular media or vegetation.

Green Stormwater Infrastructure

A resilient approach to managing stormwater runoff which aims to protect, restore, and mimic the natural water cycle by managing stormwater runoff where it falls with methods that would occur naturally. Green stormwater infrastructure places an emphasis on low-impact development with nature-based practices to increase infiltration, evapotranspiration, and transpiration, and to enhance water quality.

Green Roof

Vegetated stormwater management practices placed over a conventional roof surface to collect, treat, and temporarily store stormwater runoff.

Green Roof Growing Medium

A light-weight soil composed of mineral aggregates and a small amount of organic material.

Groundwater Contamination

Pollution or contamination of groundwater as a result of pollutants that are released or naturally present in the ground.

Hydrologic Zone

Relationship of plantings within a stormwater management system to the depth of water inundation.

Infiltration

The downward entry of water into the soil. Infiltration is often expressed as a rate (inches per hour), which is determined from an infiltration or percolation test.

Infiltration Rate

The speed or time for water to flow through a soil profile and is the measure of permeability of a soil. An infiltration rate is measured as depth of the water layer that can absorb into the soil over a given time, usually represented as inches per hour.

Living Shorelines

Stormwater management techniques to address shoreline erosion and the protection of marsh areas.

Loading Ratio

The area of contributing impervious drainage area as compared to the bed bottom area of a green stormwater infrastructure practice.

Low-Impact Development

A stormwater management technique that emphasizes the conservation of natural resources and reduction to environmental impacts associated with land development.

Outlet

Place where water is discharged. In a stormwater management practice, this would be an opening or pipe to allow stormwater to leave the practice.

Overflow

A drainage structure or opening to allow stormwater runoff to exit a stormwater management practice under high-flow conditions.

Permeable Pavement

Paving systems that provide the structural support of conventional pavements but are designed to collect, treat, convey, and temporarily store stormwater runoff.

Planter Box

Contained landscaped practices that are designed to collect, treat, and temporarily store stormwater runoff.

Plant Uptake

The act of plant roots taking water and dissolved substances from the underlying soil.

Rain Garden

Rain gardens are depressed, landscaped practices that are situated in low-lying, open areas to collect, treat, and temporarily store stormwater runoff.

Rainwater Harvesting

Collection of rainwater for reuse on-site.

Recharge

To replenish through the absorption of water

Sedimentation

A physical process by which solids are removed from stormwater runoff as a result of settling.

Soil

The upper layer of earth that supports life.

Soil Amendments

A mixture of substances intended to improve the characteristics of a soil.

Soil Contamination

Pollution or contamination of soil as a result of pollutants that are released or naturally present in the ground.

Stormwater

Water that originates during precipitation events and snow/ice melt.

Stormwater Management

The collection and treatment of stormwater runoff. Generally, management includes infiltrating stormwater back into the subsurface soils or detention and slow-release of stormwater runoff into a storm sewer after the peak of a storm has passed.

Stormwater Piping

Infrastructure which is designed to convey stormwater runoff from one place to another.

Stormwater Runoff

Precipitation during a storm that does not absorb into the soil and runs off into surface water bodies or stormwater management facilities.

Subsurface Soils

Soils that are located below the ground surface. The qualities of the soil are typically different than the first few inches of topsoil and are a result of many years of erosion and deposition cycles or man-made improvements.

Subsurface Trench

Below-grade stone storage practices designed to collect, treat, and temporarily store stormwater runoff.

Tree Pit

A hole within the ground or stormwater management practice where a tree can be planted.

Trench Drains

Infrastructure with a slotted grate that are used to capture and convey stormwater runoff to a stormwater management practice.

Urban Heat Island Effect

Condition in which the average temperature in an urban area is higher than surrounding areas as a result of human activities.

Waterproofing

The process of making a structure water-resistant to avoid unwanted water-intrusion.

Water Quality

The chemical, physical, and biological characteristics of water.

Zone of Influence

An area that is directly impacted as a result of planned stormwater management improvements.

Design with
community in mind

Stantec