Hidden Stories: Resurrecting the Garrison Creek through a Decentralized Storm-water Management System

by
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Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

This thesis examines the disconnect that is created when the urban infrastructure of cities absorbs its historic landscape. Toronto's Garrison Creek is a typical example of such disconnection; where the historic creek was buried as part of the storm-water infrastructure while the city expanded.

The ravine system is one of the most distinctive features of the geography of Toronto. Although the creek has been buried since the 1880s, it is still not entirely hidden from the surface of the Toronto landscape; it can be heard while passing by a storm sewer, its shape can be seen in ravines and parks, curving streets, and the traces of buried bridges that lie along its course. However, the Creek's lack of distinctive presence keeps up largely unknown expect to those who seek to find its traces.

The proposed design presented in this thesis offers a community landscape development that seeks to enhance the connection between the city and its buried watershed through low-impact landscape infrastructure. Working with a decentralized storm-water system instead of a conventional centralized singular system, this study focuses on the integration of a hybrid technological and natural system. This integration aims to assist in the resiliency of the overall water management system, give the public a better understanding of natural systems, and ultimately providing protection from the impacts of extreme weather events. The design also aims to enrich the public space and reconnect with the historic water system, an element that has been hidden under the city, its presence unknown for over a century. The intervention highlights issues of water remediation and demonstrates a general strategy that could be adapted to other similar sites in the city.

Acknowledgements

My deepest gratitude to my supervisor, John McMinn, and committee members, Maya Przybylski and Ryszard Sliwka, for their valuable insight, guidance, and support during the process of preparing this thesis. I would like to thank my external reader, John Potter, for his generous time commitment, and insightful commentary.

To all my friends: Thank-you for supporting me unconditionally through these years, and giving me wonderful memories to hold on to. Linda and Swati, for their energy and spirits, which made a world of difference. Anne and Pooneh, for making the last seven years unforgettable. Srinidhi and Tahoora, for their enthusiasm, and encouragement in every step. Anam and Sheida, for giving me the confidence, and providing me crucial support at times when I needed the most.

Satish, thank-you for your companionship, dedication, and sincere belief in me.

And finally, a special thank-you to my family - Dad, Ma, and Dada - for their unwavering support, encouragement, and continuous faith in me throughout all of my endeavours. I could never have come this far without you.

To my loving family
- Dad, Ma, and Dada -

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Introduction

"Water is everywhere before it is somewhere. It is rain before it is rivers, it soaks before it flows, it spreads before it gathers, it blurs before it clarifies. Water at these moments in the hydrological cycle is not easy to picture in maps or contain within lines."[1]

Toronto's landscape was originally defined by a number of rivers and creeks that flowed from the ancient glacial lake Iroquois to the present Lake Ontario.[2] As the city grew, this landscape was incrementally transformed, often in dramatic ways, as wetlands were drained and ravines infilled. While the pre-existing hydrological systems of the natural landscape were replaced with urban water infrastructure, enabling large-scale urban developments, this exchange has also resulted in unanticipated environmental impacts that must eventually be addressed.[3] With a high ratio of dense urban fabric and the advancement of engineering technology, alongside this development, cities have lost their connection with natural processes. Urban technological approaches to storm-water management bury historic creeks and drain surface water into massive underground infrastructures, instead of relying on mere natural processes; a method that may no be sustainable in the long term.

Since 2000, Toronto has been experiencing a higher frequency of extreme weather events, that have highlighted the shortfalls of the existing infrastructure. The repeated sewage overflow and flooding experienced during such weather conditions has caused damage to properties, emphasizing that the infrastructure the city currently relies on has become unsustainable. Creative solutions need to be explored to resolve these issues, and sustainable links to natural systems could form part of these initiatives.

1 "About." Design in the Terrain of Water. Accessed December 10, 2014. http://terrain.design.upenn.edu/about
2 Wayne Reeves, and Christina Palassio, eds. HTO Toronto's Water from Lake Iroquois to Lost Rivers to Low-flow Toilets. Toronto: Coach House Books, 2008, 35.
3 Jacqueline Hoyer. Water Sensitive Urban Design: Principles and Inspiration for Sustainable Stormwater Management in the City of the Future. Berlin: Jovis, 2011, 5.

Working as a part of F_RMlab, a design and research collective group initiated by masters students at University of Waterloo, the author of this thesis, in association with May Yue, Miriam Ho, and Srinidhi Sridhar, collaborated with Friends of Roxton Road Parks (FoRRP) to explore solutions to these issues. FoRRP is a community group dedicated to the revitalization of three parks along Roxton Road in Toronto: Fred Hamilton Park, George Ben Park and Roxton Road Parkette. The water revitalization committee of FoRRP has played a large role in inspiring this research, bringing an in-depth awareness of water systems and their management within Toronto to this research.

This thesis aims to design a decentralized system that utilizes the element of water to revitalize historical, ecological, and social aspects of Toronto along the path of the buried Garrison Creek. The design's intention is to bring back nature and natural processes by combining the elements of a natural system with existing programs in Toronto's public spaces. The research focuses on parks of three different scales: Fred Hamilton Park, Roxton Road Parkette, and Trinity Bellwoods Park. The design aims to respond to and address the excess storm-water run off caused by extreme weather events which are being experienced more and more frequently. The proposal imagines the City of Toronto parks system as an integral element of an overall storm-water management system, taking on an increased role to enrich the public space with a hybrid technological and natural system.

Figure 0-2 (left) Areal view of the site highlighting Fred Hamilton Park, Roxton Road Parkette and Trinity Bellwood Parks.

1700s

Garrison creek was formed with the receding and melting Wisconsin Glacier.

1787
Purchase of Toronto.

1792
British Governor, Lord John Graves Simcoe arrived in Toronto to established a military outpost which was located right next to the mouth of Garrison Creek. Simcoe and his engineers saw this location as a secure natural watershed. Simcoe and his engineers also drafted 'park lot system' which is still present in today's city grid.

1773
Establishment of Town of York.

1800s

1800s
Rise of water-powered mill industries.

1805
Sawmills were first seen in Toronto at Highland Creek.

1830s
73% of Scarborough was covered by forest.

1840s
Number of sawmills on Highland Creek increased to 23.

1850
Ontario Brewery and Turner's Brewery each increased the production of beer capacity to 24,000 pints.

1860s
Decline of water-powered mill industries.

1884
Construction of the first Crawford Bridge at Trinity Bellwoods Park.

1884-1885
First section of the Garrison Creek buried between the old lakeshore and College Street.

1889
Don Valley Brick Works opened to produce bricks.

1880s - 1909
Christie Pits opens as a gravel quarry. After the quarry was emptied, the site was transformed into Willowvale Park.

1900s

1900s-1920s
In order to create a connected open space, the city converted Garrison ravine lands to public open spaces and built bridges extending the streets over the ravines.

1910-1912
The rest of the Garrison sewer was installed. This sewer is still used today as the Combined Garrison Creek Sewer.

1912
In order to expand the Bellwoods Park, the City bought the land of Trinity College, where the building was demolished after the purchase.

1930
Burial of Harbord Bridge.

1930s-1940
As the city expanded with new development, Garrison lands turned into landfill sites. Bridges that were previously constructed to preserve the ravine were buried.

1940s-1960s
West Toronto became an ideal location for post War Housing Boom.

1954
Hurricane Hazel.

1960s-1970s
Two new storm sewers were constructed to maintain the overflow of the Garrison Creek Sewershed.

1986
63 mms of rain fell at Pearson International Airport over a 24-hour period.

2000s

2001
Longest winter in 20 years with 104-day stretch of snow on the ground.

2002
Warmest summer in 63 years with 15 heat-alert days and two heat emergencies.

2005
Warmest January in 165 years.

2006
Highest power demand of 27,005 MW due to summer heat in August 1st in one day.

2008
Total rainfall of 396.2 mm, exceeded former high water mark by more than 60 mm.

2012
Earliest heat wave started from June 19-21. Thunderstorms in southern and eastern Ontario and western Quebec in July caused $100 million in property losses.

July 2013
Storm in July 8 was marked as the most expensive natural disaster in Toronto and Ontario with $1 billion in damages as estimated by Insurance Bureau of Canada. It caused transit halts and delays, road closures, flight cancellations and left roads and underpasses under water, forcing motorists to abandon their vehicles.

2014
Toronto’s coldest winter in 20 years, with record setting levels of snow, ice pellets, rain and freezing rain. The boxing day storm in particular left roads and sidewalks covered in a thick layer of ice, knocked down hydro lines and left over 500,000 people without power for days. Damages have been estimated to exceed hundreds of millions of dollars.

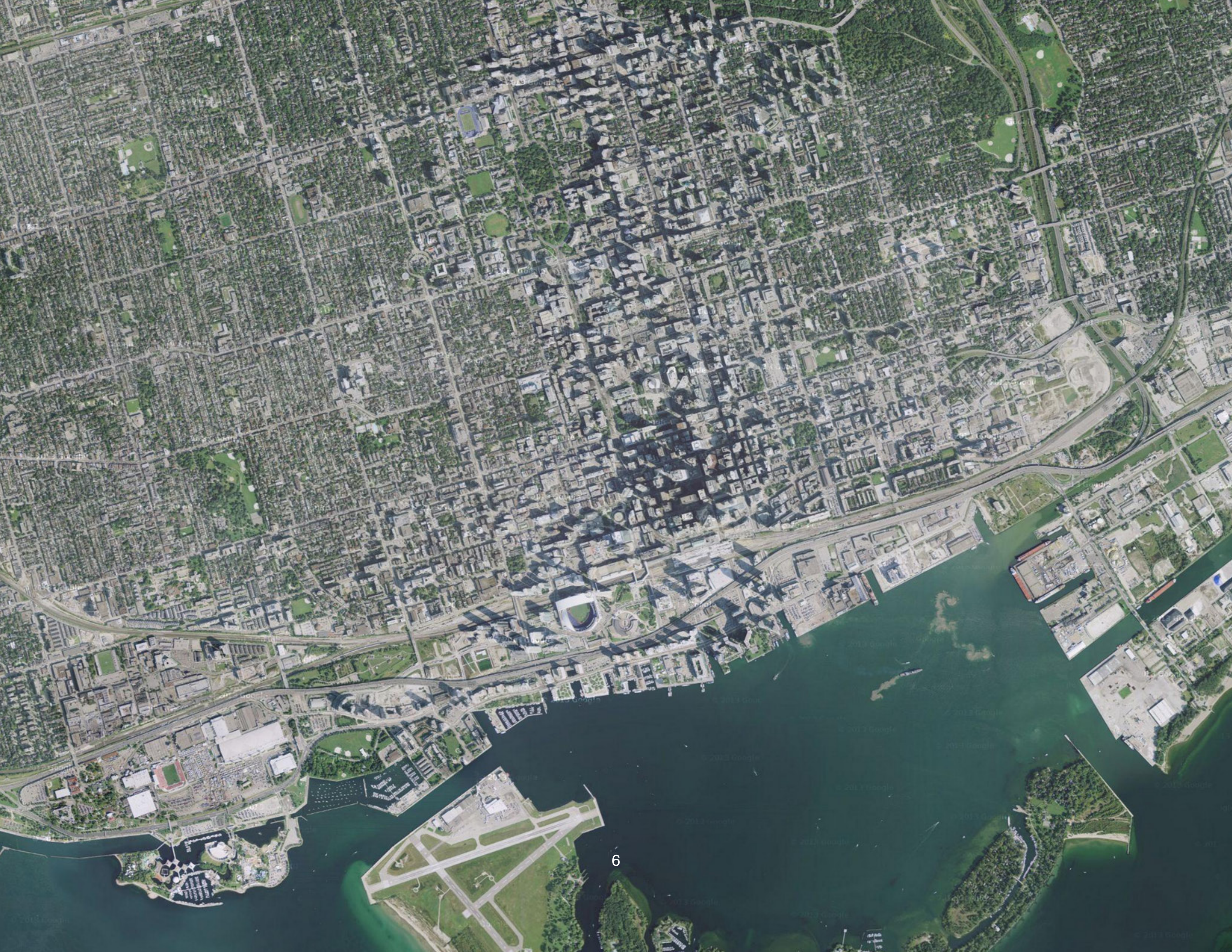
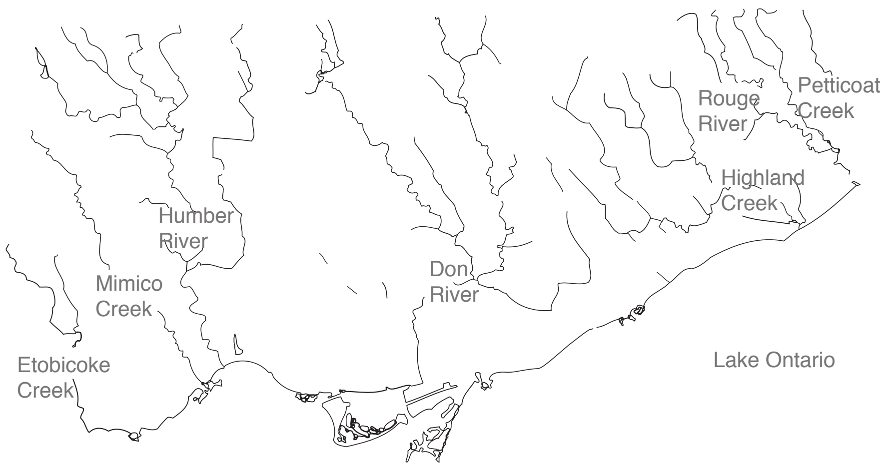


Figure 1-1 (left) Map of downtown Toronto.

Figure 1-2 (top) Toronto's original watercourses, (bottom) Toronto's water systems, 2008.



Chapter 1 | Brief History

"The history of Garrison Creek is a story of exchange between the evolving urban and environmental landscapes of Toronto".[1]

Twelve thousand years ago, the Wisconsin Glacier receded and melted off the St. Clair West lands, creating landforms that determined the drainage pattern of Toronto's Streams.[2] One of these streams was Garrison Creek, the largest stream between the Humber and Don Rivers.[3] Over time, as Garrison Creek eroded, wide valleys were filled with sand, clay and gravel from the glacier.

During this era, the aboriginal Mohawk, Oneida, Onondaga, Cayuga, and Seneca people hunted, fished and farmed in these lands.[4] In 1792, the first British Governor, Lord Simcoe, arrived in Toronto (originally called York) to establish a military outpost. Simcoe and his engineers saw the creek as a secure natural water resource for Fort York.[5] "This act (the construction of Fort York) was the birth of urban Toronto."[6]

1 "Garrison Creek Demonstration Project – Project Report." Brown Storey Architects. March 31, 1996. Accessed February 22, 2014. http://www.brownandstorey.com/project/garrison-creek-study/.
2 "Garrison Creek." Lost Rivers. Accessed November 18, 2014. http://www.lostrivers.ca/content/GarrisonCreek.html.
3 "Garrison Creek Carries Stories of Toronto's Past." Human River. Accessed May 12, 2014. http://humanriver.ca/about/garrison-creek/
4 "A Provincial Centre, 1793-1851." City of Toronto. Accessed May 10, 2014. http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=80842118b7412410VgnVCM10000071d60f89RCRD.
5 "Garrison Creek Demonstration Project – Project Report." Brown Storey Architects. March 31, 1996. Accessed February 22, 2014. http://www.brownandstorey.com/project/garrison-creek-study/.
6 "A Provincial Centre, 1793-1851." City of Toronto. Accessed May 10, 2014. http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=80842118b7412410VgnVCM10000071d60f89RCRD.

Figure 1-3 Plan of York Surveyed and Drawn by Lieut. Phillpotts, Royal Engineers. Although Phillpotts performed the survey in 1818, he did not draw the map until 1823.

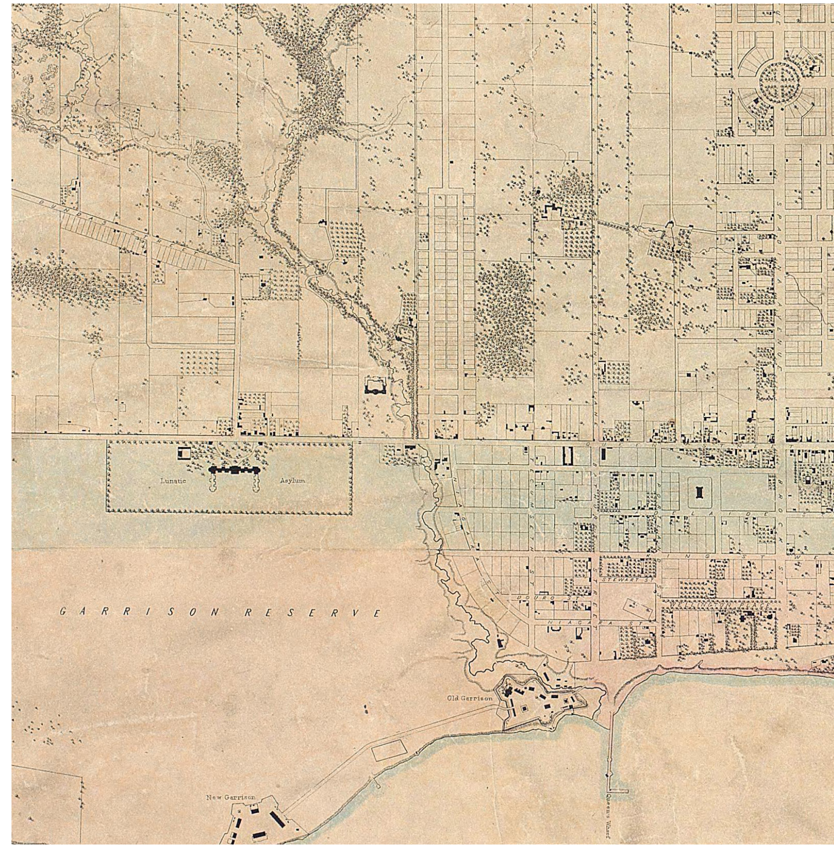
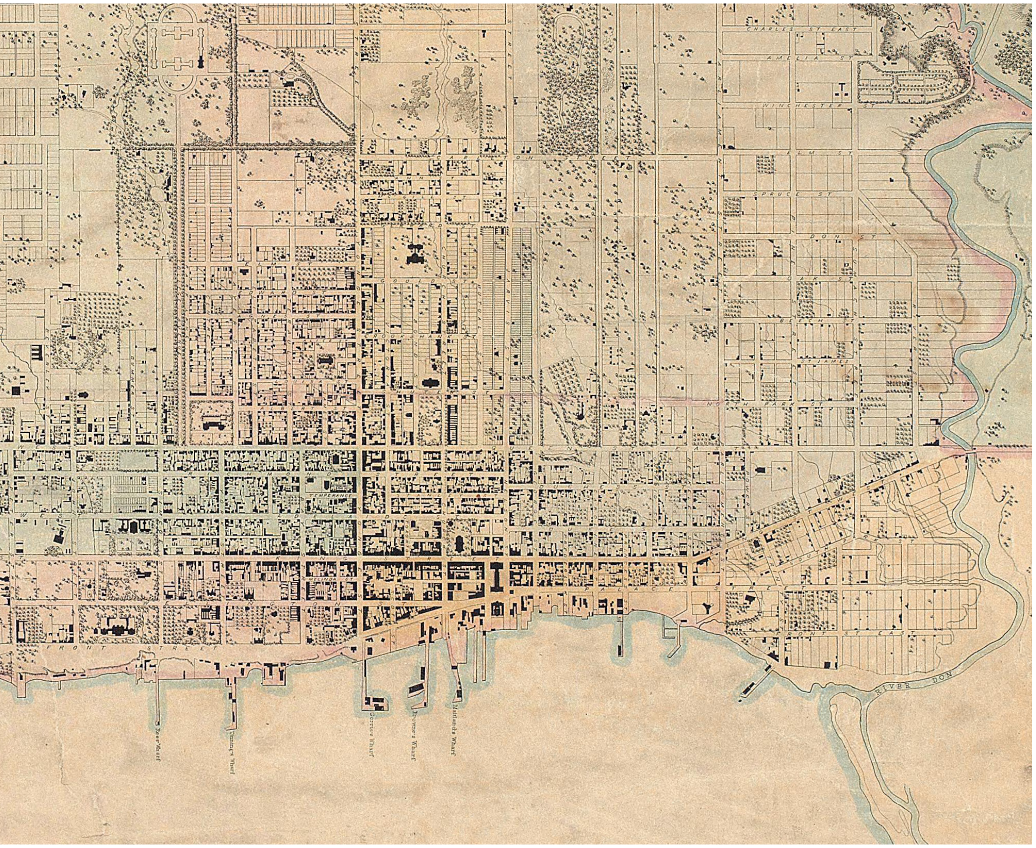


Figure 1-4 1851 Fleming: Topographical plan of the city of Toronto.



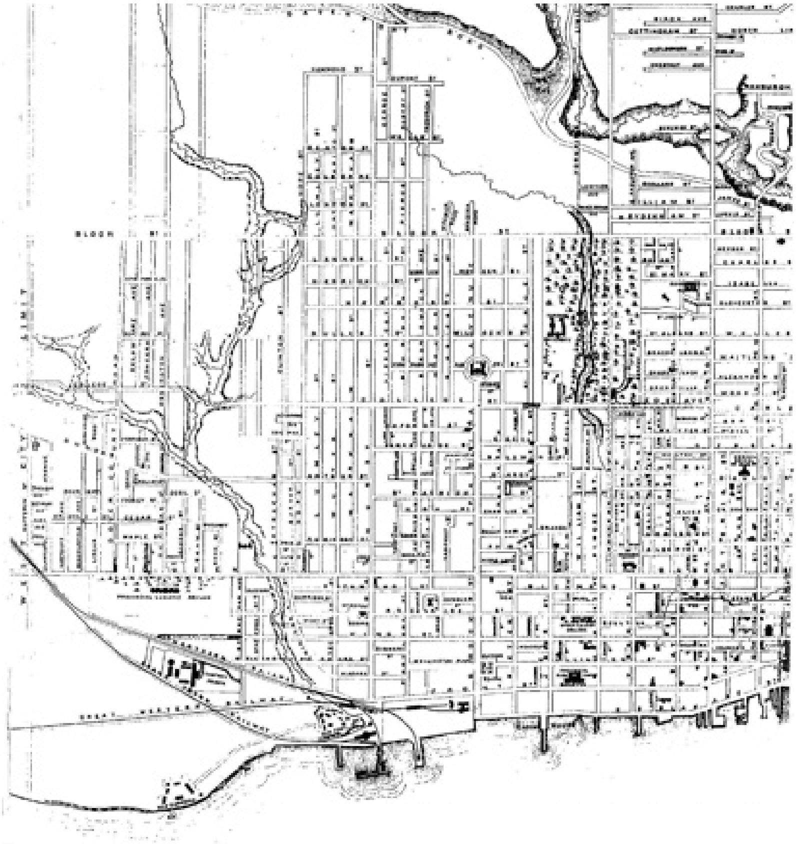
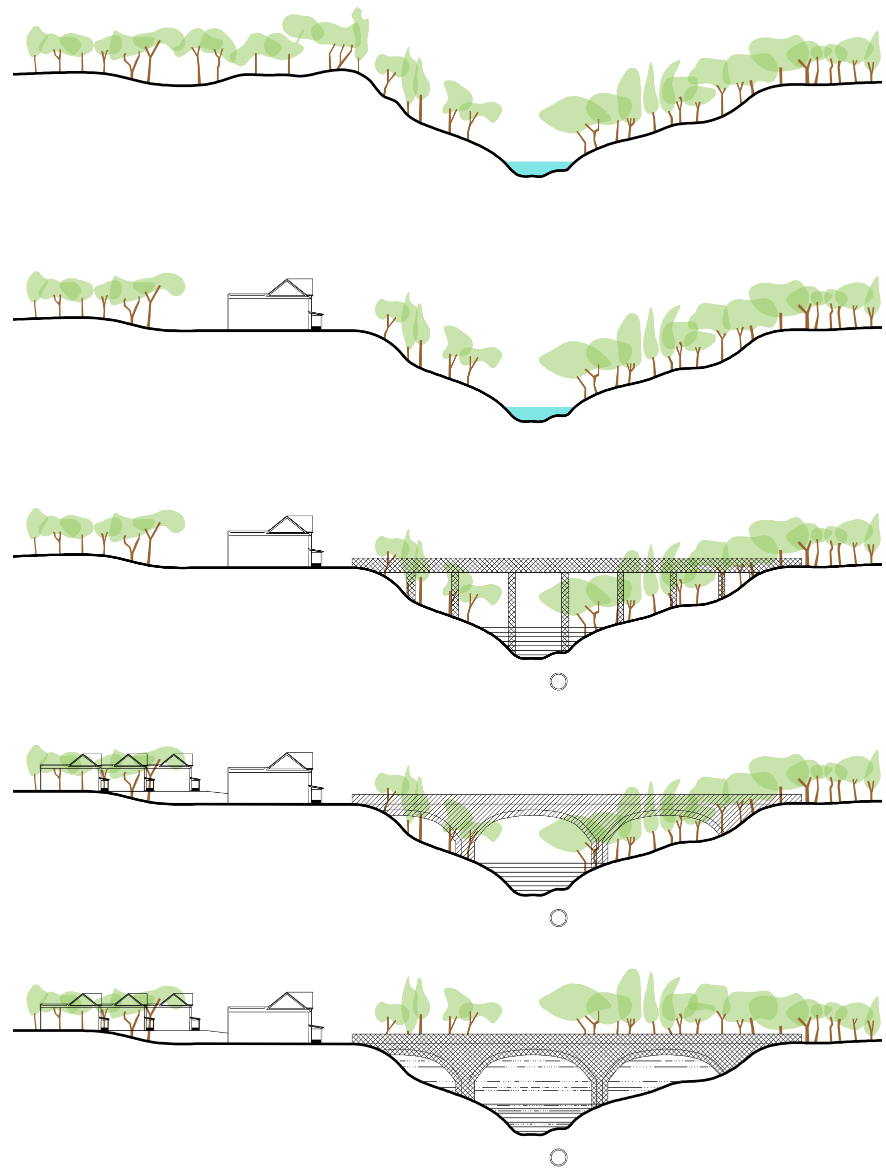


Figure 1-5 Toronto City Plan 1876, showing Garrison Ravine.

Figure 1-6 Chronology of the Co-Evolving Systems Landscape and the City, as stated in Brown and Storey's report: Rain Water Ponds in an Urban Landscape: Garrison Creek Demonstration Project.



BCE
Original Landscape formed by the receding Wisconsin Glaciers.

1792
Lord Simcoe and his engineers divided the countryside between Bloor Street and Lot Street (now Queen) into park lots. While the park lot divisions did not acknowledge the natural landscape, the villas built by the land owners were typically sited on highest point of the ravines, with direct view to the lake.

1800s
The increase in population polluted the creek with sewage and refuge. Toronto City Council decided to burry the creek into ten-foot diameter brick sewer tunnels and fill the base of the ravine, where the creek had been. Wooden and steel bridges were built to allow streets to pass over the ravines. This continuous ravine that continued to the lakeshore was called a 'parkway'.

1900-1920
With the increase of development and denser street grid, the original wood bridges were replaced by more substantial concrete structures.

1960s
As the ravines were used as dumps, majority of the ravines were levelled, and bridges were buried, with landfills. The levelled ravines became sites for new developments.

Soon after the construction of the outpost, land was cleared for farms, villas and estates such as “Earlscourt”, “Humewood”, and “Bartholomew Bull’s Farm”.[7] The first villas constructed in this area were highly influenced by the landscape. They were typically sited on the highest point of the ravine, facing Lake Ontario. Later, Lord Simcoe’s engineers used “Park Lots” to divide land into large orthogonal estates, mainly to tempt prospective settlers into Toronto with the Don River to the East and Garrison Creek to the West. This system marked the first shift of balance between town and ravine. The division created by Simcoe’s engineers marked most of the major roads in Toronto and the presence of Garrison Creek can still be seen through the curving streets that run against the normal grid where the creek’s path flowed.

With the development of roads, the population spread towards the west end of Toronto. Garrison Creek attracted new settlement, along with cultural, academic, and religious institutions, greenhouse, and aggregate mining.[8] The large increase in population polluted the creek with sewage and refuge. Rather than being used as a water resource, Garrison Creek was labelled a health hazard that emitted noxious fumes.

By the late 1800s, the City Council decided to take action, developing a plan that included diverting natural meanders of the Garrison creek into a 7.7 kilometers long system of ten-foot diameter brick sewer tunnels. They believed this action would provide a more predictable, safe and serviceable storm-water and wastewater management system.[9]

7 “Garrison Creek.” Lost Rivers. Accessed November 18, 2014. http://www.lostrivers.ca/content/GarrisonCreek.html.
8 Wayne Reeves, and Christina Palassio, eds. HTO Toronto’s Water from Lake Iroquois to Lost Rivers to Low-flow Toilets. Toronto: Coach House Books, 2008, 207.
9 “Garrison Creek Demonstration Project – Project Report.” Brown Storey Architects. March 31, 1996. Accessed February 22, 2014. http://www.brownandstorey.com/project/garrison-creek-study/.

Figure 1-7 (left) Building of the Garrison Creek Sewer in 1888.


PARKS DEPT. No 85 SEPT. 9 1913 PRITTIE RAVINE

Figure 1-8 (top) Trinity Bellwoods Park with the first Crawford Bridge in 1910.

Figure 1-9 (previous page top) Second Crawford Street Bridge 1915 looking east from Shaw Street and Dundas Street. This Bridge was buried intact in the early 1960s due to the construction of the Bloor subway.

Figure 1-10 (previous page bottom) Prittie Ravine, now known as Fred Hamilton Park, looking south towards Dunds Street in 1913.

In spite of the burial of the Creek, the City of Toronto still had a number of bridges that connected the new settlements by crossing through the continuous open spaces created by the ravine. Such infrastructure gave equal importance to the urban system and the ravine system, allowing them to coexist in balance.[10] However, this did no last long as the ravines turned into dumps for the residents and industries. It was only in the 1960s where the majority of the ravines were levelled with landfills and developments were built over them.[11] Because of this, some houses in the area experience settlement issues to this day, built as they are on landfills from the 1960s.

"If infrastructure can be considered as the connection between the city and the natural landscape, then the burial of the creek reflected the attitude that nature was to be found in the wilderness and open space within the city limits was better managed as predictable land parcels".[12]

10 Wayne Reeves, and Christina Palassio, eds. HTO Toronto's Water from Lake Iroquois to Lost Rivers to Low-flow Toilets. Toronto: Coach House Books, 2008, 207-208
11 "Garrison Creek Carries Stories of Toronto's Past." Human River. Accessed May 12, 2014. http://humanriver.ca/about/garrison-creek/.
12 "Garrison Creek Demonstration Project – Project Report." Brown Storey Architects. March 31, 1996. Accessed February 22, 2014. http://www.brownandstorey.com/project/garrison-creek-study/.

Figure 2-1 (top) Sunday Afternoon on the Island of La Grande Jatte, 1884, by Georges-Pierre Seurat.

Chapter 2 I Parks

As bridges were buried and ravines were levelled, the majority of the former Garrison Creek lands were sold to developers to build residences and complexes. However, there were leftover spaces within the grid that were set as public parks.

The concept of urban parks originated in Britain, during the late seventeenth century, as private residential squares for the upper-class city dwellers.[1] By the nineteenth century, in the expanding cities of Europe and the United States, parks transformed from private squares into public spaces. This development evolved from the Romantic Movement, where green spaces were seen to be a vital component of a city.[2] People believed that being amidst nature improved health, moral standards, and reduced the psychological and physical separation between urban and rural environments. With Parks like the Royal Parks in London, Olmsted's Central Park in New York, Mount Royal Park in Montreal and the Boston Common, it was perceived that the inclusion of natural landscape improved the appearance and livability of cities. However, urban parks had an entirely different purpose from the countryside they replaced. Rather than a natural landscape that focused on production of food, these green spaces were dedicated primarily for the public to engage in contemplation, exercise, and relaxation.[3]

1 Michael Hough. City Form and Natural Process: Towards a New Urban Vernacular. New York: Croom Helm, 1984, 14.
2 Michael Hough. City Form and Natural Process: Towards a New Urban Vernacular. New York: Croom Helm, 1984, 1984, 15.
3 Michael Hough. City Form and Natural Process: Towards a New Urban Vernacular. New York: Croom Helm, 1984, 14-15.

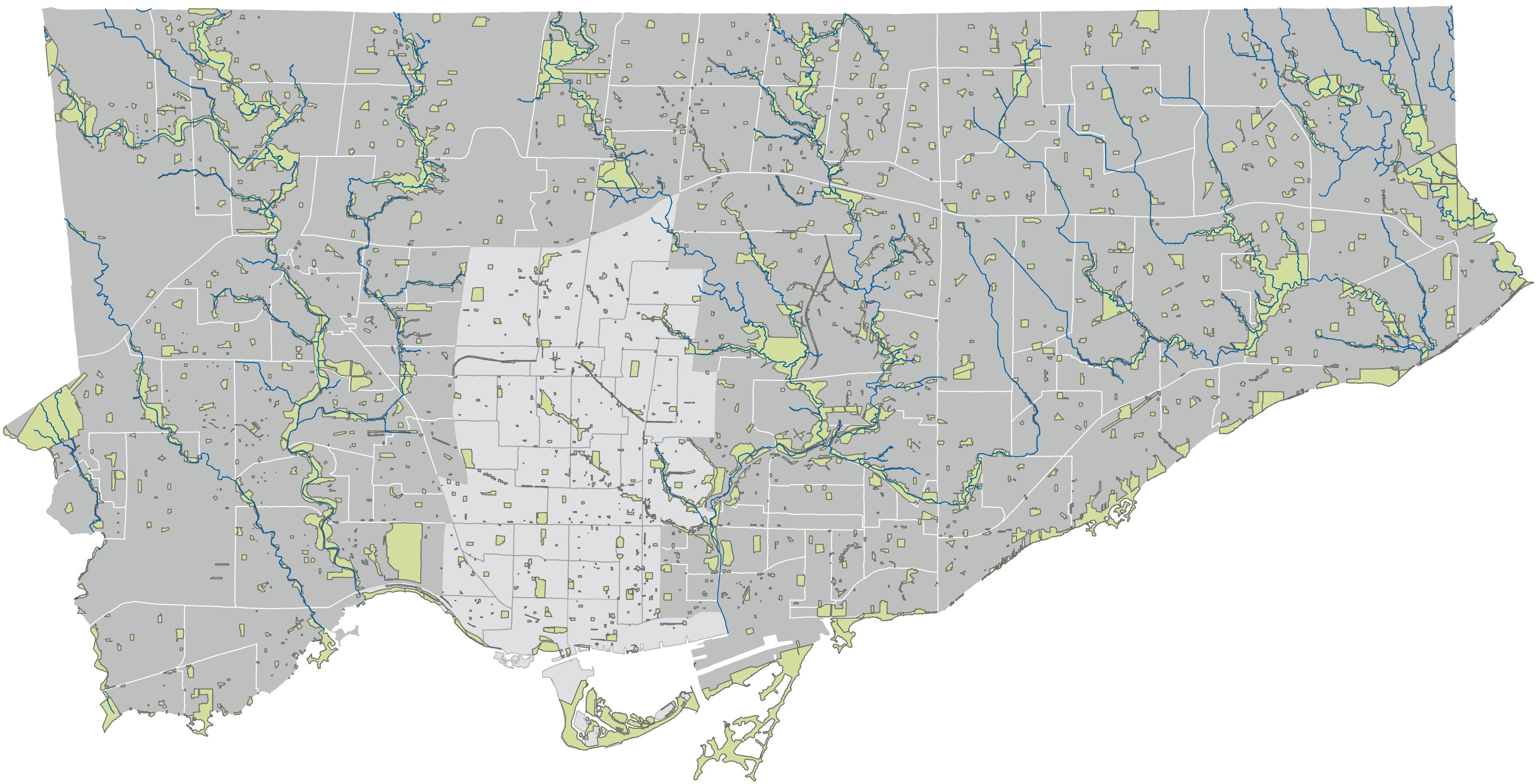


Figure 2-2 Parks and open spaces in Toronto,
along with the existing watercourses.
Scale 1:40,000

Toronto Region
Watercourses
Parks and Open spaces
Area of study

As cities expanded during the nineteenth century, new ideals for urban living standards began to emerge. People were now “living by the wheel”.[4] Having the option of greater mobility and a desire to escape the city, they were able to reconnect with rural settings and ‘country living’, a connection that the urban parks could not satisfy. As people moved away from the cities, the usage of parks drastically declined, leaving many of them abandoned in the similarly derelict downtown cores of their urban metropolis.[5]

Current urban design is starting to realize that a patch of green turf is not enough to provide healthful spaces for the city’s inhabitants. Like any other growing city, the growth of Toronto and increasing industrialization caused a larger and larger separation between the urban and natural environments to the detriment of its inhabitants. Realizing this, Waterfront Toronto, a public advocate and steward that was created in 2000 with the support of the Governments of Canada and Ontario and the City of Toronto, was designated to oversee the revitalization of the 800 hectare waterfront area in an attempt to reconnect the urban with nature.

“This project [Waterfront Toronto] is currently the largest infrastructure project in North America and one of the largest waterfront redevelopment initiatives ever undertaken in the world”.[6]

4 The End of Suburbia. Electric Wallpaper Co., 2004. DVD.
5 Michael Hough. City Form and Natural Process: Towards a New Urban Vernacular. New York: Croom Helm, 1984, 15.
6 “Scope and Scale.” Waterfront Toronto. Accessed November 18, 2014. http://www.waterfrontoronto.ca/about_us/scope_and_scale.

Figure 2-3 Wavedeck on Lakeshore Blv.

Figure 2-4 Sugar Beach located in Waterfront, Toronto.

Figure 2-5 Sherbourne Commons.

Along with the multiple projects intended to transform the abandoned lakefront industrial areas into green-spaces, such as ‘Sugar Beach’ and the ‘Wave Decks’, Waterfront Toronto has also prioritized environmental sustainability in their designs, creating projects like Sherbourne Common; the first park in Canada to incorporate an ultraviolet disinfection facility to treat storm-water from the neighbourhood before releasing it into the lake.[7] (See page 46 for additional information on Sherbourne Commons and the ultraviolet facility)

A number of park redevelopment projects have taken place in the past decade within the urban fabric of the city, but many parks in Toronto continue to be underutilized, and historical landscapes remain forgotten. There are thirteen parks that fall along the path of the buried Garrison Creek, and below these parks, the city surface covers a massive system of sewage networks, all virtually invisible to the fabric above.

7 “Environmental Assessment.” Waterfront Toronto. Accessed November 18, 2014. http://www.waterfrontoronto.ca/get_involved/environmental_assessments.

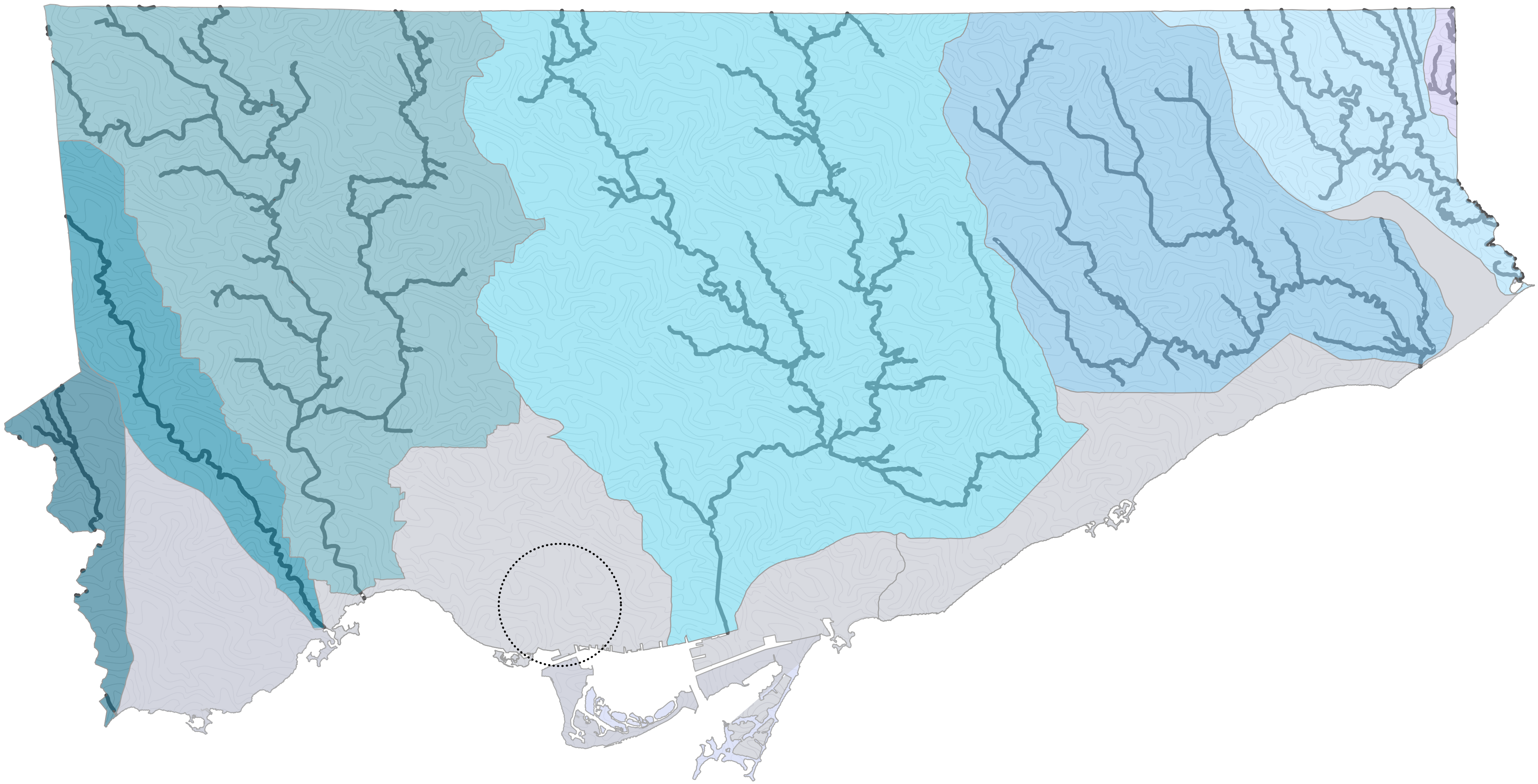


Figure 3-1 Toronto's watersheds.
Scale 1:40,000

Study Area

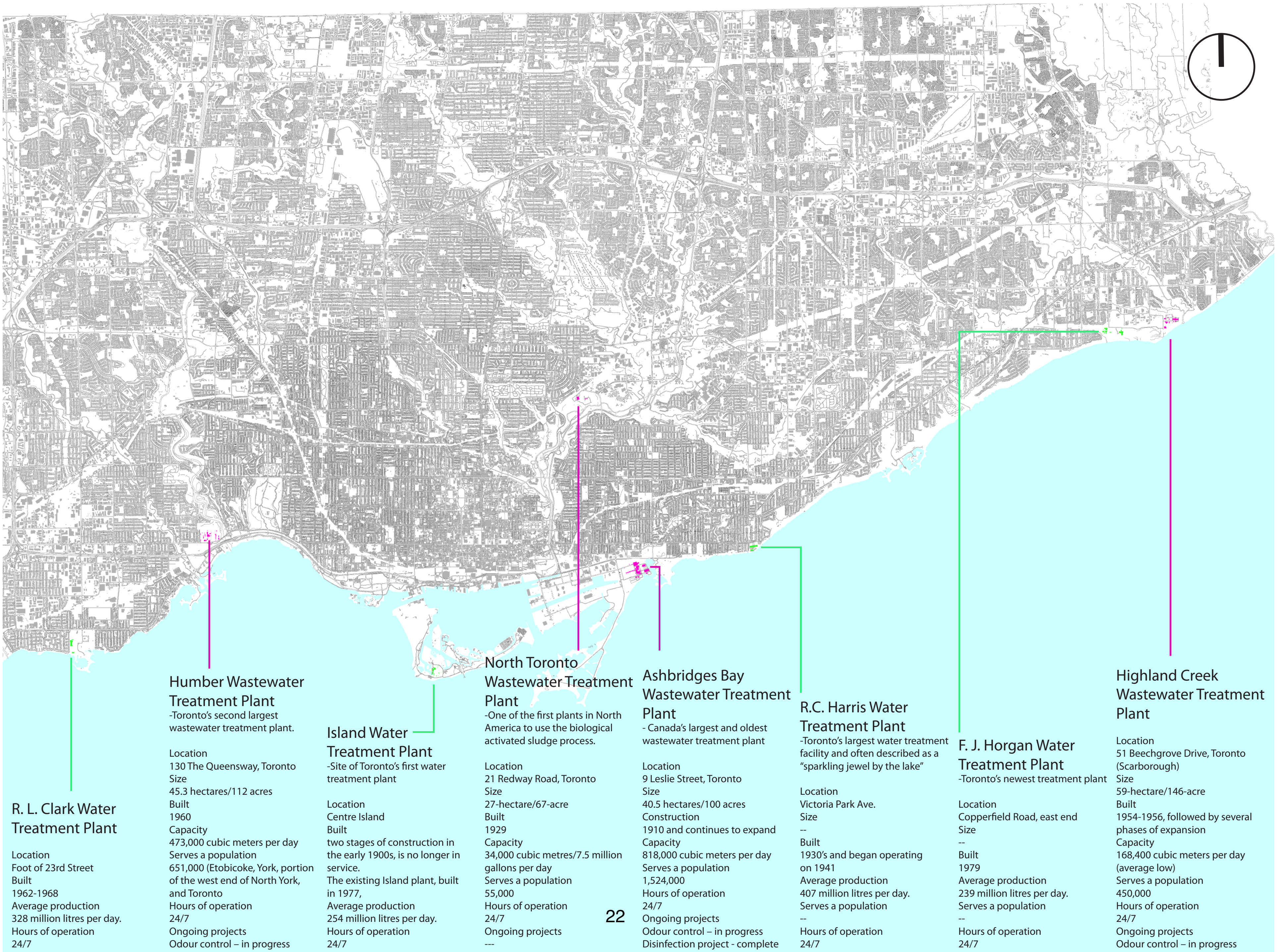
Etobicoke
Humber
Highland
Petticoat
Mimico
Don
Rouge
Waterfront

Chapter 3 I Watershed

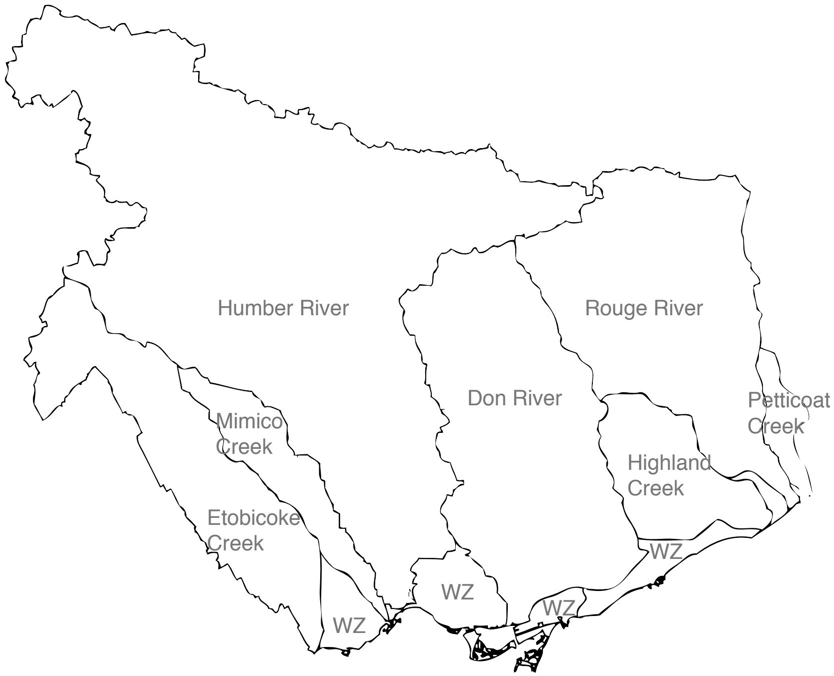
"It [Garrison Creek] is a waterway that very much does still exist, both beneath our feet and in the character of everything that surrounds it."'[1]

The first sewers in Toronto were built in 1835 as part of series of strategies to combat health issues such as cholera and typhus. These issues were thought to be caused by the unsanitary disposal of organic waste, as the residents used privies, dumping their outhouse pails into the street.[2] There were six sewers constructed along King Street that year, built in the hope of keeping the streets clean and drained. Building of the sewers was seen to be the responsibility of property owners, as they had to petition and partially finance for the construction. This strategy of self-financing lasted until 1877, after which the city took full responsibility for the construction and growth of the underground infrastructure.

1 Michael Cook. "Burying the Garrison Creek: A History." Vanishing Point. Accessed December 10, 2014. http://www.vanishingpoint.ca/garrison-creek-sewer-history.
2 "History of Wastewater Treatment in Toronto." City of Toronto. Accessed December 10, 2014. http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=0fd807ceb6f8e310VgnVCM10000071d60f89RCRD&vgnextchannel=8d3cfe4eda8ae310VgnVCM10000071d60f89RCRD.


R. L. Clark Water Treatment Plant
Location
Foot of 23rd Street
Built
1962-1968
Average production
328 million litres per day.
Hours of operation
24/7
Humber Wastewater Treatment Plant
-Toronto's second largest wastewater treatment plant.
Location
130 The Queensway, Toronto
Size
45.3 hectares/112 acres
Built
1960
Capacity
473,000 cubic meters per day
Serves a population
651,000 (Etobicoke, York, portion of the west end of North York, and Toronto
Hours of operation
24/7
Ongoing projects
Odour control – in progress
Island Water Treatment Plant
-Site of Toronto's first water treatment plant
Location
Centre Island
Built
two stages of construction in the early 1900s, is no longer in service.
The existing Island plant, built in 1977,
Average production
254 million litres per day.
Hours of operation
24/7
North Toronto Wastewater Treatment Plant
-One of the first plants in North America to use the biological activated sludge process.
Location
21 Redway Road, Toronto
Size
27-hectare/67-acre
Built
1929
Capacity
34,000 cubic metres/7.5 million gallons per day
Serves a population
55,000
Hours of operation
24/7
Ongoing projects

Ashbridges Bay Wastewater Treatment Plant
- Canada's largest and oldest wastewater treatment plant
Location
9 Leslie Street, Toronto
Size
40.5 hectares/100 acres
Construction
1910 and continues to expand
Capacity
818,000 cubic meters per day
Serves a population
1,524,000
Hours of operation
24/7
Ongoing projects
Odour control – in progress
Disinfection project - complete
R.C. Harris Water Treatment Plant
-Toronto's largest water treatment facility and often described as a "sparkling jewel by the lake"
Location
Victoria Park Ave.
Size
--
Built
1930's and began operating on 1941
Average production
407 million litres per day.
Serves a population
--
Hours of operation
24/7
F. J. Horgan Water Treatment Plant
-Toronto's newest treatment plant
Location
Copperfield Road, east end
Size
--
Built
1979
Average production
239 million litres per day.
Serves a population
--
Hours of operation
24/7
Highland Creek Wastewater Treatment Plant
Location
51 Beechgrove Drive, Toronto (Scarborough)
Size
59-hectare/146-acre
Built
1954-1956, followed by several phases of expansion
Capacity
168,400 cubic meters per day (average low)
Serves a population
450,000
Hours of operation
24/7
Ongoing projects
Odour control – in progress



Watershed	Areas of watershed in City of Toronto (ha)	Watershed as percentage of City land area	Total watershed area (ha)	Percentage of City land in watershed
Don River	20,632.6	32.5	35,806.0	57.6
Etobicoke Creek	1,478.6	2.3	21,164.8	7.0
Highland Creek	9,614.0	15.1	10,157.8	94.6
Humber River	13,731.9	21.6	91,077.8	15.1
Mimico Creek	2,900.5	4.6	7,709.1	37.6
Petticoat Creek	240.3	0.4	2,682.2	9.0
Rouge River	3,395.5	5.3	33,288.8	10.2
Waterfront Zone (WZ)	11,587.9	18.2	11,587.9	100.0
Total	63,581.3	100.0	213,474.4	29.8

Figure 3-2 (top) A graph on the areas of watershed in Toronto.

Figure 3-3 (previous page) Location of Wastewater and Water Treatment plants in Toronto.

While sewage systems proved successful in maintaining the health of the urban environment by cleaning and draining the city, this system created another problem in Toronto. Effluent from these sewers was directly dumped into Lake Ontario with the belief that the size of the lake and its ecosystem could dilute the sewage and simultaneously maintain the water quality. The city realized they were mistaken about the Lake's ability to contain the sewage only when they faced new problems: along with emitting dreadful odour, drinking water from the Lake was a risk to health, and by the 1860s the accumulation of the sewage sludge began to restrict the movement of cargo ships in the harbour. While engineers and medical professionals had succeeded in improving sanitary conditions within the city with the construction of the sewage system, the water body and trade market were greatly compromised.

Discussions about the construction of filtration plants to treat the sewage before releasing it to the lake began in the 1850s, but it was not until 1910 that actions were taken to build the first wastewater treatment plant, Ashbridges Bay Treatment Plant. By the 1960s, a total of four wastewater treatment plants collected the sewage of the city,[3] processing it before its release into the lake.

Starting in the 1980s and 1990s, the City of Toronto began to realize that the combined storm and sanitary sewers used throughout the city, constructed in the late 1800s, were too small to serve the growing urban development surrounding them. During heavy rainstorms, the sewers and treatment plants were often overloaded with combined effluent, causing untreated sewage to overflow into Lake Ontario.

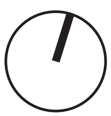
3 "History of Wastewater Treatment in Toronto." City of Toronto. Accessed December 10, 2014. http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=0fd807ceb6f8e310VgnVCM10000071d60f89RCRD&vgnextchannel=8d3cfe4eda8ae310VgnVCM10000071d60f89RCRD.

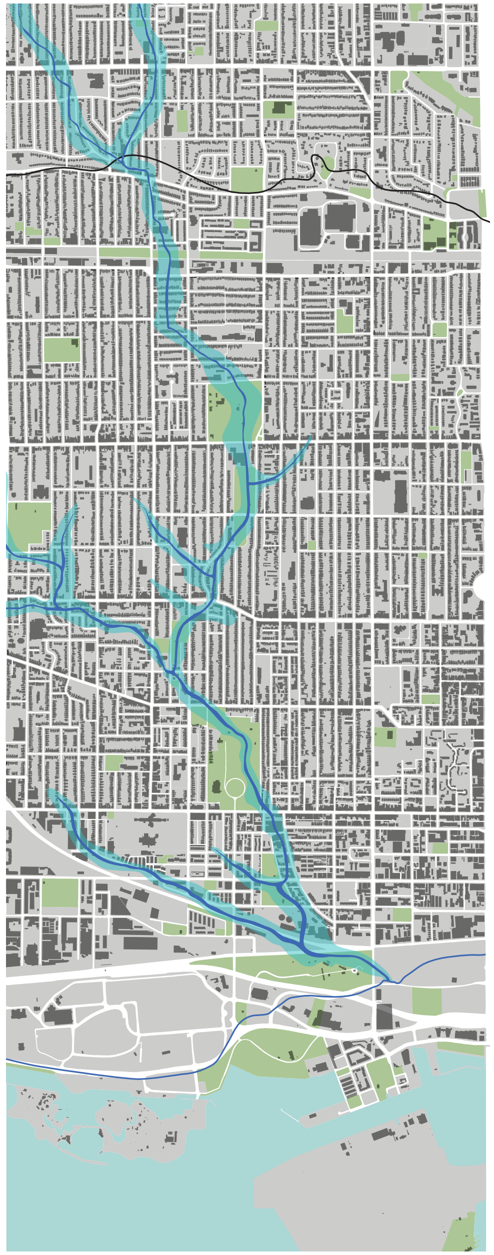
Figure 3-4 (right) Overlay of the map of the city with the historic Garrison Creek.

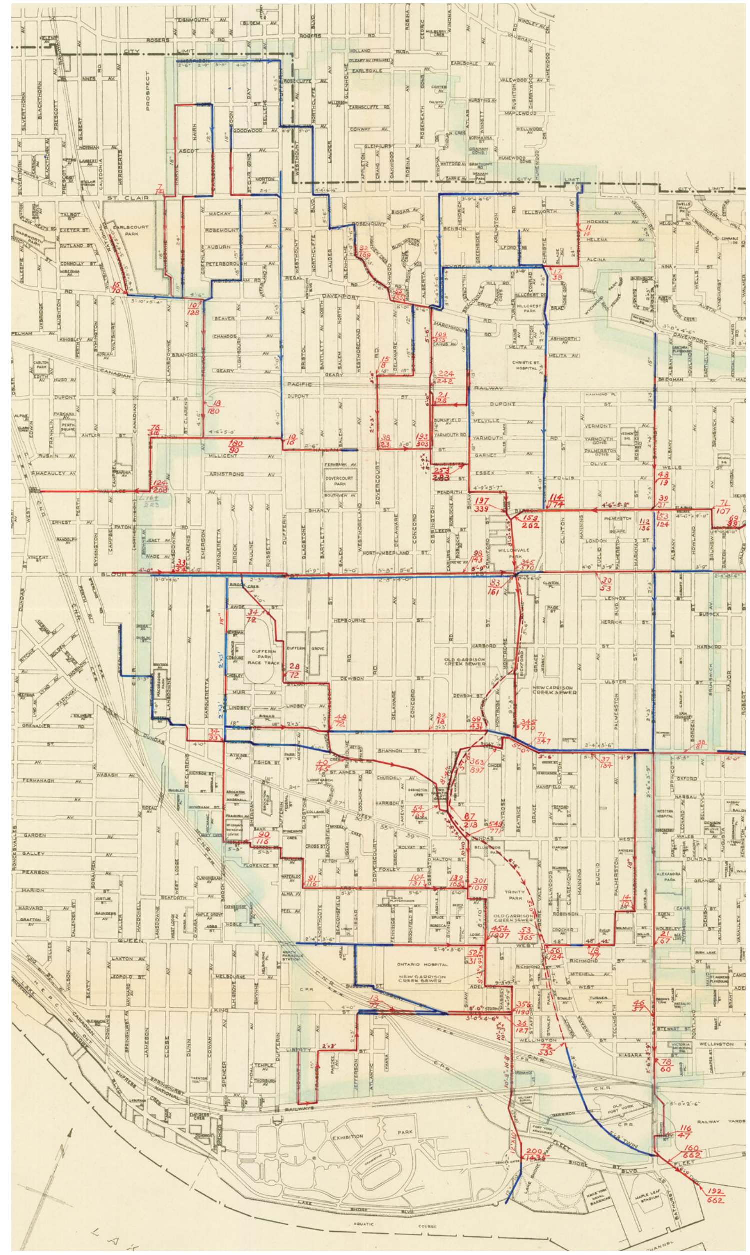
Figure 3-5 (further right) Accompany Report on Garrison Creek Sewer System: Existing Conditions. Drawn by John W. Argo, Gore & Storrie Limited Consulting Engineers, Toronto on October 5th, 1956. This map shows the surcharge of the existing combined sewers of the Garrison Creek. Surcharge of a sewer is the situation where the pipe is running full and under pressure. Sewer surcharged is shown in red and sewer not surcharged is shown in blue.

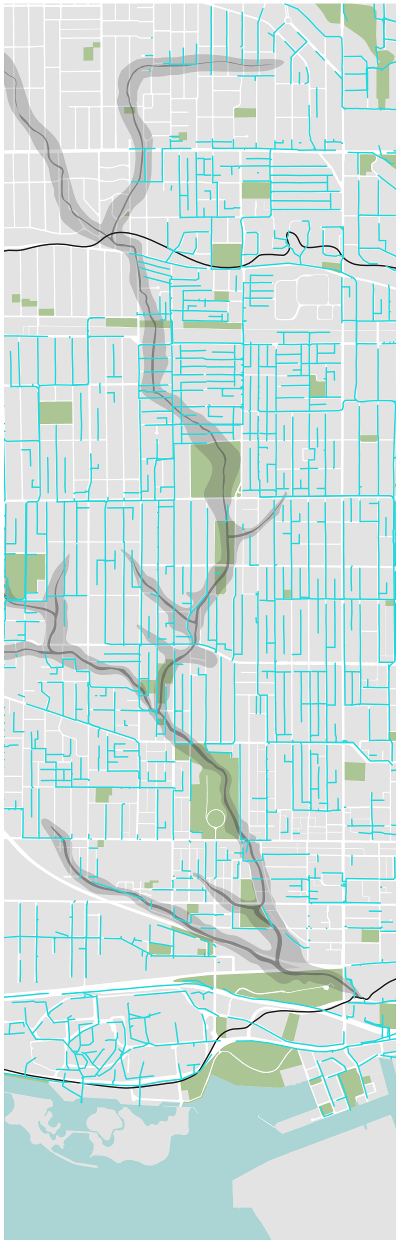
Figure 3-6 (next page left) Current Storm Sewage System in the area of the buried Garrison Creek. Storm Sewer System collects storm-water runoff from rain and melting snow from driveways, parking lots, roads, sidewalks and other hard surfaces.

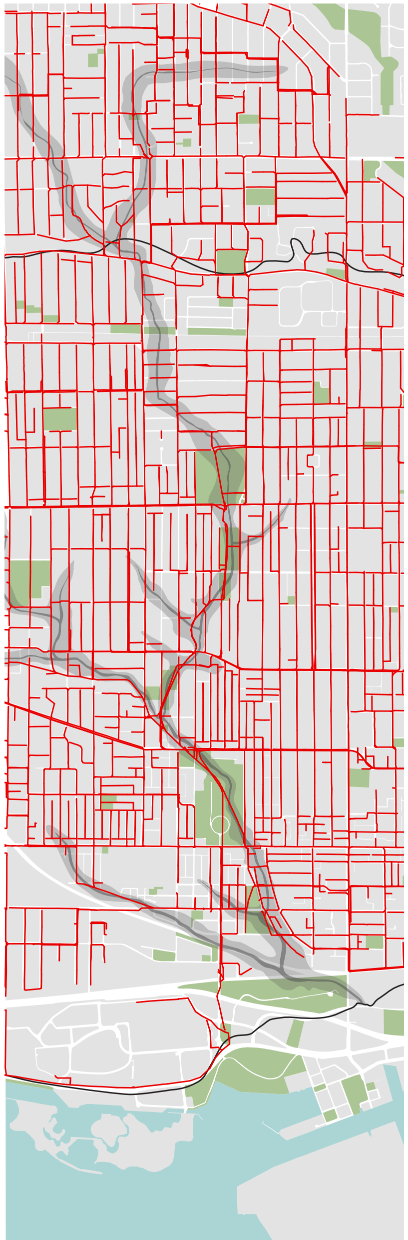
Figure 3-7 (next page right) Current Combined Sewage System in the area of the buried Garrison Creek. Combined Sewage System collects sanitary sewage and storm-water runoff in a single pipe system.











To explore alternative ways to control such hazards, the Waterfront Regeneration Trust commissioned Brown and Storey Architects to investigate the conceptual feasibility of ponds for retaining, treating, and re-using storm-water in the existing open spaces. Their study traced the route of the buried creek and suggested that the Garrison Creek Watershed could be used as a series of potential sites for storm-water management pond systems. Besides serving as a local space to collect, treat and re-use storm-water, this pond system was also proposed to be a series of connected open spaces that linked both urban and green infrastructure from Christie Pitt to Lake Ontario.[4]

Instead of implementing the Brown and Storey's proposal, in the 1990s, the City constructed a series of multi-million dollar underground reservoirs, large holding tanks, to temporarily retain overflow of sewer water from more than 3,900 km of sanitary sewers, 4,900 km of storm sewers and 1,500 km of combined sewers as a way to control overflow.[5] These tanks allowed sediments to settle down before releasing water into the treatment plant.

Such 'end-of-pipe' solutions did improve the condition of the Lake,[6] but in 2013, Eco-Justice conducted a study that found Toronto's lake water quality remained one of the worst among 12 studied Ontario municipalities. What Toronto is missing is a system that deals with storm-water at the source, through natural filtration processes and more sustainable initiatives.

4 "Garrison Creek Demonstration Project – Project Report." Brown Storey Architects. March 31, 1996. Accessed February 22, 2014. http://www.brownandstorey.com/project/garrison-creek-study/.
5 "Infrastructure." City of Toronto. Accessed May 12, 2014. http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=91d5f937de453410VgnVCM10000071d60f89RCRD&vgnextchannel=57a12cc817453410VgnVCM10000071d60f89RCRD.
6 Wayne Reeves, and Christina Palassio, eds. HTO Toronto's Water from Lake Iroquois to Lost Rivers to Low-flow Toilets. Toronto: Coach House Books, 2008, 228.

Figure 3-8 (previous page) Image of present day Garrison Creek Sewer as photographed by Michael Cook.

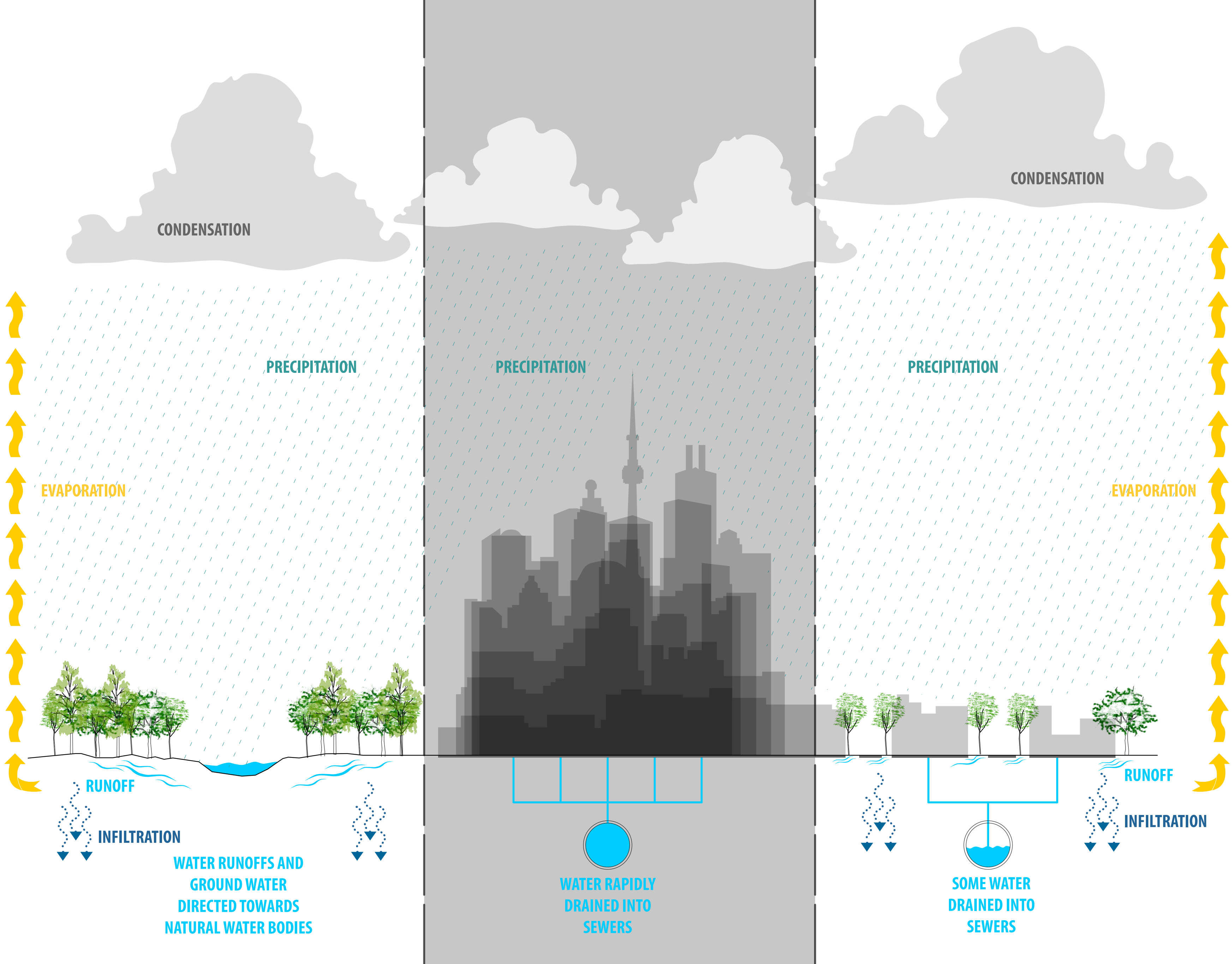
Figure 3-9 (right) A simulated color image of Greater Toronto Area. The rivers on the satellite image are hardly visible, especially in the downtown area. NASA, 2004.

Brown and Storey's project raised interest among many public groups who believe it important to understand the history of the creeks, rivers, and sewers in order to find innovative ways to reduce sewer overflow. These volunteer groups such as Garrison Creek Remediation, Friends of Roxton Road Parks, and Lost Rivers, help to focus public attention on heritage, storm-water, community planning, and the urban implications of the buried creek. Having raised awareness, communities situated around the Creek's path highly support the idea of restoring parts of the ravine. Some of these groups are working to create a series of storm-water management ponds that will recall the original creek; restoring several buried bridges; including ways to bolster business through the design, in collaboration with local merchants, and by encouraging the public to enjoy the regenerated Ravine system.

In 1996, the City of Toronto designated the Garrison Creek as an area of capital concern, and passed a resolution to revitalize the Garrison Creek Ravine System. Along with an interdepartmental committee, local neighbourhood groups took part to discuss and develop implementing initiatives to revitalize this area.[7] The outcome of this program included creating park systems following the Garrison Creek Ravine, restoring the history of the landscape by using native vegetation and bridges. "Some work was done but for the most part Garrison Creek remains a secret stream with hidden histories".[8]

This project attempts to make a contribution to the work that other groups have started to revitalize the ravine system as a natural infrastructure, while simultaneously reconnecting it to the surrounding urban fabric.

7 "Garrison Creek." Lost Rivers. Accessed November 18, 2014. http://www.lostrivers.ca/content/GarrisonCreek.html.
8 "Garrison Creek Carries Stories of Toronto's Past." Human River. Accessed May 12, 2014. http://humanriver.ca/about/garrison-creek/.



WATER CYCLE IN NATURAL SYSTEMS

WATER CYCLE IN URBAN AREAS WITHOUT SUSTAINABLE STORM WATER MANAGEMENT

WATER CYCLE IN URBAN AREAS WITH SUSTAINABLE STORM WATER MANAGEMENT

Terms used for sustainable storm-water management worldwide

LID – Low Impact Development (USA): Describes planning and design approaches for storm-water runoff management with sustainable storm-water management practices.
GI – Green Infrastructure (USA): Similar to LID, describes storm-water management approaches and practices to reduce or eliminate runoff through onsite infiltration, evaporation, and/or reuse of rainwater (compare U.S. EPA 2008).
SUDS– Sustainable Urban Drainage Systems (UK): Describes measures for sustainable storm-water management.
BMP–Best Management Practices (Europe): Describes measures for sustainable storm-water management.
DRWM - Decentralised Rainwater/Storm-water Management (Germany): Describes measures and techniques.
IURWM – Integrated Urban Resource Water Management (global): Describes an integrated approach to manage urban water (not only storm-water).
WSUD – Water Sensitive Urban Design (particularly Australia): Describes an approach that aims to integrate sustainable water management, particularly decentralised storm water management, into urban design.

Figure 4-1 (left) Water cycle in natural systems, urban areas without sustainable storm-water management and in areas with sustainable storm-water management.

Chapter 4 I Vision

"It's [Garrison Creek's] the pulsing heart beneath Toronto's west end, lamented when not completely forgotten by those who live and play above."[1]

The path of the buried Garrison Creek lies in a part of the city facing a number of problems. First, the historic landscape has been eradicated, and the majority of the population is unaware the creeks are buried sewers below. Second, there are environmental concerns developing with the conventional sewer system as urban disasters and environmental events increase. Third, the patchwork of parks that lie above the path of the creek have no connection to each other, further separating the history from the present, where there is no inclination of where and how the creek was buried. People mainly see these parks as an individual element rather than a connected system that exists for a reason, as the left over spaces from where the ravine formed the landscape.

Such problems are evident in many cities as urban societies dissociate themselves from environmental values as they develop. The idea of 'out of sight, out of mind' has been the motto of waste and water management since the beginning of concentrated settlement, and over time, this system of quickly collecting storm-water and flushing it out has become very efficient, making cities very reliant on them for their simplicity and ease of implementation.

1 Michael Cook. "Garrison Creek Sewer." Vanishing Point. Accessed May 11, 2014. http://vanishingpoint.ca/garrison-creek-sewer.

“The curb and catch basin that make rainwater disappear without trace below ground, cut the visible links between the natural water cycle, the storm sewers and dispose of it into streams, and the lakes and rivers that ultimately receive it.”[2]

However, mastering the system of rapidly collecting and flushing runoff has created a different set of problems in urban society. Rather than having a natural water cycle of precipitation, infiltration, surface runoffs, and evaporation; rainwater is completely drained from large area of impervious surfaces in the city, and piped elsewhere. Consequently, less water percolates to the sub-surface zone, resulting in a lower infiltration rate and, notably, a lower level of groundwater recharge from precipitation.[3] Such conditions can have extreme effects, where reduced infiltration and evaporation can create a warmer and dryer local climate, increasing the number of big storms, leading to sewage overflow, and ultimately resulting in urban flooding. Due to such climate change, there is a high probably of an increase in drought and storm, leading to more flooding in urban areas.[4]

Toronto has repeatedly suffered from storm-water overflow. Until 1992, beaches would be closed during the rainy season since the lake water would be contaminated with sewage and storm-water overflow, causing health hazards. This problem was only solved with the installation of retention tanks to store the effluent and stage the effluent flow to a manageable amount for the treatment plants. However, though the problems of the beaches have improved, the urban areas of Toronto still suffer from flooding caused by storm-water overflow during extreme weather events.

2 Michael Cook. “Burying the Garrison Creek: A History.” Vanishing Point. Accessed December 10, 2014. http://www.vanishingpoint.ca/garrison-creek-sewer-history.
3 Jacqueline Hoyer. Water Sensitive Urban Design: Principles and Inspiration for Sustainable Stormwater Management in the City of the Future. Berlin: Jovis, 2011, 10.
4 Jacqueline Hoyer. Water Sensitive Urban Design: Principles and Inspiration for Sustainable Stormwater Management in the City of the Future. Berlin: Jovis, 2011, 10.

Storm-water Performance on Various Ground Surfaces as stated by Wayne Reeves, and Christina Palassio in “HTO Toronto’s Water from Lake Iroquois to Lost Rivers to Low-flow Toilets.”

Surfaces	Storm-water absorbed into the ground %	Runoff %	Evaporation/ Transpiration %
Natural groundcover	50	10	40
10-20% impervious (exurban)	42	20	38
35-50% impervious (suburban)	35	30	35
75-100% impervious (downtown)	15	35	30

Rainwater harvesting potential and water-supply energy savings (based on 2006 data from Toronto’s water published in 2008) as stated by Wayne Reeves, and Christina Palassio in “HTO Toronto’s Water from Lake Iroquois to Lost Rivers to Low-flow Toilets.”

City of Toronto roof surface	134,000,000 m2
Toronto average annual rainfall	792.7
Expected volume of rain captured (80% capture)	84,977 ML
Energy savings	57,189,521 kWh
Cost savings	$5,013,643
Greenhouse gas emission reduction	11,302 tonnes eCO2

Rainwater Harvesting potential and wastewater treatment energy saving (based on 2006 data from Toronto’s Water Published in 2008) as stated by Wayne Reeves, and Christina Palassio in “HTO Toronto’s Water from Lake Iroquois to Lost Rivers to Low-flow Toilets.”

Total Roof area for the city of Toronto	134,000,000 m2
Toronto’s core roof area (40% of total)	53,600,000 m2
Core roof area connected to combined sewers (80% of total)	42,880,000 m2
Annual Rainfall	792.7 mm
Expected volume of storm-water diverted from combined sewers and wastewater treatment	34,000 ML
Energy savings	14.6 million kWh/year
Cost savings	$ 1.1 million/year
Greenhouse gas emission reduction	2,910 tonnes/year eCO2

Figure 4-2 (right) Toronto on July 8, 2013, stranded passengers were rescued from a flooded GO Train.


RDC

Toronto has experienced a number of big storms over the last decade. The torrential summer storm in 2000 and 2005 each caused damages of approximately 500 million dollars to property and infrastructure.[5] Another downpour occurred four years later in 2009, which had a similar effect. In 2011, there were 42 recorded cases of Combined Sewer Overflow between the months of April and October. In July 8 2013, the flooding that occurred in Toronto was listed as one of the most costly natural disasters in Canada, where the Insurance Bureau of Canada reported property damaged to be over 850 million dollars. This storm flooded houses, closed transit and roadways, stranded commuters, and knocked out power in several areas. People who suffered the most were the ones who had sewage in their basements again and again. As Cary Mills reported in The Star, a newspaper in Toronto, on August 14 2013, these storms turned out more costly to the home owners as they had limited insurance, which did not come close to cover the damages.[6] When dating back the records of storm since the mid 1980s, Toronto has experienced at least nine storms that exceeded the City's design standards, and "the fact is that 100-year storms are not as rare as they used to be".[7]

On July 8 2014, The Globe and Mail reported that due to reoccurring disasters, the City of Toronto has included additional funds in its budget for projects to repair following extreme weather conditions and 3.1 billion dollars has been set aside to improve wastewater and storm-water collection systems in the next ten years.[8]

5 Carys Mills. "Toronto's July flood listed as Ontario's most costly natural disaster." Toronto Star. August 14, 2013. Accessed May 11, 2014. http://www.thestar.com/business/2013/08/14/july_flood_ontarios_most_costly_natural_disaster.html.
6 Carys Mills. "Toronto's July flood listed as Ontario's most costly natural disaster." Toronto Star. August 14, 2013. Accessed May 11, 2014. http://www.thestar.com/business/2013/08/14/july_flood_ontarios_most_costly_natural_disaster.html.
7 Wayne Reeves, and Christina Palassio, eds. HTO Toronto's Water from Lake Iroquois to Lost Rivers to Low-flow Toilets. Toronto: Coach House Books, 2008, 229-230
8 "One year later, Toronto remembers the flood of 2013." The Globe and Mail. July 8, 2014. Accessed August 11, 2014. http://www.theglobeandmail.com/news/toronto/one-year-later-toronto-remembers-the-flood-of-2013/article19511329/.


ONTARIO
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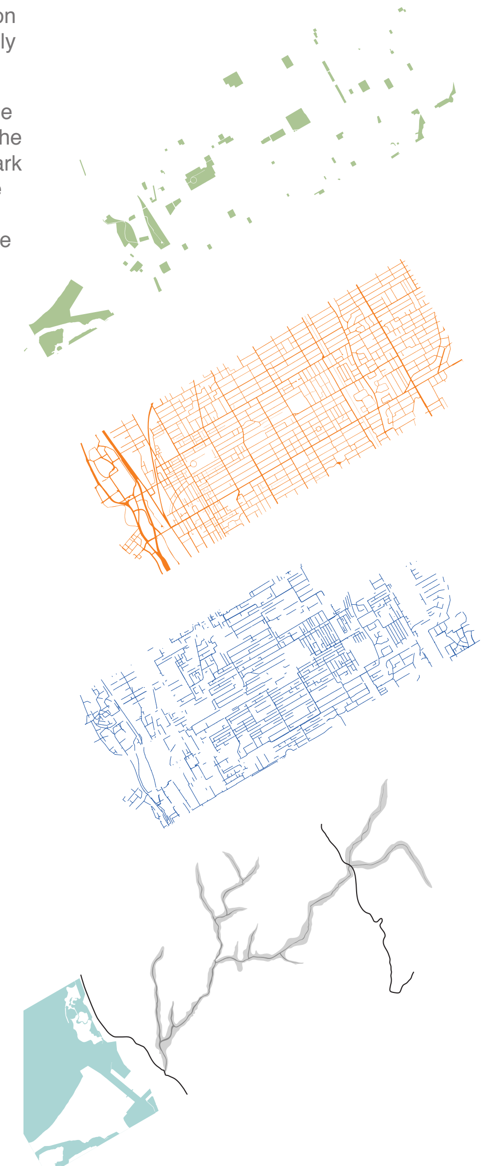
Figure 4-3 (previous page) Flooding on Lakeshore Boulevard in Toronto on July 8, 2013.

Figure 4-4 (right) Diagram showing the overlay of the existing networks over the historic path of the Garrison Creek: Park network, Path network highlighting the roads and Water network highlighting the Storm-water Sewage pipes that are buried under the city.



Urban flooding is an expensive disaster that depresses property values and degrades water quality. It is clear that cities are in need of a more effective solution to manage urban water. Cities need to consider turning the sewage system into a sustainable green infrastructure that offers sustainable solutions through the mimicking of natural hydrologic systems. Decentralized storm-water management systems, also known as sustainable storm-water systems, would solve the contradicting aims of urban drainage and urban planning. These competing views have been a recurring problem faced by conventional storm-water management systems, where people want urban drainage to be reliable, simple to construct, easy to maintain, and cost efficient, while at the same time wanting urban planning to make a city that is beautiful, meaningful, and educational to the community. Decentralized storm-water management systems aim to solve this paradox through various techniques that have developed over the last decade. This system is constructed to capture rain where it falls and uses natural hydrological cycles such as infiltration and evapotranspiration to reduce storm-water overflow. Decentralized systems have the capability to decrease rainwater flow rate, reduce water volume and improve water quality. Their main purpose is to improve the ecological, economical, social, and cultural sustainability of the city while also responding to storm-water and sewage needs.

Many cities have recently become more aware of such methods and have worked to develop in this way over the last decade. One of the first countries to research the implications of these sewage systems and practice sustainable storm-water management was Germany. Soon after, cities such as Melbourne in Victoria, Australia, and Portland in Oregon, USA, also encouraged creative solutions for such systems, influencing public perception and acceptance of sustainable storm-water.[9]

Decentralized storm-water systems could be a game-changer to solve the problems of overflow in Toronto, and by specifically implementing it on the site of the Garrison Creek it would contribute to the redevelopment of a natural water cycle where one existed in the past.

This thesis aims to design a system that brings forth the element of water for the revitalization of both the historic and ecological aspect of the site. By focusing on function and usability, the design will aim to bring together the existing park and path networks, linking with the storm-water sewage network in order to revitalize the Garrison system. Such a system would help people to experience the historical landscape that has been forgotten, could contribute to the alleviation of environmental issues of urban flooding caused by the conventional storm-water systems, while bringing more connection between the patchwork of parks that follow the path of the buried creek. Ultimately, this thesis will present how a decentralized storm-water management system can revitalize park settings through functional and attractive design.

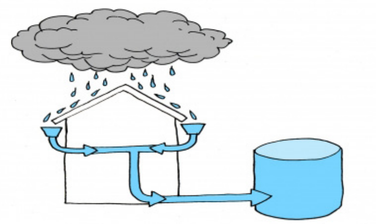
9 Jacqueline Hoyer. Water Sensitive Urban Design: Principles and Inspiration for Sustainable Stormwater Management in the City of the Future. Berlin: Jovis, 2011, 15.

Decentralized Storm-water Systems for Urban Design

Information from Jacqueline Hoyer's Water Sensitive Urban Design: Principles and Inspiration for Sustainable Stormwater Management in the City of the Future

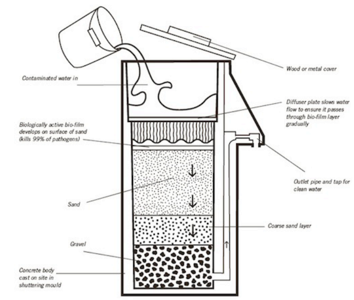
Rainwater Harvesting

Cisterns or water butts can be used to harvest water both above and under – ground. After being treated, harvested water can be used for toilets, fire sprinklers or garden irrigation. Water can also be incorporated in design elements such as fountains and pools.



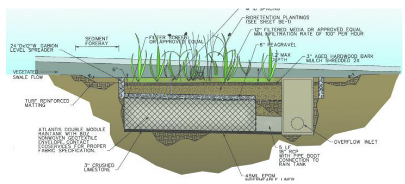
Gravel or Sand Filters:

Gravel or sand are put in chambers either above or below ground to treat runoff.



Bioretention:

Working with shallow landscape depressions, bioretention areas rely on engineered soils and enhanced vegetation and filtration to remove pollution and reduce runoff. The flexibility in sizes, shapes and the types of vegetation allows bioretention areas to adapt to different urban conditions.



Rooftop retention:

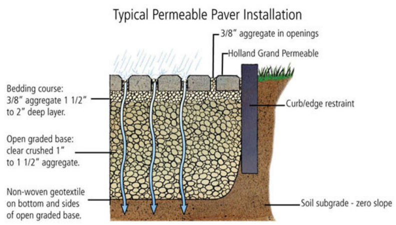
The size and the function determine the structure of this multi-layered system. There are two types of green roofs: extensive or intensive. While extensive green roofs are lighter on the structure and focuses on succulent plants, intensive green roofs are heavy to support deep-rooted vegetation.

Biotopes:

Biotopes is a landscape of plants and sometimes may include animals to stabilize the ecological condition of the area. It typically has reed beds or and wetland growth to improve water quality. It can add to the aesthetic amenity of water features such as ponds and fountains.

Permeable Paving:

Permeable paving is paving that allows water to pass through into a gravel bed (or other porous medium) below the pavement. They may include materials such as pavers, asphalt or concrete. This system retains water under the pavement, and usually works with the processes of infiltration and evaporation.



Infiltration Zones and Trenches:

Focusing on the strata of retention, filtration and infiltration, these areas have a high concentration of plants with gravel, sand and other minerals as substructures. The design of this system is reliant on the level of rainfall and the soil conditions.

Swales:

Mainly found as a linear vegetated drainage that can have either a impermeable base for water transport or permeable base for infiltration.

Geocellular system:

Varying in size, this system consists of prefabricated structures that are buried below ground to store and infiltrate storm-water.

Detention pond (dry):

Dry detention ponds are basically basins that hold storm-water and allows particle to settle. Along with slow infiltration, it can also work with other systems to drain the water.

Open storm-water channels/ drains:

This is an alternative system to underground systems to convey water from one area to the other; for example transporting rooftop and street runoffs to underground sewage systems.

Passive Evapotranspiration:

The act of utilizing transpiration and evaporation to improve indoor and outdoor climate such as adding more green space to create a comfortable climate.

Active Evapotranspiration:

Using water systems to improve or influence the temperature or air quality for indoor or outdoor conditions such as water walls, fountains and pools.

Chapter 5 I Precedents

The case studies presented in this chapter offer examples of water-guided design decisions. These projects were chosen for their sustainable approach regarding the use and treatment of water. Each project includes an analysis which focuses on the source of water, the usage, where the water goes after being drained or pumped from the site, the degree of treatment, whether naturally or chemically, and the energy required to operate the system work.

Case Study Projects:
Garrison Creek Demonstration Project, Toronto, Canada
Sherbourne Commons, Toronto, Canada
Evergreen Brick Works, Toronto, Canada
Houtan Park, Shanghai, China
Portland Sidewalk Storm-water System, Portland, USA
Tanner Spring Park, Portland, USA
Naturabad Riehen, Natural Swimming Pool, Riehen, Switzerland

Figure 5-1 (next page left) Plan of the Garrison Creek watershed with a potential pond system in a diagrammatic format.

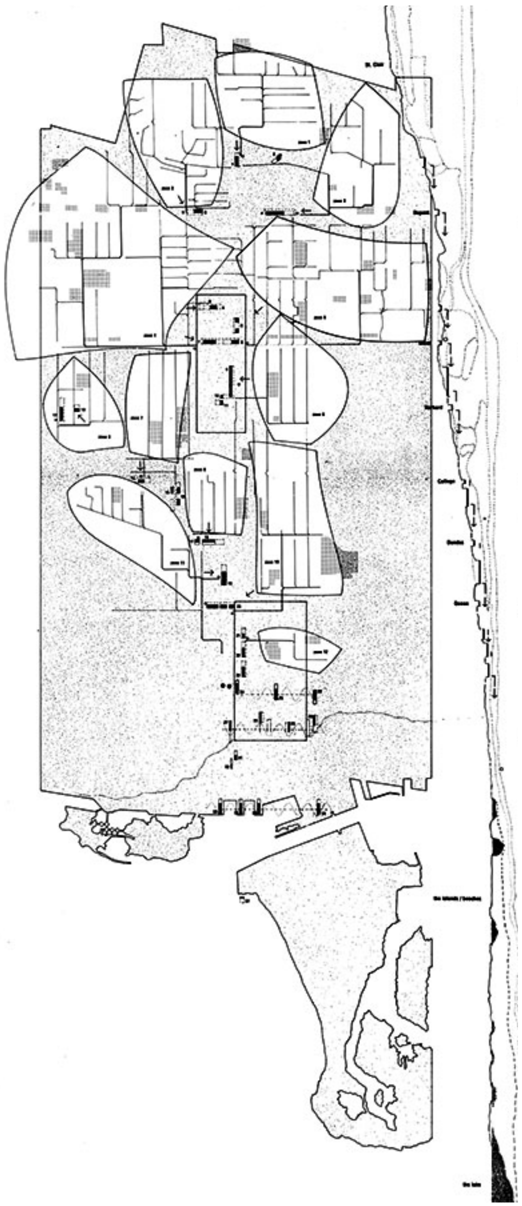
Figure 5-2 (next page right) Plan of Trinity Bellwoods Park showing the pond system, as proposed by Brown and Storey Architects.

Garrison Creek Demonstration Project
Toronto, Ontario, Canada
Brown and Storey Architects

In 1996, Toronto's Water Regeneration Trust commissioned Brown and Storey Architects to investigate possibilities of integrating storm-water management into Toronto's open spaces along the path of the Garrison Creek. They proposed an integrated storm-water infrastructure as a part of an urban landscape of public spaces by taking advantage of the natural topography of the buried creek. The design included a series of pond systems that aimed to restore Garrison Creek's historical function, draining the neighbourhood's storm-water through an ecologically-based system. The pond system designed to connect the parks was proposed not only to act as an infrastructure for the treatment of water, but also a way of encouraging a holistic renewal of the ravine system, its public spaces, and the community surrounding the former creek.

This project has served as an inspiration for the proposed design, utilizing the intensive study of the area that Brown and Storey Architects have conducted as a starting point. Although this project does not include pond systems, it does focus on taking advantage of the natural topography and storm-water remediation to create a holistic public space, as the key element guiding the design.[1]

1 "Garrison Creek Demonstration Project – Project Report." Brown Storey Architects. March 31, 1996. Accessed February 22, 2014. http://www.brownandstorey.com/project/garrison-creek-study/.




DUNDAS STREET
QUEEN STREET

Figure 5-3 (next page top left) Perspective of Sherbourne Commons.

Figure 5-4 (next page middle left) Perspective of Sherbourne Commons.

Figure 5-5 (next page bottom left) Perspective of Sherbourne Commons.

Figure 5-6 (next page right) Diagram showing the area of collected water in red, the treatment facility in blue and the reuse of water in the urban river, art fountain and splash pad in light blue.

Sherbourne Commons
Toronto, Ontario, Canada
Phillips Farevaag Smallenberg, The Planning Partnership (local consultant); Teeple Architects (Pavilion); Jill Anholt (Light Showers and Public Art); The Municipal Infrastructure Group (Municipal Servicing/Civil/Mechanical Engineer)

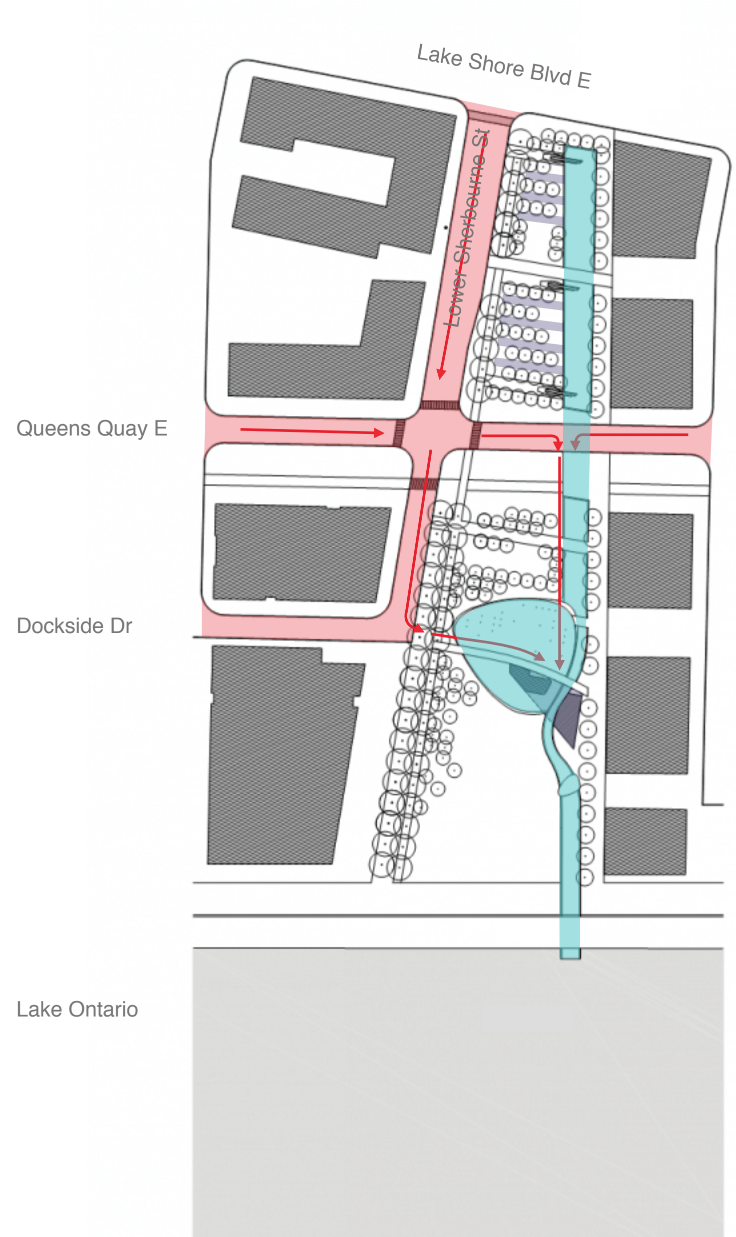
As part of the Waterfront Revitalization Process initiated by the City of Toronto, Sherbourne Commons is located at the intersection of Lower Sherbourne Street and Queen's Quay. In order to bring new life to the lake area, Sherbourne Commons includes a series of year-round water features, art sculptures and activities to draw residents and visitors to its location, serving to activate a previously under-utilized area of the city.

Sherbourne Commons is the first public park in Canada to integrate a storm-water filtration facility into their design.[1] Neighbourhood-wide storm-water runoff is collected and treated in the ultraviolet (UV) facility located in the basement of the central pavilion. After passing through the UV system, the filtered water is pumped into the art sculptures, water planters, and landscape water fountains, prior to being released into a 240 metre long water channel that runs through the site, ultimately releasing the treated water into the lake.[2]

Though this project works with a UV filtration facility rather than a natural filtration system, it still successfully integrates the process of collecting water, treating it on site, and reusing it for different activities, making it an ideal example for decentralized water treatment projects at the neighbourhood scale. This demonstrates that not all water used in recreational and landscape features of a park design have to be highly chlorinated water and can form part of a larger system.

1 "Sherbourne Common." Waterfront Toronto. Accessed May 18, 2014. http://www.waterfrontoronto.ca/sherbourne_common.

2 Valkenburgh, Michael, and Kelty McKinnon. Grounded: The Work of Phillips Farevaag Smallenberg. Vancouver: Blueimprint, 2010. 8.


Lake Shore Blvd E
Lower Sherbourne St
Queens Quay E
Dockside Dr
Lake Ontario

Evergreen Brick Works
Toronto, Ontario, Canada
Diamond and Schmitt Architects

Evergreen Brick Works is an environmental center that has transformed a cluster of deteriorating heritage buildings into a global showcase for green design[1] and urban sustainability. Located in the floodplain of the Lower Don River, this site is designed to absorb rain water while also controlling and diverting storm-water, helping to control excess water when flooding occurs from rainwater runoff or overflow from the river.

The design is a green approach to city infrastructure, where aging and unsustainable infrastructure has been replaced with new systems to aid with the issues that arise from extreme weather conditions. One of the methods used in the site is the placement of green-ways between the buildings, collecting water from the surrounding hard surfaces before filtering and channeling the water towards the storm-water management pond, which then filters sediment out of the water before it is released back into the River. Roof runoff is also collected in cisterns to be stored and used for gardening and the grey-water toilet systems.

The concept of green-ways directing water especially influences the proposed design in the area of channelization of roof runoff from buildings to the proposed decentralized system.

1 "About." Evergreen Brickworks. Accessed May 12, 2014. http://www.evergreen.ca/get-involved/evergreen-brick-works/about/

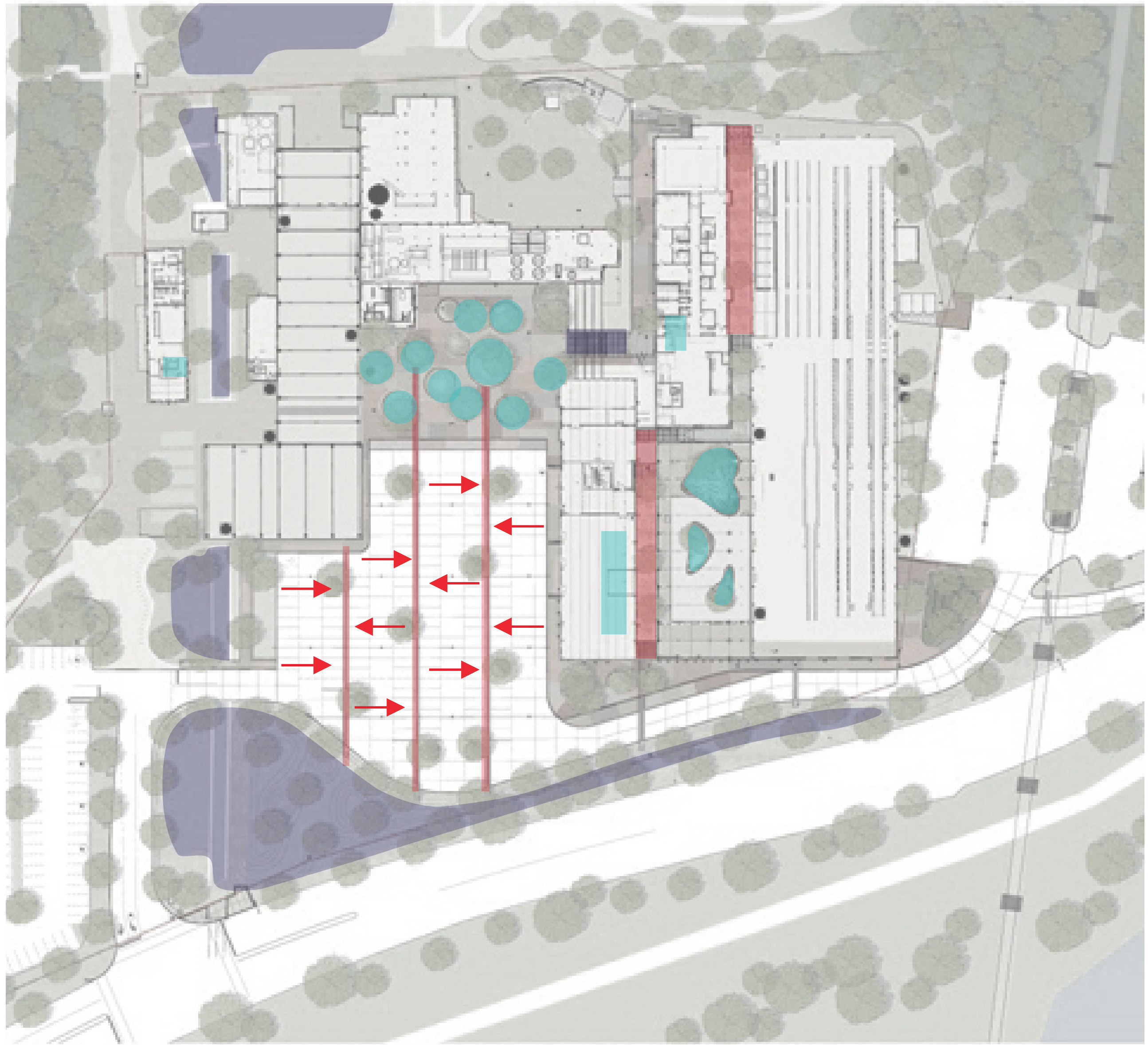


Figure 5-7 (previous page top) Aerial view of Evergreen Brickworks Park.

Figure 5-8 (previous page middle) Storm-water filtration beds.

Figure 5-9 (previous page bottom) Mounds at the entrance that reuse the storm-water for irrigation.

Figure 5-10 (right) Diagrammatic plan of Brickworks park showing the green-ways collecting water in red, the treatment of storm-water with filtration beds and storm-water ponds in blue and the reuse of storm-water in irrigation, nursery and toilets in light blue.

Houtan Park
Shanghai, China
Kongjian Yu Turenscape

Houtan Park sits on the bank of Shanghai's contaminated Huangpu River, a former industrial site. The design focuses on the creation of a regenerative living landscape along a 1.7 km long by 5-30 m wide swath of the River, utilizing constructed wetland and water ponds to treat the contaminated water.

This strategy for transforming the site in such a way demonstrates how ecological infrastructure can provide multiple services; including the integration of public spaces with "food production, flood management, water treatment and habitat creation"[1].

The scale of this project and the constant supply of water from the Huangpu River is very different from proposed design. However, the idea of a regenerative living landscape using a series of constructed wetlands and water ponds to naturally filter contaminated water as it flows into the different stages of filtration is a key element for the proposed design of a decentralized system.

1 William Saunders. Designed Ecologies: The Landscape Architecture of Kongjian Yu. Basel: Birkhäuser Verlag, 2012, 165.

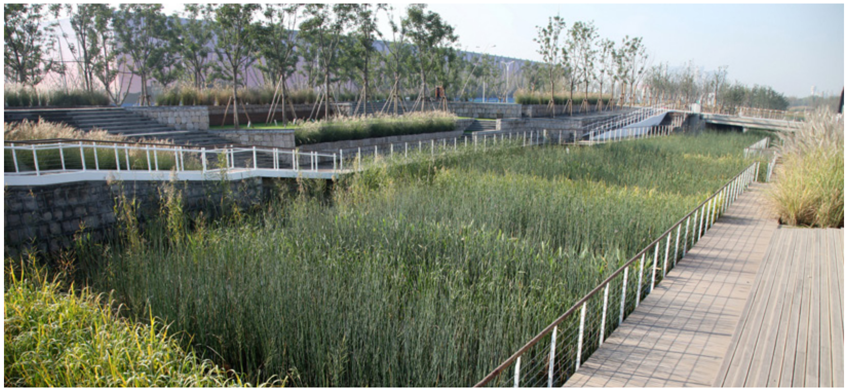
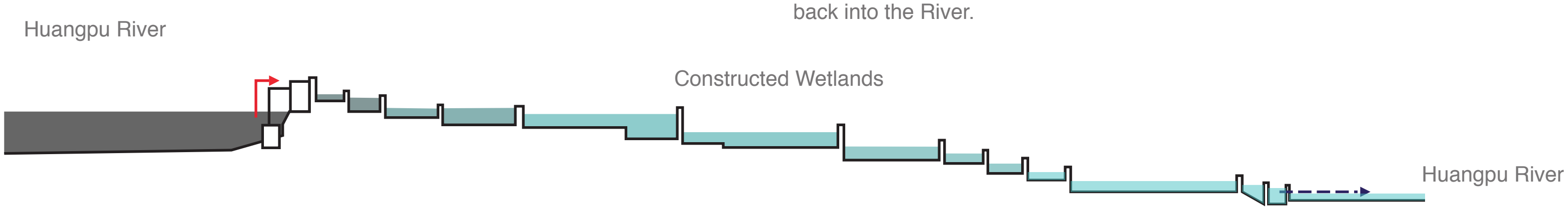


Figure 5-11 (top) Pathway along the filtration water beds.

Figure 5-12 (middle) Biofiltration reed beds.

Figure 5-13 (bottom) sectional diagram showing the water from the Huangpu River being pumped and passing through the series of constructed wetlands. The contaminated water is filtered as it flows through the wetlands, and is finally released back into the River.



Portland Sidewalk Storm-water System
Portland, USA
Portland Bureau of Environmental Services

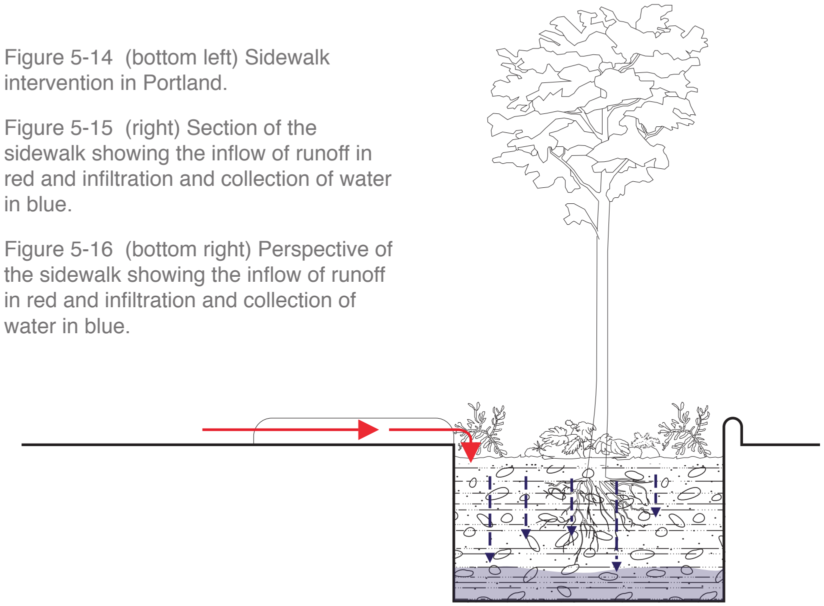
This sidewalk intervention project in Portland, Oregon, provides a precedent for surface water runoff treatment at a local level. Instead of water flowing directly into catch basins, the runoff water flows from the street into small wetlands located on a generous sidewalk. These wetlands serve the purpose of treating the water, and by landscaping the sidewalk, two different pedestrian zones are created, one for through traffic, and the other for those who have parked their cars by the street curb.

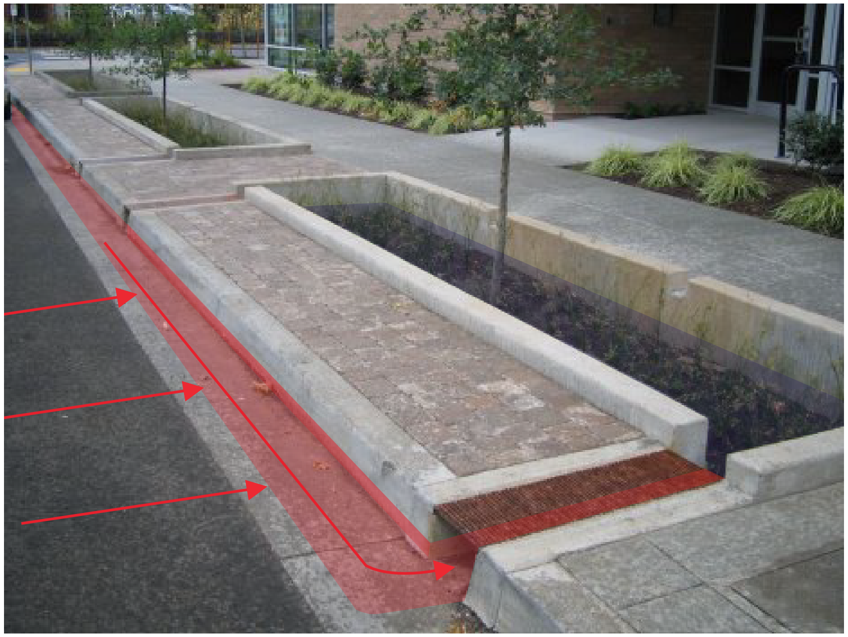
In the site utilized in the design proposal of this thesis, the site topography creates low lying areas along certain streets. In those conditions the concept of a sidewalk wetland is a relevant strategy to collect runoff directly from the street.

Figure 5-14 (bottom left) Sidewalk intervention in Portland.

Figure 5-15 (right) Section of the sidewalk showing the inflow of runoff in red and infiltration and collection of water in blue.

Figure 5-16 (bottom right) Perspective of the sidewalk showing the inflow of runoff in red and infiltration and collection of water in blue.



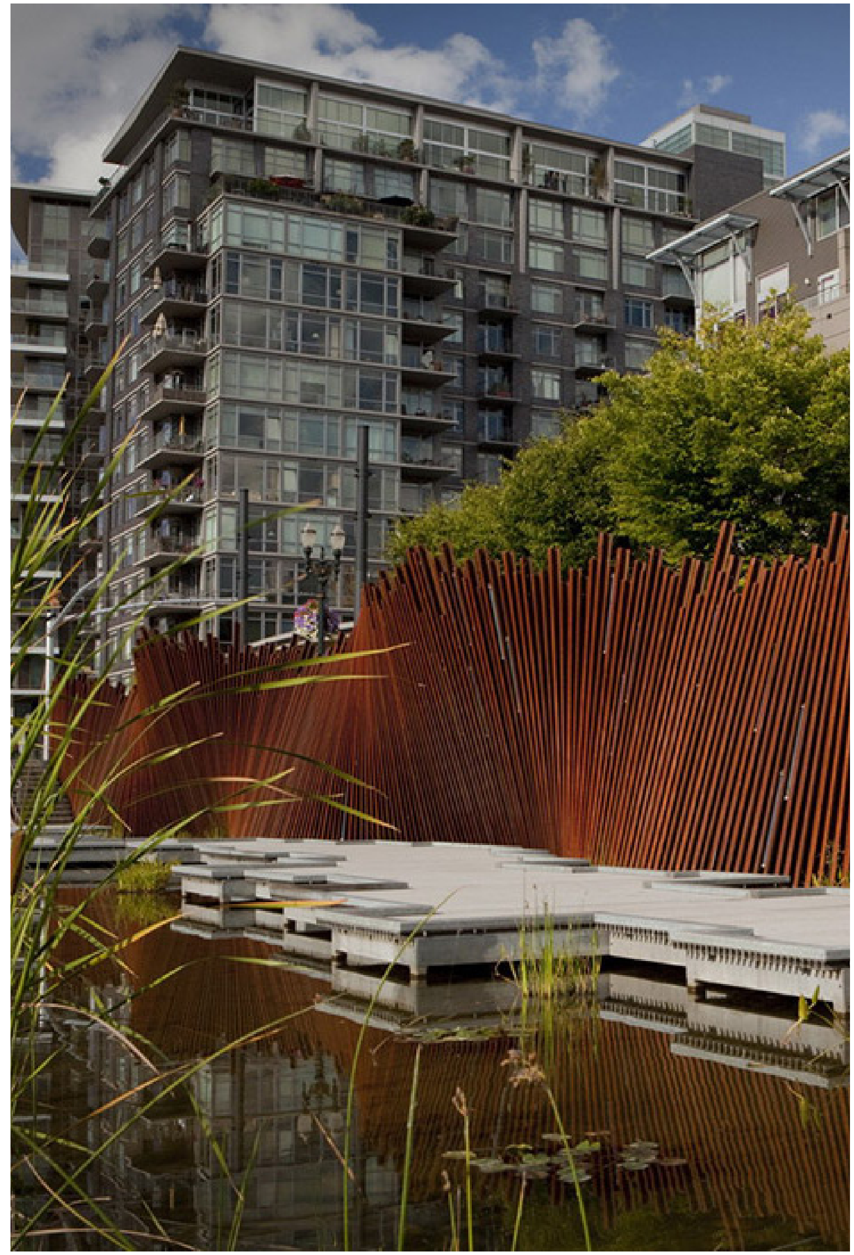


Tanner Spring Park
Portland, Oregon, USA
Atelier Dreiseitl America Inc.

The development of Portland from an aging industrial metropolis to an ethnically diverse and sustainable city has marked it as one of the pioneers in sustainable city planning in recent years. The masterplan for this revival consisted of green corridors throughout the city, made up of three different types of parks. Along with such development, the city has also worked in reviving its natural history through the design of their parks. The Tanner Spring Park is one of the parks situated along the green corridor that resurrects the history of the area, which was originally a wetland of the Tanner Creek, a creek currently channeled and buried beneath the street surface, similar to Garrison Creek.

Located in the heart of the Pearl District, Tanner Springs Park is distinctively characterized by small artificial springs flowing towards an irregular shaped pond. The pond is the key element of the storm-water management system that channels water from adjacent city sidewalks and the leaf pavilion. The water from the pond is filtered via the planted biotopes, before being pumped up to the man-made springs, and allowed to flow into the pond at this higher elevation, creating a continuous cycle. While flowing down the slope of the site's elevation, the water also serves as an element of play for children visiting the park.[1]

This park serves as a comprehensive example of a decentralized storm-water system, incorporating a variety of systems such as biotopes and storm-water management pond integrated in a medium dense urban area where water is collected, treated, stored and reused sustainably.



1 Jacqueline Hoyer. Water Sensitive Urban Design: Principles and Inspiration for Sustainable Stormwater Management in the City of the Future. Berlin: Jovis, 2011.

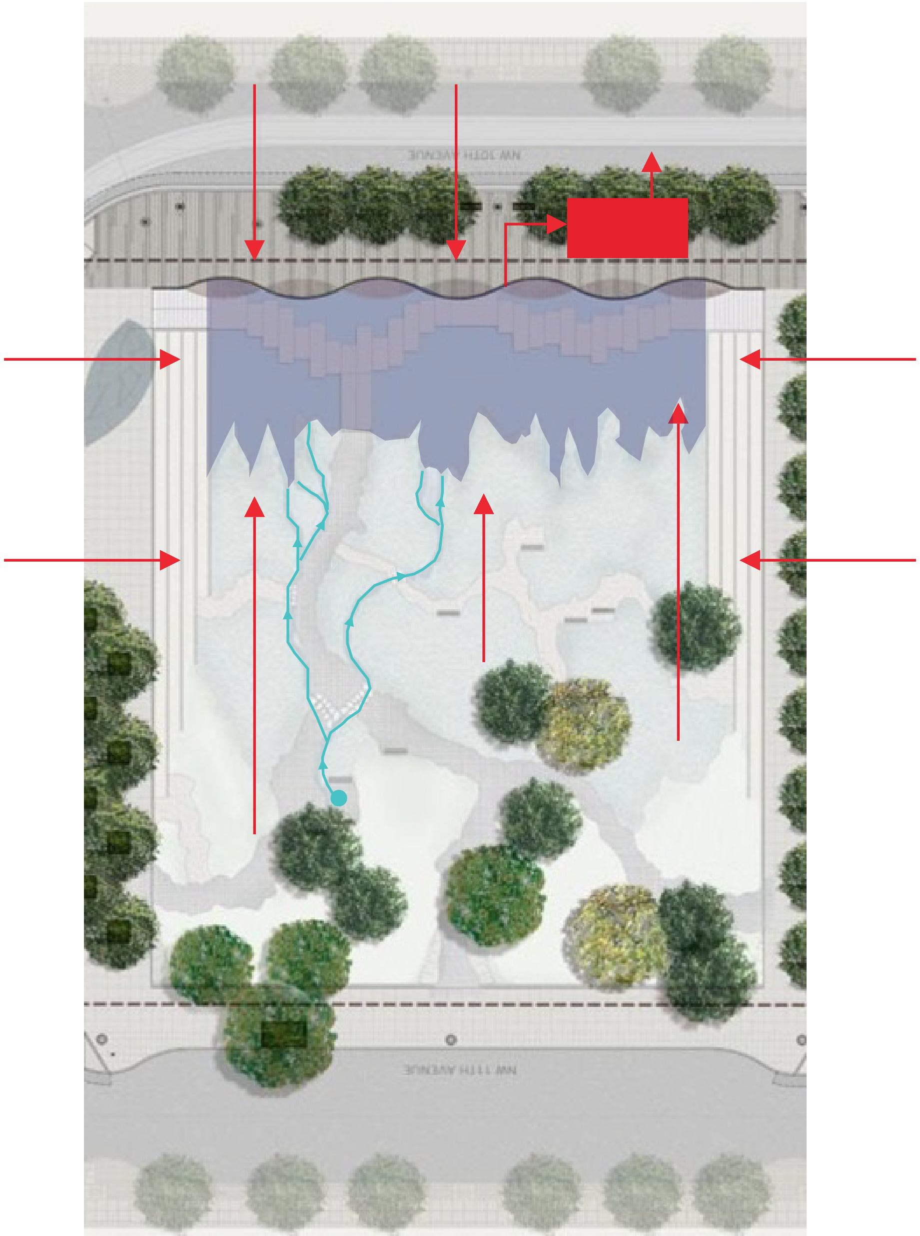


Figure 5-17 (previous page) Irregular shaped pond that filters storm-water runoff via the planted biotopes.

Figure 5-18 (left) Diagrammatic plan showing the collection of storm-water runoff in red, the treatment of storm-water via biotopes in blue, and the reuse of the filtered storm-water as man made springs in light blue.

Naturabad Riehen, Natural Swimming Pool
Riehen, Switzerland
Herzog & de Meuron

The local population of Riehen was seeking a design for a new public swimming pool to replace the existing baths by the riverbank of the River Wiese. For this design, Herzog & de Meuron altered traditional perspectives of a bathing facility by abandoning the conventional pool concept with its mechanical and chemical water treatment systems in favour of a pool closer to a natural condition with biological filtration.[1] The standard geometric swimming pool was transformed into a bathing lake where the technical systems and machine rooms are substituted by planted filtering cascades.

The cleaning process of the Naturabad Riehen requires water from the pool to be pumped to the biological water treatment basins, located in the sloping landscape on the opposite side of the road. After the cleansing process, the clean water is pumped back into the pool. In terms of ecological cleaning capacity, the baths are designed to accommodate a maximum of two thousand bathers per day.[2]

The temperature of Riehen is very close to the temperature of Toronto, therefore proving that natural filtration systems can work in extreme climates, even if it remains dormant in winter seasons. Also, the continuous cycle of collecting water, treating it through the biological treatment basins, using it for the pool and pumping the dirty water back to the treatment basin to start another cycle, is a similar idea that has been addressed in the proposed design.

1 "Naturbad Riehen, Natural Swimming Pool." Herzog & De Meuron. Accessed November 15, 2014. http://www.herzogdemeuron.com/index/projects/complete-works/301-325/319-naturbad-riehen.html.

2 "Regeneration area. in Naturbad Riehen." Accessed November 7 2014. http://www.naturbadriehen.ch/?a=1&t=0&y=3001&r=0&n=119&i=&c=25&v=page3&o=&s=.

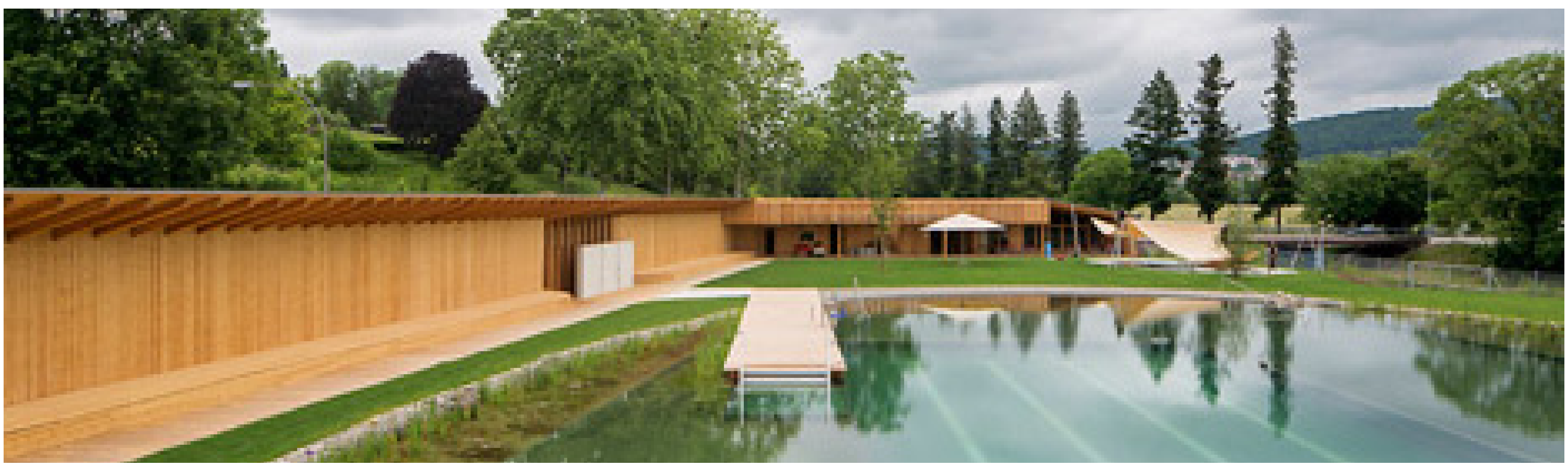
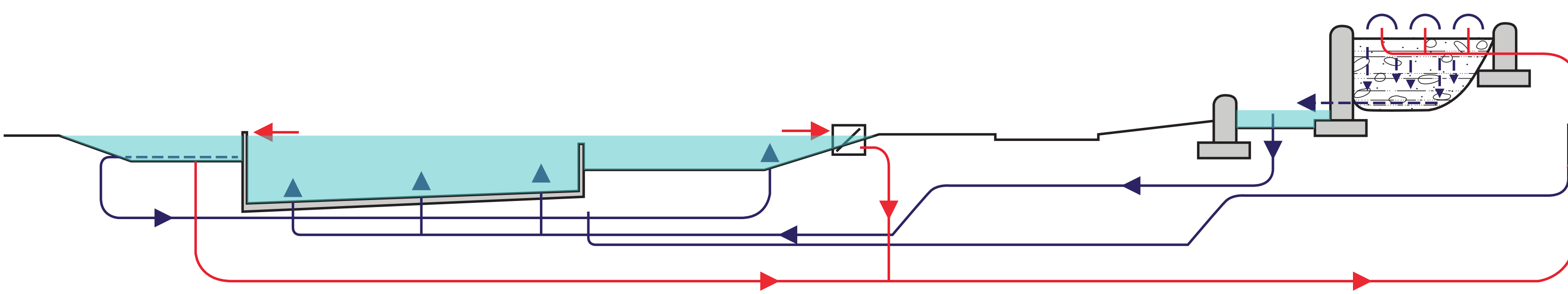


Figure 5-19 (previous page) View of the natural swimming pool.

Figure 5-20 (left) Diagrammatic plan showing the cycle of water where red arrows indicate the flow of the contaminated water from the pool and street runoff, and the blue arrows show the flow of the treated water that flows from the natural filtration system located on the slopes of the hill.

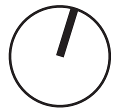
Figure 5-21 (bottom) Diagrammatic section showing the cycle of water where red arrows indicate the contaminated water from the pool and the street runoff, and the blue arrows indicate the treated water.

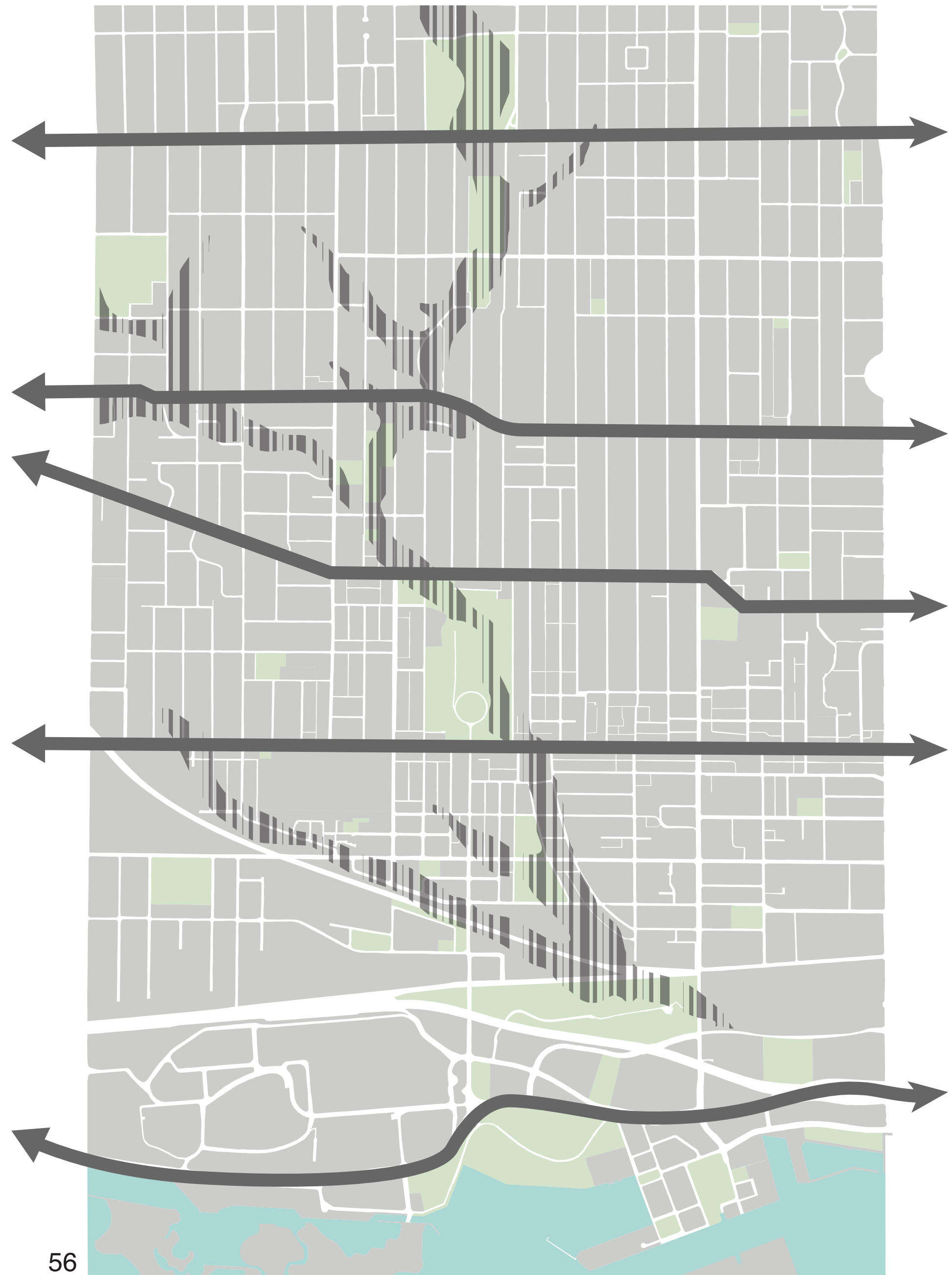


Chapter 6 I Site Study

The analysis presented in this chapter consists of topographic, density, program studies, system and infrastructure analysis, as well as depiction of native plant types of Toronto. Lastly, this chapter ends with a summary diagram of the established mandates, visions and principles between Brown and Storey's Garrison Creek Demonstration Project and the neighbourhood park groups (Friend of Roxton Road Parks and Friends of Trinity Bellwoods).

Figure 6-1 Historic pathway of the Garrison Creek overlaid with the current city grid.





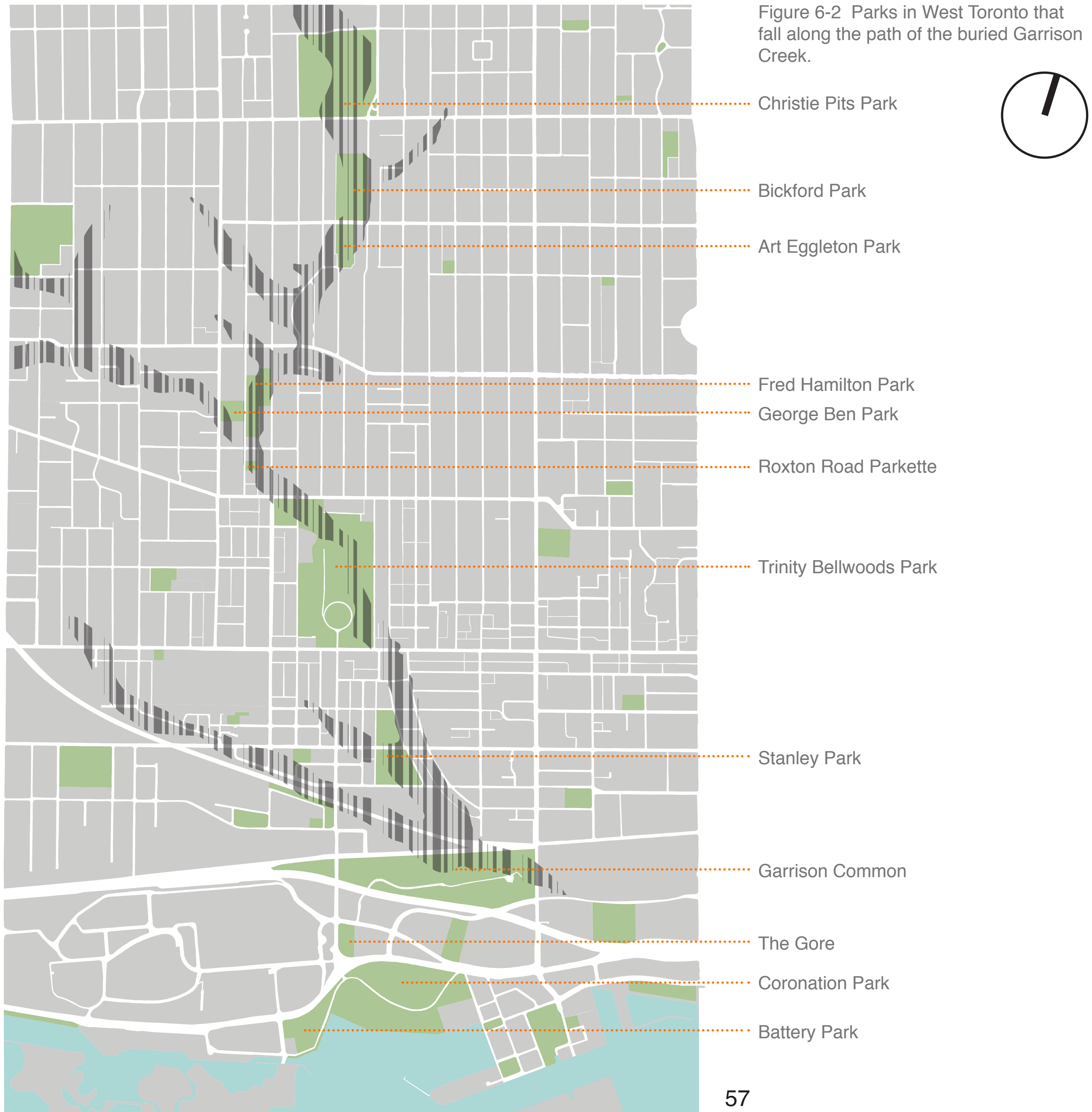
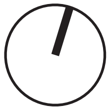
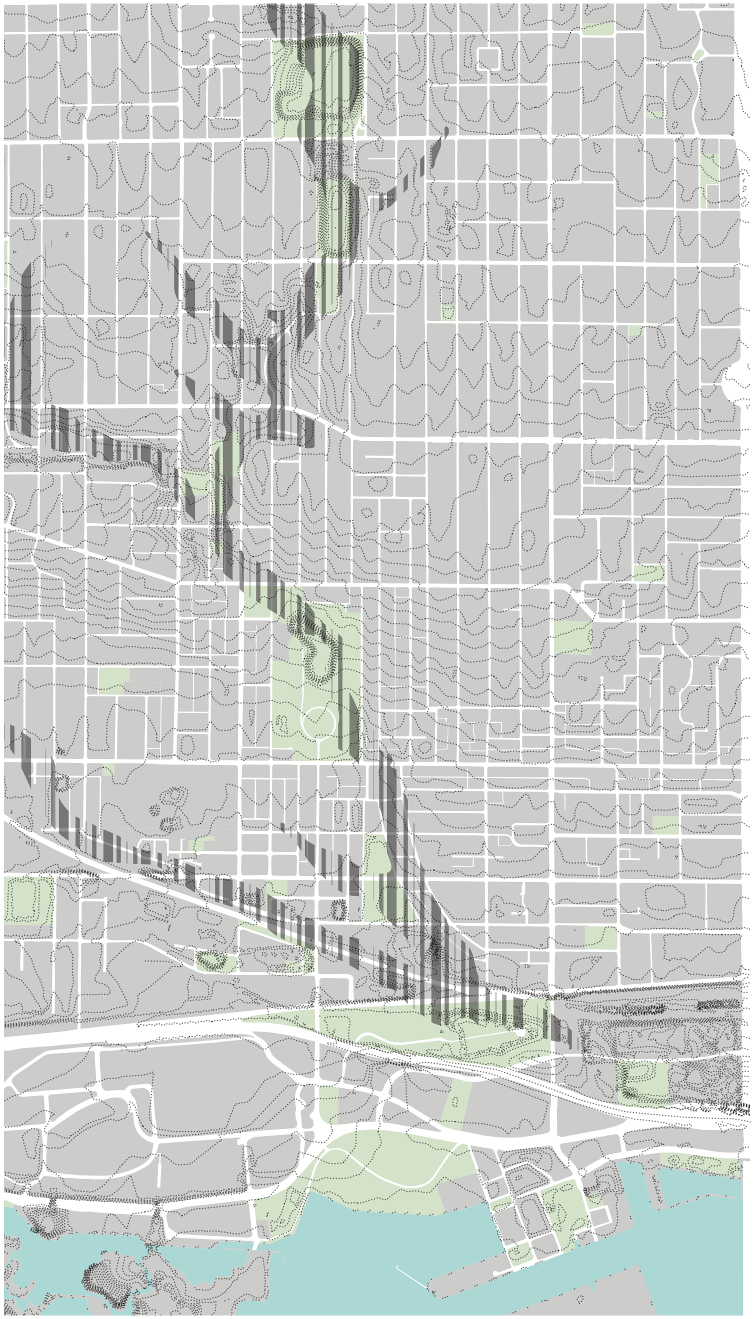


Figure 6-2 Parks in West Toronto that fall along the path of the buried Garrison Creek.

Figure 6-3 (left) Contour lines that show the current slopes at an interval of one meter.





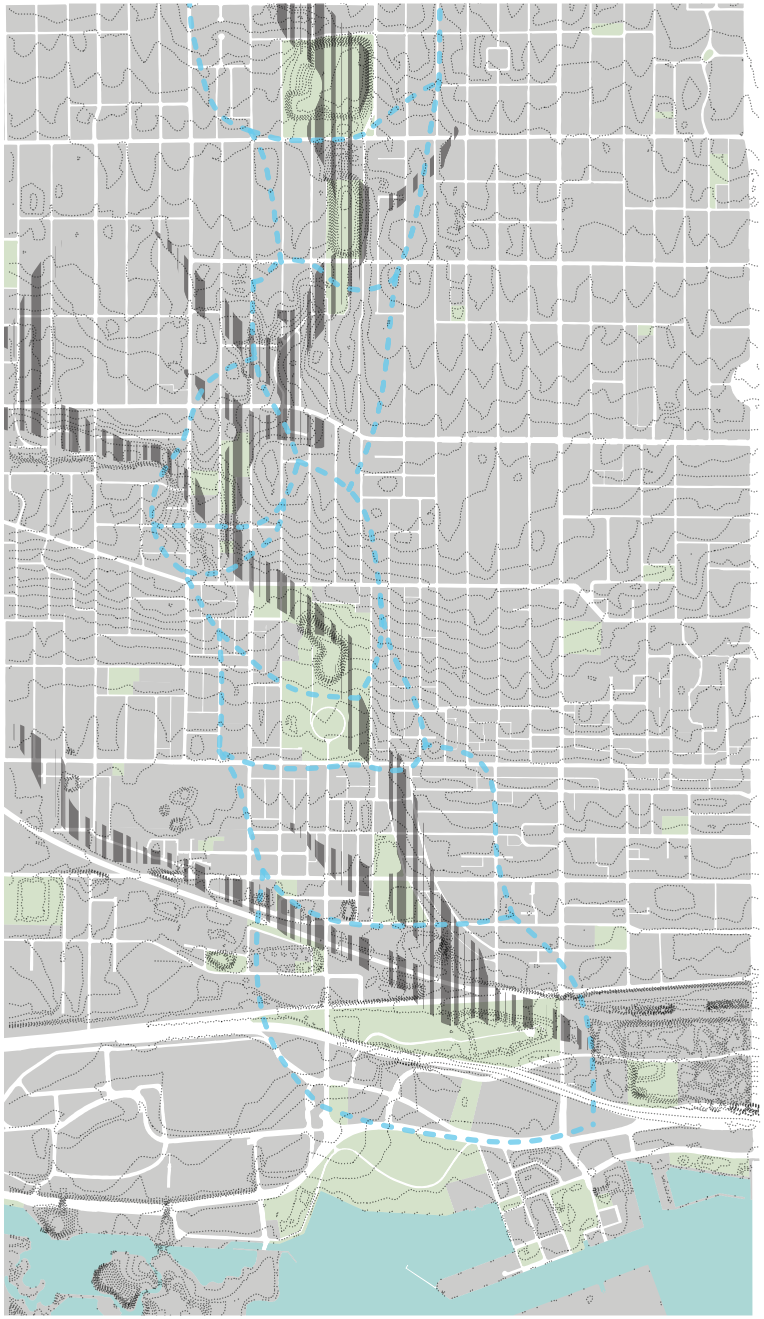


Figure 6-4 (left) Approximate outline of drainage basin at the Garrison Creek watershed. By following the contours, the blue line outlines the boundary of the areas where water runoff can be collected.

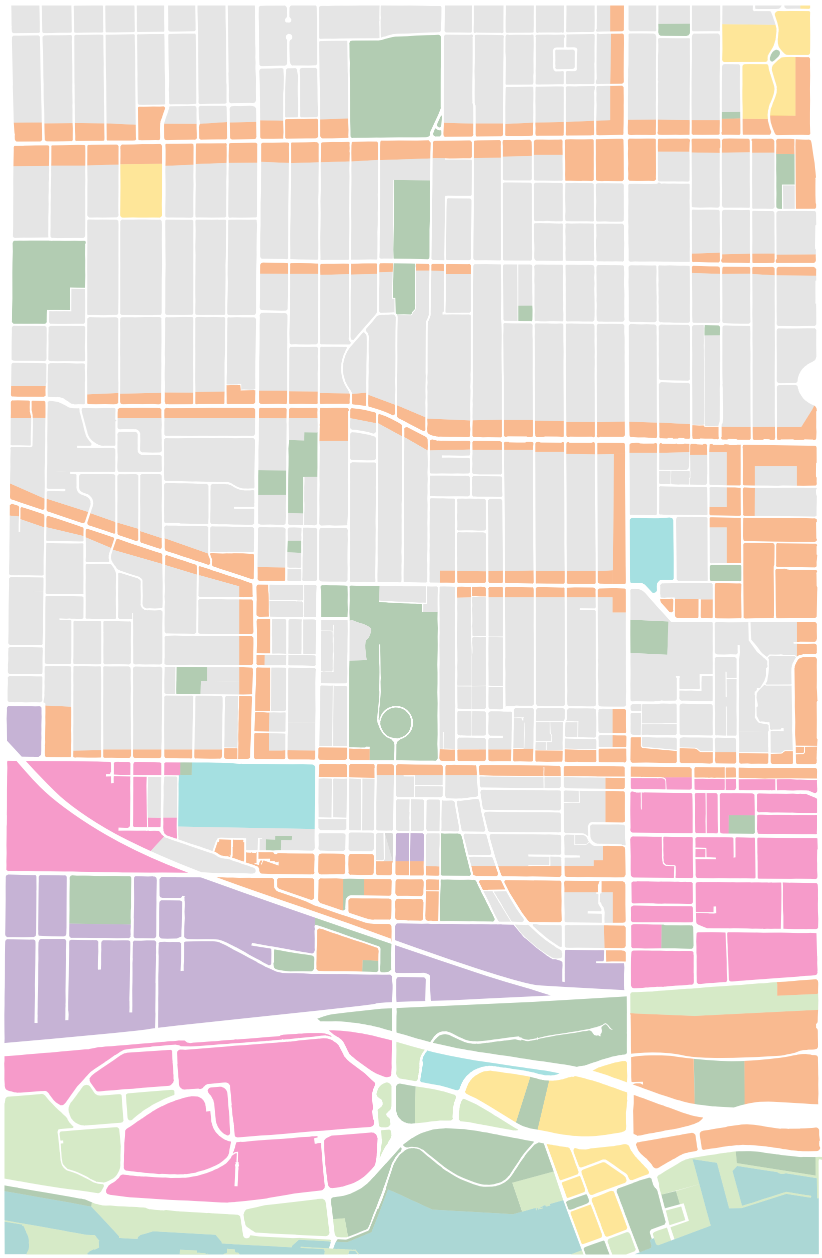
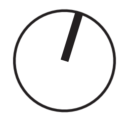


Figure 6-6 (left) Land use map of the areas of focus.



Legend

- Low Density Residential
- High Density Residential
- Mixed Use Area
- Other Open Space Areas (including Golf, Cemetery or Public Utilities)
- Parks and Open Space Areas
- Institutional Areas
- Regeneration Areas
- Employment Areas

Figure 6-5 (next page) Mapping of water fountains, washrooms, benches, and trash cans in the parks that fall along the path of the Garrison Creek. Parks in focus: Christie Pits Park, Bickford Park and Art Eggleton Park.

Legend

- Water Fountain
- Garbage Bin
- Washroom
- Bench

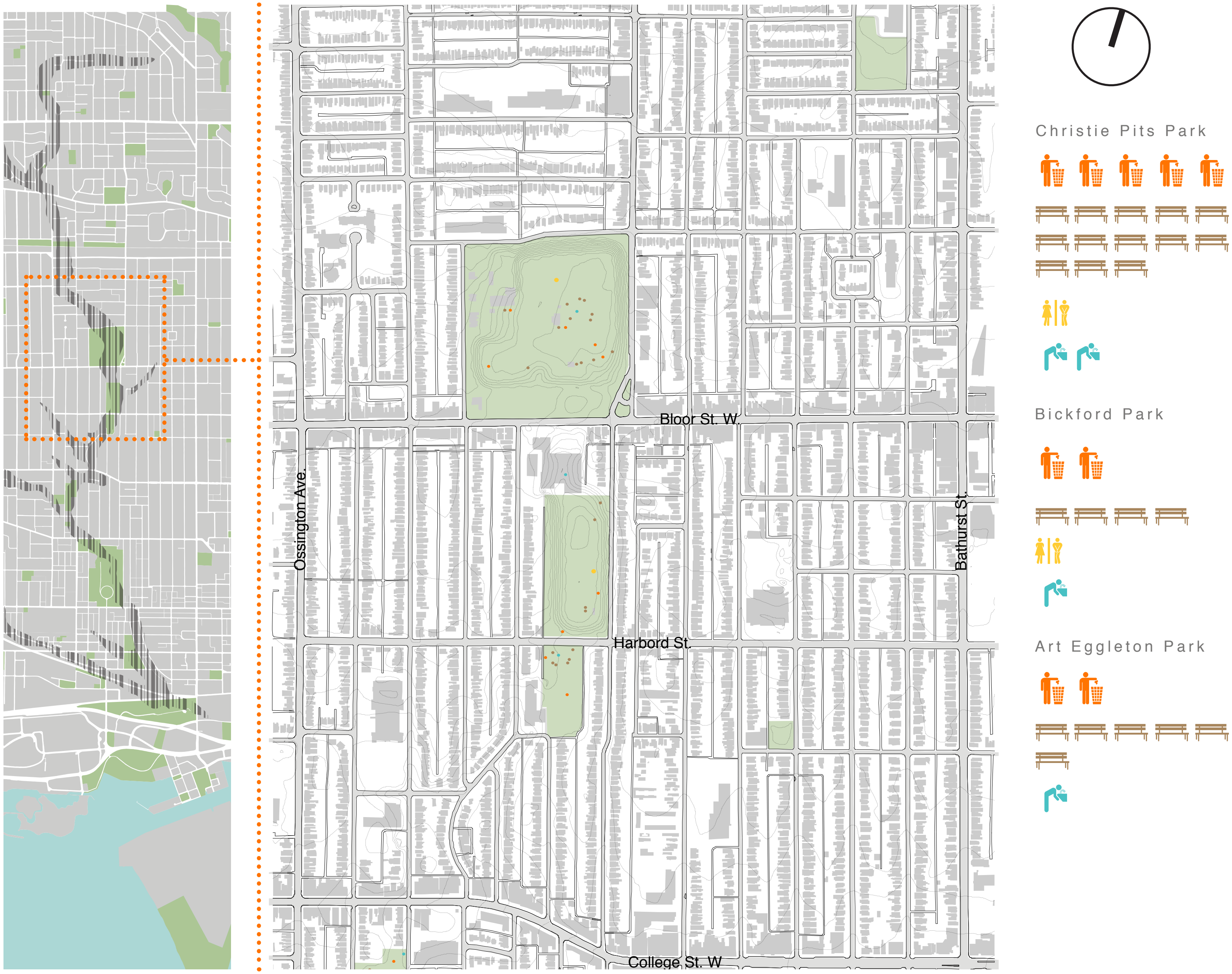

Bloor St. W.
Ossington Ave.
Harbord St.
Bathurst St.
College St. W
Christie Pits Park
Bickford Park
Art Eggleton Park

Figure 6-7 (right) Mapping of water fountains, washrooms, benches, and trash cans in the parks that fall along the path of the Garrison Creek. Parks in focus: Fred Hamilton Park, Roxton Road Parkette, Trinity Bellwoods Park.

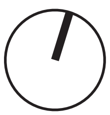
Legend

Water Fountain

Garbage Bin

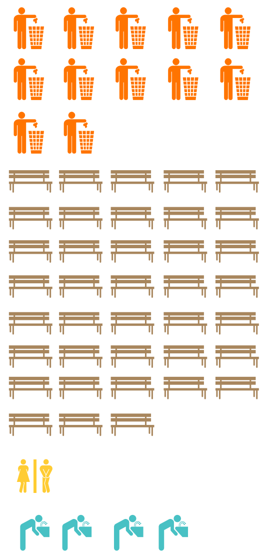
Washroom

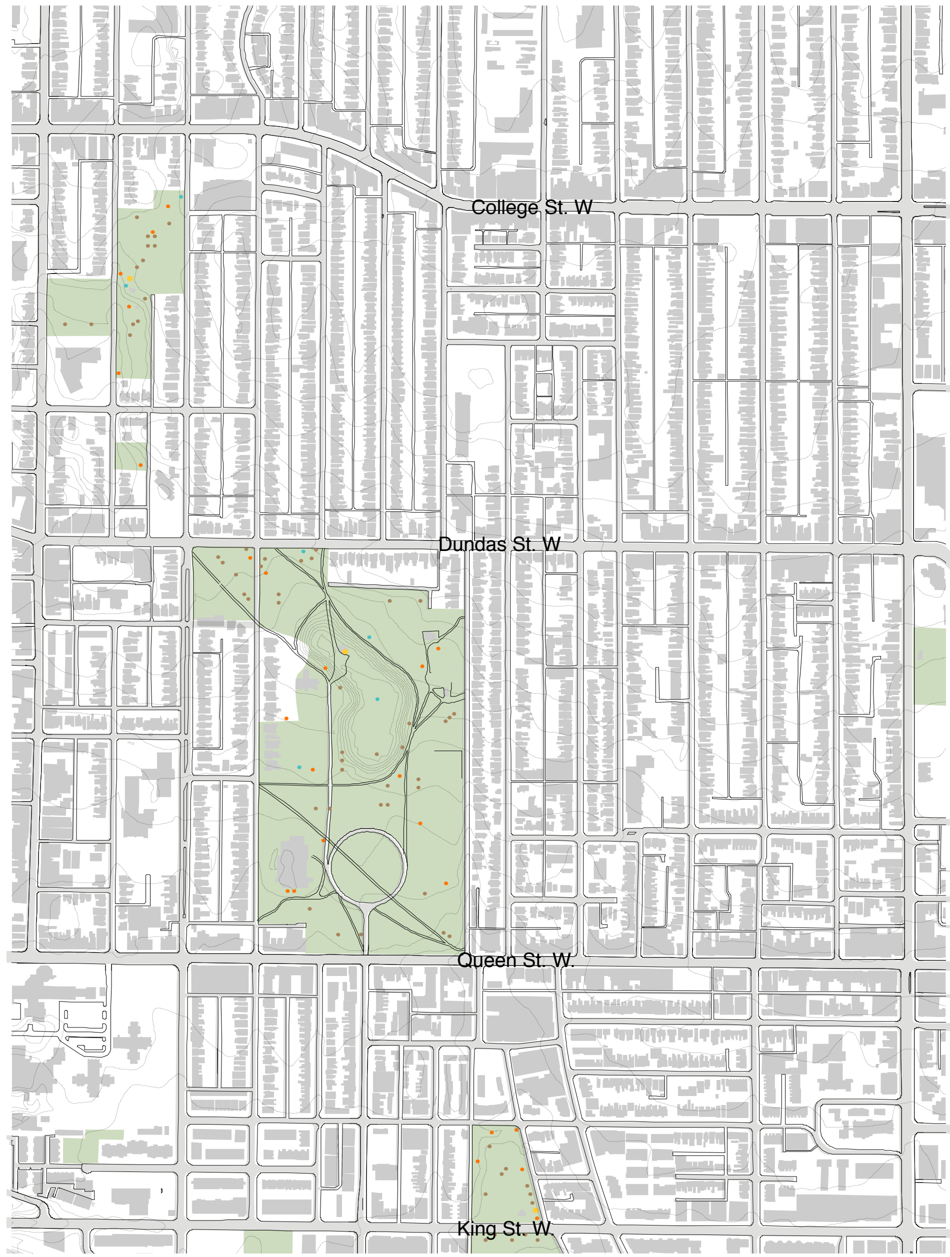
Bench



Roxton Road Parkette

Trinity Bellwoods Park





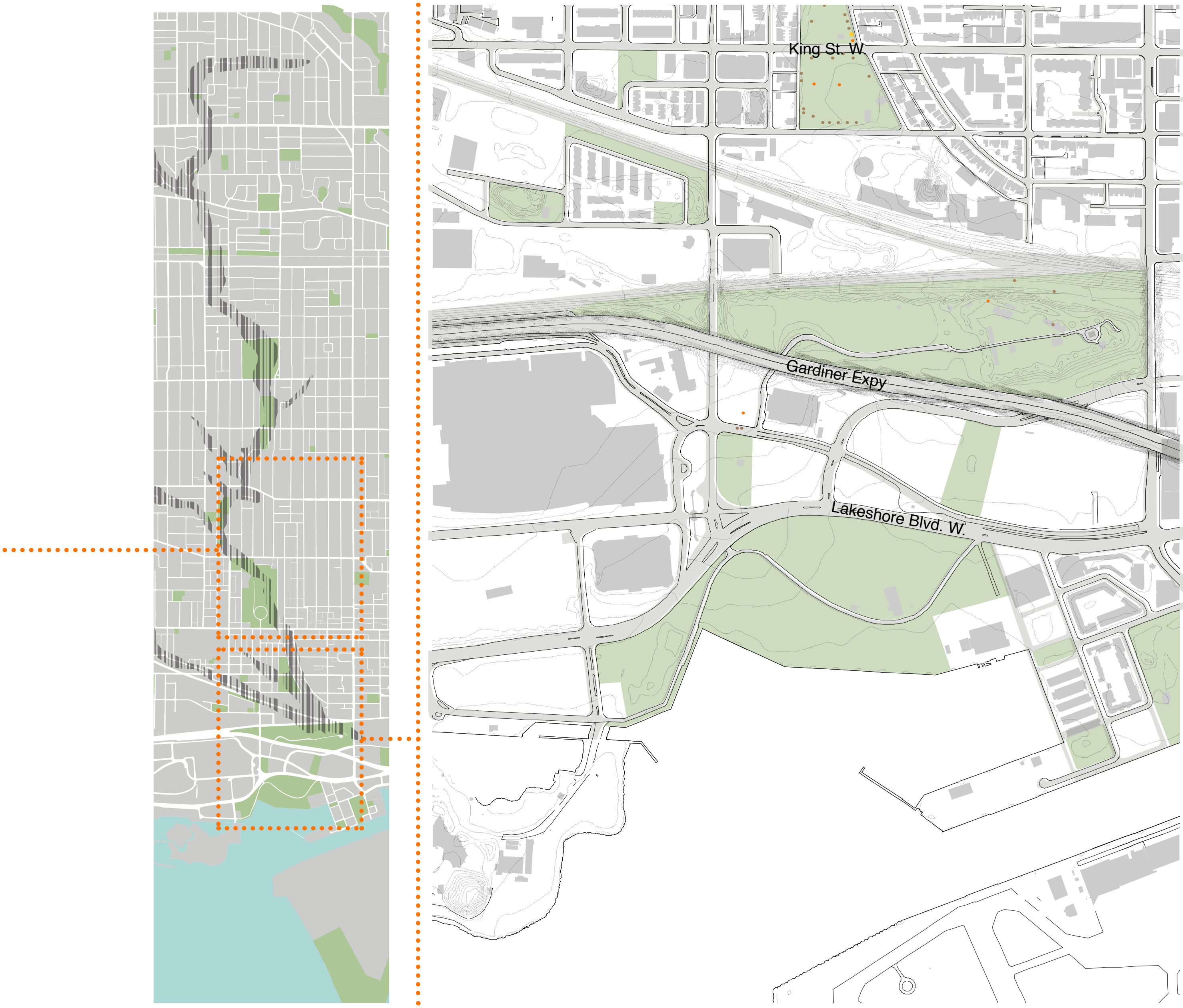
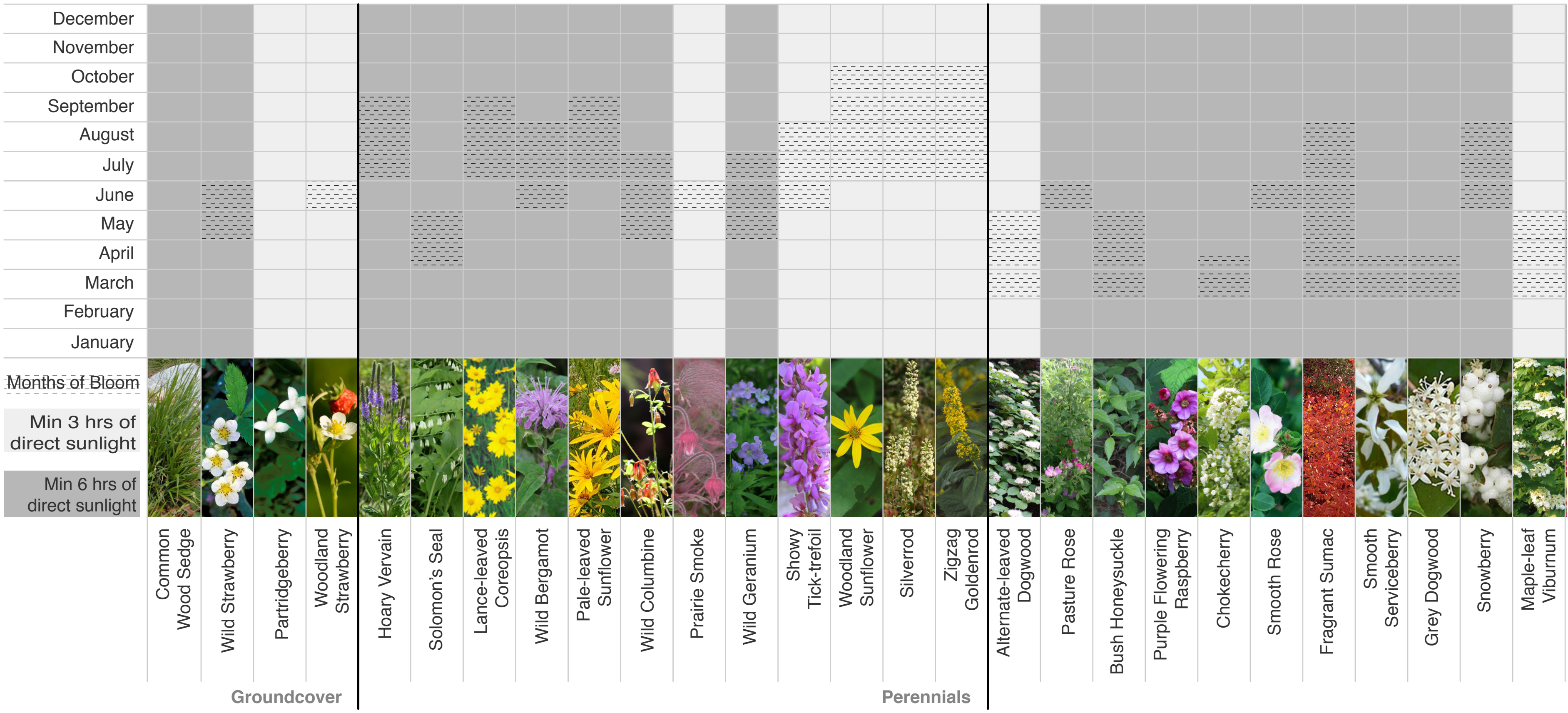


Figure 6-8 (left) Mapping of water fountains, washrooms, benches, and trash cans in the parks that fall along the path of the Garrison Creek. Parks in focus: Stanley Park and Garrison Common.

Stanley Park

Garrison Common


December
November
October
September
August
July
June
May
April
March
February
January
Months of Bloom
Min 3 hrs of direct sunlight
Min 6 hrs of direct sunlight
Common Wood Sedge
Wild Strawberry
Partridgeberry
Woodland Strawberry
Hoary Vervain
Solomon's Seal
Lance-leaved Coreopsis
Wild Bergamot
Pale-leaved Sunflower
Wild Columbine
Prairie Smoke
Wild Geranium
Showy Tick-trefoil
Woodland Sunflower
Silverrod
Zigzag Goldenrod
Alternate-leaved Dogwood
Pasture Rose
Bush Honeysuckle
Purple Flowering Raspberry
Chokecherry
Smooth Rose
Fragrant Sumac
Smooth Serviceberry
Grey Dogwood
Snowberry
Maple-leaf Viburnum
Groundcover
Perennials

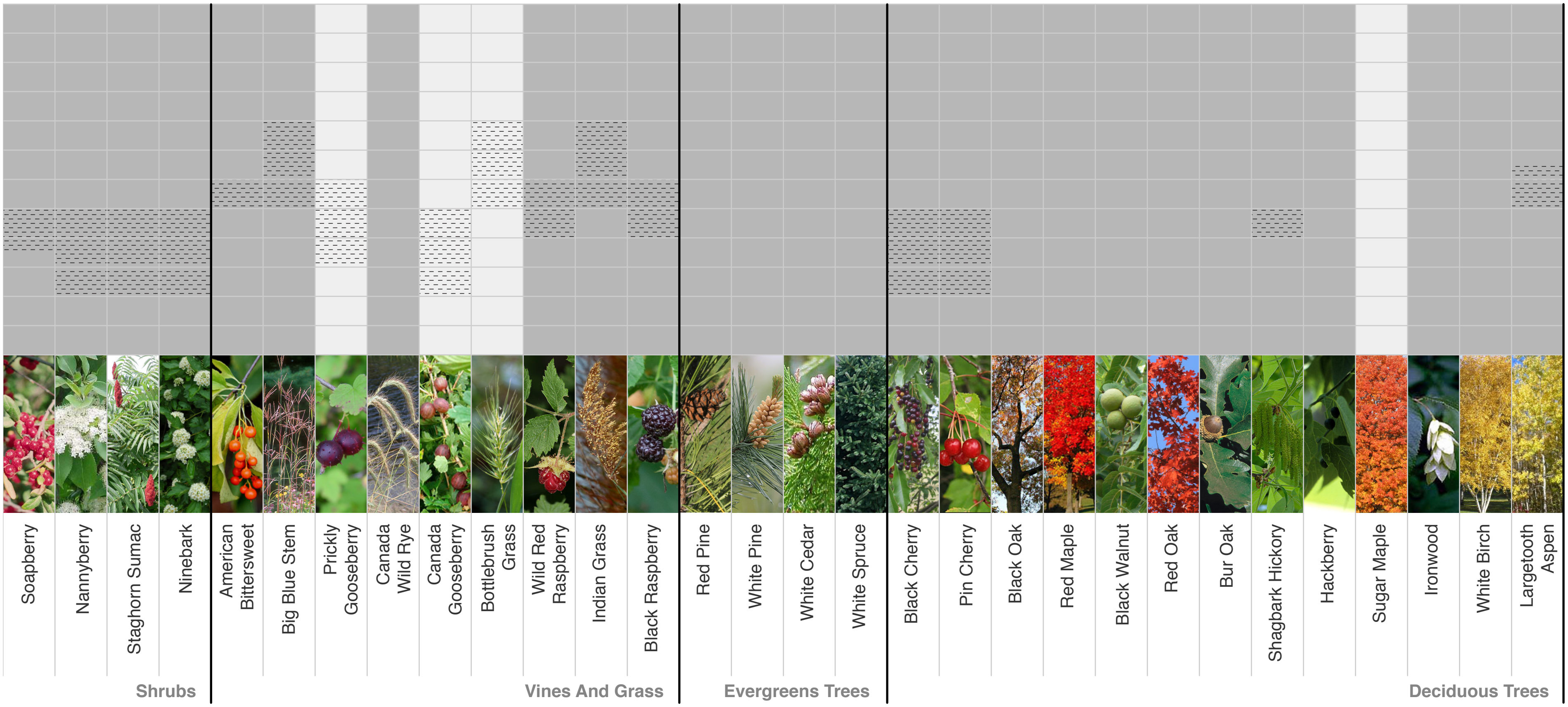


Figure 6-9 Native Plants in Toronto: The usage of Native Plants results in an increase in water efficiency and cost savings; they are already adapted to climate, pesticide use can be reduced or eliminated, and maintenance reduction associated can lead to cost savings.

Figure 6-10 Summary of established Mandates or Visions of neighbourhood park groups (Friends of Trinity Bellwoods Park and Friends of Roxton Road Parkette). It is compared side by side with the guiding principles of the connected pond system proposal of Brown and Story Architects. The summary is divided into four categories: cultural, recreational, environmental and social.


Garrison Creek Demonstration Project
-by Brown and Storey Architects
1996
condition for safe and accessable ramps and stairs, seating areas, drinking fountains and gardens
how spaces are lit
how people, cyclist and cars move down the sytem
permeable paving
linear system urban canopy
restoration of natural watershed in an urban context
raised standing pool, and a series of shallow and deep pools
use of aquifier
stormwater management techniques to improve the existing parks and make it more desirable
built form patterns and the cultural heritage in the watershed area
archeological and "burried" artifacts
public art installations
local economy development
housing intensification - as designated by the City of Toronto
transit stop
Cultural
Recreational
Environmental
Social
Friends of Trinity Bellwoods Park
2014
adopt-a-tree
bub and shrub planting event
ensure healthy public green space and take care of existing nature
clean out air pollution
Greenhouse as an educational resource
Greenhouse as a community resource
refuge from city life
weekly farmer's market
mingle between people of all walks of life and generation
make visible the historically designated airboretum
Friends of Roxton Road Parks
2014
reduce burden on stormwater system
rain water conservation
less reliance on city water supply
increase awareness of urban water cycle
increase awareness of food system ecology
tree canopy
increase biodiversity
increase habitate
making visible the history of the neighbourhood
making visible the history of the waterway
opportunities to learn about urban water cycle through play
physical activity by playing with pumping water
increase access to healthy food
increase food affordability
become park stewards and take responsibility
opportunities to participate in intergenerationl activities
more empowered, united and focused community

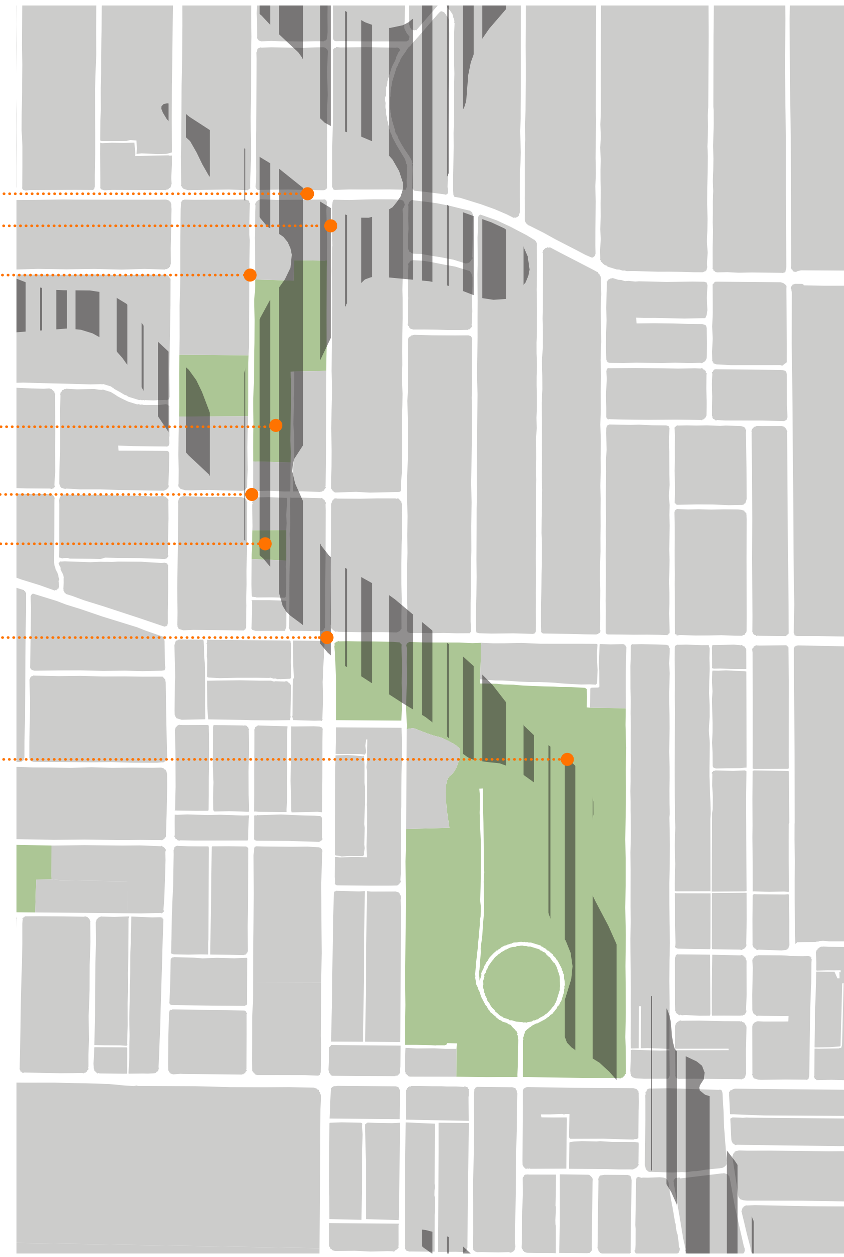


Figure 7-1 Historic Garrison Creek overlaid on the parks in focus: Fred Hamilton Park, Roxten Road Parkette, and Trinity Bellwoods Park.

Chapter 7 I Design

"It involves the creation of new landscape – a mix of the natural and the human that may not have existed before, but which recognizes the interdependence of people and nature in the ecological economic and social realities of the city."[1]

This thesis aims to design a decentralized system that utilizes the element of water to revitalize historical, ecological, and social aspects of Toronto along the path of the buried Garrison Creek. The design proposes an alternative to conventional storm-water practice that works with decentralized systems to treat storm-water runoff as close to the source as possible. By collecting localized storm-water runoff, this proposal aims to collect, treat, store, and reuse runoff where possible, helping to restore and stabilize the hydrological cycle, and ultimately decreasing the risk of downstream flooding into urban areas.

By identifying pathways, parks, and water as three different networks, the main objective of this design is to reconnect these networks by using these principles: establishing areas whose sites are determined by the existing slopes, linking paths and streets, and binding the project with the presence of water in the sites. This study also works with different scales: First, an Assembly Scale which details the construction method of the proposed system; Second, a Neighbourhood Scale where the new integrated system is working to coexist with the current parks of Fred Hamilton Park (medium), Roxton Road Parkette (small), and Trinity Bellwood Park (large). The design also looks into the street sidewalk condition at the intersection of College Street and Crawford Street, Harrison Street and Shaw Street, and Dundas Street and Shaw Street.

1 Michael Hough. City Form and Natural Process: Towards a New Urban Vernacular. New York: Croom Helm, 1984, 23.

The objective of the proposed design is to collect, treat, store, and reuse storm-water.

Collect
Working with the existing slopes, runoff is collected from two sources: paved surfaces including sidewalks, streets, laneways and plazas', and roof runoff collected from the roofs of adjacent commercial, institutional, and residential buildings in the vicinity of the parks. Although this collection of runoff will need to involve both public and private owners, and could at some stage deal with a public/private partnership, this design focuses only on the strategies of collecting and the usage of storm-water in public spaces through various landscape design interventions.

Treat
Water is treated though the process of biofiltration, as each module in the design is layered with native plants, gravel, sand, topsoil and compost to filter water. Modules are connected with male and female components, and each module has potential for four openings, designated according to the arrangement for the flow of water.

Store
Once the water flows through the modules, the filtered water is stored in underground cisterns. The size of the cisterns will vary depending on the scale and arrangement of the modules. There are two different kinds of cisterns: one that holds the filtered water, and the other that collects runoff overflow.

Reuse
Once the water is filtered and stored in the cistern, it is reused for activities such as the splash pad, water fountains, and existing public washrooms. The stored water is also pumped back into the modules to water the plants during dry climate periods. In order to generate energy for the pumps, the design includes walk-able photovoltaic panels integrated with the permeable paving system. These walk-able photovoltaic panels are placed in areas with maximum sunlight, avoiding the shadows of the existing tree canopy.

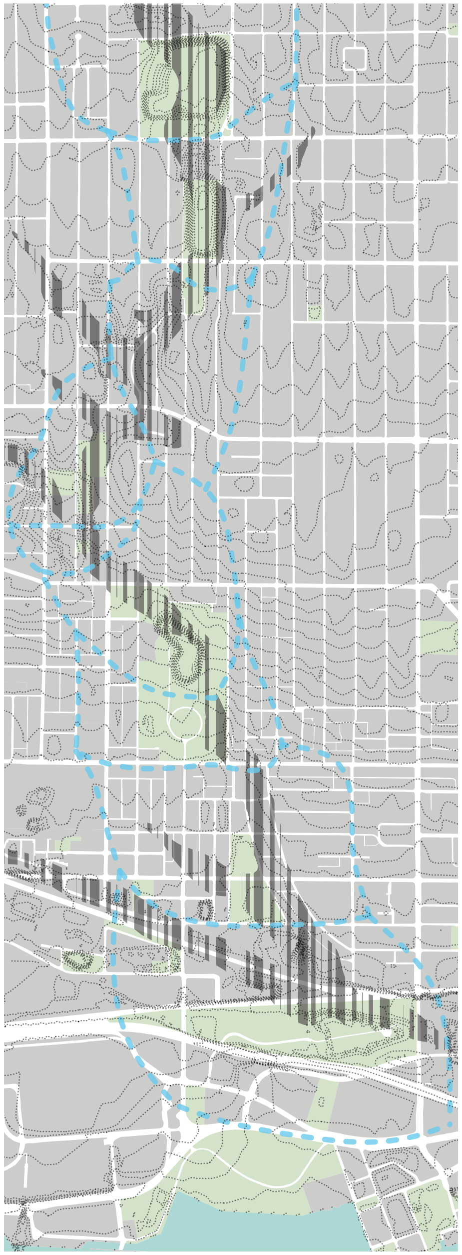
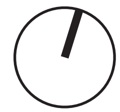


Figure 7-2 (previous page left) Approximate outline of storm-water drainage boundary along the buried Garrison Creek.

Figure 7-3 (previous page right) Area of focus showing the drain boundary for the neighbourhood of Fred Hamilton, Roxton Road Parkette, and Trinity Bellwoods Park.

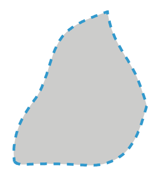
Figure 7-4 (left) Diagram showing areas of depression that alludes to the historic ravine. The design will focus on these areas to maximise the collection of water.



Conceptual water catchment area

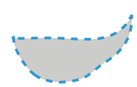
Depression on the landscape

Yearly average rainfall from 1918-2010: 717.4 mm
Month of the highest rainfall: June 82.8 mm
Highest mm of rainfall recorded in a day: July 2014 126 mm



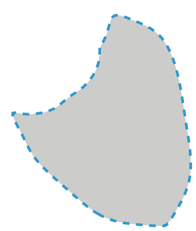
Fred Hamilton Park Catchment Area
Area: 177,606 m^2

Average volume of rainfall in a year: 63,770 m^3
Average volume of rainfall in June: 7,352 m^3
Volume of rainfall in the biggest storm: 11,189 m^3



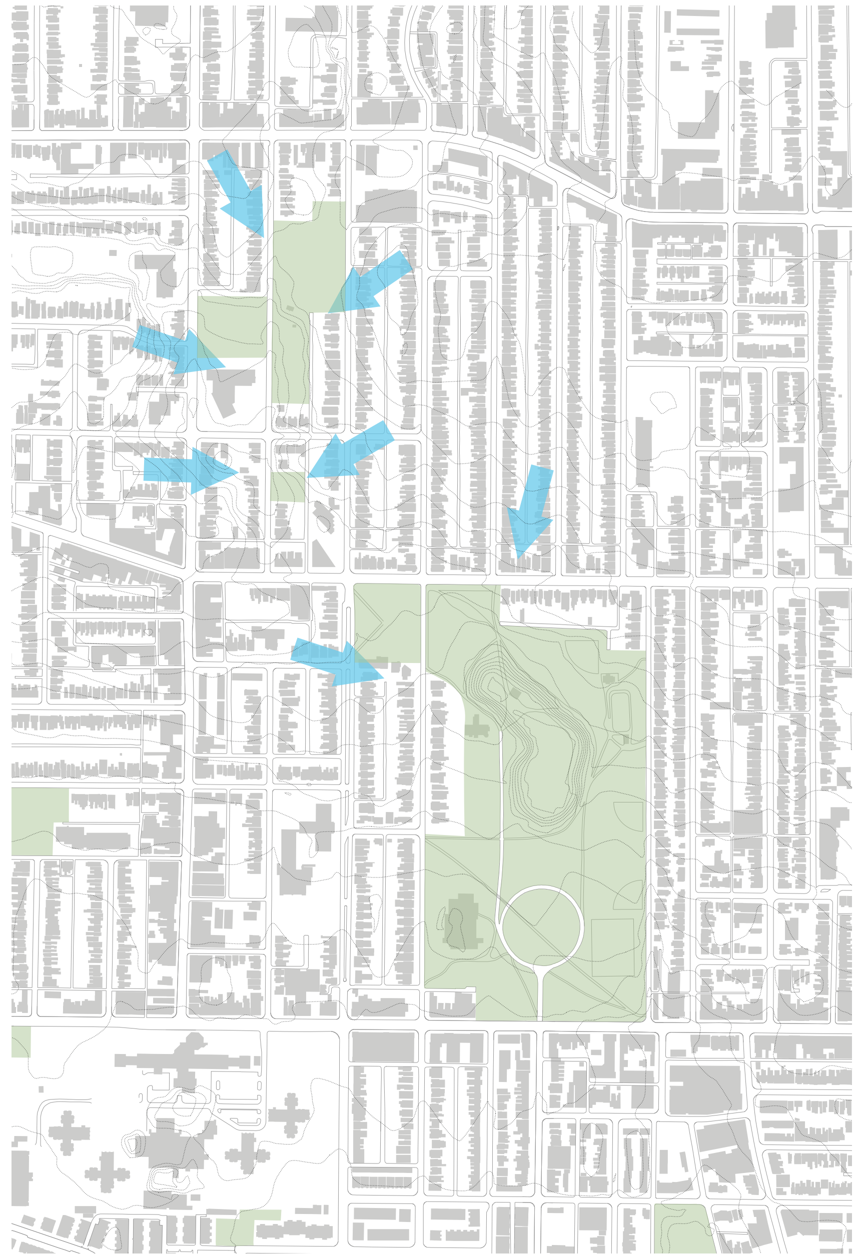
Roxton Road Parkette Catchment Area
Area: 49,737 m^2

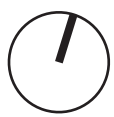
Average volume of rainfall in a year: 17,840 m^3
Average volume of rainfall in June: 2,059 m^3
Volume of rainfall in the biggest storm: 3,133 m^3



Trinity Bellwoods Park Catchment Area
Area: 297954 m^2

Average volume of rainfall in a year: 106,876 m^3
Average volume of rainfall in June: 12,335 m^3
Volume of rainfall in the biggest storm: 18,771 m^3





Arrow showing the slope of the land following the existing contours

Arrows showing the slope of the street

Figure 7-5 Arrows indicating the slope of the current urban landscape, as revealed by the contours.

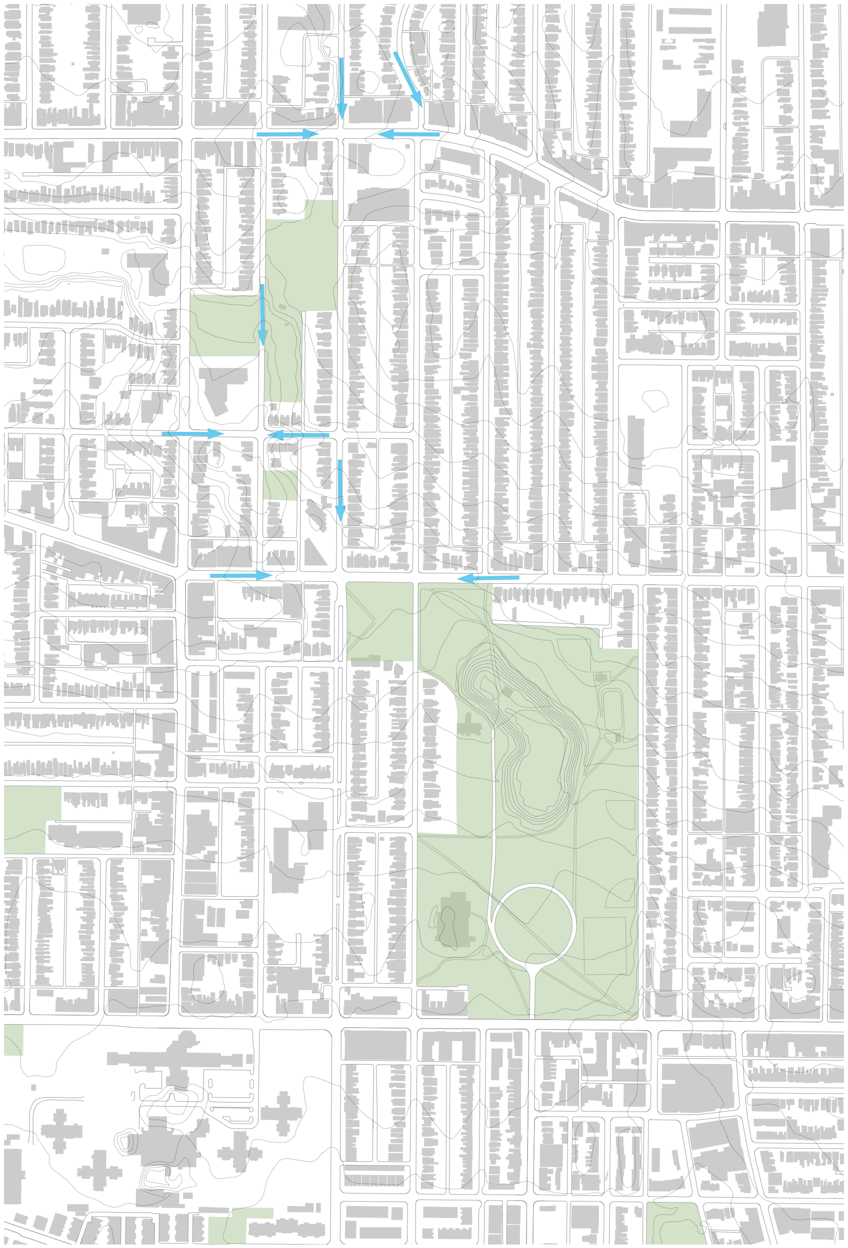


Figure 7-6 Arrows indicating the direction of the slope on the street, as revealed by the contours.

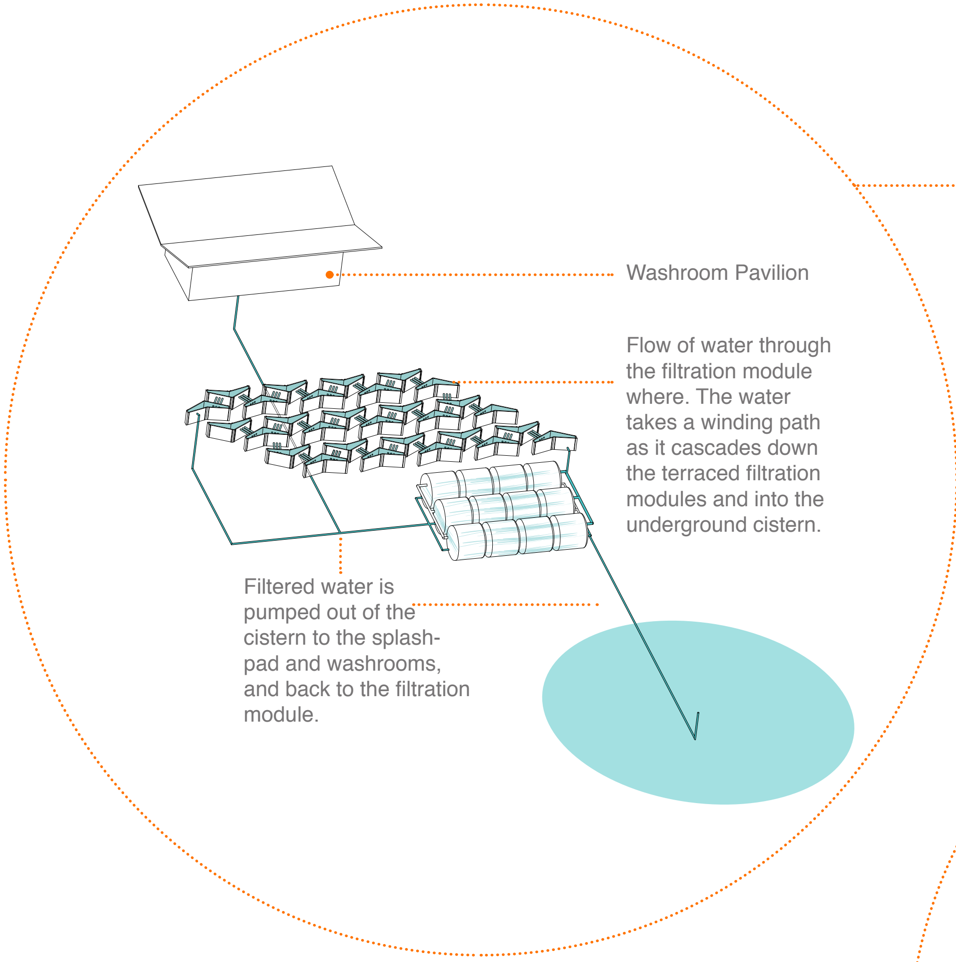
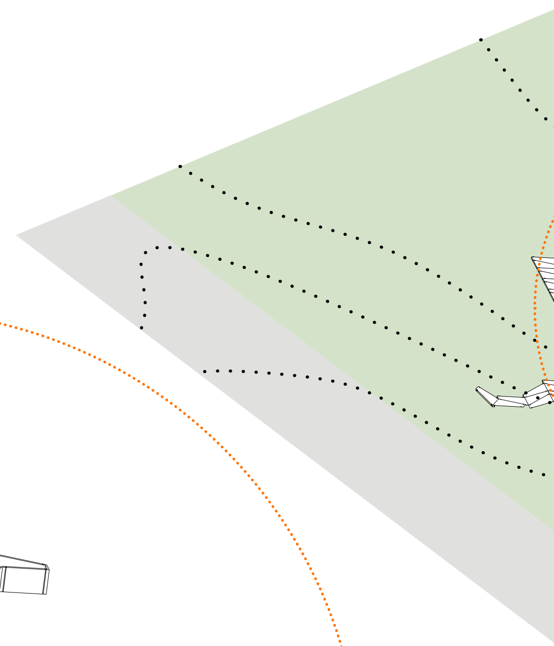


Figure 7-7 (left) System Diagram: Water flow diagram that shows the path of the filtration modules where water flows horizontally, then drops vertically, creating a winding path as it cascades down the terraced modules. The filtered water is then stored in underground cisterns. Water is then pumped from the cistern into filtration modules and other park activities such as the splash pad and the washroom.



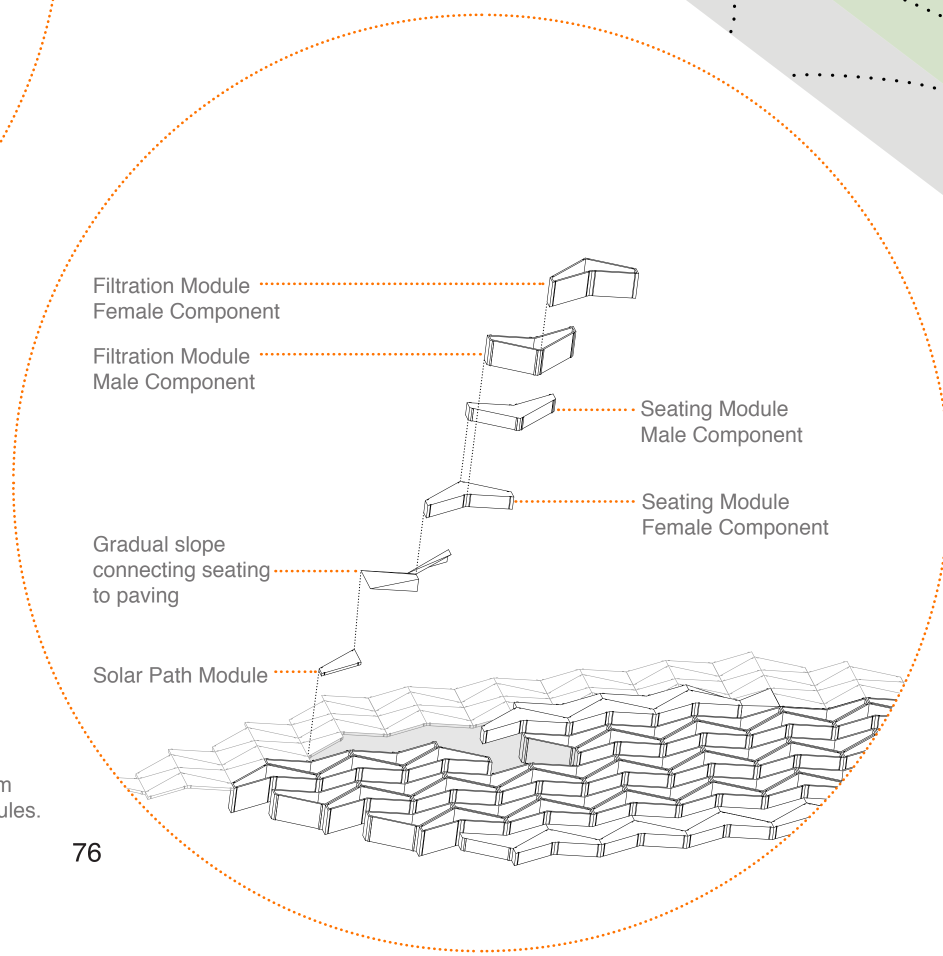


Figure 7-8 (right) Assembly diagram showing the connection of the modules.

Figure 7-9 System Diagram: Roof runoff from residential houses and road runoff are channeled towards the park and into the filtration modules.

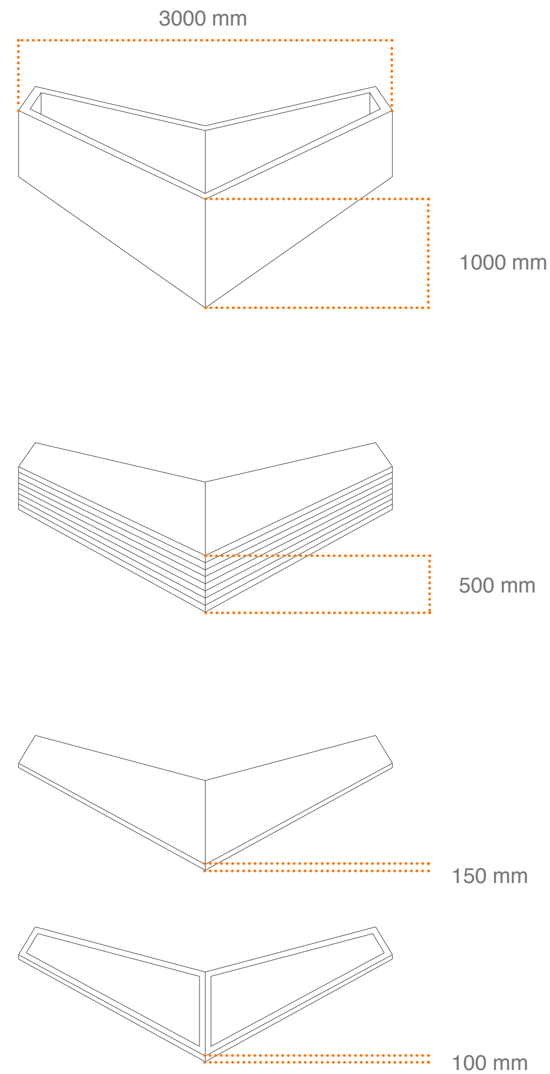


Figure 7-10 Modules designed for the filtration system.

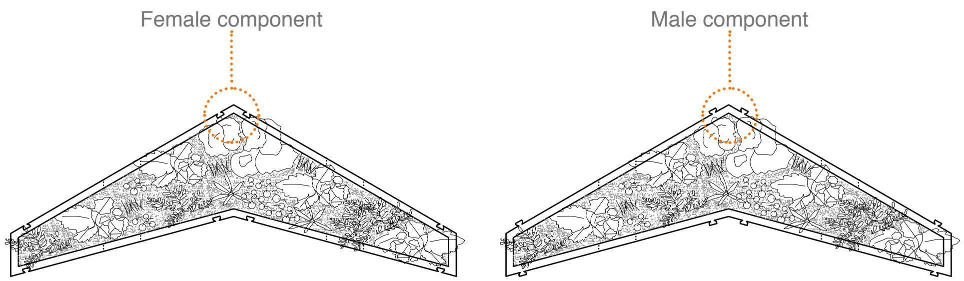


Figure 7-11 Individual modules showing the female component on the left and the male component on the right.

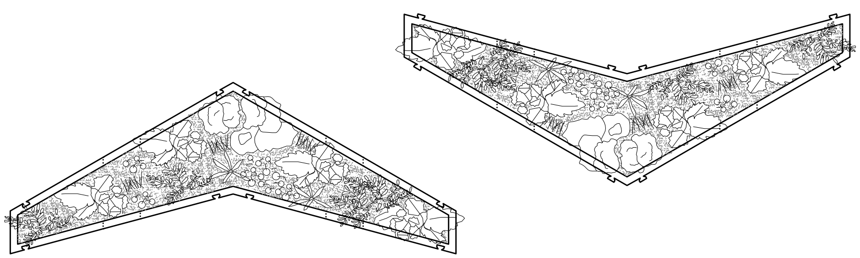


Figure 7-12 Modules showing the assembly of a male and female component where one rotates 180º to fit in with the other.

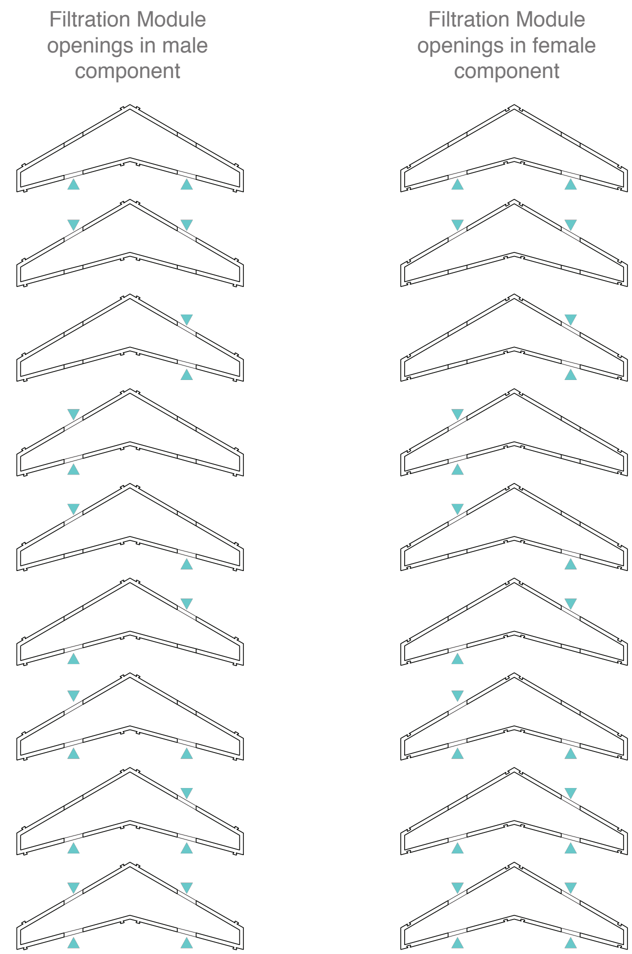
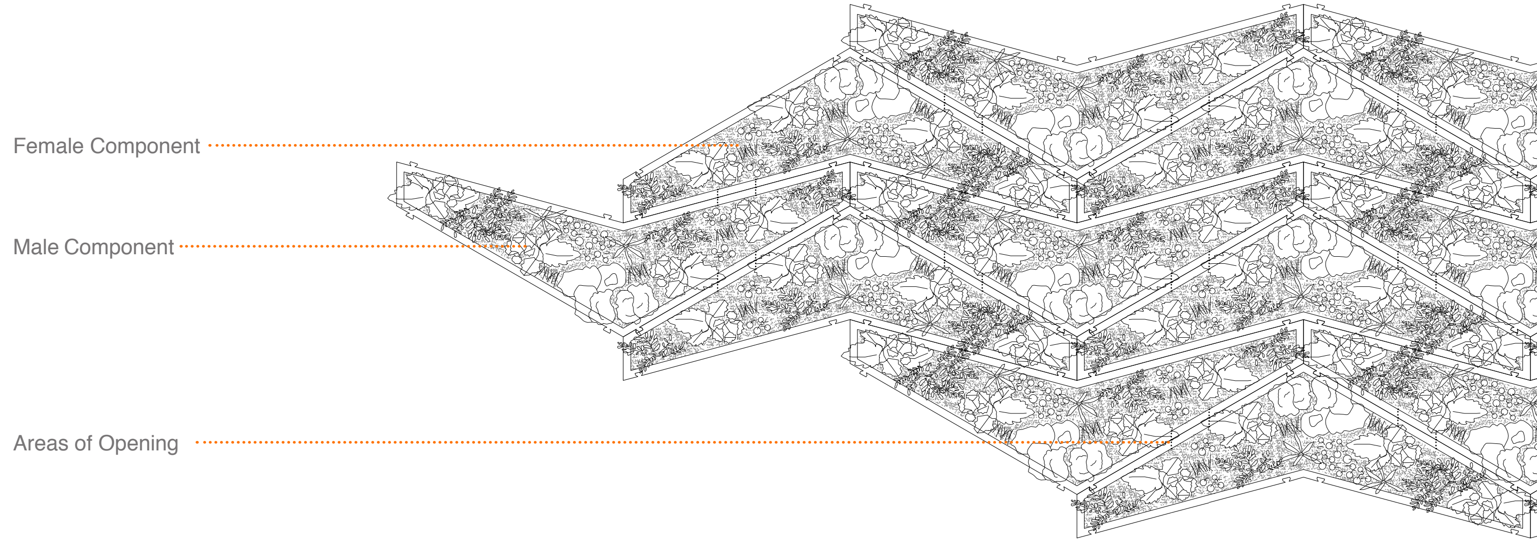
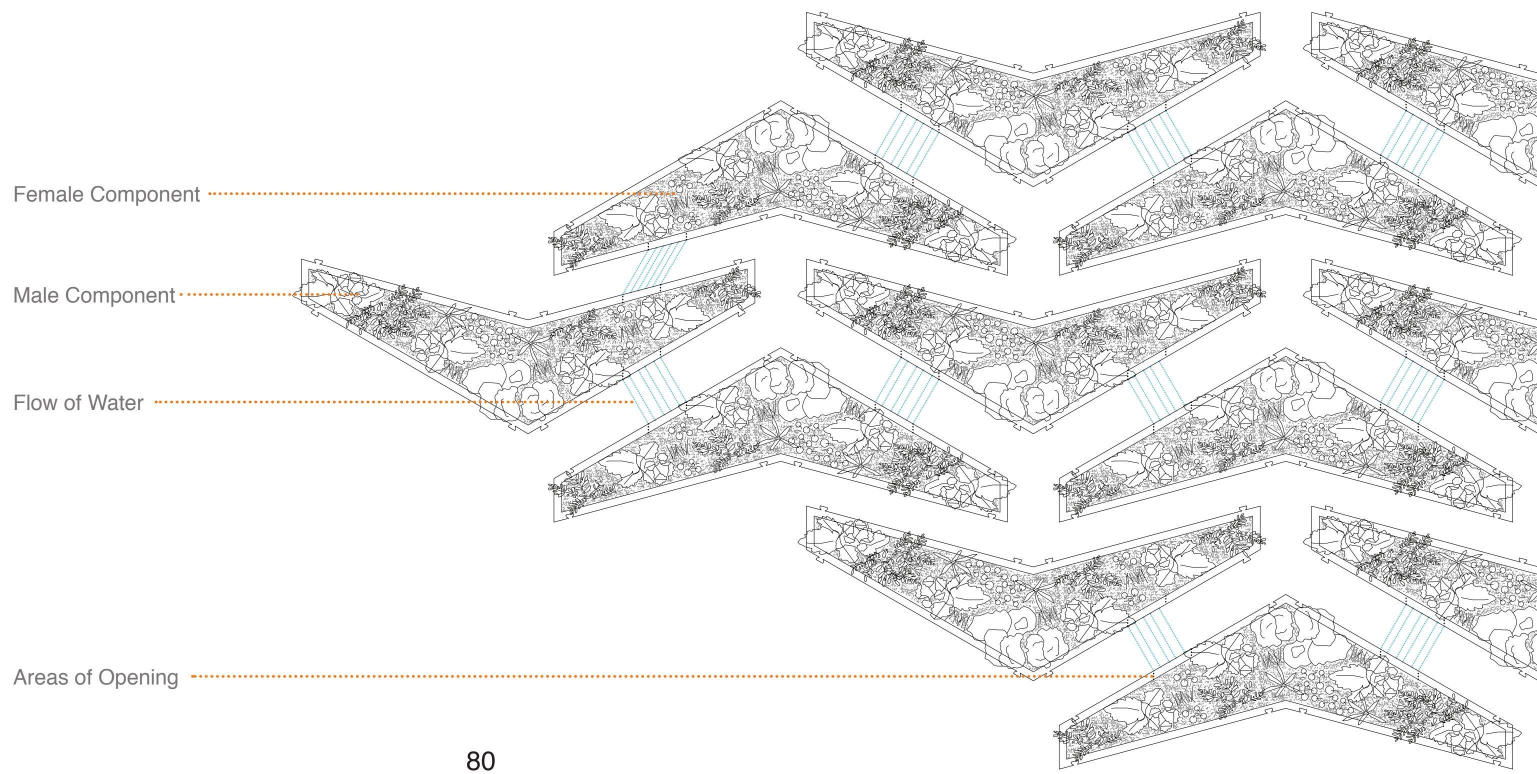


Figure 7-13 Filtration modules (male and female components) showing the possibilities of opening to allow the flow of water.


Female Component
Male Component
Areas of Opening


Female Component
Male Component
Flow of Water
Areas of Opening

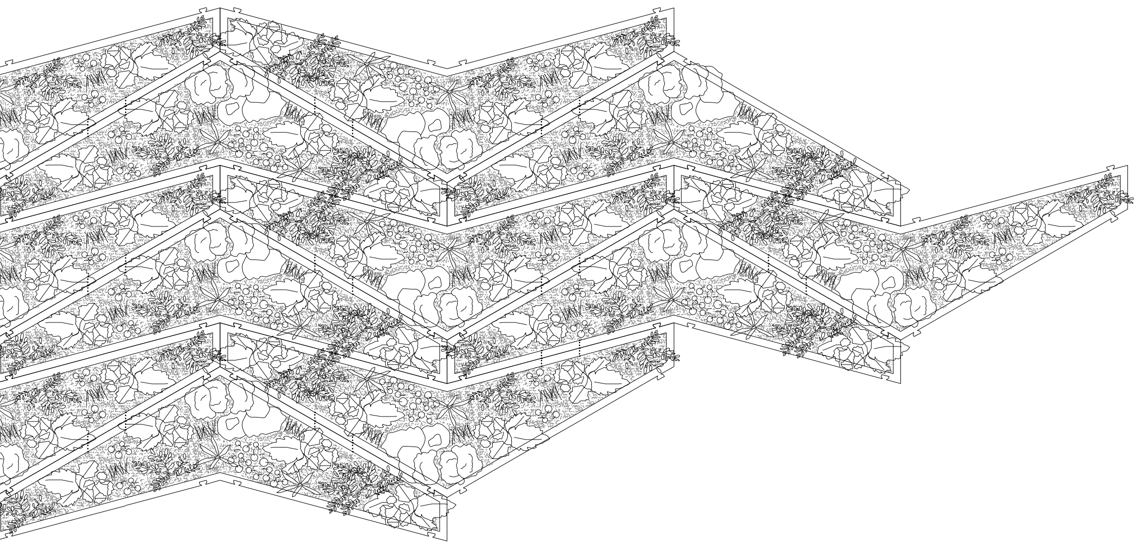


Figure 7-14 Configuration Diagram | Scale 1:50
Configuration Plan of male and female modules grouped together to work as a system. The dotted line seen in the perimeter of the modules represents areas of opening in modules to allow flow of water for the filtration process.

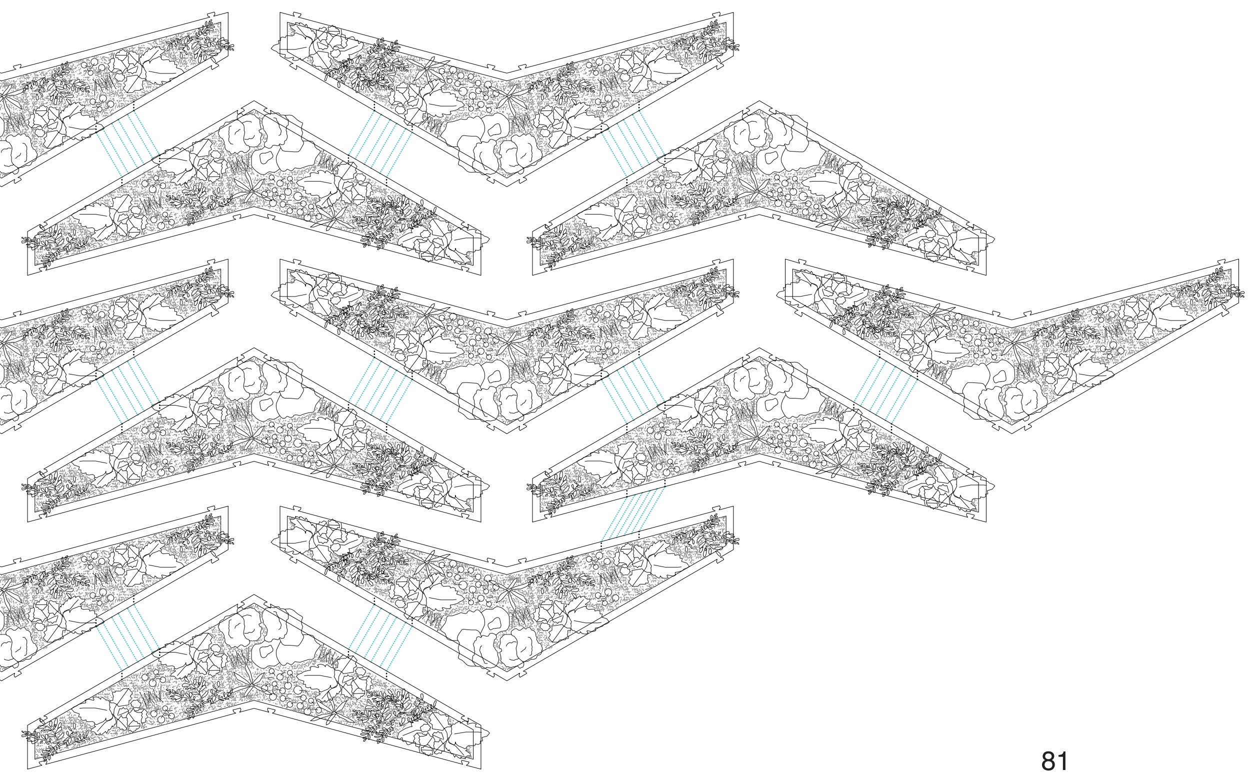


Figure 7-15 Assembly Diagram of the Configuration | Scale 1:50
Assembly diagram of the modules showing the flow of water in blue dotted lines. The black dotted line seen in the perimeter of the modules represent areas of opening in the modules.

Figure 7-16 (right) Isometric Assembly Diagram l Scale 1:100
Isometric assembly diagram showing three different levels of filtration modules to accommodate for slopes in the site. The openings in the modules show the possibility of horizontal and vertical flow of water. As the water cascades between different levels, the water is filtered, which is then stored in underground cisterns. This diagram also shows the integration of filtration modules with seating modules and solar walkway panels.

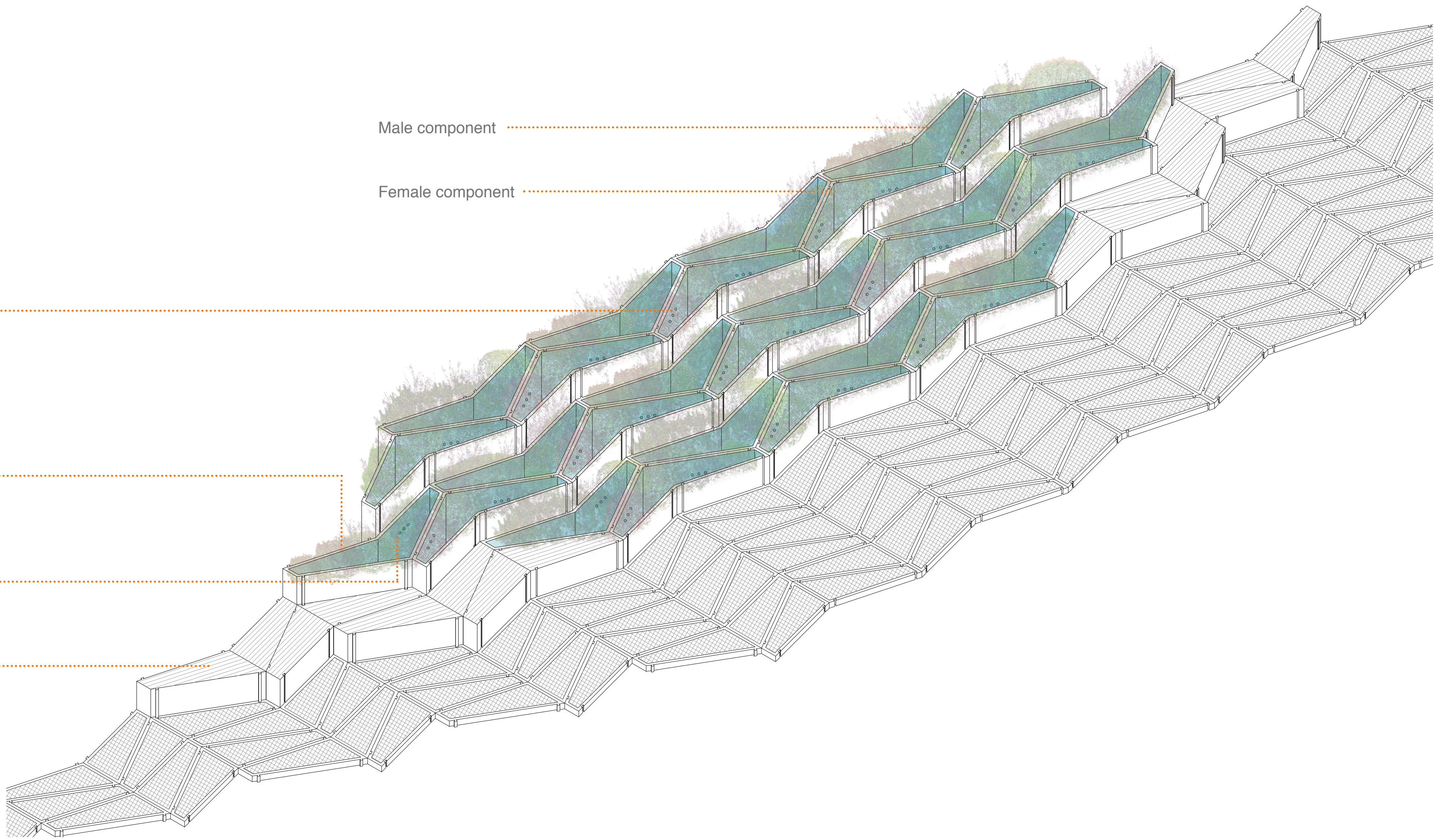
Opening located at 250 mm from the top of the modules to allow horizontal flow between modules

Arrangement of modules placed 500 mm lower in order to accommodate slopes in the ravines

Corner module with opening located at 750 mm from the top of the module, on the top level, which aligns with the opening of the module in the lower level. This allows vertical flow between module in sloped conditions

Seating modules arranged to fit together with the filtration modules to create areas of rest next to the planted area

Solar walkway panels arranged together with the filtration modules and the seating modules that capture solar energy


Male component
Female component

2,000 Gallons
7,570 Liters

4,000 Gallons
15,141 Liters

8,000 Gallons
30,283 Liters

16,000 Gallons
60,566 Liters

24,000 Gallons
90,849 Liters

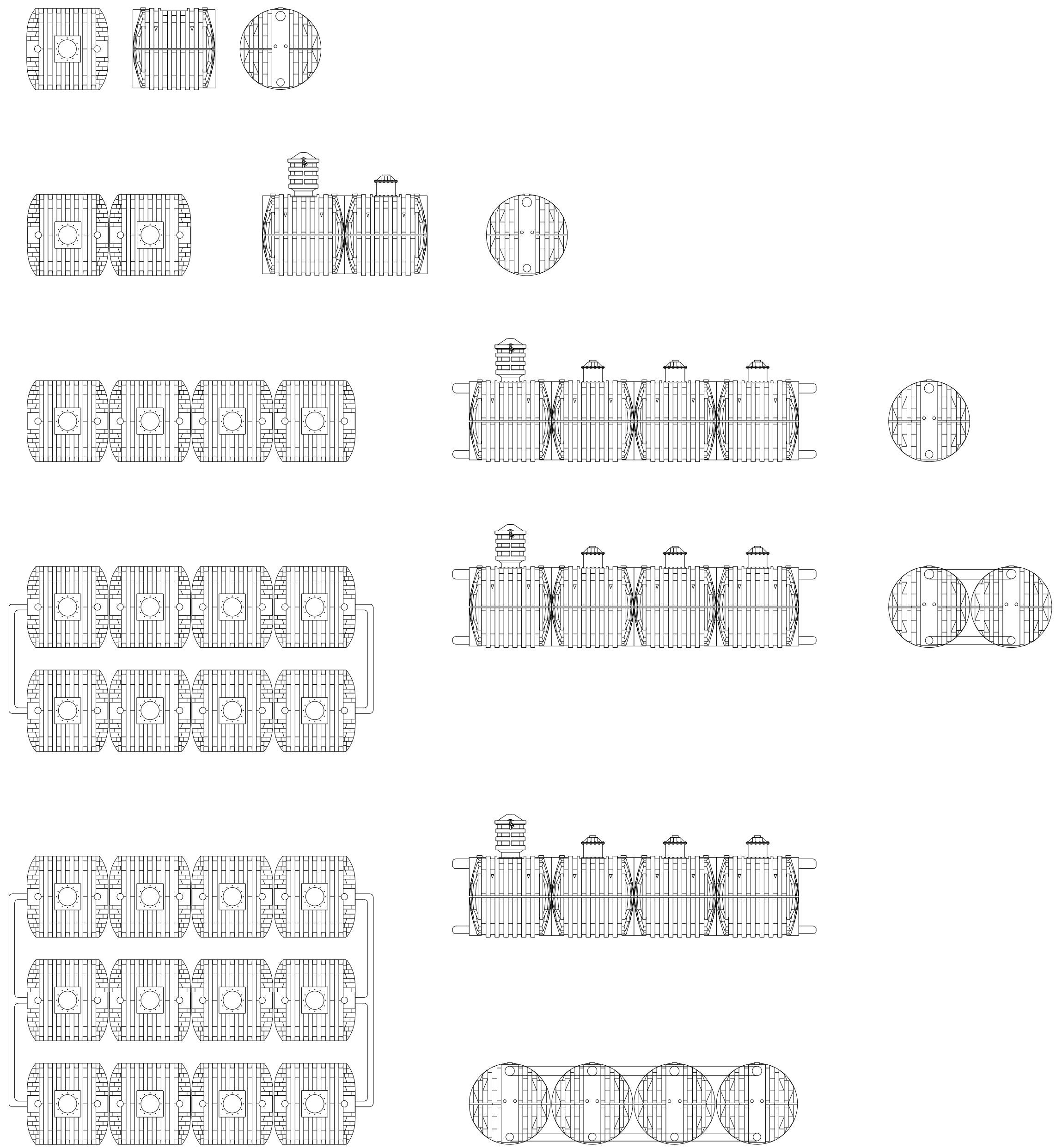


Figure 7-17 Cisterns | Scale 1:200
Underground water cistern configurations following a parallel system of interconnecting method, as manufactured by Darco Inc.

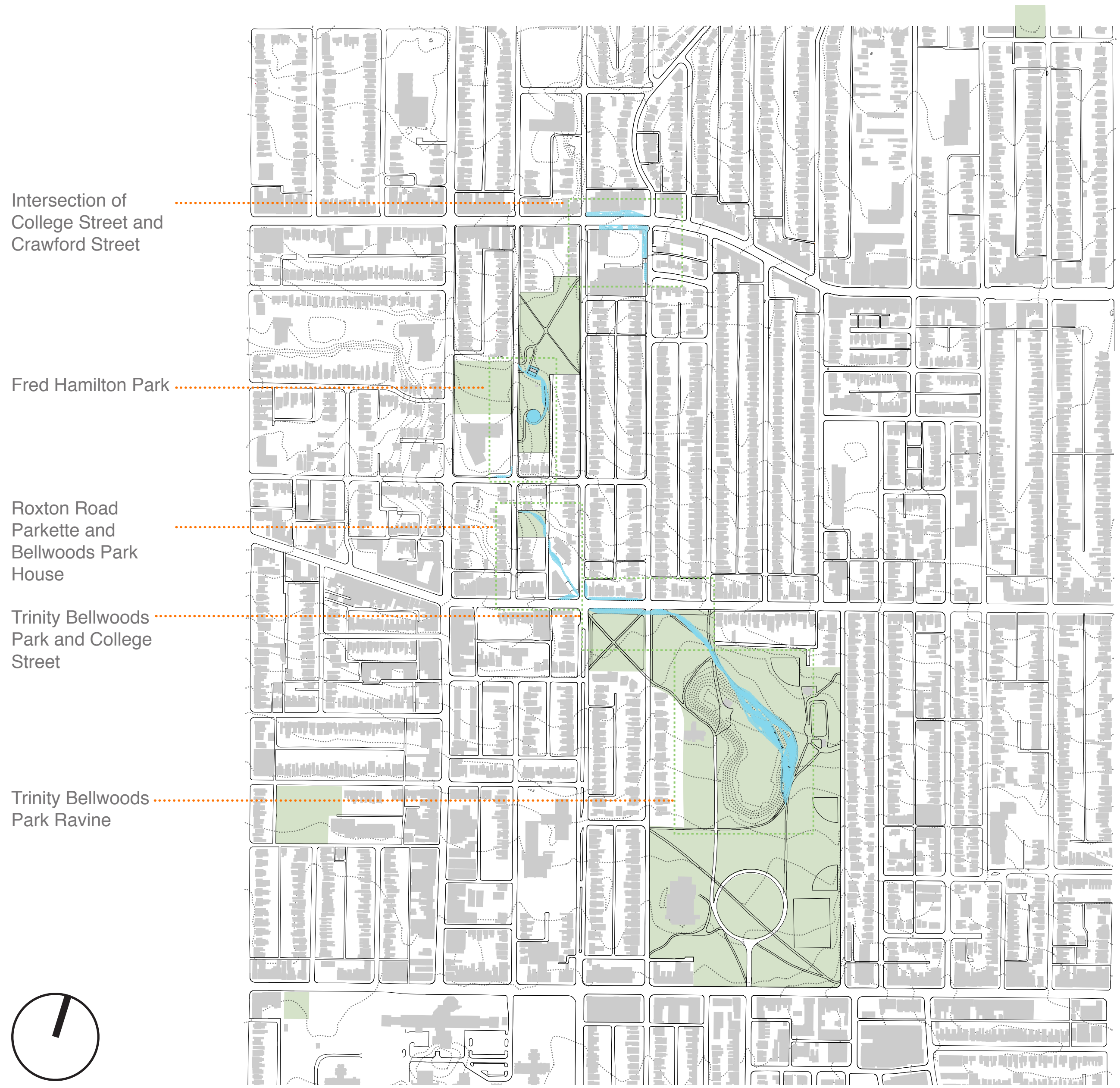


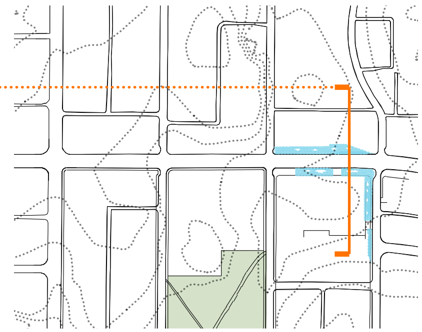
Figure 7-18 Site Plan I Scale 1:10,000
Area of focus is highlighted in green.


Legend
Filtration Modules
Seating
Permeable Pavings
Walkable Solar Panel
Green Space
Existing Catchment Basin
Existing Manhole
Existing Trees
Shaw Street
Crawford Street
College Street
Shaw Street
Crawford Street

Figure 7-19 (left) Plan of the intersection of College Street and Crawford Street | Scale 1:1000

Figure 7-20 (bottom) Section A | 1:200 Cutting through College Street and Metro Plaza parking lot.

Section A



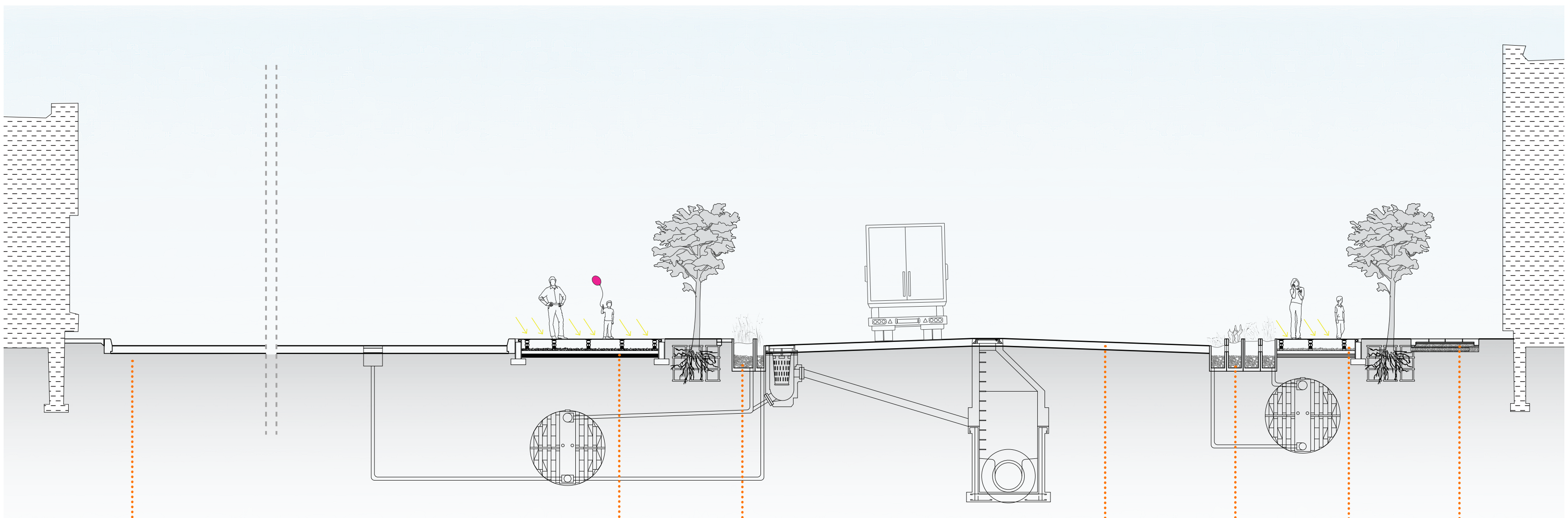
Intersection of College Street and Crawford Street

Filtration Module Area: 176 m^2
Volume of water stored in the modules: 176,664 Liters

Number of cisterns incorporated in the design: 12
Storage capacity of the cisterns: 90,720 Liters
Total capacity of water storage: 267,384 Liters

Number of pumps in the site: 5
Power needed to fill the modules in an hour: 2.4 kWh

Power generated by Solar Path Modules: 2,284 kWh



Metro Plaza parking lot- Runoff is collected from the parking lot and directed to the cistern which then pumps water into the filtration modules

Walkable solar panel

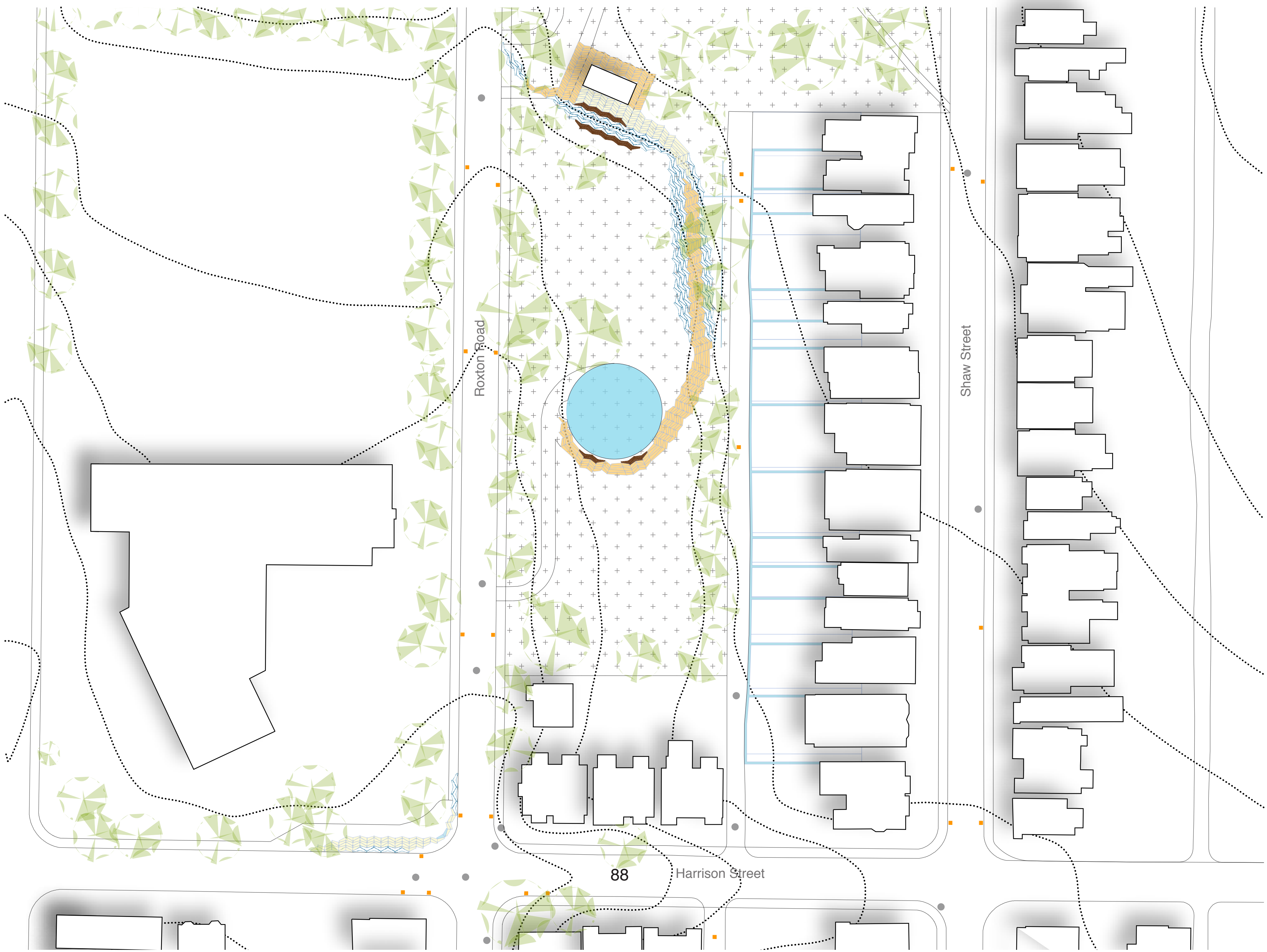
Sidewalk filtration module - Road runoff is channeled directly into the sidewalk filtration modules. The filtered water is then stored in the cistern and is pumped back into the modules during dryer climate

College Street

Sidewalk filtration module

Walkable solar panel

Permeable Paving



Roxton Road
Shaw Street
Harrison Street
88

Figure 7-21 (left) Plan of Fred Hamilton Park and an off street filtration system on Harrison Street I Scale 1:1000

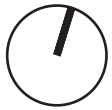
Fred Hamilton Park Neighbourhood

Filtration Module Area: 221 m^2
Volume of water stored in the modules: 221,830 Liters

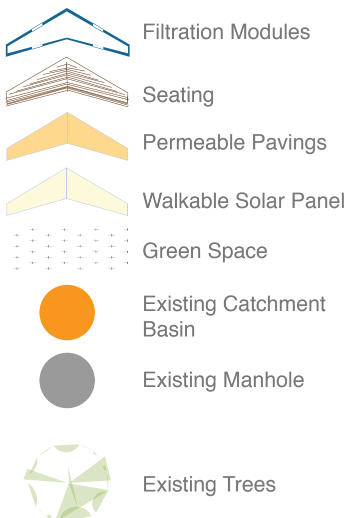
Number of cisterns incorporated in the design: 26
Storage capacity of the cisterns: 196,560 Liters
Total capacity of water storage: 418,390 Liters

Number of pumps in the site: 7
Power needed to fill the modules in an hour: 3.4 kWh

Power generated by Solar Path Modules: 624 kWh



Legend



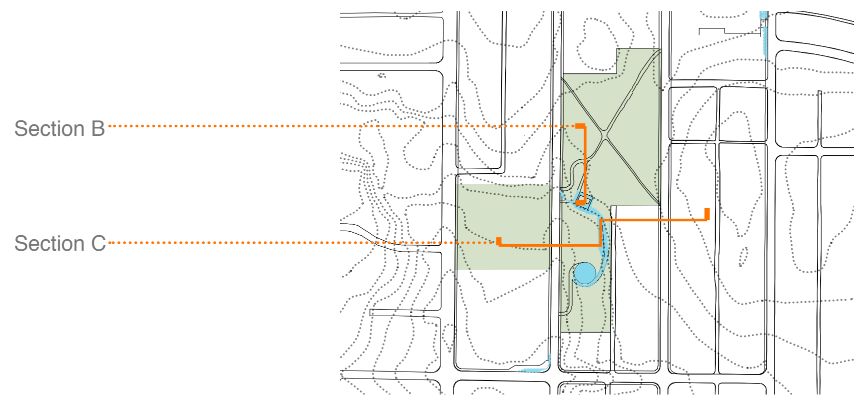


Figure 7-22 Section B | Scale 1:50
Detail section showing pavilion, showing the connection between the washroom pavilion and the filtration system.

1 Walkable Solar Panel
Glass Configuration
6 mm anti slip glass
PVB Foil
3.2 mm Float Glass
a-Si Think Film Solar Cells
6 mm Tempered Glass

2 Stackable Electric Vault

3 Perimetral Drain Channel

4 Concrete Blocks Wall

5 Compact Gravel

6 Concrete to form a 1.3% slope

7 White Gravel to hide wiring

8 Drain Pipe

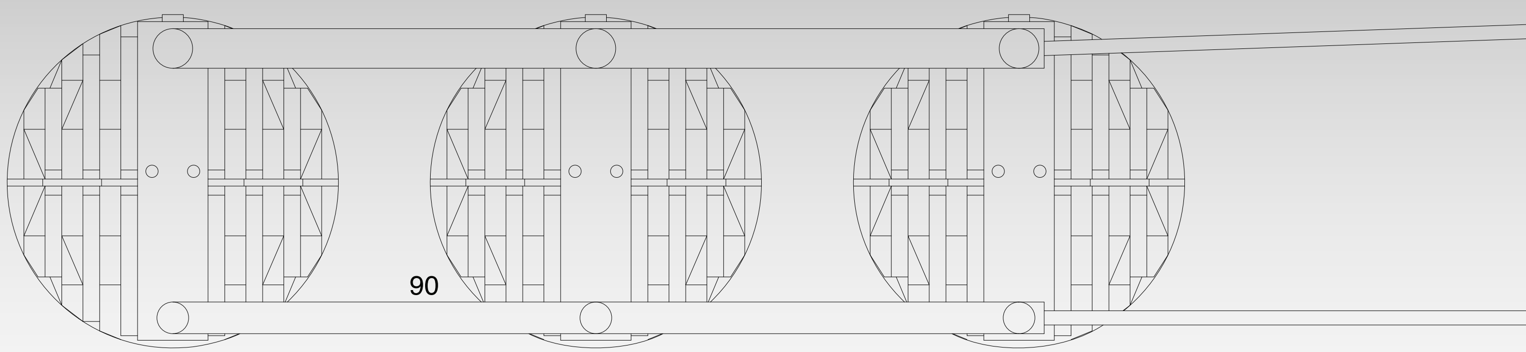
9 Seating

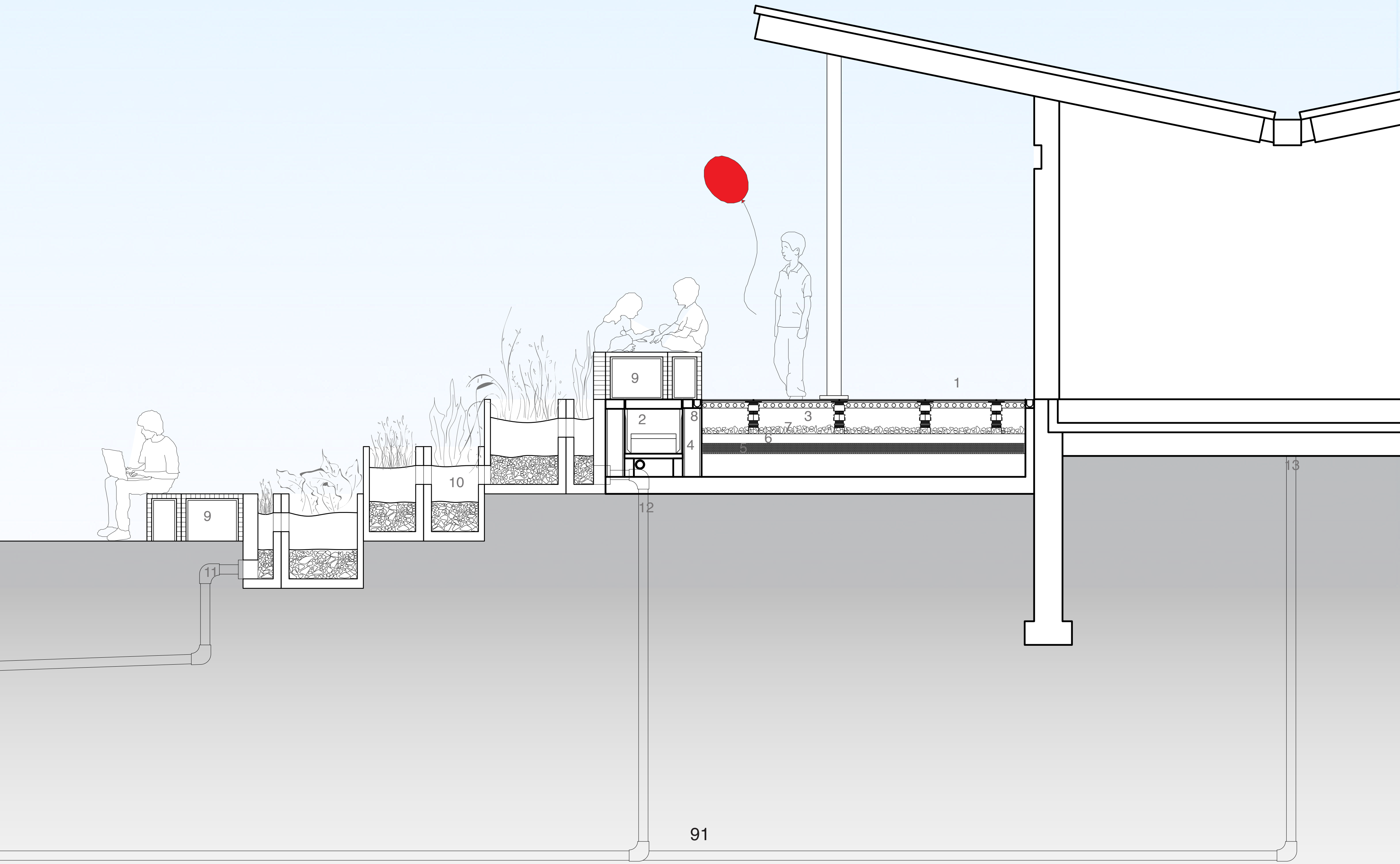
10 Filtration Module made with light weight concrete
Module Configuration
200 mm Gravel
100 mm Compact Gravel
Filter Fabric
450 mm soil mix

11 100 mm diameter pipe connecting to the cistern with a capacity of 90,849 Liters

12 100 mm diameter pipe transporting pumped filter water from the cistern back into the filtration modules

13 100 mm diameter pipe transporting pumped filtered water to the washroom pavilion




1
9
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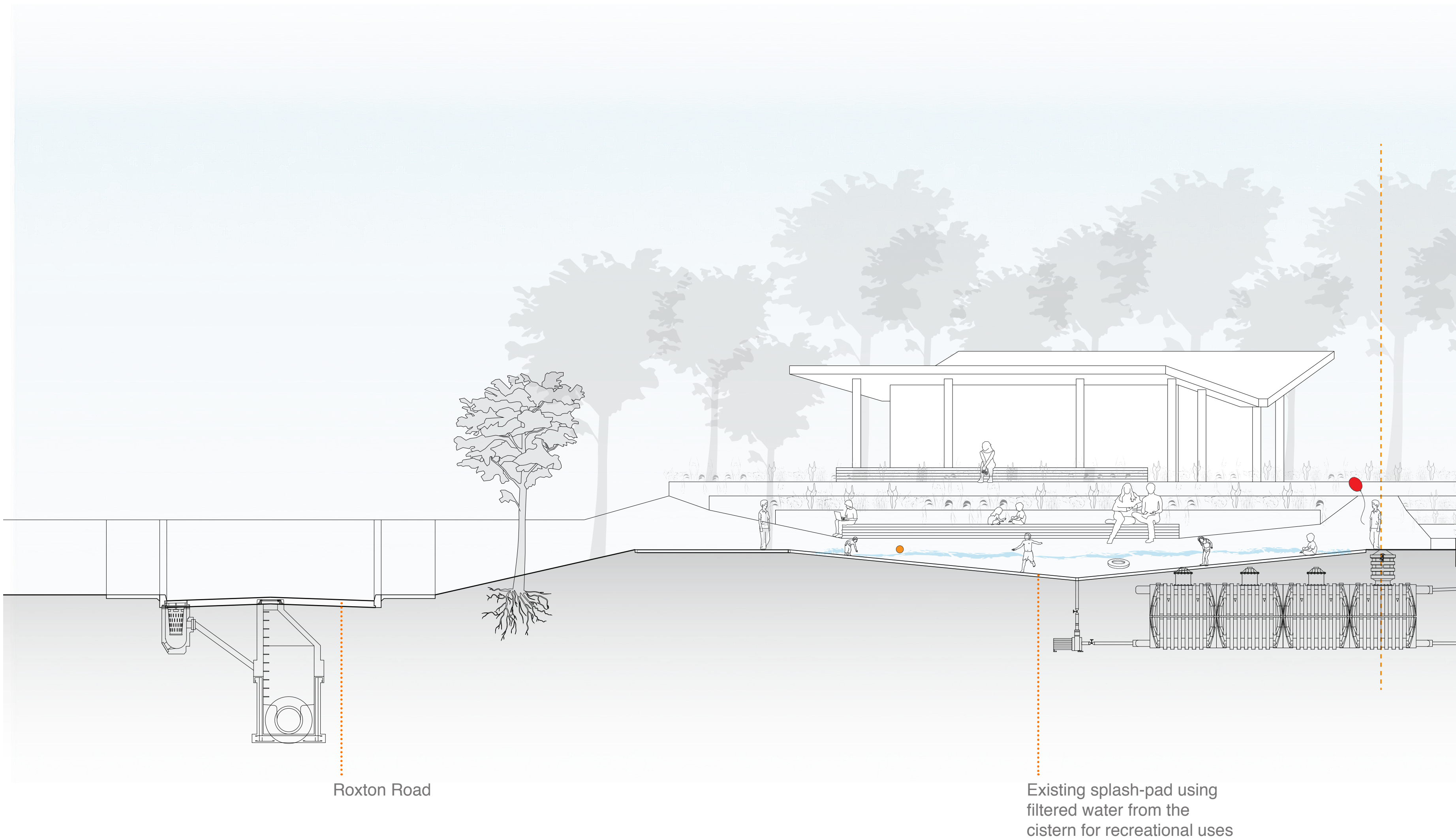
12
13
11


Roxton Road
Existing splash-pad using
filtered water from the
cistern for recreational uses

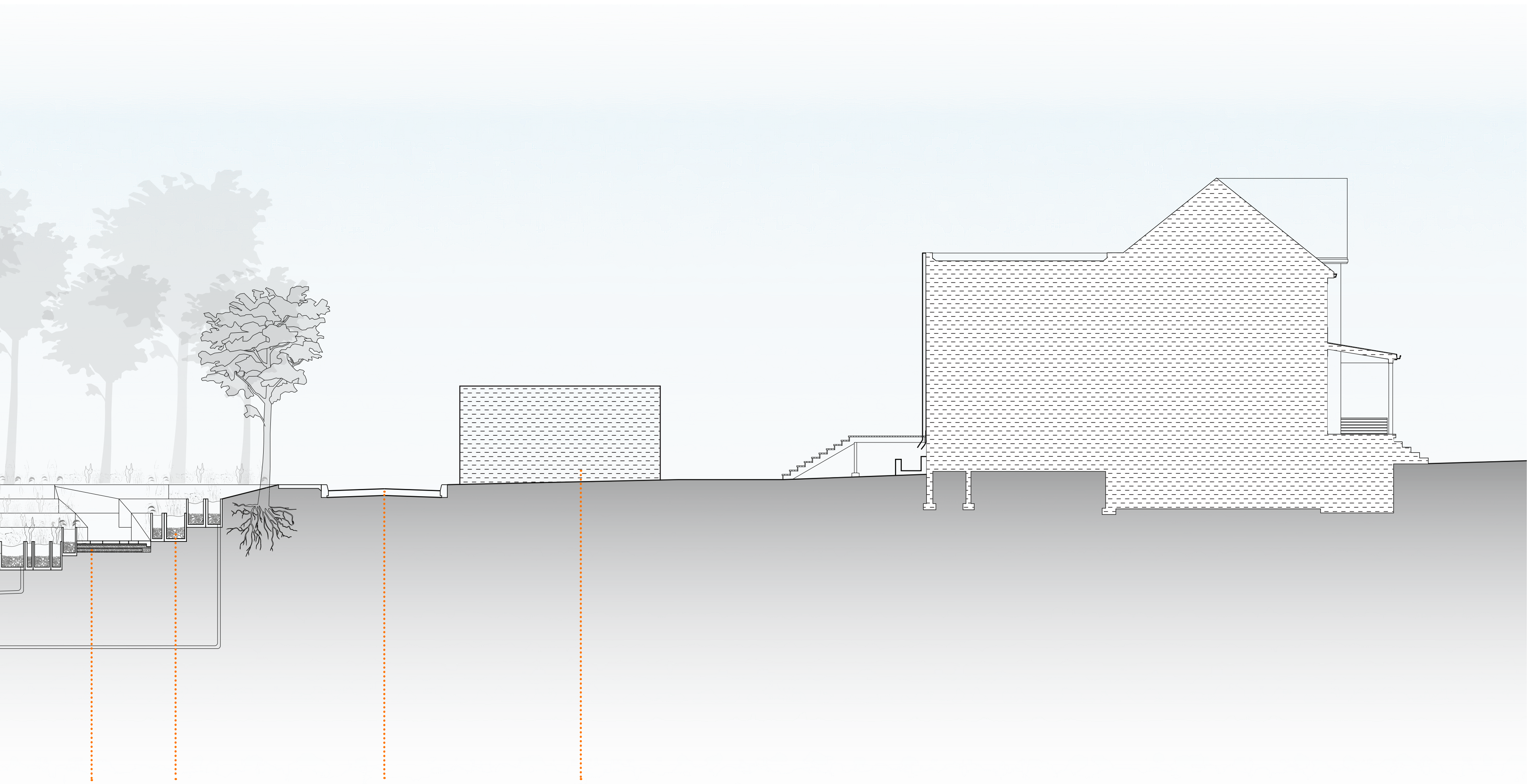


Figure 7-23 Section C I 1:200
Section taken through the proposed pavilion, showing the connection between the filtration system and the splash-pad.

Harrison Street
Roxton Road
Shaw Street
Crawford Street
Dundas Street West
Dundas Street West

Figure 7-24 (left) Plan of Roxton Road Parkette and Trinity Bellwoods House | Scale 1:1000

Legend

Filtration Modules

Seating

Permeable Pavings

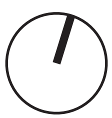
Walkable Solar Panel

Green Space

Existing Catchment Basin

Existing Manhole

Existing Trees



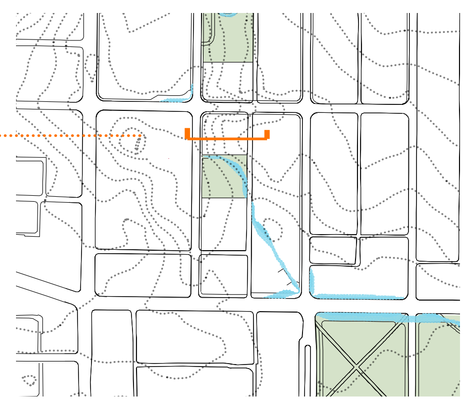
Roxton Road Parkette Neighbourhood

Filtration Module Area: 167 m^2
Volume of water stored in the modules: 167,159 Liters

Number of cisterns incorporated in the design: 20
Storage capacity of the cisterns: 151,200 Liters
Total capacity of water storage: 318,359 Liters

Number of pumps in the site: 5
Power needed to fill the modules in an hour: 2.4 kWh

Power generated by Solar Path Modules: 419 kWh



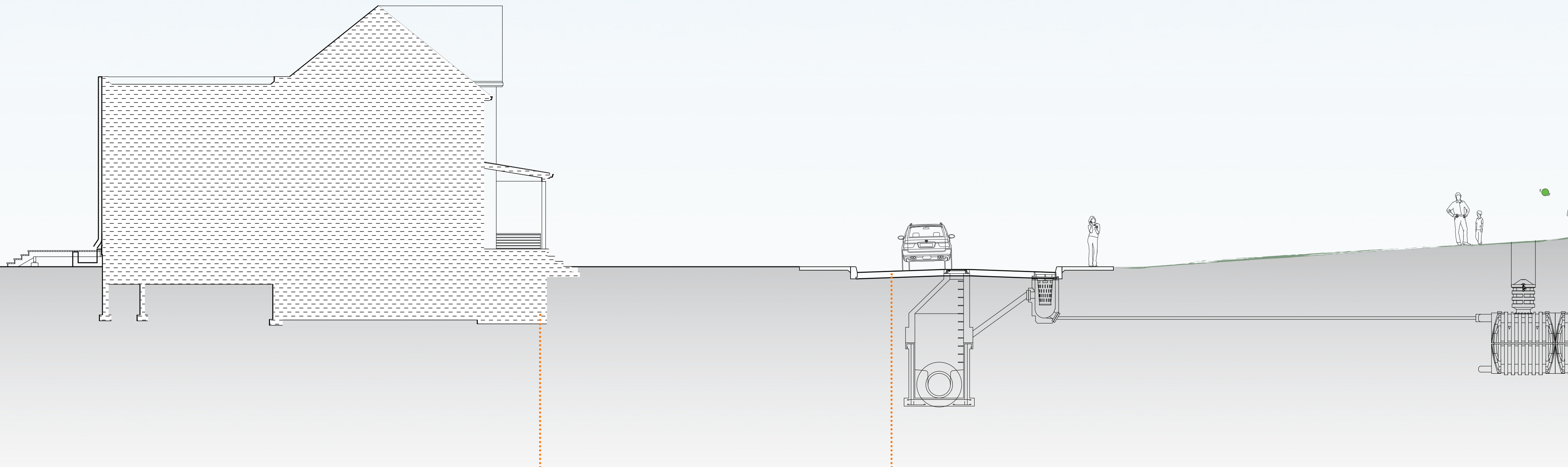
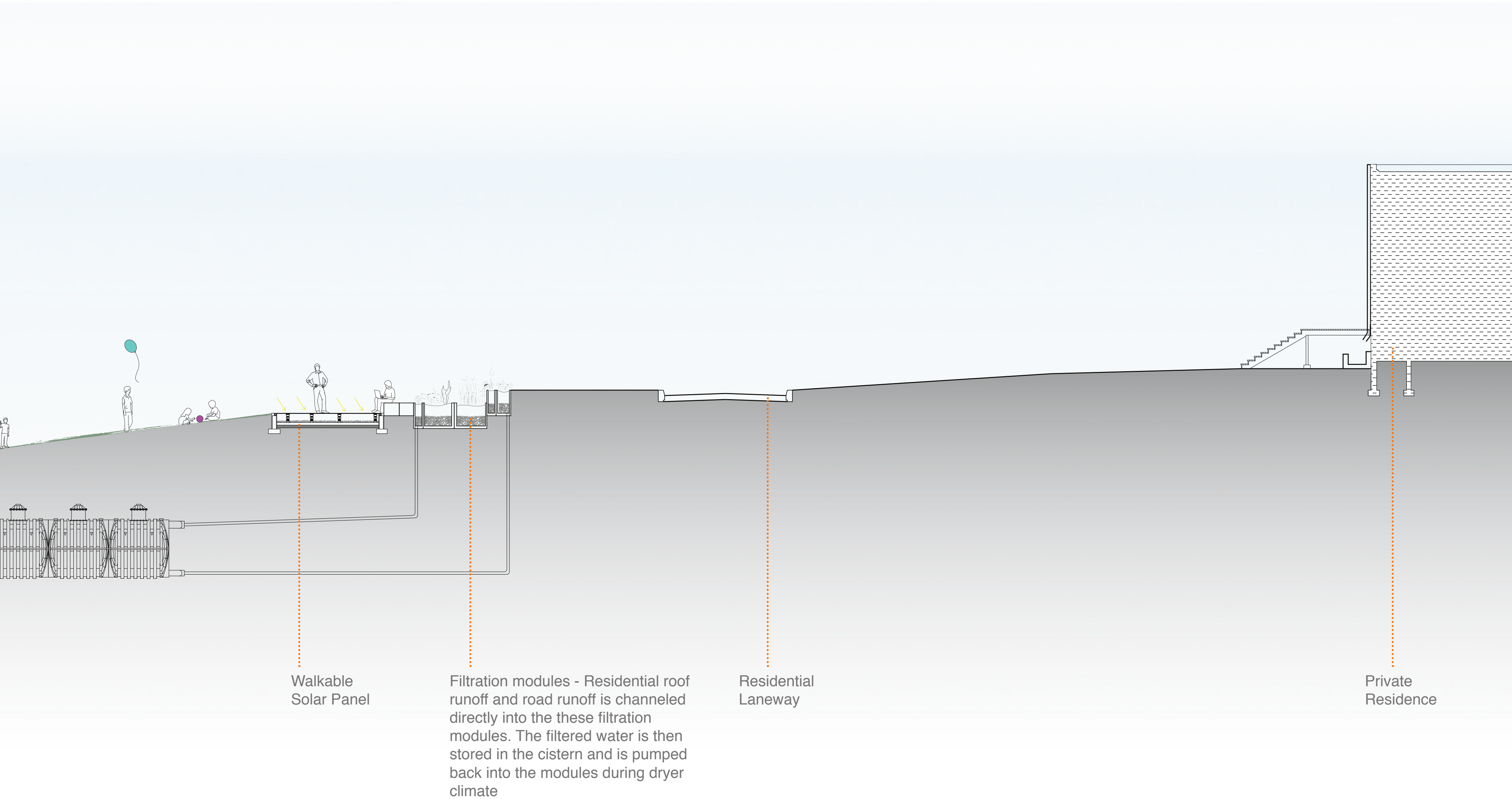
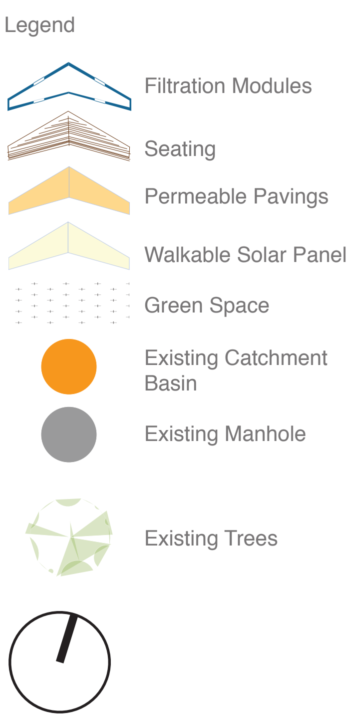


Figure 7-25 Section D | 1:200
Section of Roxton Road Parkette showing the connection with the private residential property.



Walkable
Solar Panel
Filtration modules - Residential roof runoff and road runoff is channeled directly into the these filtration modules. The filtered water is then stored in the cistern and is pumped back into the modules during dryer climate
Residential
Laneway
Private
Residence


Shaw Street
Crawford Street
Montrose Avenue
Dundas Street West


Legend
Filtration Modules
Seating
Permeable Pavings
Walkable Solar Panel
Green Space
Existing Catchment Basin
Existing Manhole
Existing Trees

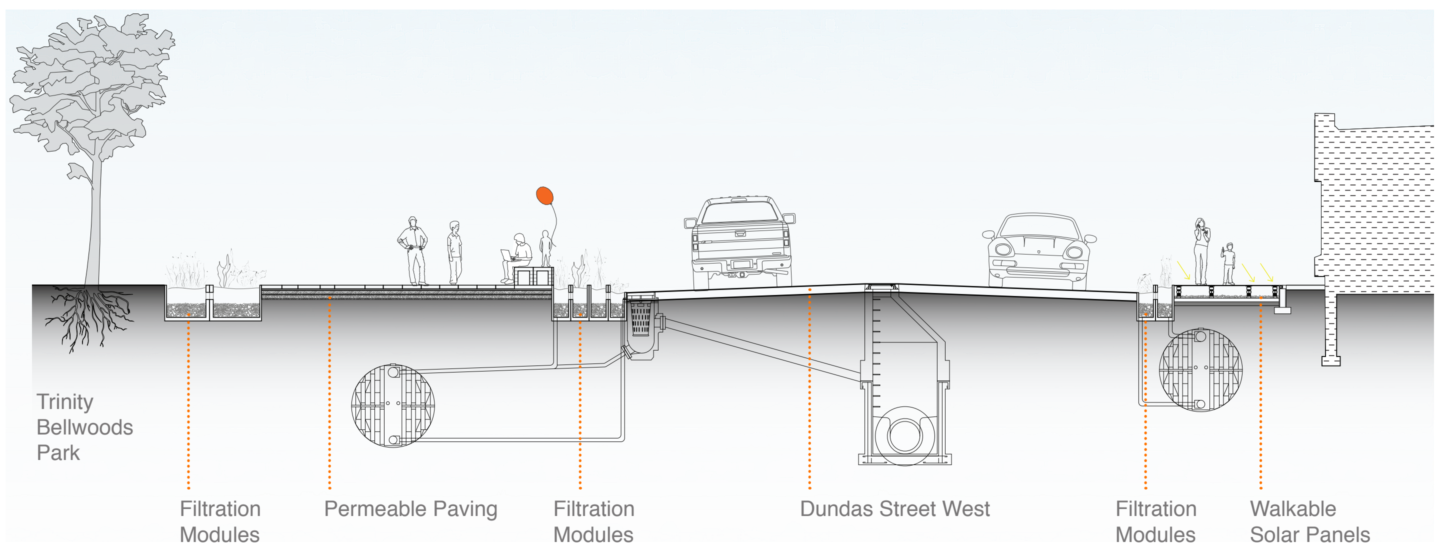

Trinity Bellwoods Park
Filtration Modules
Permeable Paving
Filtration Modules
Dundas Street West
Filtration Modules
Walkable Solar Panels

Figure 7-26 (left top) Plan of Dundas Street I Scale 1:1000

Figure 7-27 (left bottom) Section E I Scale 1:200
Section of Dundas Street West.

Figure 7-28 (right) Detail plan of Dundas Street West 1:200

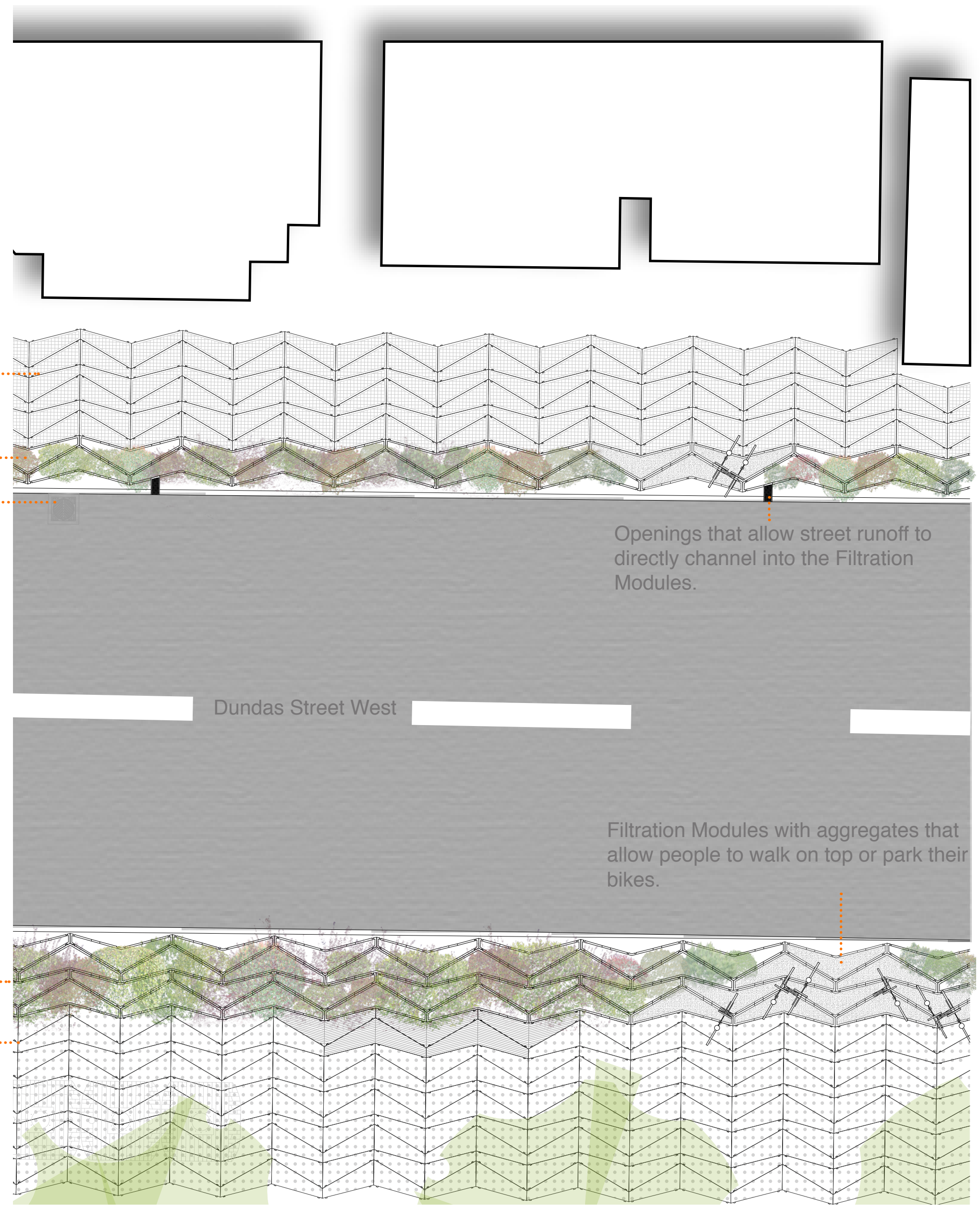
Trinity Bellwoods Park Neighbourhood

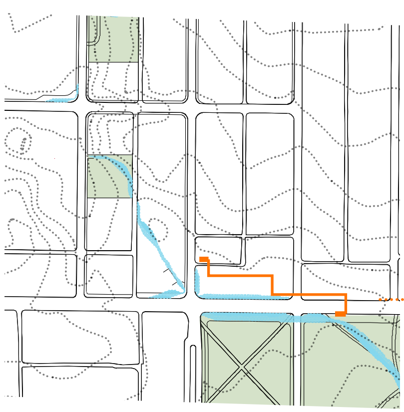
Filtration Module Area
2768 m²
Volume of water stored in the modules
2,768,252 Liters

Number of cisterns in the design
38
Storage capacity of the cisterns
393,120 Liters
Total capacity of water storage
3161372 Liters

Number of pumps in the site
77
Power needed to fill the modules in an hour
90 kWh

Power generated by Solar Path Modules
5025 kWh






CRAWFORD ST
249

Figure 7-29 View of Dundas Street and Trinity Bellwoods Park, looking East.

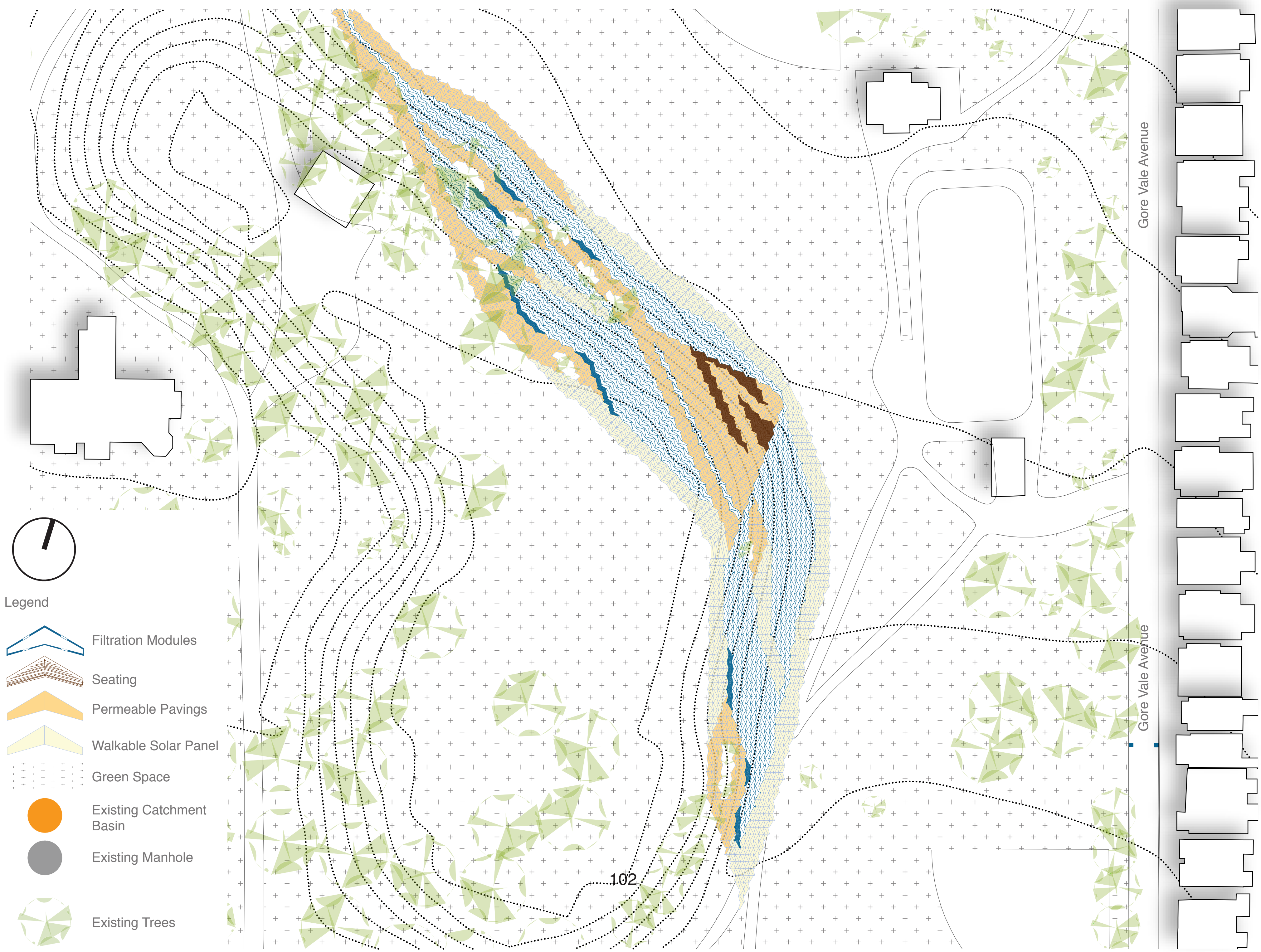
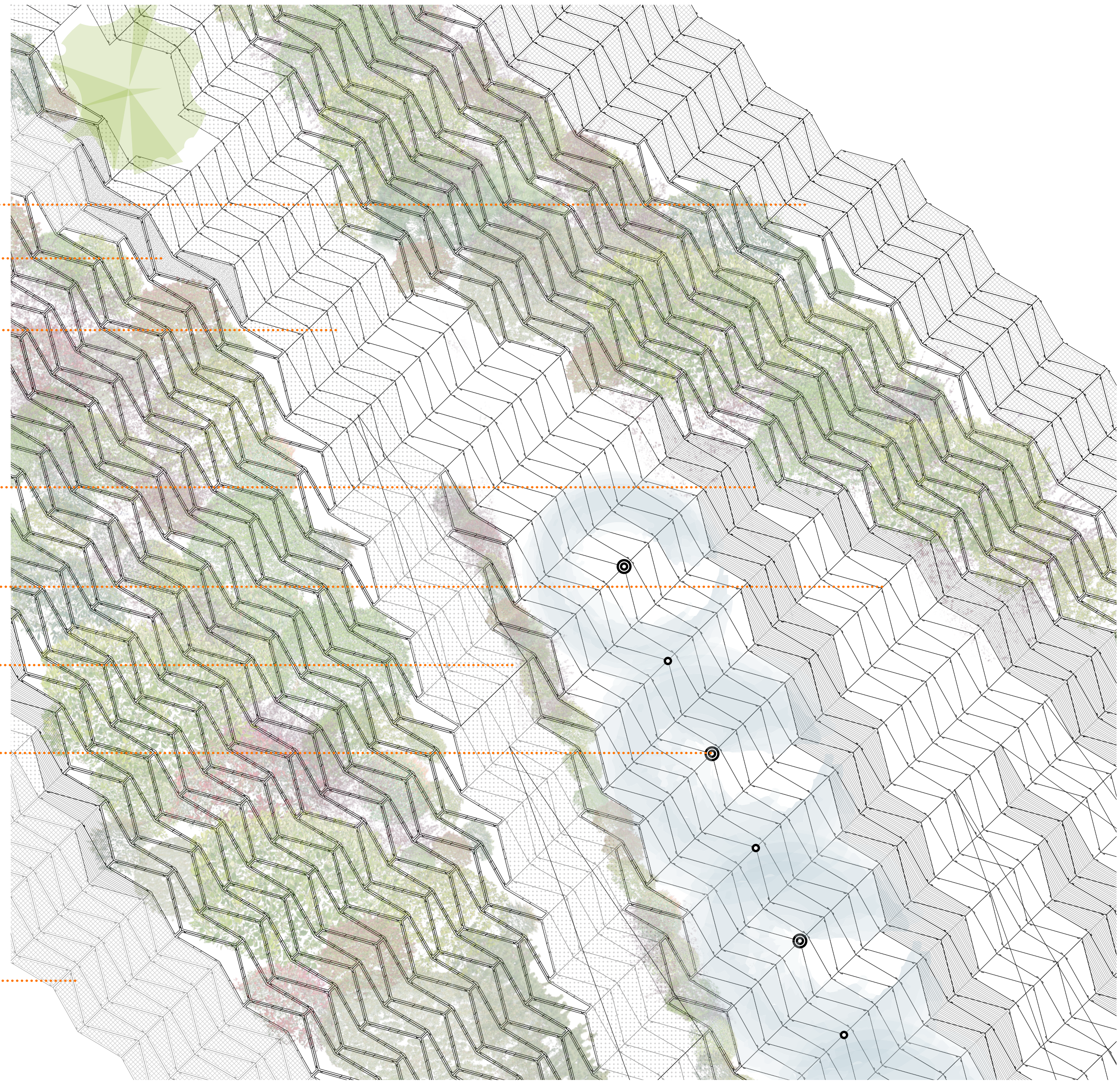

Gore Vale Avenue
Gore Vale Avenue
102
Legend
Filtration Modules
Seating
Permeable Pavings
Walkable Solar Panel
Green Space
Existing Catchment Basin
Existing Manhole
Existing Trees

Figure 7-30 (left) Plan of Trinity Bellwoods Park Ravine I 1:1000

Figure 7-31 (right) Detail Plan of Trinity Bellwoods Park Ravine I Scale 1:200



Top of the Ravine at +7 meters with Walkable Solar Paving

Filtration Modules with aggregates that allow people to walk on top of it

Permeable Paving

Seating for the amphitheater

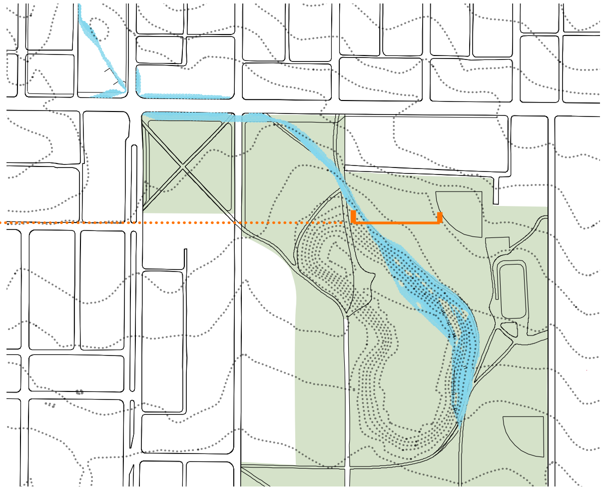
Ramp from the top of the ravine leading to the amphitheater

Ramp from the amphitheater leading to the lowest part of the ravine

Amphitheater located at +5 meters.
It incorporates landscape fountains for aesthetic as well as recreational use

Lowest level of the ravine with Walkable Solar Panels

Section F



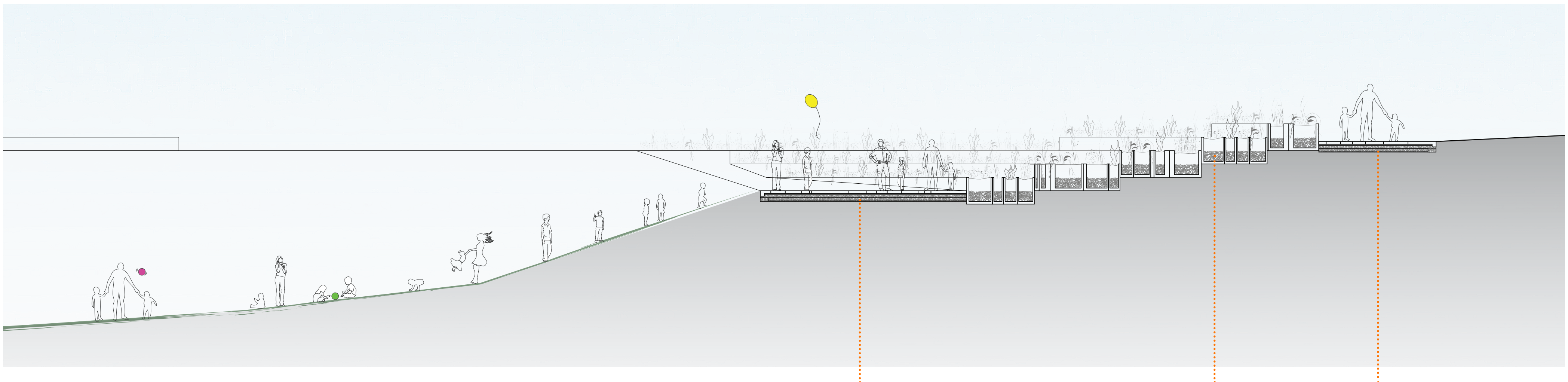
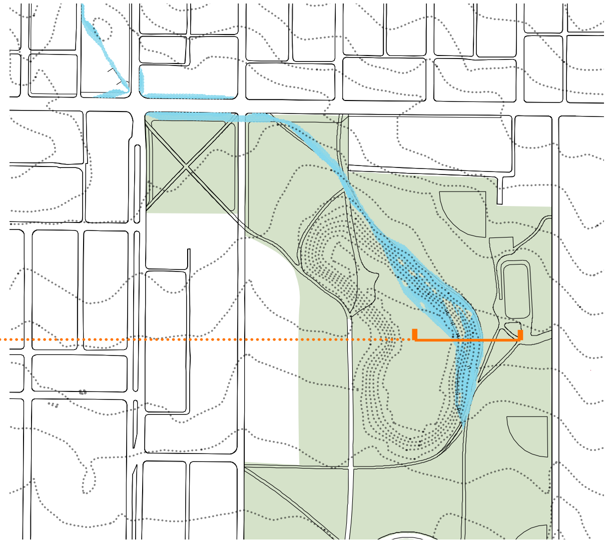


Figure 7-32 Section F | Scale 1:200



Section G

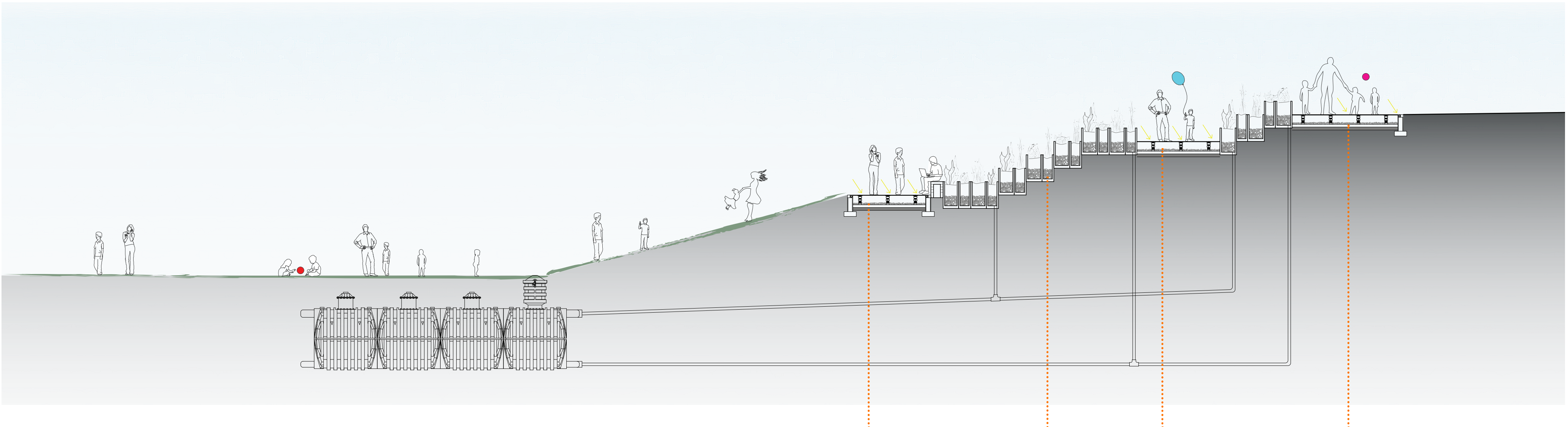


Figure 7-33 Section G I 1:200

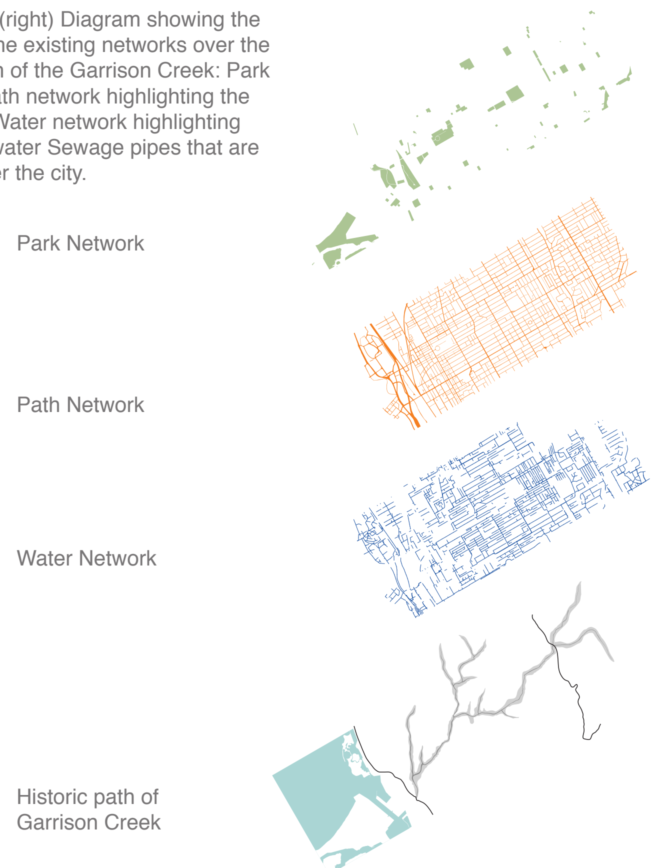
Figure 7-34 View from the top of the Ravine of Trinity Bellwoods Park looking towards the amphitheater.

Chapter 8 I Conclusion

Over the last decade, Toronto has experienced a series of extreme storms that have ravaged the city and its infrastructure. Traditional methods of building impervious surfaces and channelling runoff into the sprawling underground infrastructure are no longer sufficient to meet the needs of the growing population and extreme weather due to global climate change. In order to alleviate the existing problems of the centralized storm-water system, this thesis proposes a modular method of sustainable systems to reconnect city with nature.

The design process of the modules has gone through a series of iterations, where different shapes have been considered to represent the decentralized system. The shape proposed in this thesis, which is a modified triangle, is an ideal shape that shows the fluidity of modules when assembled together. These modules aim to enhance the perception of fluidity of water in the resurrection of the buried Garrison Creek.

Figure 8-1 (right) Diagram showing the overlay of the existing networks over the historic path of the Garrison Creek: Park network, Path network highlighting the roads and Water network highlighting the Storm-water Sewage pipes that are buried under the city.



This proposal for a decentralized system, integrated into the parks and pathways that trace the buried Garrison Creek, could offer a solution to these storm-water issues that could also become a connecting element between historical, ecological, and social aspects of the site. Designed to focus on combining the function of natural hydrologic processes with the existing park programs; this system could also offer an environmentally sustainable method of self-generating energy, educate public on urban disaster relief through natural systems and renewable energy, and ultimately connect them to the historical landscapes of the city.

If city planners were to adopt this approach, the current streetscape of the Garrison Creek sewer-shed could transform into a more pedestrian-friendly network, interconnected with the park network with pauses determined by the presence of water as a scenic display, an interactive playscape, or an educational and functional place to understand the urban water cycle. These spaces would be designed as multipurpose public spaces, accommodating a range of activities as seasons change. While the splash pad would serve as a perfect cooling activity in the summer, it could change to a small roller skating and skateboarding ring during the spring and fall, and finally to a miniature ice skating ring in the winter. This intervention could also expand from the proposed site of the Garrison Creek watershed into other areas of the city. This could then create a city-wide system of interwoven park, path, and water networks, that would simultaneously contribute to the restoration of ecological habitats and ravine spaces.

Through the process of this design, some issues have come to light that have not yet been investigated in this thesis. The issue of collaboration has not been addressed between stakeholders such as planners, water engineers, public work officials, city councillors, and private property owners as this design, as intentioned, utilizes spaces in both private and public properties. The proposal within this thesis is based on the potential of an integrated collaborative approach involving these multiple stakeholders, but for reasons of scope, does not address the many issues such as shared costs, jurisdictional distinctions and liabilities.

This proposal chooses to focus on outlining the potential of hybridized, decentralized landscape-based water management techniques, to suggest opportunities that could exist in helping to address the increasing crisis mitigation requirements, resulting from increasing climate change. Regarding financing, the balance is one of comparing the decentralized systems to the potential cost from disasters, should the systems remain unchanged.

Photovoltaic panel paving and permeable paving systems would also be an added expense above and beyond a typical intervention, but they serve to enhance ideas of sustainability and renewable energy, enabling park users to interact with these systems and become aware of the relation between the infrastructural systems and their workings and inputs. Signage outlining the various systems incorporated within the proposal would also be important as a way of communicating the project goals to a broad public audience.

An additional question the proposal brings to light is the re-use of filtered water for splash pads and other recreational water use. Such re-use of storm-water may raise health questions, as the use of un-chlorinated water for recreational use does not meet the current by-law requirements. Case study examples such as the natural swimming pool in Riehen, Switzerland and man-made springs in Tanner Spring Park, Portland, USA could be used to show how other developed countries use naturally filtered water for public activities without any detrimental impacts, overcoming any legal issues.

This thesis proposes a decentralized hybridized system linked into the natural water cycle to augment existing storm-water management systems. It explores the idea of bringing balance between natural water cycles and the built world. Innovative solutions are needed to meet current and expanding needs of the city, as the current reliance on singular centralized systems alone is no longer responding fully to the city's needs, and proposals such as the one detailed by this thesis could represent a modular approach that could respond to the needs of a variety of conditions and scales.

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