Net Positive Water

by

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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

'Net Positive Water' explores the capability of domestic architecture to combat the developing urban water problem. Urban intensification is contributing to the volatility of urban waters and the breakdown of the urban water cycle. Inhabitant water misuse and overconsumption is overwhelming aging municipal utilities, resulting in the decay of urban water quality.

LEED™ and The Living Building Challenge are recognized Green Building Guidelines prescribing sustainable site and building water standards. Case Studies of domestic Green Building projects will showcase water conservation to enable domestic water renewal. Net Zero Water Guidelines based on the Green Building Guidelines outline Potable and Non-Potable water use to achieve a sustainable volume of water demand at 70 litres per capita per day. Sustainable water practices are encouraged by utilizing domestic building systems to increase water value and water awareness. Time-of-Use and Choice-of-Use exposure for household water related tasks establish water savings through the use of best-performing water fixtures and appliances.

Net Positive Water Guidelines will establish On-site and Building standards for sustainable harvesting and storage of water resources. Clean and Dirty water management will prescribe Passive design and Active mechanical processes to maintain best-available water quality in the urban domestic environment. Net Positive Water building typology will integrate urban inhabitation as a functional component of the urban water cycle to use, reuse, and renew water resources. The method will be tested using a Mid-rise Pilot project to deploy the necessary Passive and Active mechanisms to generate Net Positive Water quality through Net Zero Water sustainable water use. The pilot project is situated in Waterfront Toronto - The Lower Don Lands development to harness regional interests for water renewal and environmental revitalization.

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039 3**.0.6** City of Toronto. Toronto Water. Indoor Water Use Breakdown. http://www.toronto.ca/water/glance.htm

Chapter FIVE

069 5**.01** Potable and Non-Potable household water Demand. Billy Ma. 2012

079 **5.02** City of Toronto. Toronto Water. Indoor Water Use Breakdown. http://www.toronto.ca/water/glance.htm

083-84 **5.03** Quantity of water that is required per household task based on logical use assumptions and NZW calculations. Billy Ma. Refer to Appendix E. Net Zero Water Calculations based on 70 LPCD.

088 **5.04** Net Zero Water Checklist. Billy Ma. 2012

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095 **6.01** Urban Water Use Breakdown. Bluewater and Green water are Clean. Greywater and Blackwater are Dirty. Billy Ma. 2012.

110 6**.02** Net Positive Water On-site Checklist. Billy Ma. 2012

130 6**.03** Net Positive Water Building Checklist. Billy Ma. 2012

Chapter SEVEN

215 **7.01** Sustainable Water Storage. Active and Passive. Billy Ma. 2012

216 **7.02** 100% Water treatment of Active and Passively stored water. Billy Ma. 2012

216 **7.03** Passive Water filtration of total NPW water storage. Billy Ma. 2012

217 **7.04** Passive Water filtration capability. Billy Ma. 2012

217 **7.05** Post-Passive Active water treatment requirement. Reduced Active water treatment demand. Billy Ma. 2012

218 **7.06** Net Positive Water Active and Passive Water Treatment. Billy Ma. 2012

218 **7.07** Excess Active Water Treatment Capacity for Net Positive Water. Billy Ma. 2012

List of Abbreviations

BTES – Borehole thermal energy storage

BTTS – Borehole thermal transient storage

CMHC- Canadian Mortgage and Housing Corporation

CSA – Canadian Standards Association

EPA – Environmental Protection Agency

FEMA – Federal Emergency Management Agency

FPS – FEET PER SECOND

IWN – Interior Water Management

GIB – Green Infrastructure & Buildings

HRV- Heat Recovery Ventilator

LEED™ – Leadership in Energy & Environmental Design

LDL – Lower Don Lands

LPCD – Litres Per Capita Per Day

MGBR – Minimum Green Building Requirements

MURB – Multi-Unit residential building

NPW – Net Positive Water

NRcan – National Resources Canada

NZW – Net Zero Water

OBC – Ontario Building Code

OMB- Ontario Municipal Board

RDI – Reference Daily Intake

SS – Sustainable Sites

STE – Solar Thermal Energy

SWS – Soil Water Storage

STTS – Short Term Thermal Storage

TRCA – Toronto and Region Conservation Authority

TSS – Total Suspended Solids

UNESCO - United Nations Education, Scientific and Cultural Organization

VPS – Vertical Percolation System

WE – Water Efficiency

WF- Water Factor

WWFMP – Wet Water Flow Master Plan

Chapter ONE - Introduction

This thesis shall explore architectural solutions to reduce water consumption and generate sustainable water renewal. Net Positive Water (NPW) domestic typology explores beyond sustainable water performance integrating Net Zero Water (NZW) sustainable inhabitant use to combat the decline of urban water resources. Domestic water use will function as an integrated component of a Net Positive Water building cycle, where buildings will mimic and function as a component of the urban water cycle to generate water renewal.

The significant impact of domestic construction on the urban water problem is identified as the focus for the thesis response in the City of Toronto. High density construction is selected as a form of urban intensification to apply NPW. Green Building Case Studies reflecting Guidelines and Standards prescribed by LEED™ and the Living Building Challenge will be utilized as precedents to showcase sustainable water in higher density building typology.

The Net Positive Water pilot project is a water independent domestic typology utilizing NPW and NZW Guidelines and Standards to establish a 'Building as a Sponge' construction strategy. 'Building as a Sponge' will yield project performance with positive water quality output by utilizing Passive and Active mechanisms for water renewal. NPW On-site and Building management will address Clean and Dirty water conditions under quality categories of Greenwater, Bluewater, Greywater and Blackwater. The pilot project will be subject to the environmental parameters and resource provisions of Toronto's Lower Don Lands Development to function as an active contributor of a restored waterfront environment.

The thesis will conclude by verifying the performance of the pilot project to deploy NPW Guidelines and Standards as a feasible building methodology. A performance matrix will outline the scale of building engagement required to generate Net Positive Water. Criticisms of NPW will identify potential issues with NPW building typology. Key recommendations will be established to explore the impact of Net Positive Water in alternative forms of high density building typology. Criticisms and recommendations will confirm the success of Net Positive Water as a capable form of architecture to combat the urban water problem.

1.1 The Urban Water Problem



Figure 1.01

The City of Toronto is a coastal city of Lake Ontario. Water related activities in the Don & Humber watershed expose inhabitants to severely polluted 'fresh' surface waters.

Humber Bay, Toronto. 2009

Canada's urban inhabitants are squandering their fresh water resources through poor water practices. Water misuse and overconsumption has the removed fresh water from local water bodies resulting in volatile conditions in the urbanized ecosystem. The volatility is diminishing nature's capability to renew regional water content. The disruption of the urban water cycle is resulting to degrading fresh water resources.

The continual decline of fresh water has been documented by UNESCO publications on urban water, emphasizing the need to address ongoing issues relating to the role of water in cities. Tony Clarke, the co-author of 'Blue Gold', a Canadian activist who identifies the regional implications of development expansion onto floodplain and wetland conditions. Over 60% of the wetlands in the world have been destroyed over the past 100 years and replaced with urban domestic inhabitation.

The movement for equity and environmental sustainability comes as global conditions are changing dramatically and becoming more demanding. We are the first generation to live on earth to witness a doubling of population in our lifetime.[1]

Urban intensification in the City of Toronto has continued to increase the demand for domestic water. Dramatic increases in urban population and redevelopment of derelict urban lands expand the urban realm onto waterfront and river delta regions. The need to accommodate urban growth onto waterfront regions has threatened efforts to regenerate decaying environmental conditions that developed previously as a result of urban water abuse. The existing problem with domestic water consumption is compounded by increasing domestic growth, creating a fundamental problem in urban water.

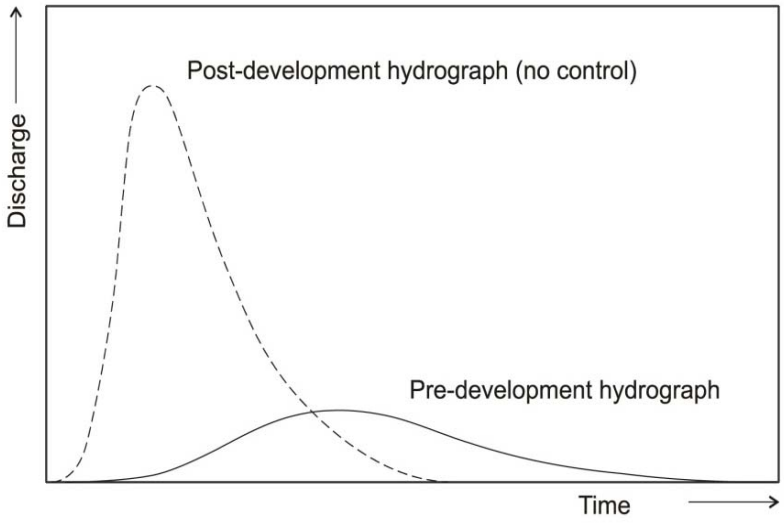


Figure 1.02

Urban Water Cycle Processes and Interactions, UNESCO, Paris, 2006. This chart displays the relationship between stormwater discharge and increasing urbanization. The volatility of discharge post development is a substantial increase from which the regional environment is incapable to absorb or manage.

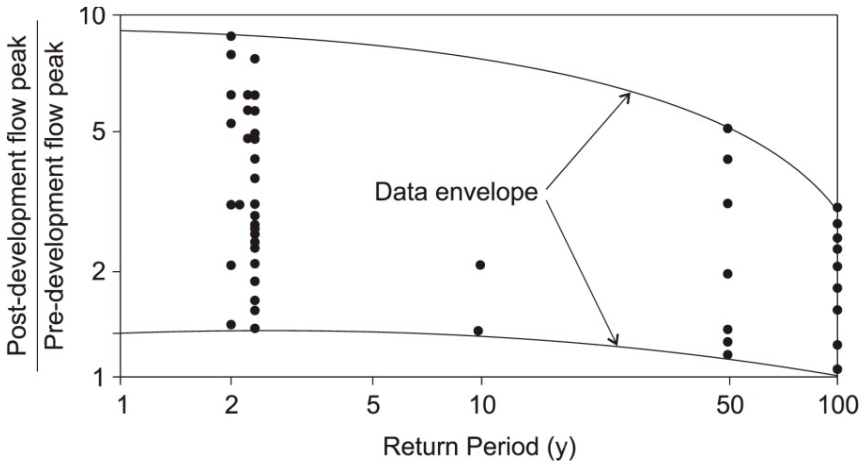


Figure 1.03

The dilemma of the urban water crisis is one of degrading water quantity and quality. Domestic water misuse and overconsumption produces wastewater at quantities that are well beyond the environments natural capacity

Municipal water utilities are severely aged and manage domestic water demand utilizing outdated and non-sustainable water management practices. The established infrastructure cannot sustain the increasing water demands of urban intensification. The increasing strain in Toronto's water profile is accelerating the rate of environmental decay.

Sustainable domestic water has the greatest opportunity for success in redeveloping waterfront regions. Waterfront land is valued for environmental exposure, communal conditions evoking pedestrian engagement, and proximity to water bodies that promotes the value of water resources. The waterfront lifestyle is a susceptible environment to generate a shift towards sustainable domestic water use. Developments on waterfront lands have become highly scrutinized for sustainable operation[2]. The opportunity to harness the energies devoted to regenerate Toronto's waterfront will establish an atmosphere to curb the urban water problem.

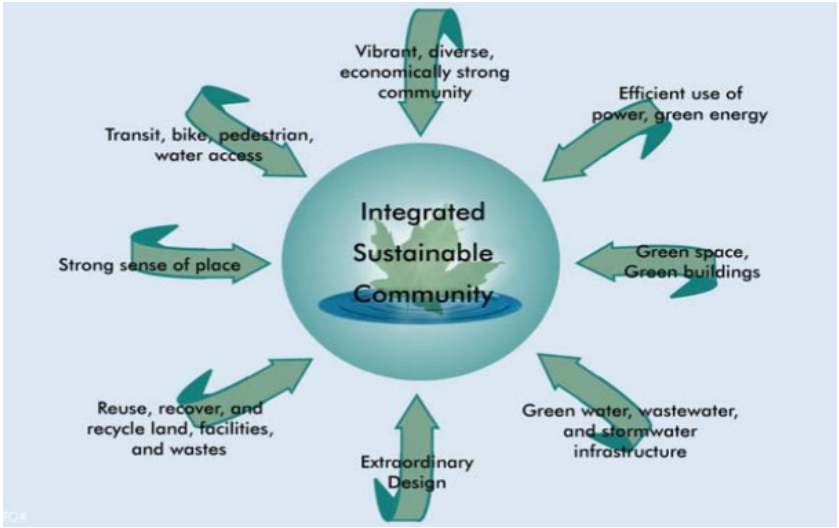


Figure 1.04

An integrated matrix for Sustainability. Emphasis on Green Water, Wastewater, and stormwater infrastructure. Sustainability Framework.

Toronto Waterfront Revitalization Corporation. July, 2005

1.2 Sustainable water in Residential Green Building

Sustainable water use will look at Green Building Guidelines to prescribe building standards and design requirements for domestic typology. Leadership in Energy and Environmental Design (LEED™) and The Living Building Challenge (LBC) are recognized guidelines in the building industry to establish sustainable building performance. This thesis will evaluate LEED™ and LBC, *Site* and *Water* initiatives to establish an architectural response to the urban water problem.

Green Building prerequisites require detailed Environmental Assessments (EA) of project site conditions to provide an understanding of the impact of domestic construction. Site development must include permeable site coverage and the use of native vegetation to reintroduce rain percolation into regional soils. Soil contamination in Brownfield sites must be remediated to re-initialize natural urban water processes. The permeable On-site coverage extends from the landscape onto building surfaces. The initiative reduces the volume of stormwater drainage off of the building envelope allowing urban construction to manage stormwater on-site.

Improving inhabitant water efficiency utilizes Energy Star™ water fixtures and appliances to develop water use reduction within the domestic household. Guidelines divert inhabitants away from using potable water provisions for outdoor irrigation and waste conveyance. Water treatment processes are required to restore post-consumed inhabitant waters to tertiary standards. This will allow water reuse in the domestic environment for non-potable household needs.

LEED™ and the LBC prescribe building performance as a response to the current levels of non-sustainable water use. Simple and advanced improvements to achieve sustainable waters increases inhabitant water awareness to influence resource conservations. Domestic architecture will assist inhabitants to moderate their water use through resource monitoring and metering. Increasing exposure of water resources within the home allows residents to sustainably manage their water profile.

A series of case studies will evaluate Green Building performance in domestic construction. Analysis of Dockside Green development, Victoria B.C., and the Millennium Water Olympic Village, Vancouver B.C. and Drake Landing, Okotoks Alberta will exhibit the Green Building systems to manage *Site* and *Water*. Assessment of the Green Buildings will divulge the necessary mechanisms for water treatment and water renewal to combat against the urban water problem.

1.3 Net Zero Water sustainable use

Net Zero Water (NZW) is a prescription for sustainable water use that places the responsibility and ownership of domestic water in the hands of the inhabitant. NZW improves upon the sustainable water performance of LEED™ to bridge the absolutely performance objective of the Living Building Challenge. NZW performance is calculated from a 'Subtractive' strategy by establishing a single goal for water neutrality at a maximum inhabitant water use value of 70 Litres per Capita per Day (LPCD). An 'Additive' process will accumulate domestic inhabitant performance as a step by step strategy to achieve the sustainable usage value.

NZW Guidelines prerequisites respond to the issue of inhabitant water misuse and overconsumption. Water resources must be sustainably harvested and retained on-site to fulfill annual NZW demand. Improving domestic water performance requires a new model national baseline for water fixtures and appliances. Current baseline values are outdated and inadequate to establish sustainable water use. Greywater must be provided for non-potable household uses.

NZW will establish Clean Potable, and Non-potable quality water provisions to optimize domestic water use. Potable water resources will only be utilized for human consumption and sanitation; with alternative water uses serviced by non-potable water quality. Dirty water Guidelines requires the removal of waterborne debris from post consumed water. Isolating waste from the water medium reduces the need for water renewal. Housekeeping Guidelines will rely on LEED™ Green Housekeeping specifying sustainable product standards that do not negatively impact urban water quality.

To achieve the target of 70 LPCD, optimal water use assumptions have been made for household water related tasks based on best performing water fixtures and appliances. Sustainable water use is based on Time-of-Use and Choice-of-Use prescriptions. Time-of-Use resource exposure prescribes the appropriate volume of water utilized for adequate tasks. Choice-of-Use exposure focuses upon educating the appropriate types of water use for specific tasks.

Guidance for optimal resource use will be provided to inhabitants and monitoring mechanisms will provide greater exposure to water use. A matrix is provided to identify the optimal amount of water required to fulfill inhabitation demands. NZW will utilize cost savings and economic value gained through water conservation as a means to encourage sustainable water use.

1.4 Net Positive Water Guidelines & Standards



Figure 1.05

Net Positive Water Icon

Net Positive Water (NPW) is the generation of positive water quality to combat the urban water problem. NPW Guidelines and Standards utilize inhabitant water consumption to induce an integrated cycle of water harvesting, storage, and the renewal of water quality for cyclic reuse. The NPW cycle manages water under 4 categories of quality; Greenwater, Bluewater, Greywater, and Blackwater under **Clean and Dirty, On-site and Building management**. Greenwater and Bluewater are subject to NPW Clean Water Standards, while Greywater and Blackwater are subject to Dirty Water Standards.

NPW On-site Prerequisites are based on an Environmental Assessment to determine the required initiatives to reintroduce the urban water cycle on a project site. NPW projects must respond to Brownfield contamination, water table levels, groundwater hydrology, and floodplain avoidance. NPW projects must manage 100-year precipitation events.

Clean On-site Water Guidelines establishes sustainable site conditions such as Landscape Areas, Vegetation Areas, Water features and pedestrian pathways. The prescribed areas will function as the Passive component of sustainable water harvesting and water storage to provide sustainable water resources for NZW inhabitant use.

Clean On-site Water Standards require site conditions to be capable to Passively harvest and store Clean water resources. The volume of landscape and soil content is dictated by water harvesting requirements to sustain annual NZW inhabitant demand. Passive storage devices must preserve the Clean water quality of all stored water resources.

Dirty On-site Water Guidelines are prescribed for urban streetscapes including roadways, at-grade parking and pedestrian pathways. Dirty site areas will isolate debris and divert on-site water content for water harvesting. Native and resilient plant species will be utilized to filter urban debris from on-site water. Site servicing will remove urban contaminants for sustainable waste management.

Dirty On-site Water Standards requires Greywater and Blackwater quality to be directed into NPW treatment processes to remove contaminants and waterborne debris from on-site water resources. Resilient ground substrates and soil content will be utilized as a Passive harvesting and storage mechanism for on-site Dirty water. The volume of landscape and soil content is dictated by water harvesting demands to sustain annual NZW inhabitant demand.

NPW Building Prerequisites requires domestic typology to harvest sufficient Greenwater resources to provide for NZW sustainable use. Building materials must be non-toxic, and must not off-gas, release leachate, or decay to the detriment of harvested water quality. NPW Buildings must maintain continual water harvesting, storage, and renewal in the NPW cycle. Building scale and inhabitant density will be determined based on the regional availability of water resources.

Clean Building Water Guidelines prescribe Clean On-site Water Guidelines on building rooftops, podiums, amenity areas, open circulation pathways, unit terraces and balconies. Drainage design for water harvesting is separated into Exterior and Interior categories. Interior water storage mechanisms will provide for NZW inhabitant demand and the NPW cycle will maintain harvested water quality. LEED™ Green Housekeeping Guidelines will be utilized with environmentally safe cleaning solutions.

Clean Building Water Standards establishes minimum permeable coverage areas for NPW domestic typology on the rooftop, building envelope, circulation spaces open to the environment, and the building podium. Exterior drainage on canopies and building surfaces will be designed to drain towards permeable harvesting areas. Interior drainage must be protected preserve water quality as harvested water is directed to storage mechanisms. Active water storage will not allow water quality to decay. NPW Buildings must provide Potable and Non-Potable water for NZW inhabitant use.

Dirty Building Water Guidelines establishes Exterior water drainage from Dirty On-site management to convey Dirty site water into water treatment systems. Interior drains dedicated for harvested water will be designed to reduce the volatility of flow as the medium travels to treatment and storage mechanisms. Dedicated drains will be provided for post-consumed Greywater and Blackwater, isolating each quality of inhabitant contribution to be directed to water treatment systems.

Dirty Building Water Standards require all 4-categories of water quality to be drained into water treatment processes. The NPW treatment processes must remove 100% of inhabitant waste from Blackwater quality resources. Active NPW Treatment must remove 100% of waterborne chemicals and debris from Greywater quality resources. Treated Greenwater and Bluewater water must be inspected by qualified water inspection staff to adhere to local health regulations and standards. Water will be restored up to and beyond tertiary quality for water reuse in the NPW cycle.

1.5 NPW Pilot Project

The application of Net Positive Water Guidelines and Standards will be applied to a pilot project to verify the sustainable water methodology. Building design will explore the effective capability of residential typology to combat the urban water problem. The application of environmental constraints and a strategy to manage available water resources will test the capability for residential architecture to generate Positive water quality. The pilot project will achieve Positive water quality by deploying sustainable water harvesting to establish sustainable water resources for Net Zero Water inhabitant use. The application of the pilot project is divided into two parts:

Part One will explore the impact of residential density to establish sustainable water. The outcome of the exploration is the selection of a sustainable building form to be utilized to combat the urban water problem. This thesis selects Mid-rise building typology as the alternative form of residential construction to generate Net Positive water.

Part Two will deploy the selected form of urban residential intensification following Net Positive Water and Net Zero Water Guidelines and Standards. This thesis will situate the pilot project in the Lower Don Lands Development, City of Toronto. The Lower Don Lands is a waterfront revitalization project that is planned as an urban revitalization effort to re-naturalize urban water processes.

The conclusion of the pilot project will outline the performance of the domestic building strategy. A matrix identifies the process of establishing greater Passive building performance to generate Net Positive Water quality.

1.5.1 Residential Density for Sustainable Water

The inhabitant density of a residential project is a significant component of a projects water use profile. Residential density has a linear relationship to the volume of water resources required by inhabitants. In conditions where too much density is situated in a fixed urban area, the volume of inhabitant water demand cannot be supported by the water provisions that are sustainably harvested on the project site. Residential density in an urban project can result in sustainable or non-sustainable water use.

Residential density also affects the scale and size of the building form. Urban construction has an environmental impact on the urban water cycle and the urban water problem. Eligible pilot project building forms will be required to accommodate residential density in conjunction to mitigating the environmental conditions that have lead to the urban water problem.

Dockside Green Development and the Millennium Water Olympic Village were constructed utilizing mid-rise, medium density construction to achieve sustainable water. Mid-rise has been utilized as a higher density building type to develop sustainable resource use for LEED™ certification. Mid-rise construction has also been recognized by the Living Building Challenge as an alternative to satisfy residential intensification with high levels of Passive Sustainability.

This thesis selects Mid-rise Multi-Unit Residential Building (MURB) as an alternative building form to develop a multi-faceted engagement of sustainable water. The mid-rise pilot project will negotiate the impact of residential density for sustainable water following the examples of Green Building construction.

1.5.2 Mid-Rise Pilot Project in the Lower Don Lands

Site selection for the NPW pilot project will be situated in Toronto's Lower Don lands to harness the interest placed upon the waterfront development to initiate water renewal and environmental restoration. Sustainable waterfront inhabitation will depend on domestic architecture to mitigate the harmful outcome of urban water demand. The NPW pilot project establishes water independence and water renewal to sustain waterfront inhabitation.

A Lower Don Lands Environmental Assessment has provided the parameters to establish building and landscape integration. NPW design will be subject to municipal weather data documenting environmental extremes gathered over the past 30 years. The post-industrial Brownfield environment requires contaminant soil remediation, a process provided by a pilot soil recycling facility operated by Waterfront Toronto. Land reclamations to establish the LDL wetlands will remove the site from Floodplain conditions. The site is subject to a high water table whereby NPW construction is not required to convey precipitation into the ground. All On-site conditions adhere to NPW On-site prerequisites.

Building program and building form is designed to emphasize the Passive Survivability of mid-rise typology. 4-single loaded residential towers with heights of 7-5 storey are situated above a 2-storey building podium. Circulation space is open to the environment and canopied for weather protection. The podium structure establishes an exterior streetscape condition with retail and residential foyers, lobbies, and water features. A centralized landscape podium traverses 3-storey's with a pavilion, outdoor amenity space, and a meandering naturalized waterway that ends in a reflecting pond. Building utilities are situated below grade, containing Active water treatment, Active water storage and waste management.

Passive water banking utilizes Building and On-site landscape Silt-loam soil content under Clean and Dirty management categories to function as a water storage medium. Exterior water drainage directs precipitation from impervious building surfaces into passive water storage devices. Green roof systems, landscape planters and surfaces, canopies protecting building circulation and building facades store and drain water resources while maintaining Clean water quality. Bioswales and infiltration galleys utilize substrate materials and resilient plant species to trap urban debris in Dirty water management. Interior water drainage receives water resources from the building exterior to direct the medium into NPW Active systems.

Active water banking utilizes building systems developed for thermal conditioning in the form of capillary radiant heating and a subterranean borehole network. The two systems utilize water as a thermal transient, whereby water is heated from roof mounted solar array, stored in the ground to retain heated energy, and distributed to residential units to fulfill thermal conditioning demands.

Active water treatment utilizes advanced systems whereby harvested water content is subject to; biological waste treatment, sediment filtration through an Ultrafiltration process, and waterborne bacteria is destroyed through innovative Ultraviolet technology. Water treatment is optimized to treat water under Clean and Dirty quality Management. Harvested water from Clean On-site Management is only subject to Ultraviolet treatment such that the medium is safe for Active and Passive water banking and NZW inhabitant use. Harvested water from Dirty On-site Management and post-consumed NZW Greywater/Blackwater is subject to Ultrafiltration and Ultraviolet treatment to renew water resources and remove waste contaminants/debris. Water treatment produces potable and non-potable water for NZW inhabitant use.

The NPW pilot project will establish sustainable water for domestic inhabitation by constructing NPW households based on Potable and Non-Potable water provisions. Household design will provide Potable water in two locations; the Kitchen for food preparation and the Lavatory for sanitation. Monitoring and metering displays will be deployed at each faucet and tap to expose water use. Kitchen sinks, lavatory basins, and additional water hardware will be deployed to expose water under Time-of-Use and Choice-of-Use awareness.

Non-Potable water will be supplied in household Kitchens, Lavatory's, and Bathrooms to fulfill non-potable sanitation, waste conveyance, and Green housekeeping. Greywater guides will be integrated into water monitoring devices to address the appropriate use of non-potable water. Greywater filtration devices will be deployed at each water drain to isolate household debris for waste disposal and to separate contaminants from the water medium. Bathrooms and shower stalls will be thermally insulated to prevent unnecessary use of hot water. Bathrooms will utilize dehumidifiers to recover moisture from thermally conditioned air in addition to drainage systems integrated into heat recovery ventilators.

1.5.3 Conclusion of the Mid-rise pilot project

A Net Positive Water matrix explains the application of Passive and Active water storage in the pilot project building performance. The matrix identifies the relationship between water Quality and Quantity management, whereby greater calculated Passive building performances equates to a greater capacity for the NPW building cycle to combat the urban water problem. The larger the quantity of Passive water mechanisms deployed throughout an NPW project, the greater the capacity to generate Net Positive Water. Key calculations and figures have also been presented.

1.6 Net Positive Water to combat the Urban Water Problem

Positive Water quality generated by Net Positive Water domestic building typology will combat the urban water problem. Positive water is generated from sustainable water harvesting, domestic water conservation through Net Zero Water and water renewal. Passive and Active water mechanisms enabling NPW projects to sustainably manage the environmental impact of residential construction. NPW building typology will continuously harvest water resources and release positive quality water as a result of a NPW building cycle.

Implications and recommendations will be established after an evaluation of existing and potential barriers for Net Positive Water. Exploring the feasibility of the sustainable water strategy identifies economic factors to subsidize increasing domestic building costs. Alternative Passive and Active strategies with higher density building forms should be encouraged to yield improvements in Net Positive water generation.

The thesis will conclude by defining the relationship between the Passive and Active strategy for Net Positive Water. The greater the Passive capability of a Net Positive Water project to store water resources, the less demand is placed on Active mechanisms to achieve water storage. The relationship between Passive and Active water mechanisms are interdependent to support Net Zero Water. Passive performance conditions will encourage the establishment of Net Positive Water capabilities where additional urban water resources can be renewed.

Endnotes:

[1] Hawken, Paul. 2007. Blessed Unrest, How the Largest Movement in the World Came into Being and Why No One Saw It Coming. Pg.13

[2] Waterfront Toronto has prescribed a minimum level of Sustainable Building performance for all Waterfront projects

Chapter TWO: Urban Water Problem

In the award winning film documentary entitled: "Blue Gold: World Water Wars" 2008; Tony Clarke outlines the current plight of global water issues by defining the limited and declining quantity of available fresh water resources.

'If we massively remove water out of an area, the ecosystem is disrupted, the natural habitat damaged, biodiversity reduced, and aquifers dried.'

The remark outlines the environmental decline that has occurred as a result of urban intensification and water overconsumption.

Canada's water use within Cities is no longer sustainable under current economic and environmental conditions. Canada's aging water infrastructure is unable to support the increasing demands of urban inhabitants. Cities are relying on an aged and decaying water infrastructure that is unintentionally destroying the environmental conditions that make water resources renewable. Urban inhabitants are squandering their fresh water resources through poor water practices and what can best be described as a 'lack of awareness' of the developing water problem. The affects of water overconsumption is the removal of fresh water content from local waterways and volatility in the regional water cycle.

The lack of awareness and the belief of water abundance are all social traits that reflect an urban population that is oblivious about the current state of urban water. One of the leading reasons why Canadians are unaware of the current state is due to the fact that the problem is not visible in the urban realm. City infrastructure and building development are distributed over tremendous areas of land, making it difficult to pinpoint a specific component of the degrading water profile. The breakdown of aging water infrastructure is hidden beneath urban streetscapes, and the loss of groundwater flow resulting in the disruption of the natural water cycle is also invisible.

The need for water conservation and sustainable water use is a relatively new phenomenon in Canada that has developed over the past 25-years[1]. The growing interest in the health of urban waters is still in its infancy while the many years of poor water practices continue to degrade urban water resources. Unlike less fortunate regions of the world, the issue of Canada's urban water problem is not that our Cities are running out of potable water resources. The urban water issue is a component of the non-sustainable Canadian lifestyle combined with pressures on aging water infrastructure that is leading to the decay of urban water quality.

Past generations of urban inhabitants were not informed about the impact of domestic water conservation on the environment. As a result of the lack of awareness, the tendencies that have led to urban water waste have gone largely unchecked. Many urban households are oblivious to the decline of urban water because they live in an established environment that provides the resource for very little value[2]. The practice of saving water has not had as much significance in the domestic household when compared to the need to conserve expensive energy and electricity[3]. The federal government's Green Plan prescribes that the key to increasing domestic engagement for water conservation is to increase the value of urban water resources so that inhabitants pay the fair market cost for the amount of water they use.



Figure 2.01

There are very limited regions of the world which provide inhabitants with fresh potable resources direct from regional water bodies.

2.1 Canada's Water Use

Canada's population is fortunate to live amongst a wealth of natural resources and a landscape of environmental abundance. Canada borders upwards of 1/5th of the worlds surface fresh water in the form of The Great Lakes Basin. The Great Lakes are a component of the image that Canada projects as a nation with plentiful clean water resources[4]. The social awareness for Canada's water profile is one of endless water flow, replenished and renewed by the wealth of the environment that we inhabit.

Over the past 100-years, Canada's population has intensified in waterfront Cities following an international trend that has its origins in maritime commerce and globalization[5]. City infrastructure was developed to accommodate for urban growth through the construction of resource networks to provide water and electricity over the greater span of a City area. The result of this utility infrastructure was the provisioning of clean, potable water resources to each and every City household.

The bulk of water infrastructure development occurred towards the beginning of the 20th century. What was then a state-of-the-art water management system was designed as a simple operation because water treatment technologies were either non-existent or still in their infancy[6]. Wastewater treatment was not deemed necessary as there was no sense that Cities would run out of fresh water. Authorities were also not aware that the dilution of freshwater resources by dumping waste back into regional water bodies would eventually lead to non-potable water quality. The water utility functioned by simple means to deliver potable water to where it was needed, transporting wastewater out of the City so that the contents would not disrupt the health and safety of City inhabitants[7].

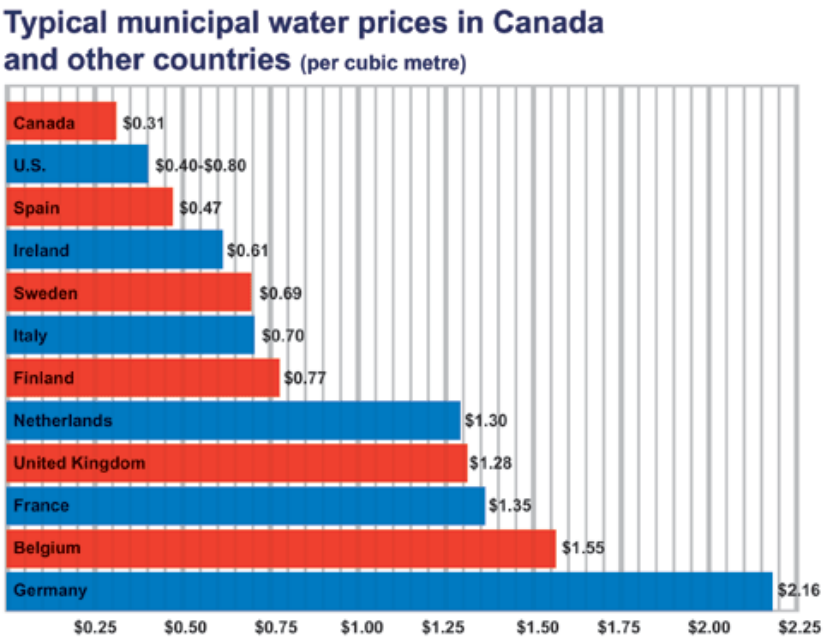
Water provisions improved the health and safety of urban inhabitants and it established an environment that allowed Cities to thrive. As the urban Canadian City developed and grew over time, water networks continued to expand in size and complexity, maintaining the constant availability of fresh water resources that has become a fundamental requirement for Canadian living. Potable water is connected to every City building, and the resource is immediately available with the simple turn of a tap.

As Cities grew and the size of water infrastructure expanded, the cost of water provisioning was kept low because the volume of urban waste output did not sufficiently impact the quality of the water that was used. The basic provisioning of water without the need for extensive treatment processes was relatively inexpensive. The urban ecosystem was capable of supporting urban water demands, and this reduced the amount of development that was required to ensure the quality of water resources.

Figure 2.02

Canadians pay substantially less for water delivery when compared to other nations. The figures above do not account for the cost of water treatment.

Environment Canada.



Canada maintains one of the lowest economic rates for water distribution in the world. The prices are so low that a significant number of existing urban housing stock does not have water meters to measure inhabitant consumption. These homes are charged a flat-rate water cost that is the most common pricing structure for water utilities in Canada.[8] The flat-rate pricing structure has been preferred because it is perceived as a simpler operation for both the customer and municipal administrators. This system allows the inhabitant to pay the same rate no matter how much water is consumed. The combination of a cheap, flat-rate water provisioning and the perception of plentiful water resources have established an atmosphere where water is not valued as much as it is in other regions of the world.

2.1.1 Development of Urban Water issues in Canada

Between the years 1994 to 1999, 1-in-4 Canadian municipalities experienced issues with water. Water shortages were reported due to insufficient provisioning of water resources as a result of degrading watermain infrastructure. Interruptions in water provisioning were caused by drought in the ecosystem during dry seasonal conditions where natural freshwater resources were sparse. In 2001, The Federal Commissioner of The Environment and Sustainable Development declared that heavy water use had severely stressed the ecological regions of Southern Canada. The stress was associated with the intensification of urban development followed by an increase of water demand that resulted in the degrading environmental conditions.

The environmental impact of water use has become the focus of urbanized Canadian Cities as they study the resource use tendencies of their inhabitants. Municipal reports have identified that Canadians are abusing their resources and water is one of the resource streams that has performed the poorest. The reports conclude that urban inhabitation is causing the fall of regional water tables, degrading water quality in urban water bodies, and the disruption of the natural water cycle. The combination of these issues has slowly developed into a water problem that is not only getting worse, but it has clearly defined the use of water in Southern Canada as a non-sustainable and environmentally damaging practice.

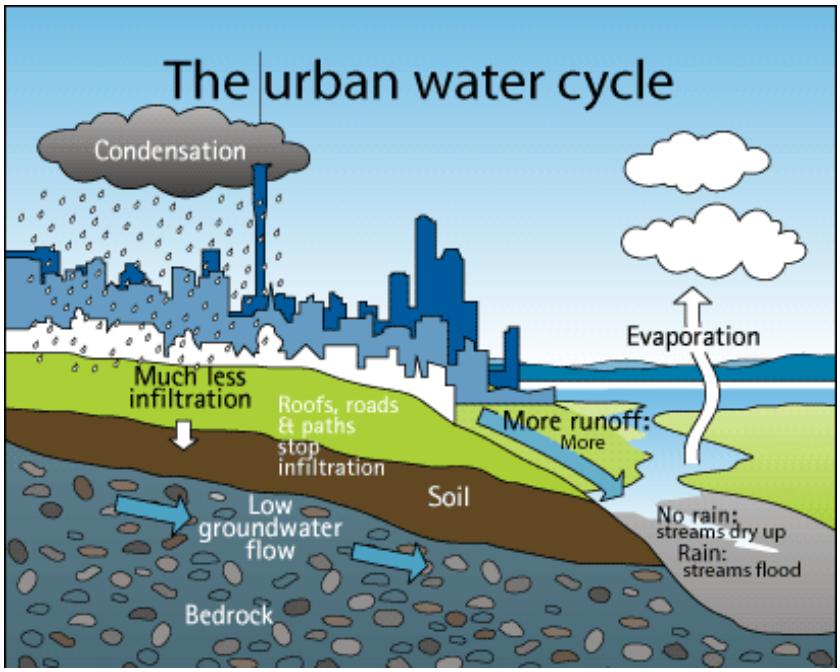


Figure 2.03

Urbanized areas disrupt the water cycle by hindering ground infiltration. The result is a lower water table, less ground water flow, and results in volatile waterway conditions.

Auckland, New Zealand. 2007.

2.1.2 Water Use impact on the Urban Environment

The environment replenishes water resources as the medium travels through the natural water cycle. Water falls to the ground as precipitation or snow, infiltrating the surface of the land and percolating through the soil as groundwater. Groundwater flows naturally towards regional water bodies where the surface waters on rivers and lakes evaporate and return into the atmosphere. Water resources are replenished in quality and quantity as a result of groundwater flow[9].

The ecosystem utilizes the cyclic water process to establish habitats capable of supporting inhabitants. With over half of the world's population located in coastal waterfront habitats, dense urban inhabitation adds great difficulty to nature's water replenishing processes. Freshwater is removed from the ecosystem and is replaced by post consumed wastewater, while groundwater flow is disrupted as a result of the urban realm.

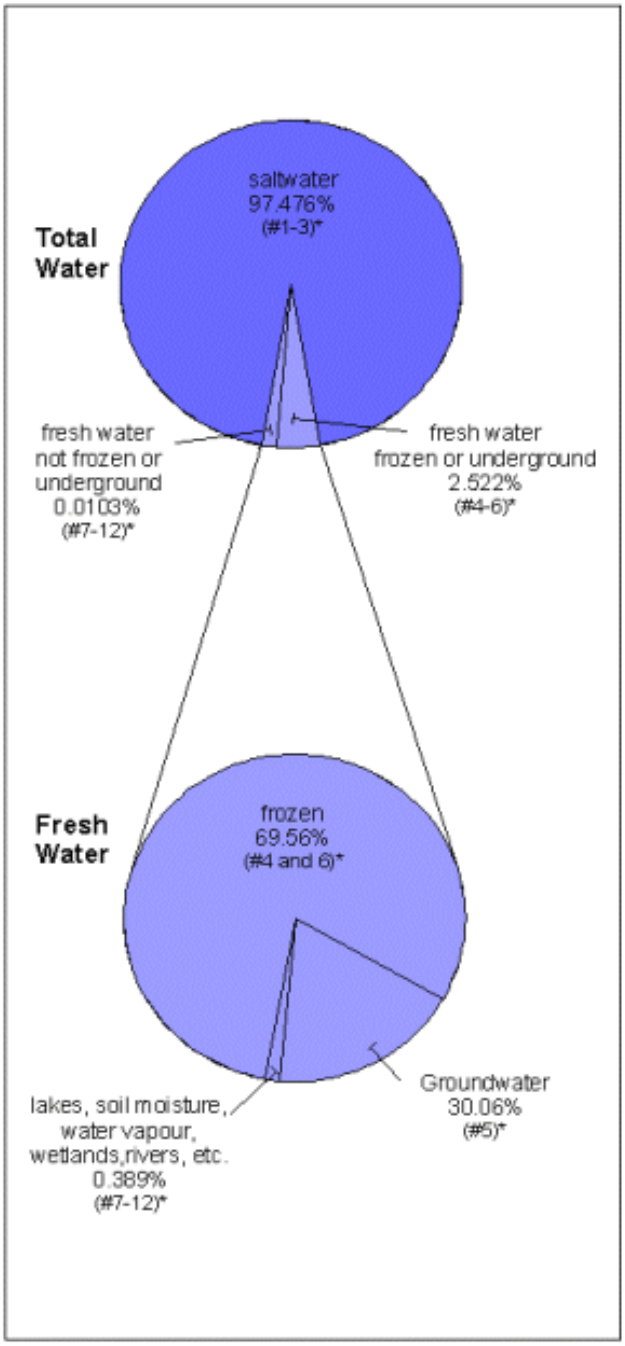


Figure 2.04

Groundwater is an essential source of fresh water containment. Urban areas have reduced their groundwater content in place of urban infrastructure and the built environment.

World Health Organization.

Canadian Cities have been constructed as a greater impervious area to support commerce, transportation, and to shade and protect its inhabitants. Urban buildings have been designed to direct precipitation off of the structure as a fundamental composition of the building envelope. Impervious building surfaces and the continuous use of surface materials that do not allow rainfall to infiltration into the ground cause a disruption in the natural flow of water. This results in stormwater runoff from urban buildings that outflow tremendous volumes of water into City water infrastructure.

Cities have been designed to flow precipitation out of the urban realm so that streetscapes are not flooded by stormwater. City water infrastructure collects precipitation from buildings and streetscapes and diverts the medium into its subterranean water infrastructure, carrying the stormwater directly into regional rivers and water bodies. The rate and quantity of the stormwater outflow can be tremendous, and the volatility of the outflow during storm events can overwhelm the natural absorption capabilities of the regional ecosystem. Precipitation runoff that is not captured by City stormwater infrastructure carries urban debris across the greater impervious area, dumping urban pollutants into surface freshwater bodies.

One example of Canada's urban water problem is the Don River Watershed, the most urbanized waterway in all of Canada supporting almost 2.7 million inhabitants in the City of Toronto. In 2007, Environment Canada documented a water quality rating of 34.8 out of 100 for the Don River. It is the lowest rated health evaluation of all the rivers in Canada. The urbanized water cycle of the Don Watershed does not have the capacity to absorb the vast quantity of dirty urban water that is dumped into the environment by the City. The waterborne debris that is flushed out into the Watershed is one of the reasons why urbanized rivers like the Don are in a state of severe environmental decay.

The Don River Watershed is a prime example of the urban water problem, displaying the environment's inability to support urban water mismanagement. The environmental consequences of disrupting the natural water cycle and groundwater percolation from the urban City area has resulted in lands to dry up, the loss of surface water in river estuaries, and the death of native plant species[10]. The developing environmental issues explain why a nation with plentiful water resources has developing issue of urban water scarcity and ecological stress.

"*More than one-half of the world's major rivers are being seriously depleted and polluted, degrading and poisoning the surrounding ecosystems, thus threatening the health and livelihood of people who depend upon them for irrigation, drinking and industrial water.*" *World Commission on Water for the 21st century.*

2.1.3 Economic impact of Degrading Urban Water

The City of Toronto will be used as an example to demonstrate the economic impact of the urban water problem in Canada. The current state of water in Toronto is in decline. Up to 77% of the City's water infrastructure is functioning past the expiration of the system's service life. A reported 1,500 watermain failures are recorded each year, costing the City an estimated $87 million dollars to renew the aging watermain utilities[11].

Toronto's water infrastructure and its wastewater management practices are severely outdated. The aging utility was mapped in a fashion where portions of the regional river system were utilized to absorb peak water flow during major storm events. Water infrastructure was designed with no separation of stormwater and sewage drainage, resulting in untreated wastewater dumping into regional waterways when the utility was over capacity[12]. In 2004, untreated sewage discharge from the City of Toronto by-passed wastewater treatment plants dumping upwards of 907 million litres of wastewater into Lake Ontario.

The cost to repair and improve Toronto's water infrastructure is estimated at 30-40 billion dollars over the next 15 years[13]. The investment is intended to eliminate the conditions that contaminate regional river systems. Municipal authorities have established the grounds to eliminate all Combined Sewage Outflow (CSO) from Toronto's wastewater system and to renew watermain freshwater infrastructure to a state of good repair.

Although government authorities have developed stimulus funding to contribute to the cost of water infrastructure repair, the bulk of the economic burden will be absorbed by the City's inhabitants. The average water bill for a metered household in Toronto cost $567 dollars in 2009, increasing to an average of $618 in 2010. Water rates have increased 510% each year for the past 6-years (2006-12). Effective of January 1st, 2012, the Toronto City Council approved an additional 9% general water rate increase for all water consumers. The traditional economic value of urban water resources is changing to meet the developing needs of population intensification and urban growth.

The increasing cost of Toronto's water is not only the product of necessary infrastructure redevelopment, it is a result of the change in pricing structure from a flat-rate water utility to a metered system that more accurately bills the financial cost of inhabitant consumption. The outdated simplified water utility is changing to encourage more responsible water use.

Canadian municipalities have also recognized the state of ecological decline of watershed areas as a result of poor urban water practices and the increasing volume of water demand as a result of urban intensification. Initiatives to regenerate degrading ecosystems like Don River Watershed Regeneration Plan require substantial economic contributions[14]. The economic demands to remediate the degrading quality and quantity of urban waters are extremely high. These factors are compounded by the added stresses to accommodate future urban development.

Provincial and Federal authorities prescribe Toronto as one of the nation's major regions for residential intensification. Toronto's urban growth is approaching the leaders of other developing urban centers such as Calgary - Alberta, and Dallas -Texas.[15] The Greater Toronto Area (GTA) is one of North America's largest metropolitan regions with a size and population that is comparable to cities such as New York, Chicago, and Los Angeles. The City of Toronto 2010 Official Plan projects a population increase of approximately 537,000 inhabitants and an additional 544,000 employment opportunities by the year 2031.

The resulting atmosphere of water stress brings to emphasis Canada's urban water problem. Canadian Cities such as Toronto will be placed under substantial economic strain to achieve environmental regeneration, water renewal, and infrastructure redevelopment while accommodating urban growth. In light of increasing strain in water infrastructure to support Canada's burgeoning urban population, establishing a profile of Canada's domestic water use will identify the state of urban waters.

How much water are Canadians using?

Recognizing the issues of the urban water problem in this thesis, the definition of water conservation and sustainable water use must be understood to clarify the extent of overconsumption that occurs in Urban Canadian cities. The questions that must be asked are: *How much water are Canadians using?* and *How much water should be used?*

To provide context to measure Canadian water consumption, inhabitants in Europe use upwards of 200 Litres per capita per day (LPCD)[16]. Our neighbours to the South, The United States, consume twice the European amount at a daily sum of 400 LPCD. Americans consume the highest volume of potable water per day in the world. Comparing North America and European nations that have a wealth of water resources, the World Water Council has documented that 1 in 6 persons worldwide have no access to safe water at all. Unfortunately, Canada's water consumption is also recorded as one of the highest per capita water users in the world, second only to the United States. Canadian inhabitants consume an average upwards of 248 LPCD as of 2010.

How much water should be used?

The World Water Council in conjunction with the United Nations Development Program has designated a minimum amount of 20 LPCD of potable water is required to maintain the adequate health of each person under initiatives to enforce social equity and fundamental water rights. Clean water is required to fulfill the demands for human sanitation, to combat illnesses, and to prevent the spread of disease. The minimum sum of clean water required to do those tasks is assessed at approximately 50 LPCD. An acceptable tolerance to prescribe a realm of comfort is assessed at 60-80 LPCD, and this range of water consumption is internationally accepted as a sustainable volume of water use.

At current levels of water demand, Canadians are using more water than what is available each day to more than 1 billion people across the world. At the recorded levels of 248 LPCD, Canadians are using 3-4 times the volume prescribed for comfortable water consumption. 248 LPCD is a national water consumption average that unintentionally hides the true volume of urban Canadian water consumption. Out of the 5 largest Cities in Canada, Vancouver records a per capita water use at 320 LPD, Calgary at 451 LPCD, 272 LPCD in Ottawa, 253 LPCD in Toronto, and 460 LPCD in Montreal.

The documented water figures highlight the sheer volume of overconsumption that occurs in urban Canadian Cities when compared to global counterparts. The heavily undervalued resource has socially transformed from a fundamental necessity of life, to a commodity that can be wasted, used, and misused as long as inhabitants can afford to do so. In the advent of changing municipal policies, needed water infrastructure upgrades, and the declining environment of urban Canadian Cities, the hidden economic value of water resources is beginning to materialize.

2.2 Domestic consumption and the urban water problem

It is the intention of this thesis to focus on the design of residential architecture as a viable means to encourage water conservation. Residential architecture can encourage water conservation by exposing the value of the resource thereby establishing sustainable water demand. The net result should transform the Canadian 'lifestyle' to provide greater awareness and knowledge of the inhabitant water profile.

Residential water demand accounts to over 50 percent of the Canada's water use profile[17]. Domestic water consumption is the largest segment of water demand in Canada and that makes it one of the most vital contributors to the existing profile of overconsumption. The 'lack of awareness', 'lack of water knowledge/education' has become rooted in the domestic lifestyle of urban Canadians and it highlights the high volume of water engagement that occurs in residential building typology. The use of household water affects other resource segments as well, with over 30 percent of a City's municipal energy profile dedicated to meeting the demands of domestic hot water heating.

Residential architecture can take a proactive role to influence the Canadian lifestyle and improve domestic water practices. Domestic buildings in Canada have been readily designed to engage inhabitants for water conservation and water use reduction. The reason why the volume of domestic water consumption is so high is attributed to the lack of building engagement in water efficient household fixtures and plumbing requirements. Outdated water hardware simplifies inhabitant controls and there is no indication as to how much water is being wasted.

Household plumbing feeds potable water at a high rate of flow providing inhabitants with large sums of water within a short period of time. Wastewater drainage is designed so that water does not overflow and flood the home. Drainage systems allow large volumes of water to flow out of the home at extremely fast speeds.

Design trends have influenced more opulent bathroom and kitchens and the diversified application of potable water use has only made the domestic water profile worse[18]. Domestic emphasis on kitchen and bathroom design has increased the number of opportunities to access water. The ease of water use and the increasing number of fixtures are the root of the water problem in dwellings.

The economic cost of water use under existing pricing policies establishes a post payment process where inhabitants are made aware of the cost of water, but the billing process does not elaborate and how the level of water demand has accumulated[19]. Canada is one of the few nations in the world that provides potable water all forms of domestic use. Inhabitants use potable water for non-potable tasks such as landscape irrigation, car washes, and waste conveyance in toilets. The educational gap between water use and water value is very large and this gap is evident in domestic water misuse.

The World Water Council in conjunction with The United Nations Development Program has developed initiatives to curb the growing threat of diminishing fresh water resources. Governing organizations and their regional affiliates have established guidelines to preserve and manage the worlds freshwater. Canadian municipalities have highlighted the need for less residential landscape irrigation, conservation guidelines for hot water use, and initiatives to bring greater awareness and improve inhabitant water use within the household. These initiatives show that the key to address the urban water problem is to shape the conservation ethics and the water habits of urban inhabitants.

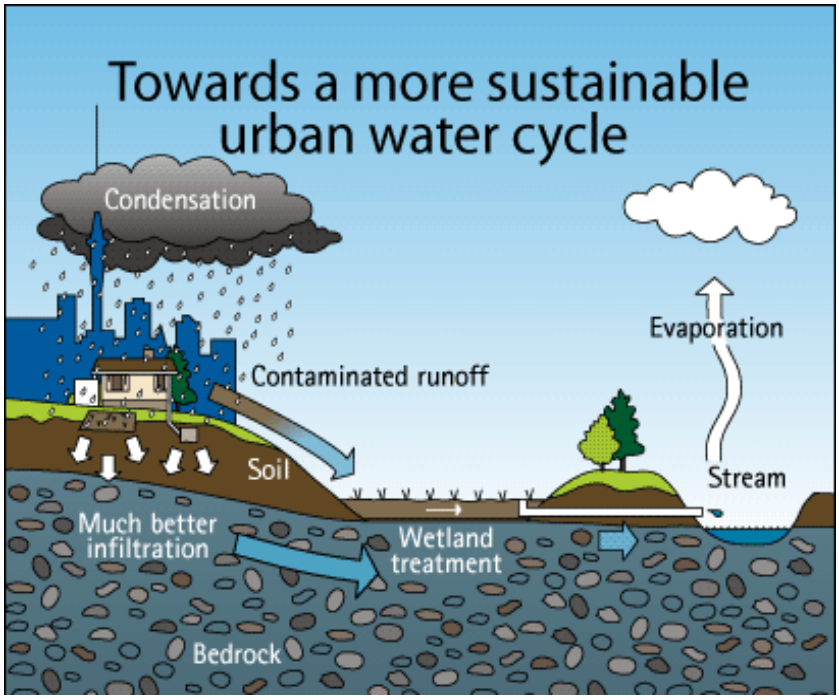


Figure 2.05

An example of sustainable urban water cycle where natural features are restored for the purposes of groundwater renewal as well as stability amongst urban waterways.

Endnotes:

[1] Environment Canada has emphasized water conservation over the past 25-years. http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=F25C70EC-1

[2] Refer to Figure 2.02

[3] The cost of water in the City of Toronto is approximately 22 percent of the cost of electricity. 2012.

[4] Municipal authorities and conservation organizations have established the need to maintain clean water conditions. http://www.swcs.org/en/publications/great_lakes_clean_water/

[5] The year 2009 marked the first time in human history that has documented a greater sum of population inhabiting urban areas over rural lands. http://www.un.org/esa/population/publications/PopDistribUrbanization/PopulationDistributionUrbanization.pdf

[6] Average age of Toronto's watermain network is 55 years old, with 17% over 80 years, and 6.5 % over 100-years. http://www.toronto.ca/water/supply/system/watermains.htm

[7] Early water infrastructure disposed of human waste by directing the material towards rivers in the outlying areas of the city, where the city itself was not affected. http://www.toronto.ca/water/sewers/about.htm

[8] 56% of Canada receives a flat rate water bill no matter how much water is used. http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=23CA8A0D-1

[9] The nation's land mass contains approximately 9 percent of the world's renewable water supply, the bulk of which is in the form of groundwater.

[10] Toronto hydrology issues result in drying urban lands and volatile environmental conditions in urban rivers and estuaries. http://trca.on.ca/the-living-city/water-flood-management/

[11] North American Cities have a history of poor water conservation with the highest recorded water loss reaching upwards of 50 percent

[12] City of Toronto Wet Weather Flow Management Program documented 79 combined sewage outflow outfall events from 2003 to 2006. 33 of these events were direct outflows into Lake Ontario

[13] Water utility costs and investment requirements to restore the infrastructure to a state of good repair. http://www.moi.gov.on.ca/en/infrastructure/building_together/introduction.asp

[14] The first five priorities of the Taylor Massey Project, a component of the Don River Watershed regeneration plan, had an initial cost of $4.7 million dollars. This is one of the many areas along the Don Watershed that require environmental regeneration

[15] The Toronto 2031 Official Plan has projected urban growth rates based on immigration and economic strength documented from Statistics Canada Census 2006

[16] United Nations Environment Programme documented Fresh water demand and Wastewater characteristics. http://www.unep.or.jp/Ietc/Publications/TechPublications/TechPub-15/3-6EuropeWest/6-1.asp

[17] CMHC water conservation study. http://www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/97111.htm

[18] The popularization of rain shower showerheads and faucets to integrate urban living with high luxury conditions results in increased water use and water waste.

[19] The Toronto Hydro water utility process charges each residential household under a 2-month cycle. The length of time between inhabitant use and the subsequent charge to use the water varies, and it is difficult to establish a connection between the level of use, and the cost of use.

Chapter THREE: Water performance in Green Building Guidelines

LEED™ and The Living Building Challenge are recognized guidelines prescribing building standards to develop sustainability in residential architecture. Sustainable water use in domestic building typology will be prescribed through a detailed analysis of their water performance standards. This chapter will identify the impact of sustainable water initiatives in LEED™ and the Living Building Challenge to combat the urban water crisis.

The Green Building guidelines will be assessed for their prescription of project performance to establish water efficiency, combat against water misuse, and to achieve resource conservation to avoid overconsumption. They must establish sufficient performance standards for the building and the site to manage stormwater conditions to reduce urban runoff. Environmental parameters will be based on values prescribed by the City of Toronto, Waterfront Toronto; following Canada's prescription for urban intensification in growing metropolitan Cities[1].

Criticism of Green Building performance is intended to highlight issues with guideline engagement that may hinder water performance. Suggestions will be made to improve sustainable water engagement beyond LEED™ and The Living Building Challenge.

3.1 LEED™

LEED™ (Leadership in Energy and Environmental Design) is a voluntary certification process guiding development projects to achieve recognized levels of sustainable building performance. LEED™ is based on evaluating the nominal, quantifiable values of building performance derived from a stringent assessment and analysis platform. The focus is to address impact on the environment as a result of construction and inhabitation through informative design, operation, and maintenance of sustainable architecture. LEED™ for New Construction and Major Renovation was first developed for Commercial building applications. LEED™ Mid-rise pilot program was developed to address residential water use. LEED™ recognizes performance in seven key segments:

- **Sustainable Site Development**
- **Water Efficiency**
- Energy efficiency
- Material selection
- Indoor environmental quality
- *Innovation in Design* (bonus)
- *Regional Priority* (bonus)



Figure 3.01

Canadian Green Building Standards

The icon signifies LEED™ Green Building Guidelines and Certification

The first two performance segments are vital to developing sustainable water in building management. **Sustainable Site Development** addresses the buildings ability to negotiate environmental site conditions. **Water Efficiency** addresses ways to reduce inhabitant water demand to curb water misuse and overconsumption.

Sustainable engagement is measured by allocating points amongst an additive credit system. When a prescribed level of points is achieved, then the building receives Green Building certification based on the number of credits.

- Certified 40 – 49 points
- Silver 50 – 59 points
- Gold 60 – 79 points
- Platinum 80 points and above

Residential building typology must achieve an immediate, 15 LEED™ credits[2] that prescribe dedicated performance standards for Sustainable Sites and Water Efficiency (Table 3.0.1).

Table 3.01

The LEED™ checklist provides a breakdown of all sustainable building components under the 7 segments of Building performance. Each segment has pre-requisites that must be achieved before additional credits are awarded.

Items highlighted in red address water in qualified LEED projects.

LEED for New Construction and Major Renovation
Net Positive Water
Toronto Port Lands

Yes	?	No			
			Sustainable Sites		**24 Points**
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
Y			Prereq 2	**Environmental Site Assessment**	Required
			Credit 1	**Site Selection**	1
			Credit 2	**Development Density & Community Connectivity**	4
			Credit 3	**Brownfield Redevelopment**	1
			Credit 4.1	**Alternative Transportation**, Public Transportation Access	4
			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
			Credit 4.3	**Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles	2
			Credit 4.4	**Alternative Transportation**, Parking Capacity	2
			Credit 5.1	**Site Development,** Protect of Restore Habitat	1
			Credit 5.2	**Site Development,** Maximize Open Space	1
			Credit 6.1	**Stormwater Design,** Quantity Control	1
			Credit 6.2	**Stormwater Design,** Quality Control	1
			Credit 7.1	**Heat Island Effect,** Non-Roof	1
			Credit 7.2	**Heat Island Effect,** Roof	1
			Credit 8	**Light Pollution Reduction**	1
			Credit 9	**Site Master Plan**	1
			Credit 10	**Joint Use of Facilities**	1
			Water Efficiency		**11 Points**
Y			Prereq 1	**Water Use Reduction,** 20% Reduction	Required
			Credit 1	**Water Efficient Landscaping**	2 to 4
			Credit 2	**Innovative Wastewater Technologies**	2
			Credit 3	**Water Use Reduction**	2 to 4
			Credit 4	**Process Water Use Reduction**	1
			Energy & Atmosphere		**33 Points**
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required
			Credit 1	**Optimize Energy Performance**	1 to 19
			Credit 2	**On-Site Renewable Energy**	1 to 7
			Credit 3	**Enhanced Commissioning**	2
			Credit 4	**Enhanced Refrigerant Management**	1
			Credit 5	**Measurement & Verification**	2
			Credit 6	**Green Power**	2

3.1.1 Analysis of Sustainable Sites

LEED™ *Sustainable Site* (*SS*) assessment is a process to identify the state and conditions of a project site. Green Building authorities understood the need to prescribe criteria to reduce the environmental impact of buildings and to engage the regional conditions of the ecosystem through a building by building initiative. The immediate segments that impact water quality in Toronto relate to *Brownfield Redevelopment*, *Site Development, Stormwater Design for Quantity control* and *Stormwater Design for Quality Control.*

LEED™ classifies the Environmental Assessment (EA) process as a prerequisite (Prereq. 2) for all applicable projects to identify the existing habitat, site contamination, and site-specific features that require preservation or conservation. The EA process discovers if a project will impede urban groundwater flow, or disrupt on-site water quality. EA's allow architects to mitigate building conditions that may harm the environment, or encourage building systems that could revitalize the environment.

LEED™ NC awards 1 Brownfield Remediation credit for admissible projects that are situated on damaged lands complicated by contamination and pollution from prior occupants. *Brownfield Redevelopment* (SS c3) requires classification and approval by the appropriate local, provincial, or federal authority in order to qualify of the LEED™ NC credit. Residential construction must remediate environmental threats as specified by local regulatory agencies such as the City of Toronto Community Improvement Plan for Brownfield Remediation[3].

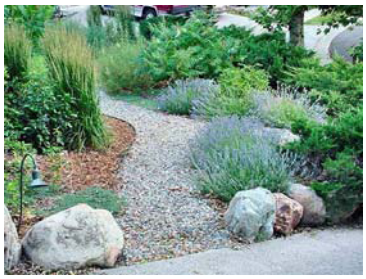
Site Development (SS c5.1) establishes a framework where LEED™ NC awards credits for the protection or restoration of the native habitat. Conservation of natural areas promotes biodiversity and growth in urban forestry[4]. Urban flora has root structures that establish soil integrity on a site to reduce soil erosion. *Site Development* ensures stormwater absorption to reduce urban runoff. The initiative is designed to ensure that urban inhabitation and constructed buildings contribute to the urban water cycle[5].

The bulk of Toronto's urban waterfront is classified as *Previously Developed Sites* (SS c5.1, Case 2), a prescription that will require 50 percent of a site area excluding the building footprint, or, 20 percent of the site area to be subject to environmental restoration and the protection of natural features.

Figure 3.02

Landscape plantings should be selected based on climatic and regional consideration to ensure water cycle integration and optimized water consumption.

Landscape design should be arranged according to plant requirements for survival, such as solar exposure and water.



Native and adaptive plant species should be utilized to restore environmental conditions to pre-construction conditions[6]. Landscaped site area is developed to ensure new building construction does not compromise urban water processes.

Percentage of buildable lot (excluding area under roof) that is permeable	*Points*
70–79%	0.5
80–89%	1
90–99%	1.5
100%	2

Table 3.02

The LEED mid-rise pilot program awards eligible projects for permeable land coverage to address *Stormwater Design for Quantity Control.*

LEED™ NC SS requires project site selection based on management parameters of *Stormwater Design for Quantity Control.* LEED™ NC will award 1 credit (SS c6.1) for the implementation of stormwater management to protect associated waterways from soil erosion and surface runoff. On-site management must decrease the rate and volume of stormwater runoff by 25 percent from the standards of a 2 year, 24-hour design storm[7]. Permeable surfaces will need to be deployed in order to achieve the 25 percent runoff mitigation.

LEED™ Mid-rise prescribes site design requiring a minimum of 70% of the built environment to be permeable. This includes vegetative landscape, permeable paving, and impervious surfaces that are designed to direct runoff towards permanent infiltration features (e.g. vegetated swale, rain gardens).

Stormwater Design for Quality Control will award 1 credit (SS c6.2) to effectively manage stormwater runoff based on a 90 percent average value of annual precipitation. LEED™ qualified projects must develop building management practices to treat water runoff and remove 80 percent of post-development total suspended solids (TSS). TSS is a measure of water quality, an index to ensure that the water treatment methods applied in a LEED™ project achieve accurate and consistent on-site water quality. If TSS is to be managed on-site, it will most likely require innovative water filtration presented by *Water Efficiency Credit 2*. SS Credit 6.2 eligible projects in Toronto's waterfront must manage upwards of 986mm of maximum precipitation, with approximately 789mm subject to TSS filtration[8].

3.1.2 Analysis of Water Efficiency

Water Efficiency measures target the present day volume of Toronto's inhabitant misuse. LEED™ NC addresses *Water Efficiency* in segments for *Water Efficient Landscaping*, *Innovative Wastewater Technologies*, and *Water Use Reduction*. LEED™ Mid-rise divulges methods to use municipal recycled water. Reducing inhabitant water demand through high-performance water fixtures, fittings, and appliances will improve the environmental impact of residential project applications.

All LEED™ projects must include a prerequisite for *Water Efficiency* (*WE*) *Water Use Reduction, 20% Reduction* to qualify for any of the accredited classifications. LEED™ NC specifies a minimum requirement for strategic deployment requiring 20 percent water use reduction from the established baselines calculated for conventional buildings.

Water Efficient Landscaping (WE c1) prescribes design criteria to reduce potable water-use for landscape irrigation. Sustainable urban landscaping utilizes the installation of native and resilient plant species that do not require irrigation[9]. Construction of residential projects without permanent irrigation systems in addition to the installation of drought resistant vegetation yields 4 LEED™ NC credits. Reducing potable water consumption for the purposes of building landscape irrigation by a total of 50 percent will award projects with 2 credits.



Figure 3.03

York Region and other municipalities have established Water Restriction By-laws to limit potable water use for irrigation purposes. This reduces the burden on Toronto's water infrastructure.

Weighing the available LEED™ credits towards potable irrigation reduction identifies the significance of water use for landscape management. Applying LEED™ NC Water Efficient Landscaping; 50 percent potable irrigation reduction to Toronto's current consumption value (60 Litres per day) reduces water consumption for multi-unit household consumption by 30 LPUD (Litres per unit per Day). Irrigation savings applied to Toronto's population would reduce multi-unit residential water consumption by approximately 13 LPCD[10], at **241 LPCD.**

LEED™ NC certification for *Innovative Wastewater Technologies* (IWT) provide up to 2 credits for projects that reduce potable water use for waste conveyance (WE c2).

The first IWT credit assess eligible projects with an option to reduce 50-percent of waste oriented potable water usage, or, the volume required is replaced by non-potable water. Suggested sources for non-potable water include captured rainwater, recycled Greywater, and on-site treated wastewater. The second credit is oriented towards on-site wastewater management requiring a minimum of 50 percent wastewater to be treated to tertiary standards.

Applying the maximum performance of LEED™ IWT to Toronto households would reduce average municipal wastewater contributions by 35LPCD, resulting in an overall domestic water usage of **218 LPCD**[11].

Water Efficiency (WE c3) provides additional credits when a project removes their water dependency from municipal distribution beyond the minimum *Water Efficiency Prerequisite*. LEED™ NC projects are awarded for a maximum of 40 percent water savings, although projects that achieve greater than 40 percent savings receive the same merit. LEED™ prescribes Energy Star™ [12] qualified products that are readily available to consumers.

Following successful exemplars of LEED™ Platinum residential construction in Canada[13], they achieved a 30 percent potable water reduction that would reflect the City of Toronto per capita consumption from 253 LPCD to **177 LPCD**[14].

Combining the recognized water savings from *Water Efficient Landscaping, Innovative Wastewater Technologies,* and *Water Use Reduction* yields an overall usage reduction of Toronto's multi-unit inhabitants down to **165 LPCD**[15].

Percentage of total water demand supplied by water reuse strategies	*Points*
≥ 10%	1
≥ 20%	2
≥ 30%	3
≥ 40%	4
≥ 50%	5

Table 3.03

LEED™ Mid-rise pilot program awards points for a maximum of 50% water reuse.

LEED™ Mid-rise prescribes water reuse in residential building typology through Rainwater Harvesting and Storage, Greywater Reuse collected from household appliances and fixtures, and plumbing design to use recycled water. LEED™ Mid-rise prescribes a default matrix to optimize household water use from fixtures and appliances. The *Duration-of-Use* and the *Number-of-Use* values are fundamental assumptions to calculate inhabitant water consumption.

Flush Fixture	*Monthly uses per resident*	*Building residents*[3]	*Flowrate (GPM or GPF)*	*Duration*	*Monthly water use (gal)*
Toilet	150			1 flush	
Bathroom Sink	150			0.25 min.	
Kitchen Sink	120			1 min.	
Shower	30			5 min.	
*Where monthly water use = monthly uses per resident * residents * flowrate * duration*					
Appliance	*Monthly uses per unit*		*Number of units in the building*	*Water consumption per use (gal)*	*Monthly water use (gal)*
Dishwasher*	16				
Clothes washer**	30				
*Where monthly water use = monthly uses per unit * units * consumption per unit*					

* For each unit without a dishwasher, add 96 gal per month to account for washing by hand.

Table 3.0.4

LEED™ Mid-rise calculates indoor water use for reuse based on the following breakdown of inhabitant uses per day.

- Toilet: 5 times a day
- Bathroom Sink: 5 times a day
- Kitchen Sink: 4 times a day
- Shower: 1 time a day

3.1.3 Shortcomings and Criticisms

If all 15 *WE* and *SS* credits are achieved, LEED™ *SS* water initiatives can mitigate up to 90 percent of the impact of urban residential construction on a project site. The sum of water conservation prescribed by LEED™ *WE* is not sufficient to meet the sustainable water use targets recognized by global water conservation authorities[16].

LEED™ 'Additive' point's methodology is challenged by the intuitive capabilities of applicants to discover diverse methods to exploit guideline definitions by chasing the easiest methods to achieve each credit. The 'points' chasing exercise has a possible outcome where projects with poor environmental models are capable of achieving high accreditation. If a project is evaluated with a high quantity of points, they could theoretically achieve 'Platinum' accreditation (80 points plus) and completely forego the necessary 15 Water Efficiency and Sustainable Sites credits for sustainable water use.

LEED™ NC Water Efficiency is one of the most readily engaged segments of the Green Building guideline. LEED™ specification for Energy Star™ qualified products already performs 20 percent better than the established water use baseline. Once a project has deployed Energy Star™ fixtures and appliances, they fulfill the guideline Water Efficiency Prerequisite. Energy Star™ products are commonplace, and do not achieve sufficient water savings to curb overconsumption.

LEED™ Mid-rise pilot program does not consider bathing as a form of household water use under the calculation matrix for water reuse. Duration-of-use and Number-of-use assumptions have been made on behalf of LEED™ but the basis of the assumptions has not been unveiled. An accurate prescription of the two water use factors should be based on water use studies from urban municipalities.

Criticisms of LEED™ provided by The Living Building Challenge questions the high level of distinction given to projects that do a great deal of things better. Achieving a high number of compulsory items for higher grades of 'sustainability' can be a paradox as the more items are applied to a structure; the greater the requirement to maintain and service sustainable building systems. Platinum rated projects require sufficient operational energy and economic funding to maintain under a system by system additive approach.



Figure 3.04

Equity is a recent addition to The Living Building Challenge 2.0 and is not displayed in the Flower Petal Diagram.

3.2 The Living Building Challenge

The Living Building Challenge (LBC) is a sustainable accreditation processes that is highly distinguished in the building industry. The challenge calls all professionals to build projects that have the potential to positively influence the human condition and cause no ill detriment to the environment. Any structure that is able to achieve recognition for being 'Living' can distinguish itself as one of the most sustainable and Green Buildings in the world.

Establishing the LBC is a set of cohesive standards to define the most advanced measures towards sustainability and a quest to achieve the necessary performance to do so in seven key areas:

- **Site**
- **Water**
- Energy
- Health
- Materials
- Equity
- Beauty

These seven performance sectors or 'Petals' suggest the evolution of sustainable architecture through the construction of a flower. The petal methodology re-evaluates buildings as entities that are routed iteratively and figuratively in place. Following the ideology of Biomimicry[17], the LBC examines the natural model and attempts to emulate the form and function of the subject. Reflecting upon the flower suggests a means towards achieving sustainability requiring a Passive response to the environment to harness the resources it provides (i.e. photosynthesis, water capture, and soil infiltration).

The goal of the LBC is explicit, but implicit requirements follow dozens of strategies that need to be achieved in order achieve sustainable resource use. All seven petals of the Living Building Challenge are prerequisites. Applicants do not have the freedom to choose between sustainable energy targets over water conservation initiatives. Unlike LEED™, the Living Building Challenge is not an additive process but it can be classified as 'temporarily subtractive'[18]. The challenge can be transformative, allowing exceptions in regions where market restrictions such as code-regulations and material-scarcity make accreditation difficult or nearly impossible.

Similar to LEED™, *Site* and *Water* petals are the first components to be considered in the LBC guideline.

3.2.1 Site Selection

The LBC addresses *Site Selection* by establishing prerequisites for the safe selection of project location and adequate processes towards environmental restoration in degrading development lands. Projects will not be constructed within 50-feet of existing wetlands or adjacent to sensitive ecological Habitats such as Primary Dunes, Old Growth Forest, virgin prairies, and prime farmland or within a regionally designated 100-year flood plain[19].

The LBC utilizes the 'Koppen' Climate Classification System[20] to prescribe *Site* design conditions across the world. The Challenge utilizes the climate system to recognize 5 major climatic groups in North America, based on annual-monthly averages in temperatures and precipitation. Toronto falls into a continental 'Great Lakes' group and Site selection within this prescription is subject to the 'Great Lakes' performance evaluation. The Koppen system is widely used and coincides with regional vegetation and soil patterns essential to understanding water hydrology and regional ecosystems.

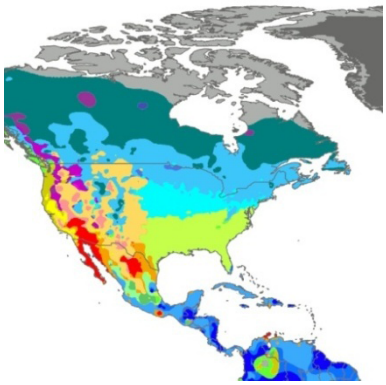
Since urban development displaces environmental conditions, the LBC prescribes a concept of *Habitat Exchange* to replace the *Site* that development must occupy. This process ensures that human occupation does not entrench on regional biodiversity by allowing environmental conditions an opportunity to thrive in alternative lands of equal size.

The LBC recognizes the contribution to the urban water crisis as a result of poor municipal utility practices[21]. Projects that are dependent on municipal stormwater and sewage treatment processes do not qualify. Wastewater diversion unintentionally depletes urban potable water stock, resulting in degrading urban environmental conditions.

One of the thought provoking reviews presented by the LBC is an assessment of standardized water treatment in North America. Toilets in each household take an isolated volume of waste and through infrastructure diversion, flushing the waste into a larger wastewater volume. City-wide waste collection allows the wastewater to fester with toxins and bacteria. The solution becomes so potent it becomes harmful to inhabitants and the environment, removing the possibility to treat the medium through natural water processes. Cities must then rely on the use of chemicals and energy resources to remove and treat the wastewater equally potent chemicals.

Figure 3.05

Toronto is classified as DFA – with summers which are somewhat wetter than winter. Although this is true, Toronto has been subject to drought. Refer to Appendix D.



3.2.2 Water

The LBC addresses the value of *Water* in two categories. The first is a Net Zero Water approach to building development, with 100 percent of occupant water provided by a closed-loop system within the building. The initiative is based on the premise of the end of water availability, where projects provide for inhabitants without relying on municipal water utilities. Net Zero Water is based on the concept of 'Water Independence'[22], a form of water management that is not recognized by municipalities across North America and is contrary to the quality and health regulations placed upon urban water to protect inhabitants. The Challenge recognizes the regulatory conflicts that will occur as a result of its guideline prescription for building performance. LBC will challenge established water handling regulations to allow water independence and cyclic water-use to succeed.

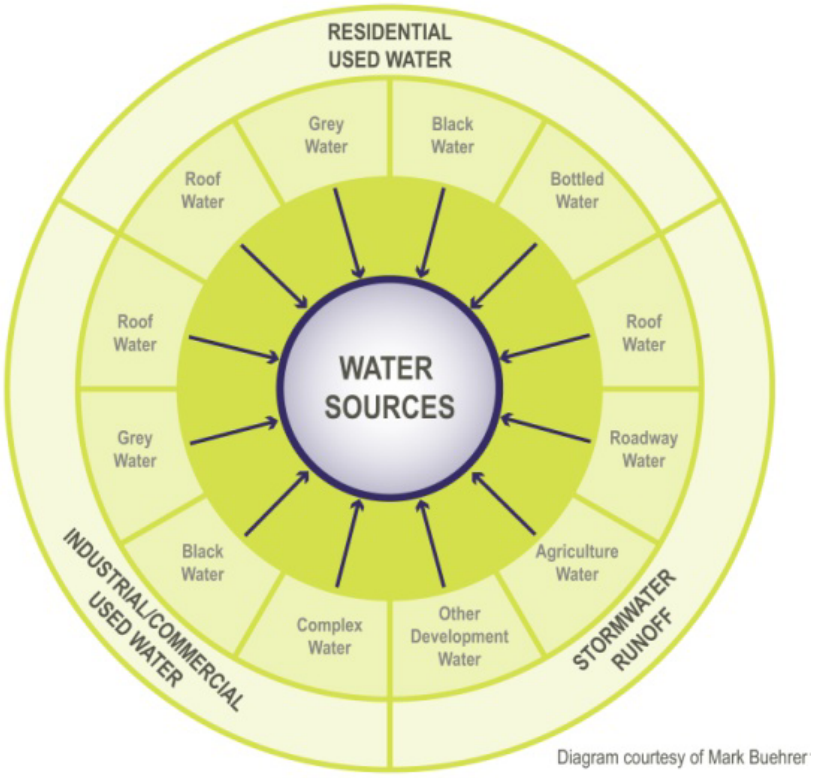


Figure 3.06

Divisions of Household Water Use establishes appropriate applications of potable water demand vs. Non-potable water demand. This will help define the extent of cyclic water use.

Water independent, Net Zero Water buildings will harvest and treat precipitation and wastewater to meet domestic demand. The LBC prescribes the capture of fresh water resources from impervious surfaces such as residential rooftops, balconies, and building podiums. The medium should be stored or 'Banked' in storage mechanisms to await future reuse. Advanced water filtration, water treatment and quality management techniques should be deployed to address inhabitant waste and remove the content from the water medium.

The second segment of the LBC is concerned with the impact of project construction and the urban water crisis. The LBC specifies that 100 percent of stormwater and building runoff must be managed within the project site. Stormwater is to be treated and reused to feed internal building demands. Water that is released from a site must be subject to an on-site management and treatment processes to control water outflow quality. Acceptable means of water egress from the project site consist of natural time-scale surface flows[23], groundwater recharging, and on-site agricultural use.

The LBC distinguishes its policy through a stringent certification process with assessments based on an audit of actual building performance, rather than projected performance targets. The challenge responds to the ecological consideration of water management by prescribing a concept of 'Scale Jumping', where multiple buildings or projects are allowed to operate in a cooperative state (Table No. 4.05).

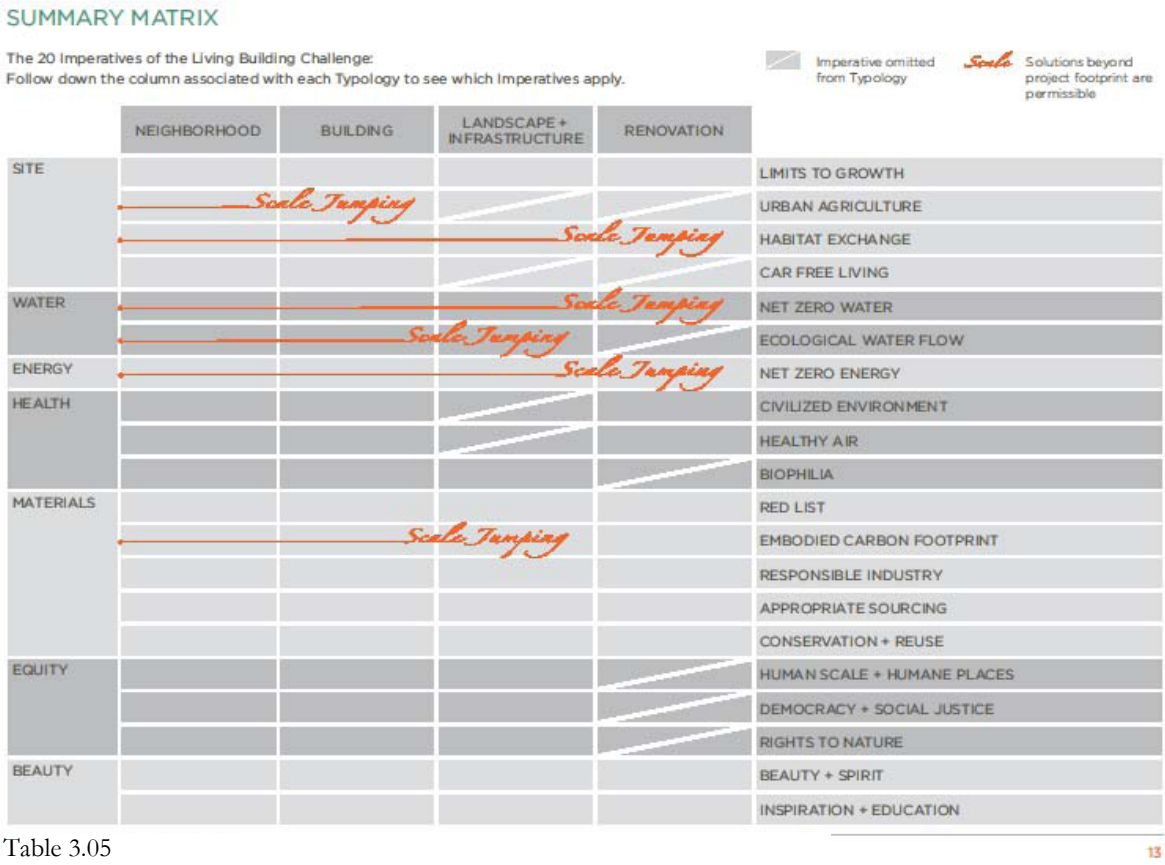


Table 3.05

Scale Jumping in The Living Building Challenge.

The following standards are required for building/development/community projects to qualify for The Living Building Challenge:

- The project may not restrict access to the edge of any natural waterway, except in hazardous conditions.
- Must not build within 100-year flood plains
- Must be built on Brownfield (Contaminated Land) and previously developed sites
- Maintain 15 meters and up to 70 meters of separation to wetlands.
- Water systems that account for downstream ecosystem impact are appropriately purified without the use of chemicals.

On site landscaping may only include native and or naturalized plant species in such a way that emulates plant density and biodiversity of the indigenous ecosystems.

Eligible LBC projects are judged post construction based on performance recorded from utility documentation such as water bills or other resource uses. If water is purchased for a project, the purchase must be a one-time event. Certification of project building performance is intended to recognize all forms of construction from landscape infrastructure, individual building scale, and up to community-neighbourhood engagement.

The LBC recognizes that climate, urban site conditions, and environmental context are primary influences that demand different 'Living' building solutions. Project owners must state that they achieved all prescribed Challenge prerequisites and provide copies of documented proofs.

3.2.3 Shortcomings and Criticisms



Figure 3.07

Eco-sense Rural Housing Application is one of the sole Canadian examples of residential construction achieving the LBC.

Vancouver Island. British Columbia. Canada.

The LBC establishes a similar guideline structure to LEED™, but it does not prescribe fixed performance standards that must be achieved in order to establish a Living Building. Living Building performance changes from project to project as they are subject to differing environmental conditions and building demands. The specialized case-by-case evaluation of each LBC candidate makes a generalized guideline broad and difficult to prescribe.

LEED™ recognition has resulted in applicable project examples that showcase *SS* and *WE* initiatives in multiple project scales. Due to a lack of case study exemplars and an incomplete listing for sustainable construction sources, The Living Building Challenge appears to be almost an incomplete standard, or a work-in-progress guideline. The sole Canadian exemplar of a certified Living Building is 'Eco-sense', a rural, low-rise residential home situated in Victoria, British Columbia. The typology is not relevant to higher density urban construction, but it showcases some of the strategies that may occur to develop Net Zero Water.

Eco-Sense is situated amongst a region with plentiful environmental resources providing fresh groundwater for potable water intake from an adjacent aquifer. The project was allowed special municipal provisions to utilize composting toilets. The sanitary and health implications of composting toilets would be an improbable application amongst urban applications, where the population density produces too much wastewater to be treated with natural processes.

The LBC certification of 'Eco-Sense' uncovers a variant in *Site, Habitat Exchange* policies with the project being awarded a *judgment of merit*. The construction of Eco-sense was able to avoid the immediate ramifications of *Habitat Exchange* standards due to the well-known affiliations of the project owners involved in volunteer organizations for regional land protection and forestry conservation.

Urban City areas are not subject to the same richness of resources and undisturbed water quality. Urbanized waterfronts are not capable of offsetting inhabitant resource consumption at the same scale of the Eco-Sense exemplar.

The LBC cautions those who attempt all seven flower 'petals' that the task is extremely difficult in light of current building and design practices. In the mean time, there is no record of any application or successful Challenge project in urbanized domestic applications. This seems to reflect a level of difficulty for the construction industry to engage in the Challenge, and that brings to question the feasibility of successful urban Living Buildings.

3.3 Simple and Advanced improvements for higher density residential Green Building

Simple improvements to achieve water savings recognize the ability for inhabitants to drastically reduce their water demand. Improving performance in water fixtures and appliances allow inhabitants to embrace water conservation without impeding on household comfort. An education strategy should be developed for inhabitants so that they can learn to utilize the improvements of water fixtures appropriately. Water use prescriptions will be based upon documented studies for residential water demand in the City of Toronto.

Indoor Water Use Breakdown					
Average Canadian Inhabitant Water usage				248	LPCD
	Percent	LPCD		Percent	LPCD
Toilet	28%	69.44	Leaks	11%	27.28
Clothes Washer	22%	54.56	Baths	3%	7.44
Shower	19%	47.12	Dishwasher	2%	4.96
Faucet	15%	37.20			
Reference: City of Toronto Wet Weather Flow Master Plan					

Table 3.06

Municipal water use studies record the volume of water that is utilized in each category of household water demand. Understanding the minimum amount of water required for each water task will provide a further breakdown of the documented water use and unveil where water can be conserved.



Figure 3.08

Approximately 1 gallon of potable water is wasted per 15,140 drips, or 1 litre in 400 drips per leaking faucet

Prescribing strategies for water conservation comes second to the simplest method to achieve water savings; a goal to eliminate all sources of household water ***Leakage***. According to Toronto's current water demand, approximately 10-12 percent (27 LPCD) of water savings can be achieved by halting current levels of household water leakage. Dripping faucets and fixtures can waste a large quantity of potable water in a short period of time. The smallest leak in water plumbing could dump up to 55 litres of potable water within a 24-hour timeframe. Although water leakage is not an expected phenomenon in new construction projects, encouraging sustainability in plumbing practices will reduce the opportunity for leaks as the building matures.

One of the first steps to deconstruct the common misunderstanding of water abundance is to calculate the amount of water that is actually required for water related household tasks. Establishing baseline usage values will provide a reference to measure and diagnose water consumption habits. Simple questions need to be asked, and answered.

For example:

How much water does it take to wash hands to sanitary standards?
How much water is required on average for the brushing of teeth?

Educating inhabitants to make smart, sustainable decisions for water use is the best means towards improved water conservation. One exemplar presented by the U.S. Environmental Protection Agency (EPA) is to curb inhabitants from leaving the faucet on until cold water reaches the tap. Another suggestion for water savings is to make sure users to turn off their faucet during teeth brushing or for facial cleansing. Showering rather than bathing can also render substantial water savings. These suggestions focus on the inhabitant to moderate the **Time-Of-Use** and **Choice-Of-Use** for their water demand. The time and duration of household faucet use will directly dictate the volume of water consumed.

If inhabitants are engaged in moderating their water demand, the necessary tools should be provided to achieve further water savings. Projects should be encouraged to deploy the best functioning faucets and fixtures available in the marketplace to improve economic and resource savings. Encouragement can come in the form of government bursaries or subsidizations for developers to implement water conserving fixtures and appliances[24].

The design of traditional North American households maintains health and well-being by utilizing water as a 'Quick-in, Quick-out' resource. Household faucets and sinks are designed for high rates of water outflow to prevent occurrences of unwanted flooding that could lead to property damage. This system of quick resource use is one of the key factors leading to water waste. If faucets and sinks can be designed to manage water outflow where inhabitants are actively made aware of the total volume of water they demand, the opportunity for overconsumption can be mitigated.



Figure 3.0.9

Conventional kitchen faucet and sink combinations provide the quickest means for water to escape from the household. Notice the linear relationship between water feed and water drainage. Conventional water related hardware is designed flush water from the inhabitable household as soon as possible, regardless of how much water resource is wasted.

Awareness in water use under the current stock of residential and mixed-use typology brings very little attention to actively monitor the volume of water demand from inhabitants. Projects are constructed without the need to expose or engage inhabitants to the benefits of water savings. That reduces the possibility of inhabitant engagement to monitor resource use and to actively see the results of their conservation efforts.

Advanced methods to achieve Net Zero Water must provide **smart monitoring** tools to engage inhabitants through the building typology. Providing water use exposure immediately through end-of-pipe monitoring and metering will show inhabitants exactly how much they use, and in turn, be able to assess how much water is required per household task.

Understanding which qualities of water are required to achieve household tasks can reduce the demand for potable water. Residential water provisioning is attributed to four core household sources; the kitchen, the bathroom, laundry, and outdoor use. Water used for food preparation and personal hygiene requires potable water quality where as domestic water for waste disposal, housekeeping, and waste conveyance do not require the same quality.

Water for food preparation may not require the same stringent post-consumption treatment processes required to address wastewater. Rather than chemically treat the medium, there may be methods of filtration to separate Greywater from kitchen sediment and debris. Bathroom potable water demand may be replaced with filtered post-consumed Greywater for waste conveyance, showers and baths, and even sink basins where water is not utilized for sanitation.

Endnotes:

[1] City of Toronto, Waterfront Toronto Growth Plan. http://www.toronto.ca/involved/projects/wfsanplan/
[2] LEED™ NC Checklist, Appendix B Pg.1-2
[3] The Community Improvement Plan (CIP) provides financial incentives to encourage Brownfield remediation supporting the development of residential and employment uses. http://www.toronto.ca/planning/newtor_cip.htm#4
[4] Urban forestry is a terminology prescribed for trees situated amongst the private and public realm in the urban city area
[5] Waterfront Toronto, emphasis on Healthy Environment dependent on flora. New Technologies developed to support urban forestry. http://www.waterfrontoronto.ca/our_waterfront_vision/our_future_is_green/healthy_environment
[6] City of Toronto has an urban forestry department providing a listing of all native and adaptive plant species.
[7] Using a 10 minute Time Stamp with a Chicago Storm Distribution, the 2-year 24-hour total depth of rainfall for the City of Toronto is calculated at a 43.85mm. David Keldershone. Toronto Water. City of Toronto Wet Weather Flow Master Plan
[8] Toronto's maximum annual rainfall is documented at 986mm. Buildings are required to manage 80% of the maximum water rainfall under LEED™ SS c6.2. The resultant amount equates to 789mm.
[9] Refer to Appendix C – Native Shrub & Trees for Naturalization in the City of Toronto, Urban Forestry. http://www.toronto.ca/trees/
[10] Refer to Appendix E. Section One Calculations No.8
[11] Refer to Appendix E. Section One Calculations No.12
[12] Energy Star™ is a government supported program for water and energy efficient appliances and fixtures. http://www.energystar.gov/
[13] Refer to Chapter 1, Section 1.5, Pg. 5.
[14] Dockside Green Score Sheet. http://www.docksidegreen.com/Portals/0/pdf/sustainability/Dockside%20Green%20LEED%20Scoresheet%20-%20Synergy.pdf
[15] Refer to Appendix E. Section One Calculations No.10
[16] Chapter 2, Pg. 21. World Commission on Water and the World Health Organization identifies 70 LPCD of sustainable water use for global water equity and equal water rights
[17] Biomimicry examines nature and it's models, systems, processes and attempts to emulate those processes in solutions for human issues
[18] Living Building Challenge User Guide specifies its structure as a temporarily subtractive methodology. https://ilbi.org/lbc/LBC%20Documents/LBC2-0.pdf
[19] The Toronto Port Lands are subject to 100-year floodplain conditions as prescribed by Waterfront Toronto. Brenda Webster. Lower Don Lands Project Manager.
[20] Native vegetation is best described by climate defining boundaries based on regional vegetation growth. http://geography.unt.edu/~mcgregor/Earth_Science/The_Koeppen_Climate_System.pdf
[21] Living Building Challenge Guideline. 06 Ecological Water Flow. https://ilbi.org/lbc/LBC%20Documents/lbc-2.1
[22] Water Independence requires a building to treat Blackwater and Greywater and renew the medium into Potable water for human intake. Water Independence and Closed-Loop water is the same. https://ilbi.org/education/reports/oregon
[23] Living Building Challenge Guideline. 06 Ecological Water Flow. https://ilbi.org/lbc/LBC%20Documents/lbc-2.1
[24] CMHC water conservation initiatives. http://www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/97111.htm

Chapter **FOUR**: Case Studies for Water sustainability

The intention of the Green Building Case Study is to determine the strategies, the mechanisms, and the performance that is required to establish sustainable domestic water use. Exploring successful examples of Green building construction will showcase the level of engagement that is required to prescribe sustainable water practices. The following projects have been acclaimed for sustainable Green Building performance in Canadian domestic construction.

Dockside Green Development is one of the first urban master planning communities to achieve LEED™ Platinum accreditation. The mid-rise, mixed-use project is situated in the reclaimed waterfront of the Victoria, B.C. Inner Harbour. Dockside Green showcases domestic Green Building construction utilizing **Passive means to retain stormwater** content in conjunction with urban domestic intensification. Integrated into the first phase of construction is a water treatment facility with the capability to support the water use of the entire neighbourhood. The development establishes sustainable means of water reuse and **Active processes for water quality renewal**.



Figure 4.01

Aerial Perspective to the Southeast.
Dockside Green, Victoria B.C.

The 2010 Vancouver Olympic Village is a LEED™ Platinum Development that showcases an urban building strategy to managing **Clean and Dirty water conditions** in conjunction with Passive water renewal. The Village was constructed in unison with the redevelopment of Hinge Park and the South East False Creek wetlands. Within the Olympic Village lies one of Canada's first multi-unit residential buildings utilizing water based building solutions to achieve Net Zero Energy. The Net Zero Energy Social Housing Project demonstrates resource savings from **Active water storage** and innovative methods to diversify water use within domestic construction.



Figure 4.02

Perspective to the South.
Millennium Waters,
Vancouver Olympic Village.
SEFC. Vancouver B.C.

Drake Landing Solar Community (DLSC) is a National Resources Canada (NRCan) R-2000 standard suburban low-rise development in Okotoks, Alberta. The project integrates advanced solar thermal energy systems, utilizing water as a means to capture and store energy for short term and long term durations in a ground source borehole network. DLSC showcases the application of Active building systems that can be adapted to **preserve the quality of water resources for long term storage**.

The selected developments manage domestic water content utilizing simple and advanced water related building systems. They prescribe the means to mitigate the impact of domestic construction on the regional environment, including **On-Site and Building strategies** to reduce the level of water that is required to operate domestic buildings. Comparing constructed references identifies the scale of sustainable water engagement to establish the guiding principles for Net Positive Water generation.

4.1 Dockside Green Development



Figure 4.03

Dockside Green Master Plan

The development looks into Victoria's inner harbour and is buffered from the coastline by operational industrial facilities.

Dockside Green Development encompasses 15 acres of previously Brownfield (Contaminated) industrial lands situated in the City of Victoria's Inner Harbour. The mixed-use development will be home to approximately 2,500 residences in conjunction with light-industrial, commercial office, and retail space. All eligible structures will be built to LEED™ NC Platinum accreditation, with the first residential building entitled Synergy achieving full certification in 2008 achieving all 5 applicable LEED™ water credits[1]. LEED™ Platinum certification resulted from a combined strategy for Active and Passive building systems developed for water resource conservation.

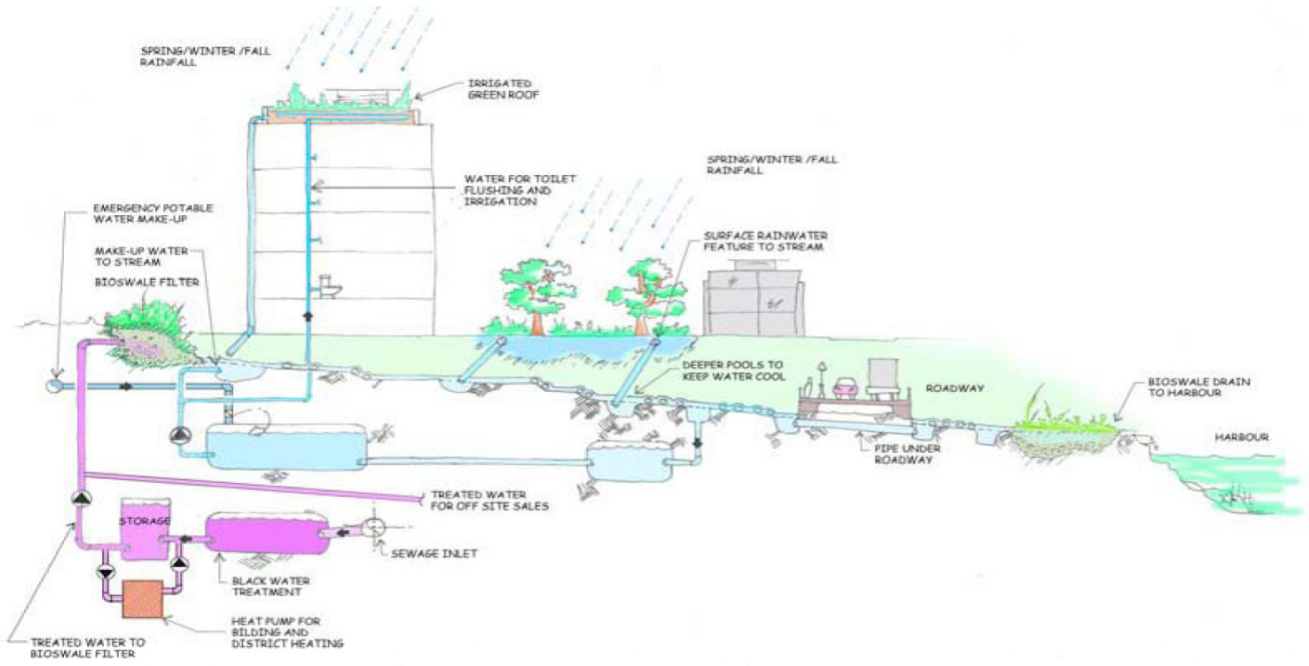


Figure 4.04

DG's integrated water system filtrates and slows the rate of outflow into the harbour. The system must be isolated and protected from contamination sources such as roadways.

4.1.1 On-site Environmental Revitalization

Synergy utilizes the first stage of Dockside Green's site-wide water-management capabilities under an Integrated Resource Recovery (IRR) strategy[2]. In adherence to LEED™ NC Platinum accreditation, the project utilizes advanced methods to renew inhabitant Greywater, and Blackwater allowing reuse of the water medium for alternative on-site purposes.

An aggressive On-site irrigation and landscaping strategy was developed to re-introduce groundwater hydrology and ground infiltration on the site, two natural urban water processes that were lost as a result of prior industrial land use and site contamination. The City of Victoria's climatic conditions are suitable to establish outdoor waterway areas as a means to retain stormwater and surface fresh water conditions throughout the seasons. Synergy is the first building to utilize Dockside Green's On-site naturalized creek and pond system as a means to reuse On-site and Building water.

The project utilizes the greater sum of all **open spaces and landscaping features as functioning landscape element to passively filter and renew On-site water**. The linear creek stretches across the entire length of the development site, collecting stormwater precipitation for future reuse in addition to developing a functional micro-ecosystem that forms a 'Synergy' between the newly established domestic construction and the environment. The Passive On-site strategy will accommodate and absorb 100-year flooding and rainfall levels.

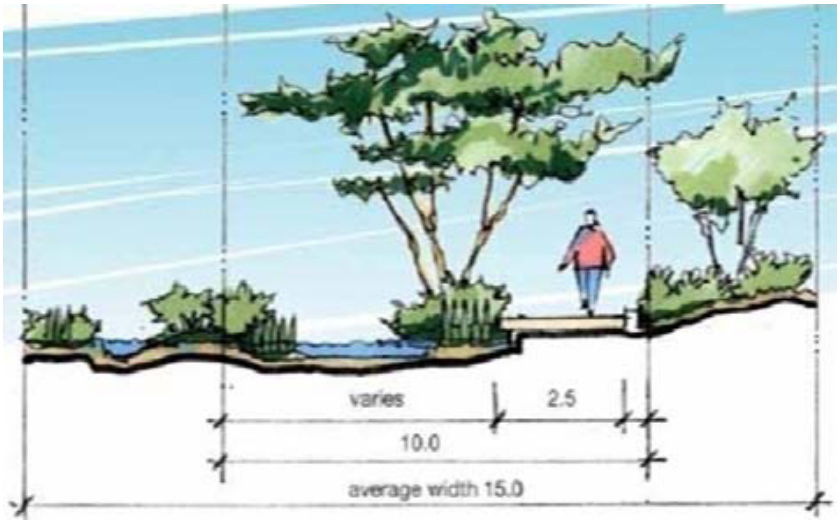


Figure 4.05

DG's integrated waterway allows for the collection of rainwater for on-site irrigation purposes as a form of cyclic water reuse.

The creek meanders and slopes throughout the site to induce water flow, preventing conditions of water stratification and stagnation that can lead to the growth of harmful bacteria and disease. Naturalizing the site by replicating native soil and shoreline conditions created a buffer between the expected densities of human inhabitation introduced by Dockside, and the natural coastline of Victoria's inner harbour. The large capacity of the **creek system is also used to as a Passive container to store Synergy's unused treated Greywater**. Water in the creek system is utilized to meet all of the irrigation demands in Dockside Green.



Figure 4.06

The ground floor condition of Synergy – DG Phase 1 embraces naturalized shoreline conditions for greater environmental awareness. The waterway re-introduces natural features into the inhabitant realm.

The design of the naturalized waterway encourages the growth of indigenous and adaptive plant species. The naturalized setting establishes a beautiful open landscape condition with reclaimed lumber for walkways and walkouts for at-grade units. All pedestrian pathways associated with the naturalized waterway are permeable to reduce water runoff into the nearby coastline. The small micro-habitat has successfully become home for terrestrial and aquatic biodiversity with signs of animal activity reflecting good environmental health. **Water leaving the site is gradually re-introduced to the regional ecosystem through groundwater and infiltration Bioswales.**



Figure 4.07

Bioswale terrain is established to buffer roadway waste from the DG cyclic water system.

Integrated building design utilized Balconies, Roof area and the building envelope a means to capture stormwater. **Green roofing systems are used to collect precipitation** on Synergy's roof. The collected rooftop stormwater is directed towards balcony mounted vegetation planters. In areas of the building envelope that do not have balconies, Green Wall systems are used to slow the rate of water runoff from the building. The integration of the landscape elements is utilized to slow the rate of precipitation flow off-site. **Building landscape elements utilize native plant species imbedded within a highly absorbent soil medium to contain and slow water infiltration.**

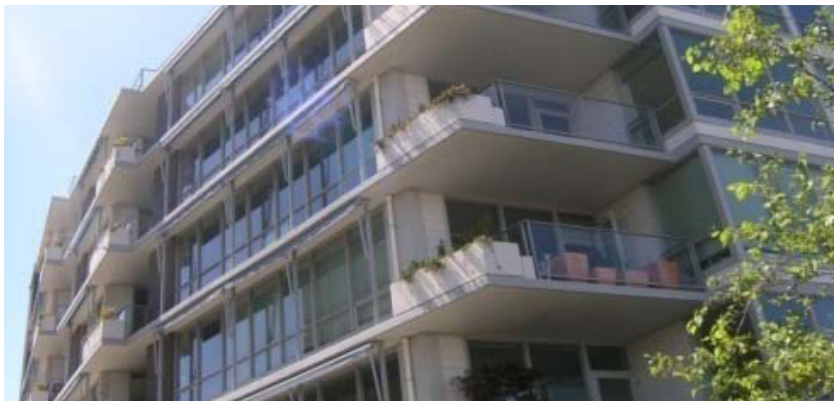


Figure 4.08

Balcony mounted planters contain maintenance free native/drought resistant plant species. Downspouts from each floor direct soil filtered rainwater throughout the tiers, establishing multiple levels of soil filtration.

The trickling 'Top-Down' process of water flow is gravity fed, allowing rainwater to flow from balcony to balcony until the soil filtered resource reaches the sites naturalized, man-made creek. Due to the climatic conditions of Victoria and the large volume of precipitation throughout the seasons, the collection of rainfall is sufficient to provide Greywater for all of Synergy's toilets, in addition to other non-potable water building services. This allows inhabitants to defer their water consumption to continuously regenerate environmental conditions On-site and on the building.

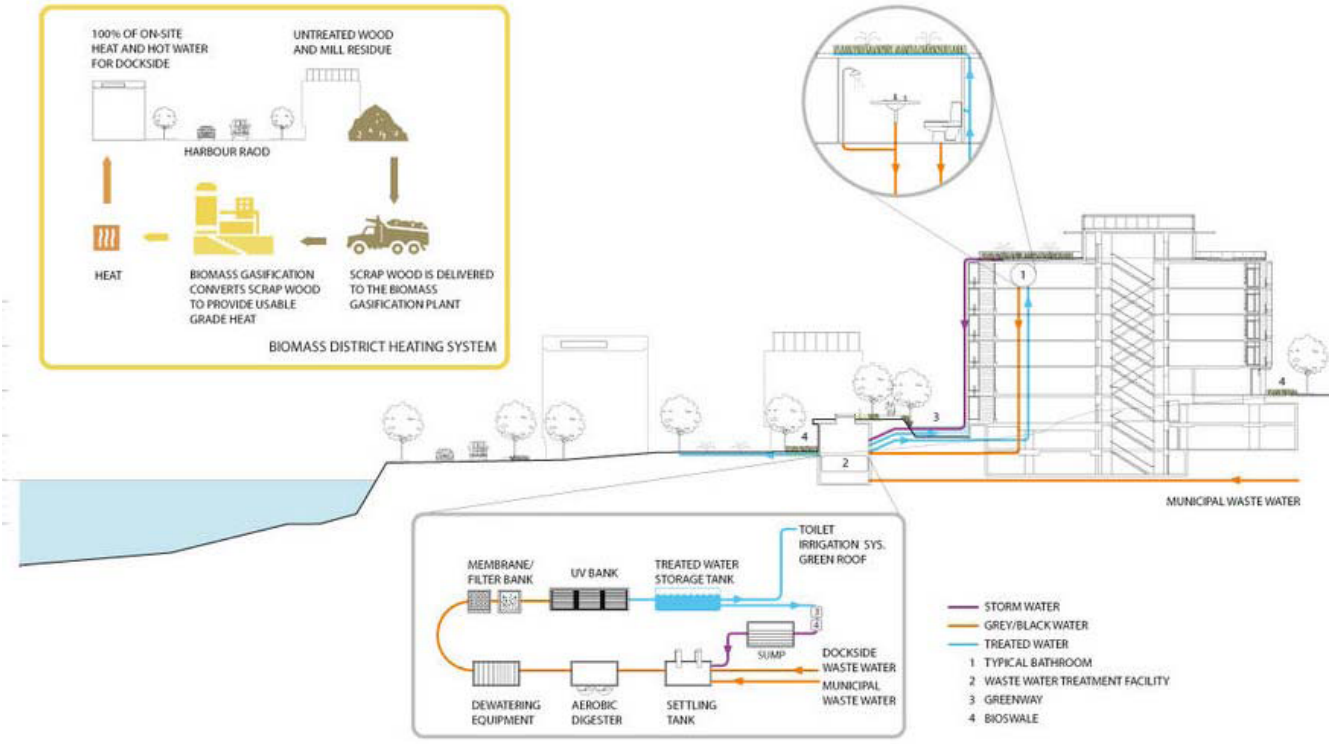


Figure 4.09

Dockside Green utilizes a building integrated cycle of water flow whereby water is used, reused, and renewed to safe quality conditions, allowing inhabitants the opportunity to embrace waterway and water-entrenched site conditions. Stormwater, Greywater, and Blackwater are all managed on the site through the buildings Wastewater and Stormwater treatment plant situated beneath Phase 1 – DG – Synergy Towers.

4.1.2 Domestic Water reuse

The key requirements that makes On-site water renewal possible is the pursuit of water conservation to reduce the volume of inhabitant water use. Inhabitant water savings reduce the scale and economic demands for active mechanical water treatment solutions, enabling Dockside development to deploy a feasible economic and sustainable strategy to reach Net Zero Water, water neutrality. Synergy Towers achieved a 65 percent (%) reduction in daily potable water consumption when compared to the average volume of water use recorded in the City.

At the heart of Dockside's sustainable water strategy is to provide the best performance in water faucets and fixtures available on the market. Each household appliance in Synergy is applicable for Energy-Star™ quality compliance including Dishwashers and front loading Clothes Washing Machines. The anticipated savings resulting from the use of high efficiency water conserving hardware is calculated at upwards of 147 million litres (39 million gallons) of water per annum. The flow rates of Synergy's water fixtures and appliances are listed below:

- **Showerheads 4.7L/min**
- **Lavatories 1.9L/min**
- **Kitchen Faucet 3.4L/min**
- **Toilets 3.0L/flush**
- **Urinals 0.0L/flush**

Situated below Synergy is the first stage of a $4 million dollar on-site wastewater treatment plant. The water treatment plant is utilized to treat 100-percent (%) of Dockside's inhabitant wastewater, generating an end water quality that is cleaner than comparable municipal distributed water. The treatment plant is capable of processing upwards of 183m^3 of wastewater per day (70 litres per person), with allotted reuse of treated water saving upwards of 113 million litres (30 million gallons) of drinking water per year. Dockside's wastewater treatment plant is a Class IV Wastewater Treatment Plant classified by the Environmental Operators Certification Program. The plant has regularly met, and exceeded the effluents requirements laid out by its operational certification[3].

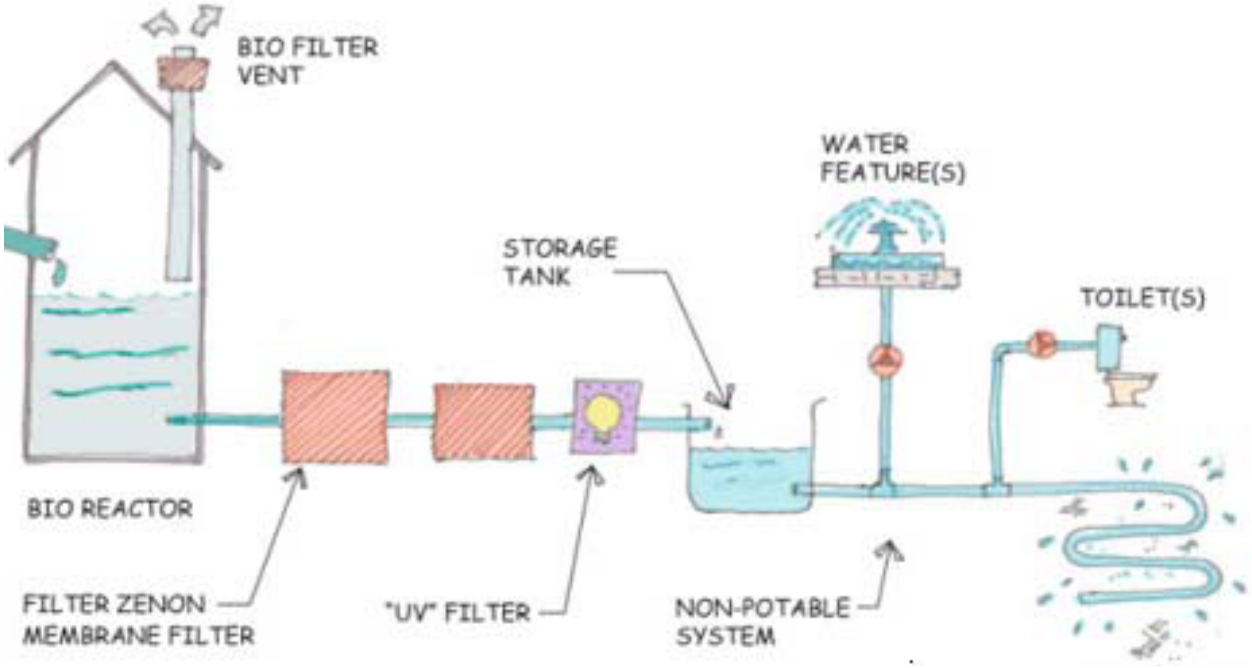


Figure 4.10

The diagram above depicts the journey from which Blackwater and Greywater is recycled. Bioreactors allow sludge and waste materials to separate water allowing the medium to enter into the DG filtration process. Once excess waste is partitioned, UV treatment removes bacteria and then the medium is stored for future reuse for water features and Greywater toilets.

Synergy's wastewater treatment system has an average water retention time of 5.5 days. Within this time, wastewater is being screen and collected in equalization tank for treatment. The application of biological additives removes waterborne waste material with the least amount of disruption to the water medium. The water then flows into a membrane tank with hollow 'spaghetti-like' filters (Fig. 4.11 Pg.54), further cleaning the medium until it is disinfected by UV processes. The resultant non-potable Greywater is utilized for On-site irrigation to sustain the vegetation in Green Walls, Green roof systems, and Balcony planters. Non-potable Greywater will also be reused for toilet waste conveyance.



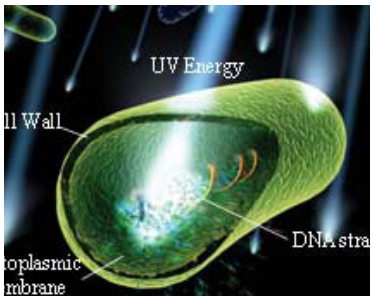


Figure 4.11

(Upper Image) GE Zenon Ultrafiltration membranes are made from a series of holly strands. Each strand is placed under vacuum allowing the strands to suck in water, while debris is blocked from the water medium.

Figure 4.12

Ultra Violet light penetrates clean water resources exposing waterborne bacteria. The UV penetration destroys the DNA of bacteria, thereby cleaning stored water resources.

Canadian based GE Zenon/Zeeweed **Ultrafiltration modules**[4] were selected for the water purification process due to their compact packaging and modular design. Just one of the processing modules is capable of processing up to 40 percent of Dockside's domestic sewage at upwards of 95,000L of sewage per day. Two units have been installed to provide for redundancy and maintenance ensuring continued filtration, with a third to be expected to fulfill the future requirements when Dockside reaches full build-out. The compact modular design allows all three units to be housed within a single building on site.

Dockside Green utilizes advanced **Ultraviolet water treatment systems** produced by Trojan Technologies. Ultraviolet technology is utilized for water cleansing by exposing water to artificial ultraviolet light. Ultraviolet treatment eliminates waterborne bacteria, contaminants, odor-causing compounds, pesticides and irregular sources of foul taste. The patented application of these systems limits the available documentation and research as each UV water treatment system is tailored specifically to project demands.

Effluent from Dockside's wastewater treatment plant is discharged in two ways. A high pressure system delivers treated water for reuse in toilets and roof-top garden irrigation. A low pressure system maintains water levels within the naturalized creek system and is used for summer creek irrigation. If levels of rainwater and treated effluents get too high, the medium is allowed to overflow into the Victoria Harbour.

Treatment systems are designed to buffer surge flows that can occur during severe weather events or flooding. If the treatment system were to shut down, on-site sewage and wastewater could be stored for future removal to off-site or municipal facilities. In addition to this system failsafe, the wastewater plant utilizes an advanced Ultra Violet (UV) air decontamination system to eliminate unwanted odors from the water treatment process.

Although the water treatment process produces potable effluents, the cleansing process leaves residual partitioned waste solids. Dockside produces a daily sum of one garbage-bag worth of Bio-solids that are compacted and reduced into smaller brick forms. The compression and processing technique reduces the polluting content of the waste which then also eliminates the opportunity for waste decay. The bricks are safe enough to be utilized amongst the urbanized setting for on-site human composting and landscape management.

4.1.3 Economic sustainability of Domestic Water Treatment

Distinctive to Dockside Green's initial planning process was a Triple Bottom Line Planning Process (TBL), expanding beyond conventional building methods by including the criteria of Social and Ecological Value. Commitment to the TBL by both the City of Victoria as well as the developer led to equal considerations for economic, social, and environmental benefits as a result of the urban intensification project. The willingness of the developer to embrace the TBL and the resulting negotiation with local authorities allowed Development Charges and Development Infrastructure costs to be waived.

The introduction of social and ecological considerations gave Dockside support from multiple levels of government allowing changes to local municipal acts. As Dockside is able to sustain its communities without significant burden to municipal services, residents benefit from exemptions to Property Tax and the substantial reduction to Energy Costs. The progressive capabilities of the systems deployed in the development also provide income generating sources as a payback for the initial construction investment.

Future plant expansion will increase the expected on-site water processing capabilities allowing Dockside to process an increased volume of 378m^3 per day. The potential processing power will make an additional 6.8 million litres (1.7 million gallons) of treated water available on the site, providing a valuable resource for off-site sales. The production of such a large volume of potable drinking water allows Dockside residents to avoid all municipal sewage and water bills as a component of Dockside's able negotiations with the City of Victoria.

Wastewater treatment processes also produces sufficient number of waste bricks to be offered as consumable fuel for off-site sales. These benefits will ultimately reduce the standards of living for Dockside's residents displaying the economic benefits of sustainable water use and water renewal.

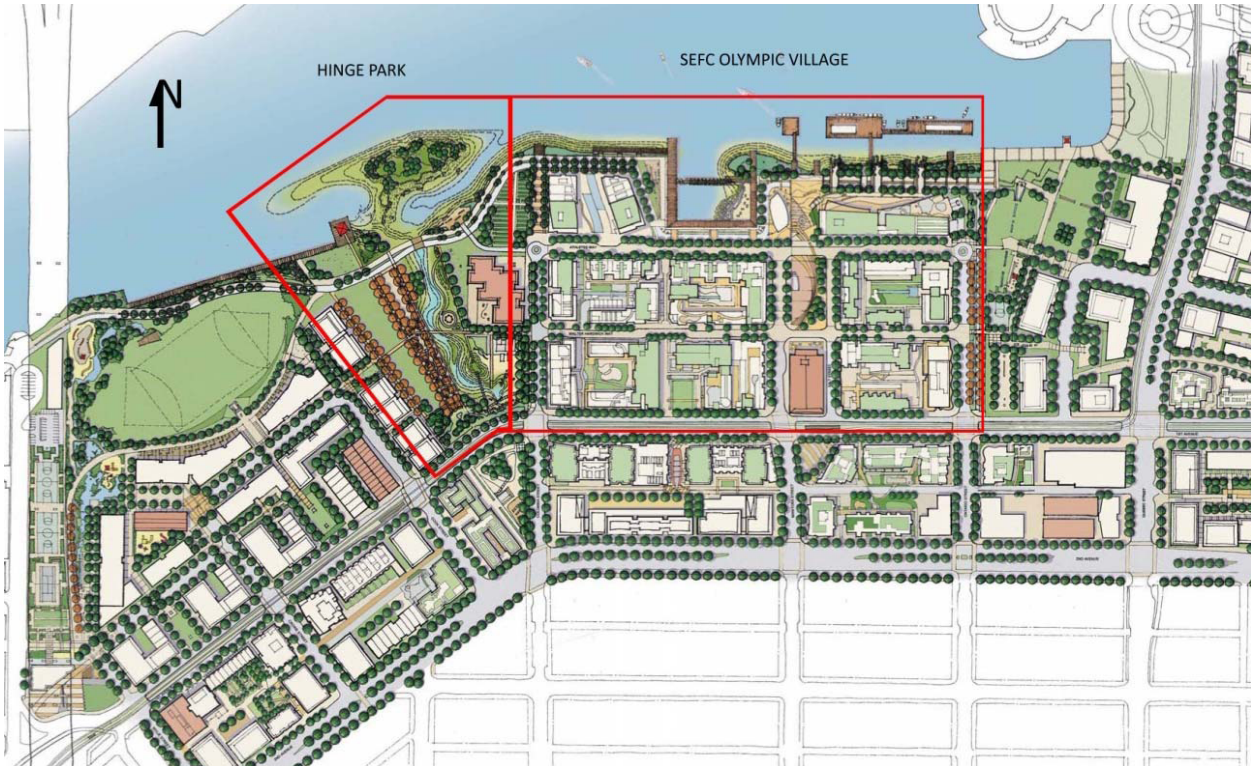


Figure 4.13

The Vancouver Olympic Village is bordered by the red boundary. The village is situated in South East False Creek, and is the first phase of a greater master plan which includes the development of key energy and resource utilities. The entire SEFC is designated as industrial Brownfield classification and requires soil remediation.

4.2 Millennium Waters Vancouver Olympic Village (South East False Creek)

South East False Creek (SEFC) served as an established industrial area over the past century as a component of Vancouver's port-based maritime economy. The site became highly valued for its waterfront redevelopment potential. The first phase of the SEFC redevelopment was selected to house the Vancouver Olympic Village when the City of Vancouver won the bid for the 2010 Olympic and Paralympic Games.

At the core of the SEFC's planning principles were considerations for waterfront environmental renewal and the regeneration of the regional ecosystem. In order to construct the SEFC Olympic Village, the Brownfield site required land remediation and the removal of 235,000 tonnes of polluted soil content. To ensure that the Olympic Village would not contaminant the land, buildings and streetscapes were designed to isolate and trap urban debris. This would allow the project to establish environmental engagement to **restore the regional hydrology and water flow** of the False Creek without any negative impact as a result of the Olympic Village intensification.

4.2.1 Urban Water Renewal

The Olympic Village was designed as an **Effective Impervious Area (EIA)**, functioning as a plane to divert all of the Villages stormwater. SEFC is a geographic region that is subject to high levels of groundwater content and a water table level that is very close to the surface landscape conditions. These On-site conditions combined with the land displacement from the Villages building intensification meant that urban water content could not be absorbed by the land, creating surface conditions that would dump water into the False Creek.

Stormwater runoff from the Olympic Village EIA became a premise to develop an independent water management area, diverting stormwater across the Olympic Village into the Hinge Park Wetlands. The wetland was geographically located in place of a prior river estuary that was destroyed as a result of industrial land use. The **reconstruction of the wetland in Hinge Park would mitigate the impact of urban intensification** and re-establish regional landscape hydrology as a component of the SEFC regional ecosystem, allowing water resources to once again flow out into False Creek.



Figure 4.14

The Hinge Park re-naturalized waterway/wetlands is a critical component to restore the natural function of the SEFC hydrology. Re-developing lost habitat is an essential component of waterfront development and also serves to cleanse outbound water naturally before it is allowed to enter False Creek.

Hinge Park Vegetation – Planting List (Appendix C Table # 3 pg. 3)

The Hinge Park wetland consists of a non-linear, meandering waterway designed to reduce the flow rate of outbound On-site stormwater. The function of the Hinge Park wetland will allow On-site soil content to saturate with stormwater, reinitiating groundwater percolation and groundwater flow in the SEFC regional water cycle. The **wetlands act as a Passive mechanism to reduce the volatility of urban water flow**, maintaining soil saturation and water retention during potential drought conditions.

Figure 4.15

Landscape Architecture is a substantial contributor to the renewal of wetlands and re-naturalized conditions in diminished waterways. The integration of Landscape and Architecture must act harmoniously to create a balance for resource management.



Urban contaminants and surface water effluents streaming into the SEFC Olympic Village from the surrounding region is diverted into the Hinge Park wetlands. As stormwater is directed into the wetlands waterway, waterborne silt and particulate debris will settle into bottom tiers of the wetlands. The soil and substrate content utilized in the wetland construction will filter and trap waterborne debris, ensuring that the contaminants become separated from water resources.

A dedicated team of landscape architects deployed resilient aquatic plant species throughout the tiers of the wetlands waterway. The **plant species were selected based on their capability to absorb waterborne debris,** bacteria, and other sources of urban contamination that could result in decaying water quality.

Figure 4.16

Completed construction of the Hinge Park wetlands shows a naturalized condition with aquatic plant species functioning to filtrate and cleanse water of sediment, contaminants and additional stormwater materials. Without these naturalized conditions, Dirty stormwater would flush into the False Creek.



An irrigation system was installed to ensure that the naturalized waterway is under constant hydration. Water pumps have also been installed throughout the wetlands to ensure proper water circulation and water flow. The Active water mechanisms have been put in place as a failsafe to ensure that Passive water cleansing processes continue to function as intended. The constant movement of water in the wetlands ensures that the quality of water resource is maintained in its natural state of motion. Water flow will stop water quality degradation by preventing the resource from stagnant conditions.

Sediment and effluent materials collected in the wetlands drain into a collecting pond at the end of the wetlands waterway. Built-up sediment is serviced and removed annually to ensure the continual function of the Passive wetlands system. The result of stormwater traversing throughout the wetlands is a clean water effluent which is discharged into the False Creek. The Hinge Park wetland successful increases the regional awareness of urban water resources by highlighting the natural water filtration processes that must occur.

4.2.2 Dirty Water Management

The design of streetscape and landscape elements within the Olympic Village were utilized as Passive water treatment mechanisms. The design intention was to ensure that urban debris from streetscapes and roadways do not contribute to the decay of urban water quality. Landscape strategies manage dirty urban contaminants by isolating and separating waterborne debris from water resources. Passive water filtration and treatment mechanisms function as components of a Dirty Water Management strategy, identifying the environmental hazards that result from urban intensification. The Dirty Water Management strategy ensures that water quality in urban areas does not degrade as a result of urban inhabitation.

Inside the village, Streetscape Bioswales have been deployed to pre-treat water content before the resource is discharged into Hinge Park. **Bioswales are filled with native vegetation to buffer the re-naturalized habitat from urban streetscape conditions**. Bioswale landscaped elements are filled with resilient native vegetation, rip rap sediment and soil content to absorb and drain surface water runoff. Bioswales are deployed throughout the SEFC Olympic Village to isolate roadway debris, trap dirty silt, and break down waterborne pollutants.



Figure 4.17

Each segment of roadway within the village is lined with Bioswale landscaping and vegetation material where stormwater runoff and roadway debris drains into the Bioswales to ensure that contaminant debris does not enter the SEFC (right).



Figure 4.18

Roadway infiltration galleries are a component of the impervious design which isolates roadway waste at the source, and traps the material without allowing them to escape into the uncontaminated groundwater flow.

Infiltration galleys are deployed to capture and contain surface runoff to prevent urban waste from entering naturalized landscape conditions. They are constructed from layers of gravel, sand, and other riprap in a cell like structure that are installed into the ground. **Geotextile fabrics and membranes prevent the erosion of substrate materials**. The substrate absorption process successfully traps contaminant debris within the galleys, ensuring that water content being diverted into the Hinge Park wetlands is free of urban contaminants. The landscape element is also utilized to mitigate surface water conditions to prevent urban runoff and the spread of debris.

4.2.3 Clean Water Management



Figure 4.19

Architecture plays a substantial role to divert stormwater. Canopies serve as rain diversion panels with dual function. This allows for precipitation and snow to be diverted and managed while reducing on-site runoff from urban structures.

The EIA prescribes a percentage of the total On-site area functioning as an overall stormwater drainage system. Over 40 percent of the Village is to be utilized for direct water management, utilizing established impervious surfaces to funnel and collect rain for the purposes of future reuse. Clean water management focused on the distribution and diversion of stormwater integrating the process as an Active component of building form rather than allowing water to concentrate on the site. Building typology is utilized to collects, direct, attract, and contain as much precipitation as received on site.

The Olympic Village was designed with a core imperative for water efficiency to disallow the use of potable water for the purposes of landscape and onsite irrigation. The development team looked towards a methodology for **'Banking' available on-site water resources contributed by rainfall and stormwater collection**. The captured water medium is stored in basement cisterns to be re-utilized for toilet flushing and irrigation. Rainfall is continually captured from building rooftops providing a 40 percent reduction in total water demand which is conventionally placed on the municipal utility. The pattern of cyclic use preserves the quality of captured water medium as the solution is not allowed to stagnate.

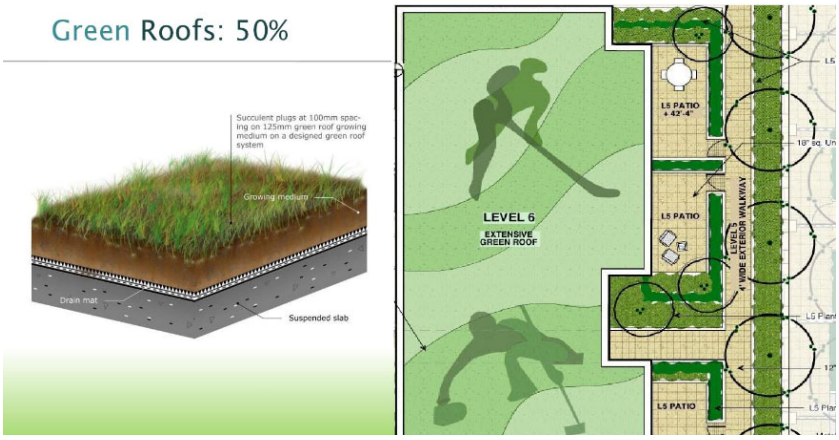


Figure 4.20

The Vancouver Olympic Village established a minimum Green Roofing system coverage of 50% of each building's roof area. This allows the roof surface to function as an absorption and short term storage mechanism to reduce stormwater runoff

The Olympic Village landscaping strategy utilized isolated **storage ponds and Green roof systems to reduce above grade impervious surfaces** allowing natural water dispersal by water evaporation and transpiration. The design would utilize landscape features to evaporate the large volume of water entering the site which provides the site with the capacity to manage the Villages water outflow.

The Village's urban schema packs a high volume of residential building typology within a small and confined area. Sufficient water management requires **buildings to function as the natural terrain, channeling precipitation through collection and storage systems to slow the egress of stormwater**. Green roofing systems were utilized in conjunction with substantial planting coverage to manage precipitation before it reaches the required impervious surfaces at grade. The plantings and soils filtered out unwanted contaminants to ensure that the Village does not contaminate outflow waters.



Figure 4.21

Architecture plays a substantial role to divert stormwater. Canopies serve as rain diversion panels with dual function. This allows for precipitation and snow to be diverted and managed while reducing on-site runoff from urban structures.

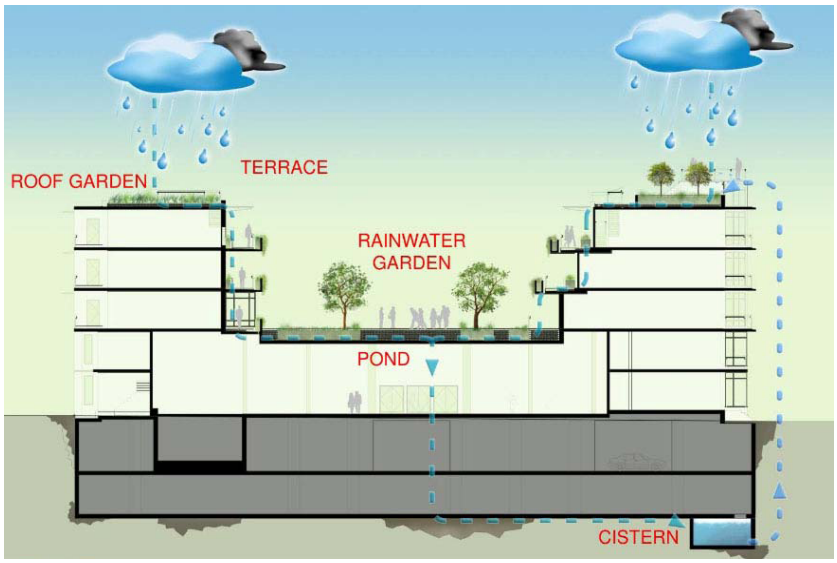


Figure 4.22

The design of the Olympic Village Parcels utilizes an internalized and elevated podium as an essential component of the passive function for rain percolation and storage. The beauty of the design is an environmental condition entrenched amongst an urban building typology, yet protected from harmful urban contaminants.

The application of above ground filtration ponds and subterranean cisterns were utilized to increase the capacity for on-site water storage. Cisterns were deployed on building roof tops and elevated Podium amenity areas not only as functional storage but they also served to cosmetically enhance interior and outdoor conditions. Water features and water fountains can be found flowing throughout the village, with constant hydraulic flow providing a means to preserve water quality throughout the seasons.

4.2.4 Domestic Water Savings

Inhabitant water consumption will be optimized at 190 litres per capita per day based on projected reductions from LEED™ NC Water Efficiency Strategies. Interior water management will utilize dual-flush and low-flow toilets (3 to 6L per flush respectively), low flow water fixtures and faucets (5 to 7L per minute showerheads, 3 L per minute faucet) and water free urinals. Stormwater when passively filtered by the permeable roof structures of each individual SEFC building in combination with the reuse of recycled Greywater can reduce the overall inhabitant potable water consumption to less than 100 litres per capita per day.

The total projected resource savings of the Net Zero Social Housing Project showed a 68 percent reduction in energy use and 40 percent reduction in potable water consumption when compared to conventional multi-storey residential typology in Vancouver.

To monitor and ensure the performance of the Net Zero Social Housing Project, The City of Vancouver Engineers recognized the need for Active metering provisions to pursue water conservation in residential housing. Water meters will be required in all new-construction within Vancouver beginning in 2012. Each residential suite within the Olympic Village is equipped with advanced Energy-Aware monitoring software (Fig 4.23). The **advanced monitoring system allows inhabitants to track the volume of water they use**, providing a grounds for users to challenge themselves for improved water conservation.

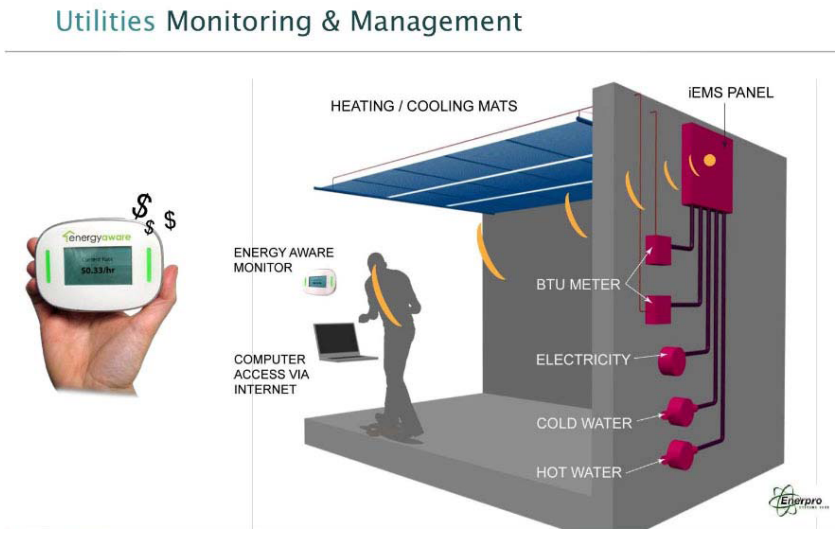


Figure 4.23

Reliable Controls in conjunction with Energy Aware Technology Inc. has developed an advanced wireless monitoring system called 'PowerTab'. PowerTab is deployed in each domestic unit within the SEFC Olympic Village, enabling smart monitoring of water resources.

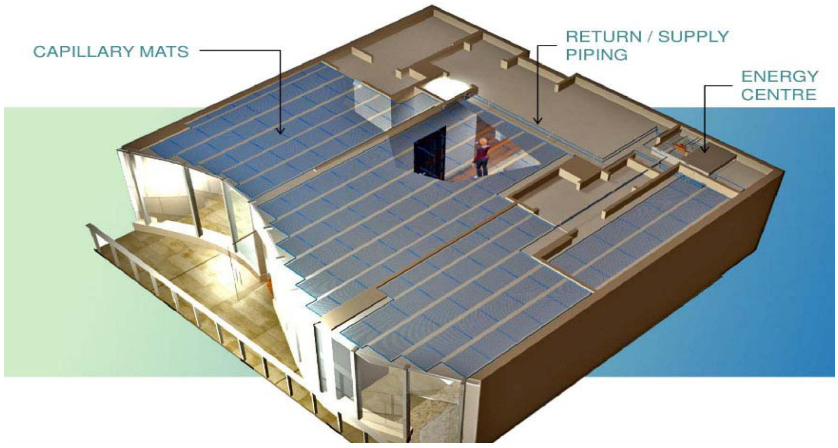
4.2.5 Innovation in Water Use

The South East False Creek (SEFC) Net-Zero Social Building is the first zero energy multi-unit residential construction in North America. Net-Zero terminology describes buildings that are resource independent. The initial construction was selected by the Canada Mortgage and Housing Corporation (CMHC) as an experiment to explore sustainable construction typology in an urban mid-rise application. The Net Zero Social Housing project achieved Net Zero Energy through the innovative use of water resources.

Net Zero energy was achieved by utilizing water based transient solutions as a means to store captured solar energy. The innovative use of clean, potable water content within the building typology is an alternative means for building water usage other than conventional inhabitant water provisions. The Net Zero Energy building showcases potential alternatives for water storage and water management to utilize domestic building construction and inhabitation as a vessel for urban water storage.

Figure 4.24

The capillary system can be applied on walls, ceilings, and even floors of the structure. In residential applications, ceilings serve as the most un-interrupted surface to provide thermal conditioning.



The structure is unique in its application of a **capillary mat radiant conditioning system, utilizing clean, potable water as a thermally energized medium** to distribute thermal conditioning in the ceilings of the Net Zero residential units in place of conventional HVAC systems. The capillary-mat consists of interconnected parallel tubules, 4 millimeters in diameter transferring heated or cooled water into radiant conditioning. The system is isolated from external environmental conditions and developed from durable non-corrosive polypropylene materials. This allows the Net Zero structure to save 40 percent on energy consumption when compared to conventional conditioning systems.

The Net Zero building harnesses solar energy from a roof mounted 280m² Solar Thermal Array. Solar energy is captured by 72 panels of 16 independent vacuum tubes translating solar radiation into heated water resources. The heat transfer fluid (HTF) is pumped into the buildings capillary mat system to fulfill the heating and cooling demands of inhabitants. A secondary array of the same size is positioned on a neighboring structure. The Net Zero structure is one of three buildings within the Vancouver 2010 Olympic Village that utilizes the water based energy harnessing technology.

Figure 4.25

The solar array can be applied above and on top of a Green roofing system. The array must be unimpeded by other structures in order to maintain an operational window to harness maximum solar energy.



At times of peak energy recovery, the system is efficient enough to produce a surplus of thermal energy. Excess heat is retained within stored water resources and sold to the greater SEFC via an integrated District Energy system. HTF is distributed to other buildings via an extensive subterranean plumbing network. The Net Zero Social Housing establishes a stable and secure source of hot water and thermal conditioning. The energy absorption system is the first time a solar powered system has been utilized within North America at such northern latitude. It is one of the advanced Active building systems allowing the Net Zero Social Housing Project to achieve beyond LEED™ NC Platinum certified performance.

To satisfy the cooling demands of the building, architects integrated an innovative water condensation technology utilizing the heated water from the solar thermal array to fulfill thermal cooling demands. Absorption chillers intake inbound hot water from the roof mounted solar thermal array. A separate, closed-loop system of heated water transient receives chemical additives that change the water into brine mixture[5] to create evaporation. The freshly evaporated water vapors are condensed and sprayed onto pipes that hold building circulated clean water. The evaporation and condensation effect cools the water in the pipes, allowing the cooled water content to cool the building through the capillary network.



Figure 4.26

Capillary Mat application in the Net Zero Social Housing Building.

The development of the Vancouver Olympic Village followed a community scale strategy for resource distribution within the SEFC. Designers embraced the potential for resource conservation as an interconnected and correlative operation, with efficiencies in one resource profile positively affecting alternative resource uses. The application of advanced Active building systems within the Olympic Village has greater economic feasibility as a result of the community scale engagement. Although the community is heavily dependent on a significant number of building systems to achieve sustainable resource use, planners continue following the established Green Building resource conservation guidelines to instill conservation ethics and reduce the resource profile of urban inhabitants.

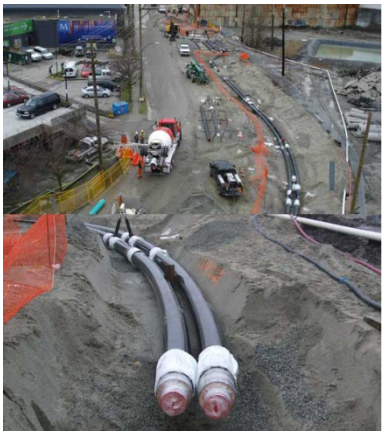


Figure 4.27

Network Energy Utility (NEU) hot water connections are established to connect all of the buildings in the Olympic village, allowing the community to function as a district energy system



Figure 4.28

Aerial Perspective of the Drake Landing Solar Community to the Northwest.

A continuous Solar Thermal Array is mounted above detached rows of garages located at the back of each property lot.

4.3 Drake Landing Solar Community

The innovation involved in DLSC and the reason for its consideration in these case studies is due to the diverse strategy to utilize water as a medium for thermal conditioning and energy. One of the many reasons why water issues exist amongst residential typology is the rapid rate from which water is diverted from the home and into local waterways and municipal utilities. The strategies deployed by DLSC may provide an explicit means to store and utilize water for building and community functions beyond the basic provisioning of human consumption. The project elaborates on the scale and complexity to maintain a functional water-based thermal system and the considerations that must be made to apply those systems in harsh climatic conditions.

4.3.1 Sustainable Domestic Water Storage

Drake Landing stores a high volume of water for short and long term use in the community's solar thermal system. The system consists of a district loop, connecting 800 garage-roof mounted solar thermal panels to short-term and long-term storage facilities situated within a District Energy Centre. Situated amongst the DLSC is a 2,500 square foot District Energy Centre housing two large insulated water tanks with a capacity of 120m^3 each. The tanks store stratified water for DLSC's Short-Term Thermal Storage (STTS) in addition to heat exchangers, pumps, tanks, and any other equipment necessary to operate the solar thermal system and the district loop. The system relies on a buried network of thermally insulated piping feeding water that is energized with solar heat into each and every DLSC household.

Anti-freezing and corrosive additives are intermixed into the water medium to ensure continual use during winter months. These additives reduce the capabilities of water to act as a thermal medium but the application of conventional building systems requires the additive to maintain systems operation. The cleaner the quality of the water becomes; the greater capacity it has as a thermal storage medium. In regions where temperature volatility is less extreme, innovative applications could be utilized without anti-freezing additives allowing water to be used in its naturalized state[6].

A long term water storage strategy utilizes a Borehole **Thermal Energy Storage (BTES)** developed as a series of boreholes that allow water to circulate slowly throughout a subterranean network transferring captured solar heat into the surrounding subterranean soil. DLSC applied its borehole system beneath a neighbourhood park, establishing landscape and open community space that indirectly protects the system. The 144 boreholes are insulated to avoid heating surface soils and reach down to depths of 35 metres. The BTES field covers approximately 35 square metres utilizing approximately 1,225m^3 of soil thermal storage.

The STTS and BTES systems are solutions to utilize water on-site that also present the possibility of expanding closed-loop water based systems into alternative domestic uses. Although the DLSC utilizes water purely for energy purposes, it may be possible to transform such a system to mitigate the volume of potable water consumption through Greywater and Blackwater renewal. Advanced solar thermal systems are capable of increasing water temperatures to near boiling rates, while pumps and water-to-water heat exchangers maintain water quality and prevent stagnation.



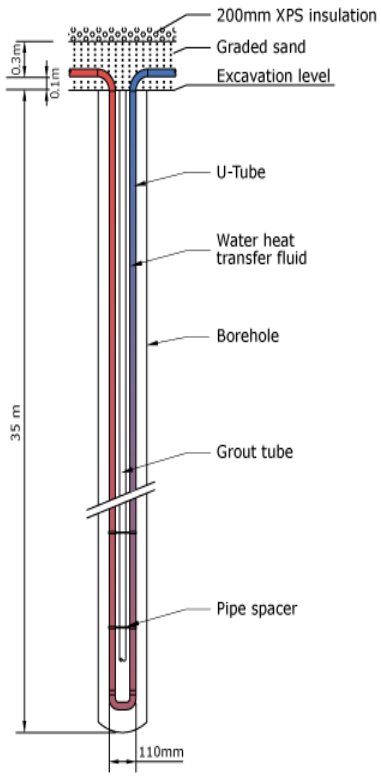


Figure 4.29

Borehole technology reaches down to depths of 37meters infusing the soil with heat captured by the solar array.

Figure 4.30

This image displays the DLSC borehole installation. The borehole area is insulated to maintain thermal isolation and prevent heat loss.

A subterranean installation for water storage as utilized in the Drake Landing BTES field effectively stores a larger volume of water on-site without the need for built infrastructure and thermal conditioning as required with storage tank and large scale collector solutions. This type of installation presents an opportunity to repurpose excavated Brownfield lands for the function of water storage based on the effective use of development area. Borehole technology has a capacity to store upwards of 3 times the volume of storage medium when compared to a basic cistern or storage tank[7].

A key design feature in the DLSC district loop is the capability to maintain water transient quality for extended durations and continuous use. The continuous movement and flow of water content ensures that water is contained in a natural state of movement to prevent water stagnation within the system. The medium is delivered throughout the district loop at an average rate of 9L/s from the STTS after it is received from the solar array at 15L/s, with flow rates reflective of the volume of user demand. The heat that is harvested in the district water medium is also another key factor to ensure the quality of the water transient. Increases in water temperature establish hazardous conditions where waterborne bacteria and other forms contamination are not allowed to grow. Water temperatures when heated will reach beyond 80 degrees Celsius by the end of summer.

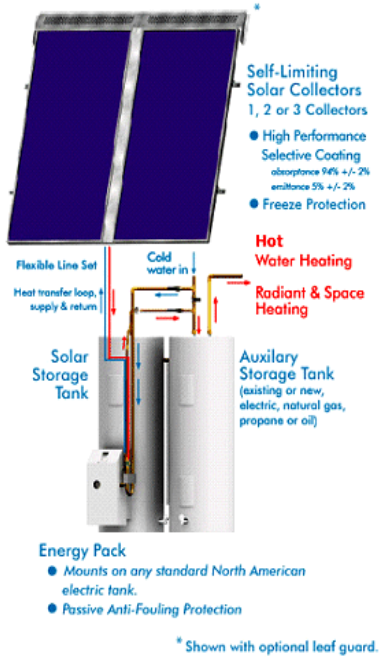


Figure 4.31

Individual applications for hot water consumption allow separated household metering and efficiency monitoring.

DLSC households utilize a separate, individual solar thermal array that is not connected to the DLSC district water loop as a sustainable method of generating hot water. The hot water system increases the efficiency and the rate from which hot water is provided to inhabitants, establishing water savings as inhabitants do not have to wait for their hot water provisions. To ensure that hot water resources can be accessed as quickly as possible, the conventional hot water tank is paired with an additional tank holding hot water transient. The additional tank functions as a heat exchanger to ensure that water provisions retain heated temperatures.

DLSC recognizes the high water demands of Canadian residential households with greater than 80 percent of energy utilized for a combination of thermal conditioning as well as hot water heating. Approximately 73 percent of household water demand is hot water.[8] Establishing the groundwork to reduce the time to provide hot water resources will directly impact the amount of energy required to continuously heat water. The DLSC solar thermal system is capable of supplying 60 percent of the community's hot water demand at peak efficiency.

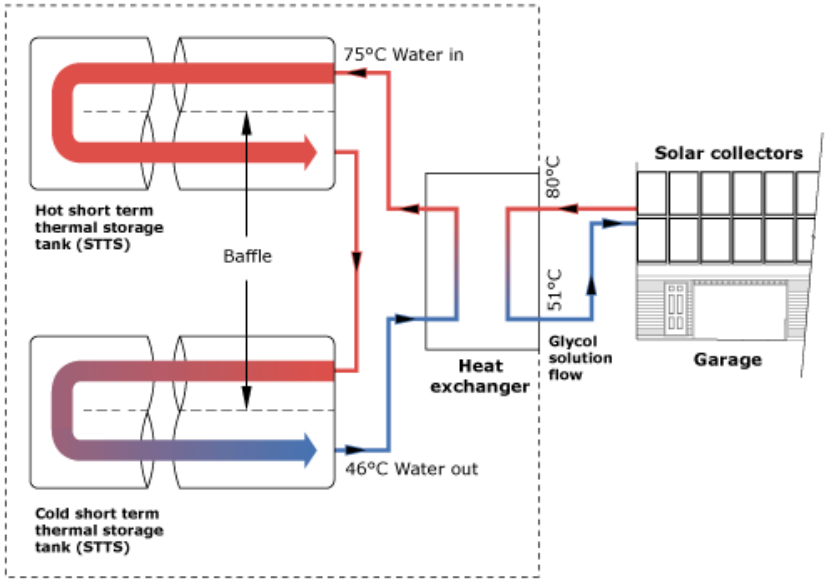


Figure 4.32

DLSC utilizes both short term and long term storage techniques to provide continuous hot water and thermal conditioning provisions throughout the year. The capability of the system to provide cold and hot thermal conditioning is vital for long term water use as a thermal transient.

4.3.2 Increasing Resource Awareness

One of the innovative strategies deployed by DLSC allows inhabitants the privilege to monitoring the community's resource use online application via the DLSC website; http://www.dlsc.ca. Online access to the DLSC solar water loop presents daily documentation notifying residence of the status of the system at 40-minute intervals, presenting the volume of resources being consumed and the flow rates of the heated water transient.

The monitoring system notifies community residence regarding water temperatures, STTS or BTES activation depending on community resource consumption levels. The successful ability to translate the complexity of the DLSC district system into quantifiable values displayed online is one of the potential monitoring innovations which provide greater awareness for inhabitant resource consumption.

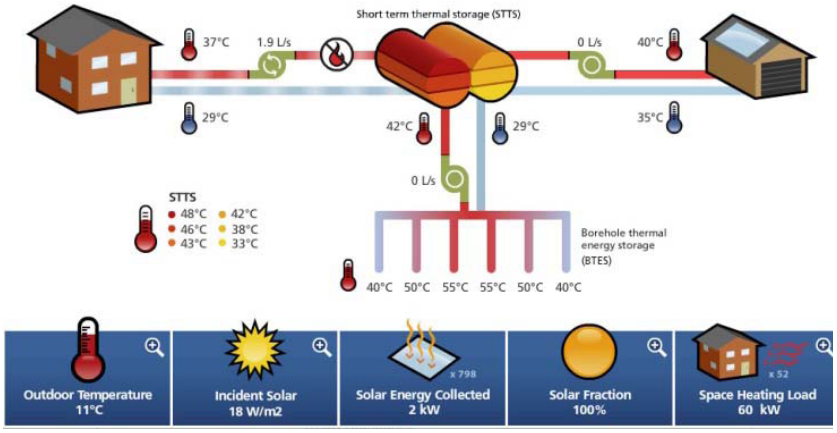


Figure 4.33

DLSC district energy system monitoring was made possible by Howell-Mayhew Engineering Inc.

The energy system allows water to reach upwards of 80 degrees Celsius, which is a sufficient temperature to avoid bacterial growth in the water medium.

Endnotes:

[1] Refer to Dockside Green Synergy Phase 1 LEED™ Score-sheet.
http://www.docksidegreen.com/Portals/0/pdf/sustainability/Dockside%20Green%20LEED%20Scoresheet%20-%20Synergy.pdf

[2] An integrated resource recovery process specifies a sustainable method for refuse disposal. IRR is a fundamental component for Green Building construction that has utility infrastructure such as water treatment, energy generation and waste management

[3] Effluent Quality Requirements (Class IV):
Suspended Solids: < 5.0mg/L BOD: < 10.0mg/L
Coliforms: < 2.2 CFU/100mL
Total Phosphorus: < 1.0mg/L
Total Nitrogen: < 10.0 mg/L
Ammonia Nitrogen: < 1.0 mg/L

[4] Refer to Appendix A. Pg.10 GE Ultrafiltration module spatial requirements

[5] Brine is a water based solution that is saturated, or nearly saturated in salt

[6] Water as a thermal transient is more energy efficient under freshwater conditions than compared to brine solutions or solvent solutions

[7] Borehole storage is more efficient with retaining thermal temperature than conventional tanks. It also has a much greater storage capacity. http://www.dlsc.ca/borehole.htm

[8] The bulk of household energy is utilized to heat water for inhabitant use. This can be substantially reduced through hot water use conservation and increased efficiency in hot water provisions. http://www.statcan.gc.ca/pub/11-526-s/2010001/part-partie1-eng.htm

Chapter FIVE: Guidelines & Standards for Net Zero Water

Net Zero Water (NZW) is a prescription for total water neutrality. To achieve Net Zero Water, domestic building performance will require best performing water related hardware as a means to establish sustainable water use. Net Zero Water Guidelines and Standards for the Domestic construction will prescribe the required fixtures and appliances in order to improve domestic water use. Specified performance of water related hardware will be based on the Green Building Guidelines of LEED™ and the Living Building Challenge.

Net Zero Water Guidelines will require the **division of Potable and Non-Potable quality Water resources**. Potable water quality will only be utilized for human consumption, with alternative water uses serviced by non-potable quality water such as harvested Greenwater (rain) and recycled Greywater (post-potable use).

Establishing water efficiency to achieve water conservation is a vital strategy to develop NZW independence in urban domestic households. This includes the need deploy the necessary household tools to mitigate water misuse, improve water savings, and the need to expand the role of architecture for increased water awareness.

The acceptance of LEED™ follows an Additive methodology towards sustainable project performance where developers are rewarded when milestones are achieved. In contrast, the Living Building Challenge prescribes a subtractive methodology, where all definitions of building performance are weighed upon an absolute goal for living buildings.

Harnessing the positive attributes of both Green Building methodologies, NZW Guidelines require a 'Subtractive from Zero' performance Standard until the goal of water neutrality has been reached. An 'Additive' accreditation Guideline will accumulate water conservation efforts to prescribe sustainable NZW use. The Additive and Subtractive strategies will be deployed under a Water Use Guideline, calculating the adequate and necessary use of domestic water hardware to achieve water neutrality.

Domestic water performance will be calculated through **Time-of-use and Choice-of-use** variables to achieve the **Net Zero Water target for 70 LPCD** (Litres per Capita per Day) of water consumption as defined by globally recognized organizations prescribing sustainable levels of water consumption. The guideline will prescribe usage values for individual household water tasks based on usage percentages extrapolated from current day usage (City of Toronto 253 LPCD).



Figure 5.01

Net Zero Water must require cyclic water use which replicates the natural function of an ecosystem. The only way to establish sustainable water consumption in urban regions is to take part in the renewal process.

5.1 NZW Domestic Pre-requisites

A project must **not be allowed to utilize municipal provisioned water supply for indoor and outdoor domestic uses**. The sole source for inhabitant water will be harnessed from the urban water cycle and the annual Greenwater precipitation that is provided. Precipitation harvesting will provide water resources for immediate and future use. The process places inhabitant water demand on the building and the immediate site, rather than depend on non-sustainable municipal water utilities.

In cases of extreme drought where sustainable sources of water cannot be sourced, NZW households will retain a connection to municipal water utilities as an emergency safety precaution. **Municipal watermain and sewage trunk connections are to be maintained** until such time as governing authorities recognize the capacity of urban domestic building typology that functions as a water independent entity.

Energy Star™ qualified fixtures and appliances are readily available to improve domestic water performance. Increasing the required water performance for domestic water hardware will force developers to deploy domestic household fixtures and appliances with improved water efficiency. NZW prescribes minimum **Energy Star™ performance as the new Model National Water Use Baseline** for domestic hardware.

Any form of water contribution from human inhabitation must be contained and disposed of without negative environmental impact. Household Refuse Management is required to **separate waste from water resources** to ensure post-consumed water content does not become a medium for waste conveyance. NZW households are required to provide waste containment provisions to increase the accessibility of household waste management as a means to divert waste from water.

Preventing dripping faucets and Water Leakage from water fixtures will eliminate up to 27 LPCD from Toronto's current average household water consumption. Removing water leakage as a factor of household water consumption will provide an allowance of 11 percent water consumption[1] to be re-distributed to other segments of household water demand. The installation of faucets and fixtures in all building typology must be regulated and certified to meet the quality of Net Zero Water with regards to leakage prevention[2].

5.2 NZW Domestic Guidelines

Water fixtures and appliances are the key to inhabitant engagement in the domestic environment. Net Zero Water Guidelines in domestic construction will identify the volume of water savings that can occur as a result of sustainable water hardware selection. Performance improvements will be calculated to verify the impact of water efficient hardware to achieve water reduction and optimize domestic water use. LEED™ prescribes the use of efficient faucets and fixtures that achieve 15-25 percent (%) improvement in water performance from established baseline prescriptions. Best available Energy Star™ ultra-low flow products are capable of further reducing water consumption by an additional 30-50 percent.

LEED™ and Energy Star™ qualified domestic water products will be used to prescribe baseline performance to achieve 70 LPCD per NZW household. The optimal deployment of qualified domestic hardware will be deployed under categories of Potable and Non-potable water supply.

Types of Household Water Demand

Household Lavatory Tasks		Water Demand TYPE	
		Potable	Non-potable
Facial Cleansing		x	
Teeth Brushing		x	
Shower			x
Bath			x
Toilet	Solid Waste Contributions		x
	Liquid Waste Contributions		x
Household Kitchen Tasks			
Food Preparation		x	
Water Consumption		x	
Dishwashing			x
Household Laundry Tasks			
Clothes Washing			x
Potable: fit or suitable for drinking			

Table 5.0.7 outlines the different types of water use within domestic households. Out of the 9 typical tasks that are associated with domestic inhabitation, only 4 types of water demand are required for inhabitant intake. Of these 4 types, *Facial Cleaning, Teeth Brushing, Food Preparation and Water consumption* require Potable water quality from 2 household locations, the Lavatories and the Kitchen.

The remaining types of water demand to achieve household related tasks do not require water of sufficient quality to meet potable levels. These tasks, *Showering, Bathing, Toilet use, Dishwashing and Clothes washing* can be satisfied with Non-Potable water resources.

5.2.1 Non-Potable Water provisions

The most significant savings for household water conservation can be found in the lavatory/washroom. The plumbing item that can achieve the most substantial savings in NZW conservation efforts belongs to the selection of **High Efficiency Toilets (HET)**. NZW households will require the use of Dual-Flush technology integrated in HET's for maximum water savings. Ultra Low Flush HET with dual flush technology can achieve **4.8L per flush for waste solids, and 3.0L for wastewater**[3].

NZW Ultra Low Flush HET with Dual Flush technology achieves a conservation volume of 3.0 Litres Per Flush (LPF) savings when compared to minimum Energy Star™ hardware (6.0L/50% savings) and an overall savings of 13.5LPF (16.5L/82% savings) over an outdated inefficient toilet. The deployment of HET's in NZW households will follow established municipal standards for 1.15 (average) toilets per unit within multi-unit residential construction in the City of Toronto[4].



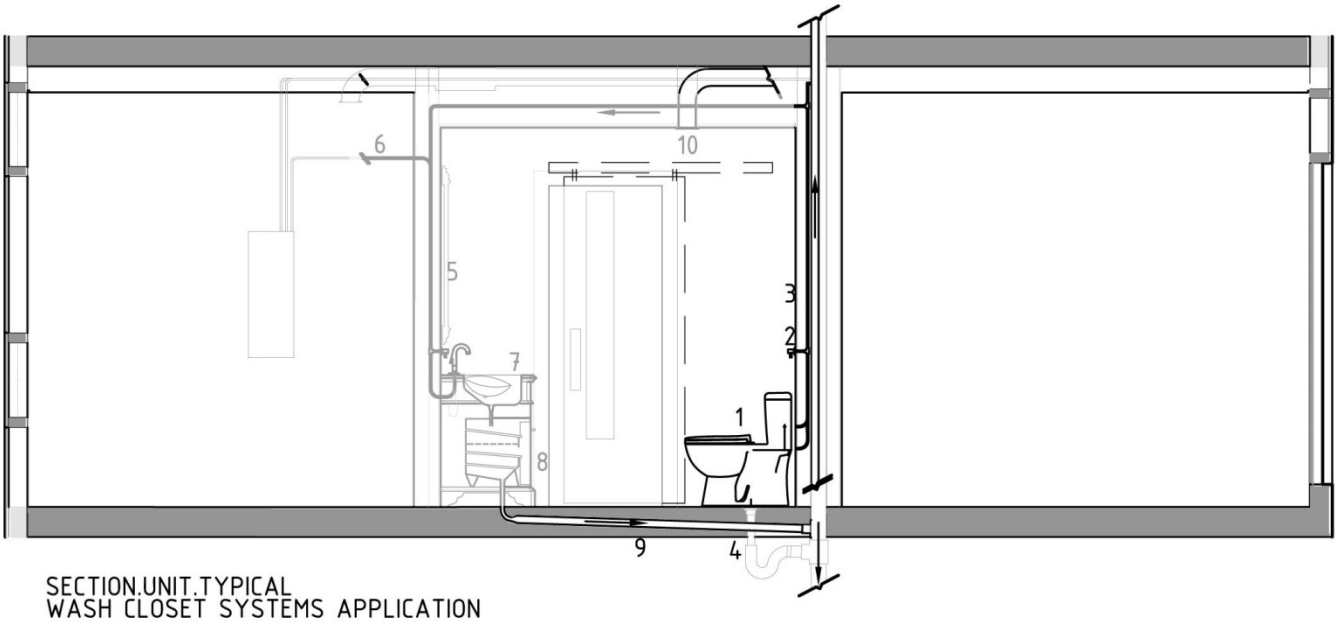
Figure 5.02

Dual Flush technology utilizes a dedicated amount of water for wastewater flushing such as urine. A larger dedicated amount of water is utilized to flush feces/human waste. Clear indication of Dual Flush technology is needed to advice inhabitants to utilize the correct flush selection for toilet related conveyance.

NZW construction requires the use of non-potable water for the purposes of toilet waste conveyance. Non-potable water demand will be sourced from sustainable water harvesting and potable water renewal in the form of Greywater. The key consideration is the fact that households do not require potable quality water for waste conveyance.

Issues that compromise the promised efficiency of HET's originate from drainage systems for waste conveyance. NZW households will utilize a **dedicated Blackwater drainage for waste and waste conveyance**. This dedicated plumbing network will mitigate the drainage backups and pressure loss that occurs in newly constructed urban development[5]. Those issues can render the single flush function of toilets ineffective, leading to multi-flush conditions that wastes more water (Chap. 2 Fig. 2.1.3 Pg. 26).

In the most ideal situation, water should not be utilized as a solvent/medium for waste conveyance. Urinals applicable in amenity areas have reached a technological state where water is not required for wastewater flushing. NZW will require 0 LPF urinals in amenity areas such as available gymnasiums and gaming rooms in sustainable mid-rise residential construction.



SECTION.UNIT.TYPICAL
WASH CLOSET SYSTEMS APPLICATION

INDEX

1	DUAL FLUSH CAROMA TOILET AVG. 3.5LPF
2	INDIVIDUAL DUAL FLUSH FUNCTION
3	GREYWATER PROVISION
4	BLACKWATER DRAINAGE

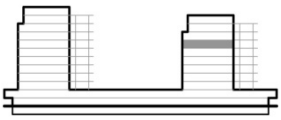


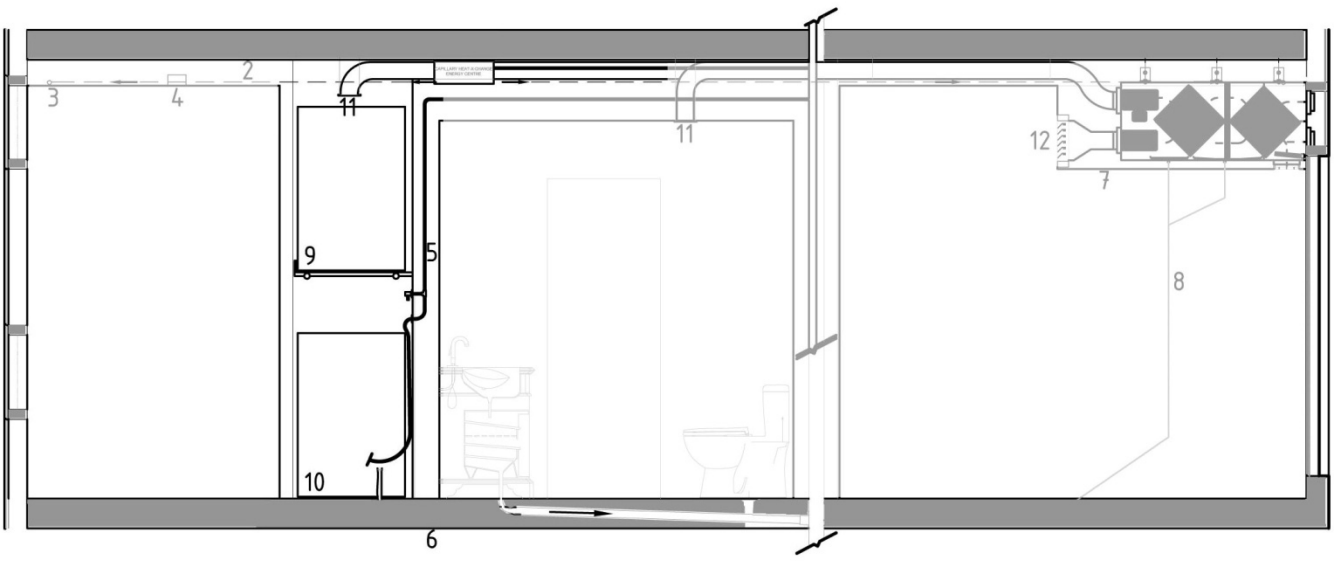
Figure 5.03 Scale 1:50



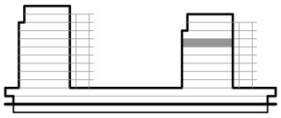
HET toilets will be installed with independent displays separating the function of single flush and dual flush operation. The separation of the two functions ensures that there is no confusion between single and double flush operation. HET's will source Non-Potable Greywater from a Non-Potable water quality plumbing source in the household lavatory/wash closet/washroom.

Toilets will only be utilized for human waste conveyance. Inhabitants will not utilize the toilet for any other source of waste disposal besides affiliated toiletries (Toilet Paper). Toilet Blackwater drainage requires a dedicated plumbing network with proper ventilation to ensure that no backflow and pressure issues occur.

Caroma is the Toilet manufacturer that has been utilized by LEED™ projects as seen in Dockside Green Development.



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9	ENERGY STAR TMDRYER UNIT (SUSPENDED)
10	WASHER UNIT 4.4CU.FT W/F 2.0
11	VENTILATION INTAKE (STALE AIR)
12	VENTILATION OUTPUT (FRESH AIR)

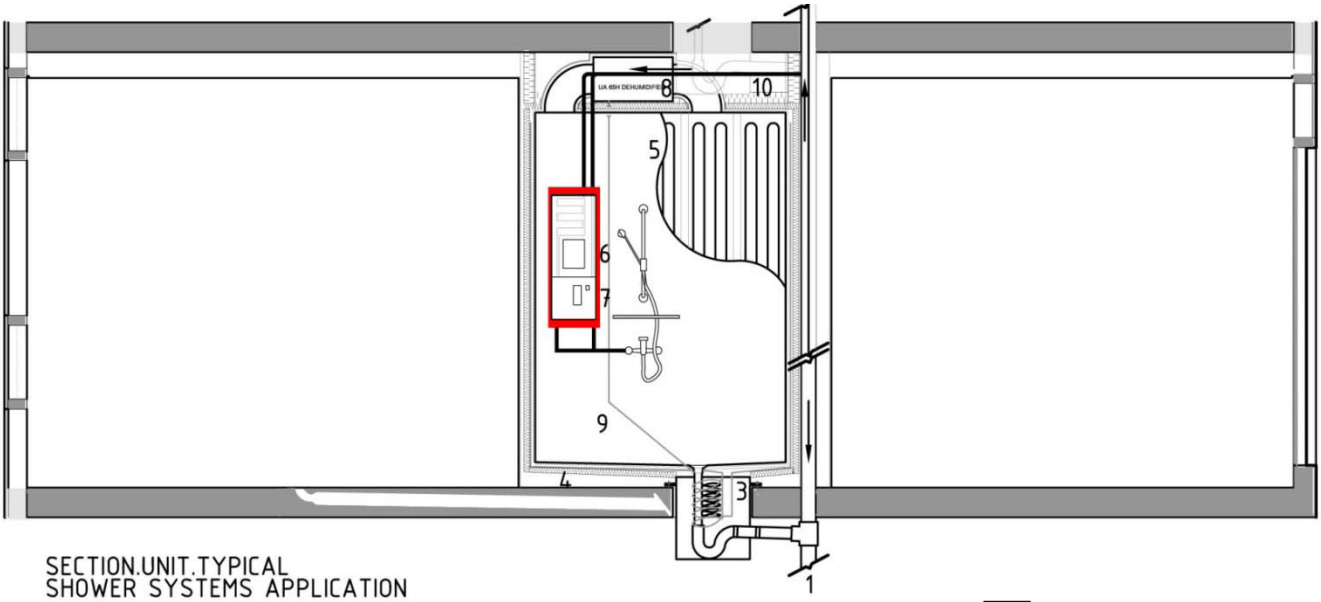
Figure 5.04 Scale 1:50



The second highest water consumption recorded within multi-residential building typology is attributed from the use of **Washing Machine/clothes washers**. NZW building typology will equip clothes washing appliances utilizing only non-potable water with a minimum High Efficiency rating of Tier 3. Tier 3 is prescribed by the Consortium for Energy Efficiency (CEE) designating a Water Factor[6] (WF) of 4.0 and less. Current Energy Star™ qualified clothes washing appliances utilized by LEED™ achieve a WF[7] of 6.0 with an established minimum federal standard at 9.5.

Best performing washing machines achieve a 2.8 WF at a volumetric capacity of 4.4ft³. Typical multi-unit Washer-Dryer combination units have a lower capacity between 2.5-3.5ft³ (Dim: 24x30"avg.) which forces inhabitants to run a greater number of washing cycles. NZW multi-unit residential typology will require increased spatial demands for higher capacity washing machines (Dim: 30x30"avg.) that achieve 2.8 WF.

Greywater by-product as a result of washing machine use will be drained and collected for water quality renewal and future reuse[8].



SECTION.UNIT.TYPICAL
SHOWER SYSTEMS APPLICATION

INDEX

1	GREYWATER DRAIN PIPE
2	GREYWATER PROVISION
3	GREYWATER HEAT EXCHANGE/PUMP
4	INSULATED SHOWER STALL
5	RADIANT WALL HEATING (SOURCE> 3)
6	VISIBLE ON-DEMAND HOT WATER HEATER
7	SHOWER TIME-OF-USE MODULE/MONITOR
8	DEHUMIDIFIER
9	DEHUMIDIFIER DRAIN
10	FIRESTOP

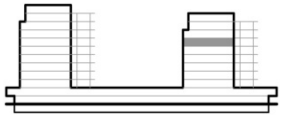


Figure 5.05 Scale 1:50

NZW Shower heads will only utilize non-potable quality water. Water conservation for bathing and body hygiene will deploy **Ultra Low-Flow Shower heads** that reduce **water flow rates to 1.9L per minute** without pressure or performance loss. Ultra Low-Flow Shower heads yield a net water savings of 7.6LPM/80% when compared to the established LEED baseline showerheads (9.5LPM).

Shower stalls will be designed to preserve in-shower temperatures as to avoid occurrences of thermal discomfort. This will allow water conservation during a shower by allowing residents to shut off the water supply temporarily without feeling the thermal impact of water loss. The strategy for water conservation in the shower stall is to halt water flow when it is not required.

Low-Flow shower heads have been designed with a shut-off button/valve to temporarily halt the flow of water while an inhabitant applies cleaning solutions. Release of the button/valve will resume the prior rate of thermally conditioned water flow while maintaining specified temperatures.

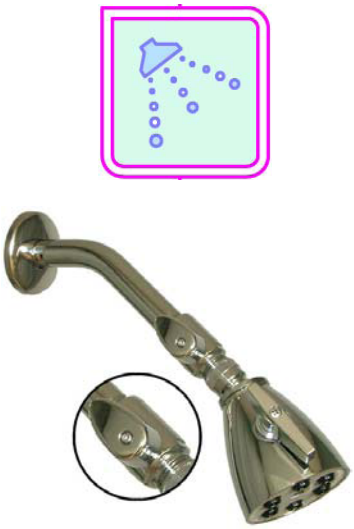


Figure 5.06

Appropriate 'Green' plumbing fixtures allow for water conservation without significant disruption for the task

Dishwashing machines are a critical appliance to deploy water use reduction within the household. High Efficiency Dishwashing Machines have been proven to be more efficient in energy, water, disinfection, and cleaning than traditional hand washing[9]. Current Energy Star™ minimum prescription identifies dishwashing machines to achieve 13L of water consumption per cycle for compact sized units[10] applied in multi-unit construction.

NZW will utilize best available **High Efficiency Dishwashers** that perform to effectively reduce Non-Potable water consumption and water savings to **5.9L per wash cycle**[11]. The key to cleaning adequately is not to utilize water as the cleaning medium but the adequate and effective deployment of sustainable solvents. Dishwashing machines are more effective than inhabitant engagement to maintain the cleanliness and sanitation of cutlery and cookware.

Non-potable quality water will be provided in NZW households as a medium for inhabitants to bathe. Bath tub sizes in multi-unit domestic construction are deployed in compact sizes, thereby reducing the total volume of water required to fulfill a bath[12]. The total volume of water required to fill a full bathtub can reach upwards of 90-120 litres per bath. Due to the large volume of water required to run a bath, NZW will prescribe that baths be filled at half capacity as a means to reduce the volume of water demand per bath.

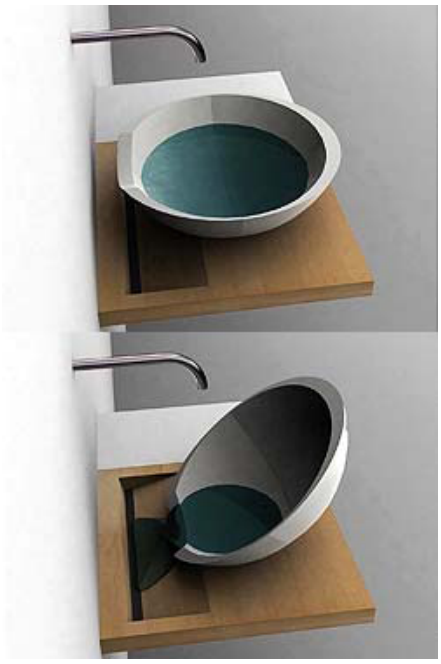


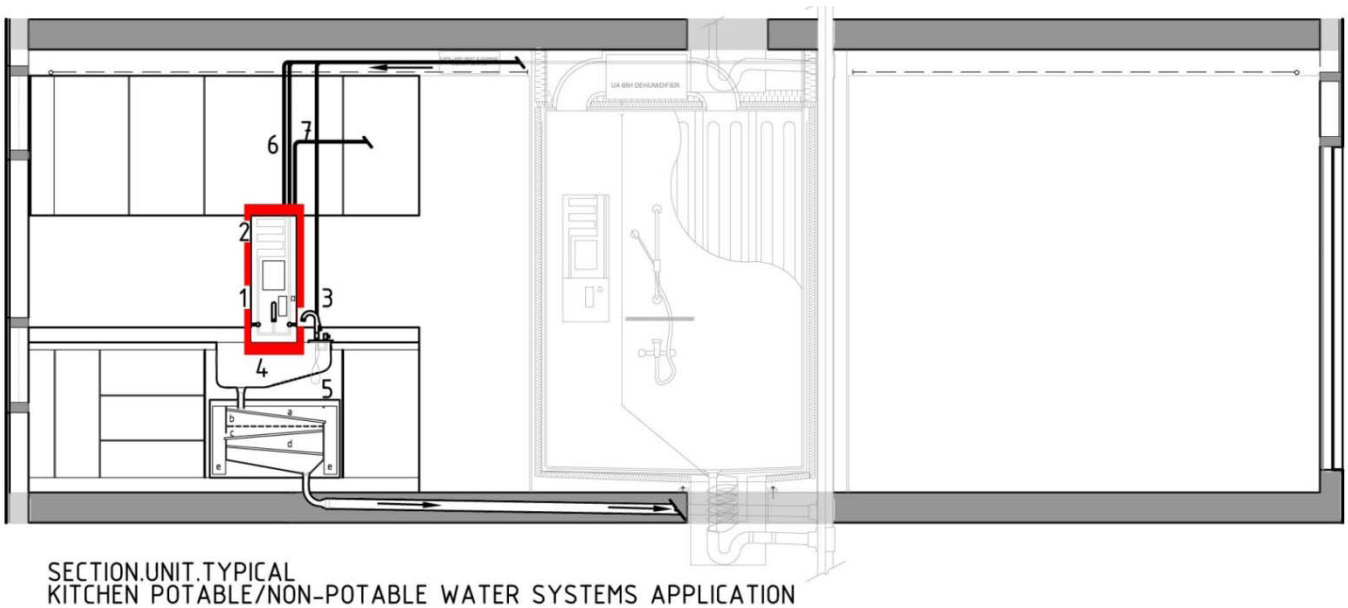
Figure 5.07

This figure is an example of a sink/basin design that separates the action of water feed and water drainage. The increased user engagement provides optimal control of required water resources

5.2.2 Potable Water provisions

Potable water demand in NZW residential construction will require water quality equal or greater than the water quality provided by the municipal water utility. NZW potable water demand must not be sourced from municipal water utilities in recognition of Toronto's existing infrastructure and water quality issues[13]. The alternative source of Clean water content is harvested from precipitation and stormwater that is treated to potable levels of water quality from building water treatment systems. There will be two sole potable water sources within NZW residential units, the first being the Kitchen Faucet followed by a Lavatory/Washroom Faucet.

Conventional household sinks and water basins are designed to feed, hold, and release inhabitant water at rapid speeds. The diverse number of inhabitant water engagement utilizes varying quantities of water to achieve different potable or non-potable water tasks. Optimizing water use would allow inhabitants to utilize specific quantities of water at faster or slower rates of water demand, based on the task.



SECTION.UNIT.TYPICAL
KITCHEN POTABLE/NON-POTABLE WATER SYSTEMS APPLICATION

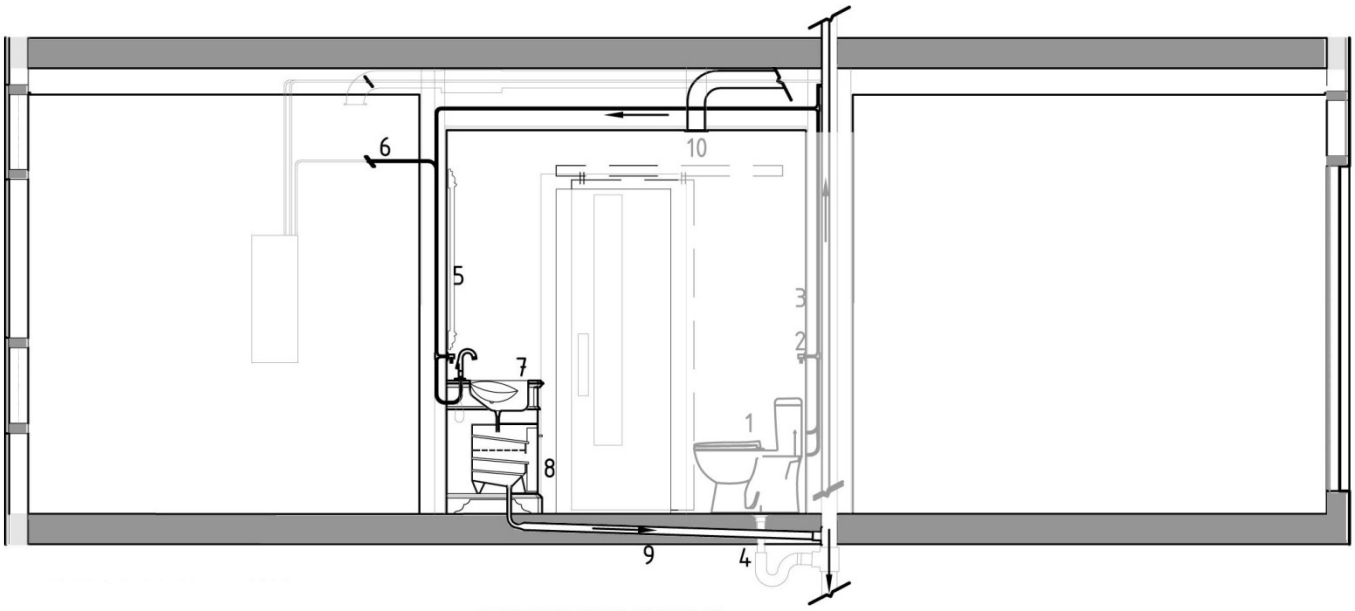
INDEX

1 POTABLE WATER CONTROL MODULE
VARIABLE FLOW FAUCET
2 VISIBLE ON-DEMAND POTABLE HOT WATER HEATER
3 GREYWATER PROVISION
4 SLOPED SINK 1' DEPTH
5 GREYWATER FILTRATION UNIT
a PROTECTIVE MESH/SCREEN
b FILTRATION MEDIUM (COARSE)
c WASTE MATERIAL OUTLET

Figure 5.08 Scale 1:50



NZW households will provide Potable and Non-Potable water provisions at kitchen sinks. Potable hot water is provided by an on-demand hot water heater that instantaneously heats water resources. The placement of the hot water heater is intended to avoid the waiting conditions of conventional hot water provisions where inhabitants must wait for hot water to arrive into the household after opening their faucet. This is a response to the E.P.A. prescription for inhabitants to turn on their faucets to activate hot water feed and moderate the temperature of the feed once hot water has arrived. When hot water is generated in boiler rooms away from washrooms, kitchens, and household locations for hot water demand, inhabitants waste the existing volume of potable non-thermally conditioned water that occupies the feed plumbing.



SECTION.UNIT.TYPICAL
WASH CLOSET SYSTEMS APPLICATION

INDEX

5	GREYWATER PROVISION
6	POTABLE COLD/HOT WATER SOURCE (KITCHEN)
7	WATER SAVING VANITY BASE
8	WATER FILTRATION MODULE
9	GREYWATER DRAIN PIPE
10	VENTILATION INTAKE (STALE AIR)

Figure 5.09 Scale 1:50



Lavatory faucets will utilize Ultra Low-Flow technology to perform at 1.9L/min flow. The main function of the lavatory faucet is to provide for inhabitant hygiene and a source of water for household sanitation. The World Health Organization establishes a minimum requirement of 7.5 LPCD[14] for a person to preserve their personal hygiene.

To optimize the use of water in the NZW household, hygiene is enforced domestic additives such as soap and cleansers to fulfill cleaning requirements. Non-potable water provisions will still be required, but the emphasis for hygiene and sanitation products is placed on LEED™ Green Seal solutions rather than the use of water resources.

Sink basins should be designed to increase the Time-of-use of water resources. Lavatory faucets should be aligned with basin/sink water drains to increase the duration of water exposure and inhabitant water contact before the water is drained away.

5.3 NZW Domestic Standards

The following standards are intended to control the use of Potable and Non-Potable water in domestic households. All of the listed standards respond to the listed types of household water demand prescribed on Table 5.0.1. The standards have been developed to ensure the appropriate quality of water is utilized for the necessary household task.

LEED™ Green Housekeeping Innovation Credit emphasizes the use of environmentally safe cleaning products and practices. The Credit is awarded when building managers prescribe a sustainable management policy within a development. NZW will rely on the guidelines prescribed by LEED™ Green Housekeeping Innovation Credit[15] as it has defined the appropriate Green Seal standard products for building maintenance[16].



Product standards specify chemical compositions that are biodegradable, do not off-gas, do not require dilution and retain recyclable packaging. The materials have been tested through alternative authorities such as the American Society for Testing and Materials (ASTM). The purpose of the Green Housekeeping Guideline is to provide available Green resources to domestic building management such that NZW households can be managed by inhabitants sustainably. **NZW will utilize LEED™ Green Housekeeping Guidelines to effectively address domestic cleaning solutions.**

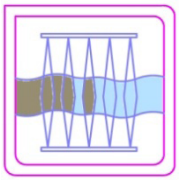
The sanitation and servicing of NZW households will be required to utilize Non-Potable water provisions and Green Seal standard GS-37 cleaning solutions.

NZW Clothes Washing Machines will only utilize Non-Potable water resources and Green Seal standard GS-41, GS-21 cleaning solutions.

NZW Dishwashers will only utilize Non-Potable water sources and Green Seal standard GS-41, GS-08 cleaning solutions.

NZW will provide Potable and Non-Potable water feed to kitchen sinks and washroom/lavatory basins.

NZW requires on-demand hot water heating as an effective means to mitigate water waste as a result of hot water provisions.



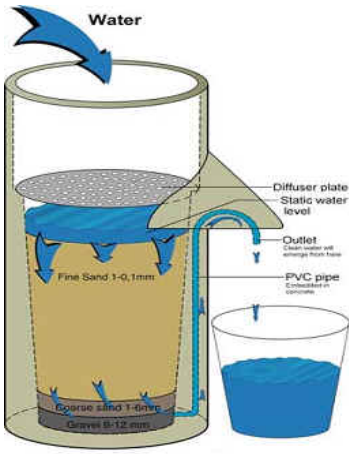


Figure 5.11

The diagram above is an example of a simplified Greywater filtration system. Water travels down a series of screens and granular material via gravity. Various sands and abrasive calibre screens isolate waterborne waste. The resulting water medium after travelling through the 'filter' is treated water near Greenwater standard.

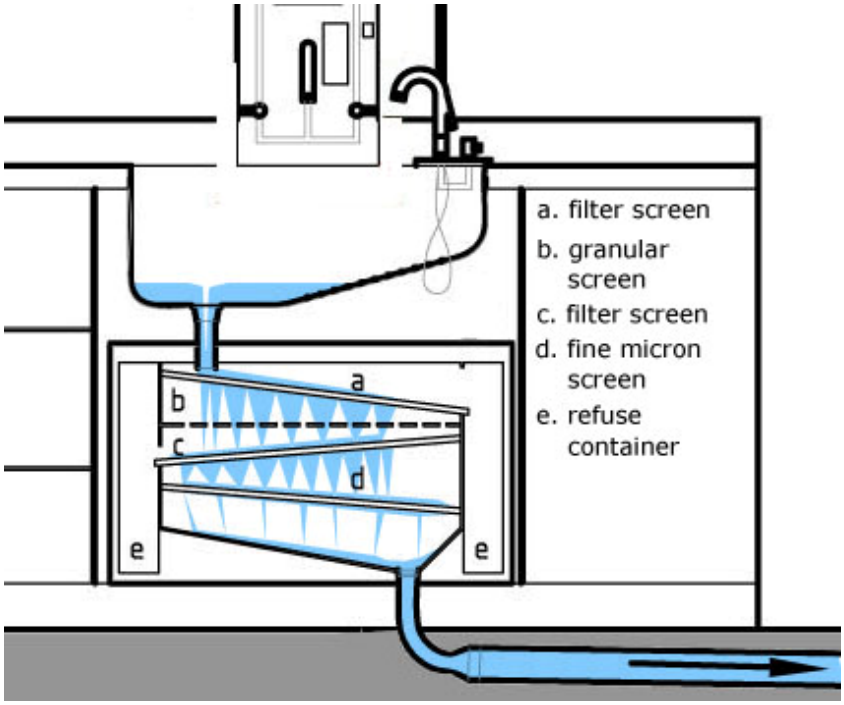
Figure 5.10

Greywater filtration post-inhabitation consumption ensures that inhabitant waterborne waste material does not get dumped into the water drain. Water drainage is not a source/output location for waste conveyance. There must be division between waste and water in order to reduce Greywater treatment demands.

The transition of Potable water into Greywater takes place after domestic use. To ensure that the resource can be renewed and reused for alternative household tasks that do not require the potable quality water (ie: showers, toilet flushing), waterborne debris and household waste must be removed from the water medium.

NZW households require Greywater filtration to isolate waste solids and non-reusable particles from kitchen and washroom sinks/basins to ensure the water medium can be reused after the initial application (Figure 5.09). Simple filtration systems such as sand and granular membranes will be acclimated in every household to capture waste solids, prevent bacterial growth and isolate unwanted waste odours (Fig. 5.11).

Remnant materials captured by Greywater filtration units will be subject to short term storage until municipal disposal or on-site waste treatment. The goal is to remove as much human content from the water medium as possible to reduce the rate of water quality decay. Solid material will be disposed under the NZW waste management strategy for sustainable waste conveyance without the use of water as a conveyance medium.



5.4 Net Zero Water Performance Guideline

Conservation efforts to halt the way urban inhabitants overwhelm the urban environment through Water Misuse and Overconsumption must be a key focus for NZW guidelines. The capability to develop sustainability in urban waters diminishes when water consumption escalates beyond a manageable tolerance. Net Zero Water will establish a target for 70 LPCD (Litres per Capita per Day) of water consumption as defined by globally recognized organizations prescribing sustainable levels of water consumption. The guideline will prescribe usage values for individual household water tasks based on usage percentages extrapolated from current day usage.

Indoor Water Use Breakdown					
Average Canadian Inhabitant Water usage				248	LPCD
	Percent	LPCD		Percent	LPCD
Toilet	28%	69.44	Leaks	11%	27.28
Clothes Washer	22%	54.56	Baths	3%	7.44
Shower	19%	47.12	Dishwasher	2%	4.96
Faucet	15%	37.20			
Reference: City of Toronto Wet Weather Flow Master Plan					

Table 5.08

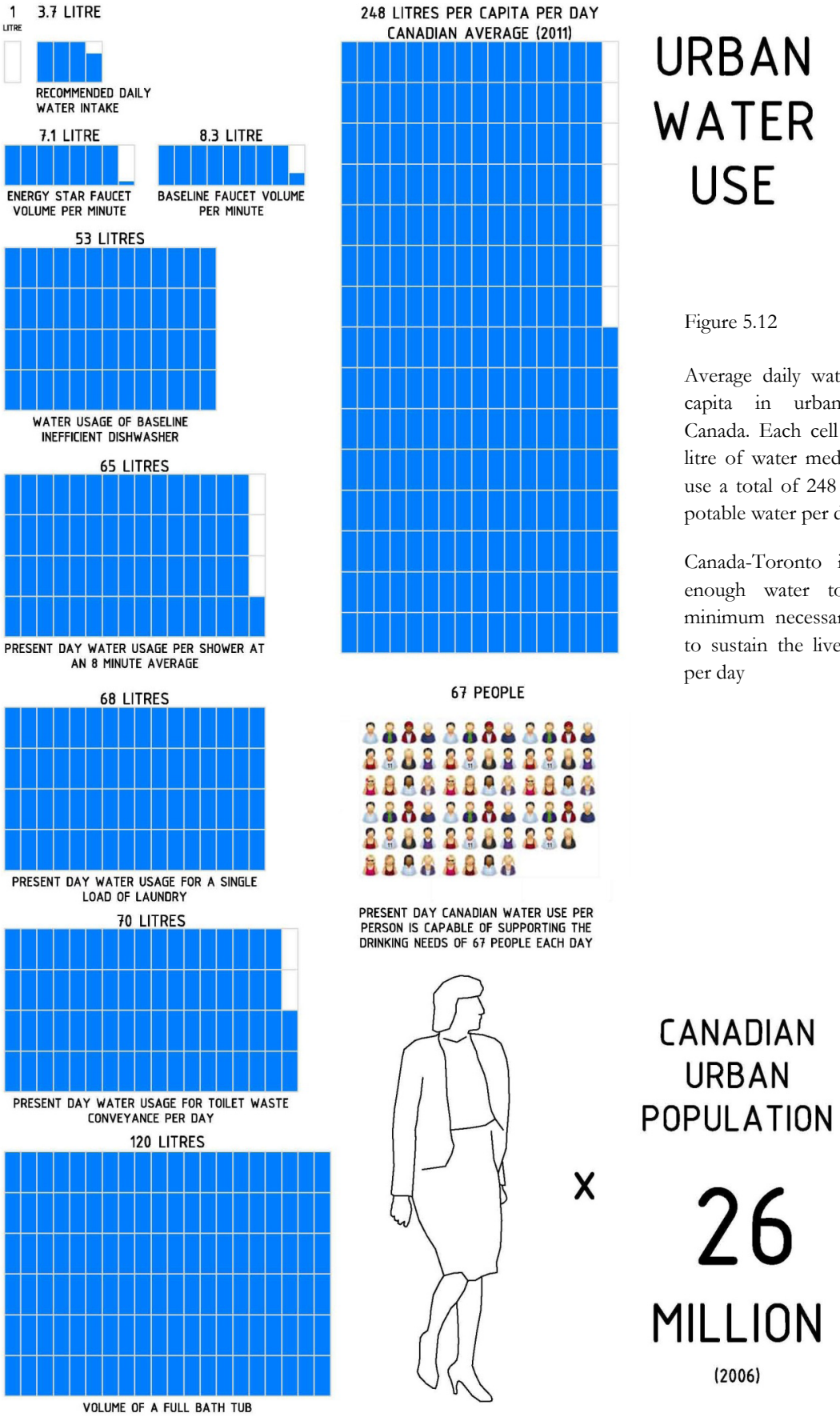
Refer to Table 3.0.6 Pg. 41

There is presently no established authority to regulate and govern household water use. NZW Guidelines will follow the prescription of global water authorities to prescribe 'appropriate' levels of water consumption to achieve 70 LPCD inhabitant use based on reasonable and logical assumptions. Performance targets must be established to specify the appropriate volume of water required each domestic task. For example:

An inhabitant is not informed as to what is adequate Time-of-User for facial hygiene. A 30 minute session of facial washing with faucets wide open would utilize 249 litres of water based on current Toronto Water Efficiency baseline standards of 8.3LPM[17].

249 litres of water utilized for facial hygiene as described in the example is a flagrant volume of water utilized for the specified domestic task. Without an adequate Guideline to suggest an ideal amount to water use, residents may not have the common sense for water conservation.

NZW will utilize Time-of-Use exposure to give greater awareness and inform inhabitants towards the appropriate volume of water required for adequate household tasks. Water use based on fixed rate water flow will be calculated in volume as a subject of the Time-of-Use. **The greater the duration/Time of water flow; the larger the volume of water used.**



URBAN WATER USE

Figure 5.12

Average daily water demand per capita in urban metropolitan Canada. Each cell represents one litre of water medium. Canadians use a total of 248 Litres of fresh, potable water per day.

Canada-Toronto inhabitants use enough water to support the minimum necessary requirements to sustain the lives of 67 people per day

5.4.1 Time of Use Exposure

To appropriately deploy water conservation in domestic households to achieve **70 LPCD**, NZW Guidelines will prescribe water use and usage values based on Time-of-Use consideration from best performing **1.9 LPM kitchen and lavatory faucets**.

Environment Canada establishes a Potable Water baseline of **10 LPCD** utilized for **Food Preparation** excluding the volume of water required for food growth. Fulfilling that daily Time-of-Use target will require best available water conservation products with 1.9L/min Ultra Low-Flow Kitchen Faucets at a total **daily duration of 5 minutes of water flow**.

Potable Water Consumption as a basic requirement for human inhabitation recommends **8 glasses of water per day at 3.7 LPCD** with a **Time-of-Use water demand at 2 minutes** of water flow.

NZW will require a limited use of **4.3 LPCD** of Potable water for **personal and domestic hygiene**[18] at **2.2 minutes Time-of-Use**. Although the 2.2 minute restriction may appear to be significantly less when compared to alternative segments of water-use, hygiene Time-of-use should not have any correlation with the volume of water consumption. Of the 8 Litres of potable water resources required per day, water demand is split into **Oral Hygiene, Facial Hygiene, Hand washing and grooming.**

- An inhabitant only requires a single cup of water (8 oz. - 0.25 Litres) to provide a sufficient water solution for Dental/Oral Hygiene at a prescription for a minimum 2 times per day (0.50L per day)[19] with a Time-of-Use potable water demand at 15 seconds.

- Facial Cleansing requires the full-hydration of a wash cloth and/or a cup (8 oz. - 0.25 Litres) of Potable water at a prescription for 2 times per day (0.50L per day) with a Time-of-Use potable water demand at 15 seconds.

- Hand washing requires 2.24 Litres of water per day to effectively utilize Green Seal Soaps and cleaning solutions. Potable water use prescription for 8 times a day with a Time-of-Use demand at 15 seconds per wash.

- Grooming (Shaving) shall be integrated as a component of Facial Cleansing as a means of non-potable water re-use. Men's and Women's grooming will add an additional daily water requirement of 0.5 LPCD with an additional Time-of-Use Non-potable water demand at 25 seconds.

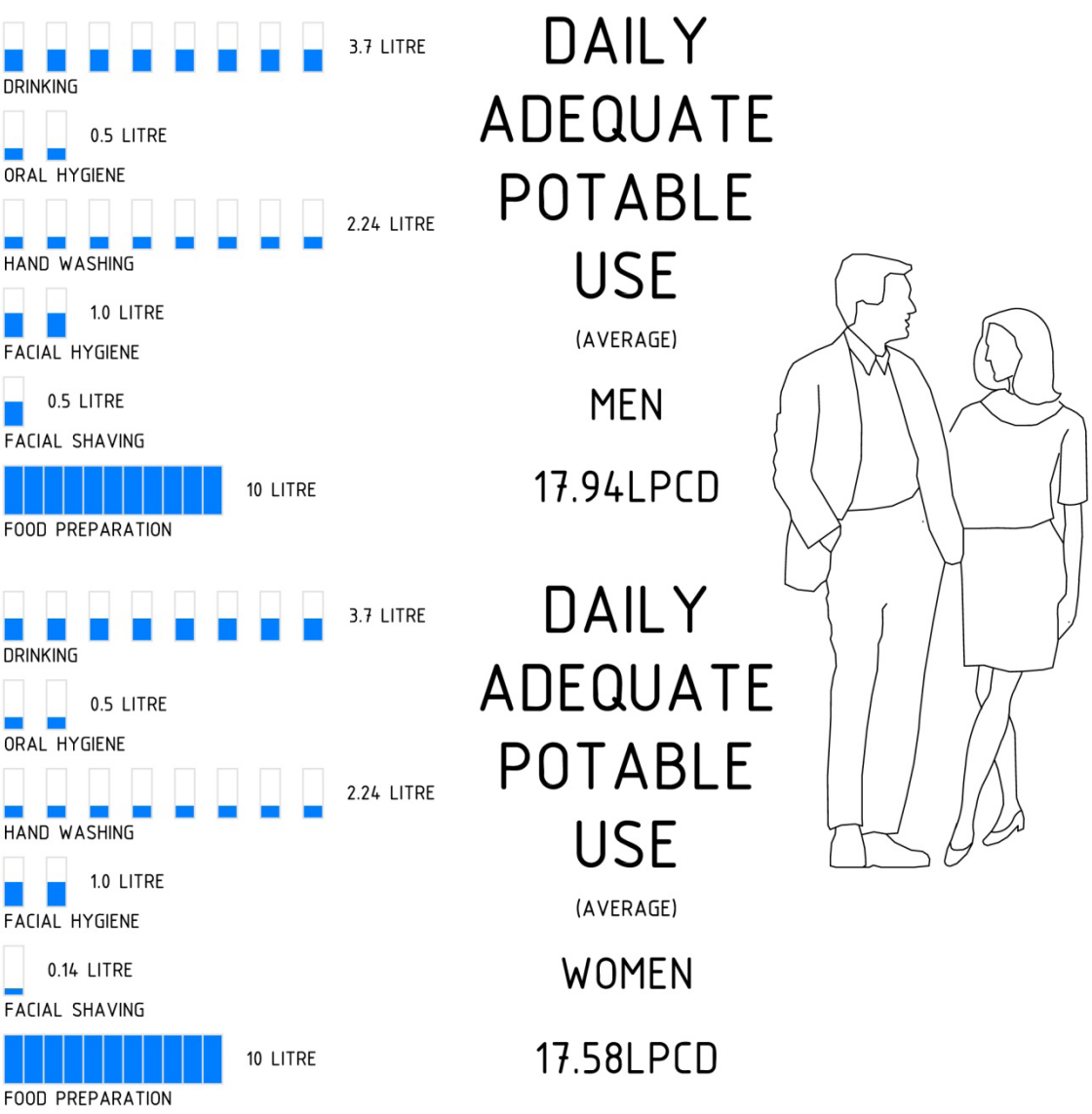


Figure 5.13

The water volumes displayed in Blue, showcase the total amount of water needed for individual tasks. Each individual Box or Cell represents 1 litre of water. These volumes are a result of projected 'adequate' Time-of-Use prescriptions.

Time-of-use will be prescribed based on the assumption that each domestic inhabitant partakes in **1 Shower per day** to maintain personal hygiene. The average Canadian inhabitant has a regular shower duration of 5-10 minutes. Based on the calculated effort to achieve 70 LPCD, NZW Guidelines will prescribe **a maximum Time-of-use shower duration of 10 minutes**. The resulting **19 LPCD** average reflects 19% of the 70 LPCD profile based on Toronto's Indoor water use breakdown[20].

5.4.2 Choice of Use Exposure

Choice-of-Use exposure focuses upon educating inhabitants to choose the appropriate number of household tasks that should be performed on an annual basis to support domestic living in conjunction to achieving the 70 LPCD sustainable water use goal.

Documented water usages in Toronto's multi-unit residential building typology witnesses an average number of 7 toilet flushes per capita per day per unit. In contrast to multi-unit inhabitants, the average single-family Toronto households utilize 5 toilet flushes per capita per day[21]. Increased water usage in MURB typology can be attributed to ineffective toilet function due to toilet misuse and drainage backup.

Eliminating drainage issues can optimize toilet usage in multi-unit residential inhabitation. NZW prescribes the separation of Toilet events into **4 daily occurrences of wastewater disposal and 1 event of waste solid removal** utilizing **Non-Potable water** supply. The usage assumption of Ultra Low HET dual flush toilet use results in NPW toilet outflow equating to **15 LPCD** (3.0LPF Avg.).[22]

Sustainable water use for **Clothes Washing** will depend on high efficiency full sized clothing machines with high load capacity. Increased washing capacity will accommodate **3 washing loads per every 2 week** based on City of Toronto average multi-unit residential occupancy of 2.5 peoples per unit[23]. Prescribing clothes washing use as a component of 70 LPCD equates to an average daily **Non-Potable water** consumption of **13.3 LPCD**[24].

Water efficient **Dishwashers** have a fixed volume of water use per cycle. To establish sustainable dishwashing use as a component of the 70 LPCD sustainable water profile, annual dishwasher usage will drop from the current average of 142 cycles per annum, to 86 cycles. The limited number of cycles equates to **2 cycles per week**, at maximum load capacity[25]. The resulting **1.4 LPCD** average reflects 2% of the 70 LPCD profile based on Toronto's Indoor water use breakdown.

1.2 LPCD of Non-Potable water demand is allocated for **Household Sanitation Use** in combination with LEED™ Green Seal certified domestic cleaning products. The allotted Non-Potable water demand equates to **a full bucket (8 litres) per week**. If NZW inhabitants choose to utilize Green Seal products outside of the provisions of the building management following the LEED™ Green Housekeeping Guidelines, water-free Green Seal products should be selected that do not require dilution with non-potable water resources.



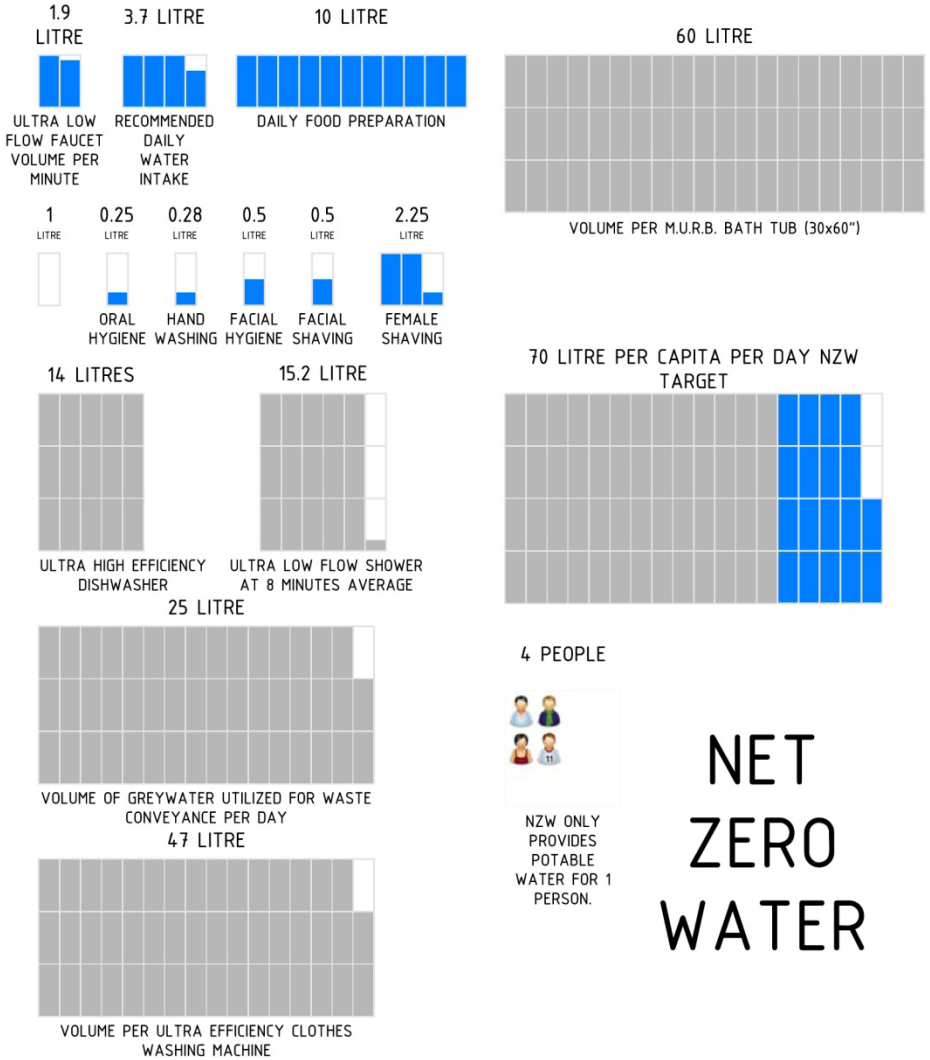
Figure 5.14

Bathtub indicator for temperature and water level. The indicator creates a noise when the preferred settings have been established.

The average Canadian bathes 46 times a year at approximately 60L per bath. NZW water conservation will require a **target reduction to 13 baths per year** reflecting 3% of the 70 LPCD profile on Toronto's Indoor water use breakdown. The prescribed **2.1 LPCD Non-Potable water** demand limit reduces the number of full baths per inhabitant to 1 event per month. For residents that prefer to bathe, the number of times they bathe can increase upwards to **26 baths per year by utilizing ½ the capacity of water volume**. For inhabitants who require adequate water temperatures while running baths, this thesis will prescribe temperature adjustment without water outflow[26] through the implementation of bath tubs fitted with radiant conditioning.

Figure 5.15

This diagram compares and contrasts the total volume of Potable and Non-Potable water consumption under the NZW projection for 'adequate' sustainable water use. Each unit or cell represents 1 litre of water. ***Blue*** is the diagrammatic representation Potable water consumption. ***Grey*** are additional elements of domestic life that can be serviced by Non-Potable demand.



Quantity of Water Required for Household Tasks

Household Lavatory Tasks						
	Time of Water demand @ faucet flow (baseline)	Time of Water Demand @ Energy Star	Time of Water Demand @ Ultra Low Faucet flow	Number of Times per day	Details	Adequate V of Water Re (litres)
FLOW RATE	8.3LPM	7.1LPM	1.9LPM			
Facial Cleansing	2 seconds	3 seconds	7.5 seconds	2	Morning & Night	
Oral Hygiene	2 seconds	3 seconds	7.5 seconds	2	American Dental Association	
Shaving	4 seconds	6 seconds	15 seconds	1 0.14	facial shave (Gillette) leg shave (Gillette) suggested Once per week (52 weeks)	
Hand Washing	15 seconds	15 seconds	15 seconds	8	Health Canada	

	Time of Water demand @ shower head (baseline)	Time of Water Demand @ Energy Star	Time of Water Demand @ Ultra Low shower head	Number of Times per day	Details	Adequate V of Water Re (litres)
FLOW RATE	9LPM	6LPM	1.9LPM			
Shower	8 minutes	8 minutes	8 minutes	0.71	National Geographic, Aquacraft: 5 times per week	
FLOW RATE	9.5LPM	9.5LPM	9.5LPM			
Bath (Tub Spout)	6 minutes	6 minutes	6 minutes	0.12	City of Toronto: Average inhabitant takes 46 baths per annum	

Household Kitchen Tasks						
	Time of Water demand @ faucet flow (baseline)	Time of Water Demand @ Energy Star	Time of Water Demand @ Ultra Low Faucet flow	Number of Times per day	Details	Adequate V of Water Re (litres)
FLOW RATE	8.3LPM	7.1LPM	1.9LPM			
Food Preparation	1 minute 12 seconds	1 minute 24 seconds	5 minutes and 25 seconds	3	maximize preparation duration without incurring further water consumption	
Water Consumption	26 seconds	31 seconds	1 Minute 16 seconds	8	at an average of 250 ML per cup	
Dishwashing	n/a	n/a	n/a	0.28	NZW suggested 2 loads per week	

Household Laundry Tasks						
Clothes Washing	n/a	n/a	n/a	0.28	at 2.5 peoples per unit as per TORONTO M.U.R.B. averages. 2 loads per week.	

NOTES:

- Time of use factor becomes significant when the scale and application of water demand changes.
- Flow Rate reduction for a Bath Tub spout does not provide sufficient cause for water conservation as the Time of Use factor is not considered.
- Dishwashing, Clothes Washing water impact is based upon an adequate number of loads.

uate Volume ter Required)	Details
0.25	Sufficient volume to saturate a terry washcloth (ASTM-4772)
0.25	per cup
0.5	1 cup of water in addition to a saturated washcloth
2.25	1 litre per each leg, ankle to thigh in addition to a saturdated washcloth for skin hydration
0.28	Before Each Meal. After each wastewater or wastesolid event. 5 event average per day + 3 meals a day

uate Volume ter Required)	Details
15.2	Showerheads should be turne off during the application of cleaning solutions (IE: soap, shampoo, conditioner)
30	An optimal bath requires 60 litres. However, one does not need to fill the full tub to take a bath. Half baths are suggested

uate Volume ter Required)	Details
10	Environment Canada prescription. World Heatlh organization prescribes a minimum of 7.5L
3.7	Health Canada prescription
5.9	Ultra High Efficiency Dishwashers utilize a pre-rinse cycle

47	Large volume clothes washers maintain greater efficiency than compact units.

ered.

Table 5.09

This table provides a day-by-day breakdown of household potable and non-potable water use, utilizing best performing water hardware.

Special emphasis is given to the number of times a household task is repeated each and every day. Water provisions are based on optimal water use to achieve 70 LPCD. Values specified for each individual household task have been extrapolated from existing urban water use practices in the City of Toronto, Refer to Chap.3 Section.3.3 Table 3.06. Refer to Chap.3 Section.3.1.2 Table 3.04 for indoor water use estimates developed by LEED™

The Time-of-Use and water use based on hardware Flow-Rates will result in an end volume of water that will accumulate to 70 LPCD.

Refer to Figure 5.13 Pg.088 for diagrammatic representation.

5.5 Monitoring and Education

NZW domestic households will prescribe an Education and Awareness campaign based on Monitoring water use. The capability of modern inhabitants to learn and adapt to their urban environment is increasing with the growth of urban intensification. New multi-unit tenants are more susceptible to embrace improved technologies that can achieve resource savings and conservation. Monitoring and metering will present inhabitants with the economic consequences of water use and water misuse, with the intention to encourage inhabitants to self-regulate their water consumption.

Water savings must be promoted to increase user awareness in the household locations where water is utilized the most. **Kitchens**, **Lavatory/Washrooms, and Bathrooms** will contain the bulk of water monitoring and conservation provisions. Educational services will be provided in the form of pamphlets, digital displays, or potentially interactive programs that prescribe adequate water consumption as components of **Time-of-Use** and **Choice-of-Use**.



Figure 5.16

Recognized hand hygiene does not utilize an immense volume of water. Time-of-Use consideration will only incur 10-30 seconds of direct water flow. Providing this education will outline adequate water use in households to optimize and minimize waste.

Establishing greater Water Savings will require simplified terminology to increase Water Value. Rebranding water use by utilizing architecture as a means to market water sustainability will emphasize Cost Savings and Economic ($) benefits of sustainable water use. Breaking down the definition of Litres per Capita per Day (LPCD) into simplified and already valued currency will bridge the existent gap between water value and water use.



Figure 5.17

Water represented as Money. The linear relationship will be fundamental to convey the idea of water conservation by exposing water savings through economic means. This will increase the impact awareness of domestic water use.

Appealing to the economic values of inhabitants is a process that has been utilized to great extents. One comparable example of technological engagement follows the advancement and evolution of the Vehicle environment. New vehicles expose the volume of fuel that is used to travel, and as a result, initiates a driver's subliminal effort to conserve and save their fuel[27]. NZW tenants are also capable of utilizing the same intuitive skill set to improve their water conservation in the household.

The continual theme of architectural engagement for water conservation is to allow inhabitants to visualize the use of water. There are many alternatives available in the construction market today that function for water savings. Metered Valve faucets deliver a fixed 0.25 gallons of water before automatic shut off and self-closing faucets that function from a spring operated mechanisms that shut off after several seconds[28]. Infrared sensors that turn on and off automatically from hand sensing is a commonly utilized commercial application that can be transferred into residential households. The development of these tools is irrelevant if they do not induce the user to change the attitude of their use.



Figure 5.18

The iHouse faucet has integrated LED technology that identifies the temperature of the water that flows out of the faucet, thereby optimizing water demand.

NZW faucets will activate for a specific time with relation to a pre-set flow rate until the specified volume of water demand is achieved for that task. Time-of-Use notification will be announced via a noise indication or by the visual display. The data presented by NZW hardware must be designed to make the most substantial impact for water savings. This reverts back to the economic argument and the linear relationships for resource demand. Increasing water savings is fundamental to saving money, and in turn, improving the environment.

NZW will require an **Active Time-of-Use monitoring system** to display and record the function of household water provision and to document the total volume of water demand from the factor of Time-of-Use. The display and recording of time is intended to simplify residential engagement by informing residents to conserve the Time from which they use water resources. A simple application of a timer or clock adjacent to a faucet or fixture can initiate exposure to the duration of water demand. NZW building typology shall incorporate simple Time-of-Use exposure into the function of household water provisioning.



Figure 5.19

Simple Time-of-Use displays can inform as to how much water is utilized. Time-of-Use indication measured against the adequate Potable and Non-Potable water use values will inform towards optimal water demand.

Enhancing water-use exposure within the household may utilize marketing material and in-home techniques to remind residents to reflect upon their water-use (Fig. 5.13 Pg. 88). Monitoring devices that show the volume of potable and non-potable use as a comparative display can also assist in highlighting the divisions of water quality within domestic use, allowing inhabitants to recognize exactly how much is needed as a necessity compared to water use for leisure.



Figure 5.20

'Refresh-N-Remind' Shower Monitor concept displays the time and volume of water demand during use. The visual indication displays 'Time-of-Use' and 'Volume of Use' expanding on a direct relation between the two variables.

Engaging residents by allowing them to monitor the volume of water and the rate of water flow represented in economic terms is a key strategy for resource savings. This exposes the linear relationship between resource savings and cost savings, a process that will reduce the standard of NPW living and in turn, motivate further conservation. Use less water, pay less for resources. By displaying the amount of water utilized as money, simple and interactive hardware at key household locations will challenge inhabitants to utilize fewer resources. The continual documentation of water use in monthly, weekly, or even daily values will be juxtaposed with the water performance recorded from the past, a reflective means to encourage inhabitants to improve on prior conservation engagement.

Net Zero Water Checklist v 1.0



NZW Building Pre-requisites	
No Municipal Water Demand	
Sustainable Water demand will not rely on a regional municipal utility	
No Municipal Sewage Output	
All water related waste will be treated on site	
Potable Water Use	
Potable Water Provisions will be alotted in household kitchens and washrooms (ONLY)	
Non-Potable Water Use	
Greywater Provisions will be allotted in household kitchens, laundries, and washrooms	
Water related Household Hardware	
All household Appliances and Fixtures must achieve Energy Star certification or equivalent recognized performance baselines	

*if the following Pre-Requisites are **NOT** achieved, NZW is not possible

Table 5.010

The NZW checklist ensures that all the hardware, education for hardware use, and necessary water use guidelines are put in place to allow inhabitants to conserve their water use.

NZW Household Performance	
Plumbing Standards & Installation	
Plumbing Certification to adhere to National Plumbing Code of Canada 2010 or equivalent	
Ensure 100% Plumbing Leakage Prevention	
Water Conservation Target	
Achieve 70 LPCD per inhabitant per household	
Follow NZW Guideline	
Water Conservation under NZW Guidelines	
Plumbing Fixtures	
Potable and Non-Potable water fixtures will contain (each) sustainable water engagement	
Household Water Mangement	
Point-of-Contact water filtration to remove all physical water debris	
Post-consumed water will be subject to multiple reuse	
Monitoring and Awareness Exposure	
Time Of Use indicators will be present at each Potable Water and Non-Potable source	
Volume Of Use indicators will be present at each Potable Water and Non-Potable source	

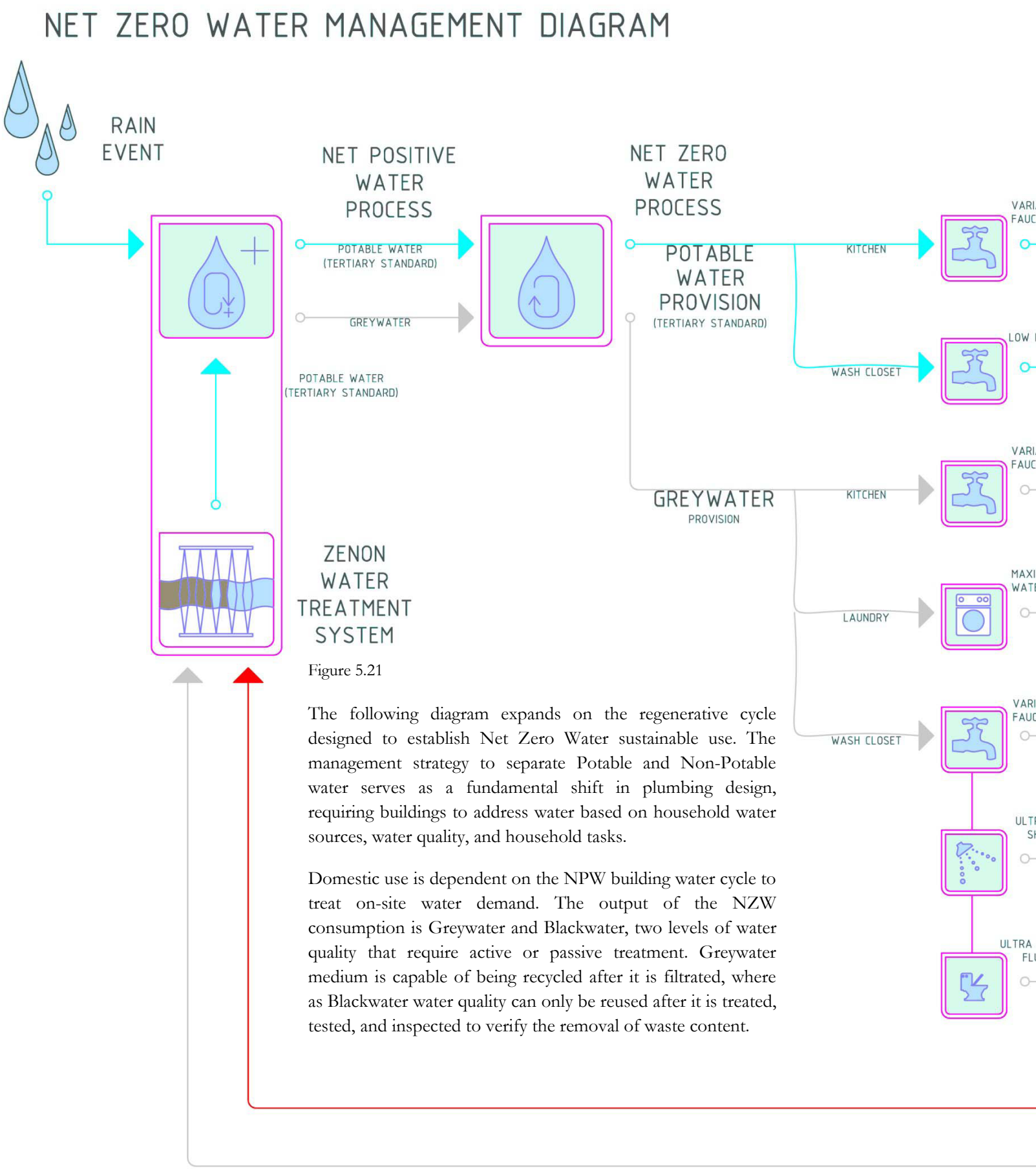
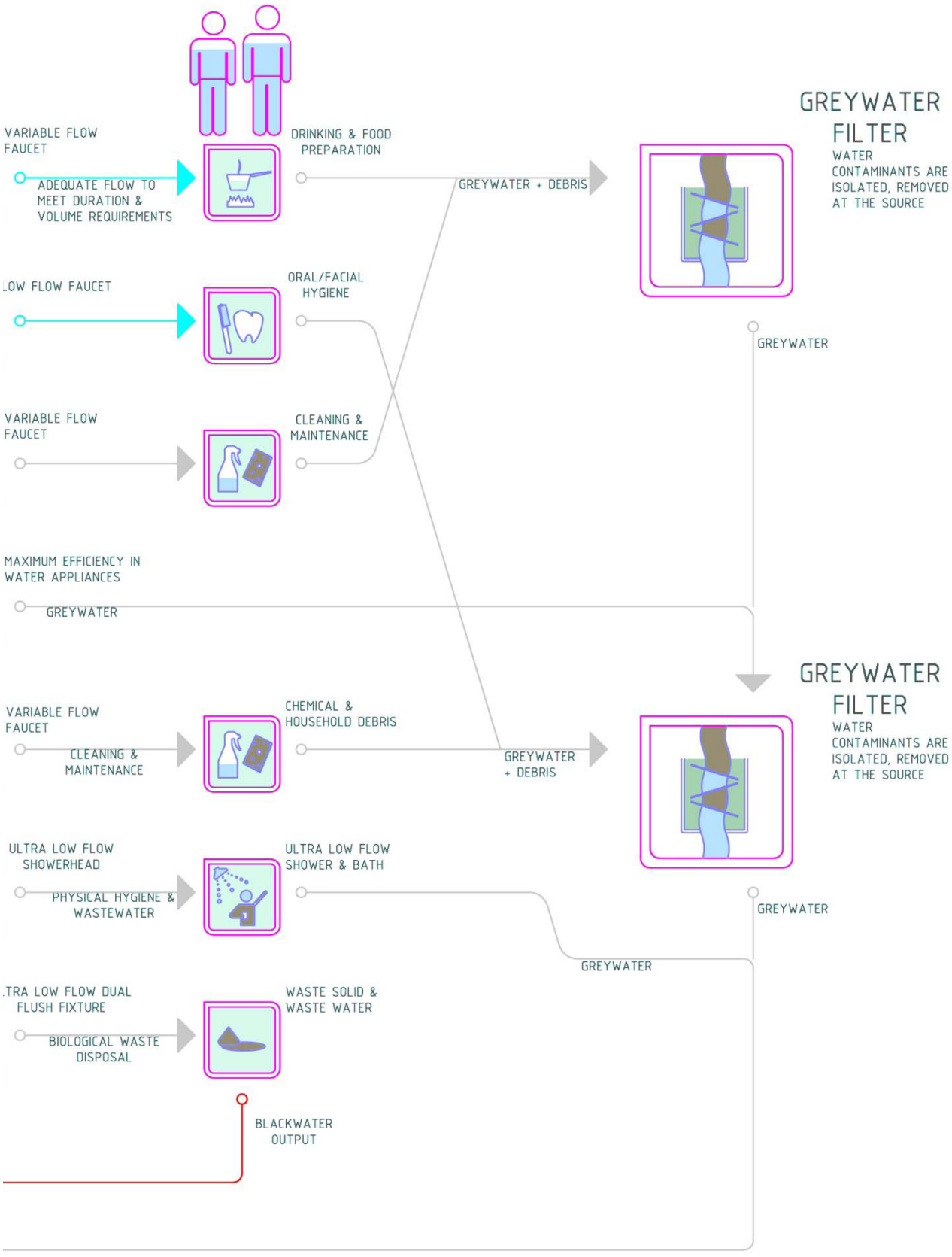


Figure 5.21

The following diagram expands on the regenerative cycle designed to establish Net Zero Water sustainable use. The management strategy to separate Potable and Non-Potable water serves as a fundamental shift in plumbing design, requiring buildings to address water based on household water sources, water quality, and household tasks.

Domestic use is dependent on the NPW building water cycle to treat on-site water demand. The output of the NZW consumption is Greywater and Blackwater, two levels of water quality that require active or passive treatment. Greywater medium is capable of being recycled after it is filtrated, where as Blackwater water quality can only be reused after it is treated, tested, and inspected to verify the removal of waste content.


VARIABLE FLOW FAUCET
ADEQUATE FLOW TO MEET DURATION & VOLUME REQUIREMENTS
DRINKING & FOOD PREPARATION
GREYWATER + DEBRIS
GREYWATER FILTER
WATER CONTAMINANTS ARE ISOLATED, REMOVED AT THE SOURCE
LOW FLOW FAUCET
ORAL/FACIAL HYGIENE
GREYWATER
VARIABLE FLOW FAUCET
CLEANING & MAINTENANCE
MAXIMUM EFFICIENCY IN WATER APPLIANCES
GREYWATER
GREYWATER FILTER
WATER CONTAMINANTS ARE ISOLATED, REMOVED AT THE SOURCE
VARIABLE FLOW FAUCET
CLEANING & MAINTENANCE
CHEMICAL & HOUSEHOLD DEBRIS
GREYWATER + DEBRIS
ULTRA LOW FLOW SHOWERHEAD
PHYSICAL HYGIENE & WASTEWATER
ULTRA LOW FLOW SHOWER & BATH
GREYWATER
GREYWATER
TRA LOW FLOW DUAL FLUSH FIXTURE
BIOLOGICAL WASTE DISPOSAL
WASTE SOLID & WASTE WATER
BLACKWATER OUTPUT

Endnotes:

[1] Refer to Table 4.06. Pg. 53

[2] Plumbing installation certification. Waterfront Toronto Minimum Green Building Requirement.

[3] Refer to Appendix E Section One. No. 16 Calculation. Best available Energy Star™ HET toilet performance

[4] Number of people per residential lavatory/bathroom is calculated at 1.15 per unit. City of Toronto Water Facts. http://www.toronto.ca/watereff/pdf/appa.pdf

[5]Drainage piping is blocked and backed-up as a result of poor inhabitant misuse. It is a common occurrence in multi-unit construction and extensive cost is incurred to clean the drainage systems out

[6] Water Factor is a measurement of water efficiency that is calculated as a ratio of water demand (gallons) per cubic foot of capacity. The lower the value, the better the water savings

[7] i.e. If a clothes washer uses 30 gallons of water per washing cycle and it has a capacity of 3.0 cubic feet, the Water Factor of the appliance is 10.0

[8] Appendix A. Pg. 4. Frigidaire Ultra High Efficiency Washing Machine – 2.8 WF

[9] Energy Star™ Dishwashers have been proven to function with greater efficiency than hand washing dishes

[10] A compact sized dishwasher typically utilized for smaller multi-unit residential units is designed with a capacity for less than 8 place settings + six serving pieces

[11] Refer to Appendix E Section One Calculation No.17

[12] http://www.allianceforwaterefficiency.org/Residential_Shower_Introduction.aspx

[13] Refer to Ecological Water Flow in The living Building Challenge User Guidelines Section 6

[14] The World Health Organization estimates are based on lactating women who engage in moderate physical activity in above-average temperatures. They require a minimum of 7.5 LPCD for personal

[15] LEED™ Credit IDc1 http://www.leeduser.com/credit/CI-2009/IDc1

[16] http://www.greenseal.org/

[17] The current established and recognized baseline for faucet fixtures is a flow rate measured at 8.3 litres per minute

[18] Refer to Table 6.0.3 Pg.103-04 for Sustainable Water use breakdown

[19] Ontario Dental Association O.D.A. recommends a minimum for brushing teeth minimum twice a day

[20] Refer to Table 4.06. Pg. 53

[21] Refer to Appendix D Pg. 2 No. 4 Average Number of Toilet Flushes in Multi-Unit Residential Construction

[22] Refer to Appendix E Section One Calculation No. 16 Best available Energy Star™ HET toilet performance

[23] 2.5 people per unit per multi-unit average inhabitant occupancy. City of Toronto Water Facts.

[24] Refer to Appendix E Section One Calculation No. 17 Best available Energy Star™ performance Washing Machine

[25] Refer to Appendix E Section One Calculation No. 18 Best available Energy Star™ Dishwashing Machines

[26] The most efficient method to fill a bath tub is to plug the bath tub drain before the faucet is activated. The system should run until receiving hot water, at which time the user can adjust the temperature with cold water. E.P.A.

[27] Automotive Manufacturers (i.e. BMW, Mercedes Benz, Audi) teach their customers how to operate drivers aids and automotive systems before car ownership is transferred.

[28] Smart faucets utilized in commercial buildings utilize infrared light to sense whether or not a user requires water

Chapter SIX - Net Positive Water Guidelines & Standards

Net Positive Water (NPW) Guidelines and Standards prescribe the means to develop domestic architecture to generate positive water quality. Projects establishing NPW performance will be required to induce a cycle of water reuse by activating architecture and the site landscape as mechanisms for water renewal. The NPW cycle manages water under 4 categories of quality; Greenwater, Bluewater, Greywater, and Blackwater. The 4 categories of water fall under Clean and Dirty Water management to optimize the NPW cycle for water renewal. NPW will integrate NZW sustainable inhabitant use where 70 LPCD Potable and Non-potable demand are integrated into the NPW cycle.

NPW water resources will be divided into measures of quality identified by Greenwater, Bluewater, Greywater, and Blackwater. Greenwater classification is derived from agricultural terminology that prescribes atmospheric precipitation and ground evaporation. Bluewater is the outcome of the natural water cycle that originates from groundwater flow and into surface freshwater bodies such as Lake Ontario[1]. Greywater in the context of the construction industry is a classification for wastewater generated from domestic activities such as laundry, bathing, and post household consumption which is capable of being recycled. Blackwater is water conveyance utilized for human waste.

Table 6.0.1

Water quality classification is intended to prescribe the management strategy to address water at varying quality conditions. Greywater and Blackwater quality conditions are capable of overwhelming the urban water cycle and require a dedicated treatment strategy to restore water quality.

Urban Water breakdown				
Types of Water	Origin	Component of the Natural Water Cycle	Subject to natural water cleansing	Clean and Dirty Quality Classification
Blue Water	Regional water bodies	Yes	Yes	Clean
Green Water	Precipitation	Yes	Yes	Clean
Grey Water	non-potable water capable of reuse in urban conditions	No	No	Dirty
Black Water	wastewater created by human inhabitation	No	No	Dirty

Clean Water management is prescribed for Greenwater precipitation and Bluewater in associative waterways and water bodies utilized in the project. Dirty Water management is prescribed for Greywater and Blackwater quality as a result of domestic inhabitation in the urban realm.

NPW On-site and Building prerequisites must be achieved to adequately assess the state of urban water resources and the capability of a project site to sustainably manage those resources. Prerequisites must define the site conditions and the environmental parameters of a NPW project to prescribe Clean and Dirty Water management boundaries. On-site prerequisites are intended to remove existing issues or threats that may hinder the restoration of the urban water cycle and the generation of positive water quality. Building prerequisites have been established to ensure the sustainability of domestic construction such that the building does not contribute negatively to water quality.

On-site and Building Guidelines prescribe strategies to achieve water harvesting and water storage under Clean and Dirty Water management. The Guidelines will prescribe the use of landscape and building systems to achieve water harvesting with the selection of sustainable materials and techniques to maintain water quality as the medium drains throughout the NPW cycle. NPW Guidelines showcase the use of Passive environmental features to implement water harvesting and water banking. NPW Guidelines will also showcase the active treatment mechanisms to available to separate waste and contaminant materials from the water medium.

On-site and Building Standards establish the minimum performance requirements of a NPW project. NPW performance Standards require Guideline strategies to achieve positive water quality based on the environmental and site variables identified through NPW prerequisites. Established standards dictate the capability for a NPW project to harvest sufficient water resources. Water storage standards must support annual NZW inhabitant demand. Water quality and treatment standards must be defined to negate the negative effect of urban building development and residential water consumption. NPW standards ensure that water resource strategies are optimized under the 4-designated water quality categories such that positive water quality can result from Clean and Dirty water management.

6.1.0 NPW On-site Pre-requisites

An in-depth **Environmental Assessment** (EA) process must be taken to analyze the environmental variables of a project site. NPW development will be required to restore the natural site conditions that once existed as a means to replace the lost habitat as a result of building construction. Hydrological performance must be reinitiated to reintegrate the project as a component of the regional water cycle. The EA process will also identify the **Available Water Resources** (per m^2 of total site area) that can be harvested by the NPW project.

NPW **Stormwater Management** must manage the total volume of water during a major weather event. On-site water strategies must be designed to accommodate for 100-year precipitation levels while protecting the medium from urban contaminants[2] in waterfront regions. NPW building typology must manage surface waters and ensure that surface runoff is not allowed to flow into local waterways.

NPW development on a non-polluted urban site will restore precipitation infiltration to surface landscapes and soil percolation into groundwater flow as a functioning component of the urban water cycle.

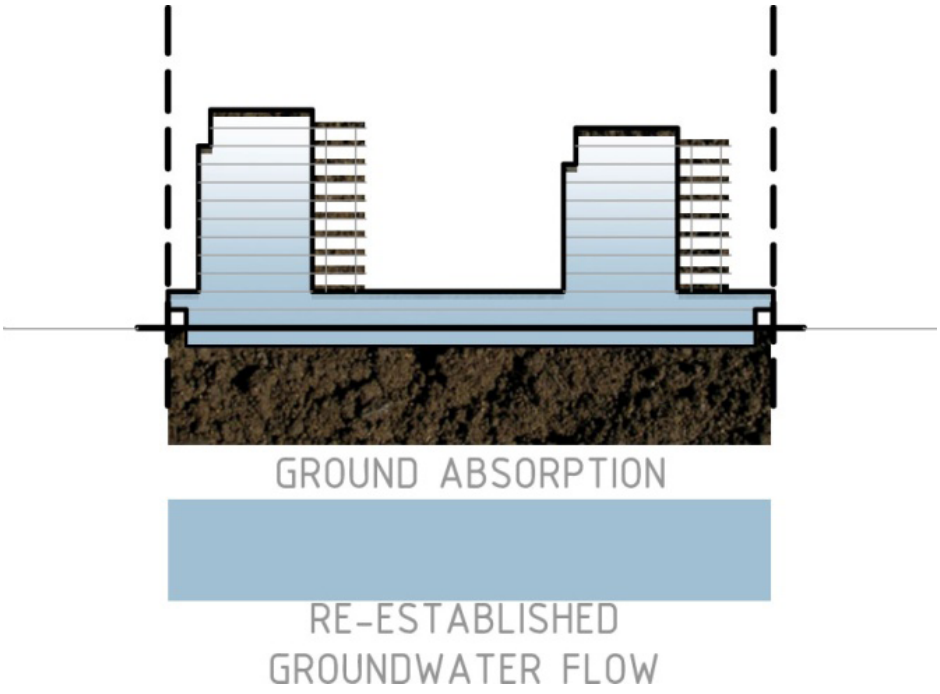


Figure 6.01

When a building is put in place of permeable land, the ground is removed from the natural water cycle. Water is removed from the soil to ensure the foundation of the structure is stable, but once this has been achieved, surrounding landscape conditions can still be hydrated and function as nature intended.

Figure 6.02

The division of Clean and Dirty on-site water management must be defined. This will allow an appropriate definition for NPW boundary conditions that places water resources under NPW Management Area.

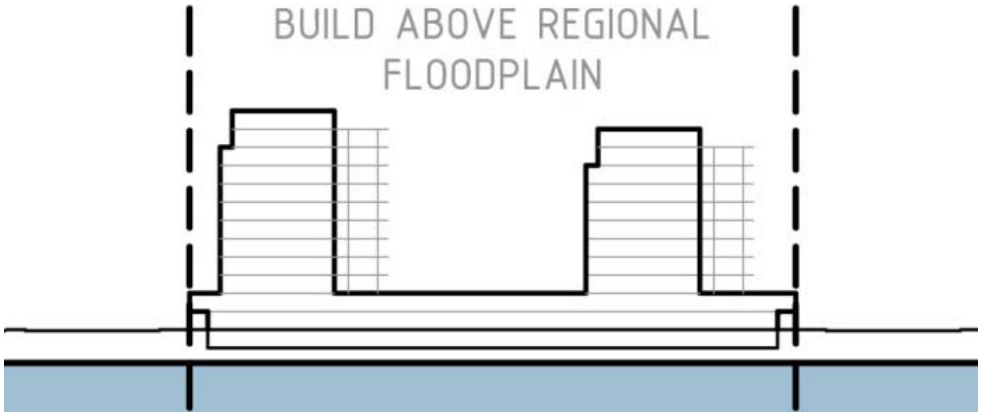
A NPW project site will not be subject to **Brownfield Contamination**, where all sources of site contamination must be removed and replaced. In environmental conditions that have suffered from contaminant decay and are subject to the interests of environmental renewal, landscape and soil content must be recycled. A NPW project situated on a **Previously Developed Site** must remove all building systems and building debris that may threaten the restoration of environmental site conditions. NPW project sites must be 100% removed from soil and landscape contaminants.



Figure 6.03

A structure must be constructed above the defined regional floodplain to protect on-site water resources and inhabitants. A site with a high water table requires construction to manage ground water resources.

A **NPW Management Area** must be negotiated between building developers and the municipality. Due to the varying demands placed on streetscape conditions including street parking, public transportation corridors such as Light Rail Transit, and site servicing for snow removal; the NPW boundary definition can differ in each project. The definition of the management area will rely on an integrated planning process between regional municipalities and developers to develop a matrix to separate water resources thereby allowing sustainable water harvesting and water banking for NZW inhabitant use[3]. **NPW projects must manage 100% of the available stormwater/water resources within the NPW Management Area.**



NPW site selection must not be constructed within a **Floodplain[4].** Flood conditions will threaten the health of inhabitants as On-site and Building water can be affected throughout an NPW project. NPW projects will require protective measures to ensure that flood contaminants do not enter the site or intermix with the NPW cycle.

NPW projects situated on lands with a **High Water Table[5]** region will not be required to re-introduce rainwater percolation onto the site as ground condition will be unable to absorb further water contributions. NPW construction on a high water table will require an **Effective Impervious Area** (EIA) to manage and process Dirty water conditions. This will divert Dirty water into treatment processes under the NPW cyclic reuse.

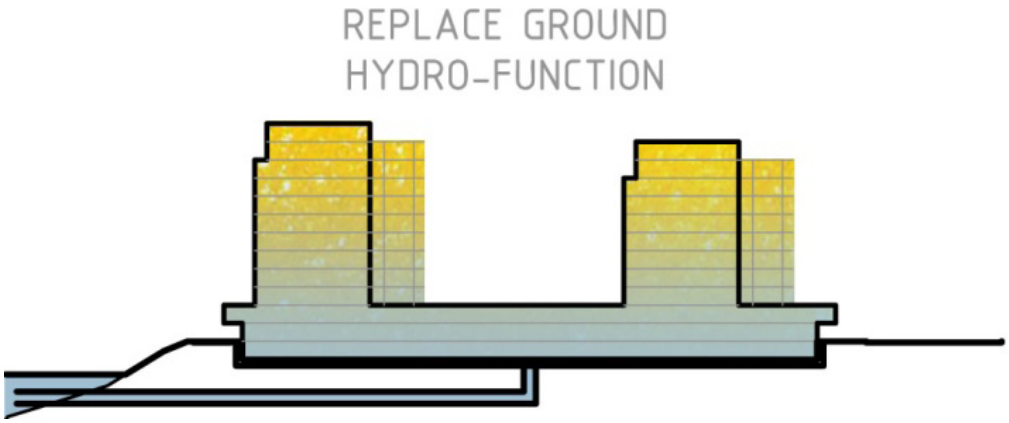


Figure 6.04

The structure replaces the natural function of the ground which is no applicable on reclaimed waterfront land. The build will be required to store water to a duration which reflects the regional water cycle, and outflow Greenwater to Bluewater.

The prescription of the EIA will also require NPW typology to establish impervious construction whereby leachate from vehicles will not be allowed to seep into the ground. NPW construction developed on land that is not capable of restored hydraulic function must fulfill the lost function of the urban water cycle in place of the site. Site criteria subject to building '**Replacement**' include:

- Brownfield land designations that cannot be remediated with current technologies
- Where ground and soil renewal is not possible
- A site that has a high water table and is not capable of groundwater absorption
- A site that is unable to properly filtrate or percolate rainfall

NPW construction must restore on-site water cycle function by redefining the ground plane utilizing building Podiums and constructed landscape for rainwater percolation and harvesting. Sites that are subject to the listed conditions shall be designed with a 100-percent Site area where all of the Clean and Dirty water conditions are harvested and utilized in the NPW cycle.

6.1.1 Required Calculations for On-site NPW Pre-requisites

Each NPW project will be subject to different environmental parameters whereby project site area, available water resources, and the quality of water resources differ. The environmental variables dictate the Passive and Active demands placed on the NPW project to establish sustainable NZW inhabitant use and the NPW building cycle. A series of figures and ratios must be identified in order to calculate the NZW requirements and the performance of the project to establish Net Positive Water. Net Positive Water is calculated from a year-by-year term.

The following calculations must be determined:

- Water harvesting capacity is based on the total NPW Management Area of the project site. NPW Management area is based on the area of the property and the negotiated area of urban streetscape coverage

- The volume of available water resources is calculated by measuring the amount of annual precipitation that falls onto the project site which is measured in Height. The volume of available water as a result of Snowfall is calculated from 10% of snowfall Height per annum.

- The total volume of water resources from annual precipitation and snowfall equates to the total quantity of sustainable water storage that must be provided.

- The number of NZW inhabitants that a project can accommodate is based on the total quantity of water stored by the NPW project.

Total NPW Management Area = Property Area (square meter coverage to Property line) + Neogitated Streetscape land Area (Property line to Edge of Curb)

Total available water resources on a NPW project = Total NPW Management Area (square meter) x [Annual Greenwater Precipitation measured in Height (mm) + (Annual Snowfall measured in Height (mm) x 10% (Percentage of water content in snow))]

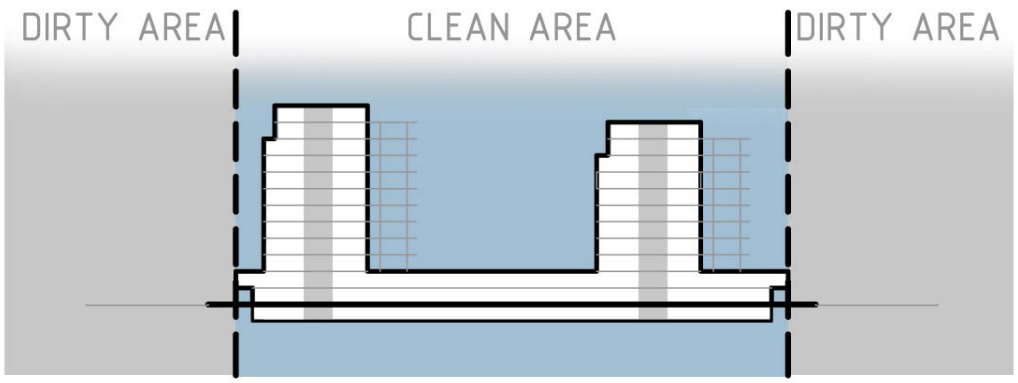
Total water quantity of storage required (cubic meters) = Total available water resources on a NPW project

Number of NZW inhabitants supported by NPW = Total water quantity for storage ÷ 25550L (NZW per person per Annum based on 70 LPCD)

6.2.0 Clean Water On-site Guidelines

Clean Water On-site Guidelines address Greenwater precipitation and Bluewater that has not, and will not be contaminated by City conditions.

To manage and preserve Clean Water quality, the NPW site will be designed to separate Clean water resources from Dirty urban streetscapes. This can be achieved by utilizing the NPW building typology to establish a **Clean Water Site Boundary** separating Clean and Dirty On-site water management. NPW buildings will physically buffer streetscape conditions, isolating the Clean Water On-site Management area from urban conditions.



6.05

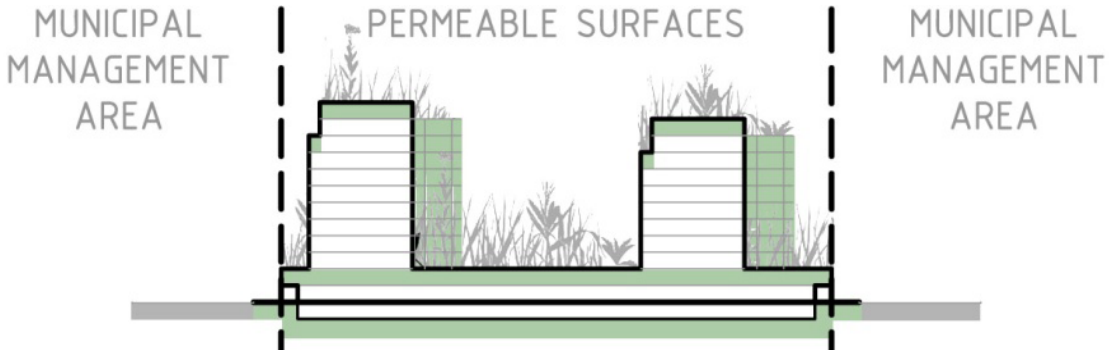
Clean and Dirty building and site management must define the conditions from which on-site water flows. Water in Dirty areas such as roadways must not be allowed to enter clean areas, and vice versa.

Clean Water On-site Management areas consist of four primary conditions; **Landscape Areas[6], Vegetation Areas[7]**, **Water features[8]**, and **Paved Pedestrian pathways[9]**. Clean water resources are preserved under best quality conditions when they are not affected by inhabitant activity. Greenwater precipitation should be allowed to permeate into paved surfaces, landscape soils, and Bluewater features such that the water medium is physically removed the urban environment.

NPW projects will prescribe **Landscape Areas** away from urban street conditions as an attempt to maintain Clean water quality. Clean Landscape areas will be designed to **retain precipitation and seasonal snowfall at the point of On-site contact**. Surface Sods will allow water infiltration into the supporting soils below. Landscape Soil and paving substrates will be utilized as a **Passive water storage** mechanism, temporarily trapping water content as it percolates and flows throughout the medium[10].

Passive soil storage medium acts as a naturally occurring filter that separates debris as water travels throughout the soils. The water that flows out of the medium is free from particulate debris thereby renewing or maintaining Clean water quality.

During the winter season, outdoor soils/substrates will no longer be able to filter available water resources as a result of winter frost. Snow will defrost and re-enter the NPW cycle during spring thaw.



6.06

Impervious surfaces lead to stormwater runoff, a condition which must not occur in waterfront locations within close proximity to waterways.

Clean On-site water conditions should be designed with **sufficient landscape soil volume to store Greenwater content for NZW use**. The volume of soil content will be determined by the absorption characteristics of the soil material. Soil selection and soil volume will be determined to fulfill NZW inhabitant use as a means of sustainable harvesting.

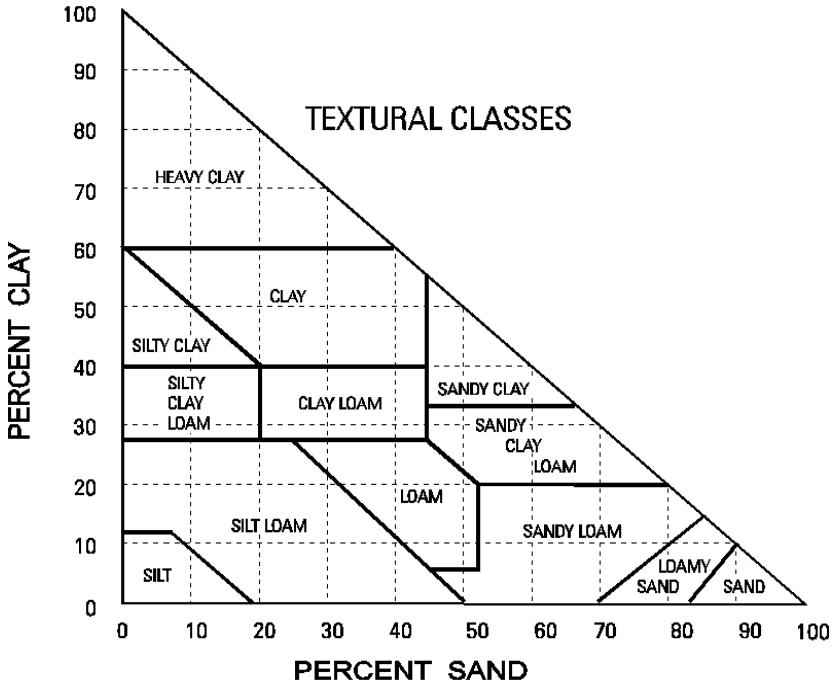


Figure 6.0.7

The diagram above displays the types of soil textures found in North America. Each soil type has an optimal water absorption and storage capacity. Soil selection should reflect the natural soil type of the regional ecosystem.

In the City of Toronto, Silt Loam soil content has a 20% water absorption rate. Sandy Loam and Loam type soils have a 10% water absorption rate. Soil texture information can be sourced from local and regional Conservation Authorities.

Clean On-site **Vegetation Areas** establish soil percolation to absorb sufficient Greenwater resources such that no additional water, whether potable or non-potable, will be utilized for purposes of irrigation and landscape maintenance. Plant species **help to maintain soil integrity and influence precipitation infiltration into planting soils**. Applicable native plant species[11] (Appendix C. Table 1 Pg. 1) will be utilized as a component of the regional ecology. The resilient plant species can survive without fertilizers or growth additives that affect on-site water quality. Resilient plant species will border paved areas to trap and isolate urban debris that is not isolated by paving substrates. Dying plants shall be replaced with the same plantings as originally designated by the original landscape plan.

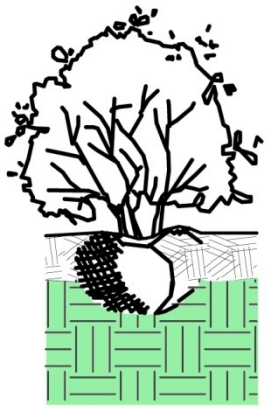


Figure 6.08

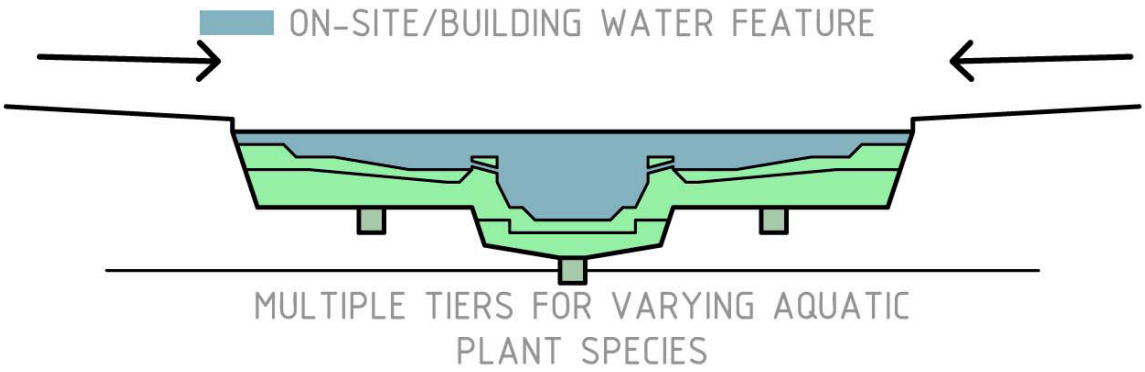
The use of native vegetation ensures that the plant is capable of surviving the environmental conditions of the regional ecosystem. Plantings will help convey water into soil content for Passive water storage. The planting's root structure will give soil content a structure to prevent soil erosion.

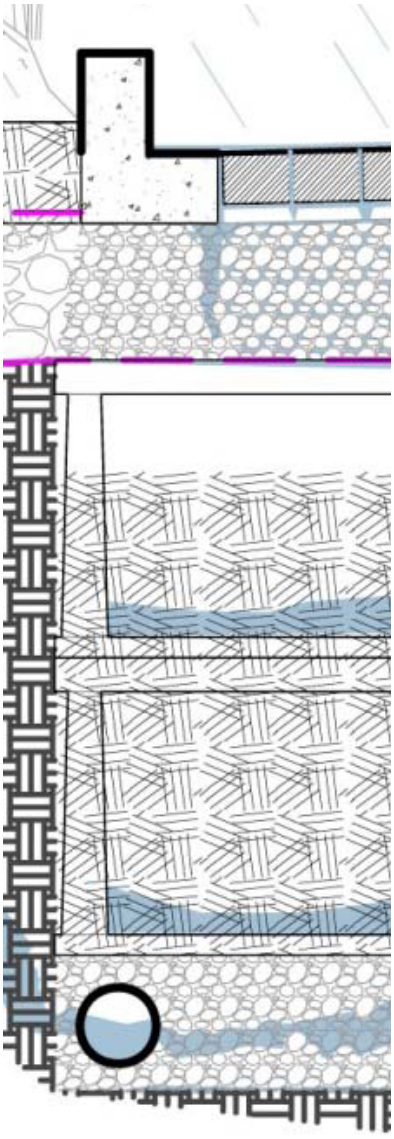
Clean On-site **Water Features** are utilized to increase the water storage potential of the site. Water that is stored in naturalized waterway conditions will **induce flow in the water medium as a means to avoid standing water and water stagnation**, two conditions that result in bacterial growth and water quality decay[12]. Aquatic plant species will be planted in Bluewater waterway/water-feature conditions with the capability to passively filter waterborne contaminants. Water that is stored in naturalized conditions is subject to ultraviolet exposure from the sun, a process that passively purifies water identified as 'Daylighting'. NPW treatment systems will be utilized to ensure that water quality is safe for inhabitant contact.

Figure 6.09

Water features expose bodies of water to inhabitants in a private domestic setting to instil a sense of ownership. Ownership will encourage the preservation and celebration of water.

Refer to the '2-tier' design of waterways in Appendix C.





Paving Solutions will be permeable throughout the Clean On-site Management area to mitigate surface water content. Surface water absorption will stop the spread of contaminant debris from NPW inhabitant activity. Salt, rocks, and other particulates are trapped in shoes and spread throughout the urban realm. Clean On-site paving substrates will **trap and isolate the urban debris, allowing water to percolate beneath the material.** Permeable paving will also ensure that Landscape and Vegetation areas are not subject to conditions that may overwhelm the passive storage capabilities of soil content.

Velocity and quantity controls of surface stormwater runoff are vital in the strategy to protect local waterways and waterfront habitat. Reducing surface runoff and the speed from which the medium reaches local waterways requires permeable paving solutions to allow stormwater ground infiltration[13]. Redeveloping the area of permeable landscape from an urban development site will inform and shape and scale of On-site coverage.

Clean **Site Servicing** will utilize sustainable practices to maintain pedestrian pathways and active building areas. Paving solutions shall be selected with self cleaning characteristics to reduce site servicing demands. Semi-annual maintenance of Clean On-site vegetation areas will be required to **remove urban debris and preserve the Passive filtering function of on-site landscape and vegetation**. Servicing must reposition or replace on-site materials as components that maintain the integrity of site permeability. Alternatives to salt/de-icing are available that have been proven to cause no ill detriment to the urban environment or native plant species[14].

Figure 6.10

This multi-tiered paving strategy allows Greenwater precipitation to permeate directly into the soils beneath, which will eventually flow back into regional waterways as renewed Bluewater resources.

6.2.1 Clean On-site Water Standards



Clean On-site Water standards establish requirements to ensure precipitation conveyance into On-site conditions for NPW sustainable harvesting. 100% of water under Clean Water On-site Management is subject to NPW sustainable harvesting.

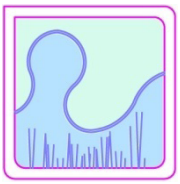
Clean Water On-site Management must be contained within the prescribed Clean Area boundary. No Clean water quality will be allowed to outflow beyond the Clean Water On-site boundary. Snow will be kept at the point of snowfall to allow the medium to melt under natural site conditions.

Clean Water On-site Management areas will consist of a minimum of Sixty percent (60%) permeable site coverage[15]. Surface conditions to accommodating this Standard can deploy Landscape Area, Vegetation Area, Water Features, and permeable paving. Clean On-site conditions include landscape podium coverage and landscape roof coverage.



Permeable landscape areas will reuse the native soil content of the project site if the quality of the soil is capable of storage performance. Recycled on-site soil content from Brownfield remediation is subject to project use. If the renewal of project soil is not plausible, soil content can be sourced from alternative sites within the urban realm.

Vegetation areas must utilize Native plant species from the regional environment. Native plant species listings are provided by regional conservation authorities. Resilient plant species should be selected to survive within the domestic environment. NPW projects will provide no potable or non-potable irrigation to Vegetation areas.



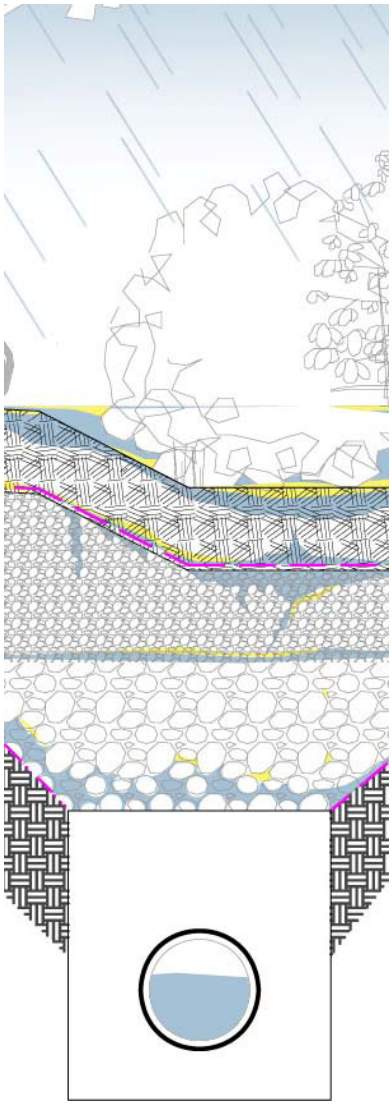
Clean Water On-site cannot allow water resources to decline in quality. Bluewater quality must be subject to natural conditions of water flow. Water flow can be induced via gravity (ie: meandering stream, waterfall) or mechanical means such as a pump. Bluewater conditions on-site must be subject to NPW treatment to ensure inhabitant safety.

Paved areas within the Clean water on-site boundary must be resilient to pedestrian activity. Paving systems must be supported by substrate materials that isolate sediment and contaminant debris as a result of inhabitant use. Snow removal must occur before sustainable de-icing additives have been utilized.

Site Servicing will follow LEED™ Green Housekeeping Guidelines.

6.3 Dirty Water On-Site Guidelines

Dirty Water On-site Management addresses urban waters that have compromised quality as a result of the urban realm. The designation of Dirty Water On-site Management is intended to buffer urban conditions from Clean Water On-site Management and the NPW cycle.



A **Dirty Water Site Boundary** (Fig. 7.05 Pg. 121) will be defined to cover a Dirty Water On-site area from the streetscape façade of the NPW building to the negotiated municipal management area boundary with the City. Dirty Water On-site Management will be subject to roadway and streetscape conditions that generate waterborne debris and contaminants. The Dirty Water Site Boundary will **contain, isolate, and adequately separate urban contaminants from NPW Greenwater resources**. Dirty Water On-site conditions will consist of Vegetation Areas, Water features, and Paved Vehicular/Pedestrian surfaces/pathways (for Landscape Areas, refer to Clean Water On-site Guidelines).

Dirty **Vegetated Areas** will be deployed as Bioswale landscape elements. Bioswale vegetation and native plantings are chosen for their filtration and absorption characteristics to **trap waterborne particles thereby ensuring the quality of stormwater drainage.** Native plant listings are available under regional conservation authorities or divisions of urban forestry from municipal offices[16]. The design of a Bioswale consists of a drainage course whereby surface waters will flow into soil and vegetation. Resilient plant species trap contaminants and urban debris while Greywater flow is slowed as it courses throughout the plantings and soils. The selection of plant species is based on native resilient and aquatic vegetation.

Figure 6.11

Bioswale's are designed as a multi-tiered water cleansing strategy utilizing resilient plantings and filtering granular to separate streetscape contamination from water



Figure 6.12

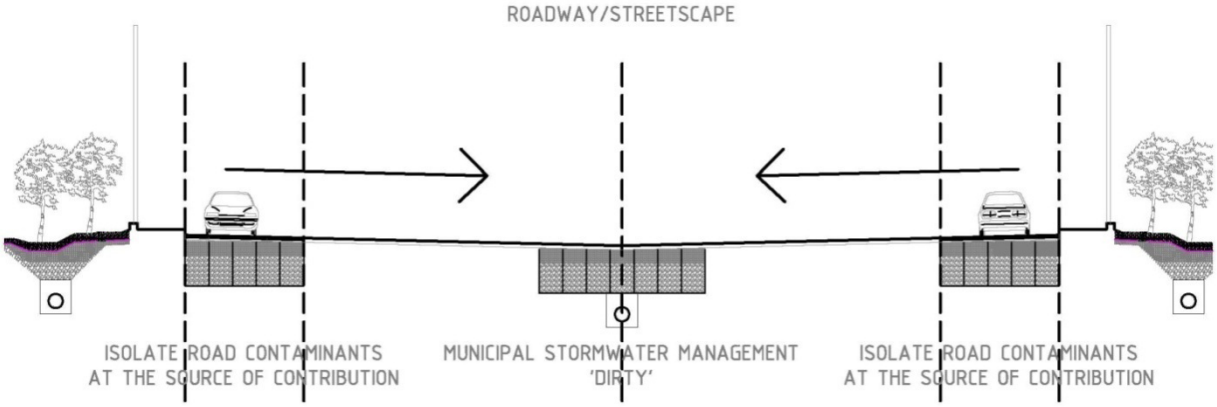
Streetscape water features act as sculptural and civic elements to bring awareness of water resources into the urban realm. The intention is to increase the value of water for urban inhabitants in addition to encouraging civic engagement.

Water Features associated with streetscape conditions should be designed to increase resource exposure and water awareness within the urban realm. Water features constructed within the Dirty Water On-site Management require Site Servicing to maintain the quality of NPW resources. Water Feature designs should be integrated where surface waters and contaminants drain away from NPW resources. Water Features within the Dirty Water On-site Management area will be subject to Clean Water On-site Management Guidelines.

Paving Solutions in the Dirty Water On-site area will be subject to Clean Water On-site Management Guidelines. Paving solutions in vehicle parking and roadway conditions will isolate and separate urban debris from On-site NPW resources. Vehicles are been proven contributors of waste and harmful environmental particles that are released into associated roadways[17]. Roadway design prescribed as an 'inverted crown' street establishes a collection channel to isolate road debris in the center of a street rather than the sides. Infiltration Galleries made of compartmentalized chambers of sand and gravel trap Dirty debris as stormwater travels throughout substrate materials.

Figure 6.13

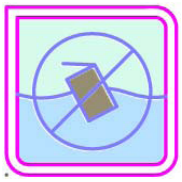
This image displays an inverted crown street, whereby the slope of the roadway is designed to focus stormwater into the centre of the street so that it can be processed through granular and screening materials. Infiltration Galleries are also present on roadside parking locations to contain the debris that falls off of vehicles.



Pedestrian Paving Solutions will be designed to drain into landscape Bioswale's to passively filter NPW resources.

Dirty Site Servicing will be subject to Clean Water On-site Management Guidelines.

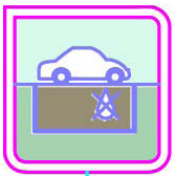
6.3.1 Dirty Water On-site Standards



Dirty Water On-site Standards prescribe the same standards as Clean On-site Standards for 100% water harvesting, Clean Area boundary, and a minimum of 60% permeable coverage, and Water features (for Landscape Areas, refer to Clean Water On-site Standards).

Bioswale vegetation areas will be designed to absorb streetscape surface waters to prevent Dirty water outflow and stormwater runoff. Bioswales must utilize resilient aquatic plant species to filtrate urban debris from NPW resources. NPW projects will provide no potable or non-potable irrigation to Vegetation areas. Bioswales will direct water towards NPW treatment process to remove Dirty contaminants and waterborne bacteria.

Paving for Dirty Water pedestrian streetscape pathways must drain surface waters away from Water features where urban Dirty water quality will not contaminate Clean water content. Streetscape paving must drain surface waters towards Bioswale landscape elements.



Paving for parking areas must be permeable, where substrate and paving design will isolate contaminants and debris from vehicles.

Paving for roadways must be impervious, where roadway debris from cars will be drained directly into NPW treatment processes.

6.4 Required Calculations for NPW Clean & Dirty On-site

The fundamental composition of NPW landscape design is to initiate Passive On-site Water storage. To calculate the total water harvesting capability of On-site features, the performance of each On-site surface material and supporting material must be identified.

The following calculations identify the total capacity of selected NPW On-site strategies to achieve Passive water storage.

- Total volume of soil/substrate required, where the volume of soil content is interconnected with project passive storage performance
- Passive storage capacity per on-site element, where landscape, vegetation, water feature, and paved areas have differing passive storage capabilities based on substrate materials and construction design.
- Total passive on-site water storage capability as a component of 100% sustainable NPW harvesting.

Total Volume of Soil/Substrate required	=	Minimum 60% Permeable coverage the NPW Management Area	X	Selected Height of Soil/substrate content		
Passive Storage Capability per On-site Element	=	Volume of soil/substrate	X	Water absorption ability of soil/substrate content (%)	X	water loss rate as a result of evaporation (%)
Total Passive On-site Water storage capacity (Clean + Dirty)	=	Landscape Area + Vegetation Area + Water Feature Area + Paving Area	X	Passive Storage Capability per On-site element		

Net Positive Water on-site Checklist



NPW On-site Pre-requisites

NPW & Municipal Management Area	
A NPW Site Management Area must be designated, whereby everything within the prescribed area is subject to NPW resource controls (not bound by property line)	
Floodplain Restriction	
No NPW project shall be constructed within a Floodplain. Flood prevention must be maintained for health and safety	
High Water Table environment	
Where site conditions are subject to a high water table, NPW projects will not be required to re-initiate groundwater flow	
Restore Site Hydraulic Flow	
Where site conditions allow restored groundwater flow, NPW projects will reinitiate rain percolation as a component of the water cycle	
Replace Site Hydraulic Flow	
Where site conditions do not allow restored groundwater flow, NPW projects will replace the function of groundwater flow into associated waterfront water bodies	
Clean & Dirty Management Area	
An NPW site will be separated in Dirty and Clean zones. Dirty Zones must utilize passive and active treatment processes to remove contaminants from NPW water. Clean Zones must maintain Clean water quality.	

Table 6.0.2

The Net Positive Water On-site checklist is to be utilized to ensure that eligible projects adhere to the required standards to achieve sustainable urban domestic sites and sustainable building water practices.

Clean Water Management

Water Quality	
The use of NPW water resources will not be allowed to diminish in quality if and when the resource is allowed to outflow from the building or site	
Site Permeability	
Permeable paving and landscape areas must absorb the full volume of annual clean water contribution to fulfill the total consumption demand of inhabitants	
Stormwater Runoff	
An NPW project will not contribute stormwater runoff to associated municipal infrastructure or water bodies	
Stormwater Management	
NPW site conditions must be designed to accommodate for 100-year precipitation levels	

Dirty Water Management

Dirty Management Area	
A Dirty management must be designed with impervious surface coverage to direct contaminated water medium directly to treatment	
Passive Treatment	
NPW will require buildings to passively treat contaminant and toxin materials that are contributed by transportation, urban streetscapes, inhabitant contributions. Passive engagement must reduce the load on NPW building processes.	
Roadway debris	
An NPW site must be shielded from roadway and transportation debris. On-site roadways will divert roadway water directly into water treatment. 100% of on-site roadway water will be treated	
Inhabitant Water Use	
No Greywater or Blackwater will be released onto an NPW site, surrounding environment, or municipal control	

6.5 NPW Building Pre-requisites

NPW Building prerequisites are required to enforce the minimum allowable conditions to manage water quality within domestic typology. While NPW On-site Guidelines and Standards have been established to negotiate between site conditions and the urban realm, NPW Building prerequisites focus on building construction and building water performance. The design and deployment of water-related building systems must be regulated to achieve sufficient performance to generate Net Positive Water.

NPW Buildings are subject to NPW Clean Water On-site Standards. As a component of Clean Water On-site Standards, the **total site coverage of the building should provide a minimum of 60% permeable coverage**. **100% of water** on Clean Water Building Management is **subject to NPW sustainable harvesting**. Surface areas consisting of Landscaping, Vegetation, Water Features and paved areas exposed to atmosphere will follow the prescribed On-site Standards.

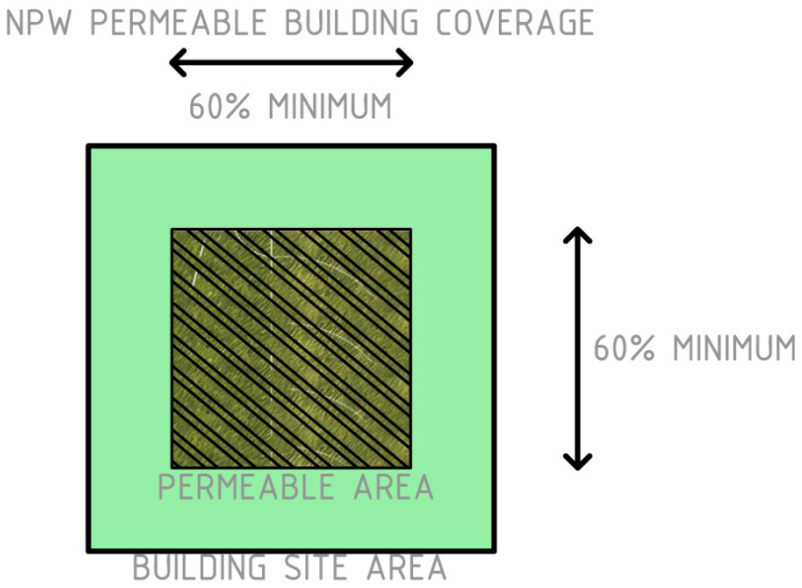


Figure 6.14

Increasing permeable coverage reflects LEED™ prescriptions for increasing on-site landscape as a means to convey stormwater into the ground. The effort reduces stormwater runoff.



Figure 6.15

Permeable landscape coverage is a natural surface that allows rainfall to infiltration and percolate into supporting soils. The percolation effect is a component of the natural water cycle.

All NPW building conditions fall within the prescription of Clean Water quality. Clean Water Building Management reflects Clean Water On-site Management, prescribing design development of building materials to **maintain Clean Water quality on NPW building surfaces**. Maintaining Greenwater quality as it lands on the NPW project is a component of the effort to **protect urban water resources from the degrading conditions of the urban realm**.

Building materials must not release chemicals, leachate or material decay that will be of detriment to NPW water quality. Only **non-toxic** and sustainable products will be allowed in the construction of the building envelope.



Figure 6.16

Building materials can decay and release chemicals as a result of material composition and poor environmental protection. The release of leachate and chemicals will pollute and degrade urban water quality.

NPW projects are constructed with impervious building envelopes. Impervious surfaces incidentally contribute to stormwater runoff by accelerating the flow of stormwater as it drains from the building. NPW building typology must divert water from impervious building surfaces as a component of water harvesting. **Impervious building surfaces will drain Greenwater precipitation and snowfall into NPW permeable coverage.** Landscape, Vegetation, Water Features and permeable paving on the NPW building will harvest stormwater drainage.



Figure 6.17

Permeable coverage in the form of planters and landscape reduces the rate of water flow from impervious building conditions, allowing the site to slowly infiltrate water content into the environment.

Passive On-site water storage and permeable building areas function as a component of NPW sustainable harvesting. NPW Passive On-site Water storage will not be sufficient to store 100% of available Greenwater resources that fall onto the NPW project. NPW projects require **Active water storage mechanisms to accommodate for the remaining quantity of harvested water resources not stored by Passive water storage.**



Figure 6.18

Active water storage is a constructed method to contain water. Constructed water storage requires mechanical systems to maintain water quality.

The drainage of Greenwater resources from Passive water storage to Active water storage is a continual function of the NPW cycle. Drainage from Passive NPW on-site conditions into interior building conditions for Active water storage demands the Clean Water management prerequisites to preserve water quality. **No Blockages or foreign materials will be allowed to enter internal building drainage of Greenwater resources.**



Figure 6.19

Debris that is trapped in drains are allowed to slowly erode as water flows through the drain. Chemicals and debris are released that affect water quality.

NPW building typology is required to **provide 70 LPCD sustainable water provisions for NZW inhabitation**. As a result of the limited but sustainable volume of annual water resources that can be harvested, building scale and density changes with varying site conditions, areas, and available water resources.

The resulting relationship that informs all NPW projects is that building scale and density is based upon the quantity of annual water resources that can be stored on (Passive), and in (Active) the NPW building.

All NPW Clean Water Building resources will be subject to NPW treatment to ensure the health of domestic inhabitants and the health of the domestic living environment.

6.5.1 Required Calculations for NPW Building prerequisites

NPW Building prerequisites identify the size and scale of water engagement in sustainable water domestic typology. Water engagement is directly connected to the number of inhabitants supported by water harvesting and storage. Water harvesting and storage influences the physical form and function of urban domestic typology.

The following calculation is required to identify the required quantity of Active water storage of the NPW building:

Total Building Water Storage Capacity required	=	Total water quantity of storage required (cubic meters)	-	Total Passive On-site Water storage capacity (Clean & Dirty)

6.6 NPW Clean Building Water Guidelines & Standards

NPW Building Water Guidelines prescribe strategies to direct harvested water resources from On-site-to-building conditions as a component of the NPW cycle. NPW building management begins when water content falls onto the building envelope as harvested water content is released from Passive On-site water storage.

Two strategies are prescribed for NPW Clean Building Water Guidelines. Passive On-site water storage is duplicated on **Exterior drainage design** with the building envelope subject to 60% permeable site coverage as prescribed by NPW Building prerequisites. As the captured water medium is released from Passive storage as a component of natural time-scale flow[18], **Interior drainage design** is implemented by managing water quality classifications. Active water storage occurs within the NPW Building to provide sufficient storage capacity to accommodate 100% of annual available harvested water resources. Passive and Active building mechanisms enable the building to function as a component of the urban water cycle to provide for NZW inhabitation.

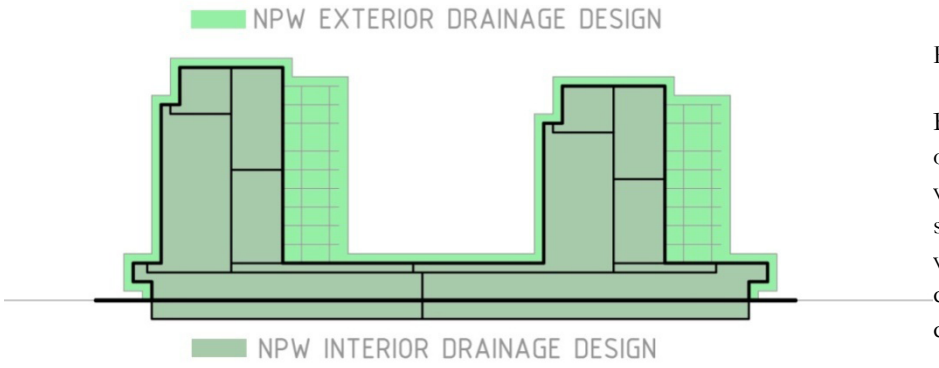


Figure 6.20

Building drainage is a component of water harvesting to convey water resources to and from storage devices. The movement of water from storage, to storage is a component of the NPW building cycle.

6.6.1 Exterior Clean Water Building management

Clean Building Water Guidelines prescribe **Passive water storage** performance on building rooftops, podiums, amenity areas, open circulation pathways, residential terraces, and balconies. The listed building conditions are impervious components of domestic building typology whereby NPW Building Guidelines require the adaptation of these spaces to not only drain available resources but to establish Exterior building conditions as a mechanism for water harvesting.

Water drainage on a building's exterior is difficult to control and maintain Clean Water quality. Urban buildings are subject to varying sources of contamination in the atmosphere (i.e. soot, carbon dioxide, airborne particulates) and those particles can accumulate on building surfaces[19]. When precipitation comes into contact with those surfaces, the surface particles are carried off the building envelope as waterborne debris. The introduction of Passive water storage and harvesting on NPW building exteriors utilizes landscape conditions as a means to isolate dirty building debris. Soil content and vegetation filter and separate foreign contaminants from Exterior building conditions.

NPW Building Rooftops will operate as an independent plane to contain 100-percent of the annual precipitation that falls onto the immediate area defined as 'Roof'. Rooftop design will **mitigate stormwater and snow runoff** from rooftop surfaces onto the building façades and NPW On-site conditions. NPW buildings will demand structural design to accommodate increased Green roof system loads and snow loads[20]. The design strategy for the winter season will retain snow at the location of snowfall as a means of exterior water storage. Winter snow will reanimate into water during spring thaw.

Passive water storage on building rooftops takes shape in the form of landscape sod and vegetation planters as a component of roof construction and permeable roof coverage. Rooftop Passive water storage is a component of section 6.4 Required Calculations for NPW Clean & Dirty On-site. The permeable surface is intended to absorb and contain Greenwater precipitation.

Designs of permeable Green roofs utilize building and landscaping materials to ensure continual water flow. Landscape soil medium will be contained within a series of membrane fabrics (Geotextiles) allowing water to be released from Passive water storage devices without soil erosion[21]. Woven and non-woven Geotextile fabrics can be selected, with woven Geotextiles utilized as a load distribution fabric and non-woven Geotextile fabrics designed with the benefit of fine filtering capability. Drainage plates and overflow scuppers should be utilized to prevent surface overflow from Green roof systems during heavy/extreme weather events.

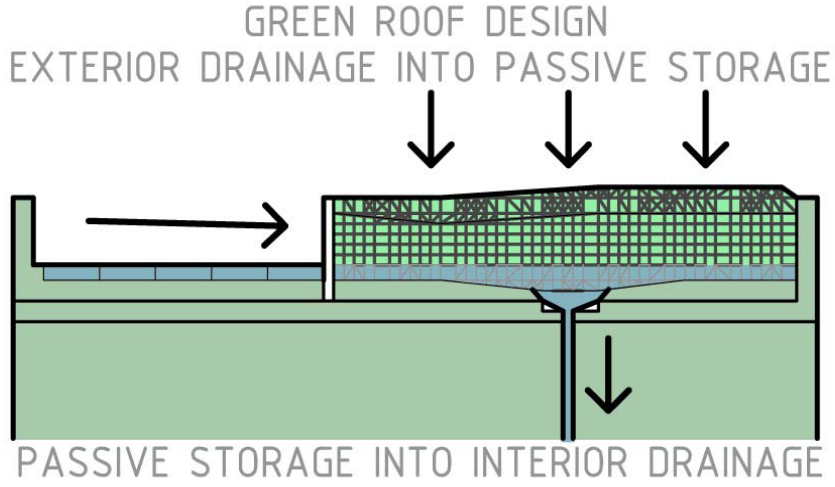


Figure 6.21

Exterior and Interior drainage design on building rooftop conditions utilizes the building as a means to mitigate stormwater runoff.

Refer to Appendix C for Green Roof System design options.

Roof area that is not covered by Green roof systems will be designed to slope and **drain into Passive rooftop storage**. Minimum construction standards for building drainage require a 2% slope on level-building surfaces with a nominal design of 4% to promote necessary drainage from beneath the system. All roof slopes in excess of 17% supporting green roof assemblies require anti-sheer measures to ensure roof integrity[22].

Rooftop paving solutions will be permeable, allowing Greenwater precipitation to infiltrate paving surfaces where the medium will enter substrate materials. Paving is levelled and supported by substrate materials that negotiate constructed drainage slope conditions. Insulation on the building envelope will be installed to avoid premature melting of rooftop snow as a result of thermal bridging.

Design of permeable paving on NPW building rooftops will be supported by screening and granular materials to replicate the prescribed surface characteristics proposed by section 6.2 Clean Water On-site management Paving Areas.

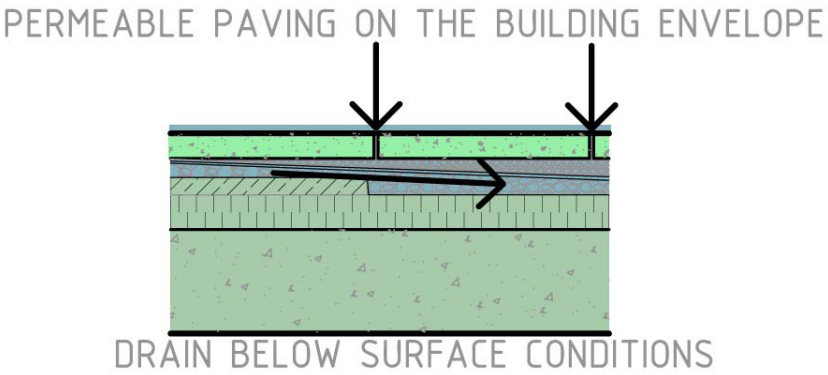


Figure 6.22

Utilizing roof top paving areas as permeable conditions allows precipitation infiltration where urban contaminants cannot reach the water medium.

Passive water storage will direct harvested water resources into the NPW building. NPW rooftops will provide drainage mechanisms to direct exterior water resources into interior water management. Drainage grates[23] will be deployed on the building envelope to filter rooftop debris and maintain harvested water quality.

The Building Envelope of domestic construction is dynamic and translates a multitude of spatial conditions to provide exterior inhabitation, panoramic viewpoints, and open environmental engagement. Open corridor, residential balconies, terraces, and building circulation condition that expose the impervious building envelope to the natural environment will be subject to canopy and permeable drainage design. Passive water storage deployed throughout NPW Building elevations will localize the volume of precipitation displaced by the building façade. The prescribed strategy will mitigate the volume and rate of stormwater runoff at podium and ground conditions when precipitation drains down the structure.

Designs for Passive water storage devices deployed on NPW Building elevations can be implemented on all of the domestic spatial conditions listed above. The strategy to achieve Passive water storage on NPW Building Elevations will prescribe vegetation planters throughout the building façade. **Planter boxes** that hang or mount onto exterior building conditions will be used in place of parapet and railing construction[24]. Planter boxes can be constructed in varying sizes to reflect the soil heights prescribed to achieve sufficient Passive storage volume.

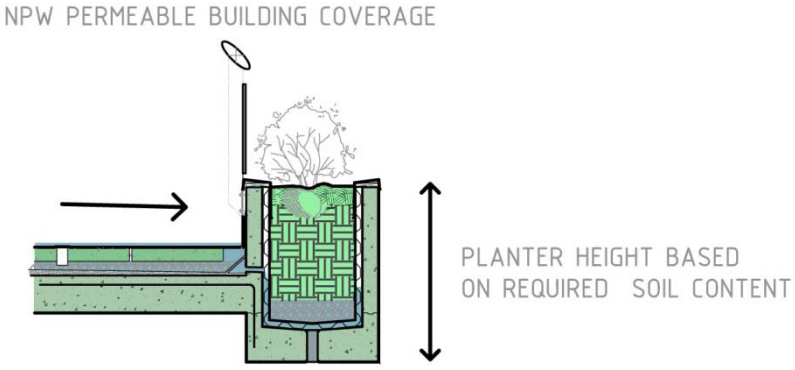


Figure 6.23

Building elevations intercept precipitation as a result of building height. The result is a large quantity of water flow down the elevation as precipitation travels towards the ground. Planters along the building elevation slow the rate of precipitation runoff.

Following the drainage design of NPW Building rooftops, impervious building conditions will drain surface waters into Passive water storage. Drainage scuppers can drain water from impervious building surfaces into planter storage devices. Permeable paving conditions should be utilized on all pathway conditions to remove surface water conditions. Drainage grates should be separated from surface conditions to prevent debris from entering NPW interior water management.

In conditions where residential balcony construction is impervious (i.e.: balcony's protruding from a building's envelope), canopies shall be deployed to direct Greenwater precipitation away from impervious building area. **Canopies remove surface water conditions and isolate inhabitant space as a source of water contamination.** Canopy coverage shall be equal to the area of impervious surface on the balcony conditions. Canopies will follow a slope design and drain into permeable Passive water storage along the Building Elevation. Conventional design of domestic typology allows precipitation to flow off balcony and terraces edges. Inset balcony's and terrace designs will utilize permeable paving solutions as a component of the building envelope.

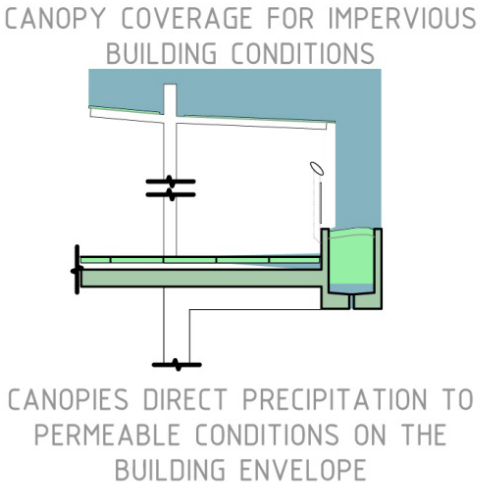


Figure 6.24

The canopy condition allows for open corridor spaces to be utilized in passive design in addition to providing shelter. Canopies must be constructed to support the loads presented by snowfall.

Cladding on the building façade will be designed to repel stormwater as a component of the building envelope in addition to functioning as a drainage plane to harvest water resources. When precipitation falls into contact with cladding surfaces, the medium will travel down the building envelope. Domestic building conditions where the residential tower structure meets the building podium or ground condition will require drainage mechanisms to direct water into interior water management.

Construction of the domestic building **Podium** in urban conditions will be designed as a management plane with the same permeable Passive water storage strategy as prescribed for NPW building rooftops. 100-percent of the precipitation that falls onto the immediate area defined as a 'Podium' will be subject to sustainable water harvesting and storage. In building prescriptions where podium conditions cover 100-percent of a project property area and residential towers are situated above, a minimum of 60-percent of the remaining NPW building site area will provide permeable landscape area to absorb precipitation runoff.

6.6.2 Interior Clean Water Building management

Water management within NPW building typology shall be designed to control domestic water resources at different quality conditions to fulfill domestic water use. The first tier of NPW building Clean Water management will be designed to **convey harvested Greenwater precipitation from Passive water storage into Active water storage**. Drainage design focuses on diverting harvested water into NPW water medium at different states of quality. The second tier will provide dedicated Potable, and Non-potable water supply for NZW residential use.

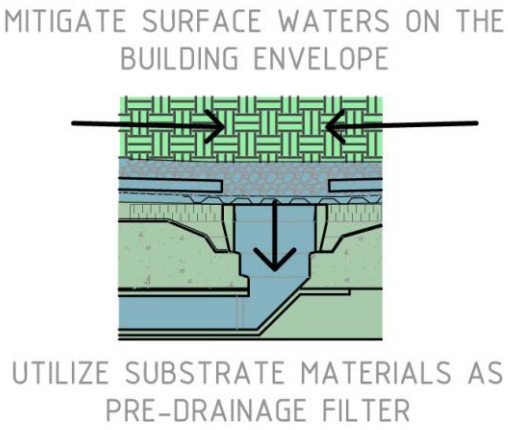
The conveyance of NPW harvested resources from Passive water storage into Interior Clean Water Management will focus on quality assurance of water content at drainage locations on the building envelope. The proposed strategy will prevent debris and materials from entering the interior water management.

Drainage into the building on the building envelope will be protected from surface water conditions where sloped building planes can also accumulate urban debris (i.e. leaves, garbage, soot, etc.). To prevent debris from contaminating harvested water content, drainage inlets will be situated beneath permeable paving solutions on the building envelope. Geotextile fabrics and substrate screening materials to support permeable paving solutions will function as a filtration layer to isolate urban debris. The implementation of drainage covers/grates will act as a secondary mechanism to stop foreign materials from entering Interior Clean Water Management.

Drainage areas situated within proximity to Passive water storage landscape areas and restored urban forestry require servicing and maintenance to manage conditions to ensure Clean Water quality and continual water harvesting processes.

Figure 6.25

Drainage beneath surface conditions utilizes substrate materials as a water filtering mechanism. The rate of drainage can increase and decrease based on the size and volume of substrate material utilized. Substrates will be designed to mitigate standing water conditions.



Potable water supply will be sourced from NPW Active water storage, where stored resources are subject to NPW treatment as water is conveyed to NZW households. Emphasis on health and safety is a primary focus in potable water distribution to ensure potable quality is maintained at all times. Interior Clean Water Management will ensure that potable water quality is provided to NPW domestic households following recognized municipal and national plumbing standards[25].

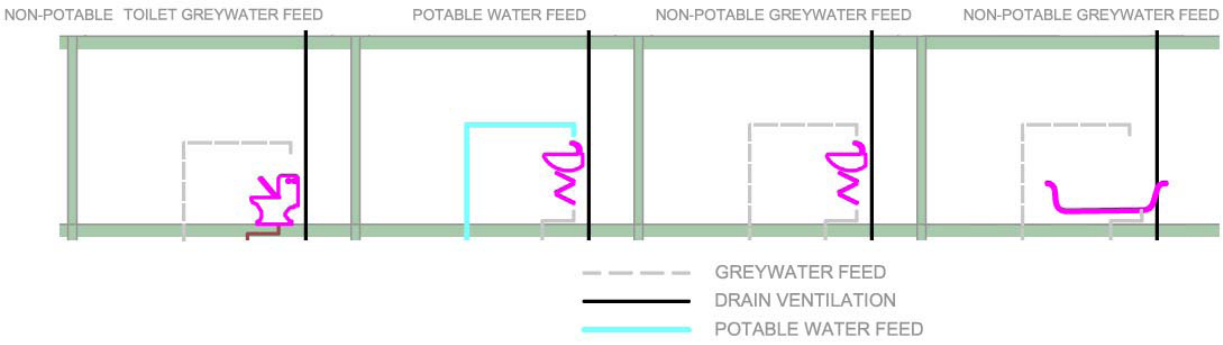
Interior Clean Water management will only be provide potable water for potable water uses following NZW Guidelines. Potable water will be provided in household kitchens for inhabitant intake and food preparation, and lavatory/washrooms for inhabitant intake and sanitation[26].

Non-potable water supply will be sourced from NPW Active water storage, with water subject to NPW treatment providing non-potable water quality. Non-potable resources will be provided for inhabitants to utilize water for non-potable household tasks. NZW Guidelines prescribes non-potable provisions in household kitchens, lavatories, and baths to fulfill non-potable household tasks.

NPW building plumbing will be designed to maintain Clean water quality by preventing water decay. Plumbing design will utilize **non-corrosive and non-off gassing materials** to ensure that the building does not affect harvested water quality. Plumbing access will be provided on each floor of a NPW project to ensure that the system can be serviced and inspected. Adequate plumbing ventilation will be provided to prevent the blockages and backflow conditions that can threaten Clean Water management

Figure 6.26

Potable and Non-Potable water provisions in NPW households is intended to separate water resources into quality streams providing inhabitants with awareness for resource quality and how to utilize differing qualities of water.



Active water storage systems situated in NPW buildings require mechanical systems to continuously maintain the Clean Water quality of harvested water resources within the structure. Active water storage will require constructed conditions that mitigate the growth of bacteria in stored water resources as well as the buildup of harmful waterborne particulates.

The best means to stabilize harvested water quality is to **induce flow and movement in stored water content to replicate the natural flow** of water. Selected storage strategies will not be allowed additional waterborne additives in the form of solvents and chemicals as a means to rectify degrading water quality. The storage strategy will avoid the chemical additives that strip water of non-harmful bacteria and nutrients.

Constructed water storage in urban building typology will be most effective in underground applications due to scarcity of open land amongst City conditions. Active storage mechanisms will be designed to accommodate sufficient volume of water medium to support the total annual water demand of NZW residence in conjunction with Passive water storage. Subterranean solutions such as buried storage tanks or subterranean wells are an adequate solution as long as **water is not allowed to stagnate and degrade in quality**[27].

Active thermal condition systems utilizing water based thermal transients are the most ideal candidates to embody the building typology with water resources. Thermal conditioning is achieved as cooling or heating is transmitted by radiators, condensers, and thermal exchangers utilizing conditioned transient solutions. Adapting conditioning systems to use harvested potable or non-potable water will induce water flow throughout an entire structure. The added benefits of thermal systems integration is the energy that is stored in the water medium, with the added performance to stabilize water quality as a result of increased water temperatures[28].

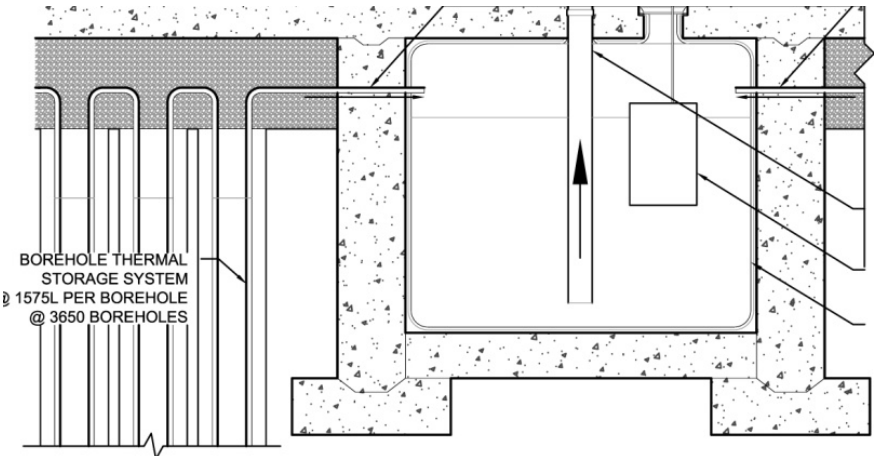


Figure 6.27

Thermal conditioning systems such as Ground Source heat pumps, Radiant Heating, and Solar Thermal Arrays utilize water-based transient solutions as the energy medium. These systems can be adapted to utilize Potable/Non-potable water as a component of the NPW cycle.

6.7 Clean Water Building Standards

Building materials utilized as a component of the NPW cycle to harvest, drain, and store water resources shall not be allowed to degrade harvested water quality.

Rooftops



Following the prescription for vegetated 'Green' roof coverage[29] by LEED™ and local municipal bylaws (City of Toronto), NPW Buildings will deploy **Green roofing systems on no less than 60-percent of applicable rooftop area**. The 60-percent coverage is based on the definition of roof boundary[30]. Remaining non Green roof coverage areas are allotted for service pathways, floor area designated for the buildings mechanical systems, and other spatial requirements associated with multi-storey domestic construction.

Alternative roof mounted building systems such as solar thermal arrays or photovoltaic panels shall not interfere or disrupt the water harvesting processes of NPW Green roof systems.

Building Envelope



Planters and storage devices located on the building envelope must accommodate a minimum coverage area of **20-percent of the immediate impervious surface area**. Planters will be utilized as a means to slow the rate of stormwater runoff from impervious building conditions. Planters will be subject to regional frost depths as prescribed by regional environmental authorities[31].

Surfaces on the building envelope must not be subject to construction thermal bridging that influences the pre-mature melting snow or frost build-up during the winter season.

Building Podium



Building podiums are utilized in urban construction to establish building scale that is relative to streetscape and pedestrian conditions[32]. The building podium will be managed as a management plane with the same water harvesting Green Roof requirement as prescribed for NPW building rooftops.

Water Provision and Drainage



NPW Building drainage systems diverting harvested water from Exterior-to-Interior Clean Water Management must be protected from winter seasonal conditions to prevent frost damage. **No blockages** or foreign materials will be allowed to clog building drainage, and plumbing networks. Under NZW Guidelines, domestic waste debris is isolated and separated from water content within the household[33], removing the need for sediment and debris treatment post inhabitant use.

Potable and Non-Potable Water is subject to NPW treatment to ensure clean water quality before water is provisioned for residential inhabitants.



Potable drinking water must be processed to tertiary and municipal levels before it is allowed to enter the household. The emphasis for health and safety is a primary focus for water distribution where water provisions must achieve potable water quality at all times.

Non-Potable water will be directed to all household non-potable tasks through a dedicated non-potable (Greywater) network of feed and drainage piping. Greywater will undergo bacteria removal and directed back into water storage and storage for future reuse.

Active Water Storage

Active water storage to accommodate harvested precipitation will not allow water quality to decay. **Water storage systems will not allow stored water resources to stagnant**, avoiding water conditions that lead to the growth of bacteria and waterborne diseases.

6.8 Dirty Building Water Guidelines & Standards

Urban domestic development is designed to support a mixture of tenants with a diversity of building programs and service areas. Mixed-use designations for urban domestic intensification require Service and Utility facilities for Loading Areas, Moving Bays, and Refuse locations for waste disposal. All of these areas negotiate Dirty water conditions that can contaminate On-site and Building water content. The listed areas will be internalized within a NPW Building as a means to contain debris.

Waste and debris management shall follow municipal code and bylaws[34] that require the separation of compost, garbage, and recyclables as a means to deter waste material from landfills. Waste containers are to be water tight to ensure wastewater is not released into utility areas. Waste materials are to be removed under servicing conditions where waste will not be allowed to escape from the NPW Management Area. Drainage in Service and Utility Areas will direct all water content directly into NPW treatment.

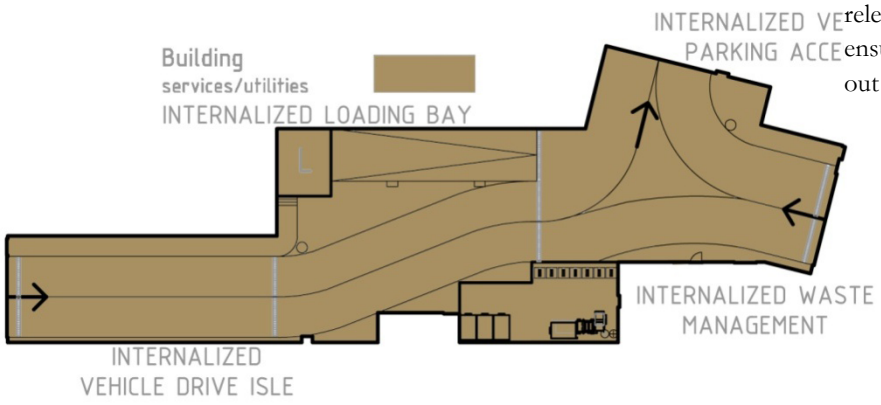


Figure 6.28

Areas utilized for building services negotiate materials, chemicals, and waste.

Constructing servicing areas within the building envelope is an attempt to ensure inhabitant debris is not released into the environment, to ensure Dirty water does not flow out of the building structure.

NPW building area allotted for Vehicle Parking will be designed with dedicated floor drains, whereby paving design will function as a sloped plane to drain the Dirty water content that falls from vehicles[35]. Domestic building typology will provide sufficient space for residential parking and vehicle ownership following municipal zoning bylaws[36].

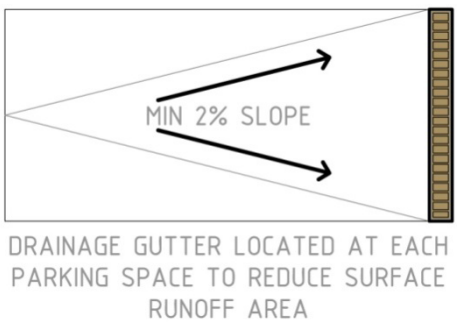


Figure 6.29

Drainage gutters constructed at each parking space will limit the flow of surface runoff.

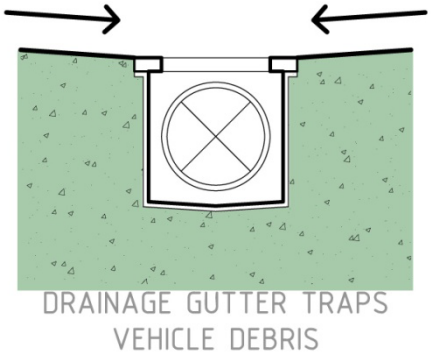
Gutters will also ensure site servicing will effectively divert Dirty paving conditions into NPW treatment.

NPW building areas allotted for vehicle laneways, municipal garbage disposal vehicles, loading bays and moving rooms are designed with an Effective Impervious Area. Impervious paving will function as a sloped plane, draining water content into floor gutters. The gutters will trap streetscape contaminants and urban debris while separating residual Dirty water medium. The gutters will drain directly into NPW treatment systems for quality renewal. Captured debris is subject to maintenance and site servicing removal.

Figure 6.30

Drainage gutters will be trap sediment debris that is waterborne.

Drainage grates will stop large debris to prevent blockages.



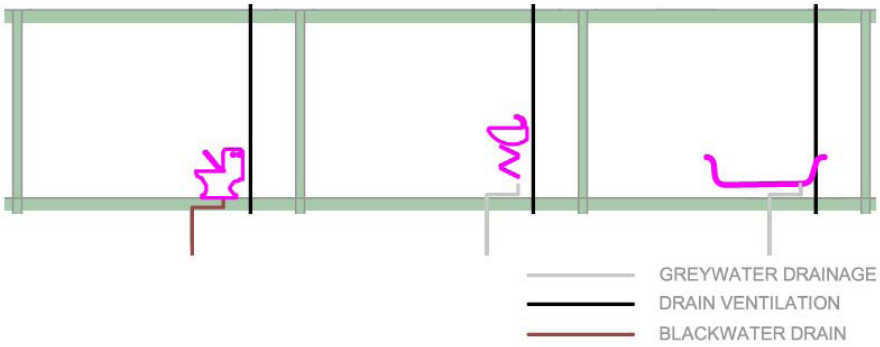
NPW residential households will provide dedicated drains to convey post-consumed Greywater and Blackwater in their respective qualities to water treatment. Drainage design will reduce the volatility of flow as the degraded water content flows into treatment mechanisms. Common multi-unit drainage issues are caused by inhabitants when they flush household items down the drain. The accumulation of debris will back up the drainage system[37] resulting in extensive servicing and maintenance costs. NPW will prescribe preventative measures in the form of strainers, grating, and screening that will control the flow of the water medium at intake locations.

NPW building maintenance will follow LEED™ Green Housekeeping Guidelines utilizing environmentally safe cleaning solutions and servicing practices. Building maintenance will continually combat Dirty building conditions as a result of inhabitant activity.

Figure 6.31

Greywater drains from NPW households must be protected by inhabitant waste debris.

Blackwater drains should be utilized for human waste only.



NPW building typology will filter, treat, and renew all Dirty water to restore Greywater and Blackwater content to Greenwater and Bluewater quality. **NPW Innovative Water Treatment (IWT)** will deploy treatment mechanisms and water processes to renew harvested water resources to pre-consumption conditions, generating a building water cycle to establish multiple water reuse. With reference to the Green Building Case Study exemplars documenting Canadian sustainable water construction, water treatment systems are available in today's marketplace that are capable of generating tertiary, and beyond tertiary water quality.

Non-potable Greywater from NPW household kitchen, lavatory, and bath drainage will undergo filtration and treatment to remove residual household chemicals, bacteria's that have been accumulated from inhabitant use, and all effluent content. Blackwater content from lavatory toilets direct inhabitant wastewater and waste solids into treatment. Solid waste material will be removed from the water medium while wastewater content will be purified of bad bacteria, toxic substances, and sources of disease.

Dedicated utility areas will be provided for NPW Treatment mechanisms including facilities to control water treatment processes. Integrated NPW treatment utilities include building area for drainage and plumbing maintenance, pump stations and sump pumps, and dedicated waste collection facilities specifically for NPW solid waste management. Treatment and water management technicians will be required to manage NPW treatment processes. The minimum grade of post-treatment water content will fulfill all non-potable water uses in NPW building typology to allow NPW cyclic reuse of harvested water resources[38].

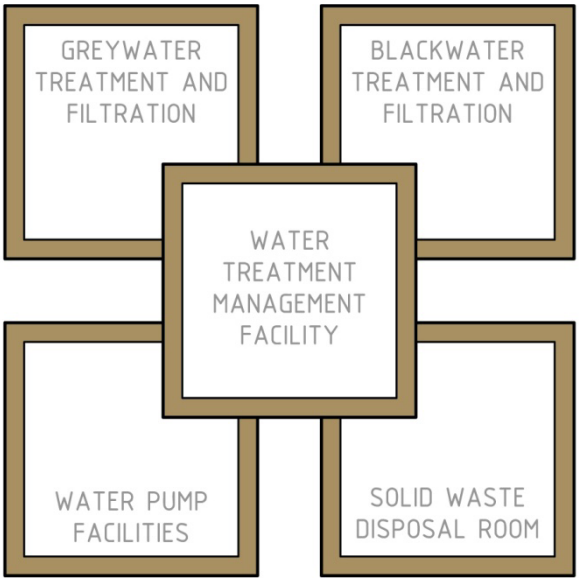


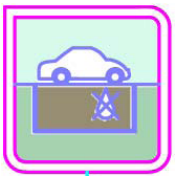
Figure 6.32

Providing isolated facilities for each water treatment process will establish quality control.

Blackwater and Greywater separation is vital to ensure treatment processes are optimized to address Dirty water content.

6.8.1 Dirty Building Water Standards

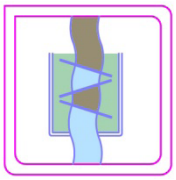
Drainage slope design for paving in Service and Utility facilities areas require a minimum slope following municipal code. The drainage slope will divert any wastewater effluent from domestic waste materials into NPW treatment. Drainage planes are required to slope towards floor gutters that trap waste solids and garbage debris. Water drainage in floor gutters will divert Dirty water content to NPW treatment.



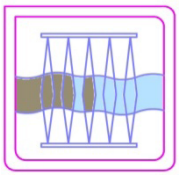
Drainage slope design for paving in residential and visitor Parking Spaces will follow the same design standards prescribed in waste management utility areas. Drainage planes and floor gutters will isolate Dirty water content from vehicles. Gutters located in the front of each parking position to minimize the spread of surface runoff.

Drainage for NPW residential households diverting post-consumed Greywater and Blackwater to NPW treatment is required to service drainage networks bi-monthly to ensure the continued function of the drainage systems.

NPW projects will follow the guideline of LEED™ Green Housekeeping innovation credit, providing up to a 6 month supply of sustainable cleaning products to inhabitants (Appendix B Pg. 8).



Innovative Water Treatment (IWT) deployed in NPW building projects are required to remove 100-percent of foreign Dirty particles and contaminants from harvested water resources. Urban debris must be removed from Passive Water Banking on Exterior Clean Water Building Management before the medium is direct into Active Water Storage.



Water filtration and treatment mechanisms are required to remove 100-percent of solid waste material and wastewater contamination from post-inhabitant use. The water content will be restored to a minimum water quality of non-potable reusable water. Treated water must be inspected by qualified water inspection technicians to adhere to local health regulations and standards.

6.9 Required Calculations for NPW Buildings

Total active water storage in NPW Buildings is the result of utilizing and adapting every domestic building system that requires water based solvents and water content. Adaptation will involve water use in thermal conditioning systems, pressurized plumbing networks, stormwater containment and dedicated water storage systems.

Water treatment for an individual building is considered a small application when compared to regional and municipal treatment utilities. Available water treatment technologies on the market have been designed to accommodate neighbourhoods and communities. The application of water treatment and filtration for an individual NPW projects will utilize the available size and capacity of water treatment mechanisms.

The following calculation is required to establish Active water storage and Water treatment in NPW buildings:

Passive Building Water Storage (Clean)	=	Green Roof Systems storage volume	X	Floor-to-floor landscape elements storage volume	X	Podium Landscape coverage storage volume
Total Active Water storage	=	Mechanical Storage system Volume	+	Adapted Thermal Conditioning System Storage Capacity	+	Volume of Potable and Non-potable water provisioning plumbing
Active Storage Ratio (%)	=	Total Building Water Storage Capacity required	÷	Total water quantity of storage required (cubic meters)		
NPW Treatment Capacity	=	Water Treatment System of available capacity (small domestic application)	+	Water filtration systems of available capacity (small domestic application)		

Net Positive Water Building Checklist



NZW Sustainable Water use	
NPW must fulfill all requirements prescribed in the NZW sustainable water use Checklist.	
NPW on-site Water Management	
NPW Building's must utilize NPW on-site Water management	
NPW Water Treatment	
NPW water treatment must utilize a combination of passive and active treatment mechanisms	
Water Quality	
A NPW building must deliver greater water quality of output water resources than when harvested	
NPW Cycle	
NPW must establish the function of a building for cyclic reuse of available water resources	
Revitalization	
NPW must contribute positively to the regional environment	

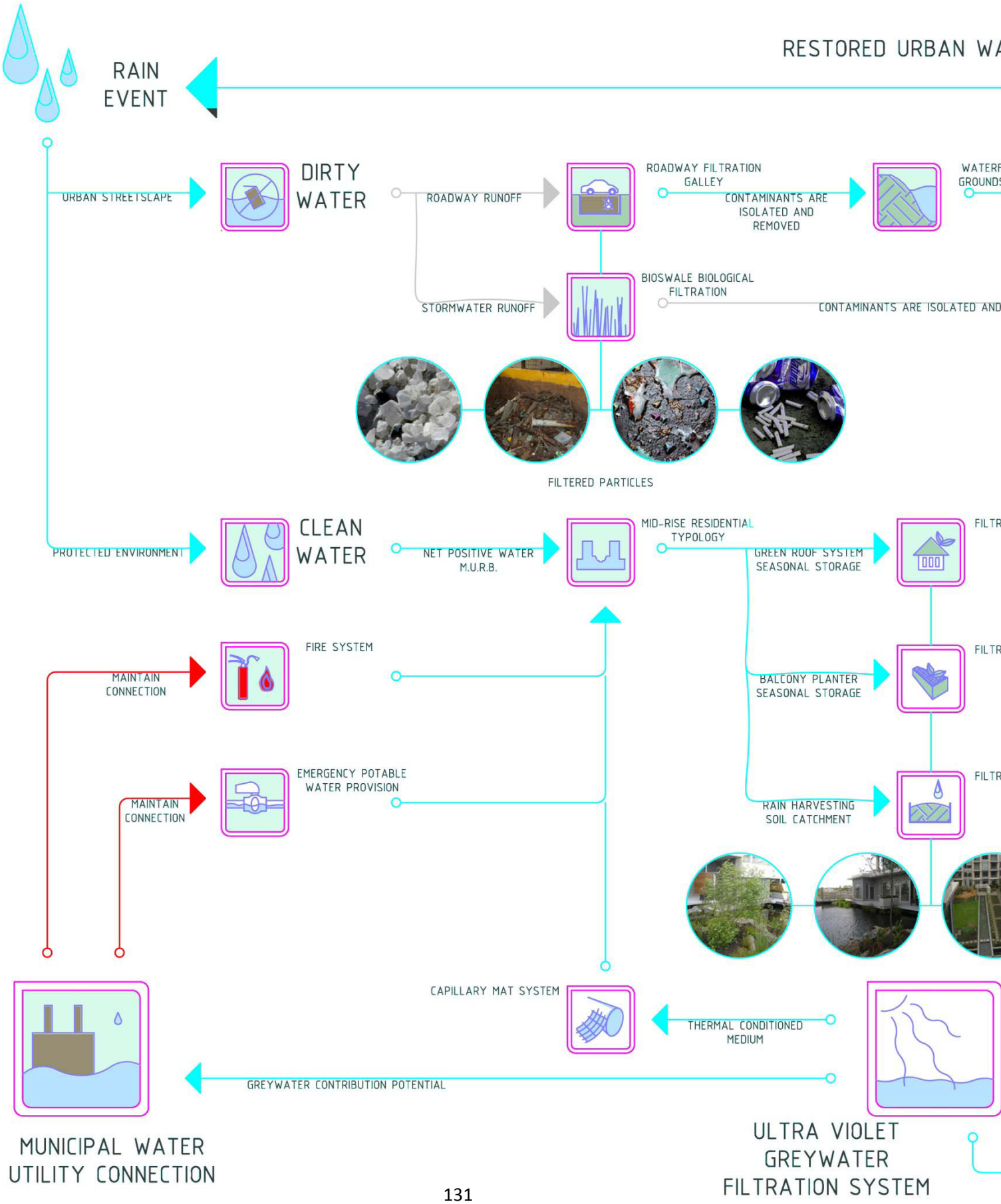
Table 6.03

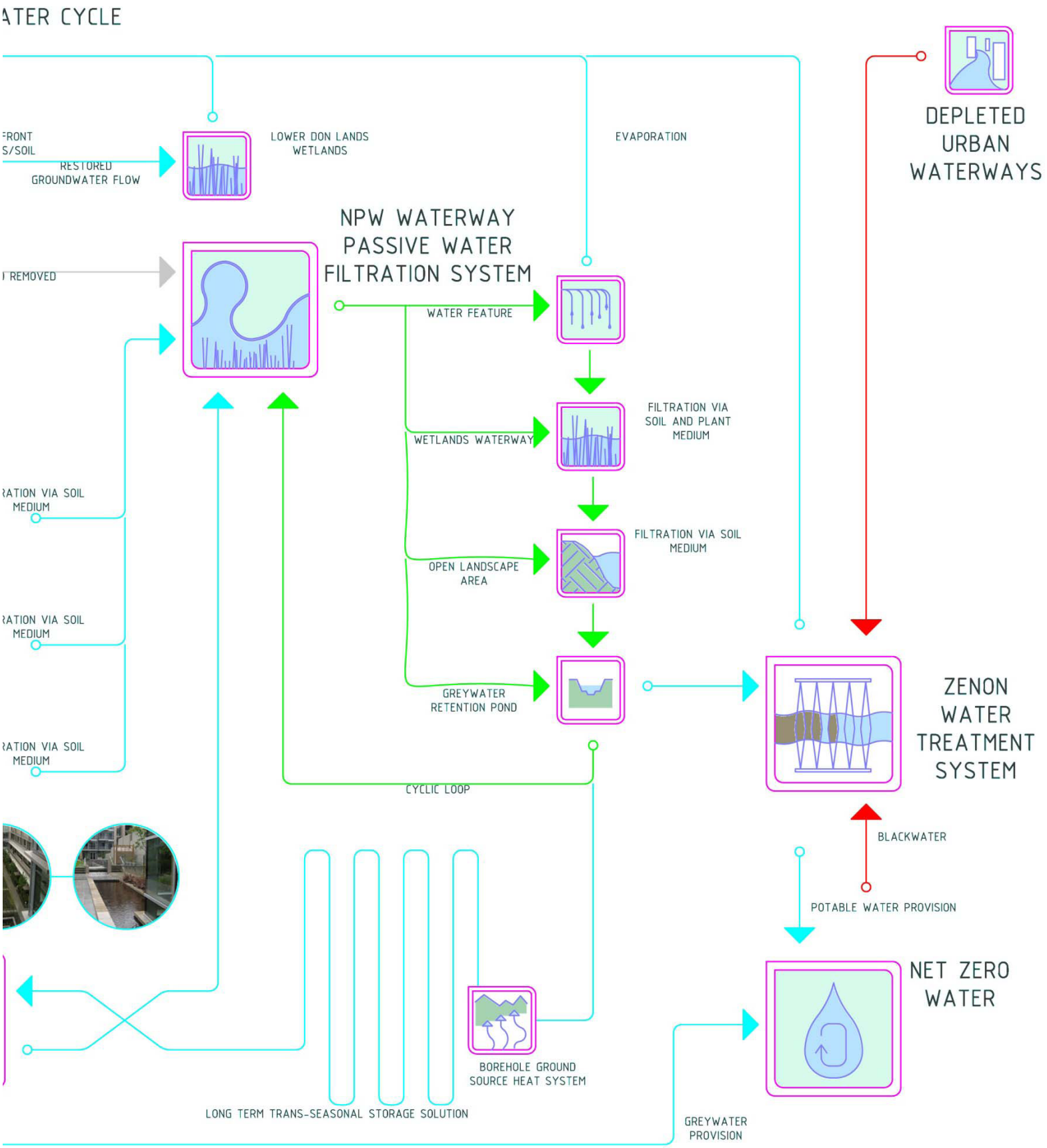
Net Positive Water Building Checklist establishes building items and functions that need to be revised to ensure sustainable building water practices. All of the listed items must be achieved in order for a project to qualify as a Net Positive Water structure.

Interior Drainage Management	
Where Greenwater drainage is directed into interior drainage systems, plumbing will not off-gas and negatively affect the water medium	
Exterior Drainage Management	
Where Greenwater drainage comes in contact with any building surface, no construction materials will off-gas and negatively affect the water medium	
Green Roof Coverage	
Minimum 60 % coverage of 100% roof area with the volume of roofing material based on absorption rates reflecting NPW on-site CWM	
Building Envelope	
Balcony, Terrace, Open Corridor and Building circulation shall maintain a minimum of 20% landscaped percolation area	
Water Storage	
Where water is stored within an NPW structure, the water medium will not be allowed to degrade in quality	
Potable Water Provisions	
Potable Water Management follows NZW guidelines for sustainable water use. NPW must provide potable and teritary grade water quality to inhabitants.	
Building Servicing	
Where solvents and chemicals are utilized for building maintenance, all applicable products shall follow LEED Green Housekeeping guidelines by utilizing non-toxic, biodegradable cleaning solutions	
NZW Water output	
NPW must manage all greywater and blackwater output from NZW inhabitant consumption	
NPW Water Treatment	
NPW active water treatment must provide an output water quality that satisfies municipal health and safety regulations for potable water and greywater	

NET POSITIVE WATER MANAGEMENT DIAGRAM

Figure 6.33




ATER CYCLE
RONT
S/SOIL
RESTORED
GROUNDWATER FLOW
LOWER DON LANDS
WETLANDS
EVAPORATION
DEPLETED
URBAN
WATERWAYS
NPW WATERWAY
PASSIVE WATER
FILTRATION SYSTEM
REMOVED
WATER FEATURE
WETLANDS WATERWAY
FILTRATION VIA
SOIL AND PLANT
MEDIUM
RATION VIA SOIL
MEDIUM
OPEN LANDSCAPE
AREA
FILTRATION VIA SOIL
MEDIUM
RATION VIA SOIL
MEDIUM
GREYWATER
RETENTION POND
RATION VIA SOIL
MEDIUM
ZENON
WATER
TREATMENT
SYSTEM
CYCLIC LOOP
BLACKWATER
POTABLE WATER PROVISION
NET ZERO
WATER
BOREHOLE GROUND
SOURCE HEAT SYSTEM
LONG TERM TRANS-SEASONAL STORAGE SOLUTION
GREYWATER
PROVISION

Endnotes

[1] Lake Ontario is the regional water body associated with the City of Toronto
[2] Urban pollution includes debris from cars, dirty roadways, and mobile debris from waste disposal bins. Soil erosion as a result of urban runoff can induce chemical imbalances in regional waterways as a result of non-natural conditions
[3] Dockside Green Development team negotiated with the City of Victoria to develop streetscape Bioswales and an integrated landscape management strategy to control on-site water. This economic relationship reduced the financial cost on the developer.
[4] FEMA Habitat Assessment and Mitigation Section 5.1
[5] A high Water Table level saturates soil with seasonal precipitation as a result of groundwater flow and soil permeability
[6] Landscape Areas are covered in sod, grasses, and native terrain
[7] Vegetation Areas are designated portions of land used to support plant species
[8] Water features are constructed building elements used to contain bodies of water
[9] Paved pathways are Areas that are constructed and designed for human mobility supporting pedestrian and vehicular travel
[10] Flow rates are dependent on the type of soil/substrate material
[11] Each City, including the City of Toronto has a list of native agricultural species under categories of urban forestry.
[12] World Health Organization identifies that stagnant water can become a breeding ground for bacteria, diseases and parasites
[13] Infiltration refers to the movement of water into the first layers of soil at grade
[14] Products such as Alfalfa meal distributed above paved areas provides grip while melting snow. Chemical alternatives are also available that do not have any environmental, or health rises to inhabitants or their pets
[15] Toronto Green Roof bylaw prescribes green roof coverage area maximums.
[16] City of Toronto urban forestry listing of plants, trees, etc.
[17] U.S. E.P.A identifies road abrasion and vehicle tyre decay as contributing factors that distribute roadway chemicals and metals onto urban waterways
[18] LEED™ SS c6.1 Stormwater Management
[19] Air Quality Health Index (AQHI) identifies the risk in urban areas as a result of smog.
[20] ASTM standard: "ASTM E2397.05 – Standard Practice for Determination of Dead Loads and Live Loads Associated with Green Roof Systems"
[21] Soil Erosion is the washing away of soil content by the flow of water
[22] Refer to Toronto Green Roof Bylaw 492-9
[23] Drainage Grate's act as filters to stop materials from entering the drain as a result of the size and opacity of the grate
[24] Dockside Green Balcony Planter Boxes. Figure 5.08 Pg. 63
[25] City of Toronto Water Supply Bylaw 851
[26] Section 6.2.2 Pg. 92 Potable Water provisions
[27] World Health Organization identifies health risks related to stagnant water
[28] CDC identifies boiling water temperature as a means to disinfect waterborne pathogens
[29] LEED New Construction Sustainable Sites Credit 1
[30] Federal environmental organizations provide regional weather details and conditions for each city.
[31] Refer to Appendix D. City of Toronto Frost Depth Pg. 3
[32] Toronto Downtown Building Project specifies building podium scaled with reference to streetscapes
[33] Greywater filtration devices installed throughout the NZW household provide an opportunity for inhabitants to dispose of their waterborne debris under waste management, rather than wastewater disposal
[34] Toronto Municipal Code Chapter 844 Article VI
[35] Toronto Municipal Code Chapter 629-40
[36] City of Toronto Zoning Bylaw Chapter 200
[37] (Chap.2 Pg.26 Fig.2.1.3)
[38] (refer to dockside green for water treatment standards)

Chapter SEVEN: NPW Pilot Project

Net Positive Water projects are dependent on the regional habitat to provide water resources. NPW On-site Pre-requisites (S 6.1.1) prescribes project scale based on sustainable harvesting of available water resources on a project site. NPW Residential density is determined by the capabilities of a project to support annual NZW at 70 LPCD with harvested water resources. The NPW project criteria highlight the relationship between sustainable urban water use and project density, where residential density is determined by the volume of available water resources.

7.1 Residential Density for Sustainable Water

Water consumption has a linear relationship with inhabitant density where greater population requires greater water demand. In regions with sparse water resources, higher residential density cannot maintain sustainable water use as a project site does not have sufficient water resources.

"... in some cases tall buildings, imposed on a city or region that simply does not have the resources or infrastructural capacity to support them, may push the area over an 'environmental cliff'."[1]

The 'environmental cliff' occurs when inhabitant densities overwhelm a project sites capacity to provide sustainable water resources. Urban water volatility and instability in the urban water cycle are consequences of the environmental cliff that has resulted in the urban water problem. Higher residential densities to fulfill urban intensification can be established as long as a project does not exceed the 'environmental cliff' of non-sustainable water use.

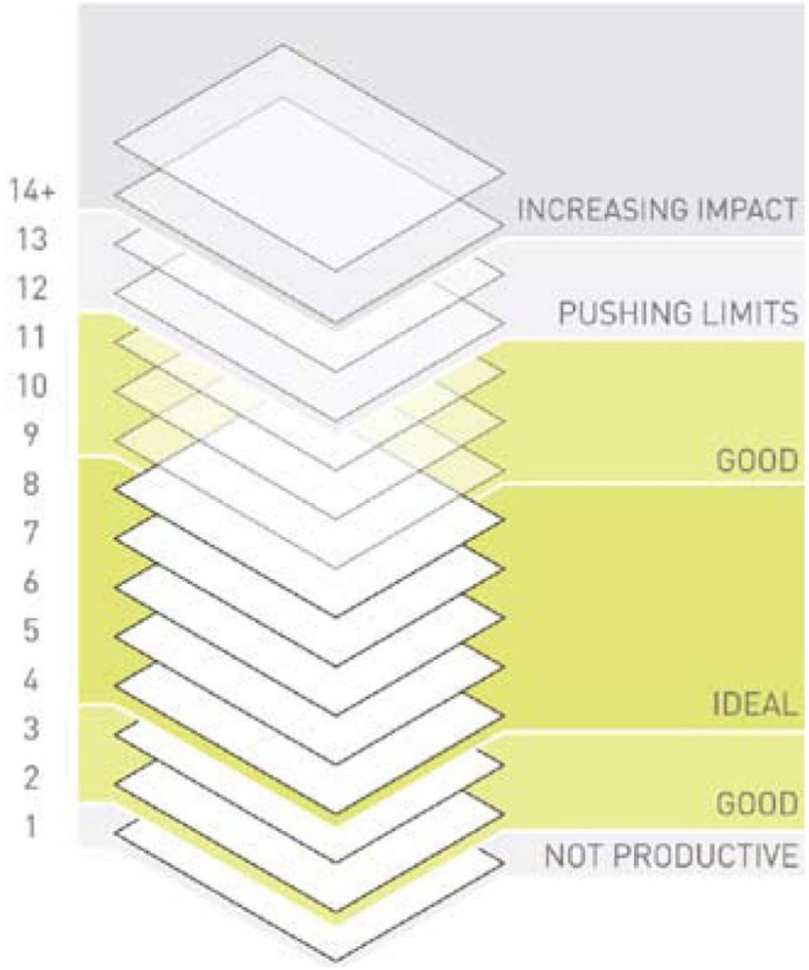
Architect Doug Farr[2] argues that increasing density can better protect water resources at a regional level, but high density development creates more impervious land coverage that leads to the water quality issues of stormwater and urban runoff. Farr's argument highlights the potential for urban intensification to worsen the urban water problem as a result of higher density architecture.

The City of Toronto has intensified urban residential density with domestic development over the past 10 years[3] as a 'Smart' growth initiative'[4]. Construction of multi-unit residential projects has increased urban density values upwards of 6-8 times the available land area. Higher density intensification has increased Toronto's urban density up to 4,000 inhabitants per square kilometre in the downtown core.

Toronto's urban intensification will mitigate the burden placed on the City's decaying water infrastructure to distribute water resources over the vast City area (Chapter 2, Section 2.1.3). The urban strategy addresses the infrastructure and economic issues of Toronto's urban water problem, but it does not account for the environmental impact of residential architecture to accommodate increasing density. The urban environment has limited land and site area to support sustainable water harvesting. Introducing too much residential density onto a limited development area can compound the existing urban water problem.

Figure 7.01

This diagram displays building sustainability respective of building height. The Living Building Challenge associates building height with residential density, where greater density will increase the environmental impact of the structure.



Architect Jason Mclennan establishes his case for limits to development density based on regional inhabitation of a given area of land. The size and scale of building construction will directly affect the capability of a project to capture sufficient water resources. When residential architecture is not capable of sustainable water harvesting and Water Independence as prescribed in The Living Building Challenge, domestic reliance on '*wasteful regional systems*' will continue to contribute to the urban water problem.

Successful examples of residential density that does not contribute to the urban water problem are the documented Green Building Case Study exemplars of Dockside Green Development and the Vancouver Olympic Village – SEFC. The two projects were able to accommodate residential intensification through medium density, mid-rise construction. Water resources were sourced from sustainable water harvesting on each project site for inhabitant and building use. The projects mitigated the risk of the 'environmental cliff' by establishing processes of water renewal that reduced the impact of residential density and water demand.

Under the conditions of urban intensification in Toronto and the need to address the urban water problem, residential density for sustainable water will be derived from the capacity of the project site to provide sustainable water resources, and the capability of the project to mitigate the environmental impact of inhabitant water use.

7.1.1 Environmental Sustainability of Mid-rise

In light of Toronto's urban water problem, this thesis follows the position that Medium density, mid-rise residential construction is a sustainable alternative to urban intensification that can accommodate the demands to increase urban density while establishing sustainable water. It is the position of this thesis to utilize mid-rise residential construction to design towards Net Zero Water conservation and sustainable water harvesting in Net Positive Water to combat the urban water problem.

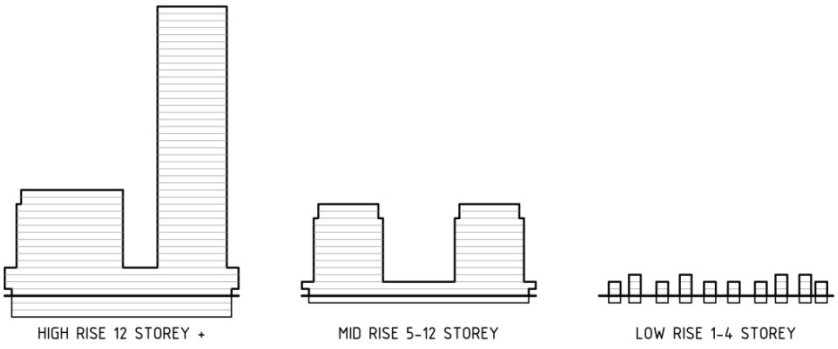


Figure 7.02

Existing urban building forms including High-Rise, Mid-Rise, and Low-Rise building typology.

Low-rise is not utilized as a building form to satisfy the demands of urban intensification.

The building typology originates from wood frame and heavy timber construction in the 19th century[5]. Mid-rise domestic buildings were constructed across North America as a building solution to satisfy urban inhabitation and increasing urban density before the age of high-rise construction and the invention of the elevator. Mid-rise building typology is a compact and efficient form of residential construction. The building scale maintains less building envelope per residential unit than comparable high rise and low rise building forms[6].

Domestic building operation is subject to a sustainability evaluation called 'Passive Survivability'; where sustainable building performance is measured based on how long inhabitants can survive with the failure of power, heating and water systems. Mid-rise construction developed at a time where building operations did not require the active use of resources in order to support inhabitants. Inhabitants were able to access their units without the use of elevators for vertical circulation. Ventilation and fresh air could be accessed by opening windows and lower building heights benefited from the passive shade provided by urban flora.

The high levels of Passive Survivability in mid-rise construction provide a sustainable building platform for household water use. Water provisions from municipal utilities were distributed at sufficient water pressures to reach mid-rise heights with minimal demands on building mechanisms[7]. Mid-rise plumbing drainage and ventilation requirements are able to function off of gravity without mechanical assistance. When mid-rise construction was modernized, stormwater drainage and plumbing requirements did not have a substantial impact on resource use and construction demands.



Figure 7.03

The Solar Siedlung (Vauban District, Germany) was designed as a model urban district utilizing mid-rise building typology to achieve Net Positive Energy domestic housing typology. Mid-rise construction is adaptable to Active and Passive building performance for sustainable inhabitation.

Beyond the application of Dockside Green Development and the Vancouver Olympic Village – SEFC, alternative communities have been developed utilizing mid-rise building typology to achieve sustainable resource use. Under the prescription of 'Scale Jumping' prescribed by The Living Building Challenge, building design for resource conservation and water renewal has an opportunity for greater success as a neighbourhood/district system. Mid-rise buildings in a district scale have the capacity to accommodate and share water resources without the dependence on municipal infrastructure. Mid-rise building form in a neighbourhood scale supporting sustainable water harvesting and water renewal becomes a decentralized system, where water resources can be diverted from one structure to the next based on resource demand.

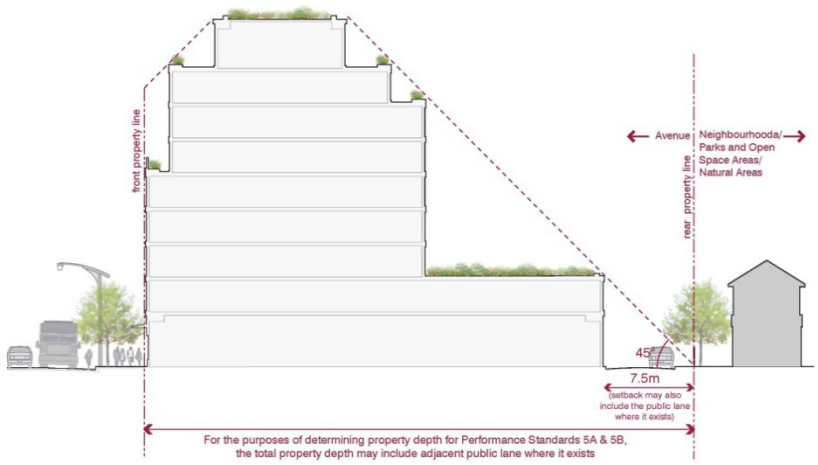


Figure 7.04

The application of mid-rise construction in existing urban neighbourhoods is designed to buffer the density of multi-unit inhabitation from low-rise residential housing. Mid-rise will also define streetscapes and Avenue's that are dedicated to neighbourhood commerce, enhancing the pedestrian condition as a component of urban lifestyle and economic development.

Planning in the City of Toronto includes mid-rise construction as a form of development to improve urban conditions[8]. The typology can achieve increased inhabitant density and residential intensification without dramatically changing the scale of established communities. Successful development of mid-rise is recognized to establish a strong visual relationship with neighbourhoods where the building is not viewed as an individual entity but a nested component of the built environment. Mid-rise for urban intensification is constructed with mixed-use designations including retail, office, and residential space. The mid-rise floor plate allowed for varying floor-to-floor residential unit sizes, accommodating tenants of varying economic classes and family sizes.

Building integration into the environment is an important performance component of sustainable water harvesting. Smaller accommodations in mid-rise inhabitation reduce the impact of domestic living on the urban ecosystem. Landscape preservation as a result of smaller mid-rise building scale maintains land permeability as a component of the urban water cycle[9]. Mid-rise stormwater management can also be implemented where landscape areas can absorb on-site precipitation, thereby preventing mid-rise construction from contributing to the issue of urban stormwater runoff.

7.1.2 Economic Sustainability of Mid-rise

Sustainability must also include the economic feasibility of mid-rise construction. Marketing mid-rise residential units offers the same level space and comfort as prescribed by high-rise developers for premium penthouse units in high-rise condominiums. Selling mid-rise means selling the neighbourhood and not just the building, reducing the need to attract clientele with the leisure and luxury benefits offered by high-rise condominiums.

The sustainable performance of mid-rise has substantial economic savings to the typologies operational cost. Toronto's multi-unit inhabitants demand less water for irrigation and landscape management per household when compared to low-rise inhabitants[10]. Water provisions are less expensive to deploy as mid-rise building height does not require additional mechanical pumps and a multi-tiered system. Multi-unit residential construction provides a reduced number of toilets per household and this also contributes to improvements in domestic potable water performance, reducing the amount of water required for waste conveyance.



Figure 7.05

The rendering that has been attached is a visual representation of the cultural and social attributes that are being sold as an active component of the City of Toronto Waterfront Revitalization. The idea of living amongst the environment is just as significant as the physical construction of the residential space.

The sustainable performance of mid-rise domestic typology will also yield economic benefits during the development phase. Mid-rise that is able to achieve sustainable building performance as prescribed by Toronto Green Standard are eligible for waved/fully refunded development charges[11]. This is a significant cost savings to developers in light of new increases to multi-unit and retail development charges (2012).

Mid-rise domestic typology constructed as apartments rather than condominiums avoid the corporate condominium structure that absorbs the cost of inhabitant water utilities and in return, charges building tenants with a dedicated condominium fee. The fee structure reflects the same fixed rate billing conditions that hid the value of water in Toronto's water utility. When inhabitants are made aware of the cost of their water provisioning and their volume of water demand, the exposure to resource use will instil value for urban water resources.

7.2 NPW Mid-rise Pilot Project

The Net Positive Water Mid-Rise Pilot Project is intended to showcase the application of The Net Positive Water Guidelines and Standards, fulfilling Net Zero Water sustainable urban water use. The project will showcase water independent domestic intensification to generate Net Positive water quality and urban water renewal as a means to combat the urban water crisis. The pilot project is situated in Toronto's redeveloping Port Lands – The Lower Don Lands development.

The project displays the application of the Passive and Active building systems that are required to enable domestic construction to harvest, use, reuse, and restore urban water. Building design will follow urban building considerations prescribed by the City of Toronto and Waterfront Toronto for successful forms of domestic typology and urban intensification that is needed to establish a sustainable Lower Don Lands community. The Toronto and Region Conservation Authority has undergone an in-depth **Environmental Assessment** (EA) to define the environmental parameters of the development area[12].

The City of Toronto is witness to a maximum daily precipitation volume of **986 mm**[13], with a total volume of 986L per m^3/34.85L per ft^3. During the winter season where precipitation falls as snow, the City of Toronto witnesses a maximum of **399 mm of snow** per annum, with a total volume of 399L per m^3/3.8L per ft^3 of water. The water content in snow is evaluated at a ratio of 10:1, whereby 1 inch of water equates to 10 inches of snow. The City of Toronto specifies building standards for 100-year storm event, where NPW **Stormwater Management**[14] is required to absorb and drain **112.72 mm of rainfall in a 10 minute time step** based on a 24 hour Storm event / Chicago Distribution[15].

Water harvesting calculations will be based upon a total NPW site area of 7970m^2 **(**Site Plan Fig. 7.16 Pg. 157-58**)**, where the total volume of annual **Available Water Resources**[16] that falls upon the NPW management area accounts to **7,839,665 litres per annum**.

To establish net positive water provisions for annual Net Zero water inhabitant use, the calculated NPW management area is able of supporting **307 inhabitants** at a daily water demand of **70 LPCD**. Based on City of Toronto's statistics on the average number of inhabitants per multi-unit household, the mid-rise pilot project will accommodate **123 residential units** at a calculated average of 2.5 peoples per unit[17]. To achieve adequate urban intensification and basic spatial requirements as prescribed by Waterfront Toronto[18], the mid-rise pilot project achieves a **3.5 times land use density.**

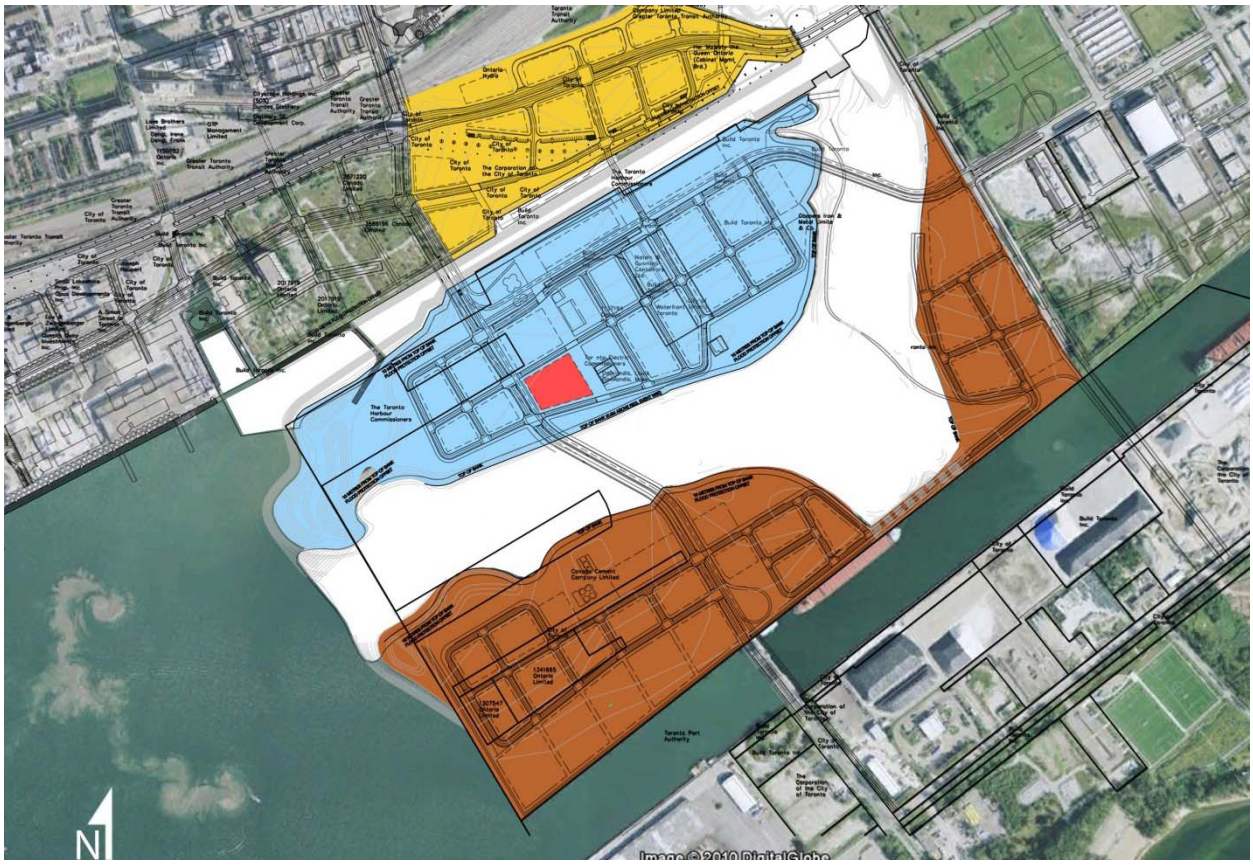


Figure 7.06

This Master Plan displays the five districts of the future Lower Don Lands development. The NPW mid-rise pilot project is situated in the centralized island, highlighted in RED.

Drawing Scale

1:2000

7.2.1 NPW Site Selection

The NPW pilot project will be situated at the heart of the Lower Don Lands on the main development island south of the Keating Channel (Blue. Fig. 8.01). The decision to select this land parcel was due to the differing array of urban and environmental conditions met at each face of the site varying from flood plain and wetland shorelines, to waterfront streetscapes, and public transportation infrastructure[19]. Project site selection will describe the environmental conditions on the site area in the South, East, North and West.

SOUTH

The Southern conditions of the NPW site face the shoreline of the restored Don River Mouth Wetlands. A Streetscape and roadway condition buffers between the site and the wetlands to establish a naturalized waterfront condition. **NPW Dirty On-site** management will mitigate stormwater runoff into southern streetscape conditions. The pilot project is protected by the designated wetlands **Floodplain boundary** prescribed in the Lower Don Lands master plan[20].

EAST

Land parcels prescribed by Waterfront Toronto and the MVVA Master Plan[21] outline a North-South oriented land parcel adjacent to the selected NPW site (Yellow. Figure 7.07). This thesis prescribes an assumption that the associated land will become public park space known as a Parkette[22]. Site frontage facing the Parkette will focus on pedestrian engagement and landscape integration under NPW Clean On-site Water Management.

NORTH & WEST

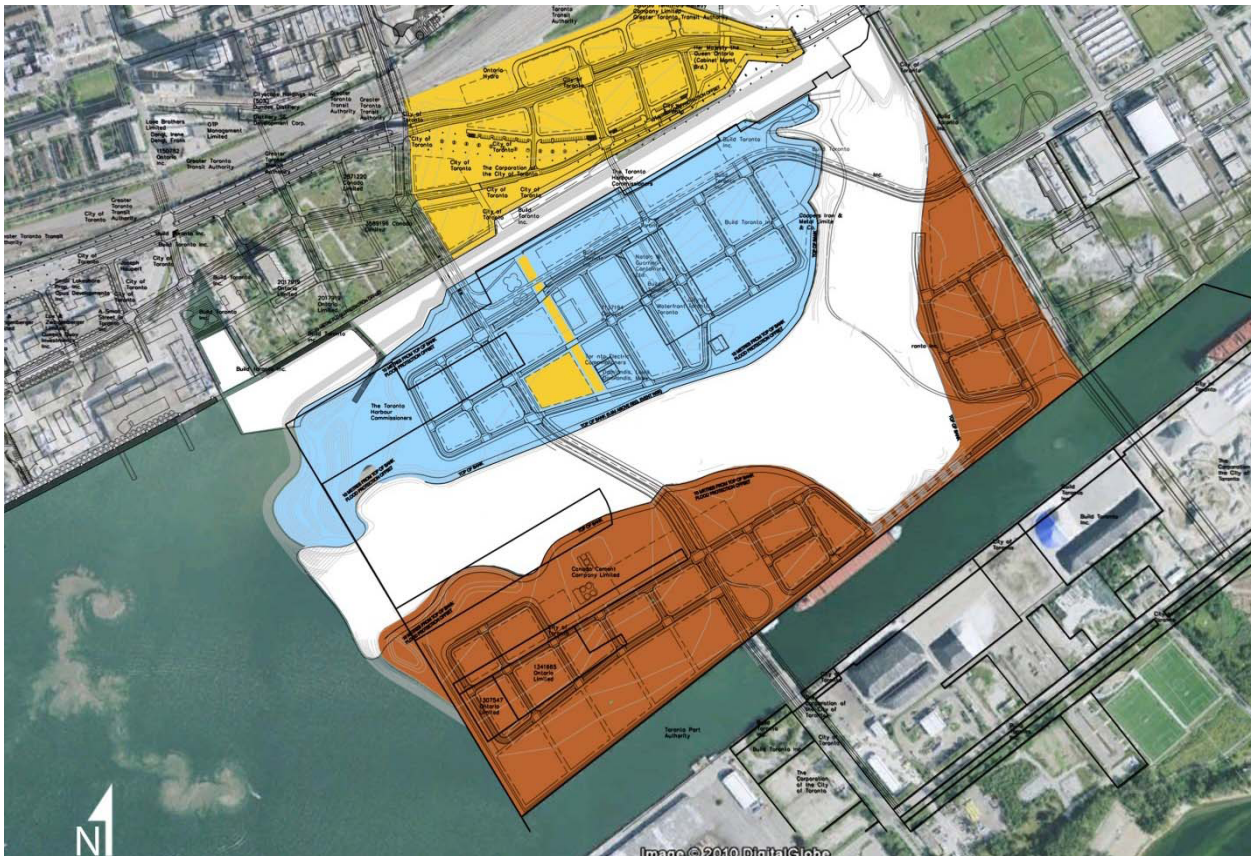
Urban streetscape conditions to the North and the West of the NPW site designate building scale under NPW Dirty On-site management following the sustainable building prescriptions and construction guidelines of the Tall Building Downtown Project (TDBP)[23] and the Municipal Green Building Requirement (MGBR)[24]. The recognized guidelines intend to establish successful streetscape engagement and building podium requirements reflecting the City of Toronto's prescription for healthy urban development. The guidelines encourage Mid-rise project development and low-rise podium building scale as a means to establish sustainable waterfront streetscapes.

Figure 7.07

Highlighted in the central neighbourhood/district is land designated by Waterfront Toronto. A North-South strip of land has been annotated and it is the position of this thesis that the land will become public park space.

Drawing Scale

N.T.S.



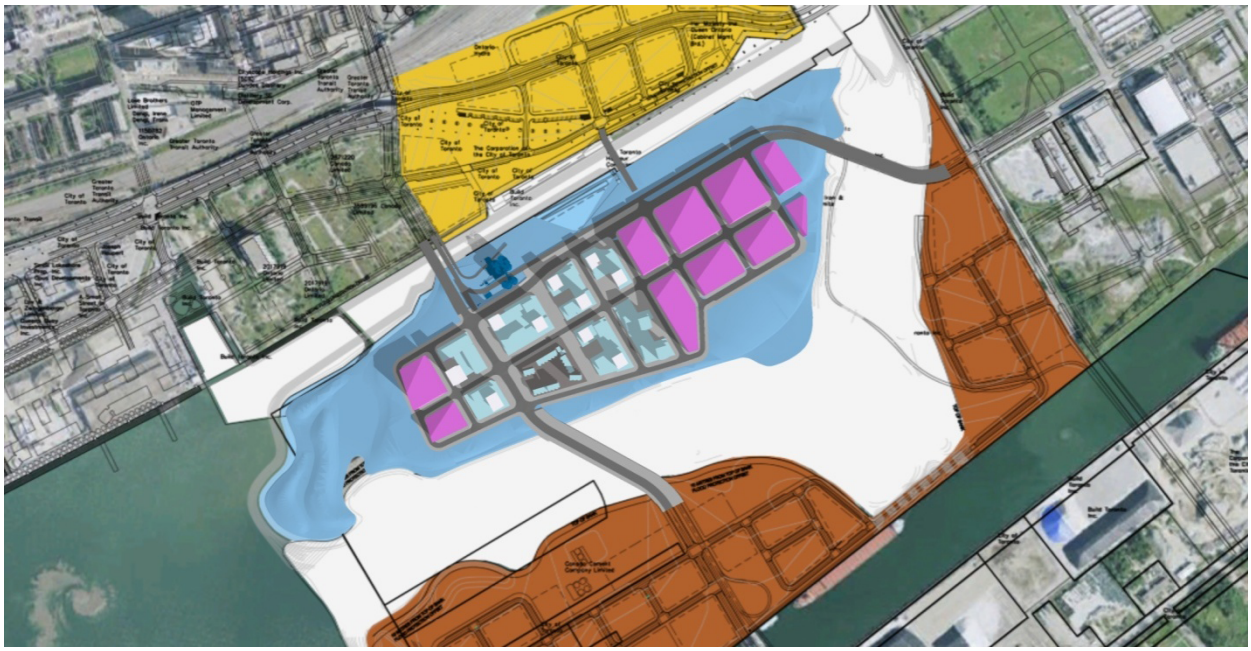
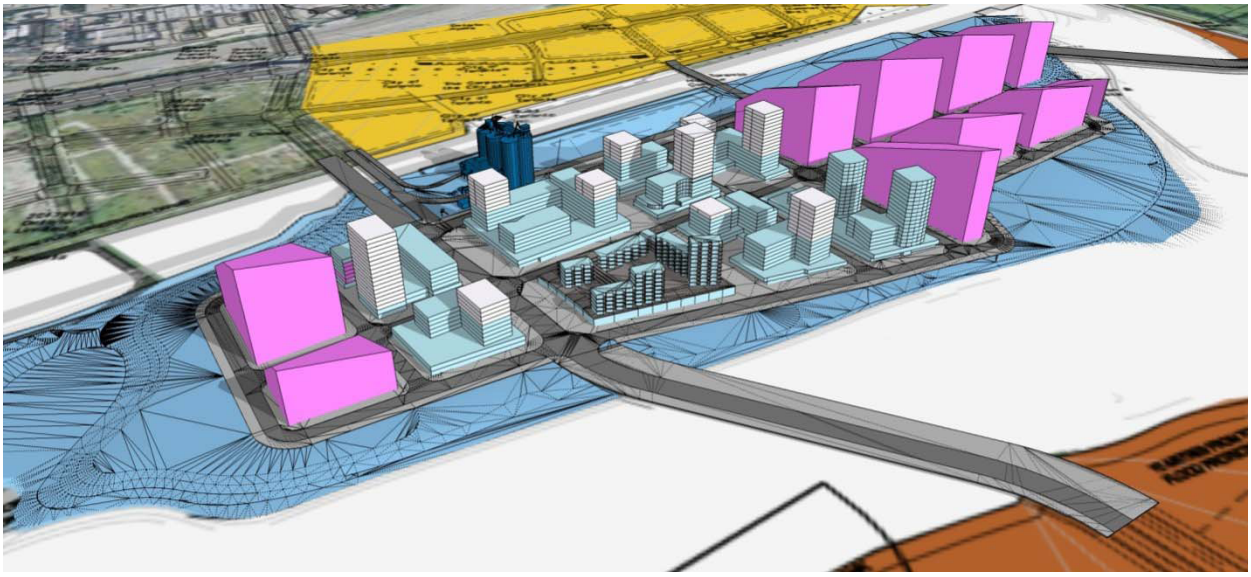


Figure 7.09 N.T.S.

The figure above is an aerial illustration displaying the negligible impact of mid-rise development solar incidence.

Figure 7.08 Aerial Perspective from the South N.T.S.

The figure below illustrates a mid-rise massing of the centralized LDL neighbourhood/district. The volumetric masses in PINK prescribe the maximum building size before a structure inflicts significant shadow on affiliated neighbouring structures to the North. The volumes are also shaped to allow for optimal solar incidence. An approximate massing of the NPW pilot project is displayed in the centre of the image. All of the massing in BLUE and WHITE have a range of 6-12 storeys in height, with varying podium heights of 1 to 2 storey.



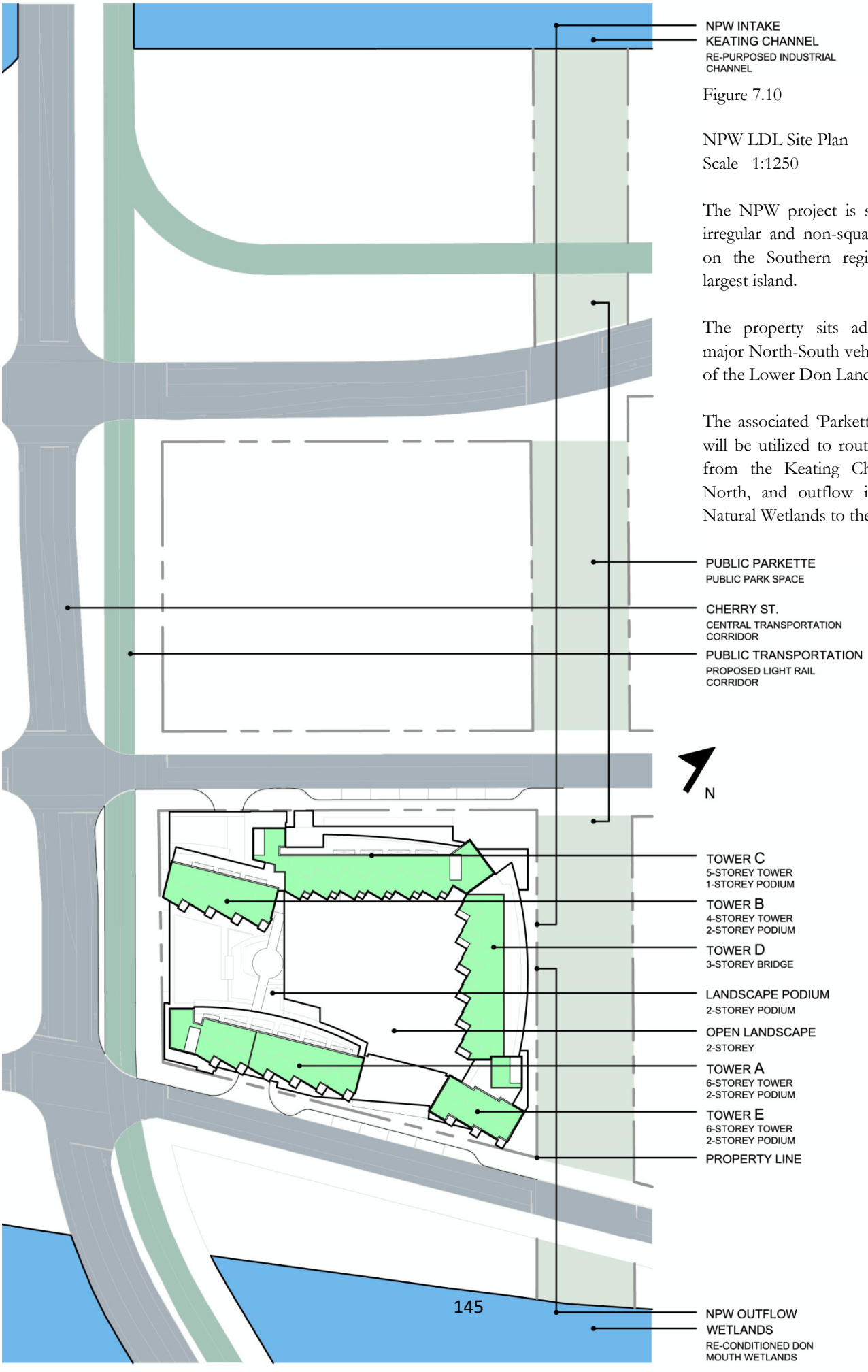


Figure 7.10

NPW LDL Site Plan
Scale 1:1250

The NPW project is situated on an irregular and non-square land parcel on the Southern region of LDL's largest island.

The property sits adjacent to the major North-South vehicular corridor of the Lower Don Lands to the West.

The associated 'Parkette' to the East will be utilized to route water intake from the Keating Channel to the North, and outflow into the LDL Natural Wetlands to the South.

7.2.2 Site Remediation & Restoration

The NPW pilot project is situated in a region where natural groundwater flow has been diminished by industrial construction and impervious paving. The Port Lands region was established by land reclamation where new waterfront land was created with soil and infill materials[25]. Prior industrial land usage has resulted in land contamination and the NPW project has been designated as a Brownfield site by the Lower Don Lands EA. Contaminated landscape composition and degraded environmental conditions remove the site as a contributor of the regional water cycle.

Figure 7.11

Waterfront Toronto's Pilot Soil Recycling Plant located south of the proposed Lower Don Lands Development.

The plant is a solution to remove the volume of soil that is transported on and off site, thereby minimizing the environmental footprint of LDL development as well as producing soil content following prescribed specifications as required for LDL landscape revitalization.



NPW mid-rise will utilize Waterfront Toronto revitalization efforts to the benefit of the NPW construction. Waterfront Toronto has developed a pilot project for Soil Recycling, whereby Toronto Port Lands soil is recycled to remove onsite contaminants and toxins[26]. The prototype facility restores soil content to specified quality levels, thereby allowing native soils to remain on-site rather than removing and replacing soil content from another site. The soil recycling pilot project can facilitate the soil quality and soil demands required for NPW pre-requisite **Brownfield Land Remediation[27],** removing all of the debris that remains from the **Previously Developed Site[28]**.

Figure 7.12

The figure above shows the outcome of Waterfront Toronto soil recycling facilities where contaminated soil content is removed. Development on the Lower Don Lands requires substantial municipal investment to remove the threats of urban contamination, in addition to the threat of 100-year flood levels.



When development land is removed from Floodplain conditions, regional soils will continue to be subject to high water table and high groundwater levels as a result of waterfront geographic characteristics. The project site is subject to a High Water Table with high groundwater levels, where the project will be required to fulfill NPW On-site Pre-requisite of Replacement to restore the hydraulic function of the land as a component of the urban water cycle.

To rectify hydrology issues that may threaten the foundation of LDL buildings, a landscape process prescribed as Wicking[29] is utilized whereby soil replacement is allowed to settle at an advanced rate. Wicking achieves soil sedimentation and compaction by utilizing an extensive grid or network of boreholes to induce capillary action[30]. Groundwater is allowed to evaporate out of the soil, thereby removing the threat of unexpected soil subsidence that may threaten LDL construction.



Figure 7.13

The wicking process ventilates substrate soils to accelerate the settling of on-site soils. The wicking process leaves residual holes in the ground.

The NPW pilot project will specify Silt-Loam grade soil content to replace Brownfield remediated land. Agriculture Canada specifies Silt-Loam soil as quality as a native soil type to Southern Ontario[31]. Silt-loam soil provides optimal water absorption capabilities at approximately 20 percent of a fixed soil volume. Silt-Loam soil quality will be utilized on all NPW pilot project soil content inclusive of below-grade soil replacement in NPW On-site and Building management.

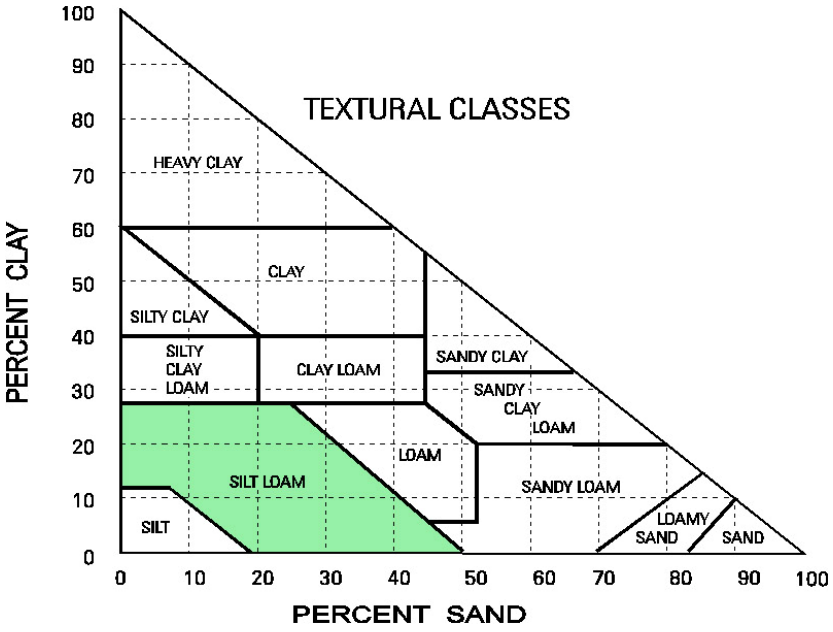


Figure 7.14

The diagram displays the varying soil type mixtures and their material composition. Toronto has a native soil content of SILT LOAM type soils in the Don subwatershed.

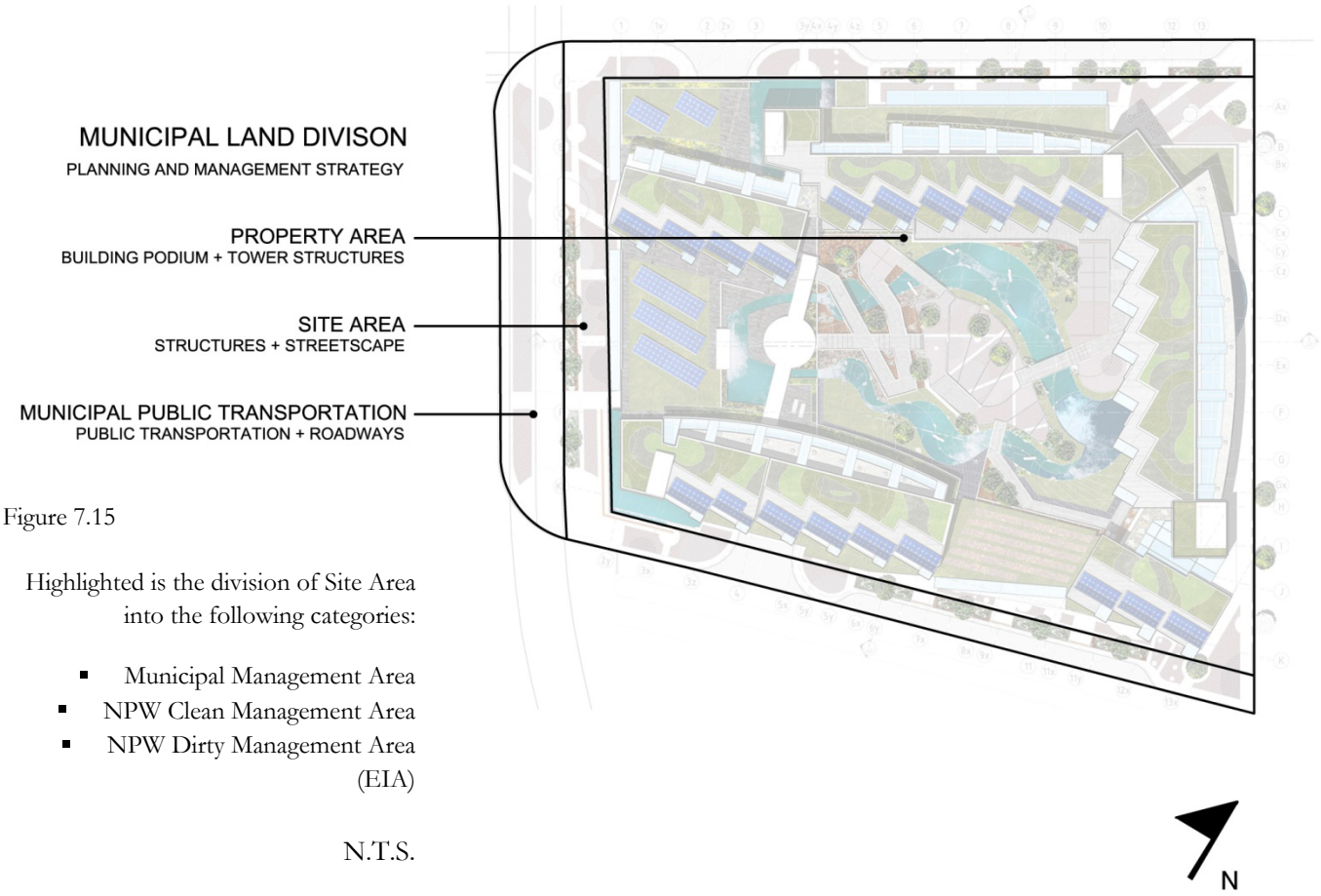
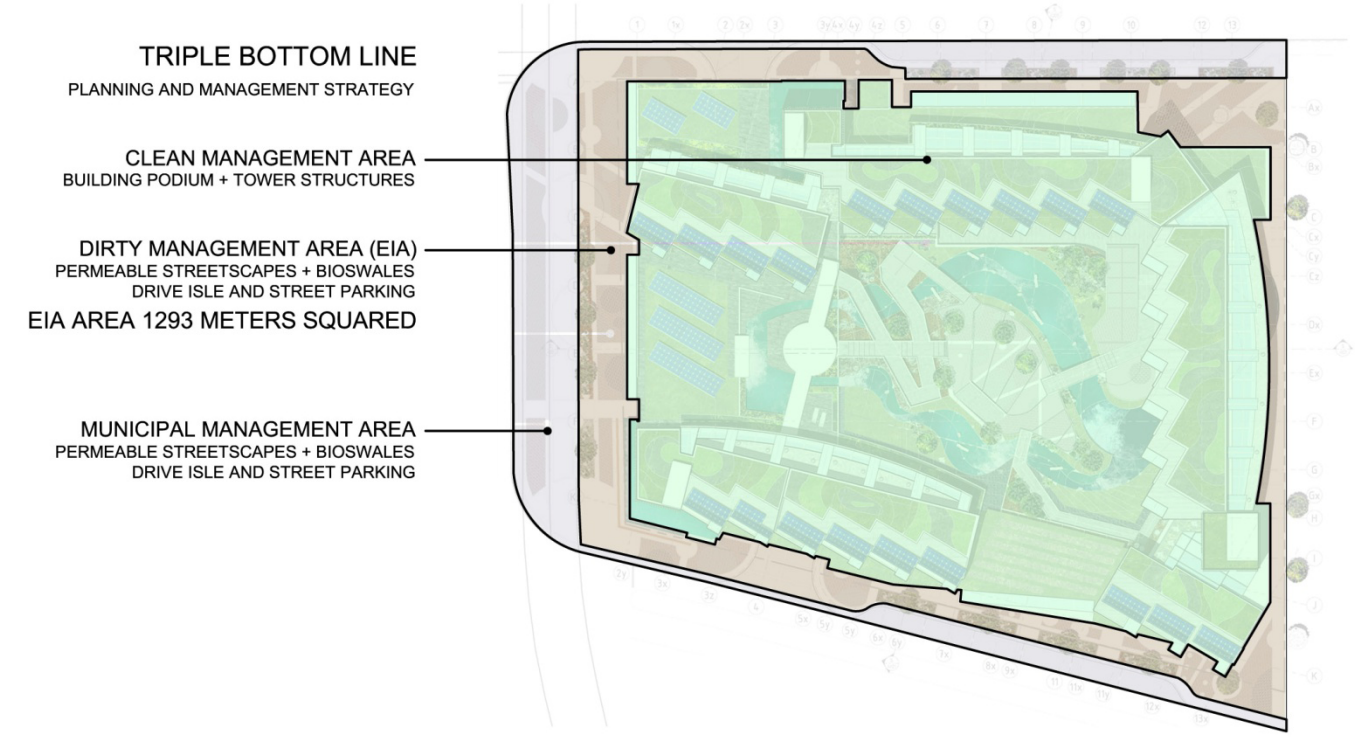


Figure 7.15

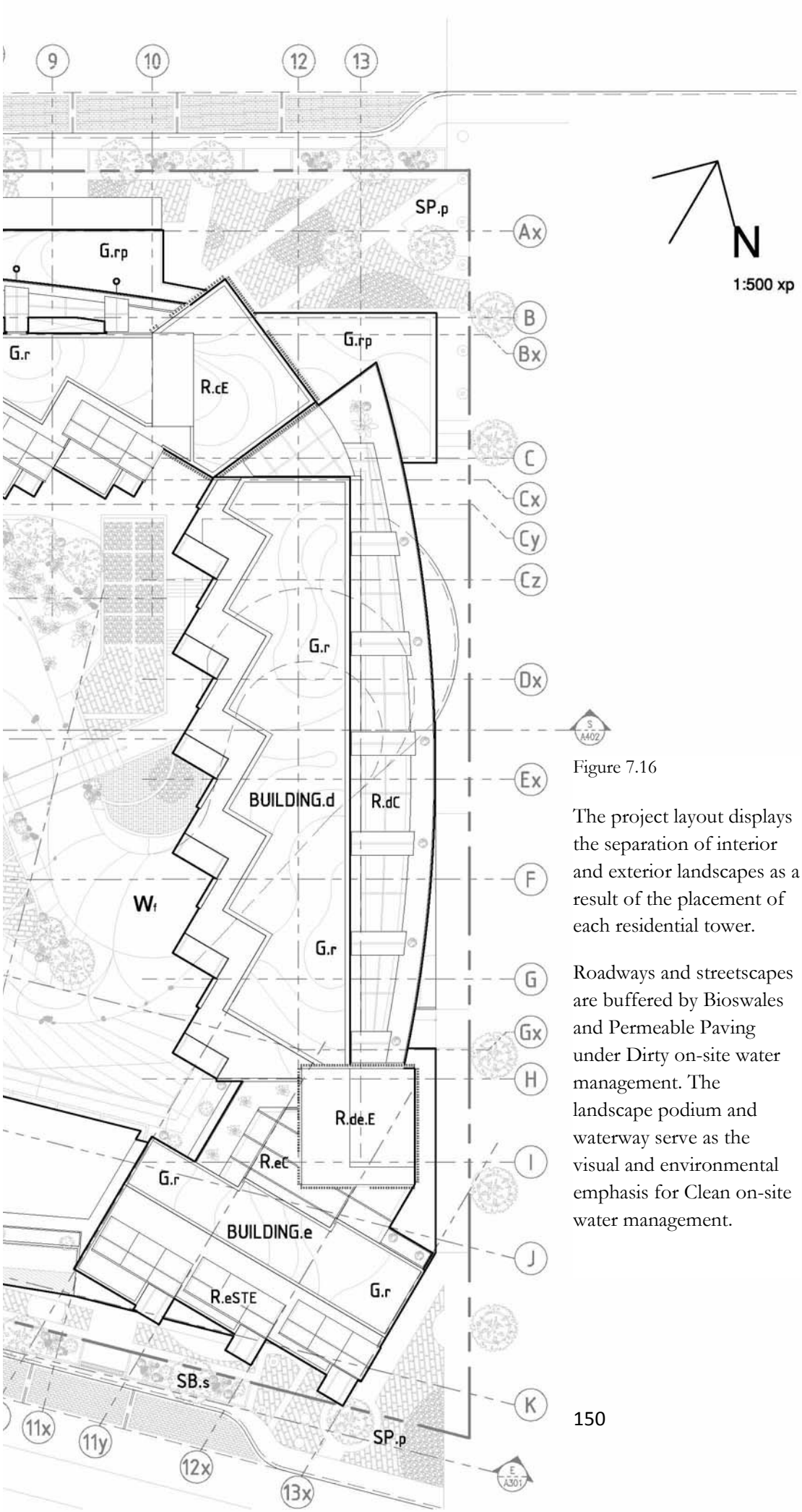
Highlighted is the division of Site Area into the following categories:

- Municipal Management Area
- NPW Clean Management Area
- NPW Dirty Management Area (EIA)

N.T.S.




1
1x
2
2x
3
3y
4x
4y
4z
5
6
7
8
MMA
A
B
C
D
E
F
Kx
SP.p
SB.s
W
G.rp
S.pv
R.bE
R.cC
R.bC
G.r
BUILDING.c
BUILDING.b
R.cSTE
R.bSTE
Wr
Wf
LANDSCAPE.p
LANDSCAPE.w
P.p
N.v
R.aC
R.aE
BUILDING.a
R.aSTE
2y
3x
3z
4
5x
5y
6x
6y
7x
8x
9x
11



N

1:500 xp

SITE PLAN A.200
PARCEL No.9 LDL

BUILDING.a
R.aC GLASS CANOPY-BLDG.a
R.aE ELEVATOR-BLDG.a
R.aSTE SOLAR THERMAL ARRAY-BLDG.a
N.unit Number of Residential Units
36

BUILDING.b
R.bC GLASS CANOPY-BLDG.b
R.bE ELEVATOR-BLDG.b
R.bSTE SOLAR THERMAL ARRAY-BLDG.b
N.unit Number of Residential Units
16

BUILDING.c
R.cC GLASS CANOPY-BLDG.c
R.cE ELEVATOR-BLDG.c
R.cSTE SOLAR THERMAL ARRAY-BLDG.c
N.unit Number of Residential Units
35

BUILDING.d
R.dC CANOPY-BLDG.d
R.de.E ELEVATOR-BLDG.d
N.unit Number of Residential Units
18

BUILDING.e
R.eC CANOPY-BLDG.d
R.de.E ELEVATOR-BLDG.d
R.eSTE SOLAR THERMAL ARRAY-BLDG.c
N.unit Number of Residential Units
18

LANDSCAPE.p
W.f WATER FEATURE

LANDSCAPE.w
W.f WATER FEATURE
W.r WATERWAY

G.r GREEN ROOF SYSTEM
G.rp GREEN ROOF SYSTEM podium
MMA MUNICIPAL MANAGEMENT AREA
N.v NATIVE VEGETATION
P.p PERMEABLE PAVING SOLUTIONS
SB.s STREETSCAPE BIOSWALE
SP.p STREETSCAPE PERMEABLE PAVING
S.pv PHOTOVOLTAIC PANELS

PROPERTY LINE
FLOOR ABOVE
WATER FEED & RETURN LINE
CANOPY ABOVE
FLOOR BELOW
GRID

Figure 7.16

The project layout displays the separation of interior and exterior landscapes as a result of the placement of each residential tower.

Roadways and streetscapes are buffered by Bioswales and Permeable Paving under Dirty on-site water management. The landscape podium and waterway serve as the visual and environmental emphasis for Clean on-site water management.

7.2.3 Passive Building Form & Program

The NPW pilot project will be constructed to optimize mid-rise residential typology with maximum water harvesting capabilities. To achieve the greatest potential for Water harvesting following the '**Building as a Sponge'** prescription, the pilot project is designed with **100% Property Area Coverage**. The design of the project will maximize the area of Clean Water On-site management to improve the Passive water filtration and treatment processes of On-site Passive water storage while mitigating the impact of Dirty Water On-site conditions. Greater Clean Water On-site area will reduce the volume of water resources diverted to Active water treatment processes required by **NPW IWT** standards.

7.2.4 Building Design

The NPW mid-rise is designed as a four tower structure interconnected by circulation pathways. The height of the towers ranges from 9 to 6 storeys, with the taller towers located to the South of the site (Tower A. Fig. 7.17) to mitigate the solar impact of the project on neighbouring properties. The towers are more slender than conventional double-loaded[32] corridor construction as a result of a Passive design, integrating a single-loaded[33] floor plate configuration. The change in building form increases the Passive Survivability of the project.

Mid-rise residential towers are situated above the podium and set back from streetscape conditions to mitigate the environmental impact of increased building height[34].

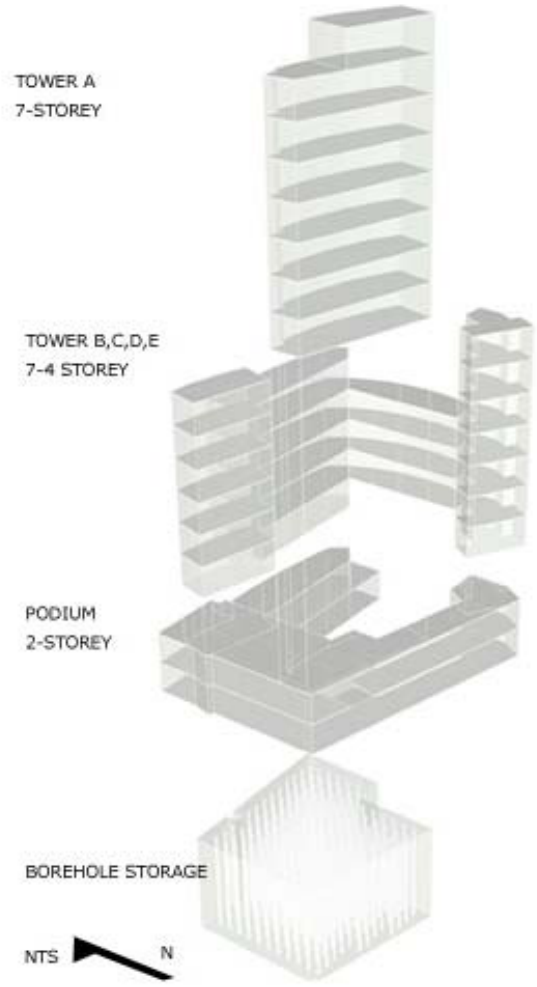


Figure 7.17

This is an exploded isometric diagram of the NPW pilot project. The Towers are designed to mitigate the environmental impact of vertical inhabitation from one mass to the other. The Podium establishes a clear boundary between interior landscape and exterior streetscape conditions at grade. The subterranean Borehole system is displayed to identify how much volume is required to provide water resources to inhabitants above.

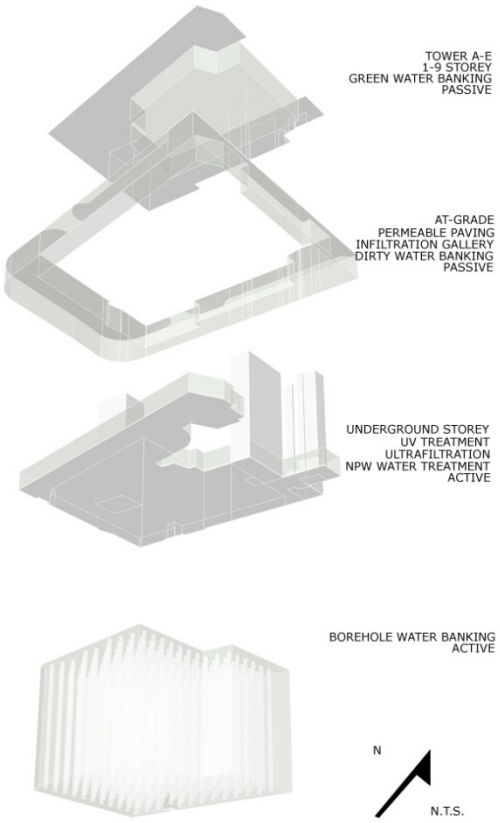


Figure 7.18

Much of the physical scale of the NPW pilot project is situated below-grade. This isometric diagram displays the subterranean components of the NPW pilot project. The idea is to allow harvested precipitation above to trickle down via gravity/percolation and into the building systems, where Clean and Dirty Water management isolates the resource.

Residential units have a North-South orientation, aligned in a longitudinal manor from East to West. The towers are arranged in two primary masses situated to the North of the site and to the South. A third mass of residential units is situated to the East of the property and connects the North-South masses in the form of a 3-storey bridge. The resulting shape of the tower structures from a Plan perspective is similar to a 'Ↄ' shape.

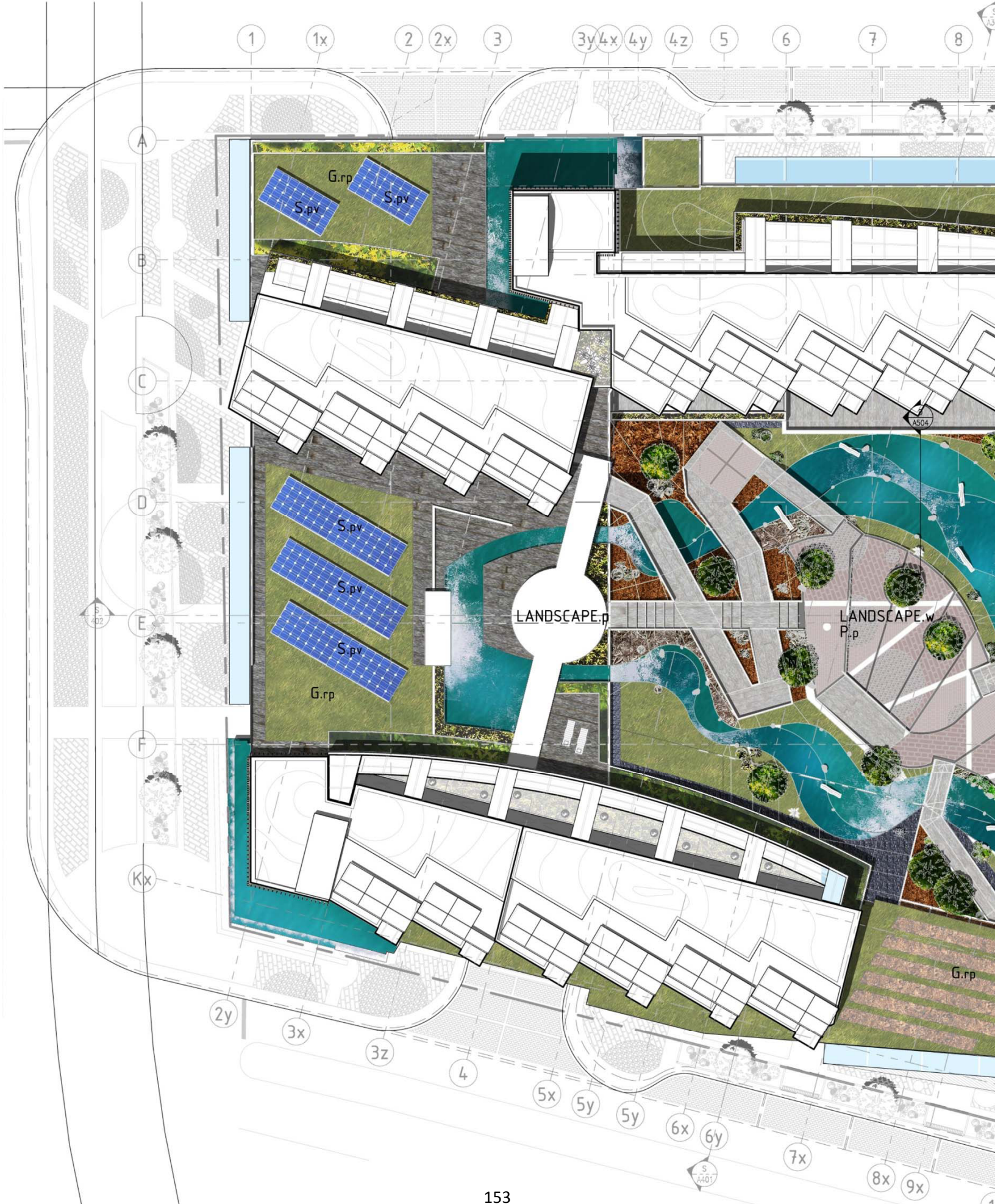
The Southern façade of each residential tower is designed following a 'Saw-tooth'[35] prescription to provide multiple axis of view for inhabitants in addition to exterior orientation to regional predominant winds.

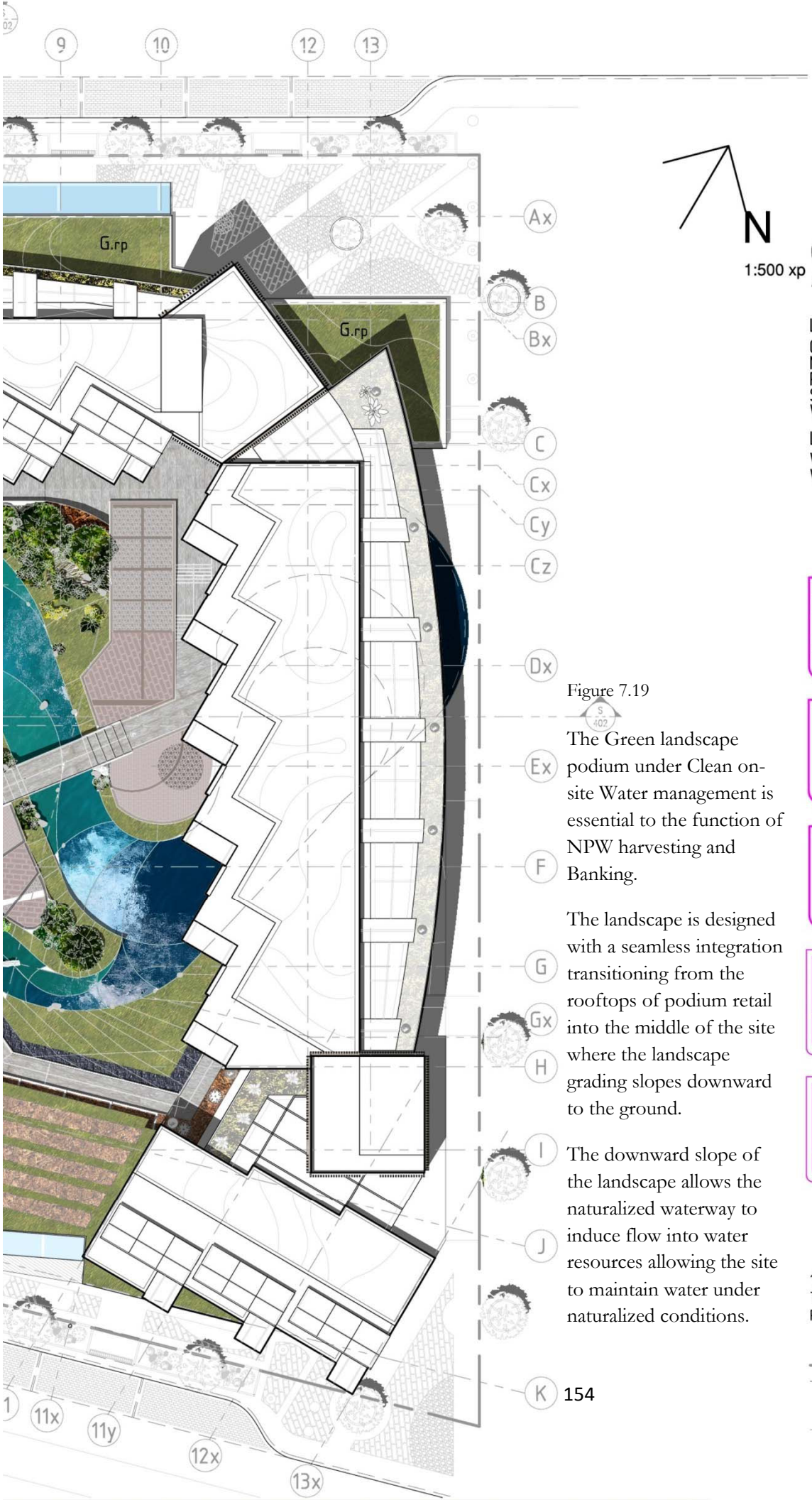
The above grade construction of the building podium is designed as a mirror of the residential towers above in the shape of a 'C'. The form provides retail and building frontage to all streetscape and roadway conditions of the site on the North, West, and South. The building podium also serves as a contiguous physical barrier between Dirty Water exterior streetscape conditions and Clean Water On-site area.

At the centre of the site is a dedicated landscape podium traversing 3-storey in height with a West-to-East orientation, where a centralized waterway meanders downward towards what is assumed as a public Parkette. The meandering water pathway is designed to mimic the natural path of river systems as they collect nutrients from sediment and cleanse water resources. Affiliated with the waterway is a sediment pond located beneath the residential bridge structure to the East of the site, where a centralized water treatment utility protrudes from beneath the podium structure and into the landscape.

An impervious subterranean level has been designated for visitor and resident parking. The subterranean level contains additional building storage spaces and locker rooms, with the bulk of building utilities situated between the Parking Level and Ground Floor (Fig. 8.13). A gated transportation pathway is provided to internalize vehicular access within the podium structure with additional loading requirements for residents and retail tenants.

A minimum number of parking spaces have been provided, while emphasis has been provided for auto share and alternative means of transportation. Bicycle storage is situated on the Ground Floor to provide easier access and additional emphasis for utilizing non-polluting means of transportation.


1
1x
2
2x
3
3y
4x
4y
4z
5
6
7
8
A
B
C
D
E
F
Kx
G.rp
S.pv
S.pv
S.pv
S.pv
S.pv
G.rp
LANDSCAPE.p
LANDSCAPE.w
P.p
P
A504
G.rp
2y
3x
3z
4
5x
5y
5y
6x
6y
7x
8x
9x
S
A401



N

1:500 xp

Green Podium Coverage
A102

LANDSCAPE.podium

G.rp	GREEN ROOF SYSTEM podium
N.v	NATIVE VEGETATION
P.p	PERMEABLE PAVING SOLUTIONS
S.pv	PHOTOVOLTAIC PANELS
W.f	WATER FEATURE

LANDSCAPE.waterway

W.f	WATER FEATURE
W.r	WATERWAY



Figure 7.19

The Green landscape podium under Clean on-site Water management is essential to the function of NPW harvesting and Banking.

The landscape is designed with a seamless integration transitioning from the rooftops of podium retail into the middle of the site where the landscape grading slopes downward to the ground.

The downward slope of the landscape allows the naturalized waterway to induce flow into water resources allowing the site to maintain water under naturalized conditions.

100% Clean Water Management
70% NPW Permeable Podium Coverage
REFER THESIS CALCULATIONS

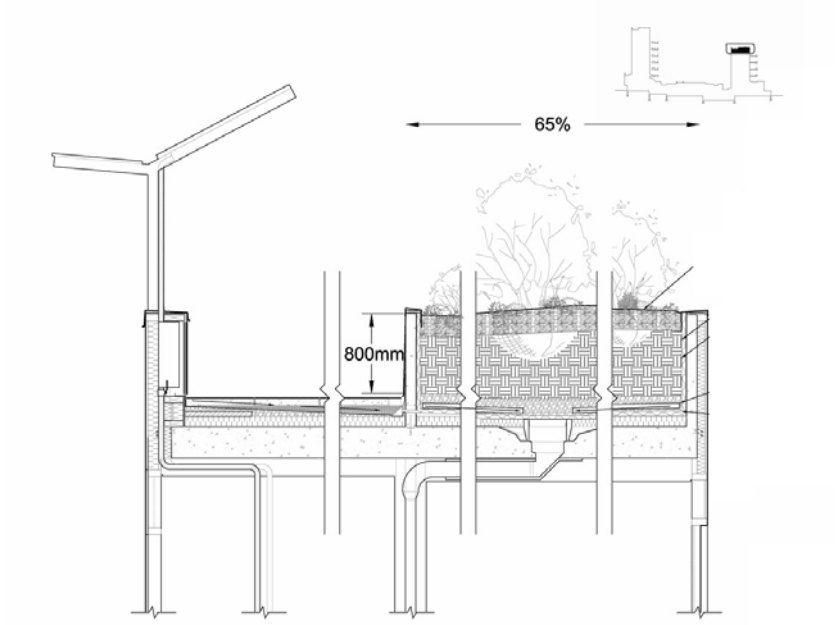
PROPERTY LINE
FLOOR ABOVE
WATER FEED & RETURN LINE
CANOPY ABOVE
GRID

7.2.5 NPW pilot project Clean Water Building Performance

Clean Water Building performance requires the pilot project to harvest and store annual precipitation and snow. All Passive water storage devices will feature a multi-tiered design arrangement, where soil content and substrate materials are separated by Geotextile fabrics[36]. The filter fabrics are deployed in layers, where solid debris is trapped as stored water content travels throughout the storage soil medium. The fabrics are required to ensure Passive water filtration occurs as harvested water is stored.

Green Roof Coverage

The mid-rise MURB pilot project applies Silt-Loam Type soil storage on residential tower Rooftops. Permeable Green Roof coverage will allow precipitation to permeate through a consistent depth of 850mm of soil medium. **The mid-rise pilot project accommodates a 65% Green Roof area** following the NPW Guideline prescription (minimum coverage %).



The Green roof supports drought resistant plantings and native plant species[37]. The water absorption capability of the selected Silt-loam soil content achieves 20% absorption. Water overflow into non-green roof surfaces will be allowed to trickle back towards supporting planter and soil conditions. This requires a re-evaluation for roof-top drainage design that will focus water drainage toward soil mediums.

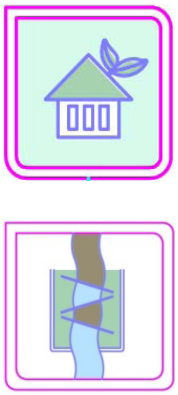


Figure 7.20

The filtrating mechanism of deployed soil planters is enforced through the use of Geotextile fabrics and filter membranes. The membranes are specified to halt the flow of particulate materials to eliminate opportunities for soil erosion.

When soil-based water storage has reached its maximum absorption capability of the specified **20% absorption to volume ratio**, excess water medium is drained into Interior Clean Water Building Management. Harvested water medium from Green Roof collectors will be diverted into the NPW water cycle where it is directed towards Active building functions such as the Capillary Mat systems and Borehole Thermal Transient Systems.

Planter Boxes

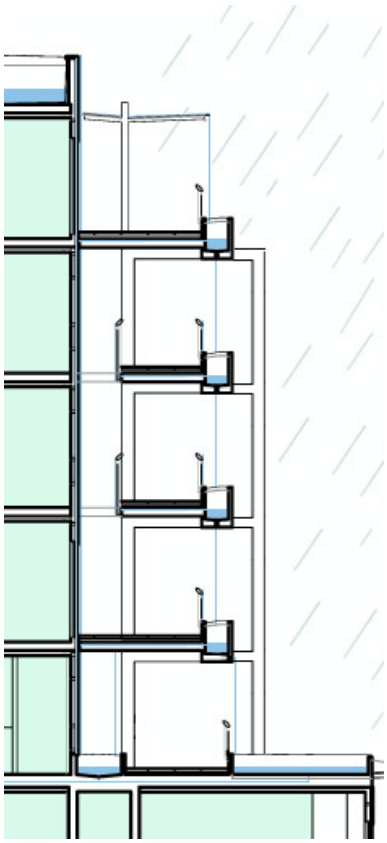
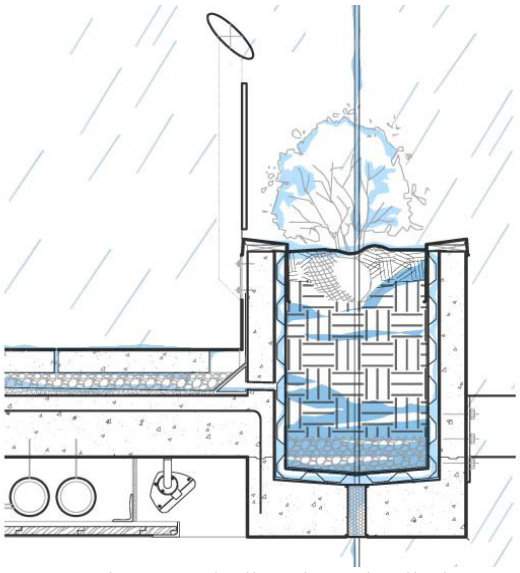


Figure 7.21-22

VPS utilizes each, individual floor of a structure as an independent and interconnected opportunity to capture on-site water resources. The slow percolation of water resources is intended to reduce the rate of water outflow as a Passive Water Banking strategy.

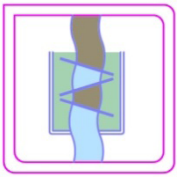
Greenwater storage is situated on each floor at open-corridor conditions. The purpose of the multi-floor engagement is to mitigate the rate of stormwater runoff that percolates down a building envelope. Storage devices mounted along terrace and circulation space will function as a component of an overall **Vertical Percolation Strategy** (VPS), where water percolates from one planter box to the next, until the water resources is drained into Interior Clean Water Building Management at the bottom of the structure, or building podium.



The building strategy places vertically oriented soil planters on each floor to fulfill the NPW Building requirement for a minimum **20% permeable coverage on open building surfaces**. Each VPS planter box will drain water resources downwards as a mechanism to slow the flow of on-site water. VPS functions as a water retention system (Sponges), holding onto water temporarily and releasing it once the maximum storage capacity has been achieved. A trickle-down gravity effect slowly percolates water from floor-to-floor. The trickle-drainage is assisted by inverted drainage pipes in the form of stainless steel cables from which Greenwater attaches itself as it navigates downwards.

The effective application of the Vertical Percolation Strategy successfully achieves a Passive storage volume that is near equivalent to Green roof systems coverage as prescribed by NPW building guidelines (90% of Green Roof storage capacity[38]). Due to the smaller scale application of balcony mounted storage, VPS will serve primarily as short term summer storage to the greatest effect. The planter boxes are designed to mitigate water loss through the use of **arborist wood chips[39]** that help retain soil moisture[40]. **Evaporative loss accounts for 10%[41] of the stored water medium.**





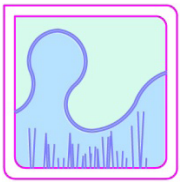
Snow or frost that is retained on VPS planter boxes shall stay situated on the system so that water is allowed to re-animate as the seasons transitions from frost conditions. This will demand construction material selections that are resilient to frost damage. VPS planter storage utilizes an **egg crate drainage & root barrier products** that is capable of expanding to accommodate frost-soil expansion. The barrier serves as a secondary drainage plane to control water resources in the event of an overflow.

NPW Green Roof coverage in addition to **VPS yields 11%** (**322,236L**) of the total Passive Water storage capability of the pilot project[42].

Mid-Rise Landscape Podium

The mid-rise landscape Podium will serve as the largest permeable Passive area for water harvesting. Following Toronto's newly prescribed Green Roof Bylaw, the mandate for landscape coverage on the building podium roof allows precipitation to permeate into soil content to continue the 'building as a sponge' strategy. Silt-Loam soil medium will once again be utilized for sustainable water harvesting. The landscaping will be constructed as a component of the building, integrating weeping tiles, infiltration cells, and stormwater drains in addition to a wide array of native and drought resistant vegetation. Vegetation will support NPW in providing environmental exposure amongst urban waterfront conditions.





The calculated performance of the mid-rise constructed podium is capable of supporting approximately 2200m^3 of designated soil content with an immediate **absorption capability of 323,491L[43]**. **The pilot project building podium achieves 63% permeable landscape coverage** following NPW building standards.

NPW mid-rise MURB shall deploy a permeable landscape podium that directs Greenwater into a naturalized waterway. The waterway functions as a multi-tiered stream that replicates the design of flood plain and channelized river conditions. The design induces flow into the water medium through gravity to mimic the natural state of the water medium in a constantly flowing stream. Water movement through the waterway will be continuous throughout the seasons which will eliminate the opportunity for frost and ice building within the system.



Figure 7.23

The pathway of the naturalized waterway is designed to induce movement and flow for on-site water resources allowing the medium to penetrate soil and gradient materials as a means to passively purify the resource. Weeping tile and substrate fabrics assist in-soil water and direct the flow into the naturalized waterway.

T

he waterway is designed in a two-tier configuration that duplicates a river floodplain. The first tier functions in conjunction with aquatic plantings to absorb potential bacteria's and small particulates that rise to the water's surface. The second tier allows heavier particulates to drop down into the lower waterway allowing the water medium to push through larger granular and sediment materials.





The waterway is designed to mimic the natural meandering path of a River delta condition, a natural phenomenon which serves as a vital component in the water cycle. As water travels throughout the waterway tiers, the Passive 'Daylighting' process will transition post consumption Greywater into renewed Bluewater quality, restoring water to a naturalized state.

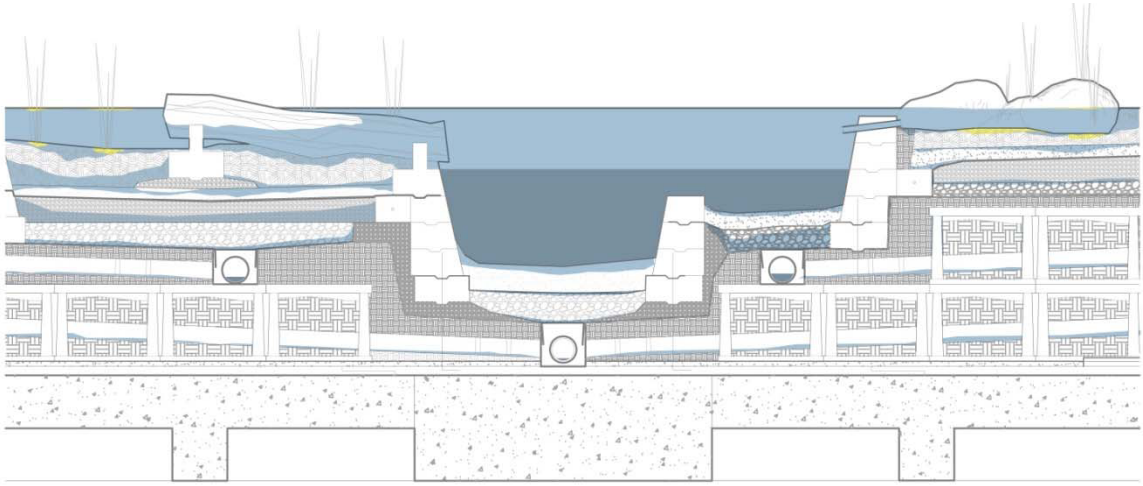


Figure 7.24

The multi-tier waterway is designed to allow water resources to penetrate into its supporting soil. The landscape design and application of selective screening and substrate materials serve to remove any and all solid physical contents from the liquid medium. The diagram above displays the water medium traversing through the multiple layers of substrate gradient. Geotextile and filter fabrics are sandwiched between each layer, trapping and isolating all waterborne additives.

The waterway establishes a micro ecosystem that replicates the urban water cycle whereby Greenwater precipitation is captured by the landscape, permeates through the soil medium and flows into the naturalized waterway as renewed Bluewater. Water is then collected from the waterway and directed into a retention pond so that the medium can be redistributed into the NPW cycle.

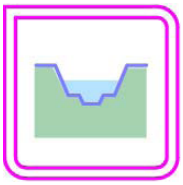
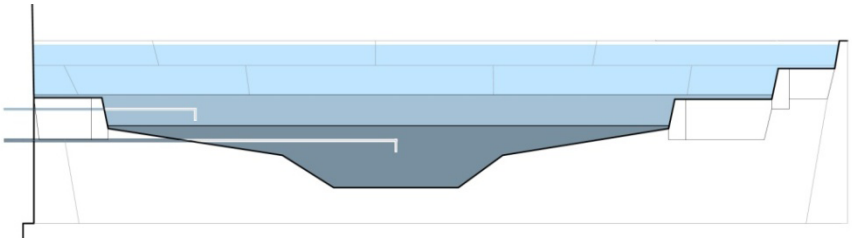


Figure 7.25

Diagram: Retention Pond
NTS

A retention pond allows remaining waterborne materials to settle to the bottom while the water medium is pumped back into the NPW building water cycle. **Bi-annual Site Servicing and Maintenance** of the pond will ensure the removal of particulates and debris from the water cycle. The retention pond is physically buffered from waterfront streetscape conditions with an emphasis on public and pedestrian association to improve water awareness.



A multi-tiered water intake withdraws water at multiple locations to continuously induce flow within the retention pond. Sediment will continue to fall to the bottom, to be removed semi-annually.

The combination of the constructed waterway and retention pond results in an **overall Water Banking volume of 1,539,700L**. The large volume ensures that on-site water resources can be maintained within Clean Water Building management. Under Passive Water Banking as designated by NPW building guidelines, the combined storage capability of the **mid-rise landscape podium and naturalized waterway accounts for 65% of the buildings Passive profile**. The podium is sufficient to storage **1,385,730L**[44] of Greenwater, a volume that can accommodate 25% of the annual precipitation that falls onto the site.

Passive Water Harvesting and Storage Performance

The **Total Clean Water Building Passive performance** of the mid-rise pilot project will harvest and store **37%** (**3,001,494L**) of the annual available water volume in the NPW Management Area. Design of the mid-rise pilot project relegates 77% of the harvested Greenwater precipitation under Clean Water On-site management conditions to preserve water quality.

The following drawings display the total Passive On-site landscape and building engagement developed for the mid-rise pilot project following NPW Building and On-site Management Guidelines.

- Clean Water On-site Vignette
- Green roof systems coverage area
- Pilot Project South Elevation
- Exterior and Interior Drainage Management Diagram
- Passive Water Storage Diagram
- Green Roof Section
- Building Envelope Section
- Building Podium Section

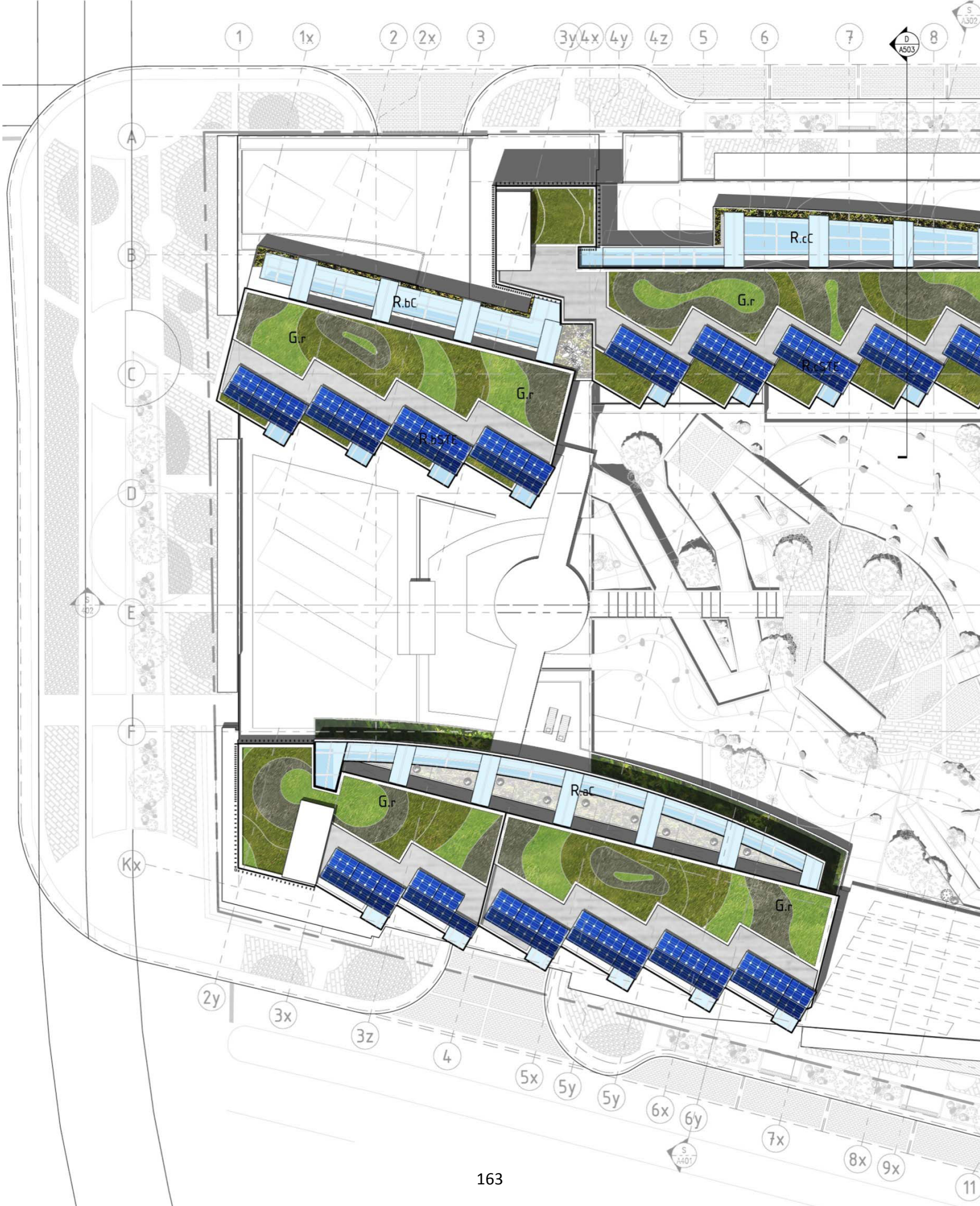


Figure 7.26

Clean Water On-site Vignette, Aerial perspective towards the Northwest.

Image taken from the roof of Tower E. Ref to Fig. 8.11 Site Plan




R.cC
G.r
R.bC
G.r
G.r
R.r5TE
R.b5TE
R.aC
G.r
G.r

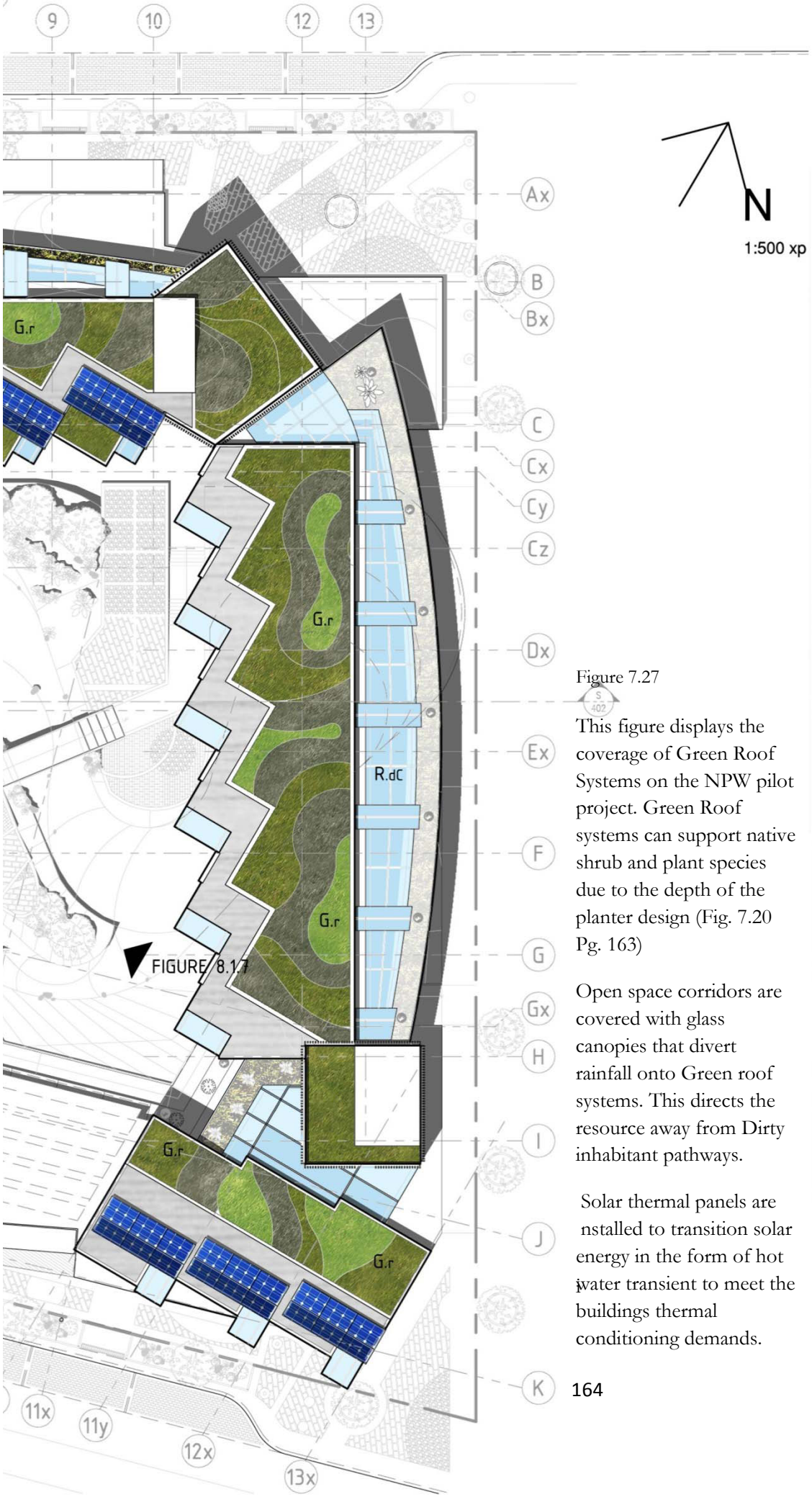


Figure 7.27

This figure displays the coverage of Green Roof Systems on the NPW pilot project. Green Roof systems can support native shrub and plant species due to the depth of the planter design (Fig. 7.20 Pg. 163)

Open space corridors are covered with glass canopies that divert rainfall onto Green roof systems. This directs the resource away from Dirty inhabitant pathways.

Solar thermal panels are nstalled to transition solar energy in the form of hot water transient to meet the buildings thermal conditioning demands.



WETLANDS-STREETSCAPE CONDITION

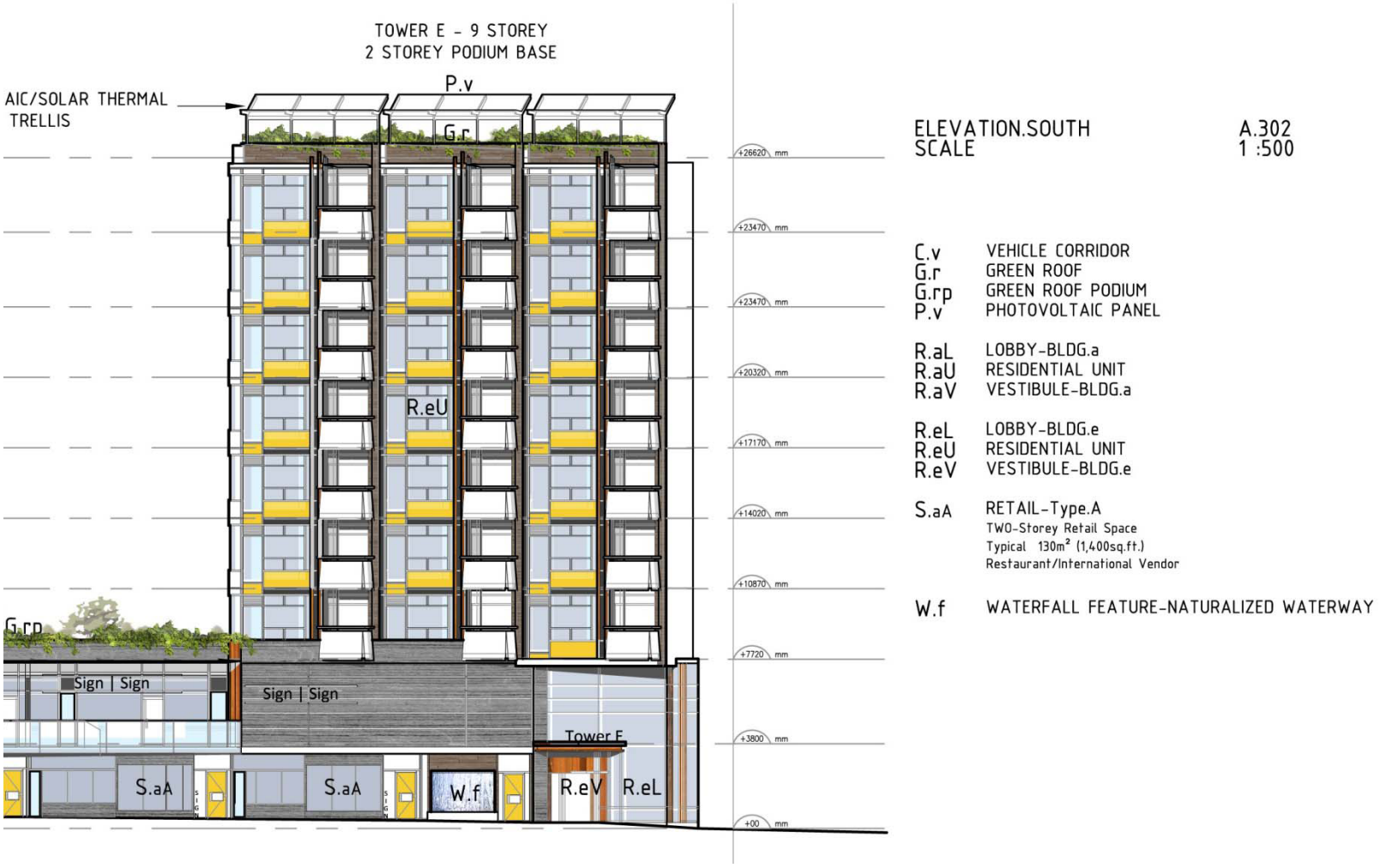
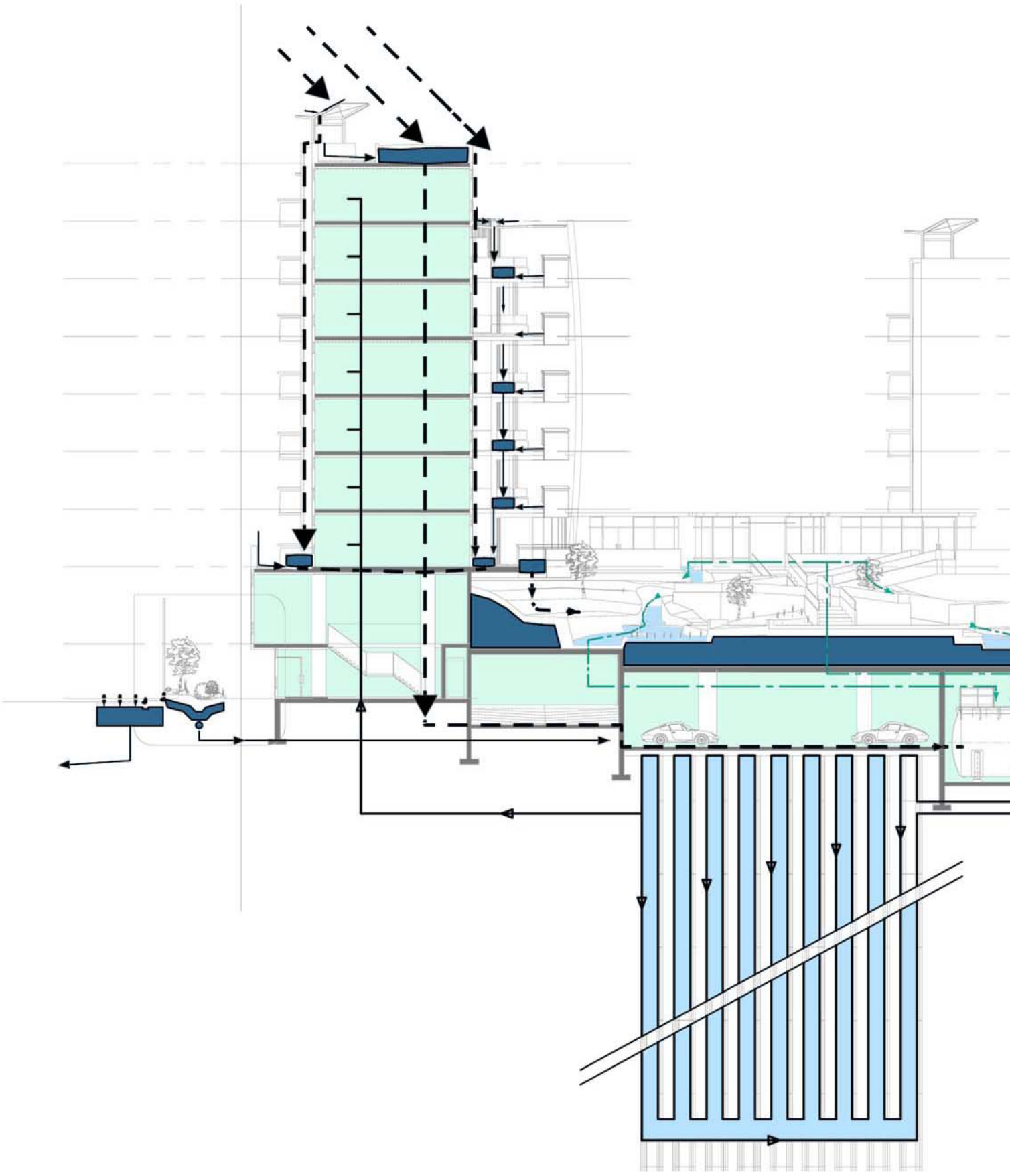


Figure 7.28

Podium elevations negotiate the economic demands of urban inhabitation with retail storefronts while residential units are elevated above. Components of the NPW cycle are made visible to encourage water use exposure. Passive and Active water use is displayed by means of the podium Water Feature, VPS, and overgrowth on Green planter systems on the buildings Green Roof podium.

Tower elevations do not bear distinctive articulation as each unit is oriented for maximum ventilation and solar gain.



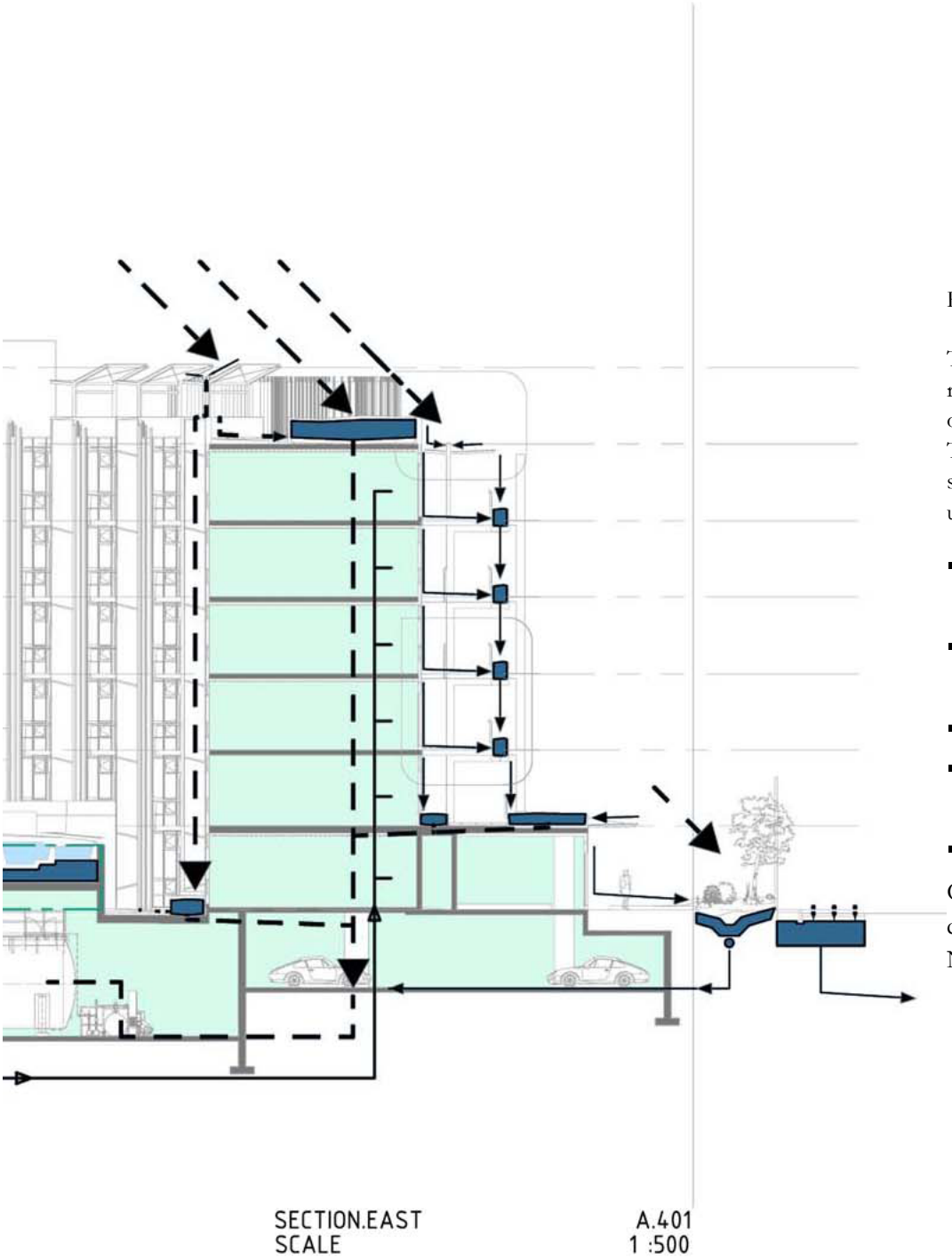
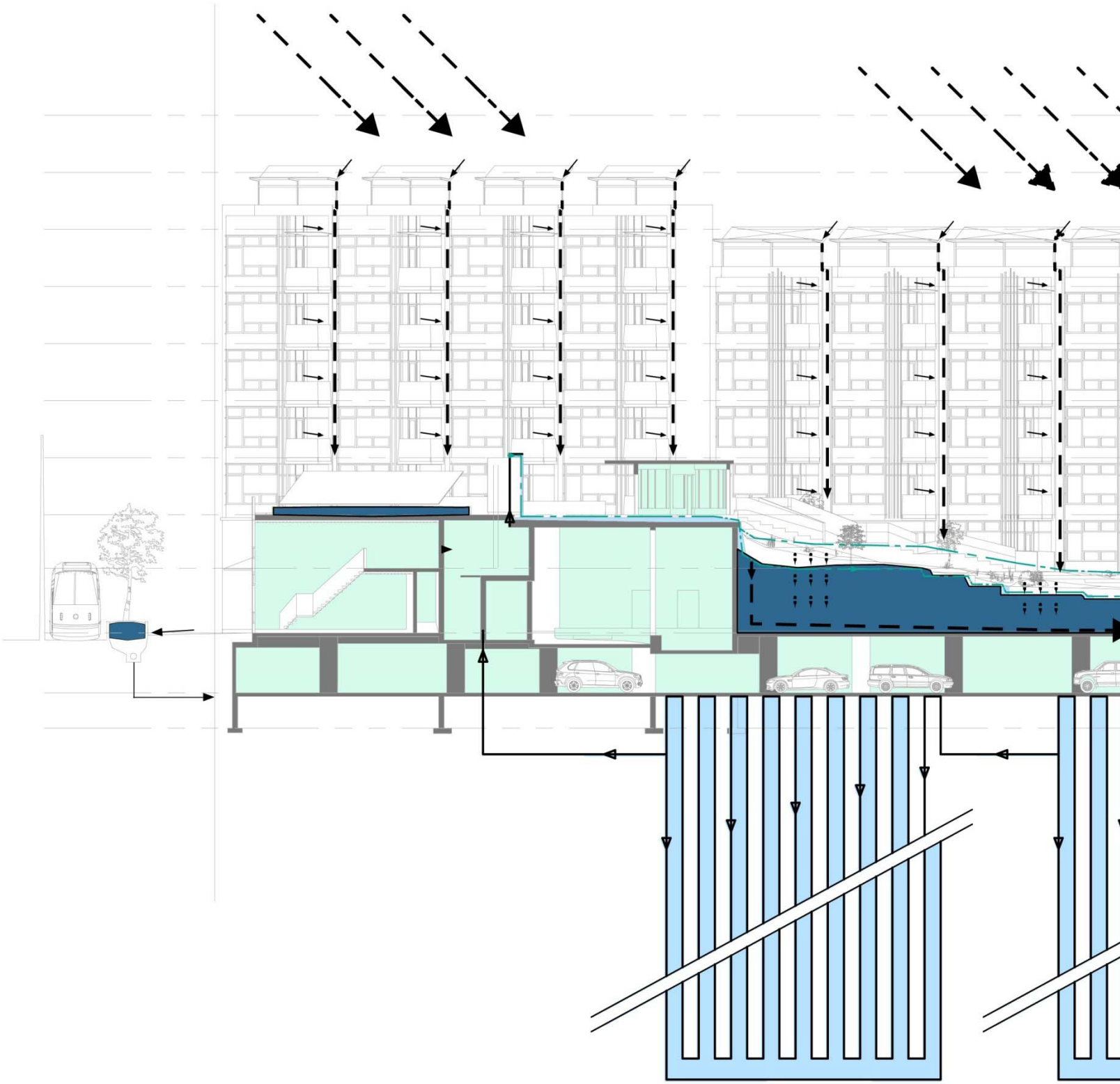


Figure 7.29

This diagram is a visual representation of Water Harvesting on-site utilizing NPW guidelines. The display showcases the following strategies deployed for sustainable urban water management:

- NPW Clean & Dirty Water Management
- NPW Interior & Exterior Drainage Management
- NPW Passive Water Harvesting
- NPW Active Water Treatment Systems
- NPW Cycle

On-site & Building water distribution reflects prescribed NPW guidelines.



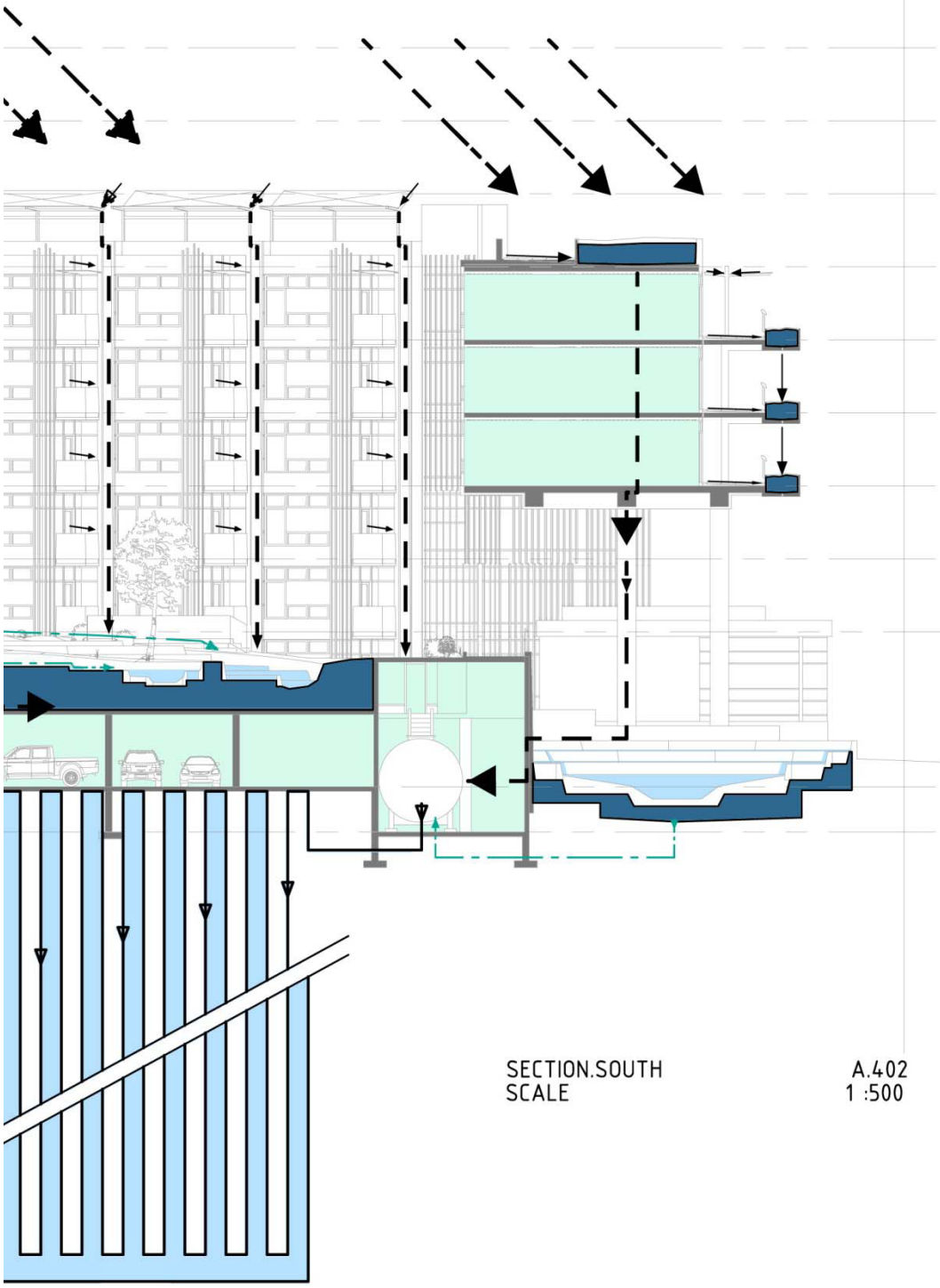
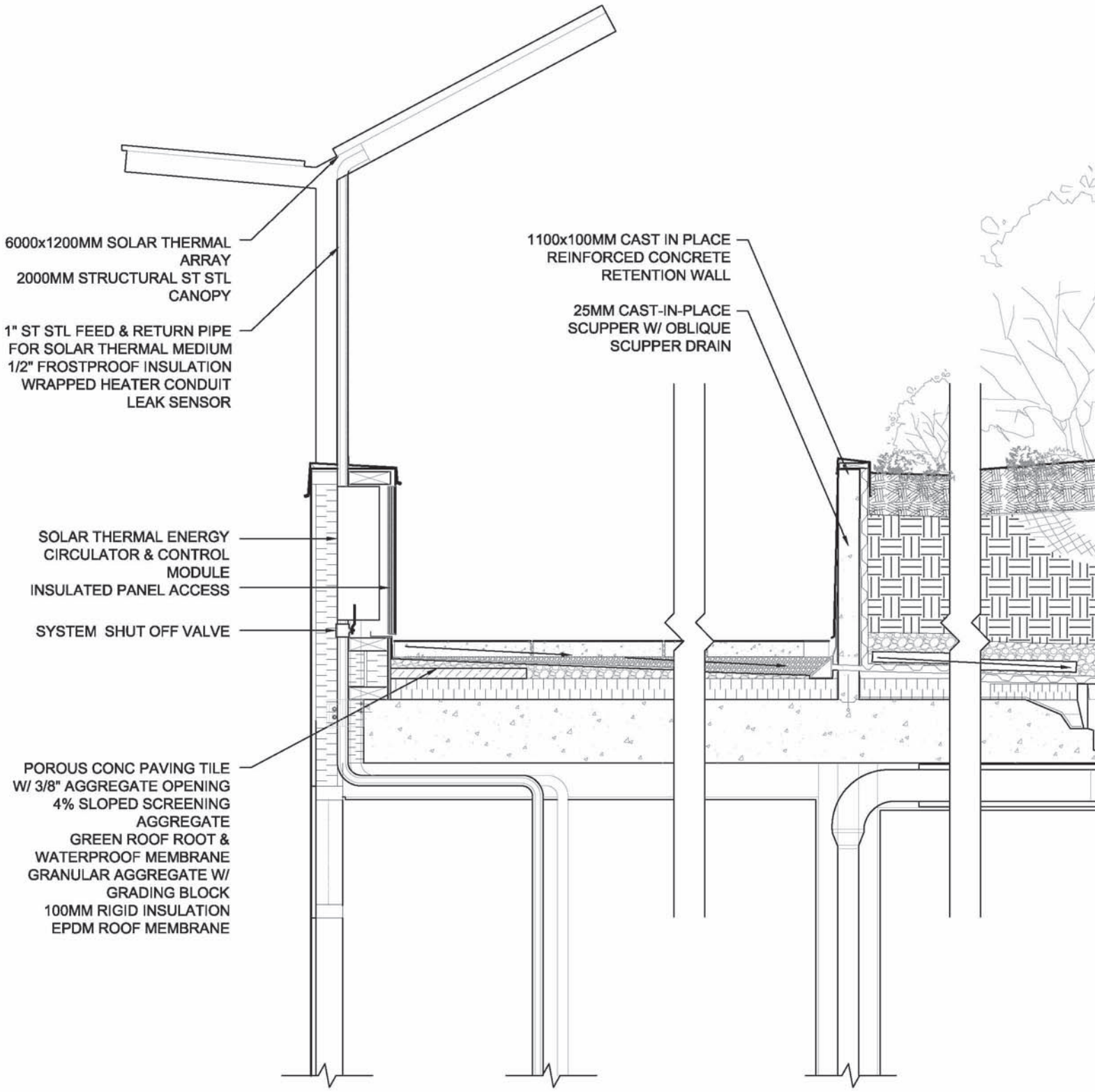


Figure 7.30

This diagram showcases Active and Passive Water Banking. Water is 'banked' within on-site soil volume under:

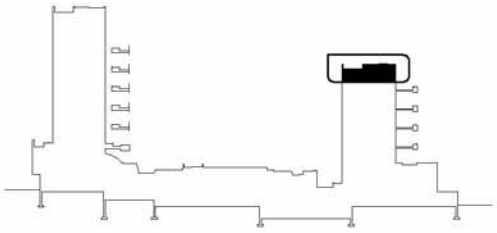
- Green Roof Systems designed for regional water resource harvesting.
- Vertical Percolation Strategy in planter boxes
- Landscaped Podium and Naturalized Waterway
- Borehole Water Storage
- Phase One Water Sediment Treatment
- Phase Two UV Water Treatment

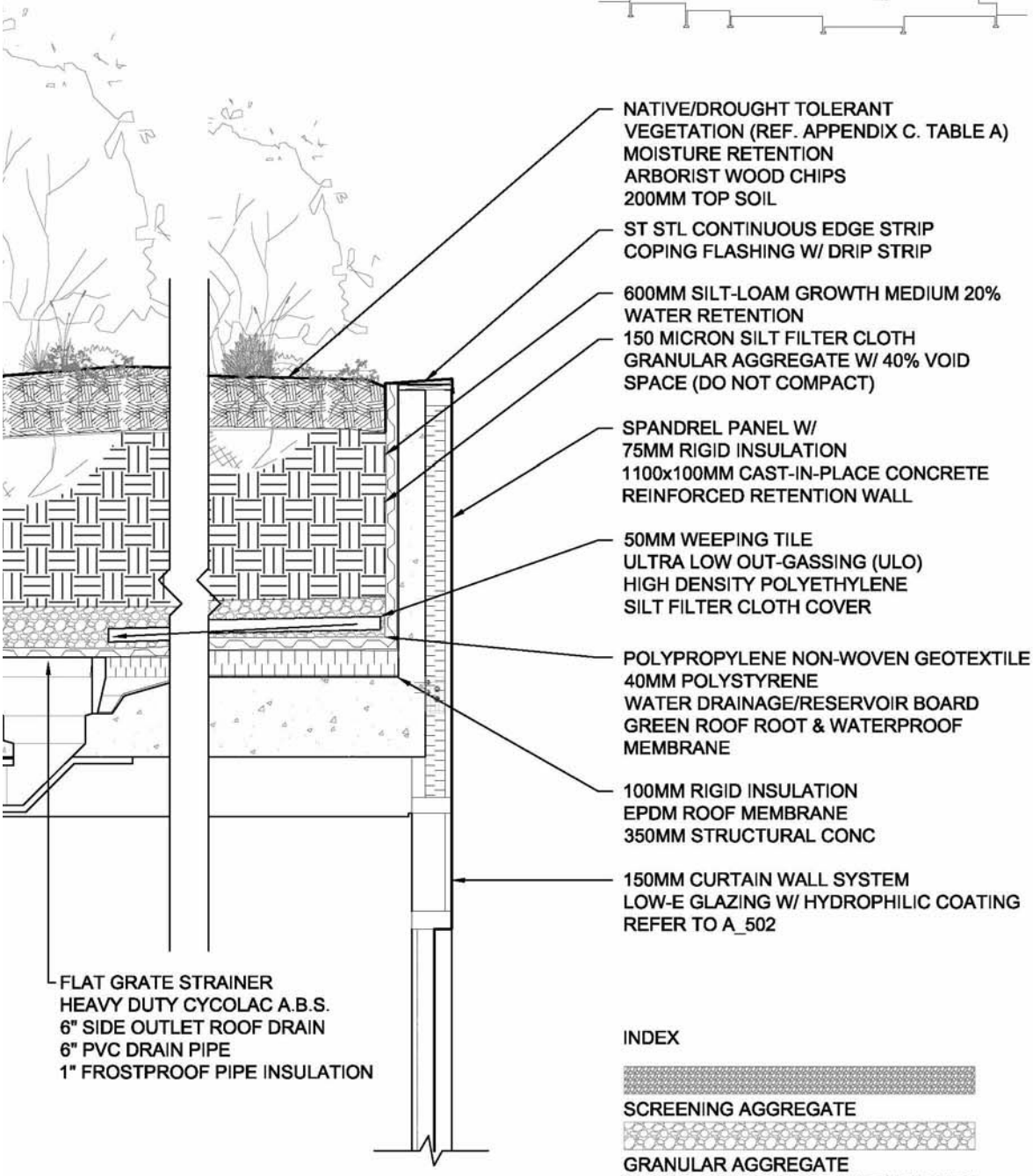

6000x1200MM SOLAR THERMAL ARRAY
2000MM STRUCTURAL ST STL CANOPY
1" ST STL FEED & RETURN PIPE FOR SOLAR THERMAL MEDIUM
1/2" FROSTPROOF INSULATION WRAPPED HEATER CONDUIT
LEAK SENSOR
SOLAR THERMAL ENERGY CIRCULATOR & CONTROL MODULE
INSULATED PANEL ACCESS
SYSTEM SHUT OFF VALVE
POROUS CONC PAVING TILE W/ 3/8" AGGREGATE OPENING
4% SLOPED SCREENING AGGREGATE
GREEN ROOF ROOT & WATERPROOF MEMBRANE
GRANULAR AGGREGATE W/ GRADING BLOCK
100MM RIGID INSULATION
EPDM ROOF MEMBRANE
1100x100MM CAST IN PLACE REINFORCED CONCRETE RETENTION WALL
25MM CAST-IN-PLACE SCUPPER W/ OBLIQUE SCUPPER DRAIN

PASSIVE WATER FILTRATION SYSTEM

LANDSCAPE ROOF DETAIL

SCALE 1:25 Figure 7.31





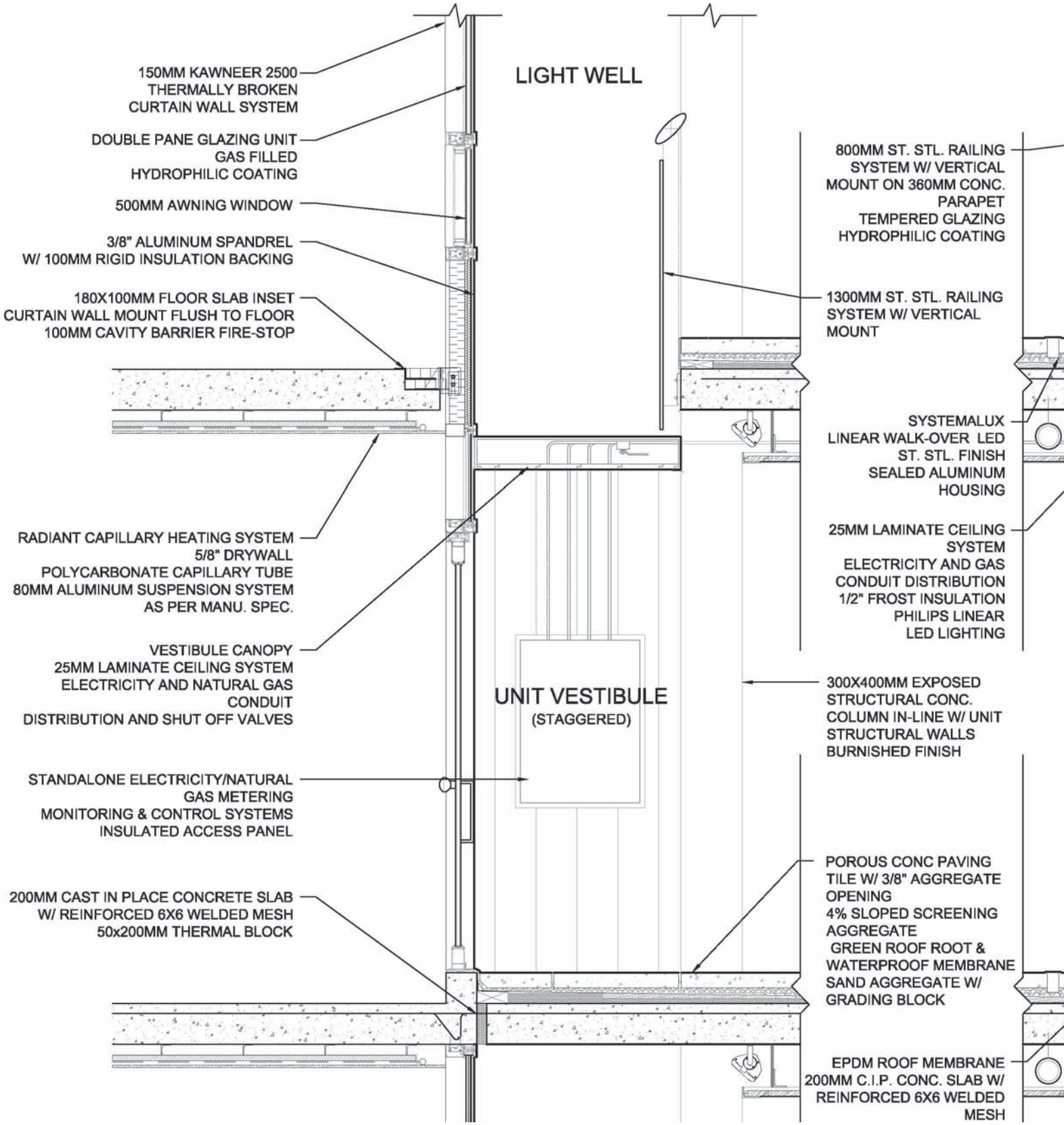
INDEX

SCREENING AGGREGATE

GRANULAR AGGREGATE

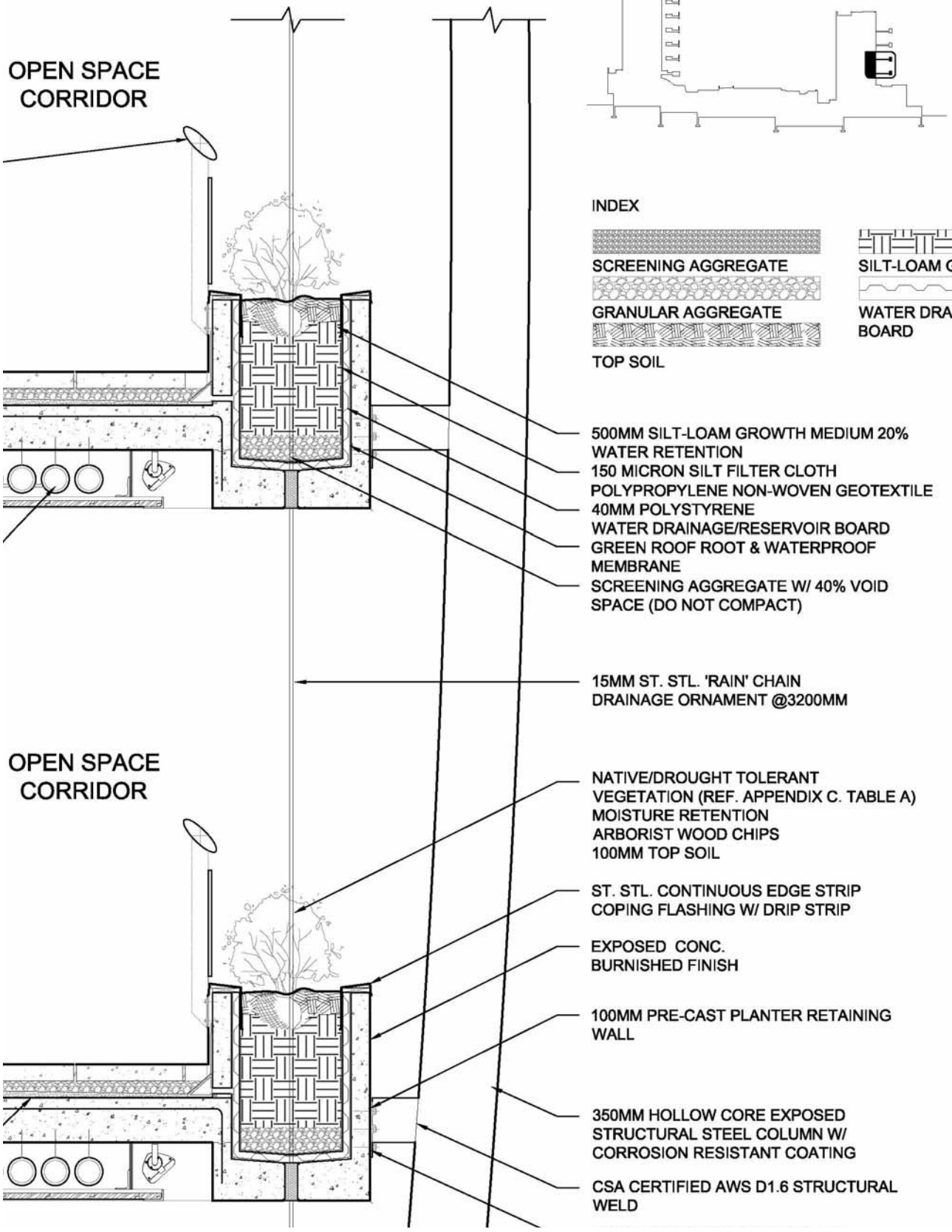
TOP SOIL

SILT-LOAM GROWTH MEDIUM


LIGHT WELL
150MM KAWNEER 2500
THERMALLY BROKEN
CURTAIN WALL SYSTEM
DOUBLE PANE GLAZING UNIT
GAS FILLED
HYDROPHILIC COATING
500MM AWNING WINDOW
3/8" ALUMINUM SPANDREL
W/ 100MM RIGID INSULATION BACKING
180X100MM FLOOR SLAB INSET
CURTAIN WALL MOUNT FLUSH TO FLOOR
100MM CAVITY BARRIER FIRE-STOP
RADIANT CAPILLARY HEATING SYSTEM
5/8" DRYWALL
POLYCARBONATE CAPILLARY TUBE
80MM ALUMINUM SUSPENSION SYSTEM
AS PER MANU. SPEC.
VESTIBULE CANOPY
25MM LAMINATE CEILING SYSTEM
ELECTRICITY AND NATURAL GAS
CONDUIT
DISTRIBUTION AND SHUT OFF VALVES
STANDALONE ELECTRICITY/NATURAL
GAS METERING
MONITORING & CONTROL SYSTEMS
INSULATED ACCESS PANEL
200MM CAST IN PLACE CONCRETE SLAB
W/ REINFORCED 6X6 WELDED MESH
50x200MM THERMAL BLOCK
UNIT VESTIBULE
(STAGGERED)
800MM ST. STL. RAILING
SYSTEM W/ VERTICAL
MOUNT ON 360MM CONC.
PARAPET
TEMPERED GLAZING
HYDROPHILIC COATING
1300MM ST. STL. RAILING
SYSTEM W/ VERTICAL
MOUNT
SYSTEMALUX
LINEAR WALK-OVER LED
ST. STL. FINISH
SEALED ALUMINUM
HOUSING
25MM LAMINATE CEILING
SYSTEM
ELECTRICITY AND GAS
CONDUIT DISTRIBUTION
1/2" FROST INSULATION
PHILIPS LINEAR
LED LIGHTING
300X400MM EXPOSED
STRUCTURAL CONC.
COLUMN IN-LINE W/ UNIT
STRUCTURAL WALLS
BURNISHED FINISH
POROUS CONC PAVING
TILE W/ 3/8" AGGREGATE
OPENING
4% SLOPED SCREENING
AGGREGATE
GREEN ROOF ROOT &
WATERPROOF MEMBRANE
SAND AGGREGATE W/
GRADING BLOCK
EPDM ROOF MEMBRANE
200MM C.I.P. CONC. SLAB W/
REINFORCED 6X6 WELDED
MESH

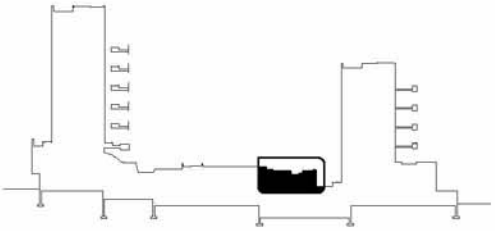
PASSIVE WATER FILTRATION SYSTEM
LANDSCAPE OPEN CORRIDOR

SCALE 1:25 Figure 7.32



NATURALIZED WATERWAY SYSTEM

SCALE 1:25 Figure 7.33



INDEX

SCREEN

GRANUL

TOP SOI

TIER ONE

PASSIVE WATER
CLEANSING VIA AQUATIC
PLANT SPECIES

250MM SILT-LOAM
GROWTH MEDIUM
20% WATER RETENTION
65MM SAND AGGREGATE
150 MICRON SILT FILTER CLOTH
NON-WOVEN GEOTEXTILE
150MM SCREENING AGGREGATE
150MM GRANULAR AGGREGATE
6PLY WATER RETENTION
MEMBRANE
150MM DRAIN PIPE
SOIL BACKFILL W/ 20% VOID SPACE
(DO NOT COMPACT)

WETLAND AQUATIC PLANT
SPECIES
(REF. APPENDIX C. TABLE B)

LOG WEIR
W/ 300MM CONCRETE ANCHOR
CRUSHED AGGREGATE BASE
WOVEN GEOTEXTILE

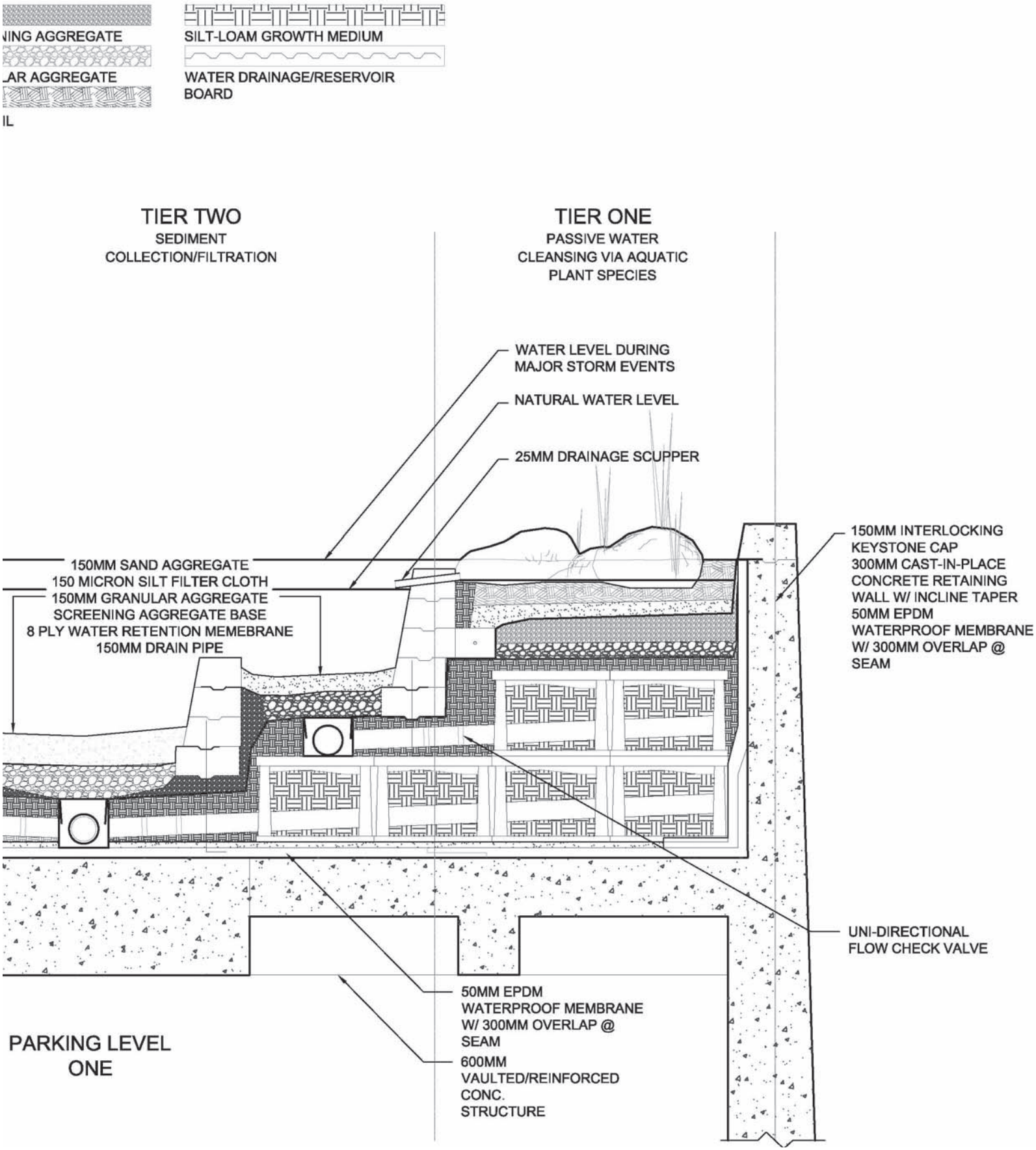
800MM SILT-LOAM
GROWTH MEDIUM
20% WATER RETENTION
150 MICRON SILT FILTER
CLOTH
SOIL BACKFILL W/ 20% VOID
SPACE (DO NOT COMPACT)

SOIL BACKFILL W/ 40% VOID
SPACE (DO NOT COMPACT)

100MM CYCOLAC A.B.S.
WEEPING TILE
WATERWAY DRAIN
OUTLET

4X5M 'SILVA' SOIL
INFILTRATION CELL
INTERLOCKED
25MM SAND
AGGREGATE BASE

ANCHORED BASALT
RETAINING WALL
150MM INTERLOCKING
KEYSTONE W/ VARYING
WIDTH
INSTALL AS PER MANU.
SPEC.
W/ SCREENING
AGGREAGATE BASE


NING AGGREGATE
LAR AGGREGATE
IL
SILT-LOAM GROWTH MEDIUM
WATER DRAINAGE/RESERVOIR BOARD
TIER TWO
SEDIMENT COLLECTION/FILTRATION
TIER ONE
PASSIVE WATER CLEANSING VIA AQUATIC PLANT SPECIES
WATER LEVEL DURING MAJOR STORM EVENTS
NATURAL WATER LEVEL
25MM DRAINAGE SCUPPER
150MM SAND AGGREGATE
150 MICRON SILT FILTER CLOTH
150MM GRANULAR AGGREGATE
SCREENING AGGREGATE BASE
8 PLY WATER RETENTION MEMEBRANE
150MM DRAIN PIPE
150MM INTERLOCKING KEYSTONE CAP
300MM CAST-IN-PLACE CONCRETE RETAINING WALL W/ INCLINE TAPER
50MM EPDM WATERPROOF MEMBRANE W/ 300MM OVERLAP @ SEAM
UNI-DIRECTIONAL FLOW CHECK VALVE
50MM EPDM WATERPROOF MEMBRANE W/ 300MM OVERLAP @ SEAM
600MM VAULTED/REINFORCED CONC. STRUCTURE
PARKING LEVEL ONE

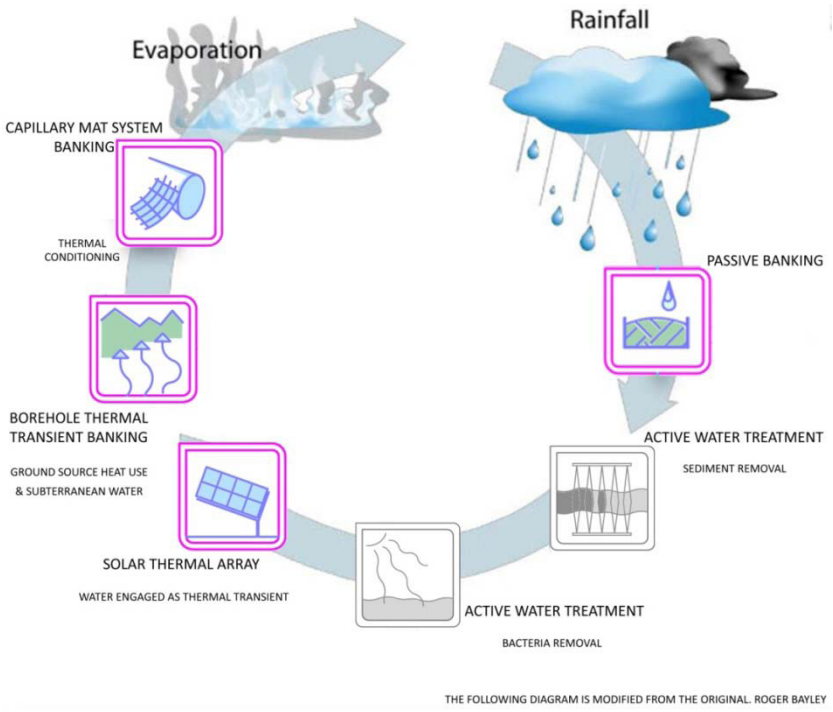


Figure 7.34

Net Positive Water – Water renewal Cycle.

Active Water treatment and renewal functions in the Mid-rise Pilot Project.

7.2.6 Active Water Banking as Thermal Transient

The pilot project accommodates Active Water storage through alternative and non-conventional streams of water containment. The conventional strategy for building water storage utilizes compact storage cisterns or surge tanks. These storage solutions create stagnant water conditions that allow stored urban water content to degrade in quality.[45]. NPW mid-rise addresses the water storage issue by emphasizing the need to store water in its natural state of water flow as a means to preserve water quality[46].

The evolution of radiant, water based building conditioning has evolved for greater sustainability where potent chemical additives are no longer needed. Sustainable thermal conditioning systems can utilize Bluewater and Greywater content to function as the thermal energy medium. The application of radiant thermal conveyance requires substantial volumes of water to provide sufficient building conditioning. Conditioning demand establishes the potential to activate radiant thermal systems as a means for Active Water Storage.

As derived from prior Case Study exemplars, Capillary Mat Radiant Systems and Borehole Thermal Transient Storage (BTTS) are capable water based systems that be utilized for Active water storage while inducing water flow. (Chap.4 Section.4.2.3 Fig. 4.26 Pg. 65, Chap.4 Fig. 4.29 Pg.67)

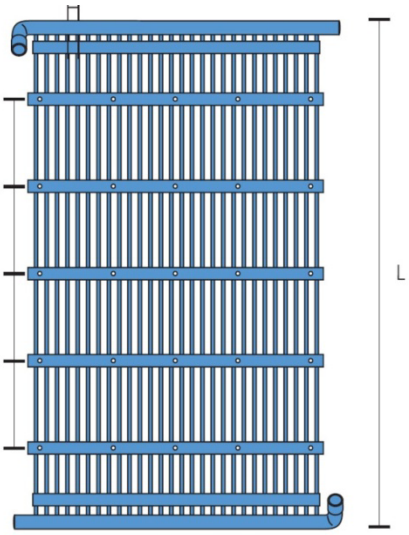


Figure 7.35

The flow requirements of the system are required to modulate the buildings cyclic water functions.

BEKA Capillary Tube Mat
Mass Filled:
824g/m² (without collector)
Water Content: 0.39L m²
Operating Pressure: 4 bar
Flow Rate (Feed): 1.8m³/h
Flow Rate (Return): 1.7m³/h

Capillary Mat radiant conditioning utilizes Potable water as a thermal transient to convey conditioning throughout the mid-rise pilot project. Mid-rise MURB applications would be deployed as a ceiling application of all residential and retail units, creating a large surface/volume for Active Water Storage. The mat is made of a system of small, non-corrosive capillary tubes that are networked together to form a radiant membrane for in-ceiling, in-wall & in-floor applications. The system is originally designed as a closed-loop where the thermal medium is cycled within itself at all times. The pilot project application will utilize the capillary mats under an open loop, withdrawing water from Passive Water Banking as a component of the greater NPW cycle.

Adapting the closed-loop capillary system into the pilot project is achieved by integrating water feed and water return into the greater building water cycle. Control systems manage flow rates to ensure that the capillary systems are maintained at full capacity. The systems application functions in a Parallel configuration, allowing each household to specify their thermal demand independent of each other.

An energy module located in each residential unit is utilized to pump the necessary volume of water required to fill each in-unit capillary mat. In each capillary mat module, Greenwater transient is fed into a condensing mechanism that translates thermally energized water into a cooling solution during the summer months. The energy unit has a salt brine mixture that is sprayed onto the conduits that flow heated water transient. The brine condenses into cool vapours that attach themselves to a capillary feed, allowing the energy unit to feed cooled water into the residential units. The result is cool, radiant air conditioning.

The application of a Capillary Mat radiant system is the sole component for in-unit Active Water Banking allowing NPW residential units to act as a fully saturated 'Sponge'. The total storage capability of the Capillary Mat network in the NPW mid-rise residential pilot project is capable of an **immediate storage volume of 2,782L**[47]. Under an open loop function following the specified flow rate of the system, the capillary system will demand an overall water intake volume of **44,512** litres per day to feed a specified duration of 16 cycles.

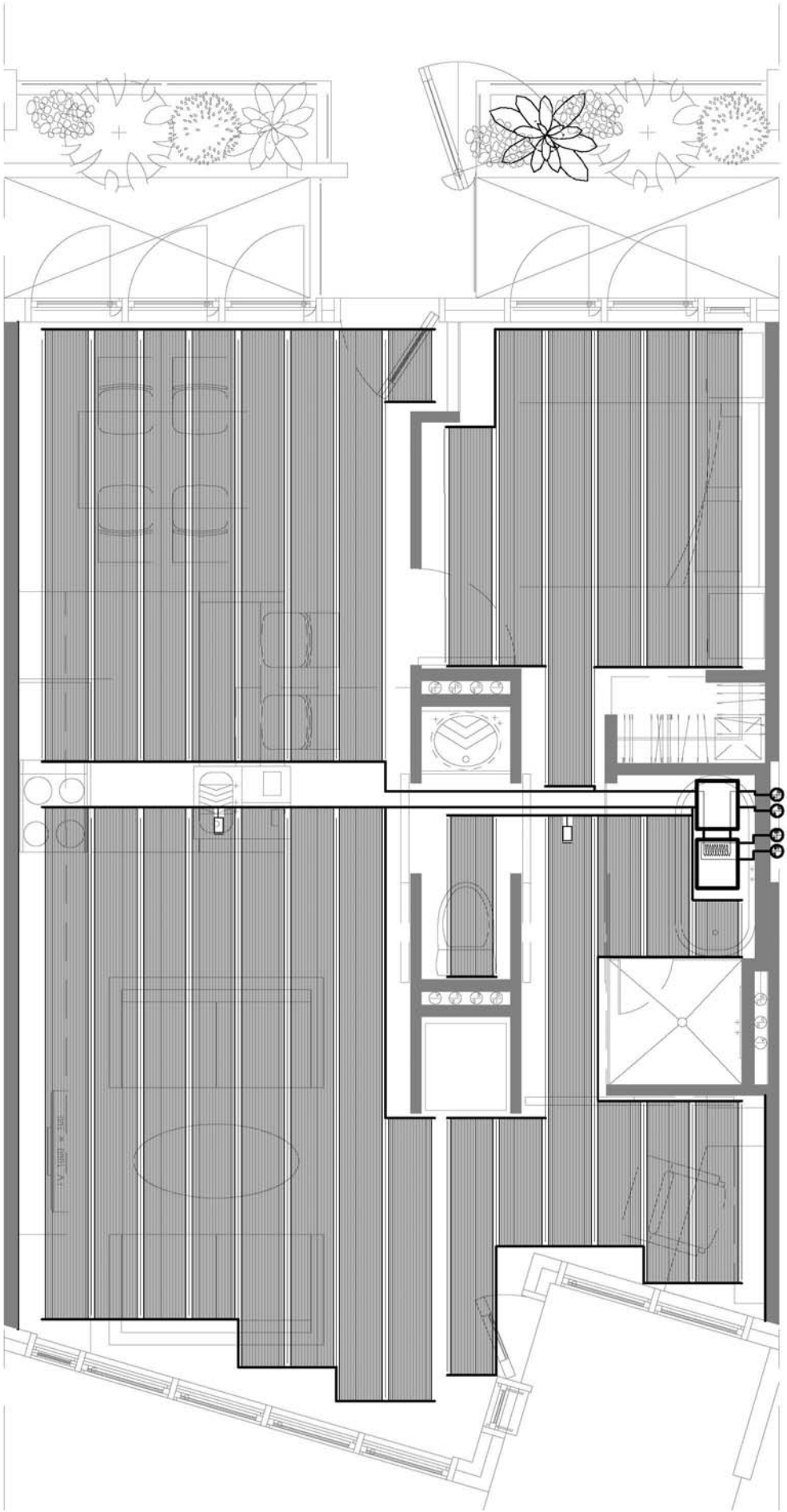
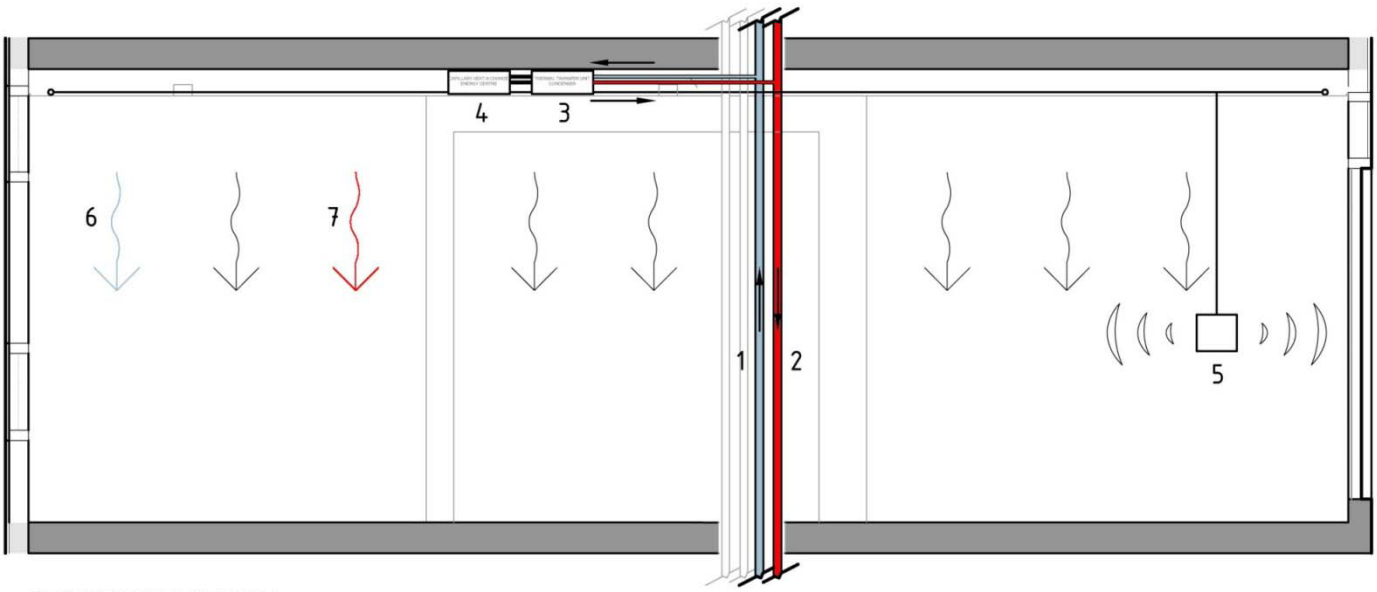


Figure 7.36

Capillary Mat System applied to typical Net Positive Residential Unit as a ceiling mounted application.

The management strategy is separated into 4 quadrants such that thermal conditioning can be provided to each independent sector of a household based off of the occupant's location.

The Capillary Mat Energy Centre controls the distribution of thermal energy where it is required. The entire system maintains an even and average flow rate to continuously cycle water throughout a household.



SECTION.UNIT.TYPICAL
SOLAR THERMAL CONDITIONING SYSTEM

INDEX

1 SOLAR THERMAL MEDIUM FEED TO ROOF ARRAY (NPW CYCLE)
2 SOLAR THERMAL MEDIUM RETURN (NPW CYCLE)
3 THERMAL TRANSFER CONDENSER
CONDENSING SYSTEM CREATES COLD AND HOT CONDITIONS FOR THE TRANSITIONAL THERMAL MEDIUM
4 CAPILLARY MAT ENERGY CENTRE
TRANSFERS THERMAL ENERGY FROM THE SOLAR THERMAL SYSTEM TO THE CAPILLARY SYSTEM
5 THERMOSTAT TEMPERATURE CONTROLS
6 RADIANT CONDITIONING (CONDENSED COLD MEDIUM)
7 RADIANT CONDITIONING (DIRECT SOLAR HEAT MEDIUM)

Figure 7.37 SCALE 1:50

The thermal source for the capillary mat system is derived from the NPW BTTS and Solar Thermal Array. Heated water transient is routed towards the BTTS for thermal and long term storage and is provided to NPW households via the NPW water cycle.

Hot Water Transient is represented in Red

Cold Water Transient is represented in Blue

The Mid-rise pilot project will utilize a **Borehole Thermal Transient System (BTTS)** as an Active Water Storage mechanism following the success of Drake Landing Solar Community in Okotoks Alberta. The NPW application of Borehole technology will fulfill the duties for thermal radiant conditioning as well as cross-seasonal Active Water Storage. Utilizing the system under an open loop cycle allows potable water to flow to-and-from the capillary mat systems. The application of the Borehole Active Water storage is eased by Brownfield site requirements to excavate and remediate site soils before construction.

Borehole technology utilizes the ground as insulation, feeding energized (heated) water into each individual borehole to preserve and maintain harnessed energy. BTTS applied in the mid-rise pilot project will be a subterranean application beneath the project. The borehole network is situated beneath the building to store harvested precipitation in longitudinal borehole/shafts that stretch 35 metres into substrate soils. The installation strategy will isolate the BTTS water medium from seasonal frost conditions and allow the system to function without any anti-freeze additives.

The Borehole system maintains harvested water resources in constant motion as thermal energy is stored and released as a component of the building water cycle. Water flow is induced by a series of pumps that pressurize the system, pushing and pulling the fluid throughout the entire borehole network. The Active motion eliminates the static water conditions that could lead to bacterial growth and degrading water quality. Water is pumped through each 30mm tubule at a variable rate of flow to control required temperature demands. The construction of each Borehole tubule is made from non-corrosive materials and manufactured for leakage prevention.



Figure 7.38

The BTTS is the largest building mechanism for Active Water Storage. The system is designed to hold harvested water throughout the year with the deployment of **3650 Boreholes spaced 1m² apart**. Maximizing storage capacity of the site will result in a total Active Water Storage volume of **5,745,600L**. The large volume of Borehole transient water will be capable of feeding the 1.6 million litres of water demand required by the buildings Capillary Mat system per annum.



The BTTS and Capillary mat network is fed by a roof mounted **Solar Thermal Array transitioning solar energy into heated water[48].** A high-efficiency solar thermal array is capable of increasing transient water temperatures upwards of 80 degrees Celsius at peak efficiency[49]. High water temperatures for thermal conditioning serve an added effect to combat the growth of waterborne bacteria as the water is stored[50]. The distribution of water resources to-and-from the array requires insulated piping/drainage hardware where the required plumbing is exposed to the exterior environment. (Fig. 7.31 Pg. 179-80).

Booster Pump Systems will be utilized in the pilot project to mobilize water resources and connect the multitude of building systems as a continuous water cycle. The pumping technology is a common application in modern MURB development and successfully supplies urban building typology with water[51].

The borehole system permeates heat from the energized water transient into the surrounding soil. Soil content is a capable medium to store the heat and transfer the resource back into the transient.

Figure 7.39

Enerworks was the chosen manufacturer designated to deploy the roof mounted STE, solar array in the DLSC. The Mid-rise Pilot Project will utilize chosen technology with proven performance capability.

Roof mounted solar thermal panels do not interrupt the function of Passive Green Roof harvesting.

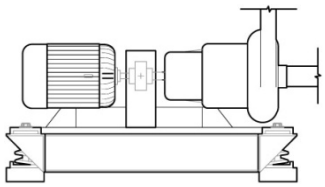




Figure 7.40

Booster pumps can be designed to induce flow into a flow medium at variable rates of speed. This can help slow, and increase the rate of thermal transient based on inhabitant demand.

Booster pumps are a series of variable speed electrically driven pumps that force water through a buildings plumbing network. To optimize the system of pumps, operations will be split between Primary and Secondary pumping utilities. The first primary use for booster pumps is to ensure the operation of Potable and Non-potable water provisioning to NPW residential households. Water is pumped into secondary distribution pumps at the base of each residential tower and then directed to each residential unit.

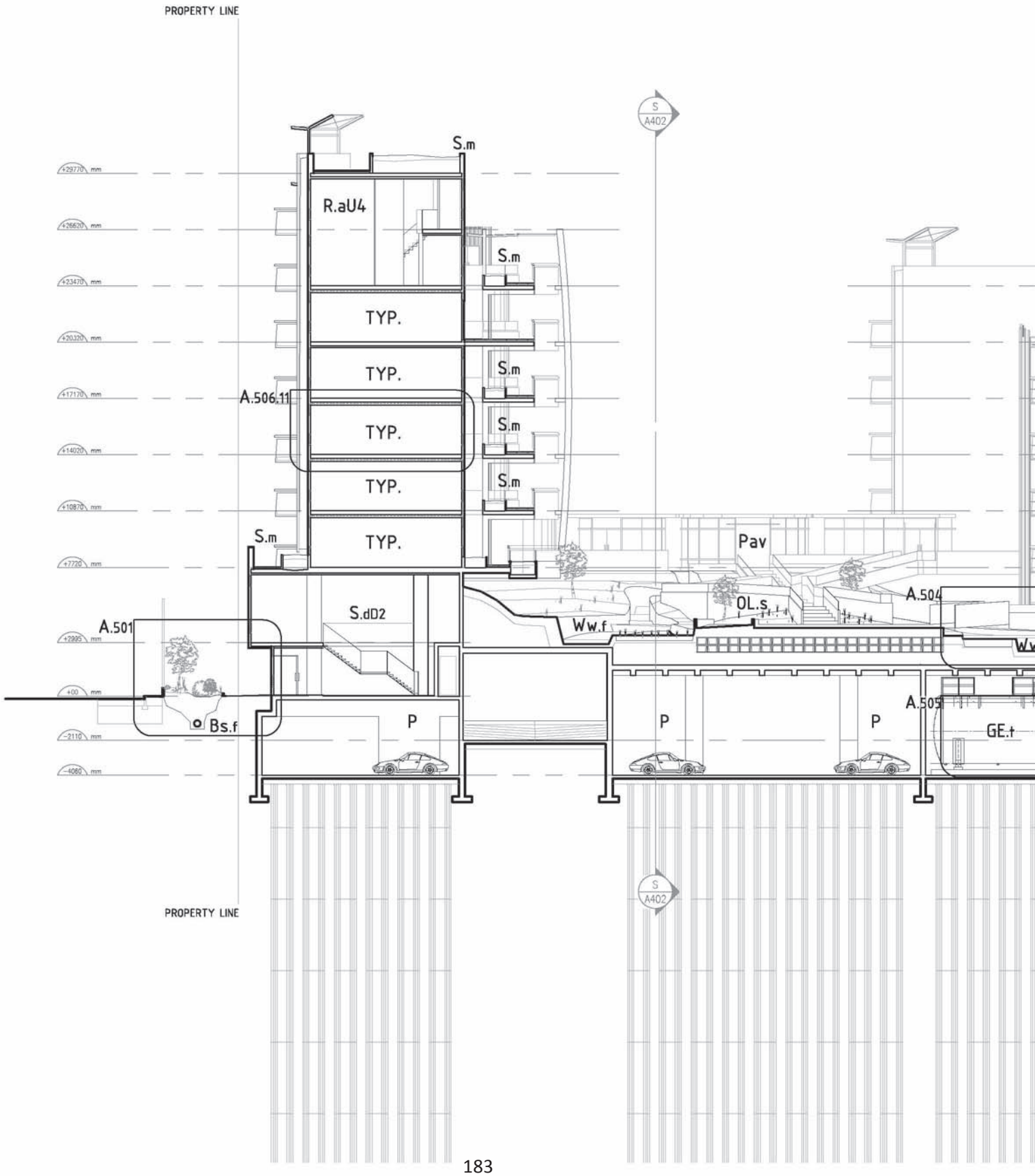
The second primary function is to induce Active and continuous flow throughout NPW thermal transient network. Booster pumps will be utilized for multiple tiers of building function including Capillary Mat transient conveyance, Borehole transient conveyance, Solar Thermal energy conveyance, Water Feature water flow and the adequate water provisioning for the NPW naturalized waterway.

For the buildings **Thermal Water Cycle**, water is withdrawn from the Passive waterway and diverted into the buildings water treatment facility (WT.r1-r2 Fig.7.42 Pg.193-94). Booster pumps feed the structures roof mounted solar thermal array to embody the water medium with thermal energy. Once the water has becomes energized, it is pumped into the Borehole system for Active Water Storage.

From the Borehole system, pumps will feed the NPW residential capillary systems to provide thermal conditioning. The pump system will then withdraw water from the thermal cycle and reinitialize water processing by delivering the medium into water treatment before the water is reintroduced into the Passive naturalized waterway. Heat exchanges are also utilized to remove auxiliary thermal energy from the medium, which is re-directed back into the structures water treatment systems.

The following drawings display the Active Water Storage requirements placed on the Mid-rise pilot project:

- Pilot Project East Section
- Pilot Project South Section
- Borehole Thermal Transient Storage network
- Ultrafiltration and Ultraviolet water treatment facilities and Waste Management facilities


PROPERTY LINE
S
A402
S.m
R.aU4
S.m
TYP.
TYP.
S.m
A.506.11
TYP.
S.m
TYP.
S.m
TYP.
S.m
Pav
S.dD2
A.504
OL.s
A.501
Ww.f
A.505
Bs.f
P
P
P
GE.f
+29770 mm
+26620 mm
+23470 mm
+20320 mm
+17170 mm
+14020 mm
+10870 mm
+7720 mm
+2995 mm
+00 mm
-2110 mm
-4060 mm
S
A402
PROPERTY LINE

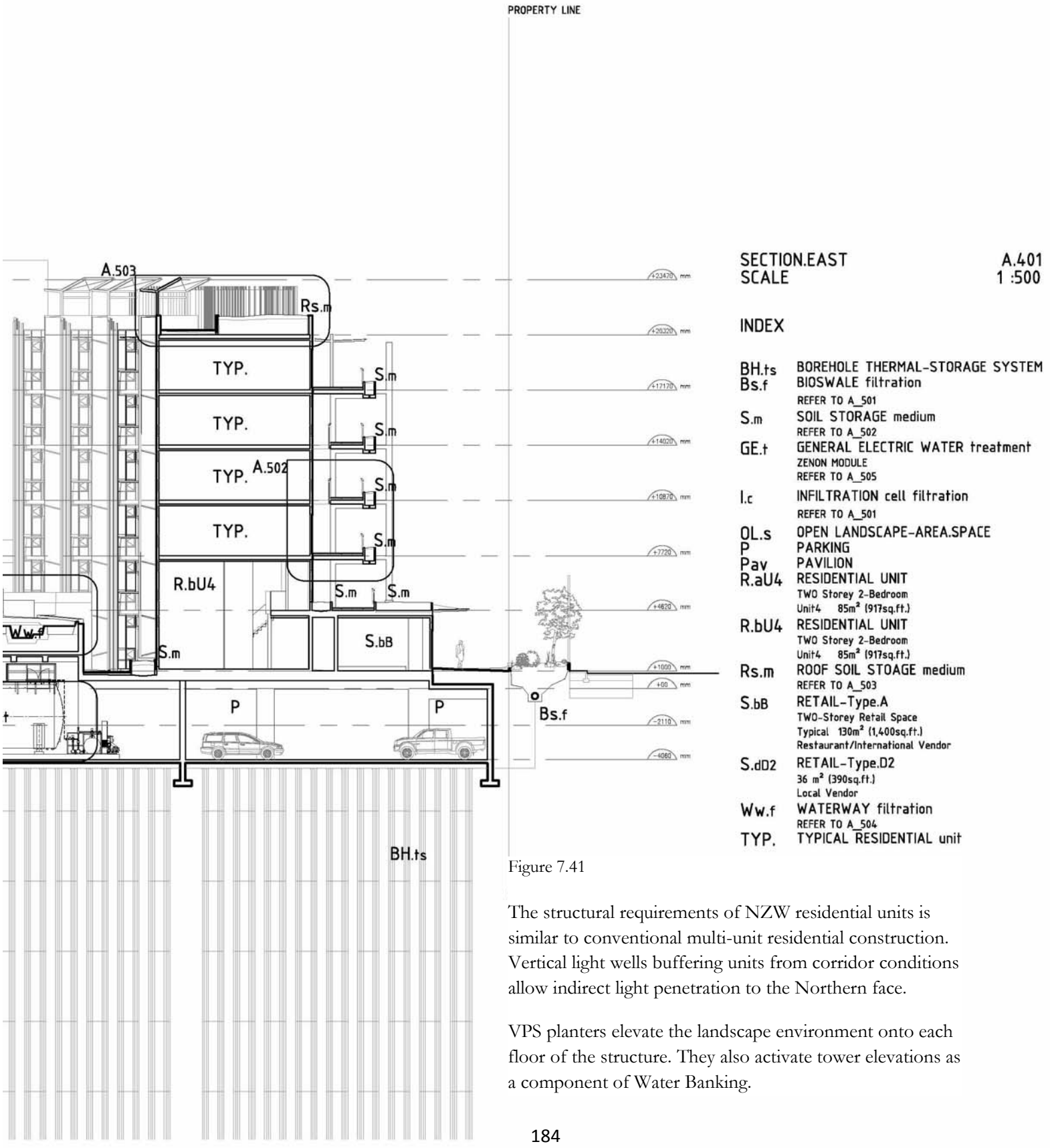
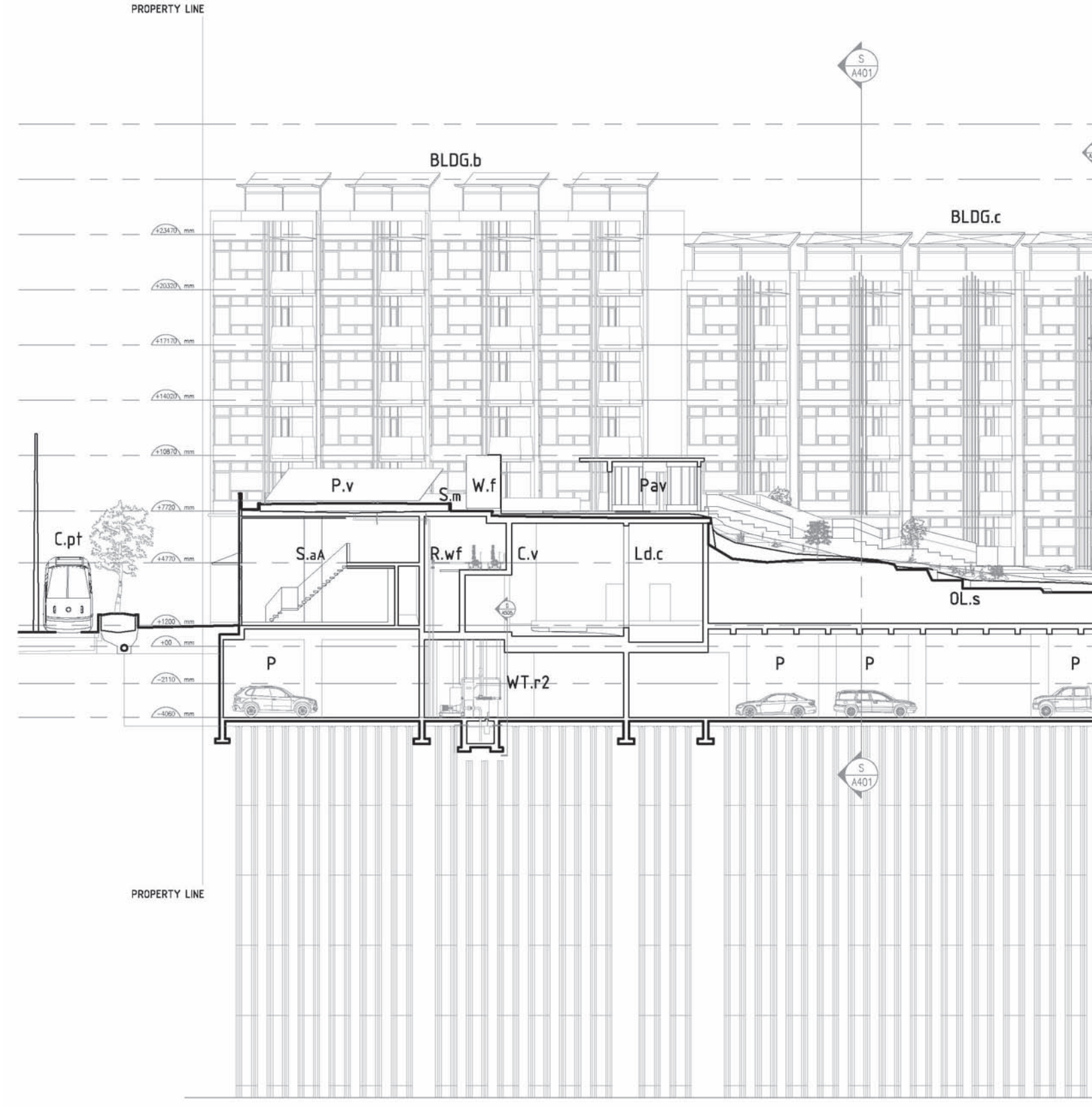


Figure 7.41

The structural requirements of NZW residential units is similar to conventional multi-unit residential construction. Vertical light wells buffering units from corridor conditions allow indirect light penetration to the Northern face.

VPS planters elevate the landscape environment onto each floor of the structure. They also activate tower elevations as a component of Water Banking.


PROPERTY LINE
S
A401
BLDG.b
BLDG.c
+23470 mm
+20320 mm
+17170 mm
+14020 mm
+10870 mm
+7720 mm
+4770 mm
+1200 mm
+00 mm
-2110 mm
-4060 mm
P.v
S.m
W.f
Pav
C.pt
S.aA
R.wf
C.v
Ld.c
OL.s
P
WT.r2
P
P
P
S
A401
PROPERTY LINE

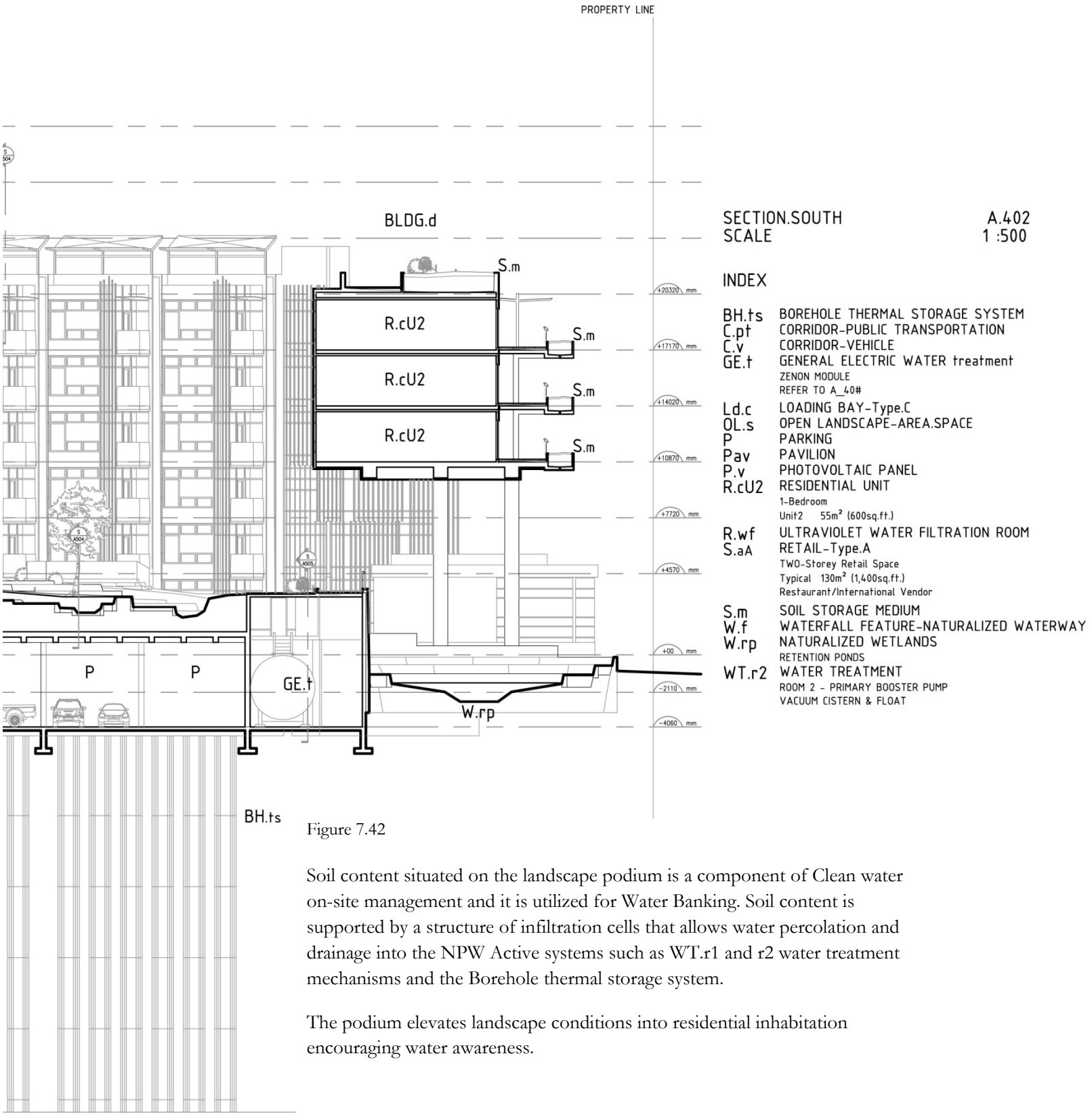
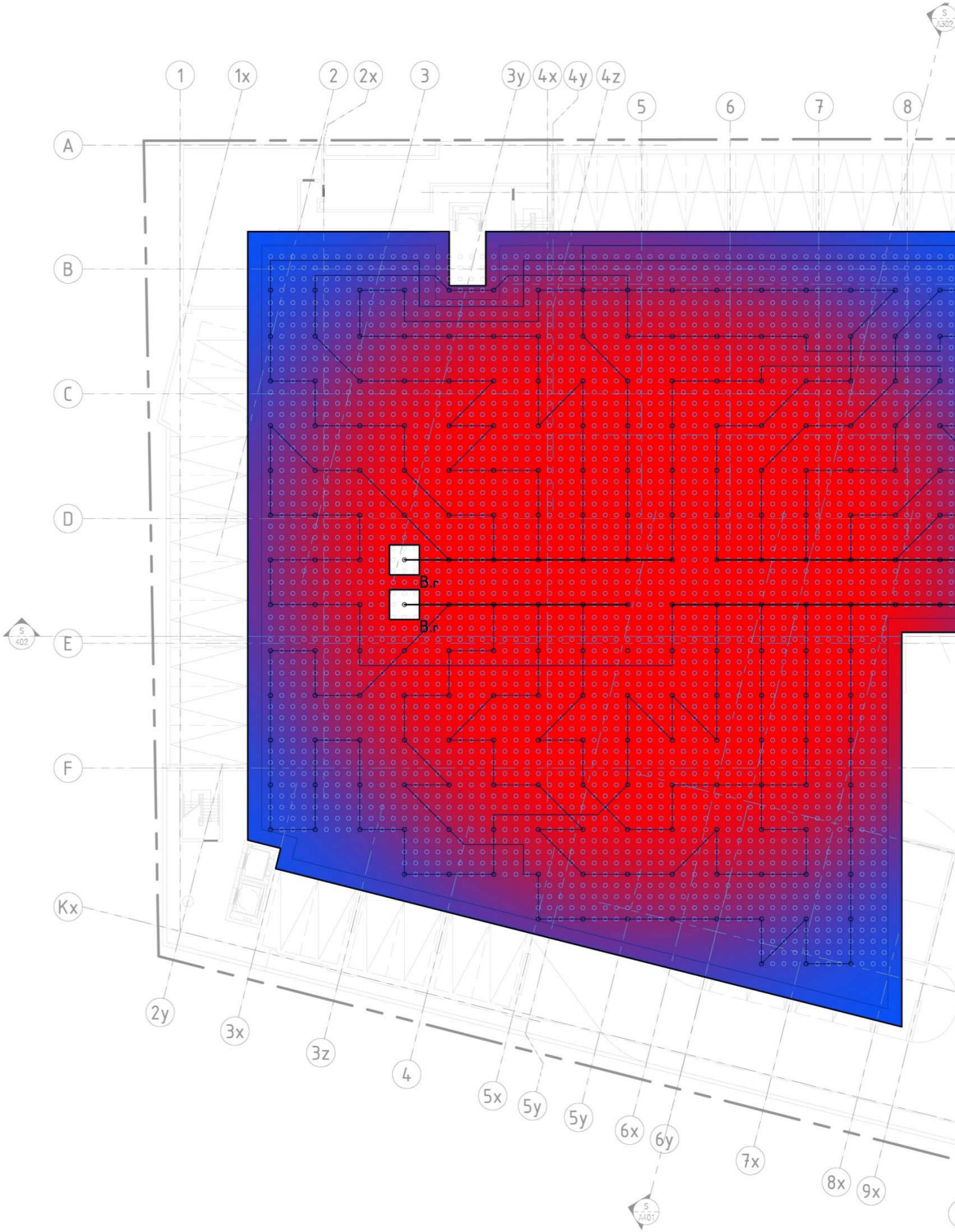
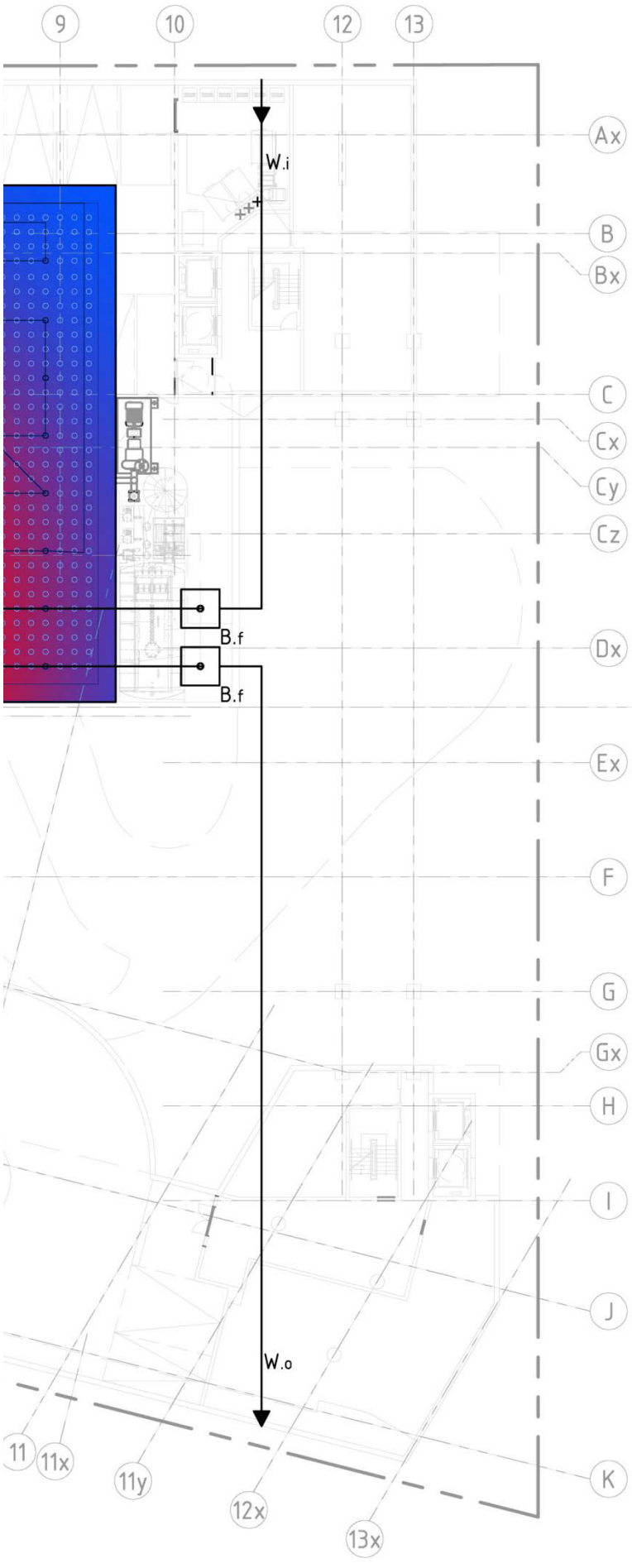


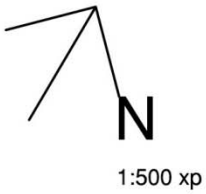
Figure 7.42

Soil content situated on the landscape podium is a component of Clean water on-site management and it is utilized for Water Banking. Soil content is supported by a structure of infiltration cells that allows water percolation and drainage into the NPW Active systems such as WT.r1 and r2 water treatment mechanisms and the Borehole thermal storage system.

The podium elevates landscape conditions into residential inhabitation encouraging water awareness.


1
1x
2
2x
3
3y
4x
4y
4z
5
6
7
8
A
B
C
D
E
F
Kx
B.r
B.r
2y
3x
3z
4
5x
5y
5y
6x
6y
7x
8x
9x





P2 BOREHOLE SYSTEM A201

B.f BOREHOLE FEED
B.r BOREHOLE RETURN
W.i WATER INTAKE
SOURCE FROM KEATING CHANNEL
W.o WATER OUTLET
INTO NATURALIZED WETLANDS



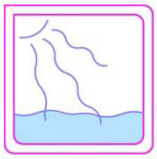


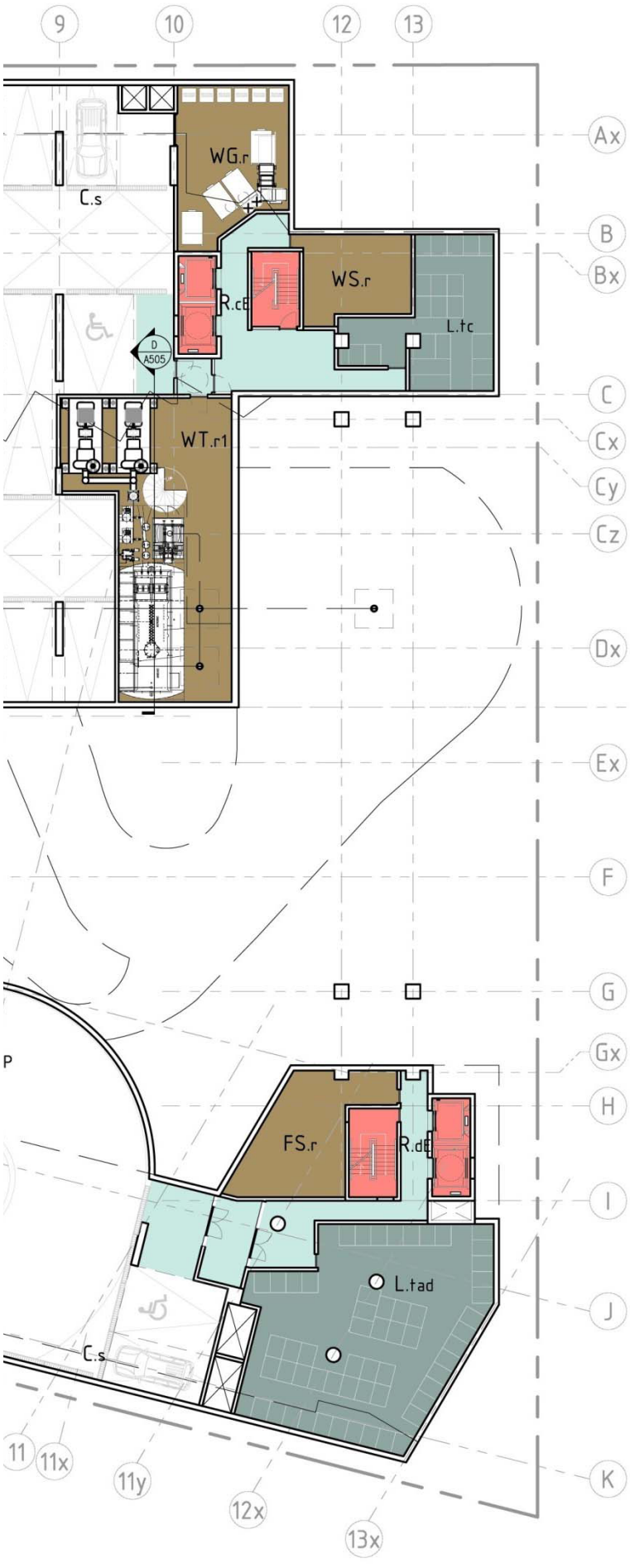
Figure 7.43

The borehole system covers the bulk area of the site beneath the buildings foundation. The system stores heated water transient that is harnessed from the roof top solar thermal array. The installation has been designed as two 'Strings' whereby borehole transient is partitioned into two compartments. This allows the half of the system to be shut down for repairs.

Hot water demand is withdrawn from the core/centre of the borehole grid, while Cold water is withdrawn from the periphery as heat radiates outward.

PROPERTY LINE
FLOOR ABOVE
FLOOR BELOW
GRID
WATER CONDUIT
NETWORK
BOREHOLE
NETWORK
35m DEPTH
3648 BOREHOLES


C.tele
L.tb
W.ft
Elec.r
R.bE
C.s
D
A505
WT.r2
S
402
C.s
R.aE
W.ft
1
1x
2
2x
3
3y
4x
4y
4z
5
6
7
8
A
B
C
D
E
F
Kx
2y
3x
3z
4
5x
5y
5y
6x
6y
7x
8x
9x
S
A302
S
A401





INDEX

1:500 xp

- Building services/utilities
- Building circulation
- Residential circulation
- Residential ammenity space
- Residential unit
- Residential/Commercial circulation
- Retail/Commercial unit
- Vehicle circulation
- Vertical circulation
- Water feature

Figure 7.44

Active water treatment and waste management places greater spatial demands on the building typology.

The structural requirements to support the naturalized waterway and landscape podium result in a subterranean application for water Ultrafiltration and Ultraviolet treatment processes.

Harvested rainwater is processed in WT.r1 & r2 to be diverted to the solar thermal array, borehole storage system, inhabitant demand, and naturalized waterway.

PARKING.level.ONE A202

70 PARKING SPACES
4 DISABILITY PARKING SPACES
C.s 4 DESIGNATED CAR SHARE

C.tele TELECOMMUNICATIONS
CONTROL ROOM
ULTRA-HIGH SPEED NETWORK
BROADBAND

ELEC.r ELECTRICAL ROOM
ILLUMINATION
GENERATOR
SWITCHBOARD
POWER DIVISION

FS.r FIRE SURPRESSION ROOM

L.tad LOCKER ROOM
TOWER A & D

L.tb LOCKER ROOM
TOWER B

L.tc LOCKER ROOM
TOWER C

R.aE ELEVATOR-BLDG.a
R.bE ELEVATOR-BLDG.b
R.cE ELEVATOR-BLDG.c
R.dE ELEVATOR-BLDG.d

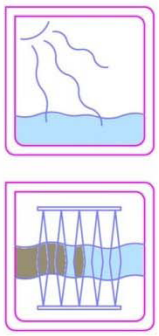
W.ft WATER FEATURE
CONTROL ROOM

WG.r GARBAGE ROOM
SORTING UNIT: GARBAGE/RECYCLE

WS.r WASTE SOLID ROOM

WT.r1 WATER TREATMENT
ROOM 1
GE WATER TREATMENT
PRIMARY PUMP SYSTEM

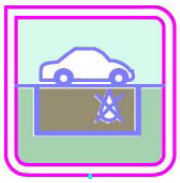
WT.r2 WATER TREATMENT
ROOM 2
TROJAN UV WATER TREATMENT
PRIMARY PUMP SYSTEM
BOREHOLE SUMP & CONTROL MODULES



DRAINAGE GRATE
PROPERTY LINE
FLOOR ABOVE
WATER FEED & RETURN LINE
CANOPY ABOVE
FLOOR BELOW
GRID

7.2.7 Dirty Water Building Management

The volume of annual precipitation that is harvested in the Dirty Water On-site Management area (Fig. 7.50 Pg. 203-04) is calculated at approximately **23% (684,000L) of the projects Passive water storage and harvesting profile**[52]. To optimize the efficiency of water treatment processes, Dirty water from exterior streetscapes, parking, and pedestrian pathways will be pre-filtered before water resources are drained into water treatment facilities**.** Pre-filtration is achieved by utilizing Bioswale allocations in Dirty Water On-site Management (Fig. 6.11 Pg. 114).



Streetscape Bioswale's function under the same premise as Passive landscape and Green roof activation, utilizing soil content, aquatic/landscape vegetation, and multi-tiered substrate fabrics to ensure the separation of urban debris from the water medium. Bioswale's have been placed as a buffering strategy to isolate and stop roadway debris from the Municipal Management Area into the NPW Management Area.

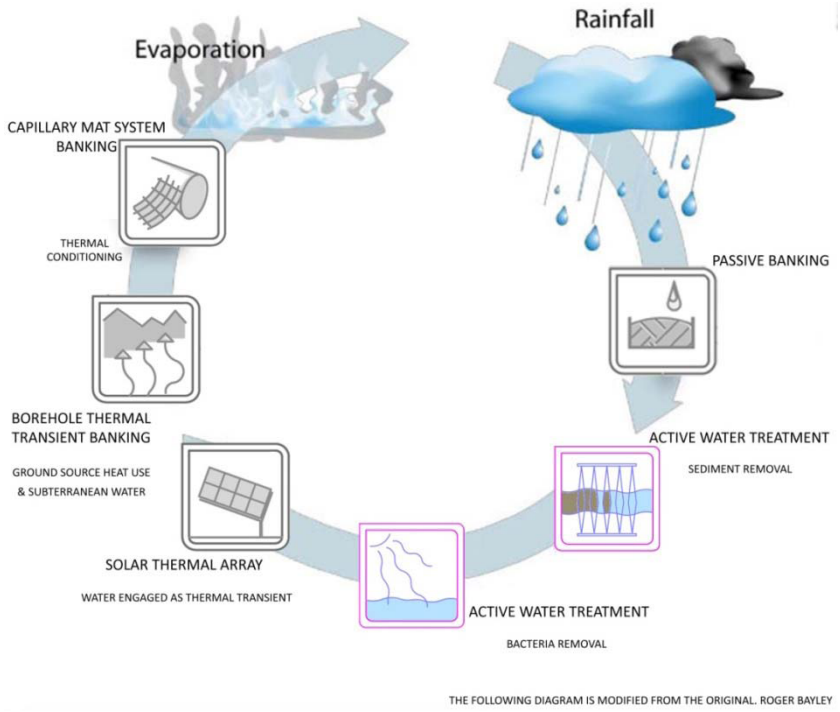


Figure 7.45

Active water treatment is targeted towards Greywater and Blackwater. Separating water waste is essential as the water medium must satisfy NPW standards before it is returned to the NPW water cycle. The two treatment systems act in unison to cleanse water resources.

Active water treatment has a large capacity with the added capability to ensure Greenwater and Bluewater quality on-site.

The mid-rise MURB will deploy a two-tiered water treatment program designed to manage water for inhabitant use in addition to building system use. The first tier of water treatment will be based on the removal of contaminant and waste materials. The second tier will focus on managing the quality of water with respect to bacteria and health considerations. Active Water Treatment processes will renew Dirty Water resources to Non-Potable, and Potable water quality.



Figure 7.46

Zenon Zeeweed membranes developed and installed in cassette form. System design allows for easy replacement and water quality assurance.

NPW mid-rise MURB shall deploy **Canadian based GE Zenon/Zeeweed modules for sediment and waste processing**[53] following the success of Victoria's Dockside Green Development. The system processes all water content from the NPW Management Area to remove sediment and bacteria from water resources. The system traps Dirty waterborne debris and human waste solids through varying gauges of stranded Ultra-fibers. The fibers utilize patented microscopic pores that physically block all suspended solids, producing Non-Potable water output.

Active water treatment must achieve a Class IV Wastewater Treatment Plant classification by the Environmental Operators Certification Program[54]. The Zenon module is capable of processing 25 gallons per minute (5.68 m^3/h) to effectively managing all of the wastewater in the pilot project[55]. The treatment module consists of a steel sausage tank bioreactor and Ultrafiltration assembly. The pilot project is a small application as the technology has been developed for community and district scale installations.



Figure 7.47

Zenon Module located at the head office in Oakville, Ontario. Forefront Initiatives Inc. is the prominent installer for this technology.

The treatment system will leave residual partitioned waste solids from the Blackwater processing. It is expected that a daily sum of one garbage-bag worth of de-hydrated Bio-solids will produced. Building management will designate specialized waste facilities to transition outbound waste material into usable compost. To ensure cleanliness and sanitation, the NPW MURB will replicate management methods developed by Dockside Green to produce brick form waste modules through specialized compression equipment. A designated waste management room is allocated adjacent to the NPW treatment facility on the PARKING.level.ONE floor (WS.r Fig. 7.44 Pg. 197-98).

The second tier of NPW water treatment utilizes **Trojan Technologies Ultra Violet Water Disinfection technology** to establish Potable water quality resources. Ultra Violet technology is only effective when water content achieves a minimum quality that allows light to pass through the medium. UV technology requires sediment removal from Zenon Ultrafiltration. The function of the treatment mechanism is capable of a maximum treatment rate up to 7.6 litres per minute.

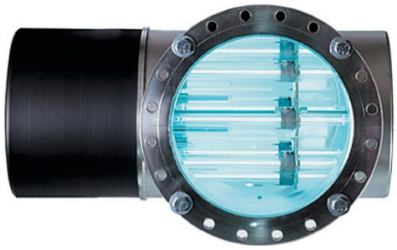


Figure 7.48

Clear Quality water is passed through the Ultra Violet lighting tubes and penetrates waterborne bacteria, thereby killing it.

The new technology by Trojan Technologies is capable of removing bacteria, waterborne diseases, and other micro organisms that are traditionally removed with chemicals (Chap. 5 Fig. 4.11 Pg. 54). Ultra violet light is emitted through specialized bulbs and penetrates the pre-treated water content from the first treatment tier. The light works in the same way as daylight, where ultra violet light capable of destroying all bacteria content in addition to removing unwanted odours.

UV water treatment maintains Clean water quality throughout the NPW building cycle without the use of harmful chemicals and the unnecessary removal of waterborne nutrients. All thermal storage systems including the Solar Thermal Array, Capillary Mat system, and Borehole Thermal Transient Storage rely on UV treatment to ensure the quality of water that is being utilized as an energized water transient. Water features and the naturalized waterway rely on UV treatment to ensure the safety of water contents in the pilot project.



Figure 7.49

The application of the UV treatment systems are deployed in

WTr.2 Fig. 7.1.9 Pg. 197-98

The UV water treatment system will also be utilized to assess inbound harvested Greenwater and Bluewater. Water quality assessed as Greenwater and Bluewater will be allowed to bypass treatment processes to prevent system redundancies. This will require an integrated control system that recognizes onsite water under the four key water quality categories[56]. The capabilities of the treatment system as well as a staffed operational facilitator will ensure the health and safety of inhabitants in cooperation with regional health regulations.

Potable water output shall be inspected by an On-site engineer once a week with health results delivered to public health authorities. This reduces the cost to maintain public health inspections as delivery to water inspection laboratories is a much more cost effective process than the alternative public health site inspection. Output potable water shall be directed towards NPW residential units for NZW provisioning via a system of primary and secondary pumps.

The water treatment capabilities derived from the combination of Ultrafiltration and Ultraviolet treatment have sufficient treatment capacity to intake excess water content beyond the volume of sustainably harvested water resources from the NPW Management Area. The pilot project has the treatment capacity to withdraw stagnant water from associative waterways such as the Keating Channel (Fig. 7.10 Pg.151) to function as a mechanism for urban water renewal. The channel is subject to poor water flow and decaying quality conditions, making the waterway an ideal candidate for additional water treatment.

The NPW building cycle will pump inbound waters from the Don River system via the Keating Channel and processes urban waters to ensure Clean Water quality. Water output from the NPW cycle will be delivered into the Lower Don Lands revitalized wetlands. The additional treatment capacity allows the pilot project to function as an integrated component of the urban water cycle, establishing regional water renewal.

The following drawings display the scale and application of Dirty Building and On-site Water Management on the Mid-rise pilot project.

- NPW Dirty Management Area
- South Streetscape Section
- Active Water Treatment Systems Section
- Dirty Water Building Management Areas
  Waste Management Areas



FIGURE 8.3.8



DIRTY WATER MANAGEMENT
A103

MMA	MUNICIPAL MANAGEMENT AREA
N.v	NATIVE VEGETATION
SB.s	STREET BIOSWALE
SP.p	STREET PERMEABLE PAVING
W	WATER FEATURE

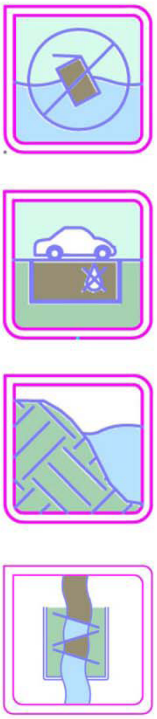


Figure 7.50

Dirty Water management surrounds the entire boundary of the site and the area consists of permeable paving and Bioswale solutions to mitigate the impact of Dirty streetscape conditions on the project and the NPW cycle.

Pedestrian pathways are designed to slope away from the building and into dedicated drains designed to direct dirty water directly into NPW IWT.

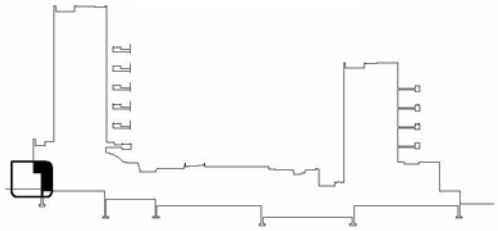
Roadways and parallel parking locations are subject to infiltration Gallery management.

ADHERES TO TBDP STREETSCAPE RATIO
ADHERES TO MGBR LEED NC SS
100% Dirty Water Management
100% EIA (Effective Impervious Area)
REFER THESIS CALCULATIONS

PROPERTY LINE
FLOOR ABOVE
WATER FEED & RETURN LINE
CANOPY ABOVE
GRID

STREETSCAPE WATER MANAGEMENT
NPW & MUNICIPAL DIVISIONS

SCALE 1:25 Figure 7.51



INDEX

SCREENING AGGREGATE

GRANULAR AGGREGATE

TOP SOIL

SILT-LOAM GROWTH MEDIUM

WATER DRAINAGE/RESERVOIR BOARD

BIOSWALE

ARBORIST MULCH/WOOD CHIP
250MM TOP SOIL
NON-WOVEN FILTER CLOTH
NON-COMPACTED SCREENING AGGREGATE
NON-COMPACTED GRANULAR BASE
GEOTEXTILE FILTER CLOTH MEMBRANE

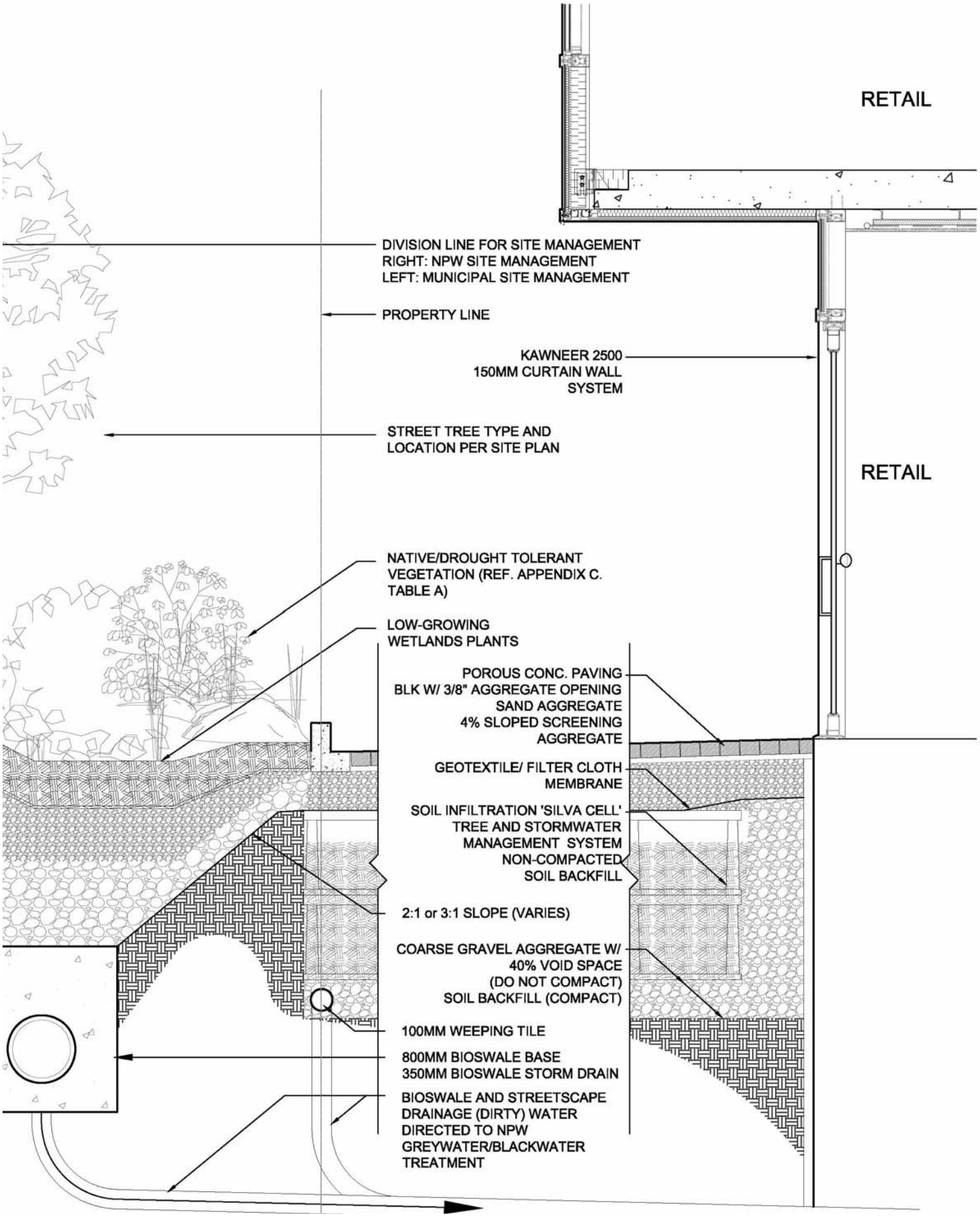
75MM STORMWATER DRAIN
PREVENTING STREETWATER FROM ENTERING NPW

POROUS CONCRETE
CEMENT SIDEWALK
2% SLOPE TOWARDS ROADWAY
DIRECITNG STORMWATER RUNOFF
TO MUNICIPAL MANAGEMENT
200 MM AGGREGATE SCREENING

150 MICRON GEOTEXTILE
ISOLATES ROADWAY CONTAMINATION

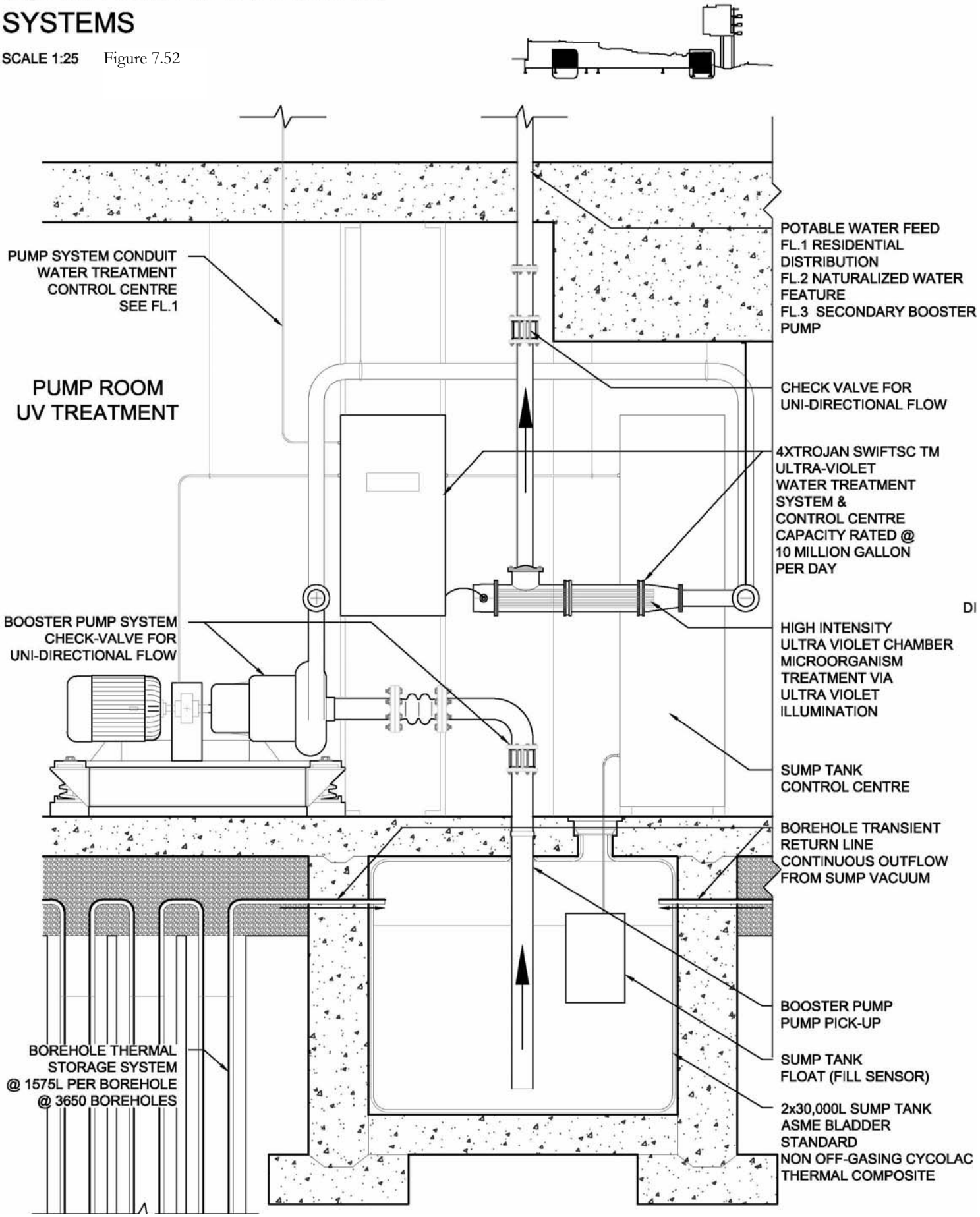
2.8 CUBIC METER
GRAVEL INFILTRATION GALLERY
ISOLATE VEHICLE CONTAMINANTS

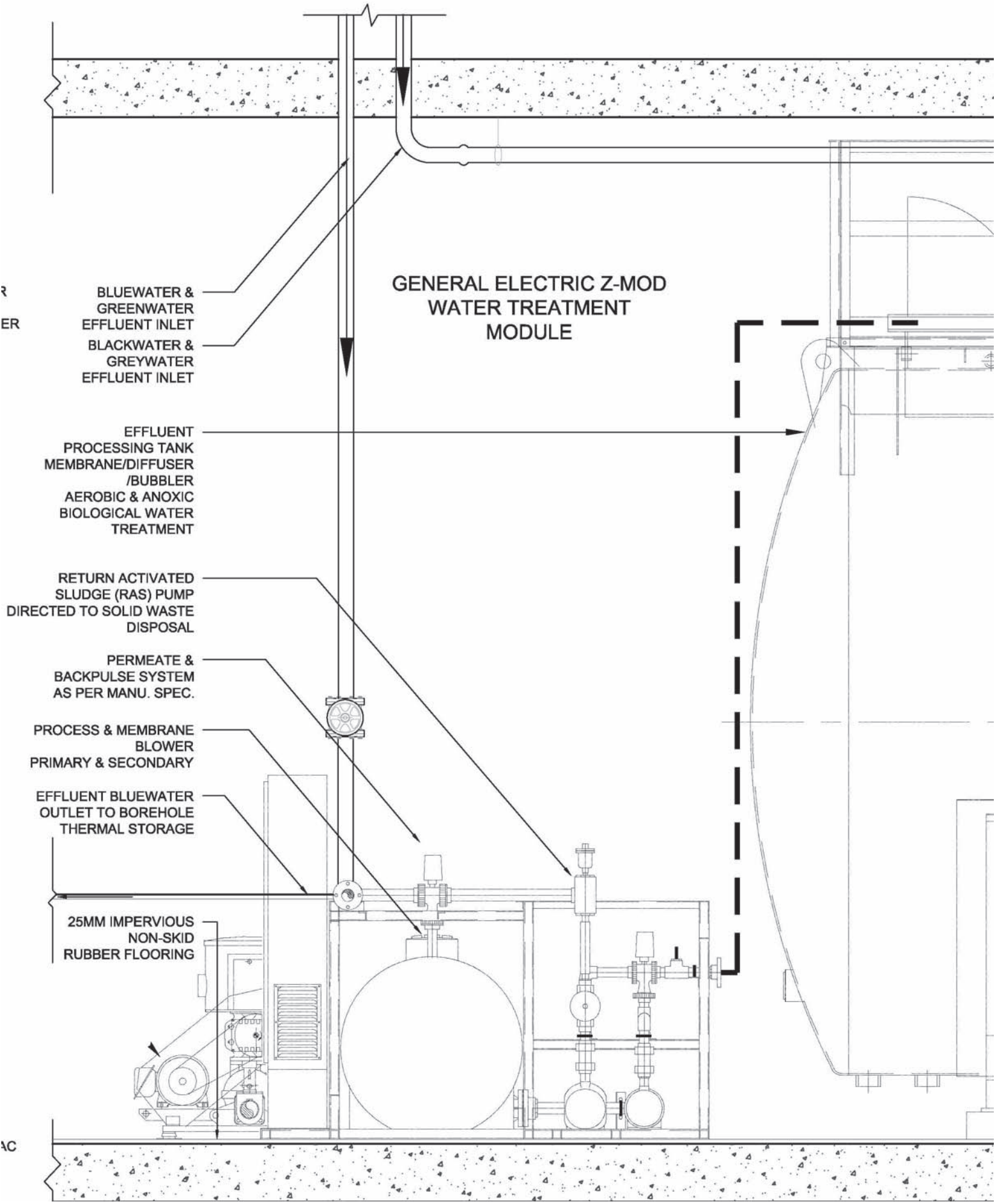
160MM DRAIN COLLECTOR
100MM WEEPING TILE
SLOPE TOWARDS
INVERTED CROWN
ROADWAY


RETAIL
DIVISION LINE FOR SITE MANAGEMENT
RIGHT: NPW SITE MANAGEMENT
LEFT: MUNICIPAL SITE MANAGEMENT
PROPERTY LINE
KAWNEER 2500
150MM CURTAIN WALL
SYSTEM
STREET TREE TYPE AND
LOCATION PER SITE PLAN
RETAIL
NATIVE/DROUGHT TOLERANT
VEGETATION (REF. APPENDIX C.
TABLE A)
LOW-GROWING
WETLANDS PLANTS
POROUS CONC. PAVING
BLK W/ 3/8" AGGREGATE OPENING
SAND AGGREGATE
4% SLOPED SCREENING
AGGREGATE
GEOTEXTILE/ FILTER CLOTH
MEMBRANE
SOIL INFILTRATION 'SILVA CELL'
TREE AND STORMWATER
MANAGEMENT SYSTEM
NON-COMPACTED
SOIL BACKFILL
2:1 or 3:1 SLOPE (VARIES)
COARSE GRAVEL AGGREGATE W/
40% VOID SPACE
(DO NOT COMPACT)
SOIL BACKFILL (COMPACT)
100MM WEEPING TILE
800MM BIOSWALE BASE
350MM BIOSWALE STORM DRAIN
BIOSWALE AND STREETSCAPE
DRAINAGE (DIRTY) WATER
DIRECTED TO NPW
GREYWATER/BLACKWATER
TREATMENT

ACTIVE WATER TREATMENT SYSTEMS

SCALE 1:25 Figure 7.52




GENERAL ELECTRIC Z-MOD
WATER TREATMENT
MODULE
BLUEWATER &
GREENWATER
EFFLUENT INLET
BLACKWATER &
GREYWATER
EFFLUENT INLET
EFFLUENT
PROCESSING TANK
MEMBRANE/DIFFUSER
/BUBBLER
AEROBIC & ANOXIC
BIOLOGICAL WATER
TREATMENT
RETURN ACTIVATED
SLUDGE (RAS) PUMP
DIRECTED TO SOLID WASTE
DISPOSAL
PERMEATE &
BACKPULSE SYSTEM
AS PER MANU. SPEC.
PROCESS & MEMBRANE
BLOWER
PRIMARY & SECONDARY
EFFLUENT BLUEWATER
OUTLET TO BOREHOLE
THERMAL STORAGE
25MM IMPERVIOUS
NON-SKID
RUBBER FLOORING


S.aA2
S.aA
S.aA
S.aA
R.bP
W
R.bV
R.bE
R.bC
S.bB
S.bB
S.bB
Rs.bL
Ma.r
R.bB
R.bG
R.bG
Mng.r
WC
RS.GR
Mech.r
Ld.C
EIA
Mech.r
RS.GR
Mr
WC
Ma.r
R.aL
R.aE
R.aC
W
R.aV
Mech.r
S.dD
S.dD
S.dD
FL.2
FL.2
FL
1
1x
2
2x
3
3y
4x
4y
4z
5
6
7
8
A
B
C
D
E
F
Kx
2y
3x
3z
4
5x
5y
5y
6x
6y
7x
8x
9x
11

FIGURE 8.3.8

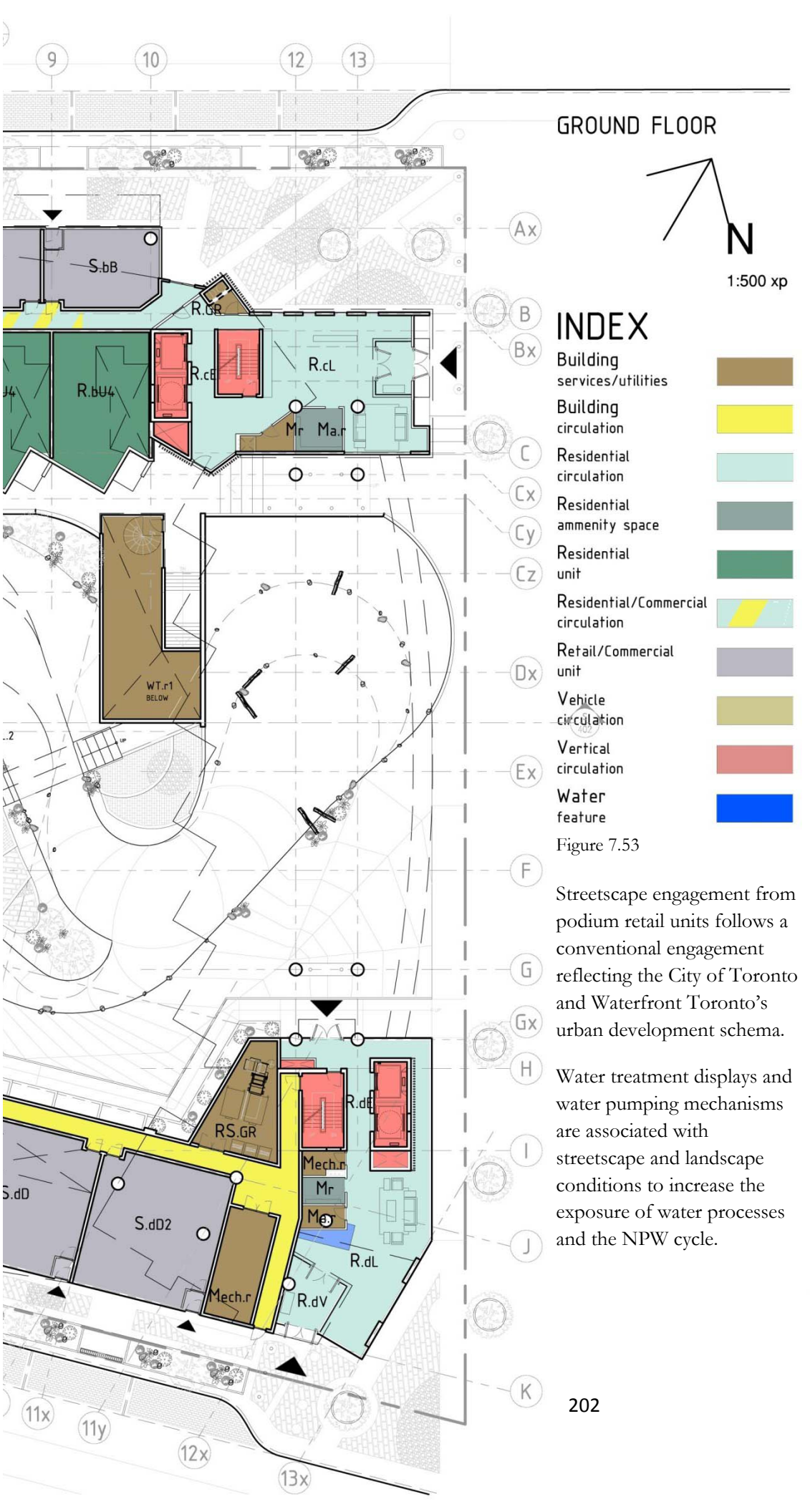


Figure 7.53

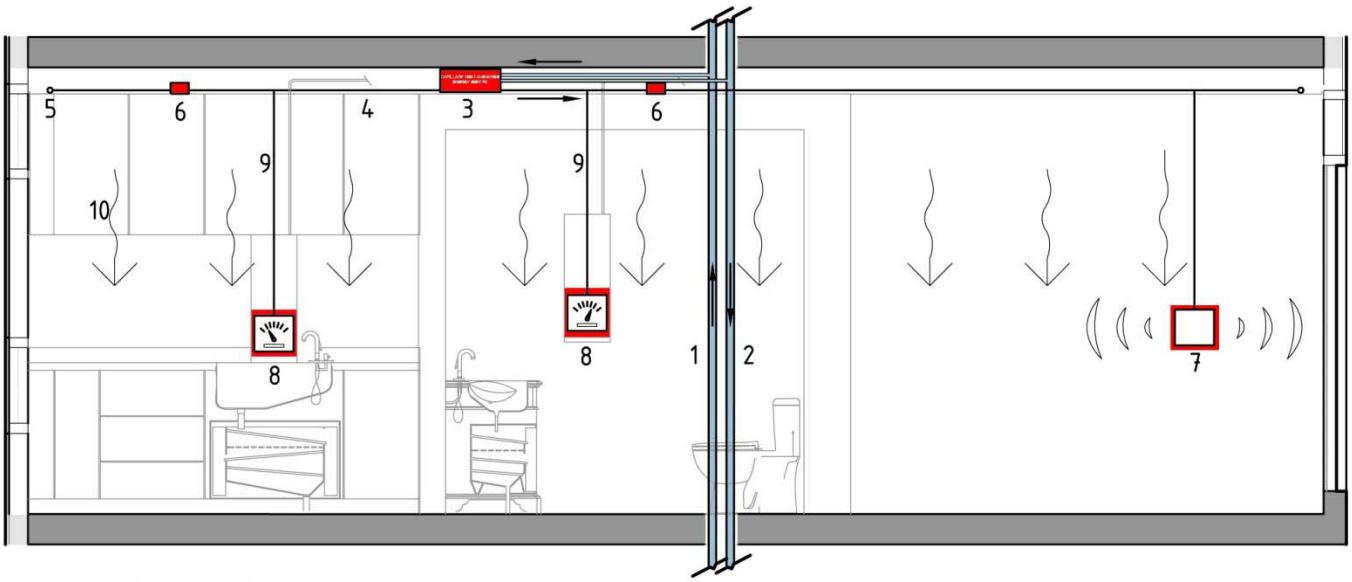
Streetscape engagement from podium retail units follows a conventional engagement reflecting the City of Toronto and Waterfront Toronto's urban development schema.

Water treatment displays and water pumping mechanisms are associated with streetscape and landscape conditions to increase the exposure of water processes and the NPW cycle.

7.2.8 Net Zero Water Residential Units

Net Zero Water residential units situated in the Mid-rise pilot project is provided with independent Potable, and Non-Potable water provisions for inhabitant use. Potable and Non-Potable water is independently fed from the buildings water treatment systems once the quality of Potable water provisions has been inspected. Potable and Non-Potable water drainage is directed into the buildings water treatment infrastructure as Greywater. Post-consumed Greywater is filtered under NZW management, separating inhabitant debris while water resources are drained into UV treatment mechanisms to removal remnant bacteria.

Monitoring and metering stations are situated at each location of Non-Potable and Potable water demand in unit Kitchens, Lavatories/Washrooms, and Bathrooms as prescribed by Net Zero Water Guidelines and Standards. The monitoring devices display the Time-of-Use and economic cost of use of water resources based on the number of inhabitants that are pre-programmed into household monitoring systems. Monitoring performance is based on the number of inhabitants in each residential unit multiplied by Net Zero Water sustainable use at 70 litres per capita per day.



SECTION.UNIT.TYPICAL
CAPILLARY MAT SYSTEM

INDEX

1 CAPILLARY MAT FEED (NPW CYCLE)
2 CAPILLARY MAT RETURN (NPW CYCLE)
3 CAPILLARY MAT ENERGY CENTRE (WATER THERMAL TRANSFER STATION)
4 CAPILLARY MAT (POLYPROPYLENE COPOLYMER 15mm x length)
5 CAPILLARY RETURN LINE TO ENERGY CENTRE
6 DEWPOINT SENSOR (KITCHEN & WASHROOM)
7 DIGITAL THERMOSTAT & MONITORING STATION WIRELESS NETWORK FOR OFF-SITE ACCESS
8 WATER USE METERING DEVICE
9 METERING DATA FEED TO MONITORING STATION
10 RADIANT CONDITIONING

Figure 7.54 SCALE 1:50

Active water metering and monitoring devices will be installed following the 'PowerTab' systems applied in Dockside Green.

The following drawings display the water provisioning and drainage of Net Zero Water residential units situated in the mid-rise pilot project:

- Diagram NZW Potable and Non-Potable Plumbing network
- Net Zero Water Unit Design Plan
- Net Zero Water Unit Potable and Non-Potable water provisions Unit Design Plan
- Net Zero Water Unit application situated in the mid-rise pilot project Third Floor Plan
- Vignette of perspective from the Net Zero Water Unit application
- Typical Mid-rise pilot project residential floor layout

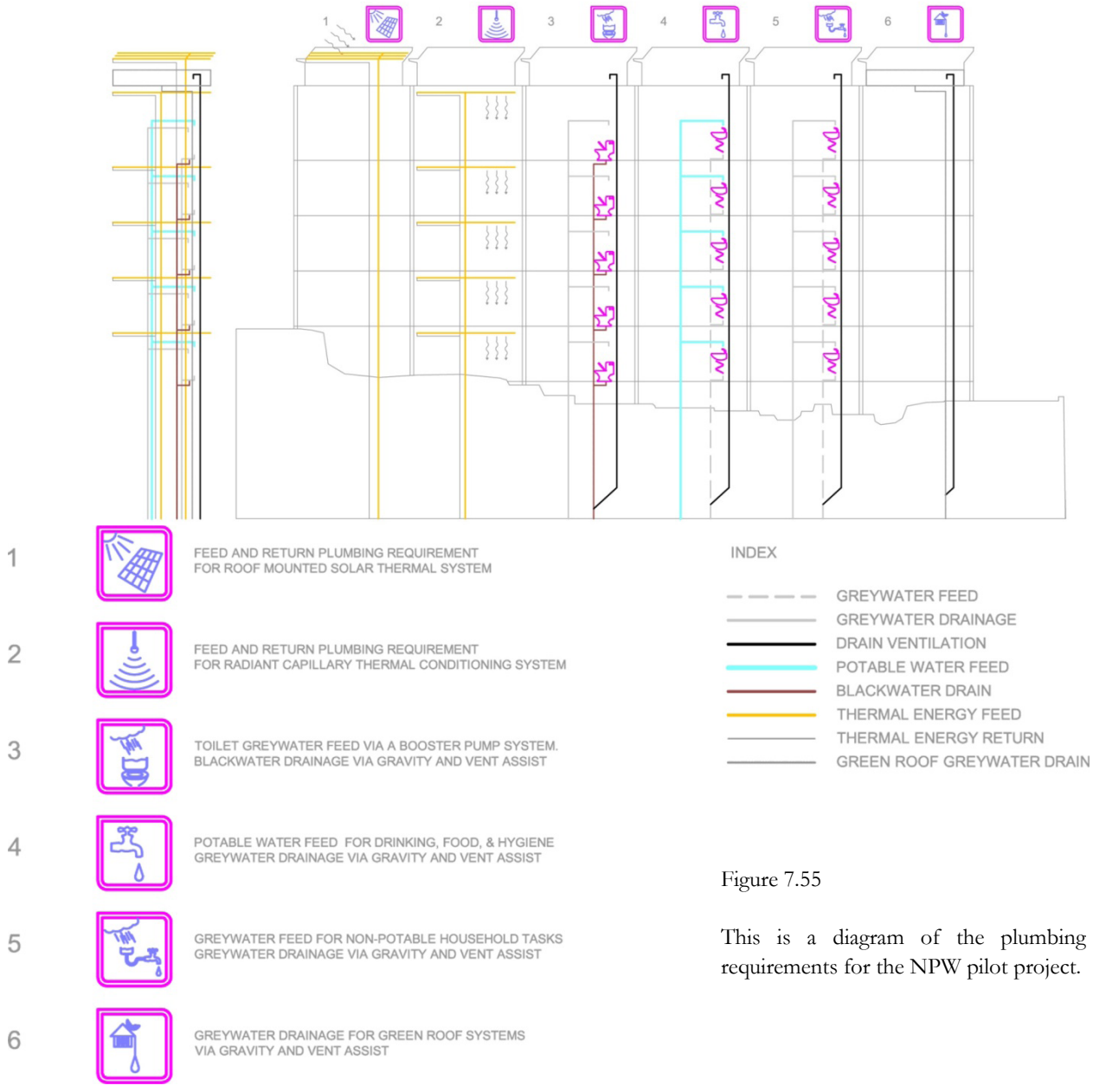


Figure 7.55

This is a diagram of the plumbing requirements for the NPW pilot project.



UNIT.02

1 + DEN 2 PERSON OCCUPANCY

INDEX
1 DINING
2 KITCHEN (WATER)
3 LIVING
4 MASTER BEDROOM
5 WALK-IN CLOSET
6 WASH CLOSET
7 BATHROOM/SHOWER
8 DEN
9 BALCONY/TERRACE

Figure 7.56

The following is a diagrammatic layout of typical NZW residential units designed for the NPW pilot project. The units are designed for Potable and Non-Potable water provisions.

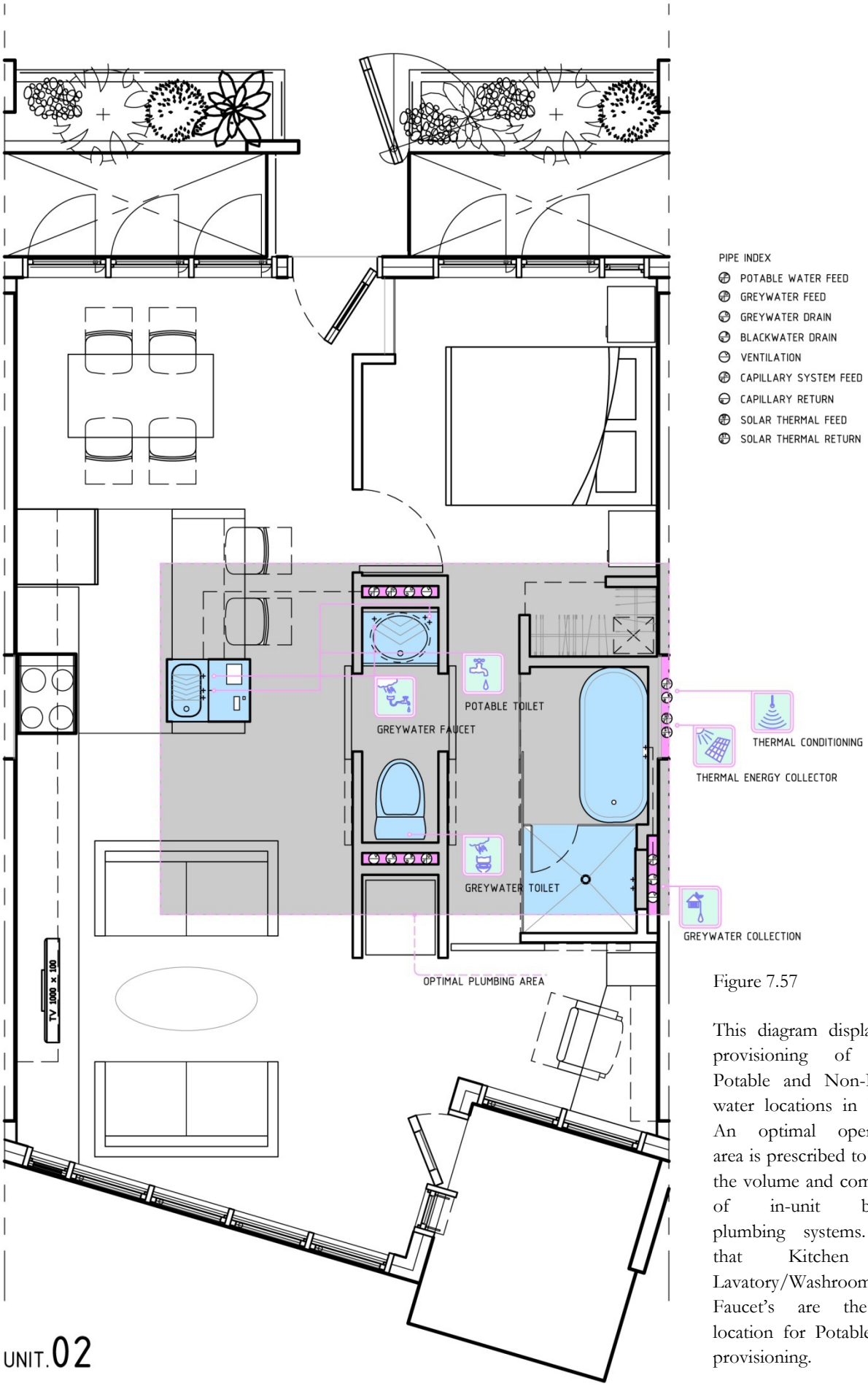
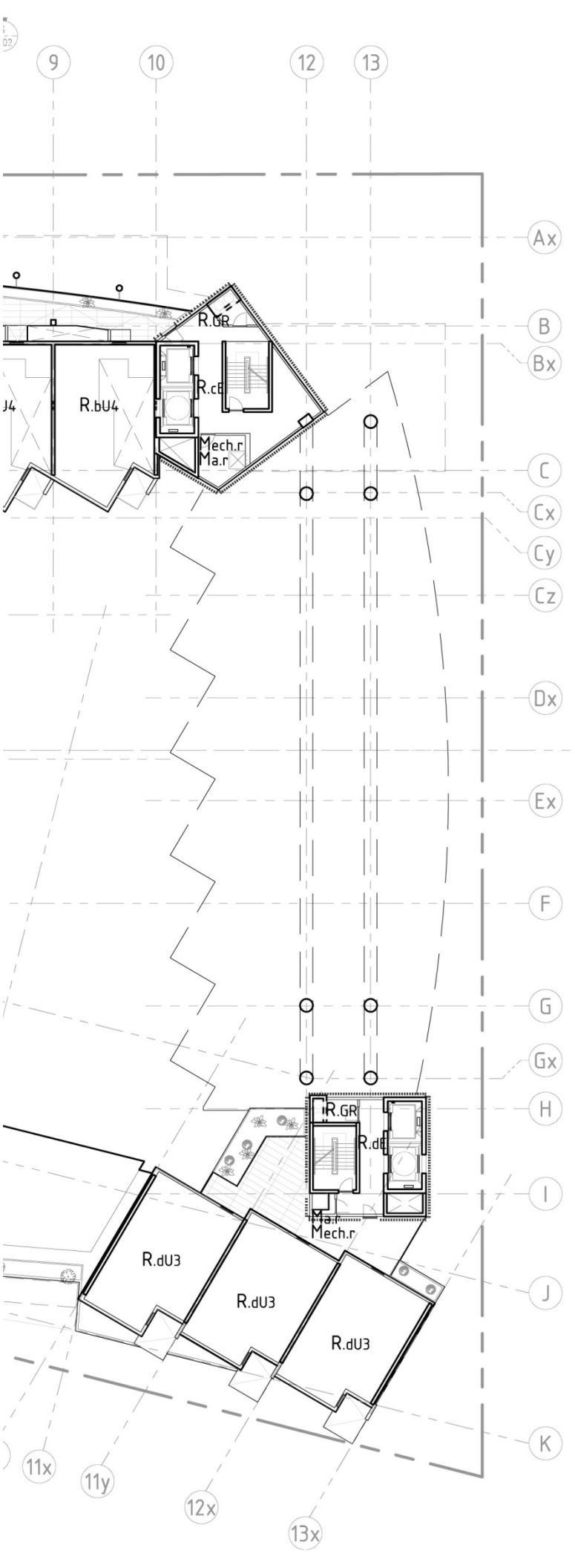


Figure 7.57

This diagram displays the provisioning of NZW Potable and Non-Potable water locations in PLAN. An optimal operational area is prescribed to reduce the volume and complexity of in-unit building plumbing systems. Note that Kitchen and Lavatory/Washroom Faucet's are the only location for Potable water provisioning.


G.rp
S.pv
S.pv
N.v
W
R.bE
Mech.r
Ma.r
R.GR
R.bU2
R.bU2
R.bU3
R.bU3
R.aU1
R.aU1
NZW
Application
R.aU3
FIGURE 8.3.7
S.pv
N.v
S.pv
W
S.pv
G.rp
Ma.r
Mech.r
R.GR
R.aE
R.aU1
R.aU1
R.aU1
R.aU3
R.aU1
R.aU2
G.rp
W
1
1x
2
2x
3
3y
4x
4y
4z
5
6
7
8
A
B
C
D
E
F
Kx
2y
3x
3z
4
5x
5y
5y
6x
6y
7x
8x
9x
11



N

1:500 xp

THIRD FLOOR

BUILDING.a A205

R.aE	ELEVATOR-BLDG.a
R.aU1	RESIDENTIAL UNIT
R.aU2	RESIDENTIAL UNIT
R.aU3	RESIDENTIAL UNIT
R.aU4	RESIDENTIAL UNIT
	TWO Storey 2-Bedroom
	Unit4 85m² (917sq.ft.)

BUILDING.b

R.bE	ELEVATOR-BLDG.b
R.bU1	RESIDENTIAL UNIT
R.bU2	RESIDENTIAL UNIT
R.bU3	RESIDENTIAL UNIT
R.bU4	RESIDENTIAL UNIT
	TWO Storey 2-Bedroom
	Unit4 85m² (917sq.ft.)

BUILDING.c

R.cE	ELEVATOR-BLDG.c

BUILDING.d

R.dE	ELEVATOR-BLDG.d
R.dU3	RESIDENTIAL UNIT
R.dU4	RESIDENTIAL UNIT
	TWO Storey 2-Bedroom
	Unit4 85m² (917sq.ft.)

Ma.r	MAINTENANCE ROOM Greywater Provision
Mech.r	MECHANICAL ROOM Water Pump & Filtration Systems Greywater Quality monitor
R.GR	GARBAGE/RECYCLING
S.pv	PHOTOVOLTAIC PANELS
W	WATER FEATURE

G.rp	GREEN ROOF SYSTEM podium
N.v	NATIVE VEGETATION

PROPERTY LINE
FLOOR ABOVE
CANOPY ABOVE
FLOOR BELOW
GRID
TOPOGRAPHY

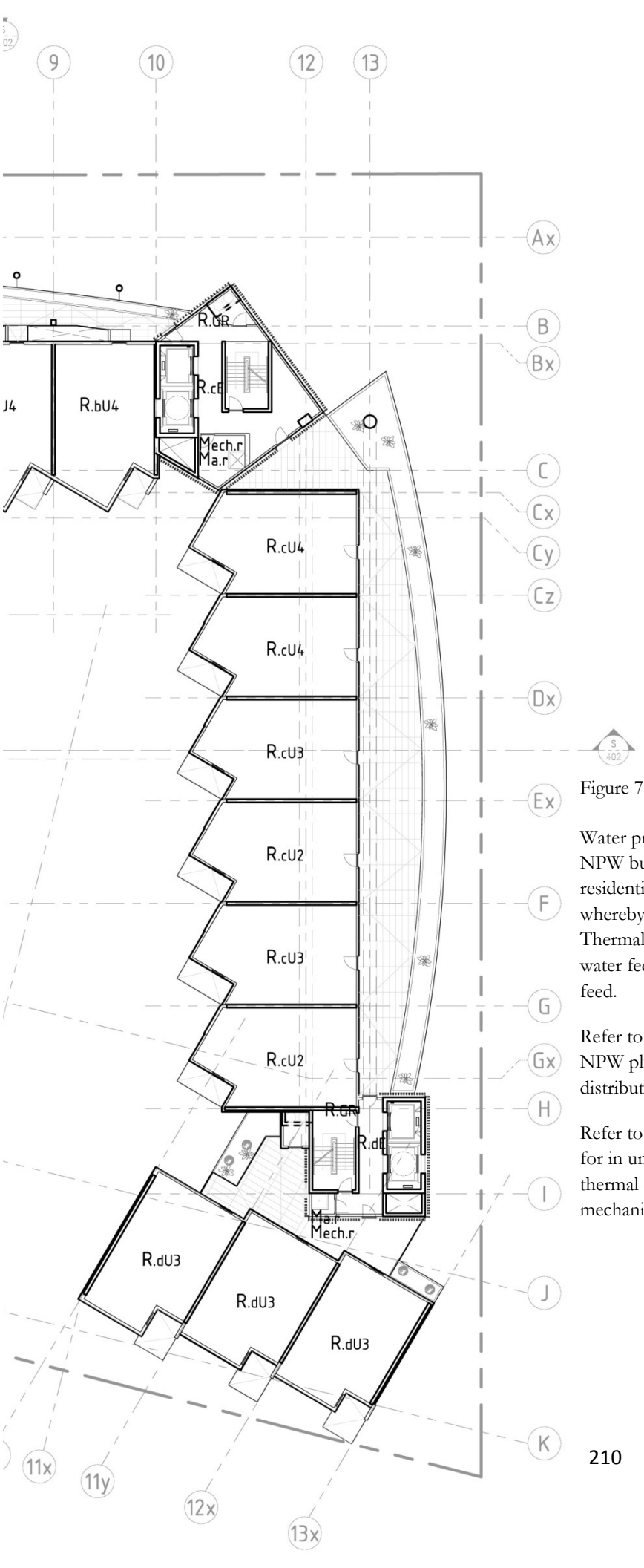
Figure 7.58

The third storey must function to pump NPW resources as a component of the water cycle. Water is fed up from **Mech.r** pumps on the Ground floor and into the podium Water Features and Waterway.

All inhabitant pathway paving is permeable and drains towards associative landscape area and rooftop planters. Inhabitants are encouraged to inhabit amenity and landscape areas to emphasis environmental exposure and Passive living conditions.

The Net Zero Water residential unit application is situated in Tower B.


1
1x
2
2x
3
3y
4x
4y
4z
5
6
7
8
A
B
C
D
E
F
Kx
R.bE
Mech.r
Ma.r
R.GR
R.bU2
R.bU2
R.bU3
R.bU3
R.aU1
R.aU1
R.aU1
R.aU3
S
NPW
S
402
Ma.r
Mech.r
R.GR
R.aE
R.aU1
R.aU1
R.aU1
R.aU3
R.aU1
R.aU2
2y
3x
3z
4
5x
5y
5y
6x
6y
7x
8x
9x
11
S
A401



N

1:500 xp

A206

TYPICAL RESIDENTIAL FLOOR 4-6

BUILDING.a

R.aE	ELEVATOR-BLDG.a
R.aU1	RESIDENTIAL UNIT
R.aU2	RESIDENTIAL UNIT
R.aU3	RESIDENTIAL UNIT

BUILDING.b

R.bE	ELEVATOR-BLDG.b
R.bU1	RESIDENTIAL UNIT
R.bU2	RESIDENTIAL UNIT
R.bU3	RESIDENTIAL UNIT
R.bU4	RESIDENTIAL UNIT
	TWO Storey 2-Bedroom
	Unit4 85m² (917sq.ft.)

BUILDING.c

R.cE	ELEVATOR-BLDG.c
R.cU2	RESIDENTIAL UNIT
R.cU3	RESIDENTIAL UNIT
R.cU4	RESIDENTIAL UNIT
	TWO Storey 2-Bedroom
	Unit4 85m² (917sq.ft.)

BUILDING.d

R.dE	ELEVATOR-BLDG.d
R.dU3	RESIDENTIAL UNIT
R.dU4	RESIDENTIAL UNIT
	TWO Storey 2-Bedroom
	Unit4 85m² (917sq.ft.)

Ma.r	MAINTENANCE ROOM
	Greywater Provision
Mech.r	MECHANICAL ROOM
	Water Pump & Filtration Systems
	Greywater Quality monitor
R.GR	GARBAGE/RECYCLING

PROPERTY LINE
FLOOR ABOVE
CANOPY ABOVE
FLOOR BELOW
GRID
TOPOGRAPHY

Figure 7.59

Water provisioning in the NPW building follows NZW residential unit demands whereby each unit requires Thermal water feed, Potable water feed, and Greywater feed.

Refer to Fig. 7.55 Pg. 212 for NPW plumbing and drainage distribution.

Refer to Fig. 7.36-7 Pg.187-88 for in unit NPW Active thermal conditioning mechanisms

Figure 7.60

Viewpoint and environmental perspective from Net Zero Water Unit Balcony.

N.T.S.





7.3 Conclusion of the Mid-rise Pilot Project

The NPW pilot project is an exercise to display the architectural considerations of Passive and Active water processes to achieve cyclic water use and water renewal. Water independence is achieved such that residential inhabitants no longer depend on the aging infrastructure of municipal water utilities. Sustainable water harvesting mitigates the impact of urban intensification and building form on the urban water problem. Sustainable water use as a result of sustainable water harvesting enables the NPW pilot project to integrate as a sustainable component of the urban water cycle.

NPW and NZW requirements are satisfied by the 'Building as a Sponge' strategy utilizing Passive and Active mechanisms to store harvested water resources. The project showcases that mid-rise building typology has the capability to support urban residential intensification in addition to combating the urban water problem. The building methodology achieves a calculated level of performance to generate Net Positive Water.

7.3.1 Net Positive Water Building Performance

The performance of the pilot project has been calculated based on a 1-year operational duration to produce Net Positive Water quality beyond the requirements of Net Zero Water inhabitant demand. The cumulative volume of the mid-rise pilot project through Active and Passive strategies accounts to a total annual storage capacity of **8,465,935L**. This volume is greater than the total annual precipitation volume sustainably harvested at a calculated maximum of **7,839,665L**. Under the design of Guidelines of Net Positive Water, the mid-rise pilot project is able to achieve water independence through On-site water storage.

Passive Banking accounts for approximately 32% of the Building as a Sponge performance profile while the Active Borehole and Capillary thermal systems make up the remaining 68%. The calculated capacity of the mid-rise construction is designed to support the total expected number of 307 inhabitants on site at 70LPCD NZW consumption without any Potable water demand on the municipal water utility. An **excess Banking capacity of 626,289L (8%)** has been achieved beyond the annual precipitation volume to supply against evaporative loss, overuse from NZW inhabitants as they adhere to NZW conservation targets, and reserve clean water resources as a result of Net Positive Water treatment processes.

Multi-year building operation accounts for a compound sum of water resources harvested each year. Positive Water contribution can be affectively achieved after the first year of building operation. Multi-year building operation enables the building to harvest a greater sum of sustainable water resources, but the sum will inevitably overwhelm the buildings water storage performance capacity.

This is not a detriment to the capability of the pilot project, as Net Positive Water quality can be generated continuously under the buildings water cycle. The result is a building that can contribute positively to regional environmental renewal as NPW harvested resources must be released from the site. The release of the water is of potable and beyond tertiary quality, enabling the NPW pilot project to function as a component of the urban water cycle. **A Positive Water contribution of 8,465,935L[57] can be generated at the end of the 2nd year of pilot project operation and a concurrent sum of the same volume each and every year.**

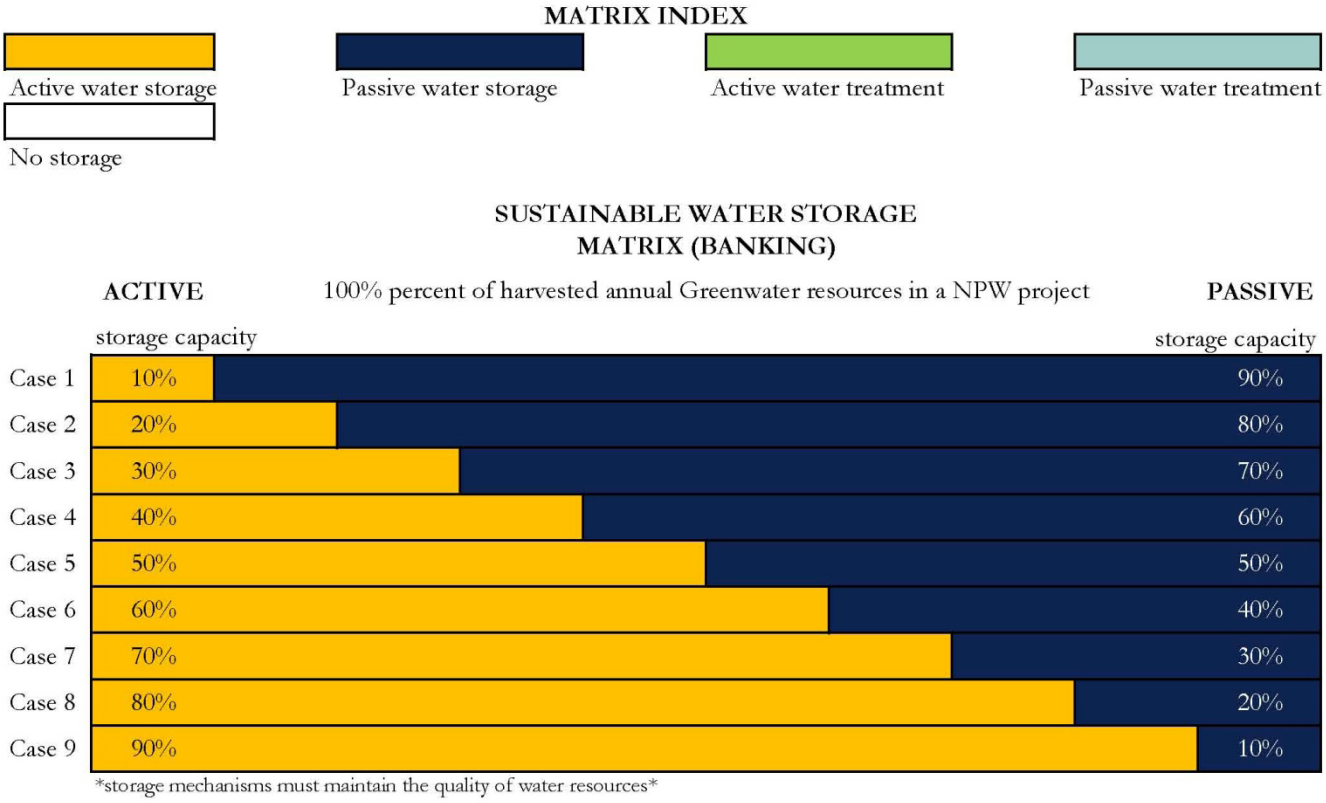
All supporting Net Zero and Net Positive Water calculations have been provided in Appendix E, Section One & Two.

7.3.2 Net Positive Water Matrix

The Net Positive Water Matrix outlines the relationship between the Passive and Active capabilities of NPW building typology. The matrix consists of a series of tables displaying the allocation of project responsibilities for sustainable water storage and water treatment. The focus of the matrix is to identify how sustainable water, generated in NPW building form is able to establish Positive water quality and quantity.

The emphasis of the matrix will focus on the Passive capabilities of a project. Passive water storage in landscape soil medium naturally filters and separates urban debris from harvested Clean water. Bluewater Water Features and the pilot project Waterway utilize natural 'Daylighting' for Passive ultraviolet treatment to maintain Clean water. NPW Bioswale landscape elements utilize the Passive capability of resilient vegetation and native plant species to filter Dirty water.

Positive water performance will be shown based on a 1-year operational timeline. The NPW building cycle continuously replenishes water resources and releases water content.



Active water storage mechanisms consist of the following:	**Passive water storage mechanisms consist of the following:**
Rain Barrels (induce flow)	Green Roofing Systems
Cisterns (induce flow)	Vegetation Planters
Storage Tank (bladder, pillow, pressure)	Landscape sod with supporting soil content
Condensing units (heat transfer thermal conditioning)	Paving substrate
Radiant heating systems (no water additives, no corrosive construction)	Bioswale Landscaping with supporting substrate
Ground source heat pumps utilizing greywater	Water Features (induce flow)
Solar Thermal Array utilizing greywater	Naturalized Waterway (induce flow)

Table 7.1

Building Cases 1 through 9 establish simplified ratios between Passive and Active water storage and the resultant capacity for NPW building typology to Passively filtrate/treat water. Case 1 displays a 90% Passive water storage capability reflecting the maximum Passive water filtration/treatment capability. Case 9 displays a 10% Passive water storage capability reflecting a minimum Passive water filtration/treatment capability.

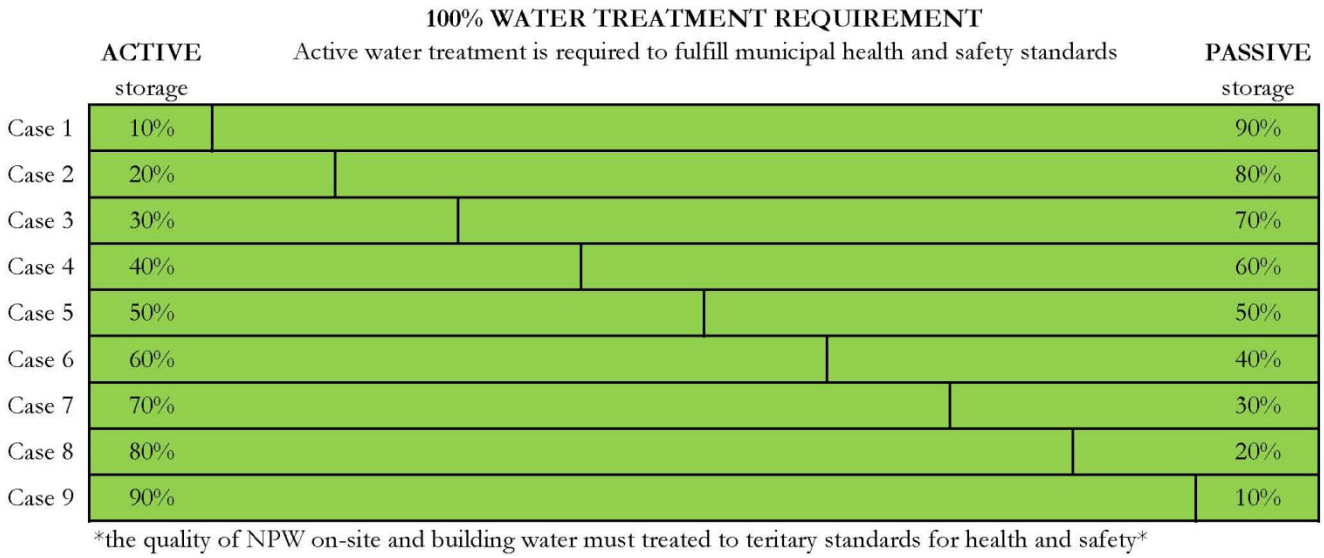


Table 7.2

Although Passive water storage maintains Clean water conditions, Passive water storage resources are subject to Active water treatment processes. The design of Active water treatment must have sufficient capacity to treat all project water resources. The process of water treatment is continuous.

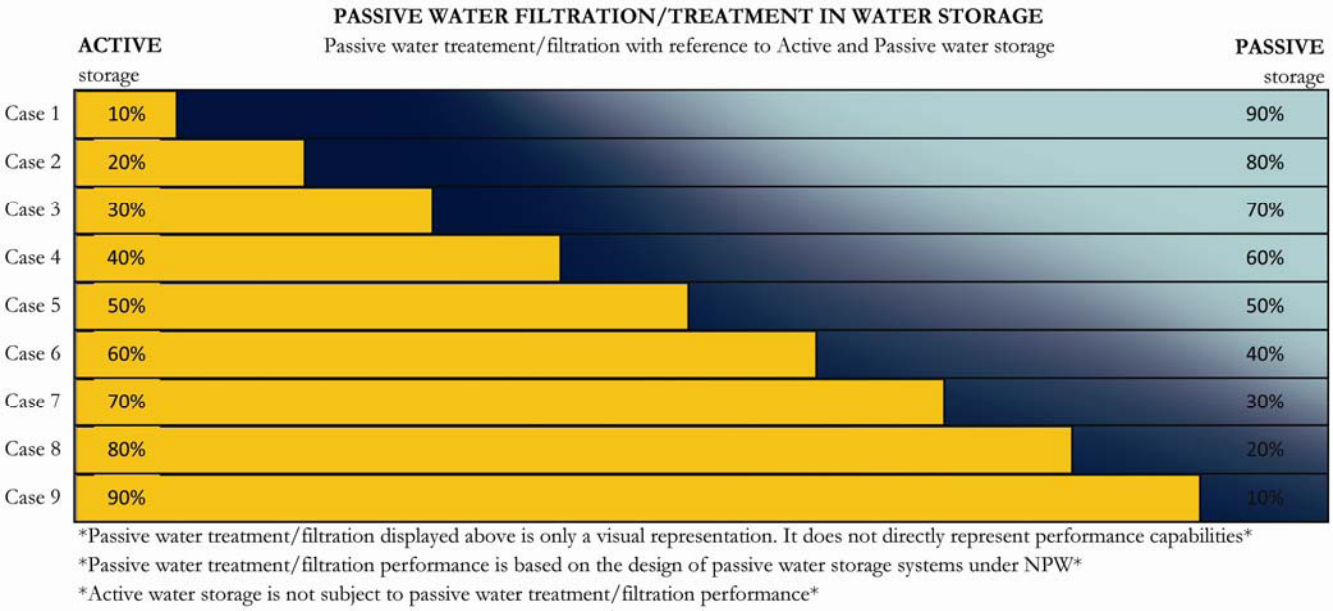


Table 7.3

Passive water filtration adds additional capability and capacity to the NPW pilot project to treat water resources. Passive water filtration is a 'by-product' of Passive water storage for annual NZW inhabitant use. Passive water storage in NPW on-site conditions duplicates the water renewal capabilities of a natural landscape in the urban water cycle.

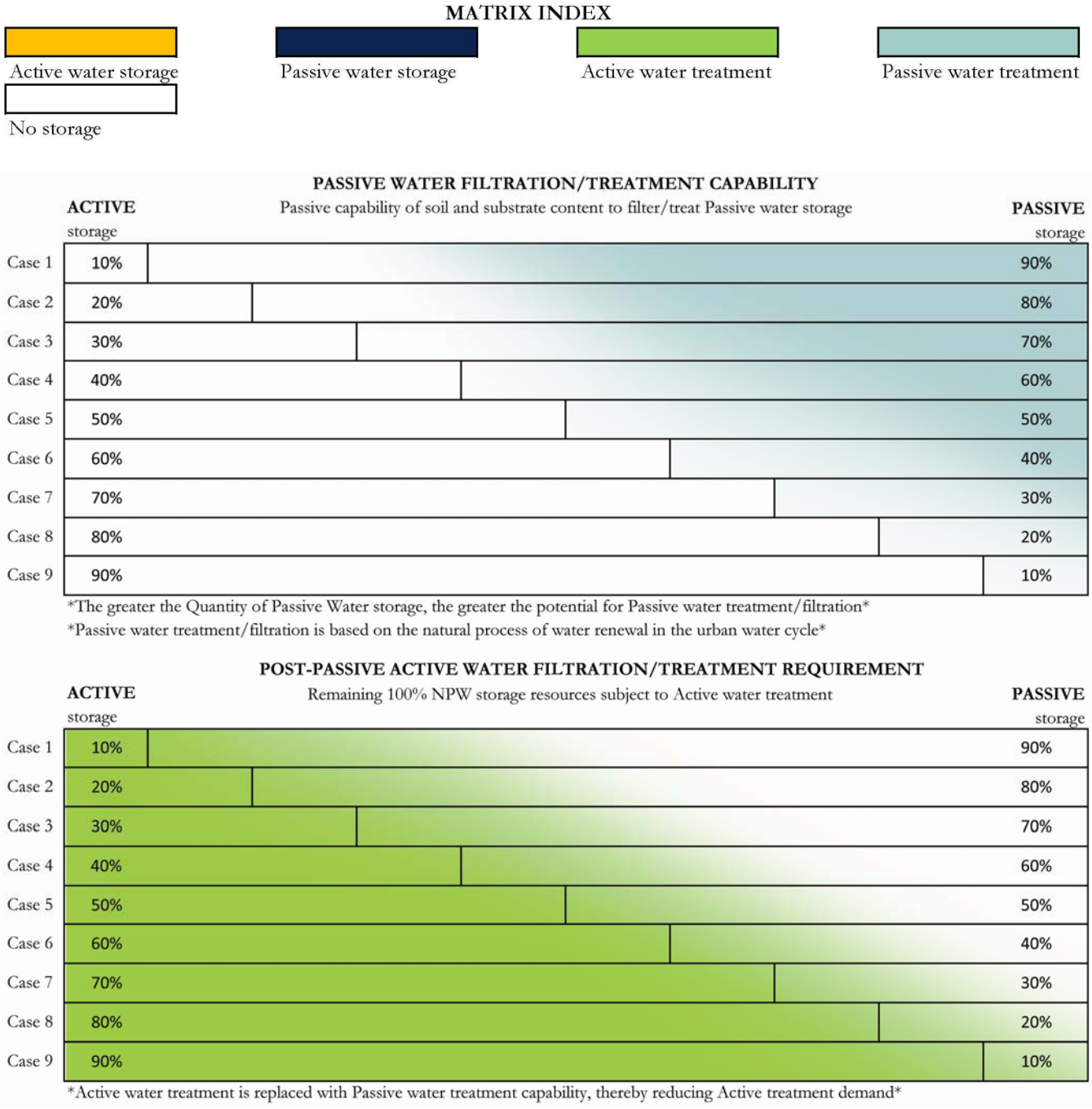
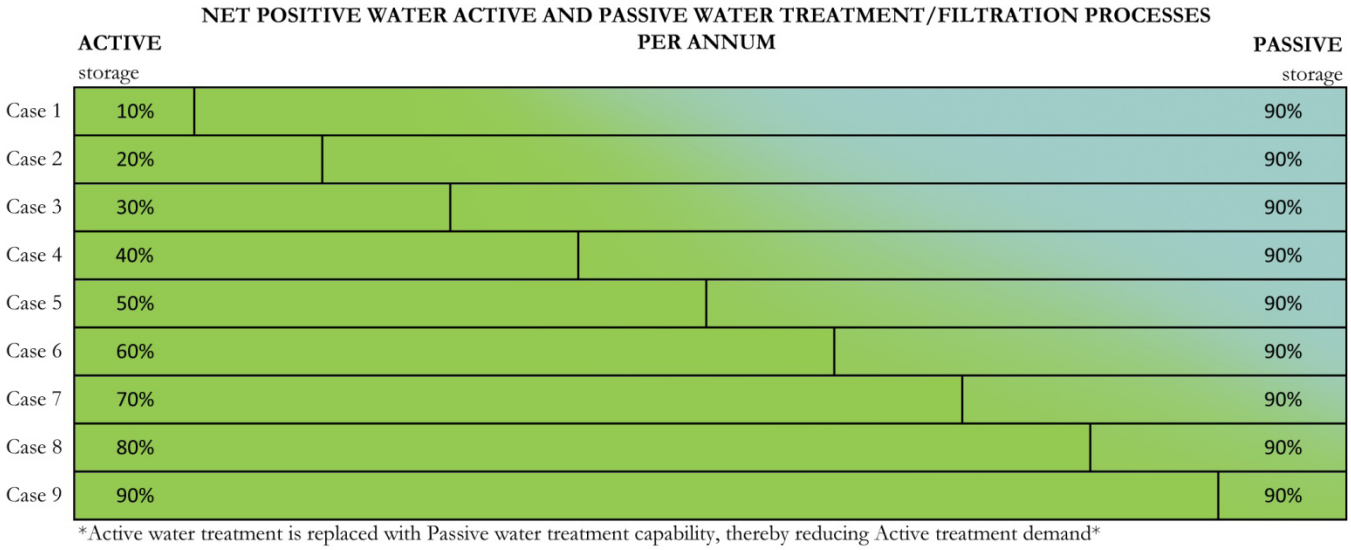


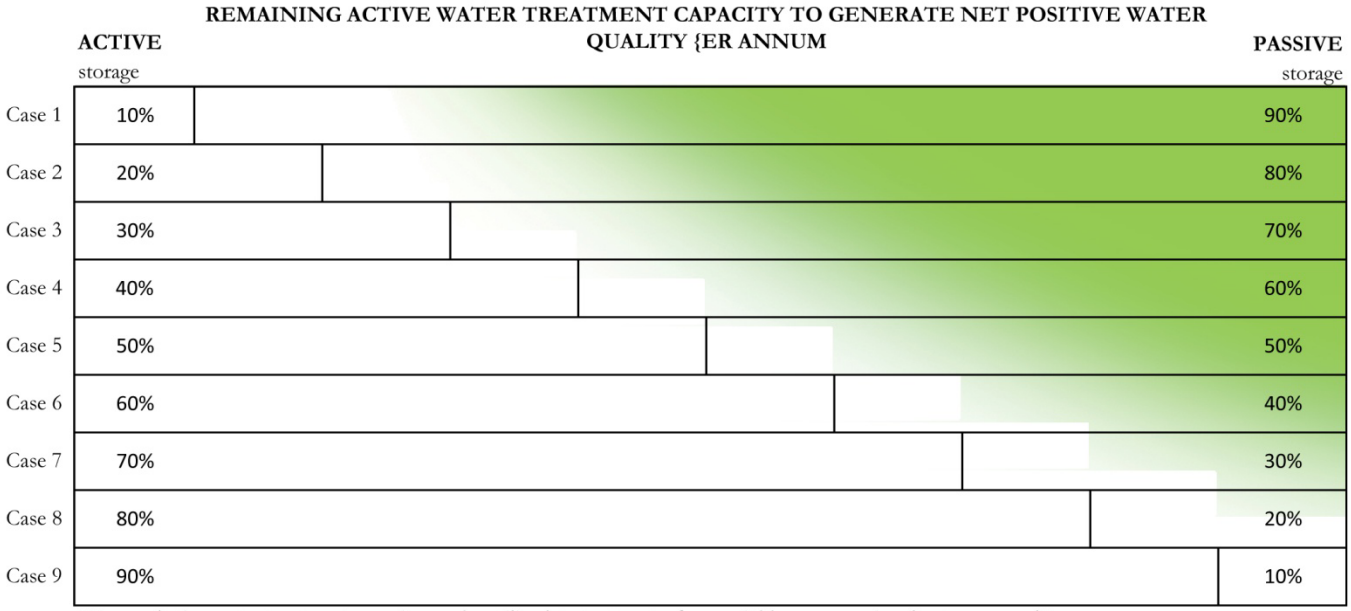
Table 7.4-5

Stored water resources in Passive Clean water conditions will only require Ultraviolet disinfection and treatment to remove harmful bacteria's without the need for Ultrafiltration sediment treatment. The result is excess Active water treatment capability without the need to increase Active water storage.



Active water treatment is replaced with Passive water treatment capability, thereby reducing Active treatment demand

Passive water treatment does not function during the winter season as a result of frost conditions



Excess Active water treatment capacity can be utilized to treat water from neighbours or regional water renewal

Table 7.6-7

The relationship between Passive and Active water treatment and filtration establishes excess Active water treatment capacity. Excess treatment capability can be utilized to generate a Net Positive quantity of Clean water under an open loop system in the NPW building cycle. An open loop of Dirty water intake and Clean water outflow allows the NPW mid-rise pilot project to generate a Net Positive quantity of Clean quality water.

Endnotes:

[1] Roaf, Sue. Ph.D. 2009. *Adapting Buildings and Cities for climate change, A 21st Century Survival Guide. Second Edition.* Chap.12-Pg.253

[2] Doug Farr, Author of Sustainable Urbanism: Urban Design with Nature is a building specialist for Green building and Green neighbourhood development.

[3] Based on City of Toronto Census profile from the year 2001-2011 documenting population increase in conjunction with increases in occupied dwelling units

[4] Smart Growth is a development initiative to ensure strong economics, build strong communities, and create a clean and healthy environment

[5] Known as 'Chicago Construction', Balloon framing methods were utilized in Canada.

[6] Mid-rise construction benefits proposed by the City of Toronto Mid-rise Symposium exploring Mid-rise construction

[7] Domestic water pressures are distributed in excess of 85-100 psi

[8] The following municipal organizations encourage mid-rise construction to improve urban streetscapes:
City of Toronto references, Avenue Studies, Transit City, Tall Buildings – Inviting Change in Downtown Toronto, Toronto Green Standard, Mid-Rise Symposium, Main street initiative, Zoning By-Law Project, Tower Renewal

[9] Canadian Mortgage and Housing Corporation has documented increased water sensitivity in urban design Refer to urban water crisis impervious surfaces leading to urban water volatility

[10] City of Toronto, Toronto Water, Water Facts

[11] Toronto Green Standard will wave development charges based on sustainable building performance

[12] http://trca.on.ca/the-living-city/green-infrastructure-projects/environmental-assessment-projects/don-mouth-naturalization-and-port-lands-flood-protection-project/whats-new.dot

[13] Maximum precipitation volume provided by the City of Toronto – Toronto Water

[14] Refer to Chapter 7 Section 7.1.0 Pg.117 NPW On-site Pre-requisites

[15] Chicago Distribution is the name of the urban storm drainage design adopted across North America

[16] Refer to Chapter 7 Section 7.1.0 Pg.117 NPW On-site Pre-requisites

[17] City of Toronto – Toronto Water – Water Facts Appendix A – Section 1

[18] Waterfront Toronto Minimum Green Building Standards for diversified multi-unit residential building typology

[19] Waterfront Toronto – Lower Don Lands Master Plan. 4WS. Michael Van Valkenburgh and Associates Landscape Architects

[20] The Wetlands Floodplain Boundary was prescribed by the City of Toronto Wet Weather Flow Master Plan – Lower Don Lands

[21] Master Plan to re-naturalize the mouth of the Don River http://www.mvvainc.com/project.php?id=87

[22] A Parkette is a name designated for a small, linear, discontinuous parkway within the City of Toronto

[23] Toronto Downtown Tall Building Performance Standards.
http://www.toronto.ca/legdocs/mmis/2012/te/bgrd/backgroundfile-44939.pdf

[24] Waterfront Toronto Municipal Green Building Requirements.
http://www.waterfrontoronto.ca/uploads/documents/2011_01_31_mgbr_final_issued_2_1.pdf

[25] Toronto Port Lands - Reclaimed land. http://www.dcsltd.ca/images/Project%20Sheet-Toronto%20Portlands%20%28TEDCO%29.pdf

[26] Waterfront Toronto – Toronto Port Lands soil recycling facility.
http://www.waterfrontoronto.ca/explore_projects2/port_lands/unwin_avenue_improvements

[27] Net Positive Water Pre-requisites - Brownfield remediation Chapter 7 Section 7.1.0 Pg 118

[28] Net Positive Water Pre-requisites – Previously Developed Site Chapter 7 Section 7.1.0 Pg 118

[29] West Don Lands – Wicking post Brownfield Remediation. http://donwatcher.blogspot.ca/2009_07_01_archive.html

[30] Capillary Action is the ability for liquid to flow in narrow spaces without any form of assistance

[31] http://cfs.nrcan.gc.ca/projects/101

[32] Double-loaded construction is a conventional design where a circulation pathway is centralized within a residential building, and residential units are situated on either side of the pathway

[33] Single-loaded construction is a non-modern design methodology for mid-rise and low-rise construction where the circulation pathway is loaded on a single side of the building
[34] Buildings with flat, uniform facades act as a barrier for wind. The resulting affect is a downdraft condition where wind is physically forced downwards. This condition can increase the volatility of at grade urban conditions
[35] The PLAN Drawing of each unit has a layout design reflecting the physical shape of a saw
[36] Geotextile fabrics are installed between different substrate materials to prevent material erosion by maintaining material separation. The Geotextiles also trap large sediment debris while water moves through the material
[37] Refer to Appendix C Native Shrubs Listings Table No. 1
[38] Refer to Area Calculation in Appendix E Section Two. Net Positive Water. No. 30/ No. 29 represented as a Percentile
[39] Mulch for landscape water retention. http://www.puyallup.wsu.edu/~linda%20chalker-scott/horticultural%20myths_files/Myths/magazine%20pdfs/Woodchips.pdf
[40] Arborist woodchips are utilized on surface landscape conditions, allowing substrate soils to retain moisture. Dr. Linda Chalker-Scott. Associate Professor and Extension Urban Horticulturist WSU Puyallup Research and Extension Center. http://www.puyallup.wsu.edu/~linda%20Chalker-Scott/
[41] Johnstone, K. & Louie, P.Y.T. (1983): Water Balance Tabulations for Canadian Climate Stations. Canadian Climate Centre, Environment Canada. 8-83. 14pp.
[42] Refer to Area Calculation in Appendix E Section Two. Net Positive Water. No. 15
[43] Refer to Area Calculation in Appendix E Section Two. Net Positive Water. No. 22
[44] Refer to Area Calculation in Appendix E Section Two Net Positive Water No. 23
[45] 24-hours is the maximum duration for stagnant Greywater storage before quality begins to degrade
[46] Refer to Figure 5.10 Pg. 65
[47] Refer to Area Calculation in Appendix E Section Two. Net Positive Water. No. 40
[48] The flow rate between the Enerworks S.T.E. is controlled by an STE control module located on the building rooftop. The module distributes heated Clean water transient at a ranging rate of $0.072m^3/h$ to $0.046m^3/h$ based on thermal demand.
[49] Refer to Chapter 5, Section 5.3.1, Pg. 80
[50] Health Canada identifies 95% of waterborne bacteria's begin to die above the temperature of 60 degrees Celsius where heated water retains Clean water quality.
[51] CMHC booster pumps for water savings and pressure maintenance. http://www.cmhc-schl.gc.ca/en/inpr/bude/himu/waensati/waensati_016.cfm
[52] Refer to Area Calculation in Appendix E Section Two. Net Positive Water. No.31c.
[53] The specification for the system has been referred upon in collaboration with the manufacturer (GE Water – Canada)
[54] ECOP – Environmental Operators Certification Program is a required standard for water treatment operators. http://www.ecop.org
[55] The maximum treatment volume per annum is rated at 49 million litres per the specified module size
[56] Aqua-Tex Scientific Consulting Ltd. Is the leading company to manage and operate privatized water treatment facilities in Canada
[57] Refer to Area Calculation in Appendix E Section Two. Net Positive Water No.32a.

Endnotes:

Chapter EIGHT – Net Positive Water to combat the urban water problem

Net Positive Water to combat the urban water problem generates positive water quality as a result of Net Zero Water conservation. NPW domestic typology sustainably harvests sufficient quantities of water resources to provide for sustainable NZW inhabitant water use. Positive water quality is generated with the renewal of water resources after inhabitant use.

8.1 Existing and Potential barriers for Net Positive Water

The first and foremost consideration for Net Positive Water is the need to amend to existing municipal health and safety standards for water treatment and water reuse. Existing health regulations in the City of Toronto specify that Greywater and Blackwater under conditions where the medium has been cleaned, treated, and renewed to tertiary and beyond tertiary levels cannot be reused for potable intake if the medium has been processed outside of the municipal water utility. City regulations continue to mandate Blackwater treatment under municipal control, and this fact will halt NPW architecture unless treatment processes within the building typology are controlled and regulated under the municipal utility.

The operation of water treatment systems within the NPW mid-rise pilot project requires highly skilled technicians. Case study exemplar Dockside Green utilized a water professional with BNR (Biological Nutrient Removal) education primary and secondary classification, anaerobic digestion, fermentation, sand filtration, chlorine disinfection, and lift station operation (wastewater pumping). She also possesses MWT-III of the Environmental Operators Certification Program. The industry of sustainable water management and water treatment is still in its infancy and there may be a lack of skilled operators to fill those positions.

The design for cyclic water use and sustainable, self-sufficient water provisions reflects the natural processes of the urban water cycle. Cyclic water renewal would continue much like the urban water cycle under natural, uninterrupted processes but this prescription has been proven to be vulnerable to the affects of current day urban inhabitation. Cyclic water renewal cannot be successful in NPW residential typology if NZW is not achieved. If water conservation cannot reach the specified target of 70 LPCD and overconsumption begins to dominate as a result of the failure of architectural inhabitant engagement, a toppling affect will impact the entire function of the NPW building typology.

8.2 Implications and Recommendations for future implementation

Outside of the achievement of Net Positive water in the mid-rise pilot project, external environmental factors and economic considerations should be explored for Net Positive Water to become a viable form of domestic urban intensification.

Developers in the City of Toronto rely on increasing residential density to establish profitable urban development. Net Positive Water in the mid-rise pilot project is dependent on residential density to establish sustainable use of available water resources that can be harvested on a fixed property area. There is a potential for future, higher density implementation of Net Positive Water that can overcome the density dependence by increasing a projects capacity for Active water storage and Active water treatment.

Under density calculations for floor space ratio imposed by local governments, the space required for the application of wastewater treatment systems should not be counted as a part of the buildings floor space ratio. When the area required for water treatment systems is exempted from the development total, a more accurate impact of inhabitant density is established.

Net Positive Water may be plausible on even higher density development as sustainable water harvesting functions as a continuous flow of water resources. When a project is capable of storing sufficient volumes of water while mitigating the environmental impact of building form, Net Positive Water could be generated without the threat of residential density exceeding the 'environmental cliff'.

In a district scale application of Passive and Active water storage, the capability of the greater area to harvest water resources is substantially increased. A District scale application for water treatment and water harvesting as deployed by Dockside Green and The Millennium Waters Vancouver Olympic Village – SEFC is a more resilient application of Net Positive Water. Buildings within a district application can rely on neighbouring buildings to provide water resources in the event of an emergency (i.e. fire). This would remove the dependence on the Municipal water system as an emergency water source in addition to establishing increased resource security in the event of water scarcity.

The cost to construct a building scale wastewater treatment and disinfection plant is still prohibitive. Water saving techniques must be employed in development projects to reduce the demand for Active water management. NZW guidelines must be continuously encouraged to ensure operational savings and resource conservation. This responsibility is placed on the developer, building management, or Condominium Corporation. Net Positive Water construction will also depend on these authoritative bodies to establish billing collection and customer management. The City is no longer responsible to bill residents for sewage treatment, or potable water provisions.

Increasing Active water storage and water treatment capacity on higher density development will have an impact on other resource streams Projects with increased Active building requirements may not be able to generate sufficient quantities of positive water quality to combat the urban water problem. It is the recommendation of this thesis to apply Net Positive Water Guidelines and Standards onto alternative forms of domestic building typology to explore the capabilities of Positive water generation in higher density domestic intensification.

8.3 Economic Feasibility of Generating Positive Water

Net Positive Water development is more feasible with the support of Federal, Provincial and private sector partners. Negotiation with multiple levels of government may help to encourage change in local municipal codes and legislative acts. This can lead to improvements in the baseline standard of water hardware and building performance, encouraged by economic changes to development and infrastructure costs.

Net Positive Water building projects should be eligible for all of the development and operational savings that were made available to the Dockside Green Development. Sustainable water harvesting and wastewater treatment on-site allows NPW inhabitants to be exempt from municipal sewage charges. The sustainable building performance of Dockside Green mitigated the environmental and economic impact of its inhabitants to such an extent that the City of Victoria no longer required Dockside Green inhabitants to pay property taxes. Development charges were also waved as a result of sustainable building engagement and Triple Bottom Line (TBL) negotiations.

Net Positive Water projects in the City of Toronto would not be subject to municipal water charges. Water infrastructure exemptions will amount to approximately $16,000[1] of construction cost savings per household. A total construction cost savings of 2 million dollars[2] can be diverted to project water treatment systems.

The application of the Ultrafiltration treatment system in Dockside Green cost approximately 3 million dollars, treating wastewater each day for the entire Dockside Green community at a cost of $0.01 per gallon. The application of the Ultrafiltration treatment systems can range between 1.5 million dollars for a small scale residential application (NPW), up to 30 million for a large scale district projects. The Ultraviolet water disinfection and treatment systems cost an additional 1 million dollars to ensure the quality and safety of Passively stored water content. Total water treatment costs can be mitigated through the Application for project funding available from The Federation of Canadian Municipalities to offset regulatory costs.

Based on the performance of the water treatment plant at Dockside Green, estimated operational costs for a two-bedroom unit is about $215 per annum, including capital replacement. Comparing the cost of water provisions to those witnessed in the City of Toronto, the projected annual cost savings for NPW inhabitants can yield upwards of 65% savings.

The value of the water generated in Dockside Green is estimated to save over $81,000 per annum for the development. The Net Positive Water pilot project is able to generate upwards of $22,000 per annum[3] in water value after the 2nd year of building performance. Positive water resources can be sold to neighbours to generate additional project revenue.

8.4 Conclusion

Water storage is a fundamental requirement for sustainable water in domestic urban construction. Maximum Passive water storage can be achieved through the use of on-site Green roof systems, landscape soil and vegetation areas, waterways/water features and paving surfaces. Active water storage can be achieved through the adaptation of thermal conditioning building mechanisms in Capillary Mat systems and Borehole ground source heat pumps. The entire Passive and Active water storage strategy makes sustainable water harvesting possible in an urban domestic building application to fulfill annual NZW demand.

NPW Quality is ensured by separating available water provisions into quality classifications. NPW achieves NZW sustainable inhabitant use by providing Potable and Non-Potable water quality in each pilot project residential unit. Potable water conservation is achieved through the use of water monitoring and metering. Non-Potable water quality is provided as the appropriate resource to achieve Non-Potable water related household tasks. Potable and Non-Potable NZW mitigates overconsumption and resource misuse.

Net Positive water is also generated as a result of the fixed quantity of sustainable water storage. Sustainable water harvesting as a component of the urban water cycle is a continuous process whereby Greenwater resources will continue to enter the NPW building cycle. Once Passive and Active storage mechanisms have reached sufficient capacity to provide for annual NZW inhabitant use, excess water resources are treated by the NPW building cycle to generate of Net Positive water outflow.

The conclusion and result of the Passive and Active strategy for water storage in Net Positive Water building typology is that the greater Passive water storage capacity, the greater the capability for a NPW project to generate Net Positive Water. Net Positive Water is also a function of the implementation of water use reduction strategies for Net Zero Water.

8.5 Afterwards

Net Positive Water divulges upon a projects capability to generate a larger quantity of positive water quality than the volume of degraded water that is produced as a result of inhabitant use. Clarification of the term is the capacity for a project to process water exceeding the volume of water utilized on an annually calculated basis.

Water independence in Net Positive Water projects may require changes in construction building processes to accommodate for water harvesting prior to tenant inhabitation in order to accumulate sufficient water resources to support resident demand. Another alternative is to initialize a one-time purchase of municipal water resources to initiate building water processes.

Net Positive Water will have a greater environmental and economic relevance in urban regions subject to drought conditions and resource scarcity. The application of NPW will have greater significance when deployed in regions that are subject to the crisis of water scarcity. The urban water problem in the City of Toronto can still be remediated by improving water infrastructure and municipal management practices. Declining water quality in the Great Lakes Basin should be noted, but the urgency of the problem is still in its infancy.

Due to the substantial wealth of water resources in the City of Toronto, inhabitants have formed a dismissive nature towards water and water use. Sustainable volumes of water use as prescribed by Net Zero Water cannot rely on the trust of inhabitants as a valid means to achieve the required conservation target of 70 LPCD. Net Positive Water construction will require contracts that must be agreed upon by residents in order to establish sustainable Net Zero Water use. Green education in the form of LEED™ and comparable green inhabitation guidelines should be provided to support the sustainable resource use initiative.

Net Positive Water relying on Water independent projects will require inhabitants to utilize processed Greywater and Blackwater for potable household use. A large volume of trust is placed upon Ultrafiltration and Ultraviolet water renewal technologies to achieve reusable water resources. There is the possibility that these systems may be unable to remove water borne particulates such as hormones as well as other remnants that result from prescription drug use. Unlike municipal water processes of 'dilution is the solution', a closed-loop water reuse cycle may increase the health risks of inhabitants if water processes do not perform as intended.

One solution to the issue of Blackwater isolation and management that has not been look at with Net Positive Water is the use of Composting toilets. Composting toilets separating waste water and waste solids may be relevant for future applications of Net Positive Water. Compositing is a Passive waste management process that can ensure the removal of hormones and other potential health risks to the NPW reuse cycle.

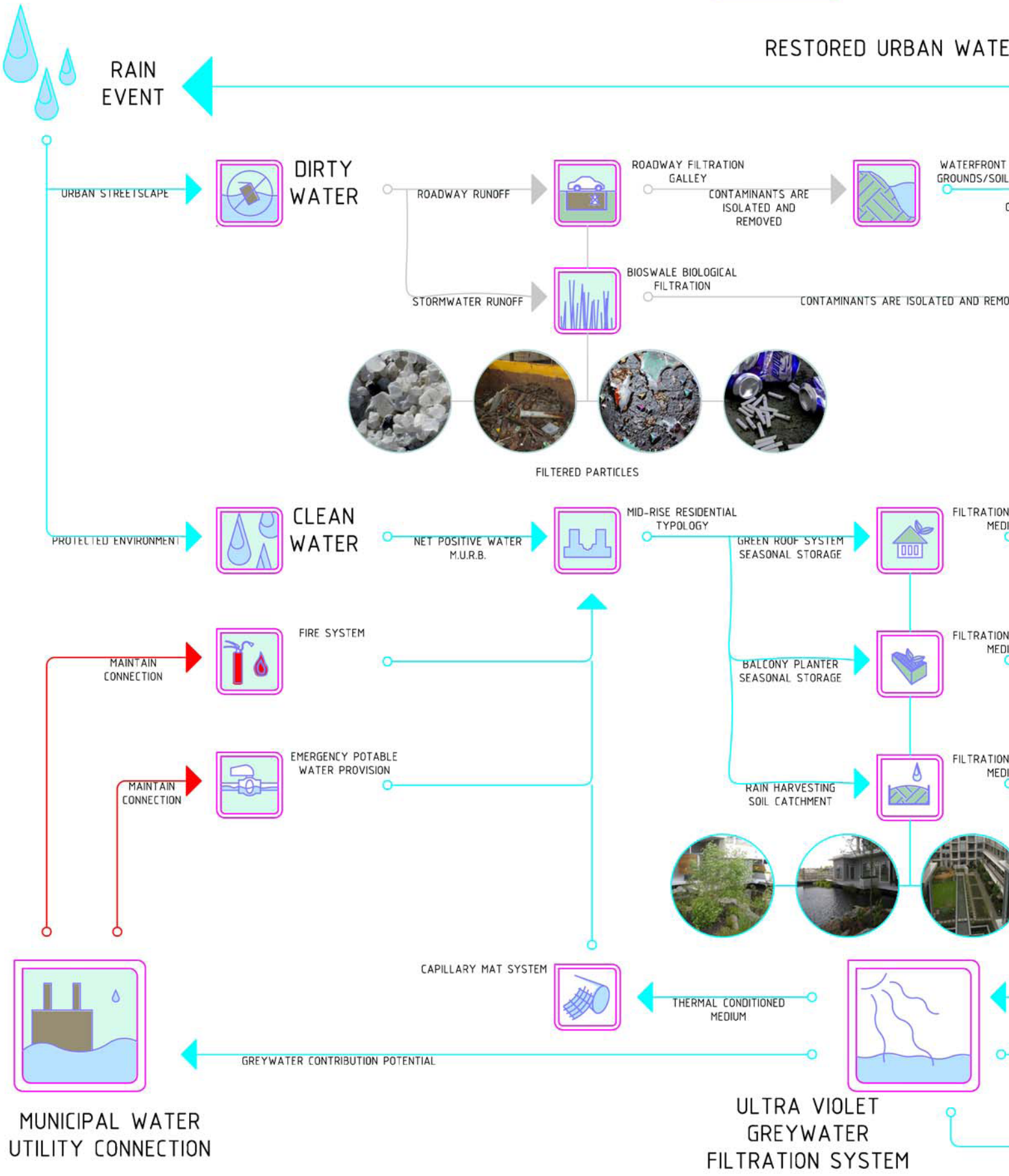
The Bullitt Center – Seattle Washington is a newly constructed commercial building that introduces composting toilets into urban buildings on a larger multi-storey scale. Touted as one of the largest Living Buildings in North America, the project's Blackwater system diverts human waste from 10 composting toilets into individual compost modules. Composting toilets introduce foaming biodegradable alcohol each flush as waste is conveyed to the subterranean modules. The modules inter-mix sod and wood chips into the waste material to initiate anaerobic composting. Technicians are required to churn each compost module once per day to maintain composting processes. A connection to municipal sewage systems is maintained in the event of an emergency.

To accommodate compositing toilets throughout residential building construction, slab type building typology in the form of mid-rise construction can serve as an applicable project platform. Logistics and plumbing organization can potentially have greater flexibility to incorporate compositing hardware under mid-rise design. Multi-unit residential applications must accommodate increased project floor area occupancy due to the scale of each composting system (81"x61"x40) per each composting toilet (+ 196m^2/ 26,263 ft^2 if applied to the mid-rise pilot project). System mechanization should be considered to 'churn' all composting modules due to the high number of composters required for residential applications.

The introduction of composting systems under the Net Positive Water Management cycle is displayed in the following diagram.

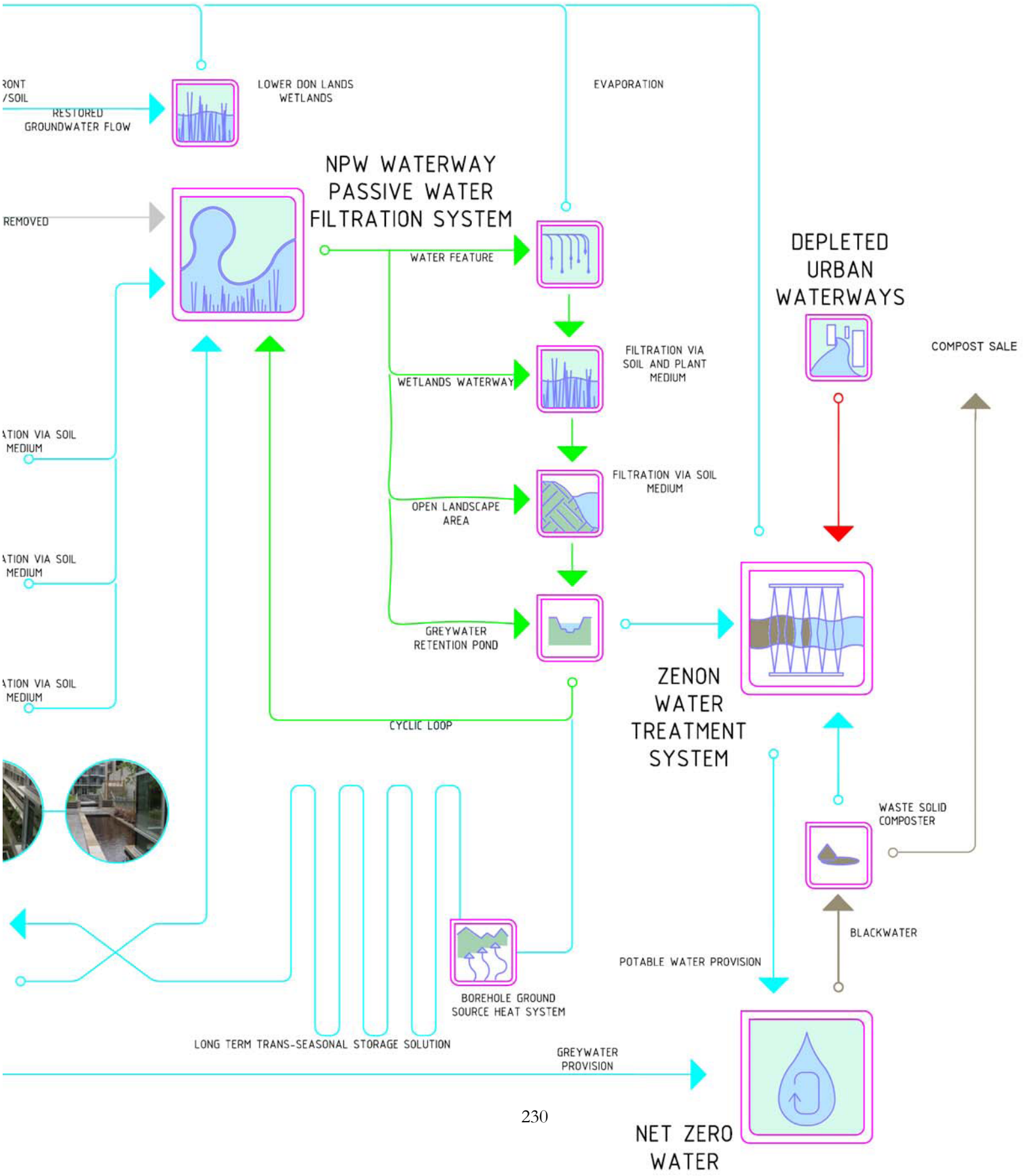
NET POSITIVE WATER MANAGEMENT DIAGRAM

PASSIVE WATER RENEWAL



AL CLEAN WATER DIRTY WATER COMPOST MUNICIPAL WATER

TER CYCLE



Endnotes:

[1] Refer to Area Calculation in Appendix E Section Two No. 35 Pg. 10

[2] $16,875 one-time construction cost savings multiplied by 123 units situated in the Net Positive Water pilot project

[3] Refer to Area Calculation in Appendix E Section Two No. 34 Pg. 10

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Environment as Infrastructure
http://www.aqua-tex.ca/

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Appendix A

Section.ONE: Net Zero Water Hardware and Appliances

Caroma High Efficiency Toilet



Walvit Wall Hung Elongated Invisi™ II dual flush high efficiency toilet (HET) is suitable for inwall, induct, inceiling and under counter applications. The 1.28/0.8 gpf (4.8/3 lpf) matched performance suite with Caroma Invisi™ II system provides the latest water saving technology in sanitaryware. Featuring smooth sides and concealed plumbing fittings with projection from wall of 24 3/8" (618mm). Multiple button options are available to suit domestic and commercial applications. Concealed tank and plumbing deliver space savings, easy cleaning and matched performance. **Important:** The Walvit Invisi™ II dual flush washdown toilet will comply with the Americans with Disabilities Act when installed to Easy Height Standards for Accessible Design, Section 4.16 Water Closets. Further reference must be made to the relevant sections of Easy Height Standards For Accessible Design with current amendments to determine clear floor space, grab bar, and operation requirements.

Closet Bowl: **Walvit Wall Hung Elongated** 1.28/0.8 gpf (4.8/3 lpf) dual flush wall hung box rim closet bowl.

Outlet: P-trap only

Tanks: Caroma concealed tank options are available: **Invisi Inwall/Induct/Inceiling** and **Under Counter Tanks**

Weight: Closet bowl 33 lbs (15 kg), tank/bracket 33 lbs (15kg)

Fixing: **Closet bowl** – fixing bracket is supplied with the toilet, options include – Inwall bracket for concrete floors and stud walls, (D402) suitable for inwall, induct and inceiling applications.

Note: The bracket systems are suitable for installation only where non compressible wall materials are used.

Tank – the tank and bracket for under counter or in inwall Invisi II systems are pre-assembled and are supplied with the flush pipe and a waste pipe suitable for installation in a 3 1/2"(90mm) cavity wall without venting and 7" (180mm) with venting. Structural brick wall systems require the cistern to be fixed to the wall. For in wall applications with raised height cisterns an extension kit is provided with the kit.

Seat: The following Caroma seats are recommended: **Elongated** Code No. 326307, **Elongated Easy Closing** Code No. 326221, and **Commercial** Code No. 326813.

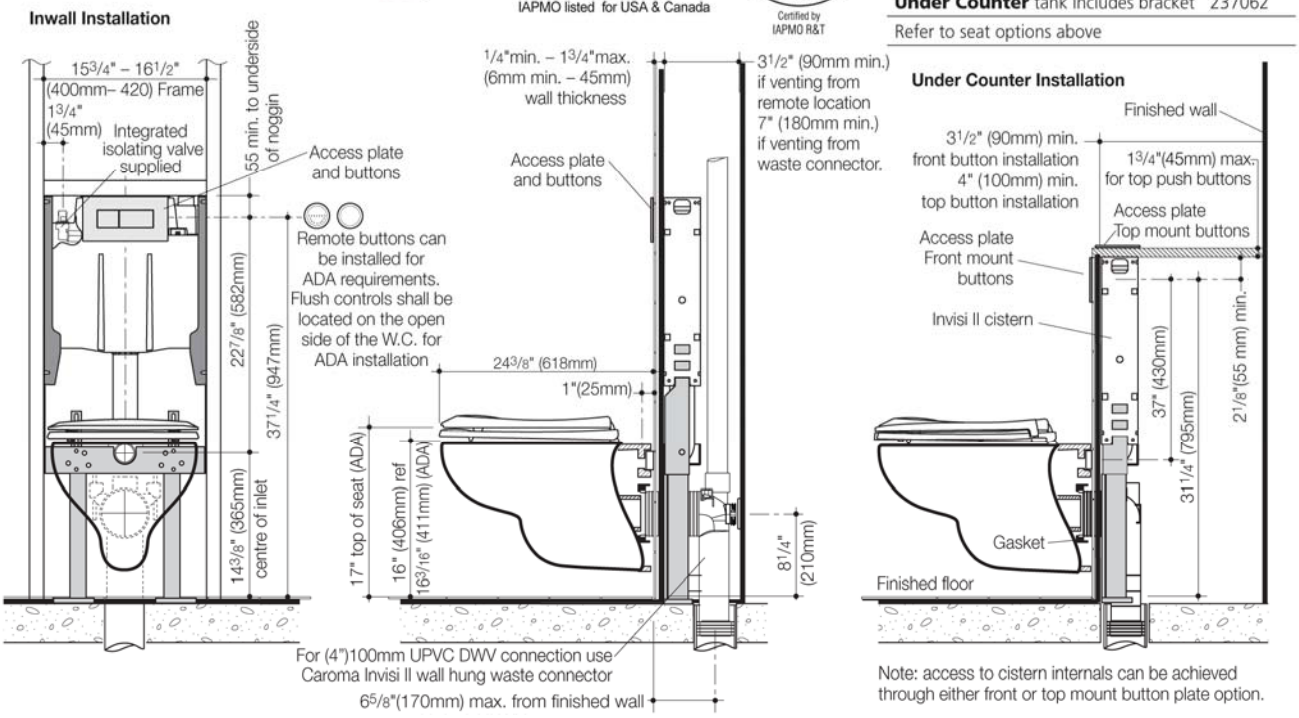
Color: White.

Dimensions: All dimensions are in inches and millimetres and are subject to normal manufacturing variations. Caroma pursues a policy of continuing improvement in design and performance of its products. The right is therefore reserved to vary specifications without notice.

HIGH EFFICIENCY TOILET HET c-UPC® IAPMO listed for USA & Canada

WaterSense Meets EPA Criteria Certified by IAPMO R&T

Walvit Wall Hung Elongated	Code No.
Walvit Wall Hung Elongated Closet bowl	604119
Inwall/Induct/Inceiling tank includes bracket	237061
or **Under Counter** tank includes bracket	237062
Refer to seat options above	



Note: access to cistern internals can be achieved through either front or top mount button plate option.

American Standard Ultra Low Flow Lavatory Faucet
670 USD

CODES AND STANDARDS

These products meet or exceed the following codes and standards:

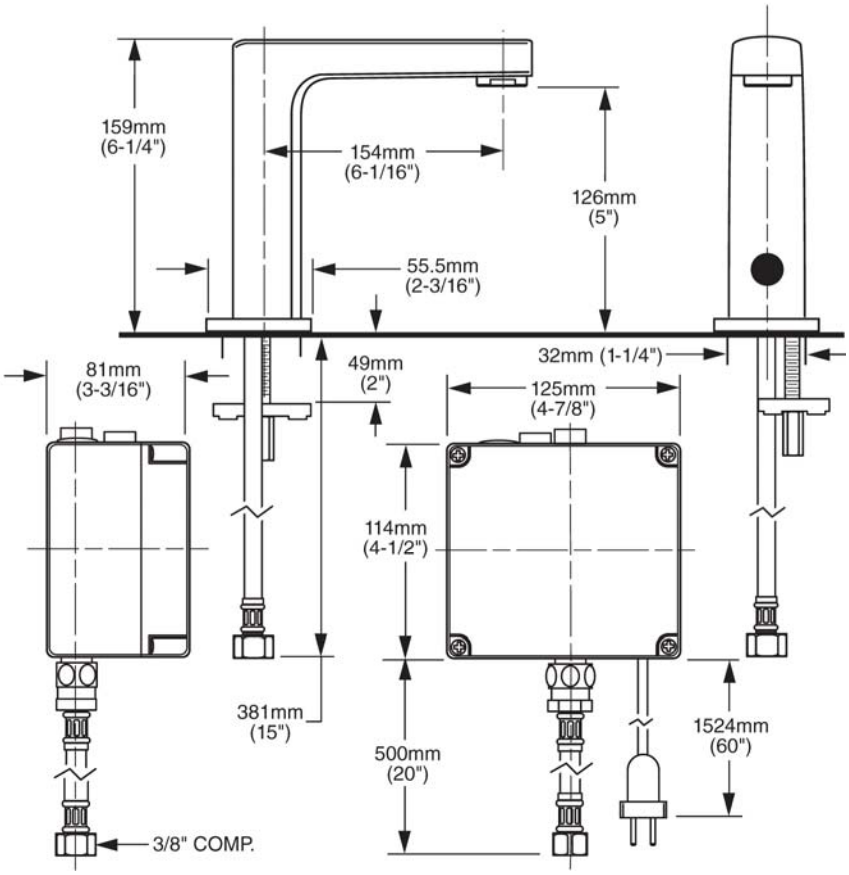
ANSI A117.1
ASME A112.18.1
CSA B 125
NSF 61/Section 9, Annex G

MEETS THE AMERICANS WITH DISABILITIES ACT GUIDELINES AND ANSI A117.1 REQUIREMENTS FOR ACCESSIBLE AND USABLE BUILDING FACILITIES-CHECK LOCAL CODES

Other Aerators Available:

Part Suffix	Description
A15LV	Anti-Microbial 1.5 gpm (5.7 Lpm) Vandal-Resistant Non-Aerated Laminar Flow Outlet
LV15	1.5 gpm (5.7 Lpm) PCA Vandal-Resistant Non-Aerated Laminar Flow Outlet
LV10	1.0 gpm (3.8 Lpm) PCA Vandal-Resistant Non-Aerated Laminar Flow Outlet
V10	1.0 gpm (3.8 Lpm) PCA Vandal-Resistant Aerator
V035**	0.35 gpm (1.3 Lpm) PCA Vandal-Resistant Non-Aerated Spray

*PCA - Pressure Compensating
**Meets Cal Green Code



Niagara Conservation Ultra Low Flow Showerhead





N2615CH*
Tri-Max Showerhead

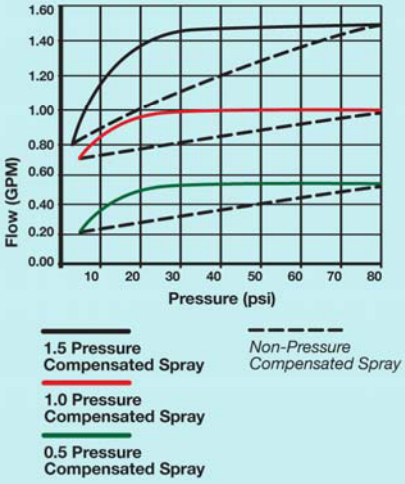
0.5 / 1.0 / 1.5 GPM
(1.8 / 3.8 / 5.7 LPM)

Conservation with a *Twist!* Tri-Max is a unique, three-flow rate showerhead, allowing you to match your flow rate to you task and save more while you shower.

- Three pressure compensated flow rate options: 0.5, 1.0 and 1.5 gallon per minute (1.8, 3.8 and 5.7 litre per minute)
- Niagara's patented non-removable pressure compensator provides a constant output of water regardless of pressure
- Easy grip turn-dial for selecting flow rate
- Even, vacillating motion with a large spray diameter
- Compact, modern design
- Corrosion resistant high-impact ABS thermoplastic body
- Large POM swivel adjustment, virtually lead free
- Overall dimensions: 2.125" diameter x 3.75" (54 x 97mm)
- 10-year warranty

Certifications: Meets or exceeds: ASME A112.18.1 / CSA B125.1
WaterSense certified - Max. Flow Rate: 1.5 GPM (5.7 LPM)
Min. Flow Rate at 45PSI: 1.13 GPM (4.3 LPM)

0.5/1.0/1.5 GPM Flow Rate



Savings

Savings	Water (gallons)	Electric (kWh)	Gas (therms)	Dollars
Electric Water Heater	7,300	949	n/a	$143
Gas Water Heat	7,300	n/a	52	$91

*based on FEMP/DOE data and an average water rate of $4 per 1,000 gallons.
*based on 1.5 GPM

Frigidaire Ultra High Efficiency Washing Machine – 2.8 WF (Water Factor)



Frigidaire
FAFS4073**

MSRP	$[illegible] $[illegible]
Capacity (cubic ft)	3.8
Modified Energy Factor	3.4
Water Factor	2.8
Annual Energy Use (kWh)*	9[illegible]
Annual Water Use (gallons)*	4,182
Total Annual Cost**	$90 $[illegible]
Lifetime Cost to Operate**	$[illegible] $[illegible]

Features:
Front load washer, NSF certified and [illegible] certified, super system sound package, [illegible] stainless steel drum, auto-[illegible] detergent, pre-wash, [illegible] and fabric softener dispenser, automatic temperature control, [illegible] cycle selections, [illegible] signal chime, [illegible] capacity, [illegible] its class, [illegible] wash-dry (in its class), water hoses included.

Whirlpool Ultra High Efficiency Dishwasher

Bauknecht Dishwasher Range

GSIP 6140 GT A+ PT
60cm Semi-integrated ECO-STYLE dishwasher



HK$14,800

Design
- Integrated type

Control
- Electronic button control
- Display of remaining time
- Start time pre-set: 1-24hours
- End of cycle indicator: buzzer

Caring Features
- Overflow protector
- Hygiene+ active self-cleaning filter

Green Features
- Green intelligence technology
- Energy / Cleaning / Drying performance: A+AA
- Multizone programme
- ProTouch surface

Cleaning Programmes
- 1 Touch sensor programme
- Express programme 45°C, 30minutes
- BIO Normal 50°C
- Normal programme 60°C
- Intensive 70°C
- Sani Rinse

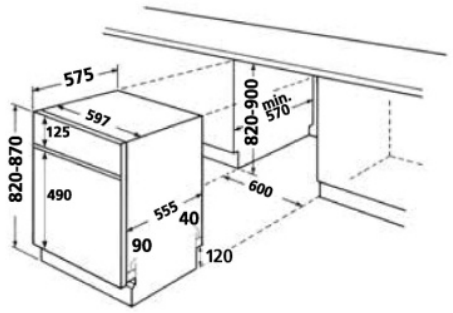
Interior Space Management
- 13 Place settings
- Cutlery Tray
  - Additional Space saving rack
- Upper Basket
  - Adjustable height and removable
  - 4 Collapsible cup holders
- Lower Basket
  - 4 Collapsible plate holders

Specifications
- Consumption rates (Normal programme)
  - Water: 6L
  - Electricity: 1.03kWh
  - Time: 185minutes
- Minimum water consumption: 6L
- Sound level:
  - Normal programme: 44dB(A)
  - Socket / Fuse spur unit: 13A
  - Drain pipe: 1800mm
  - Inlet water pipe: 1350mm
  - Length of power cord: 1400mm

Appliance Dimensions
- 820-870H x 597W x 570Dmm

Cut Out Dimensions
- 820-890H x 600W x 570Dmm

Country Of Origin
- Europe



Unit: mm
Above diagram is not to scale

49

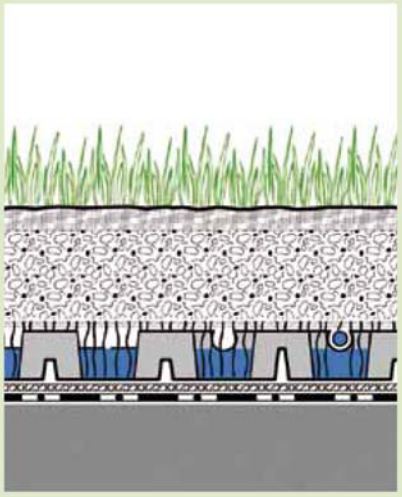
Section TWO: Net Positive Water Building Systems

Passive Water Storage and filtration – ZinCo Green Roof Systems

System Build-up
"Summer Plains"

Features:

- Intensive Green Roof with a variety of design options.
- Installation on flat roofs as well as on inverted roofs (slope max 5°).
- Minimal Substrate depth required.
- Tailored minimal irrigation possible.



Vegetation

System Substrate "Lawn"

Wicking Mat WM 40

Aquatec® AT 45 with Dripperline

Filter Sheet PV

Root Barrier WSB 100-PO,
if waterproofing is not root-resistant



	Art.-No.	Dimensions	Unit
Wicking Mat DV 40	2160	ca. 2.10 m x 25.00 m	50 m²-roll
	2165	ca. 2.10 m x 10.00 m	20 m²-roll

Roll width ca. 2.10 m including 10 cm fibre-free edge on one side for overlapping.



	Art.-No.	Dimensions	Unit	Palett
Aquatec®AT 45	3345	ca. 1.02 m x 2.02 m	2 m² board	100 boards



	Art.-No.	Dimensions	Unit	Pallet
Dripperline100-L1	9310	Ø ca. 16 mm	100m-roll	24 rolls



	Art.-No.	Dimensions	Unit	Pallet
Filter Sheet PV	2130	ca. 2.25 m x 50.00 m	112.5m²-roll	1012,5m²



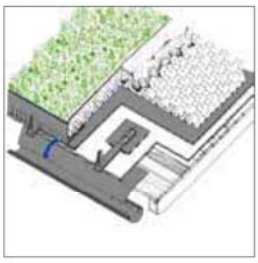
	Art.-No.	Dimensions
Irrigation-Manager BM 4	4045	L x W x H : ca. 48 x 48 x 30 cm





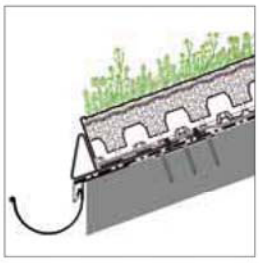


Pitched Green Roof



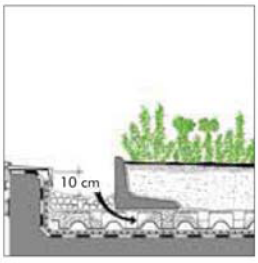
The discharge of rain water on pitched Green Roofs is mainly transfered into gutters. The shear forces, caused by the Green Roof System Build-up need to be diverted into the roof construction either by the slotted Eaves Profile TRP 140 associated with support brackets, or by stable eaves.

Shear barriers



Pitched Green Roofs are often designed right to the edge. Using Shear Fix, waterproofed shear barriers can often be replaced.

Low profile roofs



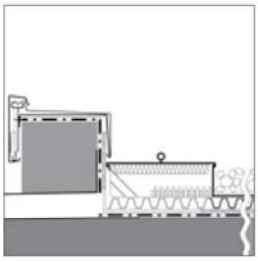
Intensive Green Roofs with higher build-ups can be installed even with low perimeter upstands Concrete L-shaped kerbs or stainless steel profiles are used to border the plant area and allow for greater depth of substrate. They also ensure continous and effective drainage.

Foundations for supporting structures



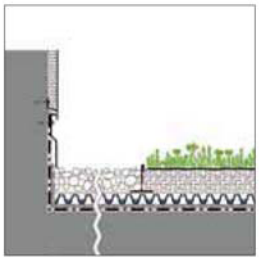
Floradrain® FD 60 can locally be used as formwork if firm foundations are required without penetration of the roof membrane. The channel system on the underside of the element ensures the unimpeded drainage of excess water.

Water spout with Inspection Chamber



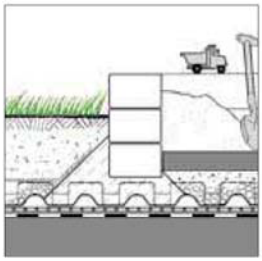
On flat roofs, water can be via edge outlets or dischanged edge water spouts. The inspection chamber ensures the accessibility of the outlets at any time, and can be cleaned easily, if necessary.

Wall connection



The waterproofing must be taken up on perimeters aprox. 150 mm above the finished surface of the roof. The upper edge of the flashing must be protected from rain water, which can be achieved by using the FZ bar, in connection with the Clamping and Protection Profile EP 150.

Play Area



Provided there are safety rails at the perimeters, it is possible to construct playgrounds on roofs with slides and sandpits. Timber planks, for instance, are a suitable border between the sandpit and the planted area. Concrete paving slabs placed at the bottom of the sandpit, above the drainage element, provide an additional protective barrier for the waterproofing and also enable an easy replacement of the sand, if needed.

Ponds and pools



With the correct design, ponds and pools can also be installed on roof decks. They should be placed above the drainage layer and lined seperately with a special plastic membrane. Should the pool ever leak, the water would flow into the regular roof drainage. On high and exposed buildings, it is recommended to have at least a 300 mm higher water level to compensate for the increased evaporation rate.

ENGINEERING AND LOADING

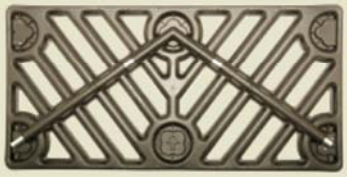
POST DETAIL



FRAME



DECK



FRAMES CAN BE STACKED, ONE, TWO OR THREE HIGH







SUMMARY OF TOP DECK STRESSES UNDER H-20 LOADING CONDITIONS (32,000 LBS/14,500 KG)

	Pavers	Asphalt	Concrete	Pavers with Concrete
English	21.3 psi • 3.15″ pavers • 1″ sand base • 12″ of aggregate	21.3 psi • 4″ of asphalt concrete • 12″ of aggregate	18.7 psi • 4″ of Portland Cement Concrete • 4″ of aggregate	15.0 psi • 2.36″ pavers • 5″ of Portland Cement Concrete
Metric	146.8 kN/m² (kPa) • 8 cm pavers • 2.5 cm sand base • 30.5 cm of aggregate	146.8 kN/m² (kPa) • 10 cm of asphalt concrete • 30.5 cm of aggregate	128.9 kN/m² (kPa) • 10 cm of Portland Cement Concrete • 10 cm of aggregate	103.4 kN/m² (kPa) • 6 cm pavers • 12.7 cm of Portland Cement Concrete



— is the recommended allowable stress that can be applied to the deck and represents a minimum safety factor of 1.45 when compared to the ultimate allowable stress value

Factor of Safety

TYPICAL H-20 AXLE LOADING AT THE PAVEMENT SURFACE



Maximum axle load of 32,000 lbs/14,500 kg

6′-0″ 1.8 m

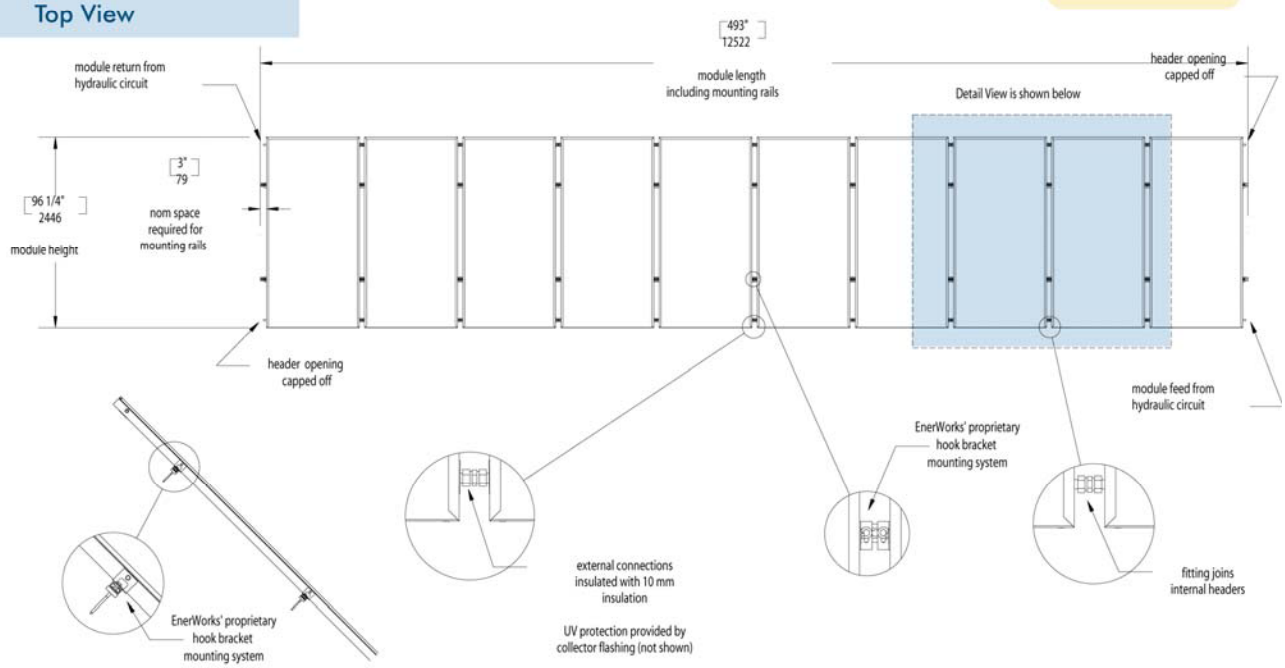
For commercial users of hot water at application temperatures between 40° C - 70° C (104°F to 158° F) and daily volumes between 400 litres - 75 000 litres (105 - 20,000 US gallons). Commercial users of warm air may use the energy via a standard fin-fan coil unit (water-to-air heat exchanger with a fan). Process fluids can be heated using fluid-to-fluid heat exchangers.

COLLECTOR MODULES

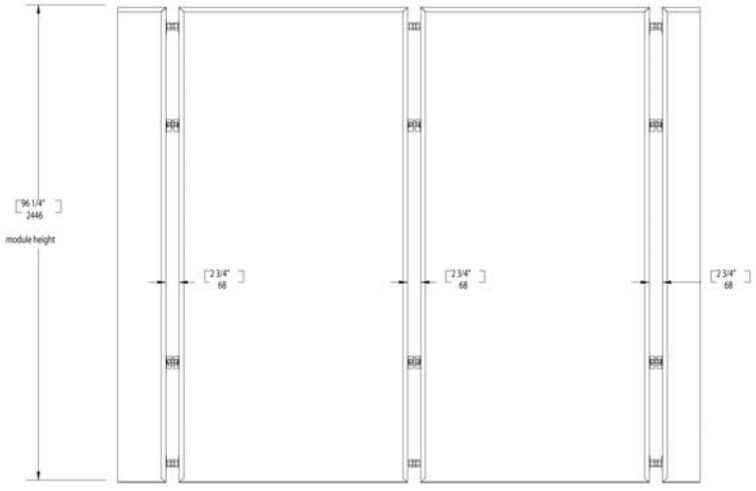
5 to 10 Collectors: Internal Headers, Hook Bracket Mounting

Collector Certification: SRCC 100-2006-006A

Top View



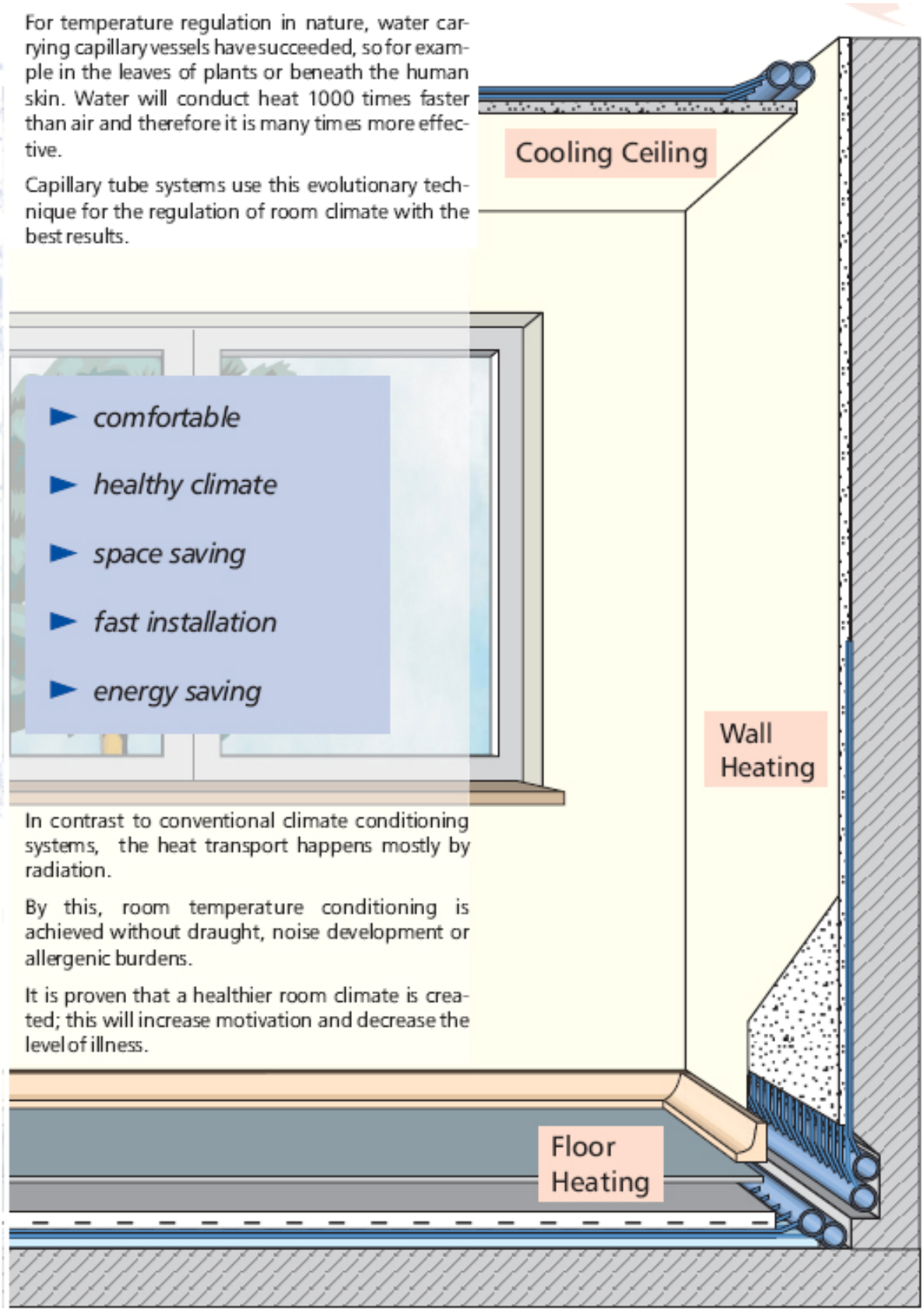
Detail View



Solar collectors are built in repeatable modules of 5 to 10 collectors. Groupings can range in size from one hundred modules (1000 collectors) in district heating applications to one module (5 to 10 collectors) in food service, farm, laundry, beauty salon, motels etc. Commercial collectors should be specified for thermal applications with year round, daily or frequent load requirements.

For temperature regulation in nature, water carrying capillary vessels have succeeded, so for example in the leaves of plants or beneath the human skin. Water will conduct heat 1000 times faster than air and therefore it is many times more effective.

Capillary tube systems use this evolutionary technique for the regulation of room climate with the best results.

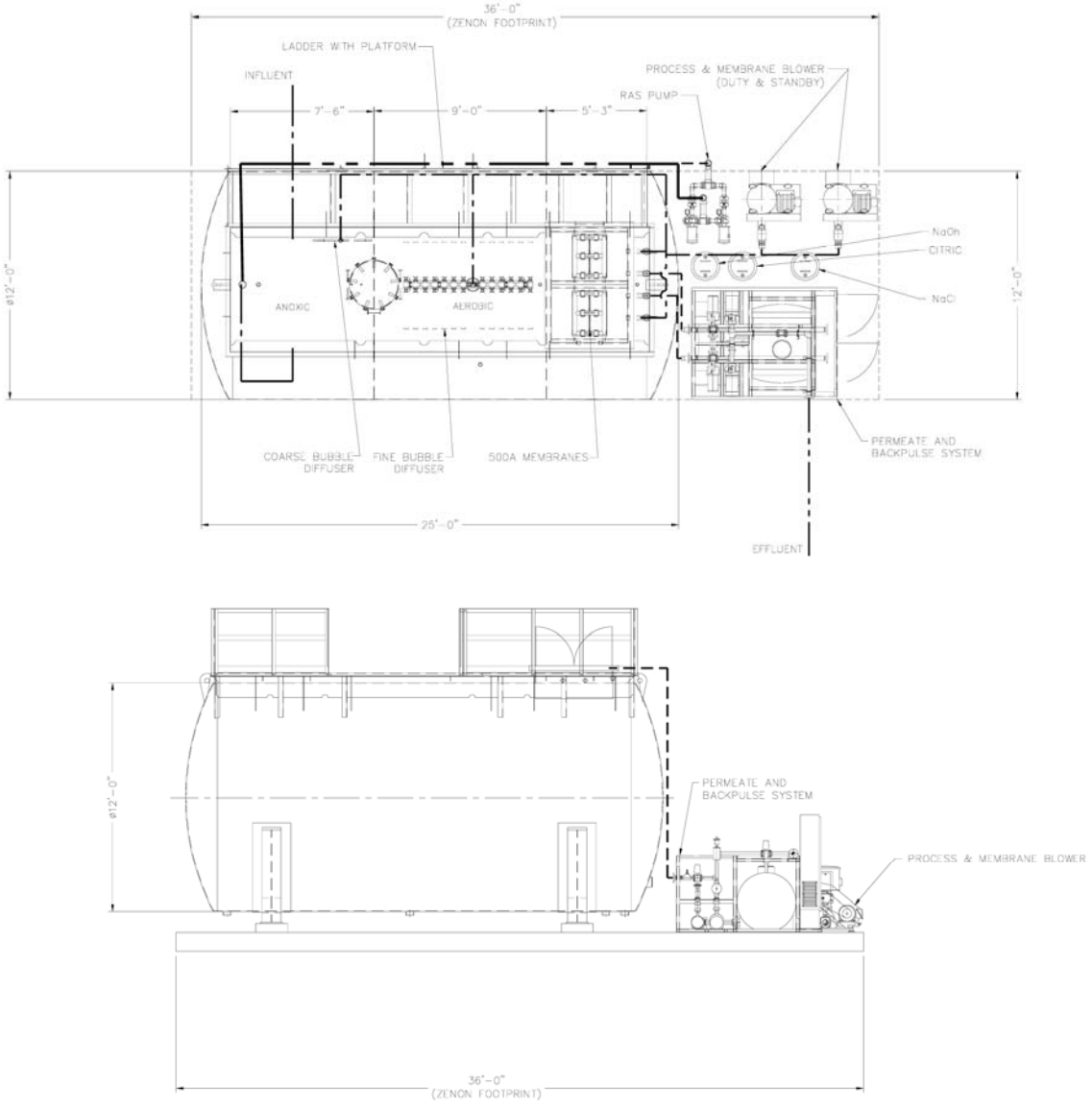


In contrast to conventional climate conditioning systems, the heat transport happens mostly by radiation.

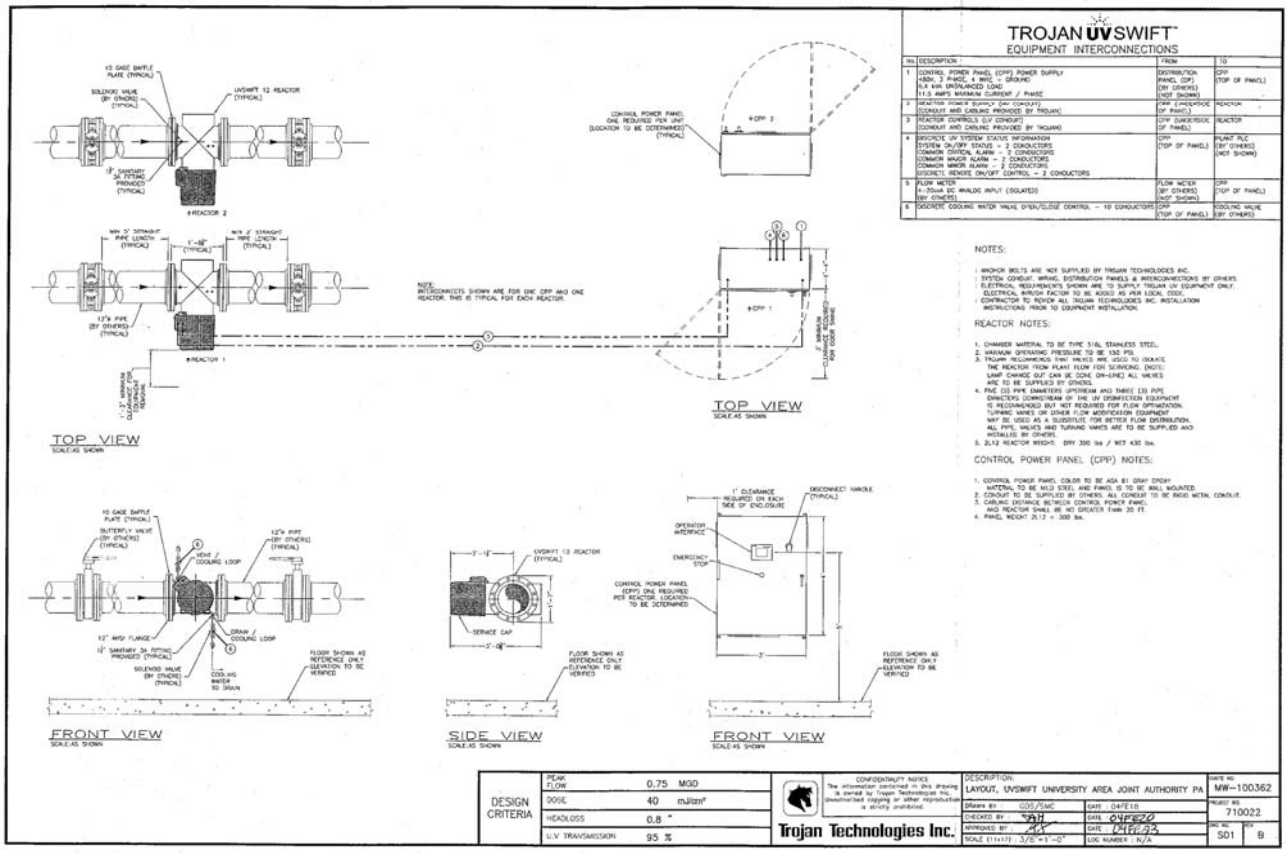
By this, room temperature conditioning is achieved without draught, noise development or allergenic burdens.

It is proven that a healthier room climate is created; this will increase motivation and decrease the level of illness.

GE Ultrafiltration Water Treatment Module – Active Water quality renewal



Ultraviolet Water Treatment Module – Active Water quality renewal



Appendix B Green Building Guidelines – Water related Principles & Standards

Table #1 LEED™ NC Water Related Credits (RED)

LEED for New Construction and Major Renovation

Net Positive Water

Toronto Port Lands

Yes	?	No			
			Sustainable Sites		**24 Points**
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
Y			Prereq 2	**Environmental Site Assessment**	Required
			Credit 1	**Site Selection**	1
			Credit 2	**Development Density & Community Connectivity**	4
			Credit 3	**Brownfield Redevelopment**	1
			Credit 4.1	**Alternative Transportation**, Public Transportation Access	4
			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
			Credit 4.3	**Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles	2
			Credit 4.4	**Alternative Transportation**, Parking Capacity	2
			Credit 5.1	**Site Development,** Protect of Restore Habitat	1
			Credit 5.2	**Site Development,** Maximize Open Space	1
			Credit 6.1	**Stormwater Design,** Quantity Control	1
			Credit 6.2	**Stormwater Design,** Quality Control	1
			Credit 7.1	**Heat Island Effect,** Non-Roof	1
			Credit 7.2	**Heat Island Effect,** Roof	1
			Credit 8	**Light Pollution Reduction**	1
			Credit 9	**Site Master Plan**	1
			Credit 10	**Joint Use of Facilities**	1
			Water Efficiency		**11 Points**
Y			Prereq 1	**Water Use Reduction,** 20% Reduction	Required
			Credit 1	**Water Efficient Landscaping**	2 to 4
			Credit 2	**Innovative Wastewater Technologies**	2
			Credit 3	**Water Use Reduction**	2 to 4
			Credit 4	**Process Water Use Reduction**	1
			Energy & Atmosphere		**33 Points**
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required
			Credit 1	**Optimize Energy Performance**	1 to 19
			Credit 2	**On-Site Renewable Energy**	1 to 7
			Credit 3	**Enhanced Commissioning**	2
			Credit 4	**Enhanced Refrigerant Management**	1
			Credit 5	**Measurement & Verification**	2
			Credit 6	**Green Power**	2
			Materials & Resources		**13 Points**
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
			Credit 1.1	**Building Reuse**, Maintain Existing Walls, Floors & Roof	1 to 2
			Credit 1.2	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
			Credit 2	**Construction Waste Management**	1 to 2
			Credit 3	**Materials Reuse**	1 to 2
			Credit 4	**Recycled Content**	1 to 2
			Credit 5	**Regional Materials**	1 to 2
			Credit 6	**Rapidly Renewable Materials**	1
			Credit 7	**Certified Wood**	1

			Indoor Environmental Quality	**19 Points**
Y			Prereq 1 **Minimum IAQ Performance**	Required
Y			Prereq 2 **Environmental Tobacco Smoke** (ETS) **Control**	Required
Y			Prereq 3 **Minimum Acoustical Performance**	Required
			Credit 1 **Outdoor Air Delivery Monitoring**	1
			Credit 2 **Increased Ventilation**	1
			Credit 3.1 **Construction IAQ Management Plan**, During Construction	1
			Credit 3.2 **Construction IAQ Management Plan**, Before Occupancy	1
			Credit 4 **Low-Emitting Materials**	1 to 4
			Credit 5 **Indoor Chemical & Pollutant Source Control**	1
			Credit 6.1 **Controllability of Systems**, Lighting	1
			Credit 6.2 **Controllability of Systems**, Thermal Comfort	1
			Credit 7.1 **Thermal Comfort**, Design	1
			Credit 7.2 **Thermal Comfort**, Verification	1
			Credit 8.1 **Daylight & Views**, Daylight	1 to 3
			Credit 8.2 **Daylight & Views**, Views for 90% of Spaces	1
			Credit 9 **Enhanced Acoustical Performance**	1
			Credit 10 **Mold Prevention**	1
			Innovation & Design Process	**6 Points**
			Credit 1.1 **Innovation in Design**: Provide Specific Title	1
			Credit 1.2 **Innovation in Design**: Provide Specific Title	1
			Credit 1.3 **Innovation in Design**: Provide Specific Title	1
			Credit 1.4 **Innovation in Design**: Provide Specific Title	1
			Credit 2 **LEED® Accredited Professional**	1
			Credit 3 **The School as a Teaching Tool**	1
			Regional Priority	**4 Points**
			Credit 1.1 **Regional Priority**: Provide Specific Title	1
			Credit 1.2 **Regional Priority**: Provide Specific Title	1
			Credit 1.3 **Regional Priority**: Provide Specific Title	1
			Credit 1.4 **Regional Priority**: Provide Specific Title	1
			Project Totals (pre-certification estimates)	**110** Points
Yes	?	No	**Certified** 40-49 points **Silver** 50-59 points **Gold** 60-79 points **Platinum** 80-110 points	

15 immediate references to Water Efficiency and Conservation credits

Table #2 LEED™ NC Water Use Reduction Prerequisite

COMMERCIAL FIXTURES, FITTINGS AND APPLIANCES	CURRENT BASELINE	
	METRIC	IMPERIAL
Commercial Toilets	6.0 Litres per flush (LPF) Except blow-out fixtures: 13.2LPF	1.6 gallons per flush (GPF)* Except blow-out fixtures: 3.5 GPF
Commercial Urinals	3.8 LPF	1.0 GPF
Commercial lavatory (restroom) faucets	8.3 L/min at 414 kilopascals (kPa) private applications only (hotel or motel guest rooms, hospital patient rooms)	2.2 gallons per minute (GPM) at 60 pounds per square inch (psi), private applications only (hotel or motel guest rooms, hospital patient rooms)
	1.9 LPM at 414 kPa all others except private applications	0.5 GPM at 60 psi ** all others except private applications
	0.95 Litres per cycle for metering faucets	0.25 gallons per cycle for metering faucets
Commercial Showerheads	9.5 LPM	2.5 GPM
Commercial pre-rinse spray valves (for food service applications)	Flow rate ≤6.0 LPM (no pressure specified; no performance requirement)	Flow rate ≤ 1.6 GPM (no pressure specified; no performance requirement)

RESIDENTIAL FIXTURES, FITTINGS AND APPLIANCES	CURRENT BASELINE	
	METRIC	IMPERIAL
Residential Toilets	6.0 LPF at 414 kPa	1.6 GPF*
Residential Lavatory Faucets	8.3 LPM at 414 kPa	2.2 GPM at 60 psi
Residential Kitchen Faucets		
Residential Showerheads	9.5 LPM at 552 kPa per shower stall	2.5 GPM at 80 psi per shower stall***

Table #3 Water Use Reduction Percentage/Credits (Water Efficiency CREDIT 3)

PERCENTAGE REDUCTION	POINTS
30%	2
35%	3
40%	4

Table #4 LEED™ Mid-rise Indoor Water Performance

Flush Fixture	*Monthly uses per resident*	*Building residents*[3]	*Flowrate (GPM or GPF)*	*Duration*	*Monthly water use (gal)*
Toilet	150			1 flush	
Bathroom Sink	150			0.25 min.	
Kitchen Sink	120			1 min.	
Shower	30			5 min.	
*Where monthly water use = monthly uses per resident * residents * flowrate * duration*					
Appliance	*Monthly uses per unit*	*Number of units in the building*	*Water consumption per use (gal)*		*Monthly water use (gal)*
Dishwasher*	16				
Clothes washer**	30				
*Where monthly water use = monthly uses per unit * units * consumption per unit*					

* For each unit without a dishwasher, add 96 gal per month to account for washing by hand.

Percentage of total water demand supplied by water reuse strategies	*Points*
≥ 10%	1
≥ 20%	2
≥ 30%	3
≥ 40%	4
≥ 50%	5

Table#5 The Living Building Challenge.

Scale Jumping Resource conservation

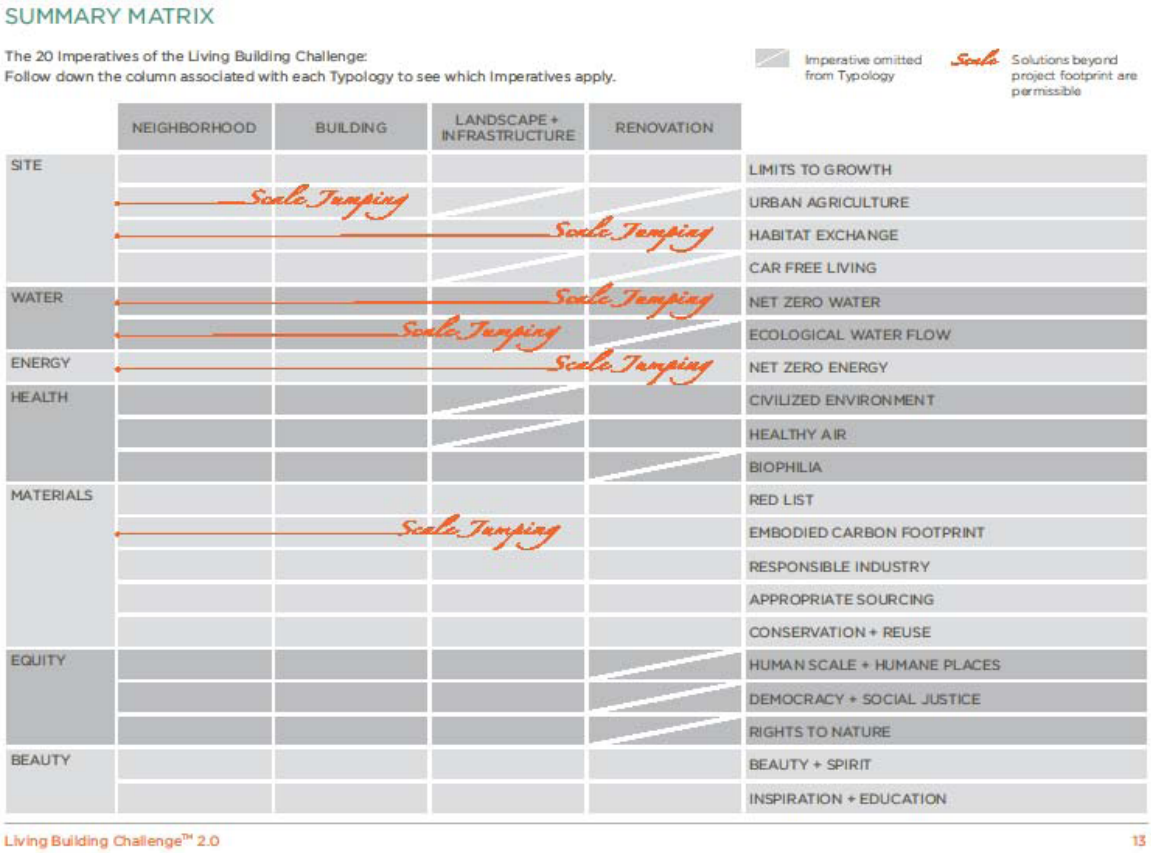


Table #6 Waterfront Toronto – Lower Don Lands

Minimum Green Building Requirement

Minimum Green Building Requirement in Waterfront Toronto

- All Buildings Must Achieve a minimum Green Building Certification of LEEDTM GOLD
- All Waterfront structures are subject to Toronto's Green Roof Bylaw
  - Buildings must provide 50 % of available Roof Space to Green Roof Systems
  - Roof area covered by Renewable Energy Systems such as Photovoltaic and Solar Thermal Panels are considered as 'Green Roof'

- All building suites must manage and segregate waste into three divisions
  - Recycling
  - Non-renewable Waste
  - Compost

All structures must be subject to District Utility systems
  - District Scale Stormwater management
  - District Energy provisions allowing individual buildings to function as components of a greater network

Optimal massing and volume of buildings
  - At-grade slab to slab floor heights shall be no less than 5 metres in height
  - 20% of residential suites will be optimized for future expansion
  - Builders must integrate and optimize building structures to allow for 3-bedroom suites

Table #7 Potential Ontario Building Code (OBC)
Water use and Water reuse Changes for 2011

CHANGE #	CODE REFERENCE	SUBJECT
W-A-01-04-01	Div. A 1.4.1.2.	Add a new definition for "rainwater".
W-B-07-01-01	Div. B 7.1.5.3.(2)	Permit the re-use of storm sewage or greywater for sub-surface irrigation and include a new list of permitted use for rainwater.
W-B-07-06-01	Div. B Table 7.6.4.1.	Increase the water efficiency requirements for shower heads in residential occupancies.
W-B-07-06-02	Div. B 7.6.4.2.	Editorial change to replace the term "flush cycle" with "maximum water consumption per flush cycle".
W-B-07-06-03	Div. B 7.6.4.2.	Increase the water efficiency requirements for water closets and urinals.
W-B-07-07-01	Div. B 7.7.1.1.	Clarify requirements for the selection of backflow prevention devices.
W-B-07-07-02	Div. B 7.7.2.1.	Clarify the marking requirements for non-potable water systems.
W-B-07-07-03	Div. B 7.7.3.2.	Permit rainwater to be used for clothes washing.
W-B-07-07-04	Div. B 7.7.4.	Add new requirements to regulate the design for the re-use of non-potable water systems.
W-B-09-31-01	Div. B 9.31.4.1(1)	Permit a drainless composting water closet to be provided as an alternative to a water closet in every dwelling unit where a piped water supply is available.

Appendix C – Passive Building Performance landscape plantings and vegetation
Table #1 City of Toronto – Native Shrubs

City of Toronto
Urban Forestry Services

Native Shrubs

Common Name	Scientific Name	Favoured Moisture	Favoured Soil Type	Favoured Light Regime	Maximum Height	Species Attributes
Mountain Maple	*Acer spicatum*	Dry-Moist-Wet	sand-silt-loam	partial shade to shade	5 m	yellow/green flowers
Downy Serviceberry	*Amelanchier arborea*	Dry-Moist	sand-silt-clay	sun to partial shade	10 m	white flowers, berries attract birds
Smooth Serviceberry	*Amelanchier laevis*	Dry-Moist	sand-silt-clay	sun to partial shade	10 m	white flowers, berries attract birds
New Jersey Tea	*Ceanothus americanus*	Dry	sand-silt	sun to partial shade	1 m	attracts butterflies
Buttonbush (RT)	*Cephalanthus occidentalis*	Moist-Wet	sand-silt-clay	sun	3m	fragrant flowers attract bees
Alternate-leaved Dogwood	*Cornus alternifolia*	Dry-Moist	silt-loam	partial shade to shade	6 m	graceful branching pattern
Silky Dogwood	*Cornus amomum ssp.obliqua*	Wet-Moist	sand-silt-clay	sun	3 m	white flowers & blue berries
Grey Dogwood	*Cornus racemosa*	Dry-Moist	sand-silt-clay	sun to partial shade	3 m	white flowers & white berries
Round-leaved Dogwood	*Cornus rugosa*	Dry-Moist	sand-silt-loam	partial shade to shade	3 m	white flowers & pale-blue berries
Red-osier Dogwood	*Cornus stolonifera*	Moist-Wet	sand-silt-clay	sun	3 m	white flowers & white/bluish berries
Beaked Hazel	*Corylus cornuta*	Dry-Moist-Wet	sand-silt-loam	sun to shade	4 m	large edible nuts in a beaked husk
Bush Honeysuckle	*Diervilla lonicera*	Dry	sand-silt-loam	sun to partial shade	1 m	small yellow flowers, fast growing
Leatherwood	*Dirca palustris*	Moist	sand-silt-loam	partial shade to shade	2 m	pale yellow flowers, red berries
Witch-hazel	*Hamamelis virginiana*	Moist	sand-silt-loam	partial shade to shade	6 m	yellow star-shaped flowers in fall
Winterberry	*Ilex verticillata*	Moist-Wet	peat-muck-silt	sun to partial shade	4 m	attractive red fruit in winter
Spicebush (RT)	*Lindera benzoin*	Moist-Wet	silt-loam	partial shade to shade	3 m	scented leaves, beautiful fall colour
Fly-honeysuckle*	*Lonicera canadensis*	Moist-Wet	sand-silt-clay	sun to shade	2 m	pale yellow flowers, red berries
Glaucous Honeysuckle*	*Lonicera dioica*	Dry-Moist	sand-silt-clay	sun to shade	3 m	orange-red berries
Sweet Gale (RT)	*Myrica gale*	Moist-Wet	sand-silt-loam	sun	1 m	conelike flower clusters, scented leaves
Ninebark (RT)	*Physocarpus opulifolius*	Dry-Moist	sand	sun	3 m	showy white flowers
Pin Cherry (RT)	*Prunus pennsylvanica*	Dry-Moist	sand-silt-loam	sun to partial shade	12 m	cherries attract birds
Chokecherry	*Prunus virginiana*	Dry-Moist	sand-silt-clay	sun to shade	10 m	cherries attract birds
Fragrant Sumac (RT)	*Rhus aromatica*	Dry	sand	sun	2 m	scented leaves
Staghorn Sumac	*Rhus typhina*	Dry-Moist	sand-silt-clay	sun	6 m	attractive crimson fruit, brilliant fall colour
Smooth Rose	*Rosa blanda*	Dry-Moist	sand-silt-clay	sun	1 m	attractive pink flowers
Pasture Rose (RT)	*Rosa carolina*	Dry	sand-silt-loam	sun to partial shade	1 m	rose hips persist into winter
Swamp Rose (RT)	*Rosa palustris*	Moist-Wet	sand-silt-clay	sun	2 m	attractive pink flowers
Purple-flowering Raspberry	*Rubus odoratus*	Dry-Moist	silt-loam	sun to shade	2 m	showy purple flowers
Bebb's Willow	*Salix bebbiana*	Moist-Wet	sand-silt-loam	sun to partial shade	6 m	yellow-green fruit attract birds

http://www.toronto.ca/trees

1

TORONTO Parks & Recreation

City of Toronto
Urban Forestry Services

Native Shrubs

Common Name	Scientific Name	Favoured Moisture	Favoured Soil Type	Favoured Light Regime	Maximum Height	Species Attributes
Pussy Willow	*Salix discolor*	Moist-Wet	sand-silt-clay	sun	3 m	fast growing, tolerant of compaction
Heart-leaved Willow	*Salix eriocephala*	Moist-Wet	sand-silt-clay	sun	4 m	early pollen source for insects
Upland Willow	*Salix humilis*	Dry-Moist	sand-silt-clay	partial shade to shade	3 m	low, small shrubs
Shining Willow	*Salix lucida*	Moist-Wet	sand-silt-clay	sun	6 m	yellowish stems
Slender Willow	*Salix petiolaris*	Moist-Wet	sand-silt-clay	sun	3 m	slender red branches
Common Elderberry	*Sambucus canadensis*	Moist-Wet	sand-silt-clay	sun to partial shade	3 m	black berries attract birds
Red-berried Elder	*Sambucus pubens*	Moist-Wet	sand-silt-loam	partial shade to shade	4 m	red berries attract birds
Soapberry	*Shepardia canadensis*	Dry	sand	sun	2 m	bright orange/red berries, red-brown twigs
Meadowsweet	*Spirea alba*	Moist-Wet	sand-silt-clay	sun	2 m	white flowers
Snowberry*	*Symphoricarpos albus var. albus*	Dry-Moist	sand-silt-loam	sun	1 m	forms low spreading colonies, white berries
Maple-leaf Viburnum	*Viburnum acerifolium*	Dry-Moist	sand-silt-clay	partial shade to shade	2 m	black berries
Hobblebush	*Viburnum alnifolium*	Moist	sand-silt-loam	partial shade to shade	2 m	large leaves, showy white flowers
Nannyberry	*Viburnum lentago*	Moist-Wet	sand-silt-clay	sun	6 m	white flowers, brilliant fall colour
Highbush Cranberry *	*Viburnum trilobum*	Moist-Wet	sand-silt-clay	sun to partial shade	4 m	red berries attract birds

Table #2 City of Toronto – Native Tree Species

City of Toronto
Urban Forestry

Native Trees for Ravines and Naturalization Projects

Common Name	Scientific Name	Favoured Moisture	Favoured Soil Type	Favoured Light Regime	Maximum Height	Species Attributes
Black Maple	*Acer nigrum*	Moist	loam, silt-loam	partial shade to full shade	35m	tolerant of urban conditions
Red Maple	*Acer rubrum*	Moist-Wet	sand, loam	full sun to partial shade	25m	orange to bright red fall colour
Silver Maple	*Acer sacharinum*	Moist-Wet	sand, loam, clay	full sun to partial shade	35m	fast growing and tolerant
Sugar Maple	*Acer sacharum*	Dry-Moist	loam, clay	partial shade to full shade	35m	yellow to orange-red fall colour
Speckled Alder *	*Alnus rugosa*	Moist-Wet	sand, loam, clay	full sun	8m	provides wildlife habitat
Yellow Birch	*Betula alleghaniensis*	Moist	loam, sandy-loam	full sun to partial shade	25m	attracts wildilfe
White Birch *	*Betula papyrifera*	Dry-Moist-Wet	sand,loam,gravel-loam	full sun	25m	fast growing and attractive bark
Blue Beech	*Carpinus caroliniana*	Moist	loam, sandy-loam	full shade to partial sun	8m	interesting bark - looks like muscle
Bitternut Hickory	*Carya cordiformis*	Moist	sand, loam	full sun to partial shade	25m	fast growing
Shagbark Hickory (RT)	*Carya ovata*	Dry-Moist	loam, clay	full sun to partial shade	25m	interesting bark, attracts squirrels
Hackberry (RT)	*Celtis occidentalis*	Dry-Wet	loam, clay	full sun to partial shade	15m	fast growing, tolerant
Hawthorn	*Crataegus spp.*	Moist	loam,clay	full sun to partial shade	12m	provides wildlife habitat
American Beech	*Fagus grandifolia*	Moist	loam	partial shade to full shade	25m	flowers eaten by birds
White Ash	*Fraxinus americana*	Moist	sand, loam, clay	full sun to partial shade	30m	purple fall colour
Black Ash	*Fraxinus nigra*	Wet-Moist	peat, wet sandy tills	full sun to partial shade	20m	dark red fall colour
Green Ash	*Fraxinus pennsylvanica*	Moist-Wet	loam, clay, gravel-loam	full sun to partial shade	25m	yellow fall colour
Butternut	*Juglans cinerea*	Moist	loams	full sun	25m	seeds provide food for wildlife
Black Walnut	*Juglans nigra*	Moist	loam, clay	full sun	30m	seeds provide food for wildlife
Red Cedar	*Juniperus virginiana*	Dry-Moist	sand, loam	full sun	4m	provides food & shelter for wildlife
Tamarack*	*Larix laracina*	Moist	peat, wet sandy-loam	full sun	25m	interesting shape
Tulip Tree (RT)	*Liriodendron tulipifera*	Moist	sand, loam	full sun to partial shade	35m	pyramidal shape, interesting leaves
Ironwood	*Ostrya virginiana*	Dry-Moist	loam, clay	full sun to full shade	12m	interesting bark
White Spruce	*Picea glauca*	Moist	sand, loam, clay	full sun partial shade	25m	provides wildlife habitat
Red Pine (RT)	*Pinus resinosa*	Dry-Moist	sand, sandy-loam	full sun	25m	stabilizes soil
White Pine	*Pinus strobus*	Dry-Moist	sand, loam	full sun to partial shade	30m	provides wildlife habitat
Sycamore (RT)	*Platanoides occidentalis*	Moist-Wet	sand, loam, clay	full sun to partial shade	30 m	interesting, peeling bark
Eastern Cottonwood*	*Populus deltoides*	Moist-Wet	sand, loam, clay	full sun to partial shade	30m	fast growing
Largetooth Aspen	*Populus grandidentata*	Dry-Moist	sand, loam	full sun	20m	fast growing
Trembling Aspen	*Populus tremuloides*	Moist	sand,loam,clay	full sun	25m	fast growing, tolerant
Pin Cherry	*Prunus pensylvanica*	Dry	sand, loam	full sun	12m	seeds provide food for wildlife
Black Cherry	*Prunus serotina*	Dry-Moist	sand, loam	full sun to partial shade	22m	interesting bark, provides habitat
White Oak	*Quercus alba*	Dry-Moist	sand, sandy-loam	full sun to partial shade	35m	provides food & shelter for wildlife

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1

City of Toronto
Urban Forestry

Native Trees for Ravines and Naturalization Projects

Common Name	Scientific Name	Favoured Moisture	Favoured Soil Type	Favoured Light Regime	Maximum Height	Species Attributes
Bur Oak	*Quercus macrocarpa*	Dry-Wet	loam, clay	full sun to partial shade	15m	provides food & shelter for wildlife
Red Oak	*Quercus rubra*	Dry-Moist	sand to loamy-clay	full sun to partial shade	25m	fast growing, wildlife value
Black Oak	*Quercus velutina*	Dry-Moist	sand	full sun to partial shade	20m	seeds provide food for wildlife
White Cedar	*Thuja occidentalis*	Dry-Wet	sand, loam, clay	full sun to partial shade	15m	provides wildlife habitat
Basswood	*Tilia americana*	Dry-Wet	sand, loam, clay	full sun to partial shade	35m	tall stately tree
Hemlock	*Tsuga canadensis*	Moist-Wet	sand, loam	full shade	30m	provides food & shelter for wildlife

Table #3 Resilient Landscape & Aquatic Plant Species

Aquatic Plants						
cro	1603	Carex rostrata	Beaked Sedge	plugs	30 cm (12")	Nursery Grown, Full Dense Plant
epa	1686	Eleocharis Palustris	Common Spike-Rush	plugs	30 cm (12")	Nursery Grown, Full Dense Plant
osa	1650	Oenanthe sarmentosa	Pacific Water Parsley	plugs	30 cm (12")	Nursery Grown, Full Dense Plant
smi	2130	Scirpus microcarpus	Panicled Bulrush	plugs	30 cm (12")	Nursery Grown, Full Dense Plant

Table # 4 City of Toronto – Native Soil Types

Water Absorption Rates

A Guide to Available Water Storage Capacities of Soils			
Textural Class	Available Water Storage Capacity (AWSC)		
	(in. water / in. soil)	(in. water / ft. soil)	(mm water / m soil)
Clay	0.21	2.5	200
Clay Loam	0.21	2.5	200
Silt loam	0.21	2.5	208
Clay loam	0.20	2.4	200
Loam	0.18	2.1	175
Fine sandy loam	0.14	1.7	142
Sandy loam	0.12	1.5	125
Loamy sand	0.10	1.2	100
Sand	0.08	1.0	83

Appendix D Water Facts

Table #1

Indoor Water Use Breakdown					
Average Canadian Inhabitant Water usage				248	LPCD
	Percent	LPCD		Percent	LPCD
Toilet	28%	69.44	Leaks	11%	27.28
Clothes Washer	22%	54.56	Baths	3%	7.44
Shower	19%	47.12	Dishwasher	2%	4.96
Faucet	15%	37.20			
Reference: City of Toronto Wet Weather Flow Master Plan					

1. Household Water use Facts:

- 12 litres per 2 minute brushing of teeth
- 2 litres per hand and face wash
- 80 litres to run a full bath
- 45 litres for a 5 minute shower

2. Leakage

Faucet: A steady drip can waste up to 55 litres of water in 24 hours

3. Single Family Household water usage trends

Average number of peoples per household: 3.2

Classification: single-detached, semi-detached, row housing (3-6 units), plexes (2-6 units)

- 34% of Toronto's Water Usage as of 2011

A. Toilet

- Average number of flushes per capita per day: 5
- Average flush volume of an inefficient toilet is 16.5 litres (82.5 litres per day)
- Average flush volume of efficient conventional toilet is 6 litres (30 litres per day)
- Average flush volume of efficient dual-flush toilet is 4.3 litres (**21.5** litres per day, 74% reduction)
- Average of 2 toilets per household

B. Shower

- Average number of showers per day: 1
- Average shower time:
  Males: 10 minutes
  Females: 20 minutes
- Average shower volume using inefficient showerhead is 45 litres per day
- Average shower volume using a flow restriction device is 38 litres per day
- Average shower volume using a low flow showerhead is 27 litres per day (46 % reduction)

C. Drinking

Average volume of water demand per day per household:

Average volume per water container: 1 litre

4 litres per average to run faucets until cold water output

4. Multi-Unit Household water usage trends

Average number of peoples per household: 2.4
Classification: high-rise or low-rise apartment buildings, condominiums, co-operatives.
All greater than 6 units

- 19% of Toronto's Water Usage as of 2011
- Average number of flushes per capita per day: 7
    - Inefficient toilet: **115.5** litres per day
    - Effective toilet: **42** litres per day
    - Effective toilet: **30.1** litres per day
- Average of 1.15 toilets per unit

5. Outdoor Water Use Breakdown

Household irrigation: 420L per home
Household (Multi-unit) irrigation: 60L per unit

Calculated Wastewater Flow: 988 ML per day
Untreated Sewage Discharge:

- 33 combined sewage or direct sewage outflow events reported: 246 ML (2006)
- 28 combined sewage or direct sewage outflow events reported: 58 ML (2007)

6. City of Toronto Water infrastructure

Area Coverage: approximately 620 square kilometres
Urban forestry coverage: 20%
Ravine and Natural area coverage: 30%
Population: 2.72million as of 2010
Number of homes: 979,000 approx.

7. City of Toronto Water assets

- 4 Water Filtration plants
- 8 water pumping stations
- 5,016km of distribution watermain

- 4 Wastewater treatment plants
- 4,048 sanitary sewers
- 1,301km of combined sewers (CSO)
- 4,305km of storm sewers
- 3 stormwater management treatment facilities

8. Toronto water consumption values (2008):

- 481,032 Megalitres (ML) per annum
- Peak Day Demand (Summer Drought Season): 2,270 ML per day
- Average Winter demand: 1,270 ML per day
- Average daily water demand: 1,317 ML per day
- Average daily water demand per household: 687L per day

9. Toronto's soil content

The majority of Toronto is clay soils, more specifically, Gray Brown Luvisolic (GBL) soil. GBL has various layers, called horizons, and each horizon has different properties. The top layer is a loamy soil, which is ideal for infiltration but it is only about a foot deep. There are also several clay levels below, which can slow down the infiltration process because of saturation. The soil profile shows the various levels within GBL, along with the clay, loam and sand content percentages.

10. Toronto Port Lands Soil Profile

- Sand
- Silt
- Gravel
- Organic Material

11. Basic Remediation Process

- Excavation
- Treatment Process
- Destination (on-site or off-site)

12. Plumbing Flow Rate in Toronto's High-Rise Condominiums

- 15 Feet per Second (FPS) in the vertical arrangement
- 4-8 Feet per Second (FPS) in the horizontal arrangement

APPENDIX E

Section ONE: Net ZERO Water (NZW) Calculations

Abbreviations

LPCD	Litres per capita per Day	WF	Water Factor
LPD	Litres per Day	NZW	Net Zero Water
LPM	Litres per Minute	NPW	Net Positive Water
HET	High Efficiency Toilet		

No. #						
1	**National Water Usage Averages**	LPCD		%	AS of 2010	
	United States Water Usage Average		400			
	Canadian Water Usage Average		248			
	Canadian usage as a percentage of American			**62%**		
2	**Sustainable Faucet Water Savings**	LPM		LPM Savings		
	Current Performance Baseline		8.3			
	Flow Restriction Devices and Energy Star(TM)		7.1	15%		
	Maximum performance Ultra Low Flow Fixture		1.9	**77%**		
3	**Sustainable Showerhead Water Savings**	LPM		LPM Savings		
	Current Baseline		9.5			
	Flow Restriction Devices		8.1	15%		
	Ultra Low Flow Fixture		1.9	**80%**		
4	**Sustainable Toilet Water Savings**	LPF		LPF Savings		
	Current Baseline		13			
	Flow Restriction Devices		6	54%		
	Ultra Low Flow Toilet		3.5	**73%**		
5	**Water Savings under Global sustainable prescription in the City of Toronto**					
	Current day Water consumption per person in the City of Toronto			253	LPCD	
	Recognized Global standard	÷		70	LPCD	
	Percentage of water saved			72%		
6	**LPCD Savings in No Irrigation Multi-Unit Households**					
a.	Toronto Multi-Unit Population (2010)			1460000		Refer to Appendix D pg. 2
	Toronto Average Consumption LPCD	x		253	LPCD	
	Toronto Multi-Unit Water Consumption per day			369380000	LPD	
b.	Toronto Multi-Unit Population (2010)			1460000		Refer to Appendix D pg. 2
	Toronto Average No. of peoples per Multi-Unit household	÷		2.4		
	Toronto Number of Multi-Unit residential Units 2011			608333		
c.	Toronto Number of Multi-Unit residential Units 2011			608333		
	No Irrigation LPD Savings per Multi-Unit residence	x		60	LPD	
	Multi-Unit LPD irrigation savings			36500000	LPD	
d.	Toronto Multi-Unit Water Consumption per day			369380000		
	Multi-Unit LPD irrigation savings	-		36500000		
	Usage Difference			332880000	LPD	
e.	**Multi-Unit Population No Irrigation Savings LPCD**					
	Usage Difference			332880000	LPD	
	Toronto Multi-Unit Population	÷		1460000		
	Multi-Unit LPCD Usage			228	LPCD	
	Per Capita Difference			253		
		-		228		
	No Irrigation LPCD Savings			**25**	LPCD	
7	**Toronto Wastewater Output per person per day 2011**					
a.	Toronto Wastewater Volume Treated Each Year			423	Billion Litres	
	Toronto Wastewater Untreated Each Year	+		0.91	Billion Litres	
	Total Wastewater Output			424	Billion Litres	
		÷		365	Days	
	Toronto Wastewater output Each Day			1.2	Billion Litres per Day	

b.	Assumption:			1.2 Billion Litres per Day	
	Toronto Domestic Wastewater output is the same % as Water consumed	x	51%		
	Residential Wastewater output estimate			0.6 Billion Litres	
	Toronto Population	÷	2700000	Refer to Appendix D pg. 2	
	Wastewater output per person per day			**222.2** LPCD	
	LEED™ NC/ND interior water usages for maximum water savings				
8	LEED™ WE c1 50% reduction for water efficient landscaping				
	Toronto Average Consumption LPCD			253 LPCD	
	WE 50% potable irrigation reduction			**25** LPCD	
	Refer to Calculation No.**5e**	x	**50%**		
				13 LPCD	
	Resultant Volume of Water used			**241** LPCD	
9	Toronto Average Consumption LPCD			253 LPCD	
	LEED™ WE c3 30% potable water efficiency & WE 20% prerequisite				
	Percentage of water savings prescribed by case study exemplars	x	30%		
				76 LPCD	
	Resultant Volume of Water used			**177** LPCD	
10	Subtotal of WE c1, c3 Calculations No. 8 & **9**			**165** LPCD	
11	LEED™ WE c2 50% potable water reduction for sewage conveyance				
	Toronto Average Consumption LPCD			253 LPCD	
	Percentage of potable water waste conveyance	x	28%		
	per Toronto usage (Toilet)			70.84 LPCD	
		x	50%		
	Estimated Water Savings	=		35 LPCD	savings
	Resultant Volume of Water used			**218** LPCD	
12	Subtotal of WE c1, c2, c3 Calculations No. **8,9,11**			**129** LPCD	
13	LEED™ ND 25% wastewater reuse				
	Refer to Calculation no. 9			222.2 LPCD	
		x	25%		
	Estimated Water Savings			**56** LPCD	
14	Total Water Savings from LEED™				
	Sum of Calculation **6** & **7**			**91** LPCD	

Net Zero Water Savings Target based on City of Toronto Household Usage Values

15	Volume of NZW consumption per person per day		70 L	
	Number of days per annum	x	365 Days	
	Total volume of NZW water required per annum		25550 L/annum	

Calculations based on Number of Events per Day, per Annum

16	**NZW Toilet Consumption Target**	28%	@	70 LPCD	
		=	**19.6** LPCD		
	HET average flush	No.	Flush Volume	Outflow	
	Estimated Wastewater flush events	4	3.0 LPF	12 LPD	
	Estimated Waste solid flush events	1	4.8 LPF	4.8 LPD	
	No. Flushes Per Capita Per Day	5			
	HET LPCD			**16.8** LPCD	
	HET average flush				
	HET LPCD		16.8		
	No. Flushes Per Capita Per Day	÷	5		
			3.4 LPF		

# of flushes per day is established by the Toronto Water Efficiency Plan (WEP) for Multi-Unit Construction Averages

Total LPCD value based upon performance standards of best-available-market fixtures

17 Establishing NZW Clothes Washing Consumption Target

a. Current Clothes Washing Water Use Per Annum

Current Toronto Water Consumption		253 LPCD
Current Toronto Washing Machine Consumption		22%
Current LPCD consumption		**56** LPCD
	x	365 Days in a year
Volume per Annum		**20316** L

b. Number of Loads based on Energy Star Appliance as Baseline

Energy Star Clothes Washer	WF	Capacity/Volume	Load (Gallons per Cycle)	
	6	3.0 cu.ft.	18 GPC	68 LPC
Current Water Usage Per load		=	68 LPC	
Volume Per annum			20316 L	
Energy Star Clothes Washer LPC		÷	68 LPC	
			299 Cycles per year	
		÷	52 weeks in a year	
Number of Loads per week			**5.7**	

c. Number of Loads based on Best Performing Appliance to achieve NZW Target

NZW Target based on Current Washing Machine Consumption	22%	@ =	70 LPCD **15.4** LPCD

Best Performing Clothes Washer	WF	Capacity/Volume	Load (Gallons per Cycle)	
	2.8	4.4 cu.ft.	12.32 GPC	46.6 LPC
Estimated Load's per week			**2.3** Loads per week	
	@	x	46.6 LPC	
			107 LP week	
		x	52 weeks in a year	
			5573 LP annum	
		÷	365 Days in a year	
			15.3 LPCD	

loads per week based are weighed upon the average number of occupants in multi-unit construction based upon the Toronto WEP

Water factor is measured by the quantity of water (gallons) used to wash each cubic foot of laundry

18 Establishing NZW Dishwasher Consumption Target

a. Current Clothes Washing Water Use Per Annum

Current Toronto Water Consumption		248 LPCD
Current Toronto Dish Washing Machine Consumption		2%
Current LPCD consumption		**5** LPCD
	x	365 Days in a year
Volume per Annum		**1810** L

b. Number of Loads based on Energy Star Appliance as Baseline

Energy Star Dish Washer	WF	Size		Load (Gallons per Cycle)	
		Standard	24x24x35	3.5 GPC	13 LPC
Current Water Usage Per load		=		13 LPC	
Volume Per annum				1810 L	
Energy Star Clothes Washer LPC		÷		13 LPC	
				139 Cycles per year	
		÷		52 weeks in a year	
Number of Loads per week				**2.7**	

c. Number of Loads based on Best Performing Appliance to achieve NZW Target

NZW Target based on Current Dish Washing Machine Consumption	2%	@ =	70 LPCD **1.4** LPCD

Best Performing Dish Washer	WF	Size		Load (Gallons per Cycle)	
		Standard	24x24x35	2.0 GPC	7.5 LPC
Estimated Load's per week				**1.3**	
	@	x		7.5 LPC	
				10 LP week	
		x		52 weeks in a year	
				507 LP annum	
				365 Days in a year	
				1.4 LPCD	

Section TWO: Net Positive Water (NPW) Calculations

Abbreviations

LPCI	Litres per capita per Day	WF	Water Factor
LPD	Litres per Day	NZW	Net Zero Water
LPM	Litres per Minute	NPW	Net Positive Water

Lower Don Lands (LDL) NPW Site Area

Conversion	m^3	=	1000 L
Total site area to curb cut			7972 m^2
Property/land parcel area as prescribed by Waterfront Toronto			6138 m^2
Immediate area of 'Dirty' Water as prescribed by NPW guidelines			1293 m^2
Immediate area of 'Clean' Water as prescribed by NPW guidelines			6138 m^2

1 Total volume of precipitation on the NPW LDL site

a. Annual precipitation maximum

		0.850 m	Depth
Total site area	x	7972 m^2	Area
		6776 m^3	
	=	**6776200** L	Volume

b. Annual snowfall maximum

		1.334 m	Depth
Total site area	x	7972 m^2	Area
		10635 m^3	
	=	10634648 L	Volume
	x	10%	
		1063465 L	

Snow to Precipitation Ratio equates to 10 to 1. 10 inches of Snow equates to 1 inch of Water

c. Total Sum of Precipitation per annum

Water precip.		6776200 L
Snow precip.	+	1063465 L
	=	**7839665** L/annum

2 Total number of peoples supported by specified NPW site

Site water capacity per annum		7839665 L/annum	
NPW demand per person per annum	÷	25550 L/annum	@ 70LPCD
	=	**307** Peoples	

3 Area required to harvest water per NPW inhabitant in Toronto

Total site area		7972 m^2
Number of NPW peoples supported	÷	307
	=	**26** m^2

4 Projected Number of Units alloted

Number of people supported by NZW site		307
Toronto average No. of people per unit as of 2010	÷	2.5
Total number of NPW units	=	**123** units

NPW Active Water Treatment Capabilities

5 GE Zenon Water Treatment Module

This building system is required to treat human waste

Integrated Z-mod Bioreactor and Zeeweed Ultrafiltration Membrane

Capacity		25 litres/minute
	x	60
		1500 L/hour
	x	24
		36000 L/day
	x	365
	=	**13140000** L/annum

6 **Trojan UV Water Treatment Module**

This building system eliminates bacteria from water content

Trojan UV SWIFT SC x 2		2	
Capacity		7.6	litres/minute
	x	60	
		912	L/hour
	x	24	
		21888	L/day
	x	365	
	=	**7989120**	L/annum

7 **Filtration and Treatment capacity for LDL NPW site**

a. Positive treatment capabilities of Zenon Ultrafiltration Module

Zenon water treatment capacity per annum		13140000	L/annum	
	-	7839665		
	=	**5300335**	L/annum	**POSITIVE**

b. Trojan UV SWIFT SC x 2 water treatment capacity per annum

		7989120		
	-	7839665	L/annum	
	=	**149455**	L/annum	**POSITIVE**

NPW Passive Precipitation Water Banking capacity (Clean Water Management)

Calculations have been made based upon a downward elevation scheme starting from the npw building rooftop and down towards building grade

8 **Building.A**

Refer to Drawing A.200 Fig. 8.1.5 Pg. 229-230

a.

Roof Area		418 m^2		
Designated roof soil storage area		270 m^2	height of storage	0.83 m
Calculated coverage percentage		65%		
	Volume of soil storage	**224** m^3		

b.

Balcony Area		120 m^2		
Balcony soil storage area		42 m^2		
Percentage of coverage		35%		
Number of storage volumes (excluding podium levels)		5	height of storage	0.55 m
	Volume of soil storage	**210** m^3		

9 **Tower B**

a.

Roof Area		289 m^2		
Designated roof soil storage area		189 m^2	height of storage	0.83 m
Calculated coverage percentage		65%		
	Volume of soil storage	**157** m^3		

b.

Open corridor/circulation area		78 m^2		
Vertical Percolation System (VPS) soil storage area		28 m^2		
Percentage of coverage		36%		
Number of storage volumes (excluding podium levels)		4	height of storage	0.55 m
	Volume of soil storage	**112** m^3		

10 Tower C

a.	Roof Area		449 m^2		
	Designated roof soil storage area		294 m^2	height of storage	0.83 m
	Calculated coverage percentage		65%		
		Volume of soil storage	**244** m^3		
b.	Open corridor/circulation area		108 m^2		
	VPS soil storage area		38 m^2		
	Percentage of coverage		35%		
	Number of storage volumes (excluding podium levels)		4	height of storage	0.83 m
		Volume of soil storage	**152** m^3		

11 Tower D - Bridge

a.	Roof Area		356 m^2		
	Designated roof soil storage area		233 m^2	height of storage	0.83 m
	Calculated coverage percentage		65%		
		Volume of soil storage	**193** m^3		
b.	Open corridor/circulation area		228 m^2		
	VPS soil storage area		79 m^2		
	Percentage of coverage		35%		
	Number of storage volumes (excluding podium levels)		3	height of storage	0.83 m
		Volume of soil storage	**237** m3		

12 Tower E

a.	Roof Area		221 m^2		
	Designated roof soil storage area		154 m^2	height of storage	0.83 m
	Calculated coverage percentage		70%		
		Volume of soil storage	**128** m^3		
b.	Open corridor/circulation area		55 m^2		
	VPS soil storage area		19 m^2		
	Percentage of coverage		35%		
	Number of storage volumes (excluding podium levels)		7	height of storage	0.55 m
		Volume of soil storage	**133** m^3		

13 Subtotal Volume of Rooftop Soil Storage Medium

Sum of Calculation No. 9,10,11,12 a.		946 m^3
Calculated evaporative water loss	-	10 %
		852 m^3

14 Subtotal Volume of Balcony Soil Storage Medium

Sum of Calculation No. 9,10,11,12 b.		844 m^3
Calculated evaporative water loss	-	10 %
		760 m^3

15 Subtotal Volume of Soil Storage Medium

NPW Residential Towers	=	1611 m^3
Engineered Silt-Loam soil water banking capacity	x	20%
		322 m^3
	=	**322236** L

note: Banking Volumes for the following calculations are located under the gridlines annotated under the following drawings

Drawing A203 Fig. 8.2.0 Pg. 242

Drawing A204 Fig. 8.2.1 Pg. 244

Drawing A205 Fig. 8.2.2. Pg. 246

	Building Podium Level 2				
16	**Tower B2 Podium**	Area	213 m^2	A204 - FL.2	
a.	Planter soil storage medium				
	Volume B.4y-10		135 m^2		
		Volume of soil storage	**112** m^3	height of storage	0.83 m
17					
b.	Green Landscape				
	Volume B-C.12-13		558 m^2		
		Volume of soil storage	**167** m^3	height of storage	0.30 m
	Building Podium Level 3				
18	**Tower A Podium**	Area	153 m^2	A205 - FL.3	
a.	Planter soil storage medium				
	Volume F.3x		21 m^2		
	Volume J.3z-6y		34 m^2		
	Volume Kx.3z-7x		27 m^2		
		Volume of soil storage	**68** m^3	height of storage	0.83 m
b.	Volume F.5y		35 m^2		
		Volume of soil storage	**21** m^3	height of storage	0.60 m
c.	Water Feature		37.5 m^2		
		Volume of water feature	**21** m^3	height of storage	0.30 m
	Building Podium Level 3				
19	**Tower B-C Podium**	Area	233 m^2	A204 - FL.2	
a.	Planter soil storage medium				
	Volume A.1-3		19.2 m^2		
	Volume B-1-3		33 m^2		
		Volume of soil storage	**43** m^3	height of storage	0.83 m
b.	Green Landscape				
	Volume A-B.1-2x		88 m^2		
		Volume of soil storage	**26** m^3	height of storage	0.30 m
c.	Water Feature		56 m^2		
		Volume of water feature	**17** m^3	height of storage	0.30 m
	Building Podium Level 1,2,3				
20	**Ammenity Space**	Area	214 m^2	A203 - FL.2	
a.	Green Open Landscape				
		Volume of soil storage	**64** m^3	height of storage	0.30 m
	Volume F-4		8 m^2		
	Volume D.3y		15 m^2		
	Volume D-E.4y		12 m^2		
		Volume of soil storage	**18** m^3	height of storage	0.50 m
b.	Water Feature	Area	73 m^2		
		Volume of water feature	**22** m^3	height of storage	0.30 m
	Building Podium Level 1,2,3				
21	**Tower D-E Podium**	Area	136 m^2	A204 - FL.2	
a.	Green Landscape				
	Volume J.7x-11				
		Volume of soil storage	**41** m^3	height of storage	0.30 m
	Volume K.7x-11y		17 m^2		
		Volume of soil storage	**17** m^3	height of storage	0.83 m

b.	Landscape element		A203 - FL.1 - FL.2		
	Planter soil storage medium				
	Green Landscape		610 m^2		
		Volume of soil storage	**1220** m^3	height of storage	2.0 m
c.	Water Feature (Naturalized Waterway)		740 m^2		
		Volume of water feature	**1480** m^3	height of storage	2.0 m

22 Subtotal Volume of Podium Soil Storage Medium

a.	NPW Podium Soil storage volume		
	Calculated coverage percentage		63%
	NPW Podium water banking coverage	=	**1797** m^3
b.	Engineered Silt-Loam Soil water banking capacity		1797
		x	20%
			359 m^2
		=	**359434** L
c.	Calculated Evaporative Water Loss		359434
		-	10 %
			323491 L

23 Subtotal Volume of on-site Water Features

a.	NPW Podium & Landscape Element		1540 m^2
	Sum of Calculations 17,18,19,20 c.	=	**1539700** L
b.	Calculated Evaporative Water Loss		1539700
		-	10 %
			1385730 L

24 Total volume of above Grade 'Clean' Passive Water Storage

Sum of calculations No. 8 - 22 = **2031457** L

NPW Active Building Storage capacity (Clean Water Management)

note: Area calculations based upon ceiling application and applicable ceiling area

25 Capillary Tube Mat System Storage Capacity

	Typical NPW unit area		58 m^2
	Capillary volume per square meter	x	0.39 L/m2
	Stationary volume per unit		**22.62** L/per unit

26	Number of Units in NPW Mid-rise construction		123
		x	22.62
	Capillary water volume per Mid-rise exemplar		**2782** L/NPW building

27 Capillary Mat Area in Circulation Areas/Building Core

a.	Tower A		
			31 m^2
	# of Floors	x	6
			186 m^2
b.	Tower B		
			18 m^2
	# of Floors	x	5
			90 m^2
c.	Tower C		
			37 m^2
	# of Floors	x	4
			148 m^2
d.	Tower D		
			12.6 m^2
	# of Floors	x	6
			75.6 m^2

e.	Tower E			12.6 m^2
		# of Floors	x	3
				37.8 m^2
f.	**NPW Residential Tower Capillary Area**			
	Sum of Calculations No. 25,26			**3320** m^2
28	**NPW Podium Capillary Area**			
	Ground Floor Capillary Mat Area			1311 m^2
	Second Floor Capillary Mat Area		+	1312 m^2
	NPW Podium Capillary Area Subtotal		=	**2623** m^2
29	**Subtotal NPW Capillary System Size**			
a.	Sum of Calculations No. 27,28			3320
			+	2623
			=	**5943** m^2
b.	Total Volume of Capillary System			
	Capillary Mass Filled			824 g/m2
	Subtotal of area coverage	Calculation No. 28a	x	5943 m^2
				4896752 g
		Gram to Litre Conversion		
		1000 g = 1 L	=	**4897** L
30	**Borehole Thermal Transient System (BTTS) water storage capacity**			
a.	Hose Diameter			0.3 m
	Radius			0.15
	lengths		x	35 m
	Volume of water in each hose			1.575 m3
b.	Volume in litres			1575 L
	Number of BTTS holes in one 'STRING'		x	1824
				2872800 L
c.	Total Water Banking Volume			2872800
	Number of BTTS 'STRING's		x	2
				5745600 L

NPW Passive precipitation storage capacity (Dirty Water Management)

31	**Subtotal volume of above Grade 'Dirty' Passive Water Storage**			
a.	Streetscape condition			1483 m^2
		Volume of soil storage		**2966** m^3
		Soil water storage capacity	x	20%
				593 m^3
			=	**593200** L
b.	Bioswale			
		South		74 m^2
		East		79 m^2
		North		74 m^2
		West		n/a non-streetscape
			+	condition
		Subtotal		227 m^2
		Volume of soil storage		**454** m^3
		Soil water storage capacity	x	20%
				91 m^3
			=	**90800** L

c.	Total Dirty Water management storage capacity			
	Sum of Calculation 30 a, b.		593200 L	
		+	90800 L	
			684000 L	

32 NPW sustainable water storage total

a.	Sum of calculation No. 23, 28, 29, 30		**8465953** L	POSITIVE
	Total Sum of Precipitation per annum	-	7839665	
	Percentage of overall precipitation on site		626289 L	
		=	**108%**	
b.	Percentage of Passive Building Performance		8465953	
		÷	2715457	
			32%	
c.	Percentage of Active Building Performance		8465953	
		÷	5745600	
			68%	

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Water Reserves in days			
Percentage of overall precipitation on site		626289	
NPW Water Consumption per day	÷	21490	
307 @ 70 LPCD		29	day reserve

NPW Economic considerations

34	Total Cost Savings at 2012 Toronto Water Utility Rate		8465953 L
		=	8465.95 m^3
	City of Toronto Water Rate 2012	x	2.62 per/m3
	Water Cost Savings per Annum	$	**22180.80** per/year

35 Unnecessary Municipal Water Services Savings (One time construction cost)

25mm residential water service and meter		2,575	$
New residential sanitary sewer service connection in road		7150	$
New residential storm sewer service connection in road	+	7150	$
		16,875	$