DATE: June 4, 2024

TO: Mayor and Members of Council

FROM: Vince Musacchio, Deputy City Manager, Infrastructure Development

RE: **COMMUNICATION – Committee of the Whole (Working Session), June 5, 2024**

Item #1
MUNICIPAL NON-CONVENTIONAL STORMWATER MANAGEMENT FACILITIES POLICY AND ACCEPTANCE PROCEDURE

Purpose

To provide a copy of Attachments 1 through 4 associated with the Municipal Non-Conventional Stormwater Management Facilities Policy And Acceptance Procedure.

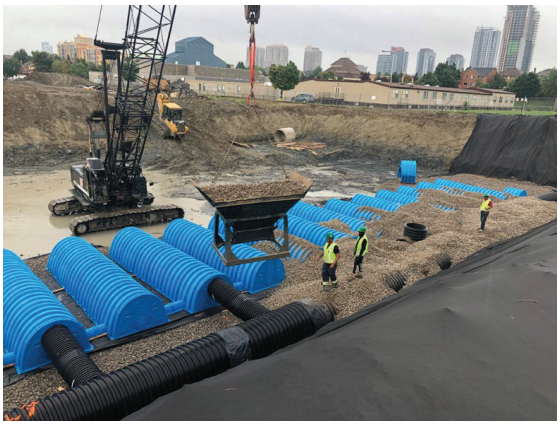
For more information, contact Frank Suppa, Director of Development Engineering, ext. 8255.

Respectfully submitted by

Vince Musacchio, Deputy City Manager,
Infrastructure Development

Attachment(s)

1. Non-Conventional Stormwater Management Facilities Background Report by Resilient Consulting Corporation, dated February 14, 2023.
2. City of Vaughan Municipal Non-Conventional Stormwater Management Facilities Policy dated June 5, 2024.
3. City of Vaughan Municipal Non-Conventional Stormwater Management Facilities Acceptance Procedure dated June 5, 2024.
4. City of Vaughan Non-Conventional Stormwater Management Facility Engineering Design Criteria & Standard Drawings dated June 5, 2024.



NON-CONVENTIONAL STORMWATER MANAGEMENT FACILITIES
BACKGROUND REPORT
Final Submission

2023-001
February 14, 2023

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Executive Summary

Resilient Consulting Corporation ('Resilient') has been retained by the City of Vaughan (the 'City') to develop a policy, procedure, and relevant design criteria/standards for the approval of non-conventional municipal stormwater management facilities ('SWMFs') associated with new development. The City, along with many neighbouring municipalities, is experiencing increased pressure to shift from requiring conventional SWMFs (i.e. wet/dry ponds) to accepting publicly owned and operated non-conventional SWMFs (i.e. underground tanks, superpipes, etc.). These facilities can be incorporated below new public parklands or below right-of-ways, as the underground feature allows for dual purpose of the land above. At the time of development of this report, approval of non-conventional SWMFs has largely been completed on a case-by-case basis with considerations for feasibility, maintenance and operation requirements, and site-specific design constraints. An interim approach for accepting these facilities was adopted by the City in 2022, however the goal of this project is to develop a new formal policy, procedure, and design criteria for accepting non-conventional SWMFs. The primary objectives in developing this framework are:

- To provide a decision framework to determine where new non-conventional SWMFs may be accepted;
- To streamline the evaluation and acceptance process for non-conventional SWMFs;
- To provide a list of allowable stormwater management technologies/facility configurations that can be accepted as municipal facilities; and,
- To examine financial implications and lifecycle costs of implementing non-conventional SWMFs vs. conventional facilities and develop cost recovery mechanisms to be apply to subject developments to ensure implementation of non-conventional SWMFs are financially viable alternatives in the long-term.
- To create a standard operating procedure (SOP) that outlines the inspection, operation and maintenance protocols for the non-conventional SWMFs to ensure the long-term success of implementation.

The City of Vaughan, and other regulatory agencies have various existing policies, procedures, guidance documents, and established criteria for the approval of stormwater management facilities, including but not limited to; City of Vaughan *MECP's CLI-ECA for Municipal Stormwater Management Systems* (2022), MECP *Draft Low Impact Development Stormwater Management Guidance Manual* (2022), City of Vaughan *Engineering Design Criteria & Standard Drawings* (2020), TRCA *Stormwater Management Criteria* (2012), and *CVC/ TRCA Low Impact Development Stormwater Management Planning and Design Guide* (2010). These documents provide regulations and design criteria in relation to the approval of conventional SWMFs, and do not explicitly reference the design requirements of non-conventional SWMFs. In 2022, the City adopted an interim approach to approving non-conventional SWMFs which detailed the financial contribution required by the developer to compensate for an increase in cost when compared to conventional SWMFs, in addition to providing some general limitations and considerations when preparing the facility design. At the time of its development, no other municipality within the Greater Toronto Area ('GTA') had created a formal overall approval policy for the acceptance for non-conventional SWMFs. A thorough review of the City's existing policies and programs has been conducted as a part of this report to identify relevant guidelines and restrictions that should be taken into consideration during the preparation of the City's formal policy, procedures and standards for non-conventional SWMFs, ensuring consistency across the City's planning and development policies.

In addition, six (6) municipalities across Ontario were contacted to confirm if any policies, procedures, design criteria, or standards have been implemented for non-conventional SWMFs within their jurisdiction. The following is a list of the contacted municipalities:

- City of Markham, Ontario
- City of Mississauga, Ontario
- City of Richmond Hill, Ontario
- City of Hamilton, Ontario
- City of Burlington, Ontario
- City of Kitchener, Ontario

Upon review of this collected information, it was confirmed that, with the exception of the City of Markham, the remaining neighbouring municipalities do not currently have any specific policies or guidelines in place to address the approval of non-conventional SWMFs.

There are many potential advantages to implementing a non-conventional SWMF, including but not limited to: providing a dual-purpose to the land (ie. not just SWM pond), requires a smaller at-surface footprint, eliminates at-surface water quality concerns such as standing-water and E.Coli contamination from wildlife, can be designed to accommodate both passive and active programming of the space above the facility or other dual utilitarian usage such as parking and roads, lowers water temperature of discharge, and improves safety by eliminating the potential of drowning and/or falls through ice. Apart from these benefits, there are many applications that cannot accommodate the required area for a dry/wet pond. As such, it is acknowledged that non-conventional SWM facilities may have advantages as opposed to conventional dry/wet ponds in locations with restricted available area.

Non-conventional SWMFs may also have disadvantages in comparison to traditional SWM ponds. These disadvantages may include:

- Reliance on engineered products with design lives of 50 to 100 years to achieve volume requirements, instead of open excavated ponds;
- Limitations on monitoring and inspections associated with confined space entry requirements;
- Elevated frequency and complexity of the maintenance and inspection of system;
- Potential presence of odour due to improper maintenance;
- Potential for significant failure or loss of storage volume through clogging if routine maintenance of pre-treatment devices is not carried out; and,
- Significant impact to park facilities and programs for major repairs and lifecycle replacement.

To support the project objective of defining a list of acceptable technologies, a detailed review of common non-conventional SWMFs was completed to assess the feasibility of each option, operation and maintenance requirements, specific advantages/disadvantages, and limitations for each facility, and estimate capital and lifecycle costs. The following non-conventional SWMFs have been assessed:

- Plastic "Milk-Crate" Systems;
- Plastic Arch Chamber Facilities;
- Modular Concrete Chambers;
- Superpipes;
- Cast-in-place Concrete Facility; and,
- Modular Form Cast-in-place Systems.

Various limitations were defined for each of the non-conventional SWMFs type examined, ranging from standard height sizes and required burial depths for many of the pre-cast systems, winter weather conditions and anticipated delays for the cast-in-place systems, and delivery considerations for

superpipe systems to ensure safe passage under bridge overpasses. Similarly, specific requirements such as load bearing capacity, separation from groundwater elevations (for infiltration facilities), and minimum cover need to be considered when selecting a preferred SWMF. Lastly, consultation with the City's operation and maintenance department is required prior to finalizing the acceptable list of technology to discuss the requirements of the preferred system and ensure proper equipment, staff training, and external services are available to complete the required maintenance.

A lifecycle assessment was completed as a part of this report to compare the financial implications associated with each of the common non-conventional SWMFs outlined above. The lifecycle assessment of these facility types found that the modular form cast-in-place systems resulted in the lowest capital cost investment, and ultimately lowest lifecycle cost as a result of its long-life expectancy (100-years). Although these costs are the lowest, this system has the highest maintenance costs, and has many limitations and considerations associated with construction. Superpipe facilities were noted as the most expensive option upfront and may not be best suited for large storage volume applications due to this associated cost.

Upon completion of the Background Report, stakeholder engagement sessions will be arranged to review and discuss the results of the report, in addition to providing opportunities for internal and external stakeholders to provide feedback on their concerns associated with the current interim approach for accepting non-conventional SWMFs. A technical review of the City's existing sixteen (16) non-conventional SWMFs will then be completed prior to proceeding with Stage 2 of the project.

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1 Introduction

The implementation of effective stormwater management is critical in mitigating the undesirable impacts of urbanization on the natural hydrologic cycle and on local watercourses and associated infrastructure. Stormwater management (SWM) infrastructure has been installed in the City of Vaughan ('City') since the early 1980s, with the City currently owning and operating 147 conventional stormwater management facilities ('SWMFs'). Conventional stormwater management ponds are a common approach for addressing stormwater management requirements within a new development, however a significant amount of developable land is required to implement these facilities. The increased demand for housing and high value of land has resulted in developers looking for alternative options for publicly owned and operated SWMFs. To date, the City has approved or is in the process of approving 16 non-conventional SWMFs, which have been reviewed and considered on a case-by-case basis taking into consideration acceptability, feasibility, maintenance, and operation requirement for each application. These non-conventional SWMFs are under roadways, passive open space blocks and within parks. These approved facilities have included underground stormwater tanks and superpipe storage. Due to the higher total cost of ownership for these non-conventional SWMFs, the City has also required a one-time cost contribution from the developer, calculated on a case-by-case basis, ensuring the financial cost differential between operation, maintenance, and replacement of conventional and non-conventional SWMFs is secured.

In June 2022, an interim approach for accepting non-conventional SWMFs was adopted by City Council to address the increased pressure for approval of innovation stormwater solutions from local developers. One of the recommendations of the Council Report suggested the City retain a consulting engineering firm to develop of a formal policy and procedure for reviewing and accepting non-conventional SWMFs. As a result, Resilient Consulting Corporation ('Resilient') was retained by the City to prepare a City Policy, Procedure, and Engineering and Parks Design Criteria for non-conventional SWMFs, thereby addressing the City's needs for evaluating, accepting, implementing and maintaining non-convention SWMFs. These new documents will strictly apply for publicly owned and maintained infrastructure, and will not apply for non-conventional SWMFs proposed on private lands.

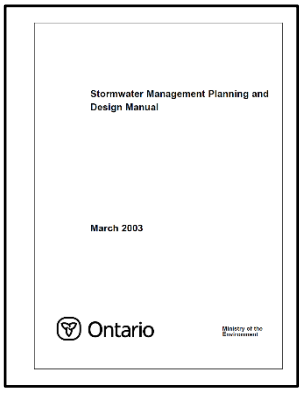
To facilitate the development of this new policy, procedure, and design criteria, the following comprehensive background review was prepared by Resilient to assess the City's current interim approach for accepting non-conventional SWMFs and to identify any design consideration, constraints and data gaps that should be taken into consideration during the preparation of the new design framework. Relevant background reports reviewed as a part of this report are provided in **Appendix A.**

2 Existing Policy and Procedure Review

As with all municipalities in Ontario, the City of Vaughan must operate according to planning and policy framework that has been developed to support provincial, regional and local objectives in growth. All new City policies and procedures must ensure that the final recommendations are consistent with these provincial, regional and local policies and objectives.

The following sections provide a review of these existing documents that may be applicable during the development of the new City of Vaughan policy, procedure and design criteria for non-conventional SWMFs.

2.1 MECP Stormwater Management Planning and Design Manual, March 2003



The MECP Stormwater Management Planning and Design Manual provides technical and procedural guidance for the planning, design and review of stormwater management practices. The manual provides practical guidance for specific circumstances and encourages the development of innovative designs and technologies for stormwater management outside of what is specified within the manual. Design guidance is provided for individual lot level, conveyance and end-of-pipe practices, taking into consideration physical constraints such as soil type and groundwater conditions, climate considerations, restoration, maintenance and financial implications.

The manual is divided into the following key sections:

- Environmental Planning;
- Environmental Design Criteria;
- Stormwater Management Plan and SWMP Design;
- Infill Development;
- Operation, Maintenance and Monitoring; and,
- Capital and Operational Costs.

Chapter 4 of the manual focuses specifically on the design and implementation of a stormwater management plan to meet all local criteria for water balance, water quality, erosion and water quantity controls. Various lot level controls, including rooftop storage, superpipe storage, infiltration trenches, and pervious pipe systems are identified within the manual to reduce peak runoff rates and promote onsite infiltration, ultimately reducing end-of-pipe storage requirements. However, these controls typically require implementation on lands held in private ownership, with maintenance and effectiveness of the system contingent on the actions of the landowners.

The end-of-pipe SWMFs identified within the manual include:

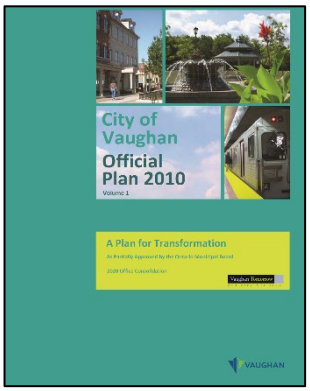
- Wet ponds;
- Wetlands;
- Dry ponds; and,
- Infiltration basins.

Detailed design criteria for the development of these conventional end-of-pipe facilities, include treatment volume requirements, forebay depth, side slopes and retention times are provided within the manual, in addition to various equations that can be utilized to determine specific design parameters.

Chapter 6 and Chapter 7 of the manual focuses on the operation and maintenance requirements, and financial implications associated with the implementation of these urban stormwater solutions. Approximate unit costs for capital construction and commonly required maintenance activities, such as grass cutting and the flushing of pipes, are provided based on industry standard pricing from 2003.

The MECP Stormwater Management Planning and Design Manual does not provide design criteria or guidance in relation to non-conventional end-of-pipe SWMFs, such as underground arch chambers systems or concrete facilities. The manual does provide some guidance on the use of superpipes to provide subsurface storage and reduce peak flows, however this is examined as a lot level control only, as superpipes must be implemented within a treatment train in order to provide the required water balance, water quality, and erosion control requirements.

2.2 City of Vaughan Official Plan 2010 and Update



The City of Vaughan 2010 Official Plan ('OP') addresses the City's long-term planning requirements to the year 2031 and, in addition to consolidating all former land use policies into one document, the Plan brings the City into conformity with recent provincial and regional land use policy direction. The OP is part of an overall Growth Management Strategy, initiated by Council, that will shape the future of the City and guide its continued transformation into a vibrant, beautiful and sustainable City.

The goals of the Official Plan are as follows:

- Goal 1: Strong and Diverse Communities;
- Goal 2: A Robust and Prominent Countryside;
- Goal 3: A Diverse Economy;
- Goal 4: A Vibrant and Thriving Downtown;
- Goal 5: Moving Around without a Car;
- Goal 6: Design Excellence and Memorable Place;
- Goal 7: A Green and Sustainable City; and,
- Goal 8: Directing Growth to Appropriate Locations.

The above goals constitute the City of Vaughan's Vision for Transformation and were developed following extensive consultation with Vaughan residents to define the main principles that would guide the development of the OP.

Policy 3.6.6 (3.6.6.1. – 3.6.6.17.) of the OP provides direction on stormwater management in the City of Vaughan. Given the extensiveness of the Policy, a summary of the main points is provided below:

- To recognize stormwater management facilities as a functioning part of Vaughan's natural water system and ecosystem, new development will employ stormwater management practices that are sensitive to the natural environment and natural heritage features.
- That new development must satisfy the City and demonstrate consistency with the TRCA Stormwater Management Criteria for water quantity (flood flow) control, water quality control, erosion control, groundwater recharge and water balance, for the protection of hydrologically sensitive features.
- Consideration of innovative stormwater management approaches must be implemented and designed in accordance with MECP's Stormwater Management Practices Planning and Design Manual and with reference to TRCA's LID Stormwater Management Planning and Design Guide.
- New stormwater facilities shall be:
    - located outside of valley and stream corridors, unless approved by TRCA and MECP;
    - located, where possible, adjacent to open spaces, parks and/or natural heritage areas contributing to a connected system and to encourage public access to these facilities, where appropriate;
    - integrated into surrounding developments as publicly accessible open space; and,
    - designed as naturalized or formal landscapes that are complementary to adjacent features, including adjacent landscapes or natural heritage features.
- Undertake stormwater management on a volume control basis that maintains recharge rates, flow paths and water quality to the extent possible, in addition to peak flow control, and to maintain pre-development water balance. Particular emphasis shall be placed on areas confirmed as significant recharge areas.

- To support the TRCA in establishing programs for ongoing monitoring of ambient conditions as part of the Regional Watershed Monitoring Program, including evaporation, stream flow, channel form, groundwater levels, water quality and terrestrial communities and species to provide baseline data to facilitate an adaptive management approach.

As summarized above, the 2010 OP encourages the implementation of innovative stormwater management approaches where appropriate, however these designs must remain in accordance with guidelines set forth by the MECP and TRCA. At this time, the MECP and TRCA have yet to implement regulations specific to non-conventional SWMFs. The OP also emphasizes the need for new SWMFs to be designed as publicly accessible facilities located adjacent to open spaces, parks or natural heritage areas.

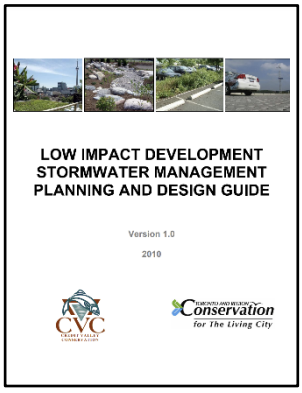
Policy 7.3 of the OP also provides detail related to parks and open spaces within the City of Vaughan, which require consideration during the implementation of non-conventional SWMFs under parkland. Parks and open space design requirements, including park size, recreational uses, and orientation will impact the feasibility of constructing underground stormwater infrastructure within these spaces.

The City of Vaughan is currently in the process of completing an Official Plan Review to guide the City's growth for the next 30 years and beyond. As a component of this review, the City has prepared seven background reports which summarize research, best practices, and feedback received from the community regarding their hopes for Vaughan in the future. The following background reports were prepared in 2022 to provide recommendations for development of future Official Plan policy:

- Agricultural System Review;
- Residential Growth, Intensification and Housing Needs Strategy;
- Employment Land Use Review;
- Climate Change Adaptation and Resilience Framework;
- Commercial Land Use Review;
- Natural Heritage Network Review; and,
- Urban Design, Built Form, Compatibility and Sustainable Development.

The prepared background reports provide an overview of existing policies and regulations in place across Canada related to the various areas of interest, in addition to providing strategic recommendations for updating the existing 2010 City of Vaughan OP. The application of non-conventional SWMFs is not directly identified within the available background reports, however policy recommendations include encouraging the incorporation of innovative and low impact stormwater management practices and green infrastructure where feasible.

2.3 CVC/ TRCA Low Impact Development Stormwater Management Planning and Design Guide, 2010



The CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide was developed by Credit Valley Conservation ('CVC') and the TRCA to provide direction on landscape-based stormwater management planning and LID best management practices for development within the CVC and TRCA watersheds. The guide provides direction on the selection, design, construction, and monitoring of these landscaped-based stormwater management strategies, with particular focus on the planning and design of structural low impact development practices.

The guide provides the key principles in the design of LIDs as follows:

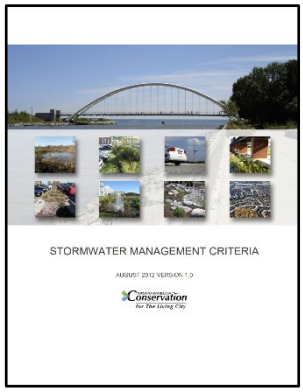
- Use existing natural systems as the integrating framework for planning;

- Focus on runoff prevention;
- Treat stormwater as close to the source as possible;
- Create multifunctional landscapes; and,
- Educate and maintain.

LID practices, applied within a treatment train approach with end-of-pipe facilities, were noted to provide increased runoff reduction, be more cost effective, have lower maintenance burdens, and be more protective of aquatic habitat than stand alone end-of-pipe facilities.

2.4 TRCA Stormwater Management Criteria, August 2012

The Toronto and Region Conservation Authority ('TRCA') Stormwater Management Criteria provides current design guidelines and requirements related specifically to stormwater management within the TRCA's jurisdiction, building upon the TRCA Planning and Development Procedural Manual (2007) that outlines the general requirements when seeking development approval by the TRCA. This document is intended to provide guidance to developers, consultants, municipalities and land downers during the planning and design of stormwater management infrastructure, outlining the requirements to achieve flooding, water quality, erosion, water balance and natural heritage standards. The primary stormwater management design criteria required by the TRCA is as summarized below:

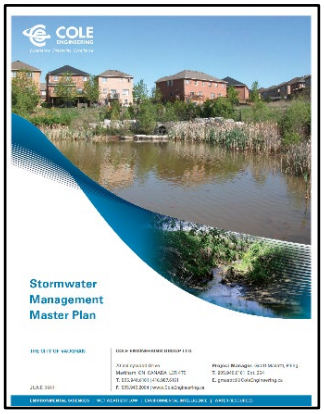


- **Stormwater Quantity**: Control peak flows to the appropriate watershed flood control criteria.
- **Erosion:** At minimum, retain 5mm on site where conditions do not warrant the detailed analysis. For sites with SWM ponds, 25mm – 48 hr detention may be required based on the completion of an erosion assessment.
- **Stormwater Quality:** Achieve Enhanced Level of Protection (80% TSS removal) and mitigate thermal and bacteriological impacts.
- **Water Balance:** For Low Volume Groundwater Recharge Area, implement best efforts to maintain recharge. For Significant, Ecologically Significant, and High Volume Ground Recharge Areas, a site specific water balance analysis and recharge is required. For natural features, maintain the hydrologic regimes.

This criteria is presented as the minimum requirements when preparing a stormwater management plan, however this criteria may not apply where a comprehensive environmental study has been completed and approved, and where the study has established refined criteria based on a location specific technical analysis.

With regards to the SWM practices that may be accepted by TRCA, the document refers to both the MECP Stormwater Management Planning and Design Manual (2003) and the TRCA/CVC Low Impact Development Stormwater Management Planning and Design Guide (2010) to outline infrastructure that may be utilized in the development of a SWM strategy. Conventional SWMFs, including SWM ponds, wetlands, oil and grit separators ('OGS') and LID practices are referenced throughout the document, however it was noted that the TRCA encourages the implementation of innovative designs and green infrastructure, provided the proposed works also satisfy all applicable requirement and criteria set forth within the document.

2.5 City of Vaughan SWM Master Plan Class EA Study, 2014



The City's Stormwater Management ('SWM') Master Plan Class EA evaluates the effectiveness of the existing SWM infrastructure within the City. The study evaluated the use of alternative SWM practices for effective treatment of stormwater from source, conveyance, and end-of-pipe controls, to promote protection of the natural environmental systems and was conducted in accordance with the Master Plan process as outlined in the Municipal Engineers Association Municipal Class EA guidance (October 2000, as amended in 2007 and 2011).

To support the overall study objective of determining the Best Management Practices ('BMPs') for SWM in support of future intensification with the City, the following three alternatives were identified for evaluation:

1. Do nothing;
2. Lot level/ at source/ conveyance controls; and,
3. End-of-pipe measures.

The "Do Nothing" alternative identified within the Class EA was noted to not require any action by the City, however no SWM strategy would be provided for future development and this approach would not meet the environmental objectives of the City's SWM practices. The implementation of lot level/ at source/ conveyance level controls were considered "small scale" controls for meeting SWM design criteria, and may include implementation of the following:

- Roof Downspout Disconnection;
- Bioretention;
- Green Roofs;
- Soakway Pits, Infiltration Trenches, and Chambers;
- Permeable Pavement;
- Rainwater Harvesting;
- Rooftop Storage;
- Parking Lot Storage;
- Underground Storage;
- Grassed Swales;
- Perforated Pipe System;
- Vegetated Filter Strips; and,
- Oil/ grit Separators.

End-of-pipe measures identified within the Class EA consisted of wet ponds, dry ponds and constructed wetlands. The alternatives were evaluated on a Secondary Plan basis, with the preferred SWM strategy for each area including a combination of lot level, conveyance and end-of-pipe controls. The recommendation of non-conventional stormwater infrastructure, including underground storage facilities remained limited to small scale applications at the lot level, and were not considered for end-of-pipe SWMFs. The use of underground storage was recommended as a part of the overall treatment train approach for Younge Steeles Secondary Plan area, Woodbridge Core Secondary Plan area, the West Vaughan Employment area, Huntington Road Community, Vaughan Mills Centre, Concord Centre, the Vaughan Health Campus of Care, Dufferin St./ Centre St. area and the Promenade Mall.

2.6 City of Vaughan Active Together Master Plan 2018

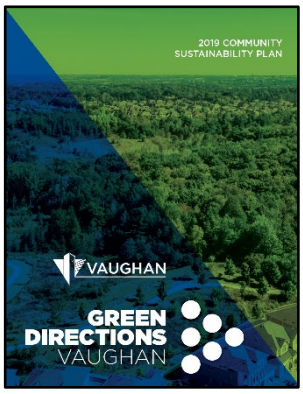
The 2018 City of Vaughan Active Together Master Plan ('ATMP') Update guides the provisions of parks and open space, recreation and library facilities within the City to the year 2031, providing an assessment of current levels of service and delivering recommendations on both policy and infrastructure requirements for this period. The 2018 ATMP Update contains 103 recommendations intended to guide municipal and community investments in parks, recreation, and library facilities. An implementation plan has been included within the recommendations, however successful implementation is noted to be highly dependent upon a variety of factors including funding, partnerships and land availability.

Recommendation #4 for the ATMP applies to the acceptance of open space lands as dedicated parkland space. As outlined in the ATMP, open space lands is defined as sites with no to low development potential, which may include land used for conventional stormwater management infrastructure. The ATMP recommends that undevelopable open space lands not be accepted as a part of the parkland dedication requirements set forth by the City. The City may assume these lands through voluntary dedication or easement, however no credit will be applied to the developer.

Recommendation #12 of the ATMP encourages the implementation of non-traditional parks and open spaces in areas of intensification and recommends the establishment of standards to provide guidance on how these are to be implemented. Specifically, the recommendation references the need to work with the development industry to identified alternative park space options to supplement prescribed parkland dedication requirements. This may include the application of strata parks, which in the context of parks and recreation refers to public spaces that are developed on underground stormwater infrastructures, parking garages or other roof slab constructions.

Based on the recommendations summarized above, the ATMP supports the City's current effort to establish standards for non-traditional parks and open spaces located above non-conventional stormwater infrastructure (strata parks) in areas of intensification, which may be able to supplement required parkland dedications required by the developer. Conventional SWMFs located in open space lands are recommended to not be acceptable as a part of parkland dedication, therefore requiring developers to utilize additional developable land to meet these parkland dedication requirements.

2.7 City of Vaughan Green Directions Vaughan, 2019



Green Directions Vaughan ('GDV') was first approved by Council in 2009 as the City's Community Sustainability and Environmental Master Plan, and most recently underwent an update in 2019. The Plan outlines the sustainable priorities of the City and provides actions to aid the City in maintaining a healthy natural environment, vibrant communities and a strong economy. The Plan provides guidance on achieving a more sustainable future by addressing environmental, cultural, social and economic values.

The following six (6) primary goals are outlined within the Plan:

1. To significantly reduce waste and the use of our natural resources.
2. To ensure sustainable development and redevelopment.
3. To ensure that the City is easy to get around with a low environmental impact.

4. To create a vibrant community where citizens, business and visitors thrive.
5. To be leaders in advocacy and education on sustainability issues.
6. To ensure a supportive system for the implementation of GDV.

The GDV provides a number of key objectives for each goal, which are further supported by the development of sustainability actions that can be implemented by the City to achieve these goals. These sustainability actions act as quantitative indicators that are critical in tracking the progress of achieving these overall goals within the next five (5) years.

Objective 1.3 of the GDV provides direction to the City on stormwater management and water conservation as it relates back to the primary goal of significantly reducing waste and the use of our natural resources. The objective identifies the need for the City to support enhanced standards of stormwater management and water conservation at City facilities, and to work with others to care for Vaughan's watersheds.

Sustainability actions identified under this objective include:

- Identify best management practices to minimize salt use on hard surfaces and protect receiving watercourse from salinity increases;
- Establish a water quality monitoring program for stormwater management assets;
- Identify stormwater management initiatives to protect and regenerate key watershed functions including the regulation of water quantity, the regulation of water quality and temperature, sediment and erosion control, hydrologic connectivity and habitat provisions. Stormwater management will be informed by watershed planning and long-term land use planning and development forecast;
- Integrate climate change considerations into guidelines for flood control and stormwater management;
- Continue to work with York Region in support of water conservation;
- Encourage low impact development and a treatment train approach to stormwater management through the development review process and by implementing and monitoring stormwater rate program, including the technical and community engagement aspects and innovative pilot initiatives; and,
- Improve tracking of potable water use at the City facilities to identify conservation opportunities and best practices, and in conjunction with he corporate energy management strategy.

Non-conventional SWMFs are not specifically identified within the GDV, however innovative approaches to enhancing stormwater management within the watershed are encouraged.

2.8 City of Vaughan Engineering Design Criteria & Standard Drawings, 2020

The City of Vaughan Engineering Design Criteria and Standard Drawings ('EDCSD') provides guidance to those engaged in the design and construction of municipal infrastructure within the City of Vaughan. The EDCSD provides criteria and standard drawings for a range of municipal projects, including but not limited to municipal infrastructure, lot grading and site development. Section 1.3 of the EDCSD provides specific design considerations as it relates to stormwater management, which have been further subdivided into the following sections:

- General Design Considerations;
- Storm Sewer System Design;
- Testing and Inspection;

- Decommissioning;
- Stormwater Management Facilities; and,
- LID Practices.

As per the EDCSD, the implementation of end-of-pipe SWMFs are typically considered only for developments greater than five (5) hectares, where the application of lot level controls is considered impractical. Design criteria within the document is limited to conventional SWMFs, with criteria provided for the design of emergency overflows, outfalls, spillways, plantings and safety measures for conventional stormwater ponds. The EDCSD does not provide design criteria or standard drawings for non-conventional SWMFs.

As part of future phases of the current project, Resilient will be responsible for developing design criteria and engineering standards for non-conventional SWMFs. The developed information will be included in a future version of the EDCSD.

2.9 MECP Low Impact Development Stormwater Management Guidance Manual (Draft), January 2022

The Low Impact Development Stormwater Management Guidance Manual, published in draft by the MECP for public review in January 2022, provides performance guidance for stormwater management specifically related to the implementation of Low Impact Development ('LID'). LID is defined within the manual as a stormwater management strategy, system or facility that seeks to mitigate the impacts of increased runoff and stormwater pollution by managing runoff close to its source. Implementation of LIDs employ small scale site design strategies to mimic the natural water cycle through the process of infiltration, evapotranspiration, harvesting, filtration, detention, and reuse. The manual offers information that is complimentary to the 2003 MECP Stormwater Management Planning and Design Manual and the 2008 Design Guidelines for Sewage Works, providing guidance on implementation of a holistic treatment train approach for stormwater management within Ontario.

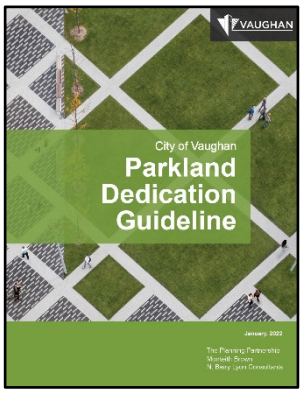
In addition to providing guidance and criteria on the design, construction and operation of LIDs, the manual also provides guidance for achieving the runoff volume control target (90^{th} percentile precipitation event) for new development, re-development, linear development, and stormwater retrofits within Ontario.

All performance guidelines provided in the manual are limited to lot level, at the source, and conveyance controls, however design guidance for end-of-pipe treatment is excluded from the document. As a result, the LID SWM Guidance Manual is of limited benefit in providing direction of the design and implementation of end-of-pipe dual use SWMFs.

2.10 City of Vaughan Parkland Dedication Guideline, January 2022

The City of Vaughan Parkland Dedication Guideline offers guidance on the parkland dedication and acquisition process, providing key considerations to assist in the implementation of a revised approach to address increased pressure for acceptance of alternative parkland spaces. The document was primarily developed to serve as a comprehensive guideline used for the development of a future

Parkland Dedication By-Law. At the time of the preparation of the guideline, the City did not have a Parkland Dedication By-Law in place. A Cash-in-Lieu By-Law, last updated in 2012, was used to impose parkland/payment-in-lieu conditions through the development process, however a new Parkland Dedication By-Law was noted to be required by September 18th, 2022.



A total of fifty-four (54) considerations are provided within the guideline, with input ranging from the amount of gross land area that should be required as parkland to administrative elements for the implementation of the new by-law. Consideration #46 provides input on the dedication of parkland for conventional stormwater management facilities, recommending that lands required to accommodate these SWMFs not be accepted for dedication. In relation to non-conventional SWMFs, the guideline considers opportunities of parkland dedication for strata parks, where the City is provided ownership of parkland located over the top of an underground structure or facility such as a SWMF. The guideline recommends that the land area of a strata park should be counted toward the required parkland dedication, but the actual amount of land counted may be discounted to reconcile issue related to lifecycle costs and lifespan of these facilities.

2.11 City of Vaughan MECP's CLI-ECA for Municipal Stormwater Management Systems, April 2022

The Environmental Compliance Approval for a Municipal Stormwater Management System was issued to the City of Vaughan by the Ministry of Environment, Conservation and Parks ('MECP') on November 25th, 2022, in accordance with the Environmental Protection Act (1990). The approval covers the entire municipal stormwater management system owned and operated by the City, which is classified as a separate system from all sanitary systems located within city limits. The approval also covers stormwater management systems located on private lands that are considered a part of the municipal stormwater treatment train, including infiltration trenches, swales and rear lot catch basins located at seven (7) different sites within the city.

A total of 245 stormwater management facilities and pumping stations are authorized under the ECA, which are broken down into the following facility types:

- 119 Stormwater Management Ponds – Wet (Including wetlands, hybrids)
- 26 Stormwater Management Ponds – Dry
- 19 Super Pipe/ Storage Facilities
- 28 Sedimentation MTD – OGS
- 1 Pumping Station

An additional thirty-nine (39) facilities are identified within the ECA to be connected to the municipal stormwater management system; however, ownership of these facilities have not been assumed by the City, and separate ECAs are required for these facilities.

In addition to providing details on each authorized facility, the ECA outlines acceptable future alterations to the system, stormwater management criteria, inspection and monitoring requirements, and annual reporting needs.

2.12 Vaughan Sustainability Metrics Program, May 2022

The Sustainability Metrics Program, developed in partnership by the Cities of Brampton, Markham, Richmond Hill and Vaughan, is a point-based system implemented as a part of the development application process to encourage sustainable performance of new developments. As a component of the application submission, development proposals are required to achieve a minimum sustainability scores dependent on the type of planning application. The Sustainability Metric is organized into the following categories:

- Built Environment (BE);
- Mobility (MB);
- Natural Environment and Parks (NE);
- Infrastructure and Buildings (IB); and,
- Innovation (IN).

The Natural Environment and Parks category provides opportunities for points related to the implementation of stormwater infrastructure. Specifically, additional points are awarded for retaining increased runoff volume on site (NE-9), for providing advanced quality controls (NE-10), and for enhancing the public use values of stormwater management facilities through the installation of beautification measures around SWM ponds (NE-12). At this time, there are no point opportunities strictly related to the implementation of non-conventional SWMFs.

2.13 City of Vaughan Parkland Dedication By-Law 168-2022, June 2022

The Parkland Dedication By-Law 168-2022 was passed by Council on June 28th, 2022 following completion of the Parkland Dedication Guideline in January 2022. The By-law includes provisions to allow the City to continue to retain the ability to require that land be conveyed for park or other public recreational purpose as a condition of development, with the amount of land determine by applying an 'alternative rate' of parkland provision. The following key elements were included:

- Updated definition for compatibility with other City documents;
- Updated list of exempt categories;
- Clarity and expansion of lands acceptable for conveyance and parkland credit;
- Provisions for off-site land dedication;
- Updated phased-in fixed unit dates for payment-in-lieu; and,
- Transition provisions.

Parkland dedication for non-conventional SWMFs is addressed in Section 3 (2) of the By-law, which states the City is willing to accept full (100%) credit towards satisfying the parkland dedication requirements for development or redevelopment of strata parks, and land encumbered by underground SWMFs, utility coordinators and other publicly owned infrastructure. As per Section 3 (3), to achieve full credit the City and the owner must enter an agreement that the land for dedication:

A. Is permit-ready for active and/or passive park programming;
B. Is designed and developable to City standards;
C. Does not prohibit or restrict public programming;
D. Will be open and accessible to the public at all times;
E. Meets applicable criteria of City's OP; and,

F. Meets requirements of Greenbelt or Oak Ridges Moraine policies.

Conventional SWMFs, such as stormwater ponds, will not be acceptable for parkland dedication, as detailed under Section 3 (5).

2.14 City of Vaughan Committee of the Whole (Working Session) Report, June 2022

The City of Vaughan Committee of the Whole Report, dated June 8th, 2022, provides a status update on the City's current interim approach for reviewing and accepting non-conventional stormwater infrastructure implementation and the associated financial contribution that is required to offset the additional costs of this infrastructure once it has been assumed by the City. The Report highlights the need for the development of a formal policy and procedure for accepting non-conventional SWMFs, as current approvals are completed on a case-by-case basis. At this time, no other municipality within the Greater Toronto Area ('GTA') has created a formal approval policy for the acceptance for non-conventional SWMFs or provided requirements for financial contributions from developers to operate these facilities on public lands. The exception to this is the City of Markham, who requires a one-time payment by the developer for the cost differential between operation, maintenance, rehabilitation and replacement cost of a conventional SWMFs compared to alternative infrastructure based on a 50-year lifespan.

The interim approach applied by the City is noted to be effective in ensuring stormwater management is achieved, however it does not take into consideration important social, economic and environmental factors and the overall integration of these non-conventional SWMFs within future communities. As a result, the City is in need of a formal policy that will ensure all development and planning matters are considered during the approval process.

The Report also provides a brief overview of the submission and review process of a dual-use SWMFs policy paper submitted in January 2022 by Malone Given Parsons. The policy paper focuses on opportunities to implement underground stormwater storage within future City parks for land use efficiency and to allow for more development areas. The City retained WSP Canada ('WSP') to complete a peer review of the policy paper, with WSP noted to be in general agreement with the findings of the report. Recommendations regarding technical design requirements, and the need for further research into the financial implications of dual-use SWMFs were provided by WSP. Results of this peer review were incorporated into the development of the interim policy and are to be taken into consideration during the development of the formal policy and procedures for approval of non-conventional SWMFs.

2.15 Existing Policy and Procedure Review Summary

The following table provides a summary of the reviewed policies and procedures as they related to the implementation of non-conventional SWMFs within the City of Vaughan.

Table 1. Summary of Existing Policies and Procedures Input on Non-Conventional SWMFs

Existing Policy/ Procedure/ Guideline	Relevance to Implementation of Non-Conventional SWMFs
MECP Stormwater Management Planning and Design Manual, March 2003	• The manual does not provide design criteria or guidance in relation to non-conventional end-of-pipe SWMFs. • The manual does provide some guidance on the use of superpipes to provide subsurface storage and reduce peak flows, however this is examined as lot level control only.
City of Vaughan Official Plan 2010 and Update	• The OP encourages the implementation of innovative stormwater management approaches where appropriate, however the application of non-conventional SWMFs is not identified within the Plan.
CVC/ TRCA Low Impact Development Stormwater Management Planning and Design Guide, 2010	• No reference to non-conventional end-of-pipe SWMFs within guideline.
TRCA Stormwater Management Criteria, August 2012	• Design criteria was not provided for non-conventional SWMFs, however it was noted that the TRCA encourages the implementation of innovative designs and green infrastructure, provided the proposed works also satisfy all applicable requirement and criteria set forth within the document.
City of Vaughan SWM Master Plan Class EA Study, 2014	• Non-conventional stormwater infrastructure was identified within the Class EA, however it was recommended for implementation at lot level rather than end-of-pipe SWMFs.
Active Together Master Plan (ATMP), 2018	• ATMP encourages the implementation of non-traditional parks and open spaces in areas of intensification, including strata parks developed on underground stormwater infrastructure, parking garages and roofs.
City of Vaughan Green Directions Vaughan, 2019	• Non-conventional SWMFs are not specifically identified within the document, however innovative approaches to enhancing stormwater management within the watershed are encouraged.
City of Vaughan Engineering Design Criteria & Standard Drawings, 2020	• The EDCSD does not provide design criteria or standard drawings for non-conventional SWMFs.

Existing Policy/ Procedure/ Guideline	Relevance to Implementation of Non-Conventional SWMFs
MECP Low Impact Development Stormwater Management Guidance Manual (Draft), January 2022	• Performance guidelines limited to lot level, at the source and conveyance controls, and excludes end-of-pipe facilities. • No reference to non-conventional SWMFs within guideline.
City of Vaughan Parkland Dedication Guideline, January 2022	• Guideline considers opportunities of parkland dedication for strata parks, where the City is provided ownership to parkland located over the top of underground structure or facility such as a stormwater management facility.
City of Vaughan MECP's CLI-ECA for Municipal Stormwater Management Systems, April 2022	• Identifies nineteen (19) non-conventional SWMFs (superpipes/ storage facilities) that have currently been authorized under the ECA. • Lists the stormwater management criteria under the CLI-ECA program.
Vaughan Sustainability Metrics Program, May 2022	• No opportunity to be awarded points for implementing non-conventional SWMFs.
City of Vaughan Parkland Dedication By-Law 168-2022, June 2022	• City will accept full (100%) credit towards satisfying the parkland dedication requirements for development or redevelopment of strata parks, and land encumbered by underground SWMFs, utility coordinators and other publicly owned infrastructure.
City of Vaughan Committee of the Whole (Working Session) Report, June 2022	• Defines the interim approach for approving non-conventional SWMFs. • Identifies the need to develop a formal policy and procedure for approval.

3 Stormwater Management Approval Process

Prior to implementation, applications for the installation of City assumed SWMFs must undergo a multi-stage review process, completed by the City and other relevant regulatory agencies, to ensure all stormwater related design criteria are achieved. The following sections provide a general overview of the current approach for the review and approval of conventional and non-conventional SWMFs within the City of Vaughan. In addition, data gaps identified during the review of the current interim approval process for non-conventional SWMFs have been identified.

3.1 City of Vaughan Approach for Conventional SWMF Approval

The City's process for approval of conventional SWMFs requires a developer to follow a multi-stage application process where several design submissions are reviewed by various internal departments within the City prior to being granted approval to proceed. Upon commencement of the project, the developer must initially determine and receive approval of the Block limits that the facility will occupy. This process is typically completed through a 'Draft Plan of Subdivision' process, where conditions for the approval of these facilities is listed. Subsequent to the Draft Plan of Subdivision is the Plan of Subdivision, where the detailed design of these SWMFs is completed and approved.

A detailed design submission of the SWMF is to follow, where the City relies on the criteria outlined in the City of Vaughan Engineering Design Criteria & Standard Drawings (2020), the MECP

Stormwater Management Planning & Design Manual (2003) and the TRCA Stormwater Management Criteria (2012) for review and approval of proposed conventional SWMF. Both the City and TRCA criteria reference recommendations detailed in the MECP SWMP Manual, including the application of the following criteria:

- At a minimum, pre-development peak flows are to be maintained to adhere to water quantity objectives. Watershed specific targets have been established by the TRCA and are to be adhered to when discharge to TRCA jurisdiction is proposed.
- A minimum 80% total suspended solids (TSS) is to be removed from 90% of the site average runoff to achieve water quality objectives.
- A minimum 5mm across the site area is to be retained on-site for water balance and erosion control criteria. Depending on the results of an erosion assessment, extended detention of the 25mm event for a 48-hour period may also be required.

Further to the above, the City and TRCA have outlined various criteria and provides guidance on the design, construction, and maintenance of the facility outlets, spillways, safety measures, and plantings. Additional design guidance including, but not limited to, the sizing of SWM pond forebays, extended detention, active storage, and sediment drying area is provided in the MECP SWMP Manual. In summary, conventional SWMF are to demonstrate:

- Satisfactory quantity, quality, water balance, and erosion control (if required).
- Acceptable lengths, depths, side slopes, area ratios, and volumes of the facility forebay, permanent pool, and active storage, if applicable.
- Satisfactory inlet/outlet minimize size, slope, and elevations.
- Adequate spillway and emergency overflow design and stone protection.
- Accessible maintenance route alignment, slopes, widths, and turn-arounds (if required).
- Acceptable safety fencing, signs, buffers, and vegetation/plantings.

A Stormwater Management Report, sealed by a Professional Engineer licenced in Ontario, that demonstrates satisfactory results of all applicable conditions and criteria, must be submitted to the City for review in order to receive final approval. In addition to the City and TRCA, the MECP must also be in receipt of this final approved SWM Report as part of the Consolidated Linear Infrastructure Environmental Compliance Approval (CLI-ECA) process. An application detailing the proposed SWMF, including site location, watershed/receiving system, drainage area size, ownership, land use, type of facility, operations/maintenance, and specific details on the facility (ie. treatment level, volume retention, storm event, treatment train, sewers/outfalls) is to be submitted to the MECP alongside the processing fee and final SWM Report for final review and approval before the construction phase of the project can commence. Additional considerations, including defining operation and maintenance requirements, costs and warranty periods must also be agreed upon between the owner and City prior to being granted final approval.

3.2 City of Vaughan Interim Approach for Non-Conventional SWMF Approval

As previously noted, an interim approach for approving non-conventional SWMFs was adopted by City Council in June 2022 in response to increased pressure by developers to approve innovation stormwater solutions for greenfield and infill/intensification developments within the City of Vaughan. The interim approach was modelled using similar policy framework to that implemented by the City of Markham, which required financial compensation to be paid by the developer to cover the cost differential between operation, maintenance, rehabilitation and replacement a non-conventional SWMF vs. conventional SWMF over a 50-year lifespan. In addition to the financial implications, the

approach provides details on design limitations and considerations that must be addressed by the developer prior to the City considering approval of non-conventional SWMFs.

Key features of the interim approach for accepting non-conventional SWMFS are as follows:

- The developer must provide reasons for the non-compliance of the City's OP policies for stormwater infrastructure;
- A recommendation report shall be prepared by a qualified engineer identifying and documenting the benefits of the proposed non-conventional SWMFs, which shall be submitted to the City for review and approval prior to development application. If City staff disagree with the provided rationale, a peer review consultant will be retained to provide their professional opinion, with costs of the review paid by the developer;
- Non-conventional SWMFs will not be supported for greenfield developments unless a compelling argument outlining the benefits is demonstrated to the City and the City's peer reviewer, if required;
- Consideration of non-conventional SWMFs may be considered for specific growth areas and intensifications/infill development based on land constraints and the proposed density;
- Prior to final approval, the owner shall provide a one-time cost contribution in present value for non-conventional SWMF to compensate for any increase in cost when compared to conventional SWMFs, based on operation, maintenance, rehabilitation and replacement costs over a 50 year lifecycle;
- Non-conventional SWMFs proposed under road right of ways should be avoided;
- For park development on top of non-conventional SWMFs, the following should be considered:
    - Park program flexibility and design restrictions;
    - Technical details (soil depths, tree canopy, etc.);
    - Disruption due to operation and maintenance;
    - Long term life cycle costs on park replacement;
    - Capital costs due to structural constraints; and,
    - Requirements for developer to build the park to ensure warranties are not voided.
- Provisions for parkland credits for dual-use parks/ underground SWMFs was considered through the Parkland Dedication By-law update, as described in **Section 2.4** above.

The overall approval process for non-conventional SWMFs follows the same general steps as conventional facilities, as outlined above in **Section 3.1**. However, the acceptance of a non-conventional SWMFs application is considered by the City on a case-by-case basis, and must include supporting documentation justifying the need to implement a non-conventional SWMF in addition to defining how water quality, quantity, erosion control and water balance targets will be achieved. These design targets are the same for both conventional and non-conventional SWMFs and are clearly defined within the TRCA, MECP and City guidelines. As noted above, these guidelines provide additional design recommendations specific to conventional SWMFs, such as spillway sizing and outlet pipe requirements for traditional stormwater management ponds, however no technical recommendations are provided explicitly for the design of non-conventional SWMFs. As a result, the preparation of the design of non-conventional SWMFs is reliant on the experience of the designing engineer, with additional support provided by the suppliers and manufacturers of these non-conventional SWMF products.

Similarly, the review and approval of the technical design of the non-conventional SWMF is also reliant on the knowledge and experience of the City's Engineering Department and all other supporting departments, as standardized technical requirements have yet to be defined within the interim approval approach or regulatory policies and guidelines.

3.3 Data Gaps in Interim Approval Approach of Non-Conventional SWMFs

As previously noted, the approval of a non-conventional SWMFs is currently completed on a case-by-case basis, which guarantees that the SWMF can effectively meet the stormwater management needs of the site while also securing financial contributions to the City to cover the additional ownership costs associated with the non-conventional SWMF. This current approach does not take into consideration numerous other factors including the social, economic and environmental impacts of implementing non-conventional SWMFs, nor assess the benefits or drawbacks this infrastructure could have on future communities.

The following data gaps have been identified during the review of the current interim approach, which have been divided into the following six (6) key categories:

- Engineering Design;
- Development Planning and Policy;
- Urban Design;
- Parks Planning;
- Active Outdoor Recreation;
- Lifecycle implications; and,
- Operation, Maintenance, Rehabilitation and Replacement.

By identifying these data gaps in the initial stages of the project, Resilient can ensure that this missing information is addressed during the development of the formal policy, procedure, and design criteria for non-conventional SWMFs approval. It is anticipated that throughout the consultation process additional data gaps within the interim approach will be identified by internal and external stakeholders. These recommendations will be documented accordingly and incorporated into the formal documents where appropriate.

Table 2. Key Data Gaps in the Current Interim Approach of Non-Conventional SWMF Approval

Engineering Design
• **Design specific criteria for non-conventional SWMFs is needed**. The design of conventional SWMFs is highly reliant on engineering design criteria outlined in the MECP Stormwater Management Planning and Design Manual (2003) and TRCA Stormwater Management Criteria (2012), which are referenced throughout many of the policies and guidelines reviewed in **Section 2** of this report. This engineering criteria is limited to conventional SWMFs and does not provide any criteria related to specific design elements of non-conventional SWMFs. • **Need for specification of acceptable technology**. At this time, the current approach for approval of non-conventional SWMFs does not provide any direction as to which types of non-conventional SWMFs may be accepted within the City of Vaughan. Numerous innovative stormwater management technologies are available on today's market, including plastic arch chambers, superpipes and concrete tanks. Each of these non-conventional SWMFs are made of different materials that adhere to various Canadian standards, require different levels for maintenance, and have varying operational lifespans. • **Direction on treatment train expectations.** Similar to conventional stormwater management approaches, non-conventional approaches are still required to achieve water quality, quantity, erosion control and water balance standards specific to their proposed site location. Achieving these standards through the implementation of the non-conventional SWMF alone may not be feasible, and lot level or conveyance controls and additional water quality measures may be required to meet these requirements. The formal approach should confirm the minimum requirements that are to be provided by the non-conventional SWMF as a standalone facility, and what requirements can be achieve elsewhere though the implementation of a treatment train approach.

Development Planning and Policy
• **Inclusion of Parkland Dedication By-Law 168-2022**. Following adoption of the interim approach for approval of non-conventional SWMFs in early June 2022, the Parkland Dedication By-Law was passed by Council on June 28th, 2022. The By-Law states that the City may accept full (100%) credit towards satisfying the parkland dedication requirements for development or redevelopment of strata parks, and land encumbered by underground SWMFs, utility coordinators and other publicly owned infrastructure, as long as the additional approval requirements as per Section 3 (3) of the By-Law are achieved. • **Good Planning Sense.** The implementation of non-conventional SWMFs may provide many benefits particularly when reviewing land value, however the social, community and mental impacts of not providing a conventional SWM pond, which is often seen as amenity space to residents, needs to be reviewed.
Urban Design
• **Urban Design Factor Integration.** The interim approach does not specify how to address potential impacts (both positive and negative) to urban design form of parklands above non-conventional SWMFs. Examples of urban design aspects to be considered ensuring that the placement of access points and maintenance routes do not conflict with critical public realm components of parks such as gathering places or recreational spaces.
Parks Planning
• **Need for specification of acceptable recreational facilities above facility.** The current approach for approval of non-conventional SWMFs identifies a list of considerations for park development to be located on top of non-conventional SWMFs, however specific expectations for what will be accepted above these facilities is not provided. A list of suitable recreational facilities that will be accepted above the facility, such as sports fields, plazas and rinks, and what will not be accepted will provide guidance in selection of the overall non-conventional SWMF design, specifically in relation to facility configuration, cover depth, soil types and loading requirements. • **Definition of planting expectations above facility**. The City of Vaughan is committed to promoting the planting of trees for enhancement of City parks. The implementation of non-conventional SWMFs below parkland can significantly impact where trees can be planted within the site, largely due to the impact of the plant roots on the structural integrity of the underground facility and the depth of soil cover above the facility. The existing approach does not define minimum planting requirements for within these parks.
Active Outdoor Recreation
• **Identification of park programming goals needed.** Early identification of the City's intentions for parkland located above these facilities, whether it be for passive or active programming, will have a considerable impact on the design and configuration of the proposed non-conventional SWMFs.
Lifecycle Implications
• **Development of standardized cost for operation, maintenance, repair, and replacement needed**. As non-conventional SWMFs are a relatively new and evolving concept for local municipalities, there is limited understanding of the cost associated with operation, maintenance, repair, and replacement of these facilities. One-time cost contributions collected from developers have largely been estimated at this time, with the hope that these financial contributions are sufficient to cover the additional costs associated with the implementation on non-conventional SWMF over their lifetime. As a result, the City has faced significant financial risks in approving these facilities.
Operation, Maintenance, Rehabilitation and Replacement
• **Development of Standard Operating Procedures (SOPs) required.** The long term operation, maintenance, rehabilitation and replacement needs for non-conventional SWMFs is not defined in the City's current SOPs. A new SOP will be required, which will include, but not be limited to, inspection programs, including frequency of inspection, the methods or test employed to detect when maintenance is required, health and safety procedures and all additional regulatory requirements identified by the MECP.

4 Review of Current Industry Practices

To develop a better understanding of the industry standard, six (6) municipalities within the GTA and surrounding area were contacted to determine if any policies, procedures, or design criteria has been applied within their municipality to address non-conventional SWMFs acceptance and implementation. These municipalities were selected based on their sizes and current development pressures being similar to Vaughan's. At the time of finalizing this report, responses were received from the following municipalities:

- City of Markham;
- City of Mississauga;
- City of Hamilton;
- City of Kitchener; and,
- City of Burlington.

Based on feedback received from these municipalities, no other municipality within the GTA and surrounding have created a formal approval policy or standards for the acceptance of non-conventional SWMFs or provided requirements for financial contributions from developers to operate these facilities on City lands. As previously noted, the exception to this is the City of Markham, who has implemented a policy to collect financial contributions for the cost differential between conventional and non-conventional SWMFs, should the developer propose implementation of non-conventional SWMFs. All correspondence with municipalities contacted as a part of this background review is provided in **Appendix B**.

4.1.1 City of Markham, Ontario

The City of Markham has been identified as the only municipality in the GTA to have prepared a document or policy addressing non-conventional stormwater infrastructure.

In 2019, the City developed an Alternative Infrastructure Policy ('AIP') which provides framework for the approval of alternative forms of infrastructure and details how additional costs incurred by the City over the lifespan of the infrastructure would be recovered. The policy is applied when a developer seeks to build alternative infrastructure, such as non-conventional SWMFs, that may result in a higher total cost of ownership to the City when compared to more conventional infrastructure, such as SWM ponds. The City requires payment by the developer of the cost differential between conventional and the alternative infrastructure based on two (2) lifecycles to a maximum of 50 years. Approval of the alternative infrastructure and determination of the required payment is completed on a case-by-case basis, and the policy has currently been applied to two (2) underground SWMFs located within the Village of Fairtree Subdivision. Lifecycle cost estimates for conventional and alternative infrastructure are currently being refined by the City of Markham to ensure all important components of future maintenance, operation and replacement are taken into consideration when determining the fee to be paid by the developer.

The latest discussions regarding the implementation of non-conventional SWMFs within the City of Markham occurred during the Development Services Committee Meeting on June 13th, 2022. A overview on SWMFs owned by the City was presented by the City's Director of Engineering, with specific focus on underground ('U/G') stormwater tanks and the opportunities and constraints associated with their implementation. The presentation touched on the City's current AIP, as well as discussed how parkland credit designation for parks located above these U/G tanks is currently being negotiated on a case-by-case basis. The following recommendations were presented and moved by the Committee:

- That proposals for U/G tanks be reviewed on a case-by-case basis by Engineering and Planning Departments, in consultation with Environmental Services Department, to ensure that the proposed location is appropriate, and the proposed type of U/G tank meets the City's specifications and criteria;
- That the Engineering Department, in consultation with Planning and Environmental Services Department, procures the services of a professional engineering consultant to assist in the development of appropriate criteria of acceptance for the considerations of U/G tanks, along with the acceptable uses above the facilities, along with the necessary specifications on U/G tank facilities.
- That the developers proposing to install U/G tanks in lieu of open stormwater ponds must provide the City with a financial contribution to offset the additional future costs to maintain and operate the U/G tanks and staff be authorized to negotiate the financial contributions from the developers.
- That the Planning Department be authorized to determine the applicability of parkland credits for proposed uses on top of U/G tanks and negotiate the appropriate parkland credit for proposed parks deemed suitable to be located on top of U/G tanks.

At this time, the City of Markham has yet to retain the services of a professional engineering consultant to assist in the development of criteria, standards and specifications for acceptance of U/G tanks, however this is anticipated to be initiated in the near future.

4.1.2 City of Mississauga, Ontario

Unlike many other municipalities within the GTA, the nature of development within the City of Mississauga is largely limited to intensification and redevelopment, as limited greenfield sites remain within the jurisdiction. As a result, Mississauga has received limited pressure from developers to implement non-conventional SWMFs on public lands and has not identified the need to adopt non-conventional stormwater management policies, procedures, or standards at this time.

Non-conventional SWMFs, including underground arch chambers and concrete tanks, have been implemented internally by Mississauga below existing public park space. These projects however have primarily been installed as flood mitigation retrofits, with the financial burdens of operation, maintenance and repair costs taken into consideration prior to implementation by the City.

4.1.3 City of Hamilton, Ontario

At the present time, the City of Hamilton is currently in the process of developing Green Standards and Guidelines related to development on private properties, with the intention to development similar guidelines for public infrastructure in the future.

Similar to many other municipalities, the implementation of non-conventional SWMFs on lands that are to be assumed by the City are completed on a case-by-case basis. At this time, proposed non-conventional SWMFs for public infrastructure is very uncommon, with the City largely only receiving development applications for non-conventional SWMFs on private land.

The City is also in the process of commencing an urbanization project that will require the implementation of municipally owned non-conventional SWMFs, however this project is still in its infancy, and the design of these non-conventional SWMFs have yet to be completed.

4.1.4 City of Kitchener, Ontario

The City of Kitchener relies upon the following set of documents when making decisions in relation to the approval of stormwater management infrastructure:

- Integrated Stormwater Management Master Plan and Policy (2016), which provides details on design criteria, targets, and fees;
- CLI-ECA, which defines MECP design criteria and maintenance requirements applied to the whole City of Kitchener stormwater network;
- City of Kitchener Development Manual (2021), which provides futher details on design criteria for end-of-pipe facilities. End-of-life facilities are identified as wetlands, ponds and infiltration facilities as per the Manual;
- Operation and Maintenance SOPs and best management practices, when available; and,
- Stormwater Asset Management Plan (2022), which provides guidance on asset maintenance, rehabilitation and replacement needs.

The City of Kitchener does not have a policy specifically related to the implementation of non-conventional SWMFs, and instead takes a non-prescriptive approach to reviewing these facilities, ensuring that objectives of the above documents are achieved by the proposed facility.

4.1.5 City of Burlington, Ontario

The City of Burlington Stormwater Management Design Guideline, prepared in 2020, is used for the review and approval of all stormwater management systems and infrastructure proposed within the City of Burlington. The Guidelines provide detail on the design process, submission requirements, modelling and overall design criteria for conveyance and stormwater management infrastructure. As defined in the Guidelines, end-of-pipe SWMFs consist of systems with open ponding areas used to provide quantity, erosion, and quality controls to mitigate development impacts, and may refer to dry ponds, wet ponds, wetlands or hybrids. The Guideline does not provide any criteria or requirements related to the implementation of non-conventional SWMFs.

5 Review of Non-Conventional SWMFs

The use of conventional SWMFs, such as dry or wet ponds, have been used for many decades as a means to adhere to stormwater management criteria set forth by provincial, regional and local regulatory authorities. The implementation of these conventional facilities, when compared to alternative forms of stormwater management, were preferred by developers as construction costs were significantly less than alternative options, such as underground facilities. As the price of developable land continues to elevate, the use of these conventional facilities is becoming less desirable as a large capital investment is needed for the land. The City currently owns approximately 147 conventional SWMFs, with another 16 non-conventional SWMFs in various phases (ie. assumed, approved, under review), which include underground storage tanks and superpipes to provide required stormwater management controls.

There are many potential advantages to implementing a non-conventional SWMF, including but not limited to:

- Provides a dual-purpose to the land (i.e. parkland above the facility);
- Requires a smaller at-surface footprint;
- Eliminates at-surface water quality concerns such as standing water and E.Coli contamination from wildlife;
- Provides both passive and active programming of the space above the facility;
- Lowers water temperature of discharge; and,

- Improves safety by eliminating the potential of drowning and/or falls through ice.

Non-conventional facilities are becoming increasingly popular, especially in the GTA, as available land is limited resulting in highly constrained sites. These facilities may be ideal for land development projects where additional land is not available for a conventional system, and in park settings where the land can be re-purposed above the facility.

Although a long list of advantages are noted for non-conventional SWMFs, there are some significant potential disadvantages including a higher overall cost for installation, maintenance, operation, repair and replacement when compared to conventional SWMFs. Non-conventional SWMFs are typically buried underground, and are reliant on engineered products or structures with design lives of 50 to 100 years to support the ground above the facility. In the case of open excavated ponds, while there may be risk of erosion of slopes or failure of outlet structures, there is no risk of collapsing ground as the facility is not buried and notable deficiencies with the infrastructure are more readily observable.

Non-conventional SWMFs typically utilize a pre-treatment system to remove a majority of suspended solids in stormwater before entry to the main facility. Pre-treatment systems are designed to be frequently maintained through relatively simple methods such as flushing and vacuuming using equipment typically owned or contracted by the asset owner. However, for many non-conventional SWMFs, if pre-treatment is not maintained, sediment will begin entering and accumulating within the main facility, resulting in loss of storage volume and reducing effectiveness of the SWMF. Removal of sediment from the main facility may be much more difficult and may require excavation and replacement of engineered products, resulting in higher costs and disruptions to facilities.

The review of several types of facilities has been completed to highlight the various advantages and disadvantages for each facility, including capital and lifecycle costs, operation/maintenance requirements, and all other identified limitations and considerations. The objective of this review is to provide the required supporting documentation for use in preparing a list of non-conventional SWMFs that will be accepted for implementation within the City of Vaughan. The detailed review of various types of non-conventional SWMFs is included in the following sections, with a summary presented in table format included in **Appendix C**.

5.1 "Milk-Crate" System

The "milk-crate" system gets it name from its appearance – a box-like modular system with thin walls that include openings to allow for the passage of water. These systems are made of high-density polyethylene ('HDPE') and are available in a variety of standard heights. The product can be stacked to achieve a required height or increase storage volume while maintaining a limited footprint. The forms have been designed for standard loading applications including loads from parking lots/industrial areas, however adequate coverage over the facility is required. Infiltration can be promoted through the system through the installation of open-bottom facilities or restricted through the use of an impermeable liner.

A variety of suppliers for this type of system exist and include:

- Layfield Group: *Brentwood StormTank Module*
- Atlantis: *Matrix Tank*
- ACO: *Stormbrixx*
- StormCon: *Greenstorm Geocellular Module*

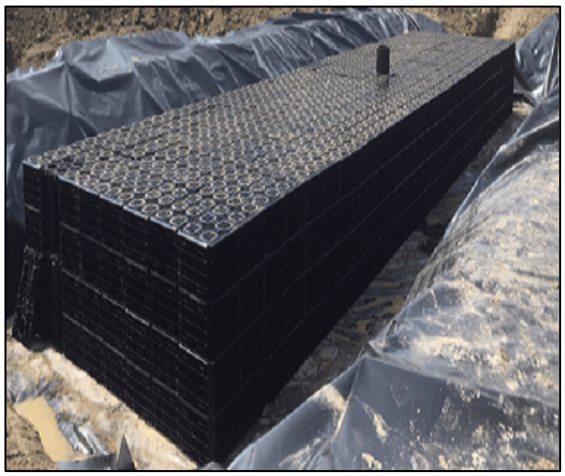


Figure 1: Example "Milk-crate" system, Source: ACO

The main advantage of the "milk-crate" system is the high void ratio (over 95%) when compared to its arch chamber competitors. The square shape of each modular unit allows for the system to maximize internal storage space without losing potential storage opportunities to exterior stone or perimeter material. Another advantage of these products is the quick and easy assembly of the facility. As the systems are made of plastic materials, the system can be snapped into place by hand without the need for large equipment. In addition, these products come disassembled and therefore packaging and shipping is improved over its competitors.

The main disadvantage of the "milk-crate" system is that it forms a closed facility in the sense that entry is not a possibility without excavation and local disassembly of the system. Further to this, the system has minimal opportunity for quality treatment and is therefore reliant on an external treatment device. This increases the risk of sediment-laden water entering the facility, increasing the maintenance frequency of the system and quality treatment system. Maintenance of these facilities is paramount to their success and therefore frequent inspection via camera and subsequent maintenance is recommended to minimize the risk of having to excavate and replace the system.

During the design of "milk-crate" systems, groundwater elevation needs to be taken into consideration to ensure groundwater seepage into the facility is not anticipated and to confirm if an impermeable liner is required. If infiltration is required by the system, verification that there is adequate separation between the bottom of the system and the groundwater table is required. This consideration is not typically required for the design and implementation of concrete-based facilities, as they are often designed to be watertight systems. Lastly, these types of facilities are less common in the industry and therefore contractor familiarly with the product may be limited, and prices elevated as a result when compared to other arch style SWMF products.

A key limitation to the implementation of "milk-crate" systems is restrictions imposed by burial depth and the standard height sizes. The pre-made structures are manufactured to specific heights that may not work within a highly constrained site. Another limitation to this system is that the facility cannot be entered for inspection and maintenance. While pathways in the facility are provided for inspection using CCTV equipment, manual entry is not possible. As a result, excavation of the system is required to address any repairs or extensive maintenance required for the system.

Maintenance of "milk-crate" systems include semi-annual inspection for the first 5-years and additional inspection after every large storm event to ensure the facility is operating as designed. After 5-years, inspection can be reduced to an annual basis where visual inspection of the facility and sediment accumulation is completed through the inspection ports. A VacTruck and high-pressure flusher nozzle is required to perform maintenance on the facility once sediment accumulation reaches the maximum acceptable depth specified by the supplier. It is noted that confined space entry is not required for inspection or maintenance of these facility types.

In regard to costs of these facility, the "milk-crate" system is more expensive than their plastic arch shape competitors, as these facilities are usually selected for the stacking capability which ultimately require deeper excavations. However, stone quantities required for installation are less than arch

chamber systems. The estimated installation cost for these systems is approximately $500/m^3 of storage.

With proper maintenance, these facilities are estimated to have 50-year lifespan before replacement is required. This assumes that inspection of the facility is performed on an annual basis, and inlets/outlets are regularly cleared of any debris. As confined space entry of these facilities is not possible, maintenance costs are reduced when compared to the concrete systems that allow entry for major rehabilitation assessment. The results of the lifecycle assessment indicate that the "milk-crate" system has the third lowest capital cost compared to over non-conventional SWMF systems. Maintenance costs of these facilities are the lowest, however life-expectancy is half that of the assessed concrete systems and therefore replacement of these structures after 50-years has been included in the assessment. Refer to **Appendix D** for the lifecycle assessment for each non-conventional SWMF.

5.2 Plastic Arch Chambers

The plastic (or polymeric) arch chamber system is widely used and accepted in industry in the GTA and south-western Ontario. These systems are made of HDPE and formed in arch shapes at various standard heights and lengths. The system consists of end caps, clear stone, manifolds, connecting piping, and modular chambers that easily snap together on-site. Plastic arch chamber systems can be designed to be water-tight through the use of an impermeable liner, or provide infiltration capabilities by designing an open-bottom facility. The plastic arch chamber system can also provide water quality treatment by incorporating an "isolator row" at the beginning of the system, which consists of a row of chambers that has been wrapped entirely in geotextile. The inlet connection in the "isolator row" is set at a lower elevation than the rest of the system, encouraging the first flush that is heavy in sediment to enter this row rather than dispersing throughout the system. There are various suppliers of the plastic arch chamber system, including but not limited to:

Figure 2: Example of Arch Chamber System, Source: ADS

- ADS: *Stormtech Chambers*
- Terrafix: *Triton System*
- Cultec: *Recharger Unit*
- Soleno: *StormChamber*

The main advantage of the plastic arch chamber system is their versatility and the industry wide familiarity with the product. As previously mentioned, the majority of underground SWMFs currently approved by various municipalities are plastic arch chamber systems. Therefore, several designers, engineers, contractors, and regulatory agencies have experience with the product, which leads to a higher chance of successful implementation. Canadian Standards Association (CSA) has a series of standards B184 "Polymeric subsurface stormwater management structures". These documents provides guidance and surety for designers and reviewers as it includes standardized requirements for:

- Materials and manufacturing;

- Design and structural integrity;
- Durability and longevity; and,
- Storage capacities and tolerances.

It is noted that the current editions of CSA B184 series covers arch-shaped stormwater management structures only, and other types of structures will be considered for future editions.

From a technical perspective, the plastic arch chamber systems have been identified to achieve water quantity, quality, and water balance requirements within the facility, removing the need for lot level and conveyance controls. The "isolator row" implemented within the facility has recently been ETV certified to achieve the minimum 80% TSS removal therefore removing the need for an external treatment system in many cases.

A large component to the function of these facilities is the clear stone placed at the system's base, between the chambers, and as cover material above the chambers. This clear stone provides a level base to install the product on, promotes infiltration between the system, and acts as structural cover over the system. The use of clear stone can be beneficial to the overall system, as it provides a void ratio of 0.40 allowing for additional storage opportunities. The placement of this clear stone is often completed using a stone slinger, therefore space for equipment setup should be considered prior to selection of this SWMF type. The import of large quantities of stone results in significant truck traffic and stockpiling requirements during construction of larger facilities.

Other disadvantages to plastic arch chamber systems are the need to confirm groundwater elevations, as high groundwater elevations will require the implementation of an impermeable liner below the system. This consideration is not typically required for the concrete facility competitors, which can be installed as watertight systems. In addition, maintenance of these arch chambers can be difficult given the shape of the infrastructure, particularly with the smaller units where manual entry is not feasible. If the facility were to become damaged and settlement from the surface is observed, a full excavation and replacement of the damage section is required, as minor rehabilitation is not an option for these facilities.

The key limitation to the plastic arch chamber system is the required burial depth to accommodate the top layer of stone and minimum cover requirements over the structures. This limitation plays a factor in the design process, particularly on sites with shallow servicing connections. While various heights of the structures are available, the heights are pre-determined and therefore changing to a smaller unit may be required when height is a constraint. Some arch chamber systems allow for stacking of more than one layer of storage units, however stacking of units may increase the potential of structural failure and must be considered carefully.

Maintenance of these facilities include semi-annual inspection for the first year of operation and after every large storm event. Annual visual inspection of the facility through the inspection ports is to be completed and sediment accumulation depth measured to confirm if maintenance on the facility is required. As sediment accumulation should be limited to the "isolator row" in a properly functioning system, maintenance should be limited to the use of a VacTruck and high-pressure flusher nozzle within this row only. Confined space entry is not required to complete maintenance on the facility; however, entry is possible in the larger systems if needed.

The estimated initial capital cost to install a plastic arch chamber system is approximately \$250/m^3 of provided storage. With proper maintenance, these facilities are estimated to last 50-years before replacement is required. This assumes that inspection of the facility is performed on an annual basis, and inlets/outlets are cleared of any debris to ensure proper function. As confined space entry of these facilities is not possible, maintenance costs are reduced when compared to the concrete

systems that allow entry for major rehabilitation assessment. The results of the lifecycle assessment indicate that plastic arch chamber systems have the second lowest capital costs and lifecycle cost. Maintenance costs of these facilities are the lowest, however life-expectancy is half of the concrete systems and therefore replacement of these structures after 50-years has been included in the assessment. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

5.3 Modular Concrete Chambers

Figure 3: Example Modular Concrete Chamber, StormTrap

Modular concrete chambers are another widely accepted non-conventional SWMF utilized in the GTA and southwestern Ontario. These systems are made of concrete box sections with partially open internal walls to allow for water movement throughout the system. The box sections are pre-cast within controlled facilities and can be formed at various standard heights and lengths. The systems can be designed to be water-tight or can promote infiltration by implementing a granular base below the facility. These facility types achieve high load bearing standards (HS-20) and are therefore attractive for roadway, parking lot, and industrial land uses. There are various suppliers of the modular concrete chamber systems, including but not limited to:

- Stormtrap: *SingleTrap, DoubleTrap*
- Contech: *Con/Span Detention System, Terre Arch*
- DECAST: *I-Storm*

The main advantage of these facilities is the high void ratio (over 95%) and high load bearing capacity, allowing for these structures to be placed at greater depths than the plastic alternatives on the market. Other advantages to modular concrete chambers include the versatility of these structure, as they can be installed below numerous services including parking structures, roadways, industrial parks, and residential buildings.

The main disadvantage of modular concrete chambers is the high upfront installation costs. These systems are typically more expensive than the plastic alternative, and have an increased cost of shipment, delivery, and staging. As this is a pre-cast structure, the pieces are large and bulky requiring numerous deliveries in comparison to an equivalent sized plastic system. The installation of modular concrete chamber system is also considerably more challenging than most other non-conventional types of facilities, as the chambers require heavy machinery to move and install. Available work space for operation and placement of this heavy machinery needs to be considered during the design phase of these projects.

Inspection of these facilities is required on an annual basis and after large storm events to confirm sediment accumulation depths and confirm the facility is operating as designed. Inspection can be completed through the facility inspection ports and confined space entry is typically not required for inspection, however entry is usually possible via standard maintenance hole openings. Once accumulation depths exceed the suppliers limit, maintenance on the facility is to be completed using a VacTruck and high-pressure flusher nozzle to break-up and remove debris. Maintenance frequency is estimated at 5-10 years for dry vault systems, and 3-5 years for wet vault systems.

The cost to implement modular concrete chamber systems can be quite high due to the pre-cast natural of the product and more strained shipment/delivery needs, with estimated costs in the range of \$1000/m^3 of installed storage. As noted above, there are many added benefits with this type of

facility, namely, the increased structural integrity of the system and its versatility. Assessment of site conditions, including expected loading for the land use and servicing depth constraints, is key when selecting if a modular concrete chamber system is required, or if a plastic unit would be better suited for the required application.

With proper maintenance, a modular concrete chamber system is estimated to have a 100-year lifespan before requiring replacement. This lifespan is conditional upon completion of the required inspection and maintenance, ensuring that inlets/outlets are cleared of debris and sediment is removed as needed. This lifecycle assessment also accounts for a confined spaced entry inspection and concrete repairs every 25-years to promote the longevity of these structures. The results of this assessment indicate that modular concrete chamber systems have the second highest capital cost investment, resulting to the second highest lifecycle cost. This can be attributed to the high cost of precast structures and relatively high maintenance costs. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

5.4 Superpipes

A superpipe facility includes the installation of large diameter pipes connected in sequence or series onsite to provide subsurface storage. These pipe systems are typically comprised of HDPE or corrugated steel pipe ('CSP') due to cost and weight considerations when compared to concrete pipes. Superpipe systems are limited in functionality, as they can only provide quantity control within the end-of-pipe facility, and do not provide infiltration or quality control. To provide quantity control, a small diameter conveyance pipe is located at the outlet of the superpipe system which acts as an orifice control reducing peak flows and retaining water within the system. Marginal water quality benefits may be experienced within a superpipe facility, as the system ultimately provides a flat space where coarser material can settle. However, credit towards 80% TSS removal through the implementation of a superpipe system is not recognized in the industry. External quality control devices are required upstream of these facilities to minimize maintenance requirements and meet SWM design criteria. There are several suppliers of storm sewers, but those particular to stormwater detention include, but are not limited to:

- Soleno: *Solfo* and *Wheolite Detention Systems*
- ADS: *N-12 Pipe Retention System*
- Contech: *CMP* and *Duromaxx Systems*

Figure 4: Example of Superpipe System, Source: Contech

Like plastic arch chamber systems, one of the many advantages of superpipe systems is their familiarity in industry and design simplicity. Installation of pipes and sewers is a common practice for many contractors and is considered the easiest of all assessed non-conventional SWMFs to implement.

The main disadvantage of a superpipe facility is its lack of versatility, as the system only provides peak flow reduction and does not achieve water quality or water balance objectives. Therefore, a treatment train approach is required to adhere to current SWM standards. In addition, the cost of

material for this system is high when compared to some other non-conventional SWMFs reviewed during this assessment.

Key limitations of a superpipe system include the restriction on available pipe sizes. Although pipe diameters up to 3.0 metres are readily available from many suppliers, delivery of this size of pipe can become complicated as travel routes need to be considered. It is common practice to assume pipe diameters of 1.8 metres can easily pass under various bridge structures, with larger pipe diameters requiring confirmation to ensure adequate clearance is available before being delivered.

Other limitations of superpipe facilities include the minimum and maximum cover depths over the pipes. Further, these facilities are not well suited for large volume structures, and the price per cubic metre of storage is high and storage space opportunities are lost through the circular pipe shape when compared to a square shape product. Lastly, due to the size of these pipes, heavy equipment is needed on-site to install the product.

Maintenance of these facilities should be completed on an annual basis to monitor sediment accumulation and ensure adequate function of the outlet pipe. Visual inspection is completed through access manholes provided at the upstream and downstream ends of the facility. A VacTruck and high-pressure water nozzle is required to complete maintenance. Confined space entry is not required to complete routine inspection or maintenance of these facilities, although entry with appropriately certified personnel is possible in the large diameter systems, if required.

The price of a superpipe system is highly dependent on the material, size of the pipe and the depth at which it is installed. In general, larger diameter pipes have a higher price per linear metre of pipe, however the price per cubic metre of storage is lower than when compared to smaller diameter pipes. Further, shallower installed systems are cheaper as a result of less excavation than deeper systems. To compare with other non-conventional SWMF pricing, a typical cost of \$2,000/m^3 has been assumed, although this cost is recognized as being highly dependent on the characteristics of the subject site. An additional potential benefit of superpipes is that they can achieve a dual function of conveyance and storage in a single piece of infrastructure.

With proper maintenance, superpipe facilities are estimated to have a lifespan of 100-years before requiring replacement. This assumes that inspection of the facility is performed on an annual basis, and inlets/outlets are cleared regularly of any debris. Sediment and debris should be removed from the facility every 5-years, or when sediment accumulation depths are noted in excess during the inspections. Maintenance is completed using a VacTruck/Flusher to flush the system. The results of the lifecycle assessment indicate that a superpipe system has the highest capital and lifecycle costs. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

5.5 Cast-in-place Concrete Facility

The implementation of cast-in-place concrete facilities utilize traditional cast-in-place techniques (using manually assembled formwork removed after concrete curing) to construct an underground stormwater tank. These facilities do not use sacrificial form systems to construct the facility, but rather use standard concrete forms to create the tank. The system is often designed to be watertight and requires the installation of

Figure 5: Example cast-in-place concrete facility

a concrete base slab, therefore removing the ability for the SWMF to promote infiltration. A baffle wall can be incorporated in the system design to provide some pre-treatment for water entering the facility. This pre-treatment chamber can promote the settling of sediment and debris; however, quality control objectives can not be achieved within the use of this pre-treatment chamber alone, and additional measures such as an OGS unit is required to meet water quality targets. With the exception of columns required for structural support, the interior of a cast-in-place concrete tank is largely open space that can provide significant storage opportunities and has a very high void ratio (over 95%). These facilities can also be designed with very high load bearing capacity making it ideal for areas with high vehicular traffic (i.e. parking lots, industrial areas, and roadways). These facilities do not have specific suppliers, but rather require a specialized concrete contractor with experience to form, place reinforcement and pour the required concrete.

The main advantage of a standard cast-in-place concrete facility is that they are highly customizable and are not constrained by any pre-made supplier products.

The main disadvantage of these cast-in-place facilities is the high costs associated with construction and increased construction time to allow for concrete curing. These SWMFs require a large quantity of concrete and reinforcement to construct, therefore cost of installation is highly dependent on the availability and price of steel and concrete at the time of construction. A significant amount of labour is required to construct forms and reinforcement, particularly for roof slabs of the facility. The implementation of this type of facility also requires specialized concrete contractors, whereas other non-conventional facilities (such as arch chambers or milk-crate systems) are constructed by civil contractors responsible for site servicing. The success of these facilities is highly dependent on the Contractor's ability to construct a high-quality concrete structure.

Another disadvantage to cast-in-place concrete facilities is construction complications associated with installation of these facilities during the winter months. Considerations for time delays, protection/insultation, and heating of the concrete should be considered when developing an accurate budget and schedule for the project. The GTA experiences temperatures below -5°C and combined with snow and mixed precipitation for 3-4 months of the year, therefore restricting the window for suitable weather conditions for concrete construction. To reduce the impact of these conditions on construction, cast-in-place concrete facilities should be planned to commence in the spring and finish before the winter.

Maintenance of these facilities should be completed on an annual basis to monitor sediment accumulation and ensure adequate function of the outlet pipe. Visual inspection is completed through the access manholes provided at the upstream and downstream ends of the facility. A VacTruck and high-pressure flusher nozzle is required to complete maintenance. Confined space entry is not required to complete routine inspection or maintenance of these facilities, although entry with appropriately certified personnel is possible, if required. An upstream treatment unit can be incorporated into the storm network to provide pre-treatment of the incoming water and ultimately minimize sediment accumulation. Alternatively, a baffle wall can be included inside the tank to isolate any sediment and debris that enters the system and minimize the area requiring maintenance.

The estimated cost of a cast-in-place structure is approximately $\$1000/m^3$ of installed storage, which may fluctuate depending on the depth of the facility. There are added benefits with this type of facility, namely, the structural integrity allowing it to be placed at all reasonable depths with various amounts of loading. Assessment of the site conditions, including expected loading for the land use and servicing depth constraints, is key when selecting if the cast-in-place system is required, or if a plastic prefabricated option would be better suited for the site.

With proper maintenance, these facilities are estimated to last 100-years before needing replacement. On a bi-annual basis, entry into the facility is recommended to inspect and perform maintenance as required, including sediment removal from any baffle walls constructed to limit sediment entry to the main facility. Every 5-years, the facility may require debris and sediment removal from the main facility by use of a VacTruck and flushing equipment. This lifecycle assessment also accounts for a confined spaced entry inspection and concrete repairs every 25-years to promote the longevity of these structures. The results indicate that these facility types are similar to modular concrete chambers and have the second highest capital cost investment resulting in the second highest lifecycle cost. This can be attributed to the high cost of the custom formwork and relatively high maintenance costs. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

5.6 Modular Form Cast-in-place Concrete

The implementation of modular form cast-in-place concrete facilities have been growing in popularity in recent years given their structural integrity, long lifecycle, and ease of installation. These systems typically include a plastic forming system that is used to replace traditional concrete forming systems required for concrete structures. The forms are entirely sacrificial and do not provide any structural support to the facility. Similar to modular plastic chambers, the modular concrete forms are lightweight and easily snap together, allowing for installation to be completed by hand. These concrete facilities can be designed to be water-tight by using a concrete base slab and waterproofing material or can promote infiltration by using a granular base for the facility. Modular form cast-in-place concrete facilities achieve high load bearing standards (HS-20) making them attractive for construction below roadways, parking lots, and industrial land uses. These facilities provide a large void ratio (over 95%) with lost capacity limited only as a result of the plastic forms located within the tank (i.e. no stone involved). At this time, the leader in the industry responsible for supplying these sacrificial forms is CUPOLEX Engineering Solutions Inc.

The main advantage of the modular form cast-in-place facility is the forming system provides significant time saving opportunities when compared to traditional forming systems. Installation of the modular forms is significantly faster than traditional forms, and no time is spent removing the forms following completion of the concrete pour as the modular forms are to remain in place during operation of the facility. An additional advantage of modular form cast-in-place facilities is the height of the system can be customized within the design range specified by the supplier, providing an advantage over competitors that have products manufactured at pre-made standard heights. There is also a structural design advantage achieved through the use of the dome shaped forms, and frequent column spacing that is not feasible with traditional forming systems.

Figure 6: Example Modular Form Cast-in-place Concrete

The main disadvantage of the cast-in-place concrete system is the increased construction time for concrete curing and rebar placement when compared to the plastic and precast SWMFs reviewed during this assessment. In addition, modular form cast-in-place facilities are a relatively new

technology, therefore additional training time and effort is required for contractors who have limited experience in installing these facilities.

Similar to traditional cast-in-place facilities, cold weather concrete work is a key limiting factor to the implementation of modular form cast-in-place systems. Cold weather conditions typically experience in Ontario during the winter months are not ideal for constructing a cast-in-place concrete facility, and heating and insulating considerations must be taken into account to ensure the proper curing of the poured concrete.

Maintenance of these facilities is the same as the traditional cast-in-place systems. Inspection should be completed on an annual basis to monitor sediment accumulation and ensure adequate function of the facility. Visual inspection is completed through the access manholes/inlets provided throughout the facility. A VacTruck and high-pressure flusher nozzle is required to complete maintenance. Confined space entry is not required to complete routine inspection or maintenance of these facilities, although entry with appropriately certified personnel is possible, if required. An upstream treatment unit can be incorporated into the storm network to provide pre-treatment of the incoming water and ultimately minimize sediment accumulation. Alternatively, a baffle wall can be included inside the tank to isolate any sediment and debris that enters the system and minimize the area requiring maintenance.

The estimated cost to install a modular form cast-in-place system is approximately $\$250/m^3$ of storage. It is important to note that the system requires the use of concrete and therefore the price is subject is variability with the price of concrete. This price is the lowest of the evaluated options but can have potential delays depending on weather conditions. Although this system can be the least capital cost alternative, it is not recommended to be constructed during winter months so timing should be considered when deciding on the preferred system.

With proper maintenance, modular form cast-in-place facilities are estimated to last 100-years before requiring replacement. This lifecycle assessment also accounts for a confined spaced entry inspection and concrete repairs every 25-years to promote the longevity of these structures. The results indicated that these facility types have the lowest capital cost investment and ultimately the lowest life-cycle costs. This can be attributed to the long-life expectancy of these facilities, when compared to the plastic competitors that are expected to require replacement within 100-years. Refer to **Appendix D** for the lifecycle assessment for each non-conventional facility.

6 Next Steps

Upon completion of the Background Report, it is recommended that a stakeholder engagement session be arranged to review and discuss the results of the report, in addition to providing opportunity for relevant internal and external stakeholders to provide feedback regarding their concerns associated with the current interim approach to accepting non-conventional SWMFs. Resilient will then initiate the next deliverable of the project, which consists of the review and evaluation of the City's existing sixteen (16) non-conventional SWMFs. These facilities will be assessed based on their performance and will include the documentation of the pros and cons of each non-conventional SWMF.

The preparation of these review documents will ultimately support the development of Stage 2 of the project, which includes the development of a formal City of Vaughan Policy, Procedure, Engineering and Park Design Criteria and Standard Drawings.

APPENDIX A

Relevant Background Information

No.	Name of Document	Author	Date	Location
1	Stormwater Management Planning and Design Manual	MECP	March 2003	https://www.ontario.ca/document/stormwater-management-planning-and-design-manual/stormwater-management-plan-and-swmp-design
2	City of Vaughan Official Plan and Update	City of Vaughan	2010	https://www.vaughan.ca/projects/policy_planning_projects/official_planning_2010/Pages/default.aspx
3	Low Impact Development Stormwater Management Planning and Design Guide	TRCA/CVC	2010	https://files.cvc.ca/cvc/uploads/2014/04/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf
4	Stormwater Management Criteria	TRCA	August 2012	https://trca.ca/conservation/stormwater-management/understand/swm-criteria-2012/download
5	SWM Master Plan Class EA Study	City of Vaughan	2014	https://www.vaughan.ca/projects/planning_growth/SWMMP_EA/General%20Documents/Volume%201%20-%20SWM%20Master%20Plan%20Report_Final%20Sections%201%20-%207.pdf
6	Active Together Master Plan	City of Vaughan	2018	https://www.vaughan.ca/projects/community/active_together/General%20Documents/96-360%20Vaughan%20ATMP_Final_May%202018.pdf
7	Green Directions Vaughan	City of Vaughan	2019	https://www.vaughan.ca/cityhall/environmental_sustainability/GreenDirections/General%20Documents/2019Green%20Directions%20Vaughan%20FINAL.pdf
8	Engineering Design Criteria and Standard Drawings	City of Vaughan	December 2020	https://www.vaughan.ca/services/DesignCriteria/Pages/default.aspx
9	Low Impact Development Stormwater Management Guidance Manual (Draft)	MECP	March 28, 2022	https://municipalclassea.ca/files/7_DRAFT_MOECC_LID%20SWM%20Manual.pdf
10	Parkland Dedication Guideline	City of Vaughan	January 2022	https://www.vaughan.ca/cityhall/departments/pipd/pp/General%20Documents/Parkland%20Dedication%20Guideline_Jan_25_2022.pdf
11	MECP's CLI-ECA for a Municipal Stormwater Management System, ECA Number: 011-S701	City of Vaughan	April 2022	https://prod-environmental-registry.s3.amazonaws.com/2021-03/Guide%20to%20Applying%20-%20First%20Consolidated%20Linear%20Infrastructure%20ECA.pdf
12	Sustainability Metrics Program	City of Vaughan, Markham, Brampton and Richmond Hill	May 2022	https://www.vaughan.ca/cityhall/departments/dp/Pages/Sustainability-Metrics.aspx
13	Parkland Dedication By-Law 168-2022	City of Vaughan	June 2022	https://www.vaughan.ca/cityhall/departments/pipd/pp/General%20Documents/Draft%20Parkland%20Dedication%20By-law.pdf
14	Committee of the Whole (Working Session) Report on "City Approach on Non-Conventional Stormwater Infrastructure" and associated attachments	City of Vaughan	June 8, 2022	https://pub-vaughan.escribemeetings.com/filestream.ashx?DocumentId=108314

APPENDIX B

Correspondence with Municipalities

From: Muir, Robert
To: Mark Bassingthwaite
Cc: Saad Yousaf; Andy Lee; Rebecca Turbitt; Samantha Archibald
Subject: RE: Non-Conventional SWMF Industry Scan
Date: January 20, 2023 4:34:49 PM

Hi Mark,

We would be glad to support this and collaborate with our good neighbours in Vaughan.

We have a policy to recover the additional costs of alternative infrastructure (can include underground tanks), based on the differential over 50 years when compared to conventional/traditional servicing (e.g., with a wet pond) – this is called our Alternative Infrastructure Policy "AIP".

Council has directed us to evaluate costs on a case by case basis. This June 13, 2022 Development Services Committee meeting Item 9.1 had the latest discussion (see DSC minutes and presentation by my Development Services colleagues that our department (Environment Services) supported): meeting minutes: https://pub-markham.escribemeetings.com/Meeting.aspx?Id=d0d6f741-feb0-47f4-8c14-a744237ce3de&Agenda=PostMinutes&lang=English&Item=23&Tab=attachments, presentation: https://pub-markham.escribemeetings.com/filestream.ashx?DocumentId=55598

While we do a case by case evaluation I do see that having a process, and some accepted standardized cost items and unit costs, would be worthwhile. As we have reached out externally for support on costing we have found sometimes, for some items, that we may have robust costs internally to rely on (as we are maintaining/operating many assets already and some of our programs are long-standing).

We have applied the AIP for 2 plastic underground arch systems (Fairtree subdivision) – that was the first time we developed and applied this policy and admittedly the cost estimation was approximate. We are refining these costs and filling gaps for the more important components on the lifecycle costs though. Last spring we did a comparison of open flood control storage vs a RC underground tank and selected the open storage based on cost and other considerations (federal grant for natural infrastructure was at risk with a tank). Over the past ½ year we are repeating the assessment for 2 underground RC tanks now for North Markham developments. While there is no agreement with the developer on the AIP amount yet, we'd be glad to share what we've estimated as appropriate costs from our perspective.

We don't have a list of acceptable/unacceptable technologies, just general direction (June 2022 resolutions below) to ensure proposals are "appropriate". Resolution 5 is to develop criteria (performance standards, as opposed to approved products) which should support our review process. Markham will be seeking outside support to develop those criteria but that has not been initiated yet (lead will be Development Services I expect).

Recommendations (General)

4. Proposals for U/G tanks be reviewed on a case by case basis by Engineering and Planning Departments, in consultation with Environmental Services Department, to ensure that the proposed location is appropriate and the proposed type of U/G tank meets the City's specifications and criteria;
5. Engineering Department, in consultation with Planning and Environmental Services Departments, procures the services of a professional engineering consultant to assist in the development of appropriate criteria of acceptance for the consideration of U/G tanks, along with the acceptable uses above the facilities, along with the necessary specifications on U/G tank facilities;

20

I hope that helps share where we are and where we are going. Let me know if there are any questions and how we may fit in to your worthwhile endeavor.

Thanks so much Mark. Have a great weekend everyone !

Rob

Robert J. Muir, M.A.Sc., P.Eng.
Manager, Stormwater | Environmental Services
Community Services Commission | City of Markham
101 Town Center Blvd., Markham, Ontario L3R 9W3
Mobile: 416.991.2106| Email: rmuir@markham.ca
www.markham.ca

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Friday, January 20, 2023 3:56 PM
To: Muir, Robert <RMuir@markham.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

CAUTION: This email originated from a source outside the City of Markham. DO NOT CLICK on any links or attachments, or reply unless you recognize the sender and know the content is safe.

Good afternoon Rob,

Resilient Consulting is currently working with the City of Vaughan to develop a policy, procedure and relevant design criteria/standards for the approval of non-conventional municipal stormwater management facilities (SWMFs) associated with new development. The City, along with many neighbouring municipalities, is experiencing increased pressure to shift from requiring conventional municipal SWMFs (wet/dry ponds) towards accepting publicly owned and operated non-conventional SWMFs (underground storage tanks, superpipes, etc.), typically within new public park lands. The primary objectives in developing this framework for the City are:

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If you are not the correct person to contact regarding this matter, could you please forward to the appropriate person?

Thank you for your assistance!

Mark

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PO Box 643
Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
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From: Muneef Ahmad
To: Mark Bassingthwaite
Cc: Saad Yousaf; Andy Lee; Samantha Archibald; Rebecca Turbitt; Jennifer Whittard
Subject: RE: Non-Conventional SWMF Industry Scan
Date: January 24, 2023 11:37:51 AM
Attachments: image001.png
image002.png

Good morning Mark,

Appreciate you reaching out. I believe I'd be the appropriate person at Mississauga that could speak to this.

Having said that, there isn't much to report actually. From past discussions with staff at Vaughan, we understand this pressure has been escalating around the GTA (e.g. thought I heard this inquiry from Oshawa as well, but could be mistaken). One of our key discussion points was the necessary inter-departmental dialogue that would be required to confirm how potential parkland credits would be handled. The nature of development is somewhat different in Mississauga from other municipalities as we don't have a lot of remaining greenfield development. The lakefront development we have does not require water quantity control so water quality and runoff volume reduction is being addressed through ROW LID and end-of-pipe OGS. As a function of these factors mentioned here, we've not found ourselves pressured to consider similar proposals for SWMF's under parks although we have constructed them ourselves as flood mitigation retrofit projects.

This is not to say it hasn't been asked in some form. Developers have asked us to consider LID on our roads to address their SWM requirements. It never got beyond my level, that is the developer didn't escalate. We've been standing firm so far that public lands are to serve communal function and are retained for the potential for any retrofit opportunities that may exist beyond subject development lands. Consequently, we don't have any relevant policies, procedures or standards that come to mind which speak to this inquiry.

Hoping this message may be helpful in some way. Do let me know if you think we could provide any further support. I'd certainly be interested to hear how this journey progresses.

Thank you very much,

MISSISSAUGA
Muneef Ahmad P.Eng
Manager-Stormwater Projects & Approvals, Environmental Services Section
T 905-615-3200 ext.4793
muneef.ahmad@mississauga.ca

City of Mississauga | Transportation & Works Department,
Infrastructure Planning & Engineering Services

Follow us on Instagram **@saugastormwater**

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Friday, January 20, 2023 3:58 PM
To: Muneef Ahmad <Muneef.Ahmad@mississauga.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

Good afternoon Muneef,

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implementation. Our goal in reviewing this information is to identify design approaches, considerations and data gaps within current non-conventional SWMFs practices which will be taken into consideration during the development of the City's formal policies and procedures. We would greatly appreciate if you could confirm if any of the above information is available within your municipality, and provide such information if possible.

If you are not the correct person to contact regarding this matter, could you please forward to the appropriate person?

Thank you for your assistance!

Mark

Mark Bassingthwaite, P.Eng.
Resilient Consulting
PO Box 643
Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
www.resilientconsulting.ca
@resilientccorp

Rebecca Turbitt

From: Daniels, Hanna <Hanna.Daniels@hamilton.ca>
Sent: February 9, 2023 10:16 AM
To: Mark Bassingthwaite
Cc: Saad Yousaf; Andy Lee; Rebecca Turbitt; Samantha Archibald; Jennifer Whittard
Subject: RE: Non-Conventional SWMF Industry Scan

Good morning Mark,

First, I have to say kudos to your Team and Vaughan for this work! I would be so happy to contribute, but I think you're at least a step or two ahead of us. We are in the process of developing Green Standards and Guidelines for private infrastructure, and will eventually get to standards for public infrastructure.

Similar to Vaughan, the implementation of non-conventional SWMFs on public lands/as City assets are assessed on a case by case basis. To be honest, those cases are not common but we approve them quite often on private property where they will remain private assets. We are in the process of kicking of a neighbourhood servicing/urbanization project that will require municipally owned non-conventional SWMFs, but it's still in its infancy and will be precedent setting for Hamilton Water. If you're interested, I can keep you posted on that work.

Sorry I couldn't provide more on this, but please do keep me in the loop as you progress and I will share our Green Standards and Guidelines for private developments once they're finalized (which is soon I hope).

Take care for now!
Hanna

Hanna Daniels
Senior Project Manager, Water/Wastewater Planning (Acting)
Public Works
Hamilton Water, City of Hamilton
(905) 546-2424 Ext.3421
Hamilton

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Wednesday, February 8, 2023 9:59 AM
To: Daniels, Hanna <Hanna.Daniels@hamilton.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: RE: Non-Conventional SWMF Industry Scan

Hi Hanna,

I am following up on the below email. We are hoping to obtain your feedback regarding the below in the next few days in order to finalize our background report.

Please let us know if you have any questions or are able to provide feedback.

Thank you,
Mark

From: Mark Bassingthwaite
Sent: January 20, 2023 3:59 PM
To: Daniels, Hanna <Hanna.Daniels@hamilton.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

Good afternoon Hanna,

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If you are not the correct person to contact regarding this matter, could you please forward to the appropriate person?

Thank you for your assistance!

Mark

Mark Bassingthwaite, P.Eng.
Resilient Consulting
PO Box 643

Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
www.resilientconsulting.ca
@resilientccorp

Rebecca Turbitt

From: Nick Gollan <Nick.Gollan@kitchener.ca>
Sent: February 9, 2023 4:05 PM
To: Mark Bassingthwaite
Cc: Saad Yousaf; Andy Lee; Samantha Archibald; Rebecca Turbitt; Jennifer Whittard; Travis Pawlick; Leah Walter
Subject: RE: Non-Conventional SWMF Industry Scan
Attachments: MUN-UTI-2003 - Stormwater Management Policy.pdf

Hi Mark,

I'm sorry for not getting back to you sooner. I have included Leah and Travis from Kitchener, who oversee operations and maintenance as well as environmental compliance, respectively.

We are interested in this work, particularly the outcomes, as we continually evolve our processes and keep the door open for innovative practices where appropriate.

I can say there are essentially five pillars we currently rely on to make decisions:

1) Integrated Stormwater Management Master Plan and the associated policy documents (infiltration in the context of source protection planning, minimum volume criteria and targets, stormwater management fee)
    - Overarching policy attached; master plan report available upon request
2) Consolidated Linear Infrastructure Environmental Compliance Approval issued by the Province to the City for the entire stormwater network
3) 2021 Development Manual
4) Operations and Maintenance standard operating procedures and best management practices
5) Stormwater Asset Management Plan

We currently have a non-prescriptive approach for when to accept “non-conventional” stormwater management approaches – as long as the outcomes and objectives of the aforementioned strategies are achieved by what is being proposed.

It might be worth having a structured conversation/meeting to share ideas.

Thanks for reaching out; as I mentioned, we are interested in following this work, providing valuable input, and using some appropriate recommendations for Kitchener.

Have a great afternoon.

Kind Regards,

Nick Gollan, C.E.T. (he/him)

Manager, Planning and Programs | Sanitary and Stormwater | City of Kitchener
519-741-2200 ext. 7422 | TTY 1-866-969-9994 | nick.gollan@kitchener.ca

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Wednesday, February 8, 2023 9:59 AM
To: Nick Gollan <Nick.Gollan@kitchener.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: RE: Non-Conventional SWMF Industry Scan

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Hi Nick,

I am following up on the below email. We are hoping to obtain your feedback regarding the below in the next few days in order to finalize our background report.

Please let us know if you have any questions or are able to provide feedback.

Thank you,
Mark

Mark Bassingthwaite, P.Eng.
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PO Box 643
Whitby, ON L1N 5V3
mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
www.resilientconsulting.ca
@resilientccorp

From: Mark Bassingthwaite
Sent: January 20, 2023 4:21 PM
To: nick.gollan@kitchener.ca
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

Good afternoon Nick,

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Thank you for your assistance!

Mark

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mbassingthwaite@resilientconsulting.ca
P: 289-943-4651
www.resilientconsulting.ca
@resilientccorp

Rebecca Turbitt

From: Malik, Umar <Umar.Malik@burlington.ca>
Sent: February 8, 2023 1:19 PM
To: Mark Bassingthwaite; Shahzad, Arif
Cc: Saad Yousaf; Andy Lee; Samantha Archibald; Rebecca Turbitt; Jennifer Whittard
Subject: RE: Non-Conventional SWMF Industry Scan
Attachments: 2020-STORM DESIGN MANUAL.pdf

Good afternoon Mark,

I hope you are doing well.

Attached is the City of Burlington's most recent Stormwater Management Guidelines document. It was prepared in 2020. We follow this to review the development applications and approve stormwater management systems and infrastructure. I hope it will provide you with the information you are looking for.

Regards,

Umar Malik, M.Eng., P.Eng.
Stormwater Engineer
Engineering Services
P. 905-335-7600, ext 7426| **E.** umar.malik@burlington.ca
Address 426 Brant Street P.O. Box 5013, Burlington, Ontario, L7R 3Z6
City of Burlington | www.burlington.ca

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Wednesday, February 08, 2023 10:00 AM
To: Shahzad, Arif <Arif.Shahzad@burlington.ca>; Malik, Umar <Umar.Malik@burlington.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: RE: Non-Conventional SWMF Industry Scan

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Hi Umar,

I am following up on the below email. We are hoping to obtain your feedback regarding the below in the next few days in order to finalize our background report.

Please let us know if you have any questions or are able to provide feedback.

Thank you,
Mark

From: Shahzad, Arif <Arif.Shahzad@burlington.ca>
Sent: January 23, 2023 9:51 AM
To: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>; Malik, Umar <Umar.Malik@burlington.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: RE: Non-Conventional SWMF Industry Scan

Hi Mark: I have copied Umar Malik on this email. He is more involved in the SWM reviews related to new developments and may be able to provide his insight on this matter.
Thank you,

Arif Shahzad, M.Eng., P.Eng.
Senior Project Manager - Stormwater Engineering
Engineering Services

P. 905-335-7600 ext. 7486| **E**. Arif.Shahzad@burlington.ca
Address 426 Brant Street P.O.Box 5013, Burlington, Ontario, L7R 3Z6
City of Burlington| www.burlington.ca

Please consider the environment before printing this e-mail.

From: Mark Bassingthwaite <mbassingthwaite@resilientconsulting.ca>
Sent: Friday, January 20, 2023 4:00 PM
To: Shahzad, Arif <Arif.Shahzad@burlington.ca>
Cc: Saad Yousaf <saad.yousaf@vaughan.ca>; Andy Lee <andy.lee@vaughan.ca>; Samantha Archibald <sarchibald@resilientconsulting.ca>; Rebecca Turbitt <rturbitt@resilientconsulting.ca>; Jennifer Whittard <jwhittard@resilientconsulting.ca>
Subject: Non-Conventional SWMF Industry Scan

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Good afternoon Arif,

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Thank you for your assistance!

Mark

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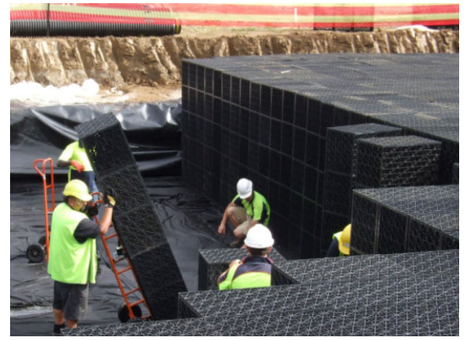
APPENDIX C

Summary Table of Non-Conventional SWMF

No.	Option	Examples	Description	Advantages	Disadvantages	Capital Cost	Maintenance Procedures / Requirements	Rating	Photos
1	"Milk-Crate" System	• Atlantis Matrix Tank. • Brentwood StormTank Module. • EcoRain Tanks. • Ausdrain EnviroModule 2. • Stormcon Greenstorm Module.	• Stackable, modular HDPE chambers in a shape similar to milk crates, designed to detain and/or retain stormwater on site. • Can be configured to infiltrate or lined to limit infiltration. • Sections of the crates snap together and are assembled on site.	• Higher void ratio compared to arch chambers, exceeding 95% in most cases. • Easy installation. • Suitable for use in parks and other land uses with little to no vehicular traffic. • Easily packaged and shipped. • Opportunity for infiltration.	• Groundwater elevation will be a constraint. • More expensive than arch chambers. • Not as commonplace as arch chambers in this area, contractors may not be as familiar. • Cannot enter main system. Therefore no opportunities for maintenance without excavation. • Little opportunity to provide quality control.	• Roughly $500 per m^3 of storage installed.	• Semi-annual inspection for first years and after every large event. • Annual visual inspection through inspection ports. • CSE not required for inspection – entry not possible. • Use for VacTruck/pump to remove sediment and flush until discharge is clean. • Can incorporate a pre-treatment element to capture most sediment/debris in an easier to maintain location.	Functional ★★★ Suitability ★★★★ Capital Cost ★★★ Maintenance ★★ **Overall** ★★★	
2	Plastic Arch Chambers	• Terrafix Triton System • StormTech Chambers • Soleno Hydrostor and Stormchamber Systems • Cultec chambers	• Modular arch plastic chambers designed to detain and/or retain stormwater on site. • Can be configured to infiltration or lined to limit infiltration. • Sections of the chambers snap together and are assembled on site. • Some products allow for "stacked" configuration.	• More void space for storage compared to subsurface infiltration trenches. • Header row for quality control can be easily incorporated into design. • Suitable for use in parks and other land uses with little to no vehicular traffic. • Easy shipping and installation. • Generally cheaper than milk crate systems. • Access ports can be installed for maintenance and flushing. • Opportunity for infiltration.	• Groundwater elevation will be a constraint. • Less void space than milk crate system. • Maintenance can be difficult, especially for smaller units. Larger units can be entered.	• Roughly $250 per m^3 of storage installed.	• Semi-annual inspection for first year. • Annual visual inspection through inspection ports. • CSE not required for inspection – entry possible on larger structures. • Vacuum/JetVac Process used to remove sediment upon accum. of 3". • CSE required if maintenance on chambers required. • Selection of vacuum/JetVac truck and nozzles key for proper maintenance. • Can incorporate a pre-treatment element.	Functional ★★★★ Suitability ★★★★ Capital Cost ★★★★ Maintenance ★★★ **Overall** ★★★★	
3	Modular Concrete Chambers	• StormTrap System • Contech Terre Arch and CON/SPAN Detention System • DECAST I-Storm	• Precast, modular concrete storage units installed underground, typically under parking lots. • Sections of arches are pieced together, can be grouted if necessary. • Can be configured to infiltrate or lined to limit infiltration.	• Higher load bearing capacity compared to plastic systems. • Large void spaces. • Opportunity for infiltration. • Can easily configure conc. chambers for long flow path for quality benefits. • Can achieve larger depths compared to plastic, meaning smaller facility footprints. • Many units are designed for confined space entry, which allows for more flexible maintenance /rehabilitation. • Simple shipping and installation, though more expensive that its plastic counterparts.	• Load bearing capacity of the concrete structure largely wasted on parks when little to no vehicular traffic is expected. • Shipment more difficult than plastic storage systems. • More expensive than plastic storage systems.	• Expensive. Up to $1,000 per m^3.	• Minimum annual inspection or after large storm events / rainy seasons. CSE not required for inspection. • Maintenance required when sediment occupies 15% of design volume. • Use of VacTruck to remove sediment. • CSE not required for maintenance – entry is possible if needed. • Maintenance frequency typically 5-10 years for dry vaults and 3-5 years for wet vault.	Functional ★★★★★ Suitability ★★★ Capital Cost ★★ Maintenance ★★★ **Overall** ★★★	

No.	Option	Examples	Description	Advantages	Disadvantages	Capital Cost	Maintenance Procedures / Requirements	Rating	Photos
4	Superpipes	• Soleno Solflo and Weholite Detention Systems. • ADS N-12 Pipe Retention System. • Contech CMP and Duromaxx Systems	• Large diameter pipes connected to form a large, underground storage chamber. • Typically made from CMP or HDPE pipes.	• No constraints from groundwater. • Easy installation. • Suitable for use in parks and other land uses. • Pipes will be large enough for confined space entry, which allows for more flexible maintenance/ rehabilitation. • Simple shipping and installation.	• Marginal water quality benefits. • High material costs. • No opportunity for infiltration.	• Large diameter superpipes can be expensive. • Approximately $2000/m^3 installed	• Access manhole provided at upstream and downstream ends for inspection/maintenance. • CSE not required for maintenance – entry possible if needed. • Flushing and sediment removal required using high pressure water and Hydrovac Truck. • Can incorporate a pre-treatment element to capture most sediment/debris in an easier to maintain location.	Functional ★★★ Suitability ★★★★ Capital Cost ★ Maintenance ★★★★ **Overall** ★★★	
5	Cast-in-place Concrete Facility	• Concrete suppliers / general contractor	• Construct a large cast-in-place concrete, underground storage facility.	• Large void spaces. • Can incorporate baffles to quality control benefits. • No constraints from groundwater. • Easily accessible with confined space entry, which allows for more flexible maintenance/ rehabilitation. • Can achieve larger depths compared to other options, meaning smaller facility footprints.	• No opportunity for infiltration. • Very expensive. • More complex construction.	• Expensive. Up to $1,000 per m^3. • During winter months, may require heating when pouring.	• Access manhole provided for inspection and maintenance. • Measure sediment depth using rod on an annual basis. • Hydrovac Truck used to remove sediment/debris. • CSE not required for maintenance – entry possible if needed.	Functional ★★★★★ Suitability ★ Capital Cost ★★ Maintenance ★★★ **Overall** ★★	
6	Modular Form Cast-in-place Concrete	• Cupolex Rialto Stormwater Tanks	• Cast-in-place concrete tank system designed to detain and/or retain runoff. • Plastic forming network snaps together on-site, concrete poured over top to fill forms.	• Large void ratio at 98%. • Minimal cover required, ideal for park applications with minimal vehicular traffic. • Opportunity for infiltration. • Simple shipping and placing form. • Easily accessible with confined space entry, which allows for more flexible maintenance/ rehabilitation.	• Groundwater elevation may be a constraint. • Increased construction time for concrete to cure. • Cannot enter main storage. Future concrete/crack repairs could be done by machine, similar to sewer repairs. • Not as commonplace as arch chambers in this area, contractors may not be as familiar.	• Roughly $250 per m^3 of storage installed.	• Access hatches provided to perform inspections and maintenance. • Inspection well provided in tank to allow for ease of inspection. • Maintenance required when sediment depth reaches 3”. • Sediment removed using high pressure water and Hydrovac truck. • Yearly visual inspection, maintenance every 9-years. • Can incorporate a pre-treatment element. • CSE not required for regular maintenance – entry possible if needed.	Functional ★★★★★ Suitability ★★★★ Capital Cost ★★★★ Maintenance ★★★ **Overall** ★★★★	

APPENDIX D

Lifecycle Assessment

Gallanough Park SWMF Class EA Addendum
Client: City of Vaughan
Project No: 2020-010
Date: 10-Feb-23
Prepared By: RJT

Cost Estimates

Capital Cost (Assuming 10,000 m^3 facility)

Alt. #	Description	Cost
1	Milk-Crate	$5,000,000.00
2	Plastic Arch	$2,500,000.00
3	Modular Conc. Chamber	$10,000,000.00
4	Super Pipe	$20,000,000.00
5	Cast-in-place Conc.	$10,000,000.00
6	Modular Form Cast-in-place	$2,500,000.00

Equivalent Annual Maintenance Cost

Alt. #	Description	Cost
1	Milk-Crate	$13,000.00
2	Plastic Arch	$13,000.00
3	Modular Conc. Chamber	$21,320.00
4	Super Pipe	$13,000.00
5	Cast-in-place Conc.	$21,320.00
6	Modular Form Cast-in-place	$21,320.00

Maintenance Cost Net Present Value Analysis (100 years, 3%)

Alt. #	Description	Cost
1	Milk-Crate*	$902,465.99
2	Plastic Arch*	$902,465.99
3	Modular Conc. Chamber	$512,469.96
4	Super Pipe	$332,198.29
5	Cast-in-place Conc.	$512,469.96
6	Modular Form Cast-in-place	$512,469.96

* Includes replacement fee at 50 years

Total Value Analysis

Alt. #	Description	Cost
1	Milk-Crate	$5,902,465.99
2	Plastic Arch	$3,402,465.99
3	Modular Conc. Chamber	$10,512,469.96
4	Super Pipe	$20,332,198.29
5	Cast-in-place Conc.	$10,512,469.96
6	Modular Form Cast-in-place	$3,012,469.96

RESILIENT CONSULTING

Non-Conventional SWMF Assessment
Client: City of Vaughan
Project No: 2023-001
Date: 10-Feb-23
Prepared By: RJT

Annual Maintenance Costs

Alternative	Facility Type	Life Expectancy	Visual Inspection	Surface Debris Removal	CSE Inspection	Debris Removal from Facility	Concrete Repairs	Total Projected Cost/Year
		Frequency	*Annual*	*Annual*	*25 Years*	*5 Years*	*25 Years*	
1	Milk-crate System	50	$ 2,500.00	$ 2,000.00		$ 30,000.00		$ 13,000.00
2	Plastic Arch System	50	$ 2,500.00	$ 2,000.00		$ 30,000.00		$ 13,000.00
3	Modular Conc. Chamber	100	$ 2,500.00	$ 2,000.00	$ 8,000.00	$ 30,000.00	$ 200,000.00	$ 21,320.00
4	Super Pipes	100	$ 2,500.00	$ 2,000.00		$ 30,000.00		$ 13,000.00
5	Cast-in place Conc.	100	$ 2,500.00	$ 2,000.00	$ 8,000.00	$ 30,000.00	$ 200,000.00	$ 21,320.00
6	Modular Form Cast-in-place	100	$ 2,500.00	$ 2,000.00	$ 8,000.00	$ 30,000.00	$ 200,000.00	$ 21,320.00

Notes:

- Assessment completed based on a 100-year duration, at a 3% interest rate
- Assessment includes replacement at end of life of plastic factilities
- Replacement costs are highly variable and are assumed at the lowest capital cost for the plastic facilities
- Underground Debris removal includes use of VacTruck/Flusher/High-pressure Water
- Frequency of Debris Removal is dependent on the sediment loading from the catchment. 5 Year frequency conservatively assumed
- Visual Inspection to occur semi-annually for the first 5-years

Interest rate **0.03**

Year	Visual Inspection	CSE Inspection	Surface Debris	U/G Debris	Concrete Repairs	Replacement	Alt 1	Discounted Cash	Alt 2	Discounted Cash	Alt 3	Discounted Cash	Alt 4	Discounted Cash	Alt 5	Discounted Cash	Alt 6	Discounted Cash
1	$ 5,000.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12	$ 7,000.00	$ 6,796.12
2	$ 5,000.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17	$ 7,000.00	$ 6,598.17
3	$ 5,000.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99	$ 7,000.00	$ 6,405.99
4	$ 5,000.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41	$ 7,000.00	$ 6,219.41
5	$ 5,000.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53	$ 37,000.00	$ 31,916.53
6	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68	$ 4,500.00	$ 3,768.68
7	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91	$ 4,500.00	$ 3,658.91
8	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34	$ 4,500.00	$ 3,552.34
9	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88	$ 4,500.00	$ 3,448.88
10	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24	$ 34,500.00	$ 25,671.24
11	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90	$ 4,500.00	$ 3,250.90
12	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21	$ 4,500.00	$ 3,156.21
13	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28	$ 4,500.00	$ 3,064.28
14	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03	$ 4,500.00	$ 2,975.03
15	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24	$ 34,500.00	$ 22,144.24
16	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25	$ 4,500.00	$ 2,804.25
17	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57	$ 4,500.00	$ 2,722.57
18	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28	$ 4,500.00	$ 2,643.28
19	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29	$ 4,500.00	$ 2,566.29
20	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81	$ 34,500.00	$ 19,101.81
21	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97	$ 4,500.00	$ 2,418.97
22	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52	$ 4,500.00	$ 2,348.52
23	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11	$ 4,500.00	$ 2,280.11
24	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70	$ 4,500.00	$ 2,213.70
25	$ 2,500.00	$ 8,000.00	$ 2,000.00	$ 30,000.00	$ 200,000.00	$ -	$ 34,500.00	$ 16,477.39	$ 34,500.00	$ 16,477.39	$ 242,500.00	$ 115,819.35	$ 34,500.00	$ 16,477.39	$ 242,500.00	$ 115,819.35	$ 242,500.00	$ 115,819.35
26	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63	$ 4,500.00	$ 2,086.63
27	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85	$ 4,500.00	$ 2,025.85
28	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85	$ 4,500.00	$ 1,966.85
29	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56	$ 4,500.00	$ 1,909.56
30	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54	$ 34,500.00	$ 14,213.54
31	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94	$ 4,500.00	$ 1,799.94
32	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52	$ 4,500.00	$ 1,747.52
33	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62	$ 4,500.00	$ 1,696.62
34	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20	$ 4,500.00	$ 1,647.20
35	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73	$ 34,500.00	$ 12,260.73
36	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65	$ 4,500.00	$ 1,552.65
37	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42	$ 4,500.00	$ 1,507.42
38	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52	$ 4,500.00	$ 1,463.52
39	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89	$ 4,500.00	$ 1,420.89
40	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21	$ 34,500.00	$ 10,576.21
41	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33	$ 4,500.00	$ 1,339.33
42	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32	$ 4,500.00	$ 1,300.32
43	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44	$ 4,500.00	$ 1,262.44
44	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67	$ 4,500.00	$ 1,225.67
45	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13	$ 34,500.00	$ 9,123.13
46	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31	$ 4,500.00	$ 1,155.31
47	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66	$ 4,500.00	$ 1,121.66
48	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99	$ 4,500.00	$ 1,088.99
49	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28	$ 4,500.00	$ 1,057.28
50	$ 2,500.00	$ 8,000.00	$ 2,000.00	$ 30,000.00	$ 200,000.00	$ 2,500,000.00	$ 2,534,500.00	$ 578,137.39	$ 2,534,500.00	$ 578,137.39	$ 242,500.00	$ 55,315.97	$ 34,500.00	$ 7,869.69	$ 242,500.00	$ 55,315.97	$ 242,500.00	$ 55,315.97
51	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58	$ 4,500.00	$ 996.58
52	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56	$ 4,500.00	$ 967.56
53	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38	$ 4,500.00	$ 939.38
54	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02	$ 4,500.00	$ 912.02
55	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47	$ 34,500.00	$ 6,788.47
56	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66	$ 4,500.00	$ 859.66
57	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62	$ 4,500.00	$ 834.62
58	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31	$ 4,500.00	$ 810.31
59	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71	$ 4,500.00	$ 786.71
60	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79	$ 34,500.00	$ 5,855.79
61	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55	$ 4,500.00	$ 741.55
62	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95	$ 4,500.00	$ 719.95
63	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98	$ 4,500.00	$ 698.98
64	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63	$ 4,500.00	$ 678.63
65	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26	$ 34,500.00	$ 5,051.26
66	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67	$ 4,500.00	$ 639.67
67	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04	$ 4,500.00	$ 621.04
68	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95	$ 4,500.00	$ 602.95
69	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39	$ 4,500.00	$ 585.39
70	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26	$ 34,500.00	$ 4,357.26

71	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78	$ 4,500.00	$ 551.78
72	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71	$ 4,500.00	$ 535.71
73	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11	$ 4,500.00	$ 520.11
74	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96	$ 4,500.00	$ 504.96
75	$ 2,500.00	$ 8,000.00	$ 2,000.00	$ 30,000.00	$ 200,000.00	$ -	$ 34,500.00	$ 3,758.61	$ 34,500.00	$ 3,758.61	$ 242,500.00	$ 26,419.21	$ 34,500.00	$ 3,758.61	$ 242,500.00	$ 26,419.21	$ 242,500.00	$ 26,419.21				
76	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97	$ 4,500.00	$ 475.97
77	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11	$ 4,500.00	$ 462.11
78	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65	$ 4,500.00	$ 448.65
79	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58	$ 4,500.00	$ 435.58
80	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21	$ 34,500.00	$ 3,242.21
81	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58	$ 4,500.00	$ 410.58
82	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62	$ 4,500.00	$ 398.62
83	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01	$ 4,500.00	$ 387.01
84	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74	$ 4,500.00	$ 375.74
85	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76	$ 34,500.00	$ 2,796.76
86	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17	$ 4,500.00	$ 354.17
87	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85	$ 4,500.00	$ 343.85
88	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84	$ 4,500.00	$ 333.84
89	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12	$ 4,500.00	$ 324.12
90	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51	$ 34,500.00	$ 2,412.51
91	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51	$ 4,500.00	$ 305.51
92	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61	$ 4,500.00	$ 296.61
93	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97	$ 4,500.00	$ 287.97
94	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58	$ 4,500.00	$ 279.58
95	$ 2,500.00	$ -	$ 2,000.00	$ 30,000.00	$ -	$ -	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05	$ 34,500.00	$ 2,081.05
96	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54	$ 4,500.00	$ 263.54
97	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86	$ 4,500.00	$ 255.86
98	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41	$ 4,500.00	$ 248.41
99	$ 2,500.00	$ -	$ 2,000.00	$ -	$ -	$ -	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17	$ 4,500.00	$ 241.17
100	$ 2,500.00	$ 8,000.00	$ 2,000.00	$ 30,000.00	$ 200,000.00	$ -	$ 34,500.00	$ 1,795.13	$ 34,500.00	$ 1,795.13	$ 242,500.00	$ 12,617.96	$ 34,500.00	$ 1,795.13	$ 242,500.00	$ 12,617.96	$ 242,500.00	$ 12,617.96				
						TOTAL	**Alt #1 Total**	**$ 902,465.99**	**Alt #2 Total**	**$ 902,465.99**	**Alt #3 Total**	**$ 512,469.96**	**Alt #4 Total**	**$ 332,198.29**	**Alt #5 Total**	**$ 512,469.96**	**Alt #6 Total**	**$ 512,469.96**			

THE CORPORATION OF THE CITY OF VAUGHAN

CORPORATE POLICY

POLICY TITLE: **MUNICIPAL NON-CONVENTIONAL STORMWATER MANAGEMENT FACILITIES POLICY**

POLICY NO.: 08.C.03

Section:	Development & Planning		
Effective Date:	June 5, 2024	**Date of Last Review:**	Click or tap to enter a date.
Approval Authority: Council		**Policy Owner:** DCM, Infrastructure Development	

POLICY STATEMENT

It is the policy of the City of Vaughan to consider and approve Non-Conventional stormwater management facilities (SWMFs), where feasible and where they will contribute positively to the surrounding community. This policy establishes the framework for evaluating, accepting, and implementing Non-Conventional SWMFs on land to become municipally owned.

PURPOSE

The purpose of this policy is to ensure a clear and transparent decision-making process for evaluation and implementation of Non-Conventional SWMFs. The intention of this policy is to provide City of Vaughan staff and the development community with a transparent process for evaluation, acceptance, and implementation of these facilities.

The objectives of this policy are to:

- Provide guiding principles to define when Non-Conventional SWMFs may be considered for integration with blocks that have already defined land uses (e.g., parks and rights-of-way), and when Non-Conventional SWMFs should not be used.
- Define the applicable criteria for acceptance and implementation of these facilities, and development of standard drawings and a list of City accepted technologies.
- Provide a cost-recovery formula to establish an Offset Fee for the increased inspections, operations and maintenance costs of Non-Conventional SWMFs (including any pre-treatment facilities).

SCOPE

This policy applies to all parties involved in the planning, design, acceptance, implementation, operations, maintenance, rehabilitation, and replacement (where applicable) of Non-Conventional SWMFs intended for municipal ownership and operation, assumed through land development processes. This policy shall be revisited on an as-needed basis.

The approval of these facilities and acceptance of the Offset Fee is the responsibility of the City Manager of the City of Vaughan and/or their delegate acting on their behalf.

LEGISLATIVE REQUIREMENTS

1. Planning Act, R.S.O. 1990, c P.13
2. Places to Grow Act, 2005, S.O. 2003, c. 13
3. Bill 23, More Homes Built Faster Act, 2022, S.O, 2022, c. 21
4. Ontario Water Resources Act, R.S.O. 1990, c. O.40
5. Clean Water Act, 2006, S.O. 2006, c. 22
6. Environmental Protection Act. R.S.O. 1990, c. E.19

DEFINITIONS

1. **City:** The Corporation of the City of Vaughan, including all departments, employees, and administrative divisions.
2. **Clean Condition:** Without visual accumulation of sediment or debris.
3. **CLI-ECA**: The City of Vaughan's Consolidated Linear Infrastructure Environmental Compliance Approval.
4. **Conventional SWMF:** End-of-pipe stormwater management practice limited to a wet or dry Stormwater Management Pond to provide water quantity control and/or quality treatment, and/or erosion control of tributary area runoff.
5. **Council:** Council of the City of Vaughan.
6. **Development Application (or Development)**: Proposal put forward by a Landowner to the City for review and decision, pertaining to a change of land use, construction of a new building, or the creation of a parcel of land, as governed under the *Planning Act*. The applicable types of Development Applications which only apply to this procedure are Block Plan, Secondary Plan, Official Plan Amendment, Zoning By-law Amendment, and Draft Plan of Subdivision.
7. **Greenfield Development:** The development of a property, site, or area on undeveloped land in an urban or rural area.
8. **Infill Development:** The development or redevelopment of a property, site, or area with a new development at a higher density or building height than is currently permitted by the Official Plan within an area that is already developed.
9. **Initial Submission**: The stage of a Development Application process whereby an applicant submits documents for the first time to the City for staff review.

10. **Landowner:** The party who owns the property or is the representative of the party who owns the land.
11. **LID:** Low Impact Development
12. **Manufactured Treatment Devices (MTD's):** Devices used to target the treatment and removal of pollutants from stormwater runoff from development sites, to achieve regulatory water quality objectives.
13. **Non-Conventional SWMF:** All end-of-pipe stormwater management facilities outside the Conventional SWMF, as defined above, that are designed to provide quantity control and extended detention.
14. **O&M:** Operations and Maintenance
15. **Offset Fee:** A one-time cost contribution to be paid by the Landowner to the City for the implementation of the Non-Conventional SWMF to compensate for any increase in cost when compared to a conventional SWMF, calculated by a formula. Is the differential between the calculated fees for a Conventional and Non-Conventional Facility. Inspection/Monitoring Costs + Maintenance Costs=offset fee.
16. **OGS:** Oil-Grit Separator. Is considered a facility that will provide pre-treatment prior to runoff entering the Non-Conventional SWMF.
17. **PEO:** Professional Engineers Ontario
18. **Permanent Pool:** A volume of water that is retained within a conventional SWM facility to provide for the settling and dilution of sediments and pollutants; provides water quality control.
19. **Pre-treatment:** Treatment of stormwater upstream of/prior to entering the quantity control/extended detention area of a Non-Conventional SWMF or a Conventional SWMF via a single or multiple measures in series. Facilities do not require confined space entry for maintenance. This single or treatment train provides the removal of sediment.
20. **Qualified Engineer:** Licensed Professional Engineer, licensed to practice in Ontario, and competent to practice in the specified engineering discipline.
21. **Qualified Engineer of Record**: Licensed Professional Engineer who has sealed any submitted drawings or reports.
22. **ROW:** Right-of-way
23. **Sealed:** Documents that have been stamped using the rubber stamp/impression of the rubber stamp issued by Professional Engineers Ontario (PEO) to all license holders. The seal (or stamp) identifies the Engineer taking personal and professional responsibility for the content of the documents. The seal must be signed and dated by the license holder.
24. **SWMF:** Stormwater Management Facility
25. **Treatment Train Approach:** Providing stormwater treatment first, at the lot level, then in conveyance, followed by "end-of pipe" (where stormwater gets discharged). A treatment train is required to meet the multiple objectives of water balance, water quality, erosion control and flood control in an overall stormwater management strategy.

POLICY

General Considerations

1.1. Non-Conventional SWMFs may be considered for both greenfield and intensification/infill developments if sufficient design information is provided to show that implementation of a Non-Conventional SWMF is possible, and a Non-Conventional SWMF Justification Report is provided to and reviewed by the Development Planning Department and the Development Engineering Department and accepted by the City.

1.2. A Stormwater Management solution applying the use of a Non-Conventional SWMF, as required through the development process, may be accepted by the City if:

1.2.1. The draft plan has been developed and accepted by the City with the intent that a Non-Conventional SWMF will be implemented as the stormwater solution.

1.2.2. Justification is presented within a Non-Conventional SWMF Justification Report, prepared by a licensed Qualified Engineer, which provides sufficient evidence a Non-Conventional SWMF can be implemented while remaining in conformance with applicable City of Vaughan, York Region and Provincial legislation, by-laws (as amended or superseded), policies, and design criteria. The Non-Conventional SWMF Justification Report shall: i) identify the conceptual design of the proposed Non-Conventional SWMF; ii) In accordance with the considerations of the Vaughan Official plan, document the social, environmental, and economic benefits, impacts, and long-term O&M requirements and high-level maintenance costs of the proposed facility; and iii) be submitted to the City for review and acceptance at the Initial Submission of the development process, which may include but is not limited to a Master Environmental Servicing Plan, Block Plan, Secondary Plan, Official Plan Amendment/Zoning By-law Amendment or Draft Plan of Subdivision. The City may retain a qualified external Peer Reviewer to assist with technical review as needed, to be paid for by the Landowner.

1.2.3. The proposed Non-Conventional SWMF, as an end of pipe control, is a part of a treatment train approach which will include source and conveyance controls in series through MTD's and/or LID techniques, where applicable.

1.2.4. The proposed Non-Conventional SWMF adheres to the City's list of accepted SWM practices and technologies outlined in the Non-

Conventional SWMF Criteria, as well as MECP's Stormwater Management Planning and Design guidelines, outlined in the Design Criteria for Non-Conventional SWMFs.

1.2.5. Frequent inspections and maintenance (such as sediment removal from pre-treatment facilities and visual inspections) shall not require confined space entry and shall use conventional equipment such as vacuum and flushing trucks.

1.2.6. Major concrete rehabilitation (25 year interval) and structural inspection is permitted to require confined space entry.

1.2.7. The proposed Non-Conventional SWMF (both plastic and concrete) adheres to applicable CSA standards and/or be approved by the City's Products and Standards committee, as outlined in the Non-Conventional SWMF Criteria.

1.3. Non-Conventional SWMFs may be considered within parkland, open space, and proposed road ROW's if supporting documentation can demonstrate that the proposed facility is not in conflict with proposed surface features and functions, underground services and utilities, and planned park programming. Frequent inspections, operations and maintenance of the proposed facility shall not conflict with planned City programming, operations, and maintenance. Traffic considerations for application in road ROWs shall be provided in the Operations & Maintenance manual. Major maintenance, rehabilitation or replacement of Non-Conventional SWMFs, resulting in disruption to park programming, operations and maintenance, shall be on an infrequent basis. All the above must be confirmed for detailed design acceptance and municipal assumption.

2. Technical Considerations

2.1. A Stormwater Management solution applying use of Non-Conventional SWMF may be accepted by the City if:

2.1.1. The proposed solution, defined in the detailed Stormwater Management Report, achieves all required water quantity, water quality, water balance and erosion control targets for the development, as defined by City of Vaughan's Engineering Design Criteria and Standards and the 2003 MECP Stormwater Management Planning and Design Manual. The proposed Non-Conventional SWMF shall only be used for water quantity control and extended detention and shall not be used for water balance controls. Water quality treatment may be provided by separator/isolator rows, and any additional measures required to

meet 80% TSS removal. Pre-treatment is required to meet those criteria, as described below in Section 2.1.2. Water quality and water balance shall be achieved by employing a Treatment Train approach.

2.1.2. The proposed solution provides pre-treatment of captured runoff through a Treatment Train approach that may include the use of LID measures, OGS Units, pre-treatment cells (such as isolator/separator rows), or other acceptable technology by the City prior to discharging to the Non-Conventional SWMF. Stormwater shall be pre-treated to a minimum of 80% total suspended solids (TSS) removal, using a particle size distribution defined by City standards, prior to discharging to the quantity control portion of the Non-Conventional SWMF. All pre-treatment measures shall be easily maintained by the City and must not require confined space entry (except for major maintenance events as detailed in Section 1.2.5). The implementation of treatment measures to achieve water quality targets for the subject development located downstream of the Non-Conventional SWMF will not be accepted.

2.1.3. Non-Conventional SWMFs that provide infiltration will not be accepted.

2.1.4. Non-Conventional SWMFs with a permanent pool will not be accepted.

2.1.5. All Non-Conventional SWMFs shall be gravity draining. Any Non-Conventional SWMFs requiring pumping to drain the facility will not be accepted.

2.1.6. An O&M Manual for the proposed Non-Conventional SWMF and any pre-treatment systems is required for review and acceptance by the City. The O&M Manual shall include at a minimum, the requirements for inspections and monitoring, sediment loading estimates, and an Offset Fee assessment for the proposed stormwater infrastructure, all of which shall be completed based on a 50 year time period, according to the City's Procedures, Standards and Design Criteria for Non-Conventional SWMFs. The manual shall also specify staging areas for anticipated maintenance operations to ensure park accessibility and right-of-way functionality during maintenance.

2.1.7. The design of Non-Conventional SWMF must adhere to the requirements outlined in the City's Criteria and Standards, CLI-ECA, other applicable Environmental Compliance Approvals, or other legislative requirements.

3. Parkland Considerations

3.1. Provisions of parkland credits for dual-use park/Non-Conventional SWMF may be considered through application of criteria contained within the Parkland Dedication By-Law 168-2022, as amended, or superseded.

3.2. To receive Parkland Dedication, the design of dual-use park block with proposed park space above a Non-Conventional SWMF must meet the following requirements.

3.2.1. The SWMF does not impact the City's ability and obligation for park space or ability to include active and/or passive programming of the park space. The SWMF must not inhibit the park from being permit-ready for any programming.

3.2.2. The SWMF does not prohibit or restrict public programming.

3.2.3. The park space must be open and accessible to the public at all times and will not be out of use as a result of frequent operations and maintenance of the Non-Conventional SWMF, with the exception of areas identified for staging requirements, as described in the Operations and Maintenance Manual.

3.2.4. The park space and SWMF is designed, developed, and maintained to City standards.

3.2.5. The park space meets applicable criteria in the City's Official Plan and Secondary Plan.

3.2.6. The design of the Non-Conventional SWMF will be based on Park needs (e.g., the location of the SWMF), stormwater management criteria and City of Vaughan Engineering design criteria.

3.2.7. As a result of the Non-Conventional SWMF design, lands will not be encumbered with poor drainage, erosion issues or extreme slopes.

3.2.8. Design SWMF, landscaping and park feature placements are to consider future rehabilitation/major maintenance requirements to minimize mature tree removal in the future.

3.3. The design of Non-Conventional SWMFs located below proposed parkland blocks shall comply with the technical design requirements defined in the City's Park's Design Criteria and Criteria and Standards for Non-Conventional SWMFs, including but not limited to, minimum facility cover depth, static and dynamic loading conditions, and access requirements.

3.4. To be accepted as programmed park space, frequent inspections, operations, and maintenance of the proposed SWMF shall not conflict with, prohibit, or restrict planned park programming, operations, and maintenance. Major maintenance, rehabilitation, or replacement of Non-Conventional SWMFs, resulting in disruption to park programming, operations, and maintenance, may be accepted on an infrequent (>25 year period) basis. Accessibility to the park by the public will not be infringed on by frequent operations and maintenance of the Non-Conventional SWMF, with the exception of staging areas identified in the Operations and Maintenance Manual.

3.5. To be accepted for parkland use, the Landowner shall agree to design and construct the park to the City's satisfaction and the Landowner shall enter into a developer build agreement with the City to design and build the Park as per Developer Build Parks Policy, No. 07.2.05.

4. Right-of-way Considerations

4.1. Implementation of Non-Conventional SWMFs within a ROW will only be accepted if they do not require modification of the total ROW width in order to accommodate the facility, and the Non-Conventional SWMF infrastructure is capable of fitting within the right-of-way without infringing on other existing or planned services within the ROW.

4.2. The design of Non-Conventional SWMFs located within City of Vaughan ROW shall achieve the required separation and offsets from other municipal infrastructure and servicing, as outlined in the MECP Stormwater Management Planning and Design Manual, March 2003, City of Vaughan's most current Engineering Design Criteria, Standard Drawings, and Criteria for Non-Conventional SWMFs.

4.3. Major operations, maintenance, or rehabilitation to the Non-Conventional SWMF, resulting in disruption to traffic may be accepted on an infrequent basis (>25 year period). In anticipation of major maintenance, traffic considerations and construction staging considerations, using current traffic considerations, shall be included in the Operations & Maintenance Manual for the facility.

4.4. The design shall consider placement of inspection ports/access manholes/clean out access locations that will minimize impacts to traffic during frequent inspections and maintenance.

4.5. To be accepted by the City, the Landowner agrees to design and construct the facility within the ROW to the satisfaction of the City.

5. Operations and Maintenance

5.1. An O&M Manual for all components of the Stormwater Management solution that are to be assumed by the City, including pre-treatment units or measures and the Non-Conventional SWMF, shall be provided to the City for review and acceptance. The O&M Manual shall detail the required operation and maintenance procedures/efforts, required equipment/certifications, maintenance frequency on all related infrastructure, and associated costs. In addition, the O&M Manual shall include the following:

5.1.1. Maintenance frequency of the facility, which shall be provided based on the sediment loading rate from the development.

5.1.2. Detailed breakdown of the procedure, effort, equipment, and cost for each inspection / maintenance item for the entire Stormwater Management Solution.

5.1.3. A list of equipment required to complete the required inspection and maintenance, as well as any required certifications for staff completing both frequent and infrequent inspections and maintenance (e.g. confined space entry).

5.1.4. Maintenance procedures with a high disruption level to the public must be highlighted during the preparation of this manual and considered during the development of the annual O&M costs.

5.1.5. Frequent inspections and maintenance (such as sediment removal from pre-treatment) must not require confined space entry; must be completed using conventional equipment such as vacuum and flushing trucks; shall minimize disruption to the public; and shall be completed from hard surfaces to eliminate restoration costs.

5.1.6. Major maintenance or rehabilitation of Non-Conventional SWMFs requiring confined space entry and resulting in disruption to park programming, operations, and maintenance, shall be assumed to be on a basis of >25 year period for concrete SWMFs, and > 50 year period for plastic SWMFs. The O&M Manual shall delineate the area of disturbance.

5.1.7. Any additional information requested by the City related to operations, maintenance, rehabilitation, and replacement is to be provided by the Landowner.

5.2. Any additional cost to the City of the proposed Non-Conventional SWMF over a 50 year time period shall be determined with consideration of the following:

5.2.1. The Landowner shall provide a 25-year Manufacturer's extended warranty on SWMFs. In the event that a warranty cannot be provided, the City will require the Landowner to provide a rehabilitation fee as a component of the maintenance cost in the Offset Fee.

5.2.2. Costs are to be compared (Inspection/Monitoring Costs + Maintenance Costs= the offset fee costs) between a Conventional SWMF of equal volume and/or function to assess any increased costs associated with implementation of the Non-Conventional SWMF (if applicable).

5.3. The Landowner shall demonstrate, through the completion of a minimum three-year monitoring and reporting program to the satisfaction of the City and Schedule E of the CLI-ECA policy, that the Non-Conventional SWMF and all other stormwater management systems, are functioning as designed.

6. Cost-Recovery

6.1. As part of assumption, the Landowner shall provide a one-time cost contribution in present value to the City for the implementation of the Non-Conventional SWMF to compensate for any increase in cost when compared to a Conventional SWMF. The value of the cost contribution shall be calculated using the City's standardized financial formula.

6.1.1. This Offset Fee will be calculated as a component of the O&M Manual for acceptance by the City.

6.1.2. The Maintenance cost component of the Offset Fee shall include costs associated with removing and/or replacing SWM infrastructure, park assets and removal/replacement of trees located above underground facilities that require repair and/or replacement.

6.1.3. The Landowner shall provide a 25-year Manufacturer's extended warranty on SWMFs. In the event that a warranty cannot be provided, the City will require the Landowner to provide a rehabilitation fee as a component of the maintenance cost in the Offset Fee. Any such warranty must be provided in a legally binding agreement acceptable to the City solicitor.

7. Assumption

7.1. Prior to assumption, the Landowner shall prove, using CCTV, or other methods to the satisfaction of the City, structural stability of the Non-Conventional SWMF including a certificate of conformance from a Qualified Engineer; confirmation that the Non-Conventional SWMF (including all pre-treatment facilities) is provided to the City in clean condition (no sediment or debris is present); is operating as designed; has been maintained as specified by the O&M Manual; and has met all other requirements for assumption per the Subdivision Agreement (if applicable).

7.2. Prior to assumption, the Landowner shall provide record drawings for the Non-Conventional SWMF, sealed by the Qualified Engineer of Record, certifying that construction was carried out as per the accepted design. Record drawings are to be in accordance with the PEO's guidance document on Preparing As Built and Record Documents.

7.3. If the City is responsible for implementation of the Park features after assumption, the Landowner shall be responsible for any additional costs, outside of standard development charges, caused by the Non-Conventional SWMF. Costs shall be documented through the cost estimate prepared for park construction, and will be compared to the approved Park's budget, per the Developer Build Parks Policy No. 07.2.05.

ADMINISTRATION

Administered by the Office of the City Clerk.

Review Schedule:	SELECT If other, specify here	**Next Review Date:**	Click or tap to enter a date.
Related Policy(ies):			
Related By-Law(s):			
Procedural Document:			

Revision History	
Date:	**Description:**
Click or tap to enter a date.	

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Click or tap to enter a date.	

THE CORPORATION OF THE CITY OF VAUGHAN

CORPORATE PROCEDURE

PROCEDURE TITLE: MUNICIPAL NON-CONVENTIONAL STORMWATER MANAGEMENT FACILITIES ACCEPTANCE PROCEDURE

PROCEDURE NO.: Procedure number to be assigned by Policy Coordinator.

Section:	Development & Planning		
Effective Date:	June 5, 2024	**Date of Last Review:**	Click or tap to enter a date.
Policy Parent: MUNICIPAL NON-CONVENTIONAL STORMWATER MANAGEMENT FACILITIES POLICY		**Procedure Owner:** **DCM, Infrastructure Development**	

PROCEDURE STATEMENT

The City's acceptance process for Non-Conventional Stormwater Management facilities (SWMFs) is a comprehensive guidance document that can be used by City Staff for the review, acceptance, and implementation of Non-Conventional SWMFs within land intended for municipal ownership, in support of development planning applications.

PURPOSE

The purpose of this procedure is to outline requirements for the evaluation, approval, and feasible implementation of Non-Conventional SWMFs.

The objectives of this procedure are to:

1. Establish a transparent process for internal and external stakeholders to evaluate acceptable Non-Conventional SWMF requests.
2. Establish a method for financial impact assessments, to accurately determine an Offset Fee.
3. Ensure the long-term financial viability of Non-Conventional Stormwater Management Facilities.
4. Define where Non-Conventional SWMFs can and cannot be integrated within City parkland and right-of-ways.

PROCEDURE TITLE: MUNICIPAL NON-CONVENTIONAL STORMWATER MANAGEMENT FACILITIES ACCEPTANCE PROCEDURE

PROCEDURE NO.: Procedure number assigned by Policy Coordinator.

SCOPE

This procedure document replaces the existing guidance found in the *City Interim Approach on Non-Conventional Stormwater Management Infrastructure* procedure.

This procedure applies to internal and external stakeholders involved in the design, acceptance, implementation, and operation/maintenance of municipally owned and operated Non-Conventional SWMFs, assumed through the land development process for Development Applications which may include but are not limited to Block Plan, Secondary Plan, Official Plan Amendment, Zoning By-law Amendment, and Draft Plan of Subdivision.

The acceptance of these facilities and confirmation of the Offset Fee(s) is the responsibility of the City Manager of the City of Vaughan and/or their delegate acting on their behalf.

LEGISLATIVE REQUIREMENTS

1. Planning Act, R.S.O. 1990, c P.13
2. Places to Grow Act, 2005, S.O. 2003, c. 13
3. Bill 23, More Homes Built Faster Act, 2022, S.O, 2022, c. 21
4. Ontario Water Resources Act, R.S.O. 1990, c. O.40
5. Clean Water Act, 2006, S.O. 2006, c. 22
6. Environmental Protection Act. R.S.O. 1990, c. E.19

DEFINITIONS

1. Definitions

1. **City:** The Corporation of the City of Vaughan, including all departments, employees, and administrative divisions.
2. **Clean Condition:** Without visual accumulation of sediment or debris.
3. **CLI-ECA:** Consolidated Linear Infrastructure Environmental Compliance Approval.
4. **Conventional SWMF:** End-of-pipe stormwater management practice consisting of a wet or dry Stormwater Management Pond to provide water quantity control and/or water quality treatment, and/or erosion control of tributary area runoff.
5. **Council:** Council of the City of Vaughan.
6. **Development Application (or Development)** Proposal put forward by a Landowner to the City for review and decision, pertaining to a change of land

use, construction of a new building, or the creation of a parcel of land, as governed under the *Planning Act*. The applicable types of Development Applications which apply to this procedure may include but are not limited to Block Plan, Secondary Plan, Official Plan Amendment, Zoning By-law Amendment, and Draft Plan of Subdivision.

7. **Greenfield Development:** The development of a property, site, or area on undeveloped land in an urban or rural area.
8. **Infill Development:** The development or redevelopment of a vacant, underutilized, or previously developed property, site, or area where the surrounding area is already developed.
9. **Infrastructure:** Physical assets developed and used by a municipality to support its social, cultural, and economic services (Source: FCM, 2017)
10. **Initial Submission:** The stage of a Development Application process whereby an applicant submits documents for the first time to the City for staff review.
11. **Landowner:** The party who owns the property or is the representative of the party who owns the land.
12. **LID:** Low Impact Development.
13. **Offset Fee:** A one-time cost contribution to be paid by the Landowner to the City for the implementation of the Non-Conventional SWMF to compensate for any increase in cost when compared to a conventional SWMF, calculated by a formula. Is the differential between the calculated fees for a Conventional and Non-Conventional Facility. Inspection/Monitoring Costs + Maintenance Costs=offset fee.
14.
15. **Manufactured Treatment Devices (MTD's):** Devices used to target the treatment and removal of pollutants from stormwater runoff from development sites, to achieve regulatory water quality objectives.
16. **Non-Conventional SWMF:** All end-of-pipe stormwater management facilities outside the Conventional SWMF, as defined above, that are designed to provide quantity control and extended detention.
17. **O&M:** Operations and Maintenance.
18. **OGS:** Oil-Grit Separator.
19. **Park Recreation Facility:** A public facility designed and equipped for the conduct of sports, leisure activities, and other customary and usual recreation activities, used by the public for active and/or passive recreation.
20. **Permanent Pool:** A volume of water that is retained within a conventional SWMF to provide for the settling and dilution of sediments and pollutants; provides water quality control.
21. **Pre-treatment:** treatment of stormwater upstream of/prior to entering the quantity control area of a Non-Conventional SWMF or a Conventional SWMF via a single or multiple measures in series. Facilities do not require confined space entry for maintenance. This single or treatment train provides the removal of large to micro size debris.

22. **Qualified Engineer:** Licensed Professional Engineer, licensed to practice in Ontario, and competent to practice in a specified engineering discipline.
23. **Qualified Engineer of Record**: Licensed Professional Engineer who has sealed any submitted drawings or reports.
24. **ROW**: Right-of-way.
25. **Sealed:** Documents that have been stamped using the rubber stamp/impression of the rubber stamp issued by Professional Engineers Ontario (PEO) to all license holders. The seal (or stamp) identifies the Engineer taking personal and professional responsibility for the content of the documents. The seal must be signed and dated by the license holder.
26. **SWMF**: Stormwater Management Facility.
27. **Treatment Train Approach:** Providing stormwater treatment first, at the lot level, then in conveyance, followed by "end-of pipe" (where stormwater gets discharged). A treatment train is required to meet the multiple objectives of water balance, water quality, erosion control and flood control in an overall stormwater management strategy.

PROCEDURE

The following steps provide comprehensive guidance and information on the review of acceptable Non-Conventional SWMFs proposed as part of a Development Application. Refer to appended flow charts and checklists for each step for additional guidance on this process.

1. Procedural Steps

1.1. Step 1: Initial Submission

1.1.1. Non-Conventional SWMF Justification Report

i. A Non-Conventional SWMF Justification Report must be submitted by the Landowner to the City for review and acceptance, at the initial stages of the development process, which may include but is not limited to the submission of a Master Environmental Servicing Plan, Block Plan, Secondary Plan, or Official Plan Amendment/Zoning By-law Amendment. However, if possible, intent to use a Non-Conventional SWMF should be identified as soon as possible in the development process, prior to any formal submissions as listed above, during any pre-consultation with the City. The Non-Conventional SWMF Justification Report must clearly demonstrate the benefits to the City of implementing a Non-Conventional SWMF solution compared to a Conventional SWMF. The Non-Conventional SWMF Justification Report must be reviewed and accepted by the City prior to proceeding to a

Technical Report to the Committee of the Whole.

ii. At the discretion of the Director of Development Engineering of the City of Vaughan and/or their delegate acting on their behalf, submitted Non-Conventional SWMF Justification Reports may be subject to an external peer review, with costs to be paid for by the Landowner. The option to undertake an external peer review will be on a case-by-case basis, based on factors including but not limited to the size and type of the Non-Conventional SWMF, the complexity of its incorporation into the proposed development, and availability of City resources.

iii. The Non-Conventional SWMF Justification Report must, at minimum, meet the following requirements:

- Must be prepared and sealed by a Qualified Engineer.
- Must provide sufficient evidence that the Non-Conventional SWMF can be implemented to meet SWM criteria for the site, without infringing on other design criteria or site-specific constraints.
- Must identify the conceptual design of the proposed Non-Conventional SWMF, including but not limited to, the proposed location and functions over the Non-Conventional SWMF, surface grades, sub-surface infrastructure elevations, outlet elevations, potential impacts to natural heritage, and overview of existing underground utilities.
- Must provide overview of existing site-specific conditions such as soil type and group, existing topography, and any known groundwater concerns or historical groundwater data, to be later confirmed through Geotechnical and/or Hydrogeological Investigations to ensure adequate subsurface conditions for the conceptual design.
- Must document the social, environmental, and economic benefits of implementing a Non-Conventional SWMF within the development, as well as any potential impacts to above ground programming; and,
- Must provide a high-level overview of the anticipated operation and maintenance (O&M) requirements to maintain the facility, including the equipment required.

1.1.2. Financial Compensation Consideration

To be included in the Non-Conventional SWMF Justification Report, an estimate of the required financial compensation for implementation of the Non-Conventional SWMF must be prepared for the City, including the estimated Offset fee costs of the facility over a 50-year period.

Refer to **Appendix 1** for the Initial Submission Flow Chart and Checklist for additional guidance.

1.2. Step 2: Draft Plan of Subdivision Submission / Functional Servicing

1.2.1. Coordination of Park Requirements

i. Where Non-Conventional SWMFs are proposed under a park, coordination is required between the City of Vaughan Parks Infrastructure Planning and Development Department and the Landowner to identify the required features and programming that should be protected for during design of the Non-Conventional SWMF. This coordination should take place prior to City staff bringing forward a Technical Report to the Committee of the Whole for the proposed Draft Plan of Subdivision.

ii. The City of Vaughan Parks Infrastructure Planning and Development shall provide direction to the Landowner as to the needs of the park block, based on location, demographic, and the size of the proposed park block, as guided by existing City Policies, any relevant Master Plans, and existing City Guidelines.

iii. The Landowner is to reference the City's Parks Design Criteria for Non-Conventional SWMF to ensure all applicable criteria are achieved, including but not limited to, minimum cover depth, offset distances, static and dynamic loads, access requirements, etc.

iv. Prior to City Staff bringing forward a Technical Report to the Committee of the Whole, the Landowner is required to indicate if their intentions are to achieve full Parkland Dedication of the parkland location above the Non-Conventional SWMF. The Landowner must illustrate; that all criteria to achieve full Parkland Dedication is met and in accordance with By-Law-168-2022, as amended or superseded; that park criteria can be met based on the proposed park block; and that the proposed Non-Conventional SWMF, inclusive of maintenance, will not impact the intended function of the park and park recreation facilities.

v. Parkland dedication credit continues to be determined and issued by the Parks Infrastructure Planning and Development Department through By-Law-168-2022, as amended or superseded.

1.2.2. City Acceptance of Stormwater Management Strategy & Non-Conventional SWMF Technology

i. At this stage, the Landowner shall determine whether the proposed Non-Conventional SWMF meets the requirements of Schedule D in the CLI-ECA and is therefore qualified for pre-authorization.

ii. Review of the overall SWM scheme for the proposed development is to be completed in accordance with the City of Vaughan's standard engineering review process, ensuring that all control targets are achieved by the stormwater infrastructure proposed for the development. The Functional Servicing Report (FSR) submitted to the City for review and acceptance shall include details on the Non-Conventional SWMF proposed for the development site. City Staff shall be in general agreement with the overall SWM scheme prior to bringing a Technical Report to the Committee of the Whole for the Draft Plan of Subdivision.

iii. The City shall consider the proposed Non-Conventional SWMF to achieve only the water quantity control and erosion control through extended detention targets for the development. Water quality control and water balance targets must be achieved by SWM infrastructure provided independently from and upstream of the Non-Conventional SWMF for the overall SWM scheme to be accepted by the City. An 'Isolator' and 'Separator' Row type pre-treatment at the inlet of the Non-Conventional SWMF, in combination with other upstream pre-treatment for water quality controls, is acceptable to achieve the required 80% TSS removal.

iv. A Treatment Train approach upstream of a Non-Conventional SWMF for quality control is required prior to discharging runoff into the Non-Conventional SWMF. The implementation of treatment measures located downstream of the Non-Conventional SWMF will not be accepted by the City.

v. Captured runoff must be pre-treated to a minimum 80% TSS removal prior to entering the main cell of the Non-Conventional SWMF, using the ETV Canada particle size distribution, or as defined by current City standards, whichever is more stringent. All pre-treatment measures must be easily maintained by City staff and must not require confined space entry. Infrastructure considered acceptable by the City for treatment train implementation include:

- LID Measures;
- OGS Units; and

- Pre-Treatment Cells (isolator/separator row).

vi. The following information related to the proposed Non-Conventional SWMF must be included within the FSR / Draft Plan of Subdivision Submission for the City's review and acceptance prior to City staff bringing forward a Technical Report to the Committee of the Whole:

- Location of the proposed facility, including justification for the selected location (i.e., in parkland, open space, ROW, etc.). The FSR must confirm that there is no conflict with proposed surface features, underground utilities, and planned park programming;
- Confirmation that the proposed volume of the facility meets the defined targets for water quantity control and extended detention, including preliminary design of any proposed flow control structure(s);
- Confirmation that the proposed water quality control strategy adheres to the specified TSS removal rate prior to runoff entering the quantity control component of the Non-Conventional SWMF;
- Confirmation that all retention requirements are satisfied independently from and upstream of the Non-Conventional SWMF;
- Supporting Geotechnical and Hydrogeological Investigations to demonstrate adequate conditions for the Non-Conventional SWMF and the upstream Treatment Train facilities.
- Preliminary grading above the facility, and facility access locations to confirm adequate O&M access for City crews;
- All supporting calculations and/or models for the design of the Non-Conventional SWMF; and
- Outlet controls must be of gravity type. No pumping will be accepted.

vii. A list of City of Vaughan Acceptable Technologies for Non-Conventional SWMFs is available within the City of Vaughan Engineering Standard Criteria for Non-Conventional SWMF. The proposed technology for the subject development must adhere to these standards.

viii. The Landowner is to indicate their intent to provide a 25 year Manufacturer's extended warranty on concrete SWMFs. In the event that a warranty cannot be provided, the City will require the Landowner to provide a rehabilitation cost as a component of the Maintenance cost Acceptance of these warranty plans is solely at the discretion of the City and requires a legal agreement between the City and the supplier, to the satisfaction of the City Solicitor.

ix. Once the proposed Non-Conventional SWMF technology category has been accepted by Council through the acceptance of Technical Report

to the Committee of the Whole for the associated Draft Plan of Subdivision or Site Plan (i.e., Cast-In-Place Modular System, Superpipes, Plastic Arch Chamber etc.), substitution for an alternative form of technology will not be accepted. A proposed alternative to the accepted Non-Conventional SWMF technology category may require a full Draft Plan of Subdivision or Site Plan resubmission.

Refer to **Appendix 2** for the Draft Plan of Subdivision / FSR Flow Chart and Checklist for additional guidance.

1.3. Step 3: Detailed Design / Perfect Submission

1.3.1. City Acceptance of SWM Report and Design Drawings

i. Review of the detailed design of the Non-Conventional SWMF and all pre-treatment water quality measures are to be completed in accordance with the City of Vaughan's standard engineering review process. Following Draft Plan of Subdivision Approval, a detailed Stormwater Management (SWM) Report is to be submitted by the Landowner to the Development Engineering Department for review and acceptance, in addition to detailed design and shop drawings for the proposed facility prior to the execution of a Subdivision Agreement or other Development related Agreement, as applicable.

ii. The replacement or substitution of Non-Conventional SWMF technology shall not be acceptable during review of the detailed design submission. Should the Landowner propose a replacement or substitution for the proposed Non-Conventional SWMF technology or product, they may be required to resubmit a new Draft Plan of Subdivision for acceptance by Council.

iii. Landscape Plans and Park Design Drawings completed by a Landscape Architect shall be provided to the Parks Department for review and acceptance.

1.3.2. City Acceptance of Operations & Maintenance Manual for the Non-Conventional SWMF

i. An Operation and Maintenance (O&M) Manual detailing the requirements of the Non-Conventional SWMF and any pre-treatment systems that are to be assumed by the City shall be submitted by the Landowner to City of Vaughan Development Engineering Department for circulation to Environmental Services Department for review and

acceptance prior to the execution of a Subdivision or other Development related Agreement, as applicable.

ii. The O&M Manual shall detail the required operation and maintenance procedures and efforts, required equipment and certifications, the maintenance frequency on all related infrastructure, and associated costs to perform the required operation and maintenance.

iii. Maintenance procedures with a high disruption level (i.e., Multi-day operations, earth moving, ground disturbance, traffic impacts, etc.) to the public must be highlighted during the preparation of this manual and considered during development of the annual O&M costs.

iv. Frequent/regular inspection and maintenance of the Non-Conventional SWMF and pre-treatment infrastructure must not have confined space entry and shall be maintained with conventional equipment such as vacuum and flushing trucks.

v. The O&M Manual is to be prepared in accordance with the requirements of the Consolidated Linear Infrastructure Environmental Compliance Approval, or other applicable Environmental Compliance Approvals, including development and implementation of a monitoring program.

vi. At a minimum, the O&M Manual shall include:

- Maintenance procedure and frequency of the facility and treatment devices based on the sediment loading rate from the development.
- Detailed breakdown of the time, equipment required and estimated cost for each inspection/maintenance item with cost, as well as any expected disruption to surface features.
- O&M costs that include provisions for the current Regulations based removal and disposal of sediment from the Non-Conventional SWMF.

1.3.3. Offset Fee Calculation & City Acceptance

i. An Offset Fee calculation for the proposed Non-Conventional SWMF and all pre-treatment facilities is to be completed by the Landowner based on a 50 year time period. The Offset Fee calculation can be included within the O&M Manual or provided as a separate standalone document. City staff must review and accept the Offset Fee calculation prior to the registration of the Subdivision Agreement or other Development related Agreement, as applicable.

ii. The Offset Fee and calculation will be finalized and provided by the Landowner to the Development Engineering Department, prior to executing the Subdivision and/or other Development related Agreement, as applicable.

iii. The Offset Fee is included to quantify the operation and maintenance costs associated with the Non-Conventional SWMF over a time period of 50 years.

iv. The values provided must be based on the current value of the works included in the Fee.

v. The Offset Fee is calculated to determine the additional costs for operations and maintenance of the Non-Conventional SWMF (and all pre-treatment facilities) compared to a conventional SWMF of equivalent function.

vi. The Offset Fee will be composed of two components, calculated separately, over the specified time period of 50 years:

- Inspection/monitoring costs; and
- Maintenance costs.

vii. The inspection (with no confined space entry or CCTV) and monitoring cost considered in the final financial compensation formula shall be the delta between the number of inspections required for a Conventional SWMF and number of inspections required for the Non-Conventional SWMF over the specified time period of 50 years. Each pre-treatment device shall be considered to require an individual inspection. Inspection and Monitoring costs include the fees associated with routine visual inspection including inspection reporting and debris removal. The frequency of this inspection is to be completed at the frequency specified in the approved O&M manual based on recommendations from the facility supplier and/or design engineer.

viii. Maintenance costs include the fees associated with sediment removal and disposal from all components of the Non-Conventional SWMF (i.e., including OGS units, isolator/separator rows). The routine maintenance cost fee is based on the differential in cost between a Conventional and Non-Conventional SWMF for sediment removal. Sediment loading for the specified period is to be calculated based on sediment loading rates specified for various levels of imperviousness as described in the MECP

2003 Stormwater Management Planning and Design Manual.

ix. Maintenance costs shall also consider unit rates for various inspections (i.e., Confined space entry) and maintenance procedures which are available within the City of Vaughan Engineering Standard Criteria for Non-Conventional SWMF. The maintenance cost is to include provisions for rehabilitation or replacement, where applicable, of key SWM features (i.e., treatment train approach).

x. The assumption for the lifecycle of all SWMF's is to be 100 years. Should the 100-year lifecycle requirement not be met, additional approval will need to be provided including rehabilitation costs.

xi. A 25-year Manufacturer's extended warranty from the product supplier of SWMFs shall be required and supported by a legally binding agreement to the satisfaction of the City Solicitor.

xii. Should a 25-year Manufacturer's extended warranty not be provided for the SWMFs, rehabilitation costs shall be provided.

xiii. Rehabilitation and replacement costs are to consider increased cost of material and construction, disposal of the facility to be replaced, and other site-specific considerations such as available staging area, re-use of material, tree/vegetation replacement, ground cover (i.e., softscape compared to hardscape) and environmental conditions.

xiv. If the contributing drainage area to a superpipe Non-Conventional SWMF is <2ha, rehabilitation and replacement costs are not required for the SWMF regardless of an extended warranty. Operations and maintenance costs will still apply.

xv. The unit rates used in the calculation of the Offset Fee shall be subject to annual indexing per Statistics Canada Non-Residential Construction price index, beginning from the year of the Non-Conventional SWMF Design Criteria. Adjustments to the unit rates may be made by the City through updates of the Design Criteria to maintain accuracy to current typical industry rates.

xvi. Sealed engineering opinions by a Qualified Engineer for the service life of the Non-Conventional SWMF are to be provided.

xvii. Parkland dedication credit is assessed independently of the Offset Fee and continues to be determined and issued by the Parks Department through By-Law-0168-2022, as amended or superseded.

Refer to **Appendix 3** for the Detailed Design / Perfect Submission Review Flow Chart and Checklist for additional guidance.

1.4. Step 4: City Assumption

1.4.1. Steps for assumption should be read in conjunction with the Subdivision Agreement. The City may request any other details and information required by the Director of Development Engineering.

1.4.2. Prior to assumption of a Non-Conventional SWMF, the City requires that all infrastructure to be assumed is operating as designed and has been maintained as specified by the O&M Manual. To ensure this, the following information is required to be submitted to the Development Inspection and Grading Division of Development Engineering Department:

i. The Landowner shall ensure that all stormwater infrastructure to be assumed by the City is in clean, functioning condition using methods to the satisfaction of the City.

ii. The Landowner shall provide records of inspection and maintenance reports demonstrating procedures as outlined in the approved O&M Manual.

iii. The Landowner shall provide record drawings for the Non-Conventional SWMF, sealed by the Qualified Engineer of Record, certifying that construction was carried out as per the approved design.

iv. The Landowner shall demonstrate, through completion of a monitoring program to the satisfaction of the City, that the Non-Conventional SWMF and all associated stormwater management system(s) are functioning as designed.

v. Once Assumption takes place, sign off on the Director Notification form of the CLI-ECA is required to be completed and submitted to the MECP.

Refer to **Appendix 4** for the Assumption Stage Review Flow Chart and Checklist for additional guidance.

2. Related Policies

Non-Conventional SWMF Policy No. 08.C.03
City of Vaughan Parkland Dedication By-Law 168-2022, June 2022

3. References

MECP Stormwater Management Planning and Design Manual, March 2003
MECP Low Impact Development Stormwater Management Guidance Manual (Draft), January 2022
City of Vaughan Official Plan 2010 and Update
CVC/ TRCA Low Impact Development Stormwater Management Planning and Design Guide, 2010
TRCA Stormwater Management Criteria, August 2012
City of Vaughan Engineering Design Criteria & Standard Drawings, 2020
City of Vaughan Parkland Dedication Guideline, January 2022
City of Vaughan MECP's CLI-ECA for Municipal Stormwater Management Systems, April 2022
City of Vaughan Committee of the Whole (Working Session) Report, June 2022

ADMINISTRATION

Administered by the Office of the City Clerk.

Review Schedule:	SELECT If other, specify here	**Next Review Date:**	Click or tap to enter a date.
Related Procedure(s):			
Related By-Law(s):			
Supporting Documentation:			

Revision History

Date:	**Description:**
Click or tap to enter a date.	
Click or tap to enter a date.	

1.0 Appendix: Review Checklists

Each reviewer from the Development Engineering, Planning and Park's Department shall assess the submission for completeness based on the items outlined below (where applicable for each department). Each reviewer shall provide their sign off that all relevant material has been provided and is deemed acceptable. If only one Department is responsible for the approval of a listed item, the required Department approval is indicated per the below key.

☐ = Approval required for Sign-Off

☐ = Approval not required for Sign-Off, review recommended.

\- = Approval not required for Sign-Off.

Initial Submission/Justification Report

	Development Engineering	Planning	Parks	Environmental Services
General				
Prepared and sealed by a Qualified Professional Engineer (P.Eng.), licensed to practice in Ontario;	☐	☐	☐	-
Report has been submitted in "Initial Submission" to the City (accompanying whatever materials are provided for first official submission). For example, the Justification Report should accompany one of the following submissions: • Master Environmental Servicing Plan (MESP); • Block Plan; • OPA/ZBA; • Draft Plan.	☐	☐	☐	-
Identification of Benefits				
Social benefits have been identified. These may include, but are not limited to: • Additional recreational space (i.e., Parkland Dedication) • Reduce risks of safety hazards	☐	☐	☐	-

	Development Engineering	Planning	Parks	Environmental Services
Environmental benefits have been identified. These may include, but are not limited to: • Reduction in pests/bugs • Reduction in presences of invasive species	☐	☐	☐	-
Economics benefits have been identified. These may include: • Economic growth	☐	☐	☐	-
Conceptual Design				
The Non-Conventional SWMF drains through gravity drainage and does not require a pump.	☐	☐	☐	-
The Non-Conventional SWMF design does not provide any permanent pool volume.	☐	☐	☐	-
The Non-Conventional SWMF is a watertight concrete structure, or plastic structure wrapped with sufficient impermeable liner.	☐	☐	☐	-
The quantity control portion of the Non-Conventional SWMF achieves water quantity control and extended detention targets only, with additional SWM controls measures provided elsewhere on site	☐	☐	☐	-
Pre-treatment measures are provided upstream of the Non-Conventional SWMF with 80% TSS removal achieved prior to runoff entering the quantity control portion of the Non-Conventional SWMF.	☐	☐	☐	-
The conceptual design is in accordance with the City of Vaughan Design Criteria and Standard Drawings for Non-Conventional SWMF.	☐	☐	☐	-
The report identifies any potential impacts to above ground programming.	☐	☐	☐	-
The conceptual design does not create any obvious obstructions or challenges for land use above the Non-Conventional SWMF.	☐	☐	☐	-
Operation and Maintenance Requirements				
Anticipated O&M requirements of the Non-Conventional SWMF have been identified.	☐	☐	☐	☐

	Development Engineering	Planning	Parks	Environmental Services
Requirements are in accordance with the City of Vaughan's O&M standards	☐	☐	☐	☐
O&M be completed using equipment and technology currently owned by or available to the City.	☐	☐	☐	☐
Conceptual design of Non-Conventional SWMF allows for easy access for frequent O&M.	☐	☐	☐	☐
Financial				
An estimate of the financial requirements for the facility is included in the Justification Report.	☐	☐	☐	-
Development Engineering Sign-off:			**Date:**	
Planning Department Sign-off:			**Date:**	
Parks Department Sign-off:			**Date:**	
Environmental Services Sign-Off			**Date:**	

Draft Plan/ Functional Servicing Submission

	Development Engineering	Planning	Parks
General			
Justification Report has been submitted and accepted (Refer to Initial Submission Checklist if Justification Report has been submitted in conjunction with Draft Plan Submission.)	☐	☐	☐
The proposed technology is included on the City of Vaughan's Acceptable Technology for Non-Conventional SWMF's List.	☐	☐	☐
Preliminary Design			
Sufficient details been provided to assess the preliminary design of the Non-Conventional SWMF.	☐	☐	☐
All overall SWM targets have been achieved per City of Vaughan's standard engineering review process and most recent design criteria.	☐	☐	☐
Location and justification for park placement has been provided.	☐	☐	☐
FSR confirms there is no conflict with: • Surface features • Underground utilities • Maintenance/access requirements	☐	☐	☐
Proposed Non-Conventional SWMF meets defined targets for quantity control and extended detention, and preliminary design of flow controls has been provided.	☐	☐	☐

Preliminary grading above facility and access locations have been provided and are acceptable.	☐	☐	☐
A treatment train approach has been proposed to treat runoff prior to it entering the main cell of the SWMF, treating it to a minimum of 80% TSS removal, using a City defined particle size distribution. Acceptable measures include: • LID Measures (Bioswale, infiltration gallery, etc.); • OGS Units; and • Pre-treatment Cells (Isolator Row, etc.).	☐	☐	☐
Park's Considerations			
City of Vaughan has provided direction regarding requirements for Parkland Block (i.e., programming) which has been incorporated into design.	☐	☐	☐
Owner has indicated intention to apply for Parkland Dedication for parkland above SWMF	☐	☐	☐
Owner has illustrated all criteria to achieve full Parkland Dedication has been met, in accordance with By-Law 168-2022.	☐	☐	☐
FSR confirms there is no conflict with planned Park programming.	☐	☐	☐
Financial Considerations			
FSR outlines cost of proposed facility.	☐	☐	☐
Intent to provide an extended warranty plan for SWMFs has been confirmed.	☐	☐	☐
Development Engineering Sign-off		**Date:**	
Planning Department Sign-off		**Date:**	
Parks Department Sign-off		**Date:**	

Detailed Design/ Perfect Submission

	Development Engineering	Planning	Parks
General Submission			
A detailed Stormwater Management Report and detailed design drawings have been received, prepared, and sealed by a Qualified Professional Engineer (P.Eng.), including:	☐	☐	☐
• SWM Report;	☐	☐	☐
• Detailed Engineering drawings; and	☐	☐	☐
• Shop Drawings.	☐	☐	☐
Complete O&M Manual has been received.	☐	☐	☐
Review & Acceptance of SWM Report & Detailed Design Drawings			
Proposed Non-Conventional SWMF technology has not changed since Draft Plan/ Functional Servicing Submission.	☐	☐	☐

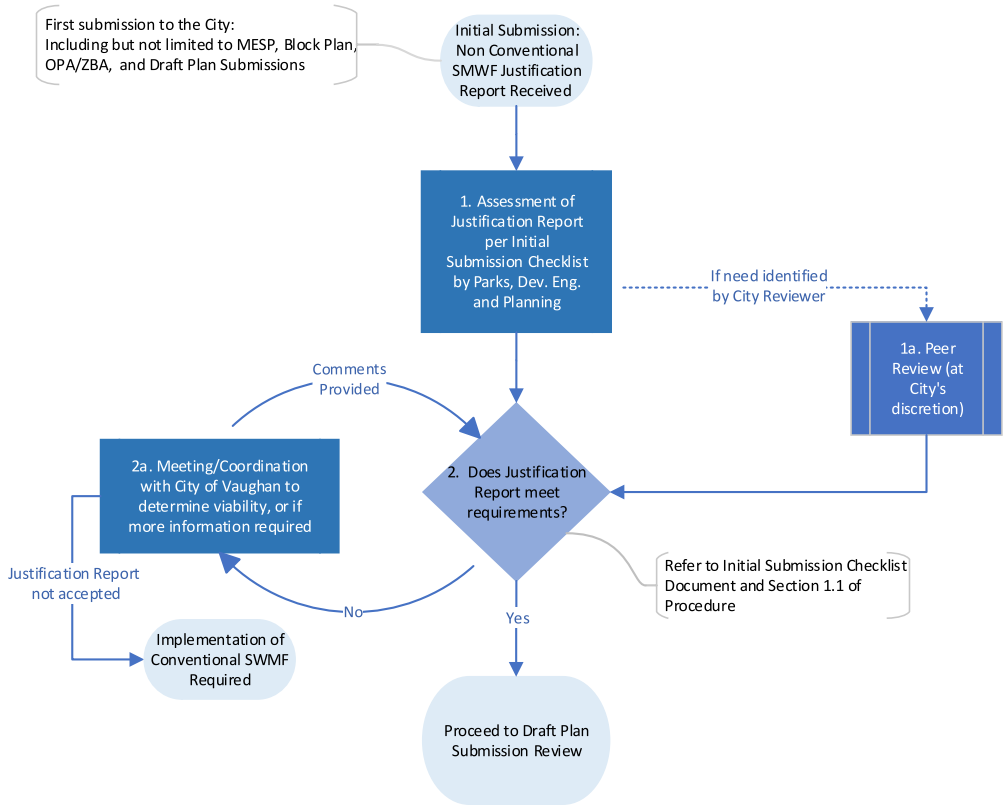
Proposed overall SWM design and drawings meet City of Vaughan's standard engineering review process and Engineering Design Criteria.	☐	☐	☐
Proposed Non-Conventional SWMF design meets City's Non-Conventional SWMF Facility Design Criteria.	☐	☐	☐
Non-Conventional SWMF only provided quantity control and extended detention controls within quantity control portion of facility (not in isolator/separator rows).	☐	☐	☐
Parks Considerations			
Proposed Non-Conventional SWMF design and associated grading meets Parks criteria.	☐	☐	☐
Proposed Non-Conventional SWMF does not infringe on Park programming.	☐	☐	☐
Parkland Dedication Credit has been finalized and applied.	☐	☐	☐
Review & Acceptance of Operations & Maintenance Requirements			
Complete Operations & Maintenance (O&M) Manual has been submitted for Non-Conventional SWMF and any pre-treatment technology, which includes:	☐	☐	☐
• Any required equipment and certifications for O&M.	☐	☐	☐
• Maintenance frequency and costs on all structures involved in SWM solution, based on development's sediment loading rate.	☐	☐	☐
• Consideration and planning for high disruption maintenance activities.	☐	☐	☐
• Consideration and planning for frequent inspection and maintenance.	☐	☐	☐
• An annual maintenance cost based on detailed breakdown of inspection/maintenance and associated time and costs.	☐	☐	☐
• Cost provisions for disposal/treatment of sediment per current Regulations.	☐	☐	☐
O&M manual meets requirements outlined in CLI-ECA.	☐	☐	☐
Frequent/regular inspection does not require confined space entry.	☐	☐	☐
A maintenance cost assessment has been provided based on a 50-year period (which can be provided as standalone document), which includes:	☐	☐	☐
• Quantification of O&M costs over a 50-year period.	☐	☐	☐
• Offset Fee has been calculated correctly per Criteria (refer to next section).	☐	☐	☐
• Unit rates to calculate the Offset Fee have been indexed appropriately.	☐	☐	☐
• Sealed engineering opinion regarding service life of SWMF.	☐	☐	☐

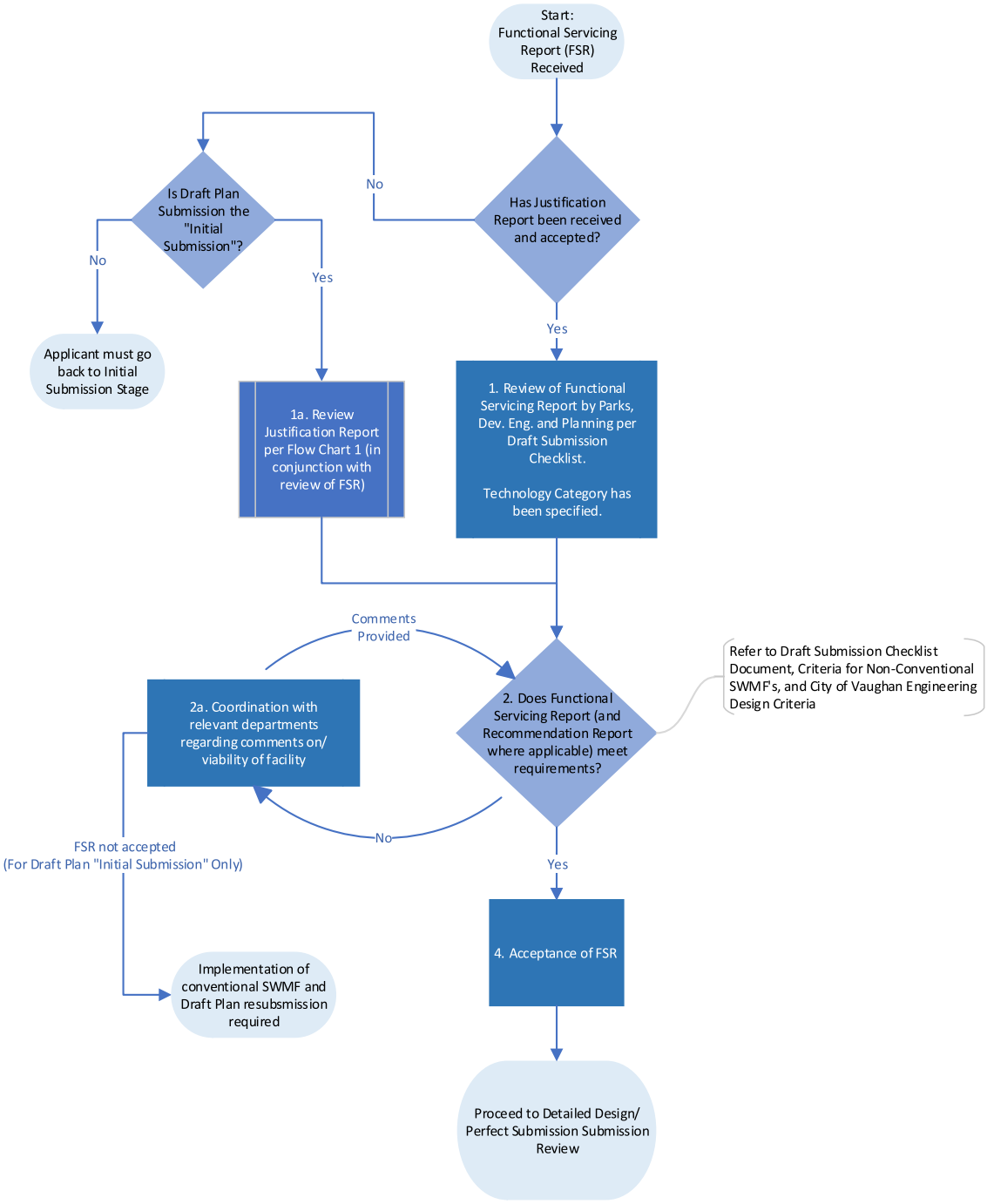
Financial Considerations			
Offset Fee has been calculated using the City's unit rates specified in the criteria, based on the sum of:	☐	☐	☐
• Inspection and monitoring costs (visual inspection, inspection report, and debris removal, and monitoring as required by CLI-ECA), is the delta between Non-Conventional and Conventional SWMF.	☐	☐	☐
• Maintenance costs (including fees associated with sediment removal, confined space entry, component replacement), is the delta between Non-Conventional and equivalent Conventional SWMF.	☐	☐	☐
• An extended warranty from SWMF Manufacturer's has been provided with appropriate legal documentation to the City's satisfaction.	☐	☐	☐
• If an extended warranty is not provided or accepted by the City, SWMF rehabilitation costs have been calculated and added to the Total Offset Fee. SWMF rehabilitation / replacement costs are not required for development areas <2ha using a superpipe facility, regardless of an extended warranty.	☐	☐	☐
Unit rates for various inspection, monitoring, maintenance procedures align with rates outlined in the Design Criteria for Non-Conventional SWMF and have been indexed appropriately.	☐	☐	☐
The Final Compensation Value has been quantified and will be issued through a subdivision / site plan agreement between the City and Landowner.	☐	☐	☐
Development Engineering Sign-off		**Date:**	
Planning Department Sign-off		**Date:**	
Parks Department Sign-off		**Date:**	

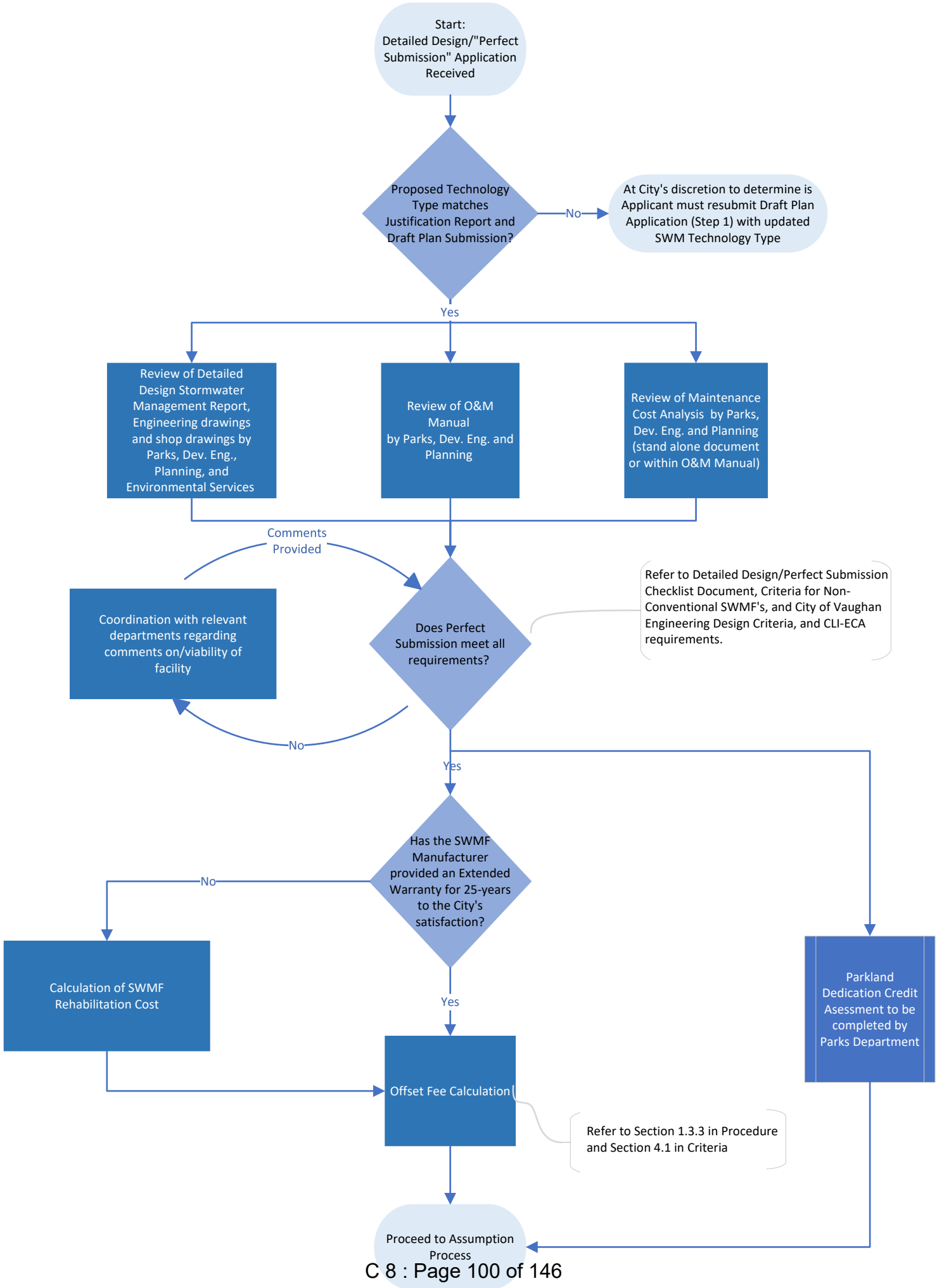
City Assumption

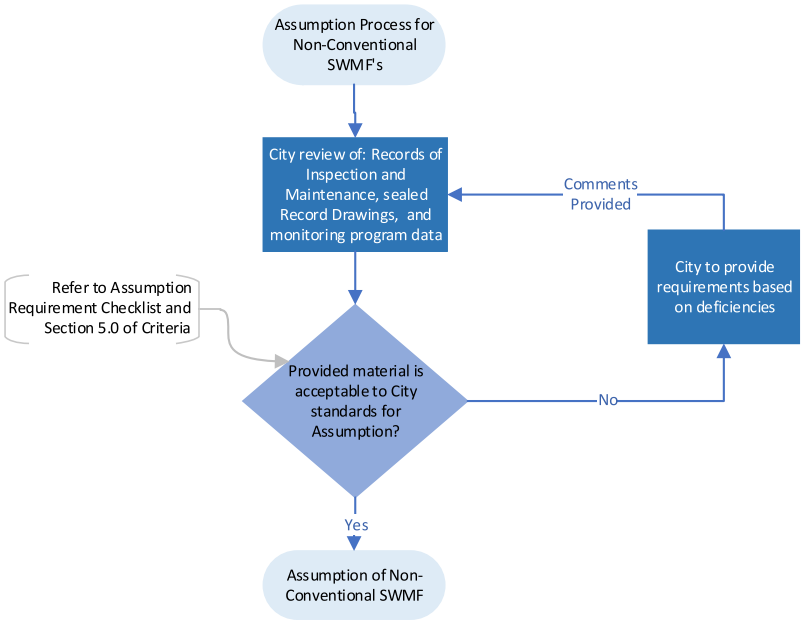
	Development Engineering	Planning	Parks
Assumption Requirements			
Sealed record drawings of Non-Conventional SWMF have been provided, which certify infrastructure was constructed per approved design, as per PEO Guidelines on Preparing As-builts and Record Documents.	☐	☐	☐
Records of inspection and maintenance have been provided and are in compliance with practices outlined in approved O&M manual.	☐	☐	☐
• Infrastructure has been maintained per approved O&M manual.	☐	☐	☐

• Infrastructure is free of debris and sediment build up (determined through methods agreed upon by City)	☐	☐	☐
Records for monitoring program as agreed upon by the City have been provided.	☐	☐	☐
• Monitoring program records, per CLI-ECA if applicable, indicate infrastructure is functioning as designed.	☐	☐	☐
Development Engineering Sign-off		**Date:**	
Planning Department Sign-off		**Date:**	
Parks Department Sign-off		**Date:**	


First submission to the City:
Including but not limited to MESP, Block Plan, OPA/ZBA, and Draft Plan Submissions
Initial Submission: Non Conventional SMWF Justification Report Received
1. Assessment of Justification Report per Initial Submission Checklist by Parks, Dev. Eng. and Planning
If need identified by City Reviewer
1a. Peer Review (at City's discretion)
Comments Provided
2a. Meeting/Coordination with City of Vaughan to determine viability, or if more information required
2. Does Justification Report meet requirements?
Refer to Initial Submission Checklist Document and Section 1.1 of Procedure
Justification Report not accepted
No
Yes
Implementation of Conventional SWMF Required
Proceed to Draft Plan Submission Review


Start: Functional Servicing Report (FSR) Received
Has Justification Report been received and accepted?
No
Yes
Is Draft Plan Submission the "Initial Submission"?
No
Yes
Applicant must go back to Initial Submission Stage
1a. Review Justification Report per Flow Chart 1 (in conjunction with review of FSR)
1. Review of Functional Servicing Report by Parks, Dev. Eng. and Planning per Draft Submission Checklist.
Technology Category has been specified.
Comments Provided
2. Does Functional Servicing Report (and Recommendation Report where applicable) meet requirements?
Refer to Draft Submission Checklist Document, Criteria for Non-Conventional SWMF's, and City of Vaughan Engineering Design Criteria
2a. Coordination with relevant departments regarding comments on/ viability of facility
No
Yes
FSR not accepted
(For Draft Plan "Initial Submission" Only)
Implementation of conventional SWMF and Draft Plan resubmission required
4. Acceptance of FSR
Proceed to Detailed Design/ Perfect Submission Submission Review


Start:
Detailed Design/"Perfect Submission" Application Received
Proposed Technology Type matches Justification Report and Draft Plan Submission?
No
At City's discretion to determine is Applicant must resubmit Draft Plan Application (Step 1) with updated SWM Technology Type
Yes
Review of Detailed Design Stormwater Management Report, Engineering drawings and shop drawings by Parks, Dev. Eng., Planning, and Environmental Services
Review of O&M Manual by Parks, Dev. Eng. and Planning
Review of Maintenance Cost Analysis by Parks, Dev. Eng. and Planning (stand alone document or within O&M Manual)
Comments Provided
Coordination with relevant departments regarding comments on/viability of facility
Does Perfect Submission meet all requirements?
Refer to Detailed Design/Perfect Submission Checklist Document, Criteria for Non-Conventional SWMF's, and City of Vaughan Engineering Design Criteria, and CLI-ECA requirements.
No
Yes
Has the SWMF Manufacturer provided an Extended Warranty for 25-years to the City's satisfaction?
No
Yes
Calculation of SWMF Rehabilitation Cost
Parkland Dedication Credit Asessment to be completed by Parks Department
Offset Fee Calculation
Refer to Section 1.3.3 in Procedure and Section 4.1 in Criteria
Proceed to Assumption Process


Assumption Process for Non-Conventional SWMF's
City review of: Records of Inspection and Maintenance, sealed Record Drawings, and monitoring program data
Comments Provided
City to provide requirements based on deficiencies
Refer to Assumption Requirement Checklist and Section 5.0 of Criteria
Provided material is acceptable to City standards for Assumption?
No
Yes
Assumption of Non-Conventional SWMF

INDEX

LIST OF TABLES

STANDARD DETAILS

STANDARD DETAIL INDEX

SECTION	PRIOR REF	DESCRIPTION
NON-CONVENTIONAL SWMF		
SWMF-01		PATHWAY (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-01a		ASPHALT PATHWAYS (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-02		ARMOUR STONE (TYP.) DETAIL ABOVE A NON-CONVENTIONAL SWMF
SWMF-03		BIKE RACK DETAIL (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-04		IDENTITY SIGNAGE (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-05		GATE (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-06		BOLLARD (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-07		TYPICAL TREE PLANTING ABOVE A NON-CONVENTIONAL SWMF
SWMF-08		TYPICAL SHRUB PLANTING ABOVE A NON-CONVENTIONAL SWMF
SWMF-09		EXAMPLE STORM CONNECTION DOWNSTREAM FROM NON-CONVENTIONAL SWMF
SWMF-10		CHAIN LINK SECURITY FENCE (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-11		PEDESTRIAN/BICYCLE HANDRAIL (TYP.) DETAIL ABOVE A NON-CONVENTIONAL SWMF
SWMF -12		ASPHALT PAVING (HEAVY DUTY) (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-13		ASPHALT PAVING (LIGHTY DUTY) (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-14		DECORATIVE POLE (TYP.) ABOVE A NON-CONVENTIONAL SWMF
SWMF-15		MAINTENANCE HOLE BUMP OUT FROM PEDESTRIAN PATH FOR NON-CONVENTIONAL SWMF DETAIL
SWMF-16		CONCEPTUAL STORM SEWER CONNECTION TO NON-CONVENTIONAL-SWMF DETAIL
SWMF-17		CONCEPTUAL NON-CONVENTIONAL FACILITY WITHIN ROW LAYOUT

1.0 INTRODUCTION

This document provides the City of Vaughan (the City) design criteria for the implementation of Non-Conventional Stormwater Management Facilities (SWMF's), such as underground storage tanks or super pipes, within park blocks, open space blocks, or rights-of-way (ROW), which are or will become City owned infrastructure and lands. Operations & Maintenance requirements are also provided, as well as guidance on associated financial requirements. It is recommended that the applicant indicate their intention to implement Non-Conventional SWMF's as early as possible in the development application process, ideally during any pre-consultation discussions with the City.

1.1 Submission Materials Overview

The following **Table 1** is a summary of the reports and materials that must be submitted to provide sufficient information for the review of the proposed Non-Conventional SWMF's, as well as the development stage at which they must be submitted.

TABLE 1: SUBMISSION MATERIAL SUMMARY

Report	Level of Design	Development Stage
Non-Conventional SWMF Justification Report	• Conceptual level of detail which demonstrates viability of facility.	"Initial Submission" (Can include MESP, Block Plan, Secondary Plan, and OPA/ZBA submissions, as well as Draft Plan Submissions if none of the above apply)
Functional Servicing Report	• FSR Level Detail for Non-Conventional SWMF and associated facilities, grading, servicing, and modelling. • FSR level detail for site specific conditions (ex. Hydrogeological, geotechnical etc.) • Justification for product choice for Non-Conventional SWMF.	Draft Plan of Subdivision Submission
Stormwater Management Report	• Detailed design for all SWMF's • Detailed modelling • Shop drawings • Detailed sections • Engineering drawings • Refer to Section 1.1 of existing City Engineering Design Criteria	Detailed Design/Perfect Submission Stage
Operations & Maintenance Report	• Refer to **Section 3.0** .	Detailed Design/Perfect Submission Stage
Offset Fee Calculation	• Refer to **Section 4.1**. • Can be submitted with Operations & Maintenance Manual or as separate memo.	Detailed Design/Perfect Submission Stage

2.0 DESIGN CRITERIA

The following criteria guides the design of Non-Conventional SWMF's in conjunction with the City of Vaughan's Engineering Design Criteria (December 2020 or most recent) and MECP's Stormwater Management Planning and Design Manual (2003 or most recent). Please refer to Section 1.1 of the City's Engineering Design Criteria for a complete list of all requirements for an Engineering Submission. All submissions must adhere to the City's overall criteria, applicable Environmental Compliance Approvals, and must not conflict with any other legislative requirements.

2.1 General Stormwater Management Criteria

The stormwater management solution shall be developed in accordance with the City's Design Criteria and Standard Drawings (December 2020 or most recent version), TRCA's Stormwater Management Criteria (April 2012 or most recent version), MECP's Stormwater Management Planning and Design Manual (2003 or most recent version), and Schedule D and E of the Consolidated Linear Infrastructure Environmental Compliance Approval (CLI-ECA) (where applicable). Additional studies, including but not limited to Subwatershed Studies, Stormwater Management Master Plans, Environmental Impact Studies, and Monitoring programs should be reviewed on a site-by-site basis to ensure the standard SWM criteria requirements are refined as needed.

It should be noted that these criteria represent a minimum requirement that may be superseded by the results of further studies and local constraints.

2.2 List of Acceptable Technologies

Table 2 below outlines acceptable Non-Conventional SWMF's that will be considered. Criteria specific to each technology type is also provided to inform product choice. Products chosen should not require Confined Space Entry for routine maintenance (as discussed in **Section3.2**). Plastic facilities are acceptable provided they meet the below criteria. The use of plastic must be justified in the Functional Servicing Report submission stage. It should be noted that this document is subject to future review, which may result in the addition of other acceptable technologies.

TABLE 2: LIST OF ACCEPTABLE TECHNOLOGIES

Acceptable Technology	Criteria
Cast-in-Place Concrete	• Provided concrete must meet CSA A23.1 (Concrete Materials and Methods of Concrete Construction). • Is in accordance with CSA S269.1 (Falsework and Formwork) and CSA G30.18 (Rebar) • Structural design to be sealed by P.Eng.
Pre-Cast Concrete	• Provided concrete must meet CSA A23.4 (Precast Concrete Materials Construction). • Structural design to be sealed by P.Eng.
Superpipes (Concrete)	• Must meet CSA A257 (Standards for concrete pipe and manhole sections). • Standard strength class must be specified and shall be selected in accordance with OPSD 807.010 for Height of Fill • Structural design to be sealed by P.Eng.
Polymeric (plastic) Chamber	• Meets CSA B184 Series of Standards for Polymeric subsurface stormwater management structures and/or be approved by the City's Products and Standards Committee. • Meets ASTM F2787 (Standard Practice for Structural Design of Thermoplastic Corrugated Wall Stormwater Collection Chamber) OR ASTM F2418 (Standard Specification for Polypropylene Corrugated Stormwater Collection Chambers). • To be completely lined with minimum two layers of woven geotextile with minimum 1400 N grab tensile strength, 533 N tear resistance and 4600 N Puncture CBR. • Structural design to be sealed by P.Eng.

2.3 Overall SWMF Design Requirements

The following is a list of overall principles and design criteria for the implementation of all Non-Conventional Stormwater Management Facility (SWMF) Types. The Stormwater Management Report must address each item listed below. Any product specific requirements shall be adhered to by the designer. For requirements specific to different use cases, please refer to the relevant sections below:

- The proposed stormwater management solution and design of the Non-Conventional SWMF must be sealed by a Professional Engineer licensed to practice in Ontario and documented in a design report appropriate to the stage of development.
- The proposed SWMF must only collect, receive, and control stormwater runoff, not sanitary or combined sewage.
- The proposed SWMF must be entirely located on municipally owned lands and shall not discharge to non-municipally owned land without the express written consent of landowner receiving the drainage.
- Quality control criteria must be met prior to runoff entering the quantity control portion of the Non-Conventional SWMF, which shall be achieved through an upstream treatment train approach.

  - OGS units shall only be credited for a maximum TSS removal of 60%, provided they have been sized using ETV Canada Particle Size Distribution (PSD).
  - Isolator/separator rows or baffle walls within underground storage tanks will be considered for quality control, however, it must also be accompanied by other pre-treatment strategies upstream of the SWMF. The volume contained in the isolator/separator rows or by the baffle walls shall not be counted towards quantity control storage.
- Quality controls included in treatment train must be included on the City of Vaughan Approved Technology List and/or be verified by ETV Canada.
- Quality control facilities (e.g., Oil Grit Separator (OGS) Units) will be designed using the entire range dataset of ETV Canada Particle Size Distribution or distribution otherwise specified by the City of Vaughan.
- No infiltration credit will be given for Non-Conventional SWMF's.
- Infiltration facilities may be provided downstream of the Non-Conventional SWMF for water balance credit only. Infiltration facilities may not be located within the park block unless they are designed to exclusively treat runoff from the park, and quality control is provided upstream of the SWMF.
- Standing water will not be acceptable within the Non-Conventional SWMF, including:
  - Permanent pools
  - Retention
- The Non-Conventional SWMF may provide extended detention in the facility, provided existing drawdown criteria is met. The minimum orifice diameter for the outlet shall be 100 mm. The number of orifices should be minimized as much as possible to reduce O&M requirements and costs.
- A stone layer is required above and below the proposed facility to facilitate drainage around the facility.
- The SWMF must be able to accommodate a dual drainage system.
  - Non-Conventional SWMF's must be sized for major system flows.
  - Pre-treatment (quality control of 80% TSS removal) is only required for minor system flows (5 year storm events and lower). Pre-treatment of major system flows is not required.
  - The access points to the Non-Conventional SWMF shall not be used for flow conveyance.
- Outlet locations shall be approved by the City of Vaughan (and TRCA where required).
- Service life of chosen Non-Conventional SWMF product must be a minimum of 100 years. This must be documented by a qualified Professional Engineer.
- Facilities shall be positively sloped, with a minimum slope of 0.3% to facilitate complete drainage and flushing. A minimum slope of 0.5% is preferred. Facilities that require pumping of active storage volumes (outside of operations and maintenance) will not be approved.
- The maximum distance between maintenance access points into the Facility shall be 60 m, or as determined by available maintenance equipment.
- At least one maintenance access point shall be provided directly above or beside all outlet and inlet structures.

- "Hybrid" facilities (e.g., the combined use of a Non-Conventional SWMF with above ground storage) will be considered, provided the following criteria is met:
    - Above ground storage shall not be located within the Park Block and must be in a discrete pond block. Any accompanying pond block must meet all existing City criteria.
    - Quality Control criteria must be met prior to any runoff entering the Non-Conventional SWMF.
- Emergency outlet locations, route and capacity of major system receiver shall be analysed and identified. Emergency outlets shall be able to convey the highest design inflow rate of the facility, while maintaining a minimum 0.30 m freeboard.
- Polymeric (plastic) Chambers:
    - Must be lined with double layer of woven geotextile to ensure stability of stone layer.
    - Manifolds shall be a minimum of 1200 mm in diameter to allow for access.
    - All row connections shall be a minimum of 600 mm in diameter and inverts shall match the chamber bottom elevation to permit flushing.
    - For polymeric (plastic) chamber facilities, Operations and Maintenance (O&M) Manual must demonstrate facility and park layout is to demonstrate that on-site stockpiling of overlying materials during replacement is possible. Stockpile locations must not interfere with park facilities/features and must be located within open space areas. Topsoil, fill and granular materials shall have separate stockpiles.
- Proposed facilities must be able to withstand a minimum traffic rating of the Canadian High Bridge Design Code (CHBDC) CL-625ONT.
- On-site groundwater conditions are to be assessed by a Geotechnical Engineer prior to Detailed Design to confirm groundwater elevations in relation to the proposed Facility depth. A Qualified Engineer will determine whether buoyancy analysis is required to show whether the system can withstand hydraulic uplift conditions. Hydrogeological inspections must support the use of a Non-Conventional SWMF.

2.3.1 Right-of-Ways

Non-Conventional SWMF's may be implemented within right-of-way's (ROW), which will provide conveyance and detention for runoff from the contributing drainage area. The SWMF design should ensure that all existing City of Vaughan Design Criteria for Roads can be met and shall not be modified to accommodate a Non-Conventional SWMF.

2.3.1.1 General

Inlets and Outlets

The proposed on-site storm sewer system will serve as an inlet to the facility.

Sizing

The length of the pipe and diameter or height and span will be a function of the storage required to meet required discharge rates for the site.

Layout & Locations

Non-Conventional SWMF's in ROWs should be located in the typically approved storm sewer alignment under the roadway asphalt. Alternative locations may be acceptable (i.e., under boulevards) providing separation/offset requirements are satisfied under standard ROW cross-sections. The applicant shall provide a modified ROW cross-section if they are proposing to shift the facility from the typically approved storm sewer alignment, shall consider all crossings in the design of the system, and be responsible for coordination with other utility providers. Plan and Profiles will be required to show all clearances are met.

Facilities should be located within proximity to fire hydrants to supply flushing water for sediment removal.

If located within the asphalt of the right-of-way, facilities are to be located 1.5 m west or south of the road center line from the centreline of pipe, in a separate trench. On crescent roads, or roads with multiple bends, the facility position may follow the same relative side of the road allowance. The minimum horizontal clearance between the outside wall of the adjacent sewer pipes shall be 800 mm.

Curvilinear alignment through deflection at joints of the facilities within manufacturer's specifications are permitted with acceptance from the City.

Minimum clearances between the facility and other services shall be provided in accordance with MECP guidelines. Minimum horizontal and vertical separations between facilities and watermains are established in MECP's Procedure F-6-1.

Additional considerations and consultations shall be required with local service providers to ensure there are no conflicts between other proposed services, utilities, or underground infrastructure.

The ROW width shall not be expanded to accommodate facilities. Detailed cross sections shall be required to demonstrate that the facility fits within the proposed ROW, while achieving all required offsets.

Facility Depth

The facility shall have a minimum of 1.2 m cover to the top of the stone layer, per City of Vaughan Engineering Criteria. Maximum depth specifications are product dependent and shall not be exceeded.

Facility By-Pass

A by-pass pipe should be provided to redirect flows around the Facility during maintenance, where possible. Per Section 1.3.5.6 of the City's Design Criteria, the by-pass shall be designed to convey the peak flow from the 2-year return period storm event and in accordance with the Stormwater Management Planning and Design Manual ("Maintenance By-pass" in Section 4.7 of 2003 edition). Valves should be avoided as a by-pass option to reduce maintenance requirements and costs. Less maintenance intensive options, such as stop logs, should be used.

Emergency Flow Conveyance

The rights-of-way shall provide sufficient conveyance capacity for the major system flows in the event of the outlet failure or blockage, or if the storm event is greater than the facility's design capacity. Major system flows shall be diverted away from surrounding buildings as much as possible, and the overland flow route should be identified on relevant figures and drawings, with sufficient erosion control specifications if required.

Pipe Loading

Facilities shall be constructed per the standards listed in **Section 2.3** to ensure structural integrity of the system. Pipe loading calculations shall accompany the Detailed Design submission and be completed per City of Vaughan Engineering Criteria. Selected native backfill may be used above the facility with acceptance from the City and if supported by an opinion from a Geotechnical Engineer. Facility structural design is to be sealed by a Qualified Professional Engineer.

Ponding

The Facility shall provide enough storage volume to contain the runoff volume generated by the 100 year storm without causing surface ponding. For Climate Change consideration, the maximum depth of ponding/flow for the August 19th, 2005, storm event shall not exceed 0.30m above the gutter line of the right-of-way, and the water level shall be contained within the right-of-way.

2.3.1.2 Operations & Maintenance Design Requirements

The facility should be designed to allow for routine maintenance without the need for Confined Space Entry, and to minimize traffic disruptions. As such, the following criteria should be met at the detailed design submission:

- Confined Space Entry only required for infrequent maintenance/rehabilitation (>25 year period) and structural inspections (10 year period).
- The maximum distance between inspection/maintenance ports shall not exceed 60m.
- Inspection ports and maintenance access points should be located to facilitate inspection/maintenance with closure of one lane on multi lane roads.
- Personnel access points shall be provided at the upstream and downstream ends of the facility.
- A personnel access point shall be provided above or adjacent to the outlet structure for the facility.
- The footprint of the facility and associated infrastructure must be fully located on municipally owned land.

The Operations & Maintenance (O&M) Manual for the facility must identify frequent and infrequent O&M tasks, related costs, and show clean out options that minimize disruption to the ROW. Further requirements and elaboration are provided in **Section 3.0** .

2.3.2 Parks & Open Space Blocks

Non-Conventional Stormwater Management facilities may be implemented within park blocks or

open space blocks to provide conveyance and detention for a site. The proposed facility shall be designed to ensure that all existing City of Vaughan criteria for park grading, servicing, and programming and facility requirements can be met if full parkland dedication is to be achieved for the land above the proposed facility. Standard levels of services for park programming, facilities, amenities, and structures shall not be compromised to accommodate a Non-Conventional SWMF.

2.3.2.1 General

Inlets and Outlets

The proposed on-site storm sewer system will serve as an inlet to the facility. Inlets and catchbasins are to be a minimum of 5 m away from all property lines.

Sizing

The height, length and width of the Facility will be a function of the storage required to meet target discharge rates for the site. The minimum and maximum height of the Facility will be dictated by the product choice. SWMF inverts will be dictated by the requirement for gravity drainage.

Layout & Location

The location of the facility shall be placed so that safe excavation (as per OHSA) is possible without the use of shoring between the facility and any services or property lines when excavation and facility replacement may be required. Park block services shall not cross over the top of the proposed facility. A minimum horizontal clearance between the outside wall of adjacent sewer pipes shall be 800 mm. Minimum clearances between the facility and other services shall be provided in accordance with MECP guidelines. Minimum horizontal and vertical separations between facilities and watermains are established in MECP's Procedure F-6-1.

Additional considerations and consultations shall be required with local service providers to ensure there are no conflicts between other proposed services, utilities, or underground infrastructure.

Consideration to proposed and future park landscaping is required. The Applicant should consult with the Parks Department to determine preferred tree planting locations within the park block and where installation should be avoided. This will allow the development of mature tree canopy within the park, which can be preserved if system excavation is required.

For polymeric (plastic) chamber facilities, facility and park layout is to demonstrate that on-site stockpiling of overlying materials during replacement is possible. Stockpile locations must not interfere with park facilities/features and must be located within open space areas. Topsoil, fill and granular materials shall have separate stockpiles.

The City shall provide the proposed park programming to inform the location of the Non-Conventional SWMF. Park programming shall not be dictated by the design/location of the SWMF. **Table 3** outlines various Park Programming options and whether a Non-Conventional SWMF will be permitted underneath. Any park facilities or features not listed below shall be confirmed with the City that a Non-Conventional SWMF can be located underneath. Inspections

ports and maintenance access must always be accessible and should not be located underneath any of the Park facilities listed in **Table 3** below. The facility placement, as well as preliminary access route locations, and approximate locations for maintenance and monitoring ports as determined by minimum spacing criteria, should be reviewed and agreed upon by the City's Parks Department prior to Detailed Design submission. It is noted that outside of the Non-Conventional SWMF area and associated buffers, standard Park's Criteria will still apply.

TABLE 3: PARK FACILITY ACCEPTANCE

Park Facility	Acceptable Feature above Non-Conventional SWMF
Park Facilities	
Playgrounds (Neighbourhood/Urban Park)	Yes
Playgrounds (District/Regional)	No*
Outdoor Fitness	Yes
Water play	No
Seasonal Domes (Slab on Grade)	No
Permanent Domes or field covers	No
Outdoor Swimming Pools	No
Outdoor Ice Rinks and Ice Skating	No
Skateboard and Wheeled Sports	Yes
Sports Fields (baseball diamond, soccer field, cricket pitch, football field, rugby/multiuse field)	Yes
Structures Requiring Deep Footing (e.g., Baseball backstops, football goal posts)	No
Sports Courts (tennis, basketball, bocce, pickleball, volleyball, ball hockey, multiuse court)	No*
Recreational Trails and Pathways	Yes**
Park Buildings (any kind)	No
Picnic Shelters (on ground or concrete slab)	Yes
Shade Structures (on Concrete Slab, cantilevered or standard)	Yes
Off Leash Dog Areas (Primary/Local)	Yes
Irrigation	Yes
Emergency Signage	Yes***
Amenities, Utilities, and Servicing	
Waste Receptacles on Concrete Slab	Yes
Electrical Transformers/Panels	No
Sanitary/Watermain Servicing and unrelated Storm Servicing	No
Typical Lighting	Yes
Lighting Conduits	Yes
Court and Sports Field Lighting	No
Benches/Seating on concrete slab	Yes
Signage	Yes
Retaining Walls	No
Bridge Structures	No

*Facilities require additional design considerations for implementation above Non-Conventional SWMF's. Applicant shall coordinate with City Park's Department to determine feasibility of Non-Conventional SWMF beneath feature.

**Primary accessible routes and emergency access routes not permitted above SWMF.

***Although discouraged, emergency signage placement is subject to approval by Emergency Planning, Fire and Rescue Services staff.

Grading

Grading over the proposed facility shall meet the City's requirements for Parkland grading, which allow for a minimum 2% and maximum 5% slope. Steeper sloping and/or retaining walls shall not be permitted over the facility, however armourstone seating may be provided over the Non-Conventional SWMF with the height of seating not to exceed 460mm. It is recommended that consultation with the City's Parks Department be undertaken early in the design process to ensure the proposed seating is acceptable.

Facility Depth

The Facility shall have a minimum of 1.8 m depth of cover to top of stone to allow flexibility with potential future Park programming. Maximum depth of cover specifications are dependent on the design of the Non-Conventional SWMF and shall not be exceeded. All access points should not exceed 5 m depth to avoid safety platforms, which may complicate inspection and maintenance procedures.

Facility By-Pass

A by-pass pipe shall be provided to redirect flows around the Facility during major maintenance. Per Section 1.3.5.6 of the City's Design Criteria, the by-pass shall be designed to convey the peak flow from the 2-year return period storm event and in accordance with the Stormwater Management Planning and Design Manual ("Maintenance By-pass" in Section 4.7 of 2003 edition). Mechanical valves should be avoided as a by-pass option to reduce maintenance requirements and costs. Less maintenance intensive options, such as stop logs, should be used.

Emergency Flow Conveyance

The facility outlet configuration shall be designed with an emergency overflow spillway to allow storm drainage to safely exit the facility if the outlet fails to function, or if the storm event is greater than the Facility 's designed capacity. The spillway and/or emergency outlet shall be sized to safely convey the highest design inflow rate of the Facility, including the August 19th, 2005, storm for Climate Change consideration. The flow should be directed away from adjacent properties, and the overland flow route should be identified on relevant figures and drawings. Sufficient erosion control should be provided if required.

Loading

The facility shall be constructed per the standards listed in **Section 2.3** to ensure integrity of the system. Maximum depth specifications are product dependent and shall not be exceeded. Facility loading calculations shall accompany the Detailed Design submission and shall assume Canadian Highway Bridge Design Code (CHBDC) CL-625ONT loading. Selected native backfill may be used with acceptance from the City and if supported by an opinion from a Geotechnical Engineer. The facility structural design is to be sealed by a Professional Engineer.

Ponding

No surface ponding shall be permitted within the park. The facility shall provide enough storage required to meet required target discharge rates. The required storage volume for the design storm event shall be fully contained within the facility with no use of surface storage.

2.3.2.2 Operations & Maintenance Design Requirements

The facility should be designed to allow for routine maintenance without the need for Confined Space Entry, and to cause no park use disruptions during routine maintenance and minimize use disruption as much as possible during major rehabilitation and replacement. As such, the following criteria should be met at the detailed design submission:

- Confined Space Entry only required for infrequent/major maintenance (>25 year period) and structural inspections (10 year period).
- The footprint of the facility and associated infrastructure must be setback 5.0 m from property lines and other infrastructure to allow for excavation without the use of shoring.
- Availability for flow by-pass for infrequent/major maintenance must be considered in the design of the facility. Valves are to be avoided to decrease maintenance requirements. Less maintenance intensive options, such as stop logs, are preferred. The maximum distance between access points for maintenance points shall not exceed 60m.
- Maintenance/inspection ports and maintenance holes shall not be located within field of play, or pedestrian pathways through the park.
- Personnel access points shall be provided at the upstream and downstream ends of the facility, as well as above or directly adjacent to the outlet structure of the facility.
- The facility is to be designed to prevent scouring during routine flushing.
- A warning system shall be incorporated when installing the facility to provide notice to future excavators of the facility's location. Requirements include:
    - Tracer wire around the perimeter of the facility.
    - Warning layer of orange delineation material (such as snow fence) over the top of the stone layer of the facility.

The Operations & Maintenance Manual for the facility must identify frequent and infrequent O&M tasks, related costs, and show clean out options that minimize disruption to the park or open space block. Further requirements and elaboration are provided in **Section 3.0** .

2.3.2.3 Access Route Design

The access routes for maintenance of facilities within a park block or open space block are to be considered as part of the overall system. As such, they should conform to the criteria described below. Access route paving will be dependent on the type of maintenance carried out, and type of vehicles used. Should only one access route be provided, the design shall be in accordance with the "heavy duty" maintenance access requirements. O&M requirements, as well as replacement and rehabilitation for the access routes should be considered in conjunction with the facility.

"Light Duty" Maintenance Access Routes

- "Light Duty" Access Routes shall be designed as dual-purpose access routes/pedestrian pathways and are for inspection purposes only. Routes will be constructed with either limestone screening with a stabilizing/binder agent (Urban Design Division Standard Drawing MLA-305) or asphalt paving (MLA-208A).
- Routine Maintenance Access/Inspection Ports should be placed so that they are immediately adjacent to but offset from the pathway. The minimum width of these access routes shall be 4.0m. A turnaround, pathway loop or hammerhead is to be provided for a standard vehicle.
- Maintenance ports/manholes should not be located where overhead obstructions could occur (e.g., overhead wires).
- Sufficient lighting to be provided to ensure adequate illumination and shall conform to applicable guidelines in the Section 1.8 of the existing City criteria.
- Tree plantings adjacent to the access route shall be offset a minimum of 3.0 m. Additionally, columnar species shall be proposed, to avoid conflict with overhead branches.

"Heavy Duty" Maintenance Access Routes

- Access routes for major rehabilitation or frequent sediment clean out shall be separate from all pedestrian pathways and shall be constructed from concrete.
- Minimum route widths shall be 6.0 m to accommodate large trucks, as determined by the City's Environmental Services department at the detailed review stage. Curves in the road will have a minimum centreline radius of 12.0 m. A turning circle or hammerhead shall be provided for vehicular ingress/egress.
- Access route shall be constructed from concrete.
- Access route should be assessed by a Transportation Engineer to confirm sufficient turning radii at entrances, exits and turning circles within the site.
- The route shall be constructed to be in accordance with the Urban Design Division Standard Drawing ULA-303.
- The route structure and makeup shall be designed to accommodate the following truck dimensions:
    - Weight: 35,000kg
    - Length: 12.2 m
    - Width: 3.3 m
    - Turning Radius: 15 m
- Sufficient lighting to be provided to ensure adequate illumination for maintenance activities and shall conform to applicable guidelines in the Section 1.8 of the existing City criteria.

2.4 Facility Sizing and Modelling

Facilities will be sized to meet quantity control requirements, per TRCA's SWM Criteria (April 2012 or most recent version). To address climate change controls, the IDF curve from the York University (YUG) rain gauge for the August 19, 2005, storm event shall be used to model ponding limit requirements within rights-of-way. The IDF curve can be found in Section 1.3.1.16 of the City criteria document.

Facilities shall be sized to ensure that the largest storage volume required does not exceed 90% of the total volume of the Facility. If Regional Controls are required for the proposed development, the required volume may be detained within a Non-Conventional SWMF, provided sufficient details are included to demonstrate feasibility.

Runoff Coefficients for contributing areas shall be determined per Section 1.3.1.17 of the City of Vaughan's Engineering Design Criteria. For storms larger than a 5 year return period, runoff coefficients shall be increased per Section 1.3.1.17 of the City's Engineering Design Criteria.

Computer modelling, as outlined in the Provincial Urban Drainage Design guidelines shall be required in calculating major and minor system flows for design areas greater than 5 hectares.

When the Rational Method is used, the general format of the City's Standard Storm Sewer and Overland Design Sheets are to be used. When computer modelling is used, the report shall indicate model parameters, assumptions used, outflow hydrographs and hydraulic grade line levels where applicable, flow depths and spreads and any other pertinent information.

A computerized hydrologic and hydraulic model is to be developed and used to conduct a dual drainage system analysis for developments greater than 5 hectares in size, although smaller developments may require such analysis depending on receiving drainage systems (at the discretion of the City). In cases where drainage from the development is to discharge to existing systems, detailed modelling of such downstream systems may be required, at the discretion of the City. The analysis is to be fully documented, prepared, and signed by a Professional Engineer.

Pre-treatment facilities (OGS units, low impact development facilities etc.) for quality control will be sized to meet City of Vaughan and TRCA SWM criteria (80% TSS removal). OGS units shall be designed to treat the incoming 5-year flows and will be credited for 60% TSS removal, provided the units have been sized using ETV Canada PSD.

2.5 Extended Detention

Extended Detention volume requirements shall be based on the criteria established in the Stormwater Management Planning and Design Manual, the TRCA's Stormwater Management Criteria, or site specific requirements as established in an approved Master Environmental Servicing Plan, Master Drainage Plan, City-Wide Storm Drainage & Stormwater Management Master Plan or as otherwise established by the City, TRCA or other relevant authorities with jurisdiction. Extended Detention may be provided within the Non-Conventional SWMF after pre-treatment. Minimum orifice sizes as outlined in **Section 2.3** are applicable.

2.6 Pre-Treatment Facility Options

A treatment train approach is required to accompany the proposed end-of-pipe Non-Conventional SWMF to meet water quality, and water balance criteria. Pre-treatment will also help reduce peak flows from the development and storage requirements by impacting the overall imperviousness of contributing drainage areas (directly and indirectly connected). It should be noted that erosion control capabilities of each pre-treatment facility should be considered against any site-specific detailed erosion analyses.

The following **Table 4** is a list of possible low impact development facilities and manufactured treatment devices assessed for pre-treatment, and what criteria that facility can address (which is dependent on the design of the facility).

TABLE 4: PRE-TREATMENT ALTERNATIVES

Technology/Facility	Examples	Benefit
Separation Manufactured Treatment Devices	ETV Verified OGS Units	Quality – maximum of 60% TSS removal if sized with Canadian ETV Particle Size Distribution (PSD)
Infiltration/Filtration	Basins, chambers, trenches, soakaway pits, dry swales, bioswales, grassed/vegetated swales, vegetated filter strips, rain gardens, etc.	Water Balance, Quality (public lands only), Erosion
Exfiltration Trenches/Systems	Perforated pipes, catchbasin exfiltration system	Water Balance, Quality, Erosion
Deep Sump Catchbasins	n/a	Large particle/ debris and garbage removal
Downspout disconnection to Soakaway Pits	n/a	Water Balance, Quantity, Erosion

The following general screening steps should be completed to help select which pre-treatment facility options will be most effective based on-site specific characteristics, however, the ultimate decision of the proposed pre-treatment facility must be acceptable and to the satisfaction of the City.

1. Assess site conditions (hydrogeological, geotechnical, environmental, development regulations).
2. Define design criteria per **Section 2.3**.
3. Screen pre-treatment options (site constraints, opportunities based on land-use types, performance requirements, operations & maintenance requirements)

All pre-treatment facilities should be included in the Operations & Maintenance Manual and Offset Fee calculation.

2.7 Design Drawings and Details

Submitted drawings shall adhere to Section 1.1 of the City of Vaughan's Engineering Design Criteria (December 2020, or most recent).

3.0 OPERATIONS & MAINTENANCE MANUAL

An Operations & Maintenance (O&M) Manual shall accompany the Detailed Design submission for all proposed facilities included in the SWM solution, which includes the Non-Conventional SWMF and any

pre-treatment facilities. The Manual shall be in accordance with guidelines set by MECP's Stormwater Management Planning and Design Manual (2003, or most recent version) and requirements in Schedule E of the CLI-ECA (if applicable). The Low Impact Development Stormwater Management Practice Inspection and Maintenance Guide (TRCA, 2016, or most recent version) and other guidance documents from local regulatory agencies can be referenced in the development of the O&M Manual, however CLI-ECA requirements shall remain paramount and takes precedence.

The manual shall outline the following:

- Description of types of facilities including function of facility (e.g., quantity, quality etc.), design volumes, discharges, design events etc.
    - Consultation with the City may be required to determine which department is responsible for various maintenance activities, for outline in the O&M document (e.g., Environmental Services or other).
- Maintenance frequency for all facilities and treatment devices included in the SWM solution, based on the sediment loading rate from the contributing drainage area.
- Annual maintenance costs calculated through a detailed breakdown of cost/frequency for relevant inspection, monitoring, and maintenance items.
- Calculation of costs associated with sediment disposal per most current Excess Soil Management Regulations.
- Facility Surface Inspection and Monitoring plan.
- Detailed execution plan for operations & maintenance based on maintenance type (frequent versus infrequent), including but not limited to the location of maintenance and monitoring ports and relevant access routes.
- Identification of any required personnel, training, and equipment (including dimensions) for all maintenance activities.

An Offset Fee Calculation is to be provided at the same time as the O&M Manual, which can be included in the manual, or provided as a separate document (refer to **Section 4.0** for guidance).

3.1 Inspection & Monitoring

The O&M manual shall provide sufficient detail on inspection and monitoring requirements, as well as the calculation of associated fees for inspection and monitoring. The cost differential between the fees for inspection and monitoring for the Non-Conventional SWMF compared to the fees for a Conventional SWMF of equal size/function over 50 years will be used in the calculation of the Offset Fee, as the "Inspection & Monitoring Cost" component. Refer to **Section 4.2** for applicable unit rates.

<u>Inspection</u>

The O&M Manual shall outline the inspection schedule for the proposed facilities, to ensure effective performance, as designed. Discharge from the facility is to be free of floating and settleable solids, and not contain oil or other substance in amounts sufficient to create a visible film, sheen, foam, or discoloration on receiving waters.

Within the first two years of post construction, facilities will require inspection after every significant storm to ensure proper functioning, (typically 4 times a year). After the first two years, the facility

should be inspected at a minimum of once a year, and after storm events which cause flooding. Inspection frequency shall also be determined by the recommendations from the chosen facility supplier. Standard inspections will determine what maintenance activities are required and should not require Confined Space Entry or CCTV monitoring.

The O&M Manual should provide a template for inspections, which are to be recorded and be available at the Owner's administrative offices. The template should include the following:

- Name of Inspector
- Asset ID of the Works inspected.
- Date and time of inspection
- Observations from inspection including (where applicable):
    - Hydraulic operation of works (e.g., length of occurrence since the last rainfall event, evidence, or occurrence of overflows.
    - Condition of surface vegetation in and around the Works.
    - Occurrence of obstructions at the inlet and outlet of the Works.
    - Evidence of spills and/or grease/oil contamination.
    - Frequency of surface trash build-up.
    - Measurements of sediment accumulation and water levels.

Monitoring

The O&M Manual shall outline a monitoring program of the facility in accordance with CLI-ECA requirements (Schedule E) to ensure proper functioning of the facilities from a quantity and quality perspective and inform any corrective measures that may be required prior to assumption. The monitoring plan must be reviewed and approved by the City and at the City's discretion, a third party to verify monitoring plan adequacy. The plan shall:

- Be carried out by the Landowner, or a delegated third party Qualified Person, with data recorded in an electronic database.
- Verify the operation performance of the Non-Conventional SWMF is as designed.
- Assess the environmental impact of the Non-Conventional SWMF.
- Identify the works to be monitored (outlets and facilities providing quantity and/or quality control).
- Identify key receivers to be monitored and monitoring locations.
- Consideration of relevant municipal land use and environmental planning documents.
- Identification of rainfall gauges to be used.
- Develop a program that includes:
    - Characterization of water quality and quantity conditions and development of quality and quantity goals.
    - Hydrological, chemical, physical, and biological parameters as appropriate.
    - Water level shall be measured with water level gauge clearly visible to take readings.
    - Monitoring methodology, including frequency and protocols for sampling, analysis, and recording, with consideration of dry and wet weather events and timing of sampling during wet weather events, and date and time of sampling.
- Identify schedule for plan implementation.

- Result in a report with analysis of monitoring information and data, with findings and recommendations.
- Identify adaptive measures based on results of monitoring.

Monitoring Plans shall be kept current following any alterations to the Non-Conventional SWMF and will be available to members of the public upon request. Monitoring plans shall be in accordance with the existing City of Vaughan monitoring requirements, per Section 1.3.5.20 of the City criteria. At minimum, monitoring will be required for the first two years of operations, and one additional year to be completed by the City, through the monitoring fee collected through the subdivision agreement, for a total of three years of monitoring.

3.2 Maintenance Cost

Sediment Removal

Sediment removal frequency should be calculated for any component of the treatment train that accumulates sediment. Sediment removal procedure shall be outlined in the O&M Manual. Overall sediment loading rates will be calculated based on the loading rates per impervious area outlined in Section 6.0 of the MECP Stormwater Management Planning and Design Manual, also shown below in **Table 5**.

The manual shall provide a detailed execution plan for sediment removal, which considers:

- Sediment removal construction drawings to demonstrate feasibility.
- Frequency of maintenance.
- Identification of access routes and paving requirements (heavy duty vs. light duty).
- Identification of staging locations.
- Sediment removal technique.
- Assessment of restoration requirements.
- Identification of confined space entry requirements (and applicable certifications).
- Equipment requirements.
- Flow diversion strategies.
- Traffic management considerations
- Consideration of impact on park uses.
- Plan for facility entry.
- Identification of Emergency Overland Flow Route

TABLE 5: SEDIMENT LOADING

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m^3)	Annual Loading (m^3/ha)
35%	770	1,230	0.60
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

*Source: MECP Table 6.3 in MECP Stormwater Management Planning and Design Manual

Increased Maintenance

A Maintenance Cost Assessment shall be completed for the proposed Non-Conventional SWMF and any proposed pre-treatment (e.g., OGS or other LID measures) units, which details the increased maintenance costs for the facility over a 50 year period. All unit rates used in the calculation of the Offset Fee shall be subject to annual indexing per Statistics Canada Non-Residential Construction Price Index, beginning from the year of the Non-Conventional SWMF Design Criteria. Adjustments to unit rates may be made by the City through updates of the Design Criteria to maintain accuracy to current typical industry rates.

Items that may need to be considered in the maintenance cost assessment, depending on product choice and placement, are:

- Structural inspection requirements.
- Replacement and maintenance of maintenance access routes in parks.
- ROW reconstruction.
- Restoration and/or replacement of vegetation/trees above and surrounding the facility after major rehabilitation.
- Replacement of components including OGS units, and inlet and outlet structures.
- Ongoing OGS maintenance.
- Flow by-pass contributions for major maintenance/replacement.
- Traffic Management for major maintenance/replacement within ROW's.
- If the City is responsible for implementation of any Park features, structures, facilities, and amenities where a Non-Conventional SWMF is located, the developer shall be responsible for any additional costs caused by the Non-Conventional SWMF.

Maintenance activities for the first 50 years of the proposed facilities, such as debris removal, shall be outlined in the Manual, including frequency for each maintenance activity and associated cost. Required maintenance activities shall be determined through visual surface inspections of all facilities included in the SWM solution. The Manual must consider the following items in the maintenance cost assessment of the proposed facilities, and provide detailed plans where applicable:

- Frequency of maintenance.
- Identification of access routes and paving requirements (heavy duty vs. light duty).
- Identification of stockpiling locations.
- Identification of staging locations.
- Sediment removal technique.
- Assessment of restoration requirements.
- Identification of confined space entry requirements (and applicable certifications).
- Equipment requirements.
- Flow diversion strategies.
- Traffic management considerations
- Consideration of impact on park uses.
- Plan for facility entry.
- Identification of Emergency Overland Flow Route.

Typical maintenance costs for non-conventional facilities are provided in the table below:

TABLE 6: EXAMPLE MAINTENANCE COSTS AND FREQUENCIES FOR NON-CONVENTIONAL SWMF'S

Item	Unit/ Frequency	Non-Conventional SWMF Rate
Confined Space Entry Structural Inspection	Every 10 years	$5000/day
Reconstruction of SWMF Inlet/Outlet Components (grates, orifice, weirs, etc.)	Every 50 years	Based on construction cost of inlet/outlet components
Replacement/Maintenance of OGS Components	Every 25 years	Based on construction cost for internal components
Restoration Activities		
Seed and Topsoil	m^2	$7
Grass Sod and Topsoil	m^2	$30
Upland Vegetation	m^2	$5
Trees	each	$550

The maintenance fees for the operations and maintenance of a comparative Conventional SWMF shall be calculated assuming a design life of inlet/outlet structures of 50 years. The cost of replacement shall be calculated based on current construction costs. Any other maintenance typically associated with Conventional SWMF's shall also be included in the maintenance cost calculation. The below table provides unit costs for typical maintenance activities that can be used in this calculation.

TABLE 7: EXAMPLE MAINTENANCE COSTS AND FREQUENCIES FOR CONVENTIONAL SWMF'S

Item	Unit/ Frequency	Conventional SWMF Rate
Standard Maintenance		
Inlet/Outlet Structures	Every 50 years	Based on construction cost
Grass Cutting	Per ha per year	$292
Litter Removal	Per ha per year	$105
Vegetation Maintenance	Per year	$1,000
Tree trimming for overhead clearance of Access Road	Every 3 years	$2,000
Restoration Activities		
Seed and Topsoil	m^2	$7
Grass Sod and Topsoil	m^2	$30
Upland Vegetation	m^2	$5
Trees	each	$550

Items with "Per ha area" listed as their frequency above are for the pond block area. The delta between the total maintenance cost, including sediment removal, over a 50 year period for a Conventional and Non-Conventional SWMF will be used in the calculation of the Offset Fee as the "Maintenance Cost" component. All unit rates used in the calculation of the Offset Fee shall be subject to annual indexing per Statistics Canada Non-Residential Construction Price Index, beginning from the year of the Non-Conventional SWMF Design Criteria.

4.0 FINANCIAL REQUIREMENTS

Compensation fees will be calculated and collected by the City after the submission of Detailed Design, prior to assumption. All facilities (quality and quantity) included in the SWM solution to be assumed by the City should be included in the calculation of the fees (pre-treatment and Non-Conventional SWMF).

4.1 Final Offset Fee

An Offset Fee Calculation is to be provided at the same time as the submission of the Operations & Maintenance Manual at the detailed design stage. It can be included in the manual or provided as a standalone document. The Offset Fee will quantify the operation and maintenance cost differential between the Non-Conventional SWMF (and pre-treatment facilities) and a Conventional SWMF of equal size/function over a period of 50 years.

The Landowner is to provide a 25-year Manufacturer extended warranty for non-conventional SWMFs. Should an extended warranty to the City's satisfaction not be provided, inclusion of a SWMF rehabilitation fee will be added to the total Offset Fee. Rehabilitation of SWMF's is necessary to ensure the structural integrity and longevity of the facility.

The Offset Fee calculation is to use the unit rates for each activity provided in the tables in **Section 3.2** and **Section 4.2**, and is to be the summation of:

- Inspection and monitoring costs over the specified period.
- Maintenance costs over the specified period.
    - Increased cost of construction, materials and over the specified period shall be considered in the fee calculation.
    - Any proposed pre-treatment units shall be included in the maintenance cost calculation.
- Inclusion of a SWMF rehabilitation fee should a 25-year extended warranty to the satisfaction of the City Solicitor not be provided for the facility:
    - Concrete rehabilitation of 40% of the facility inner surface area for concrete SWMFs.
- If the City is responsible for implementation of the Park features after assumption, the developer shall be responsible for any additional costs caused by the Non-Conventional SWMF.
- In the case of infill developments with drainage areas of 2 ha or less which propose concrete superpipes, a replacement/rehabilitation fee is not required regardless of an extended warranty plan. Additional infrastructure such as inlet and outlet structures and components of pre-treatment devices shall still be considered.

All unit rates used in the calculation of the Offset Fee shall be subject to annual indexing per Statistics Canada Non-Residential Construction Price Index, beginning from the year of the Non-Conventional SWMF Design Criteria. Adjustments to unit rates may be made by the City through updates of the Design Criteria to maintain accuracy to current typical industry rates. All calculations must be accompanied by a Sealed Engineering opinion that corroborates the assumed service life of the proposed SWMF.

The Final Offset Fee shall be a requirement of the Subdivision or other Development Related Agreement and paid to the City by the Landowner prior to the registration of the Subdivision or other Development Related Agreement. The fee shall be determined by the following:

$$Final\ Offset\ Fee = Inspection\ \&\ Monitoring\ Costs + Maintenance\ Costs$$

Where:

"Inspection & Monitoring Costs" is defined as the differential between the inspection and monitoring costs calculated for a Conventional versus Non-Conventional SWMF, outlined in the O&M Manual. Refer to **Section 3.1** for a full description of what is involved in these costs. Refer to **Section 4.2** for estimation methodology.

"Maintenance Costs" is defined as the differential between the costs, including structural inspections, OGS component replacement, sediment removal, and inlet/outlet replacements, for a Conventional versus Non-Conventional SWMF, outlined in the O&M Manual. Refer to **Section 4.2** for estimation methodology.

4.2 Final Offset Fee Estimation Methodology

"Inspection & Monitoring Costs"

The following unit rates shall be used in the calculation of the inspection costs for the proposed Non-Conventional SWMF and Conventional SWMF of equal size/function.

TABLE 8: EXAMPLE INSPECTION COSTS

Item	Frequency (years)	Unit	Non-Conventional SWMF Rate	Conventional SWMF Rate
Inspection Activity				
Surface Inspection	1	each	$500	$2000

"Maintenance Costs"

The sediment removal cost for a Non-Conventional SWMF shall be determined using a unit rate of $500/m^3 of sediment. This fee covers all associated restoration, disposal and equipment required for sediment removal.

The comparative maintenance fee for a Conventional SWMF of equal size/function shall be calculated based on a unit rate of $200/m^3 of sediment. The calculation assumes that the sediment loading rate is consistent between the two facilities. For the purposes of the Offset Fee, sediment accumulation will be calculated over a period of 50 years.

Rates were determined through a survey of recent cleanout costs collected from various municipalities in Southern Ontario.

Overall maintenance costs will be highly dependent on the specified product. Maintenance costs shall be calculated over a period of 50 years and shall include general maintenance for the continued operation of the facilities including upstream treatment train approach. An Engineer shall provide recommendations for structural inspection, and replacement of components such as OGS units, inlets and outlets, based on design life. Further details and considerations are provided in **Section 3.2**.

Rehabilitation of SWMF's facilities may be added to the Offset Fee should a 25-year Manufacturer extended warranty not be provided or accepted by the City. The warranty must cover any

rehabilitation works that will be required over the first 25 years, beginning at the time of Assumption. Suppliers providing a warranty shall be subject to the terms and conditions of a legal agreement provided by the City, and to the satisfaction of the City solicitor.

TABLE 9: EXAMPLE ADDITIONAL MAINTENANCE COST

Item	Unit/ Frequency	Non-Conventional SWMF Rate
Concrete SWMF Rehabilitation (without extended warranty)	40% of the inner SWMF surface area every 50 years	$2600/m^2 of internal concrete SWMF surface area

Restoration and rehabilitation/replacement costs for the inlet and outlet structures of a Conventional SWMF of equivalent size/function shall be used to calculate the comparative maintenance costs for a Conventional SWMF. Further details and considerations are provided in **Section 3.2.**

5.0 ASSUMPTION

Prior to City assumption of the Non-Conventional SWMF's, the following must be provided through a Certificate of Conformance which has been completed by a Qualified Engineer, in addition to any requirements of assumption provided within the subdivision agreement:

1. Proof of structural stability – to be confirmed through CCTV, or other methods to the satisfaction of the City.
2. Proof that the facility is functioning as intended through flow monitoring.
3. Proof the facility is free of sediment and debris - to be confirmed through CCTV, or other methods to the satisfaction of the City.
4. Record drawings sealed by the Engineer of Record, certifying that the construction was completed per the design. Record drawings are to be in accordance with PEO's guidance document on Preparing As-Built and Record Documents, and the City of Vaughan's As-Constructed Document Requirements.
5. If applicable, record of and agreement on any extended warranty for the rehabilitation of SWMF's.
6. Completion of and records for a minimum two-year monitoring and report program to the satisfaction of the City Terms of Reference and CLI-ECA requirements.

Additionally, requirements per the City's Engineering Design Criteria Section 1.3.5.20 and 1.3.5.21 must be met, where applicable. The following materials required include but are not limited to:

- Annual Sediment Level Monitoring
- Inclusion of:
    - O&M Manual sealed by a qualified P.Eng.
    - SWM Report Sealed by qualified P.Eng.

  - Digital photos of the SWM Facility
  - AutoCAD drawings of facility
  - GIS Shapefiles of facility
  - Monthly Outlet Inspection Records
- Inlet and Outlet Flow Monitoring records
- Digital set of approved and the as-constructed technical drawings (sealed by a qualified P.Eng.)

For a comprehensive list, refer to the relevant sections of the City Design Criteria Sections 1.3.5.20 and 1.3.5.21. Depending on results shown in monitoring data, remedial works may be required to the satisfaction of the City, which will require at least one additional complete season of monitoring of remedial works. The City will reserve the right to require additional monitoring until the facility is performing to its satisfaction.

It is noted that in a scenario where the developer does not complete the installation of the park features prior to assumption, the applicant shall be required to provide payment for any additional park development expenses that are due to the implementation of the Non-Conventional SWMF. A budget for the development of the park will be provided by the City which will include estimate construction costs, consulting fees, contingency, applicable taxes, and administrative fees. Per Developer Build Park Policy No. 07.2.05, the landowner will prepare detailed construction drawings at the appropriate stages, as well as a detailed cost estimate. Costs that are incurred that are specific to the Non-Conventional SWMF and in excess of the standard park specifications are the landowner's financial responsibility and will be considered separate from standard development charges.

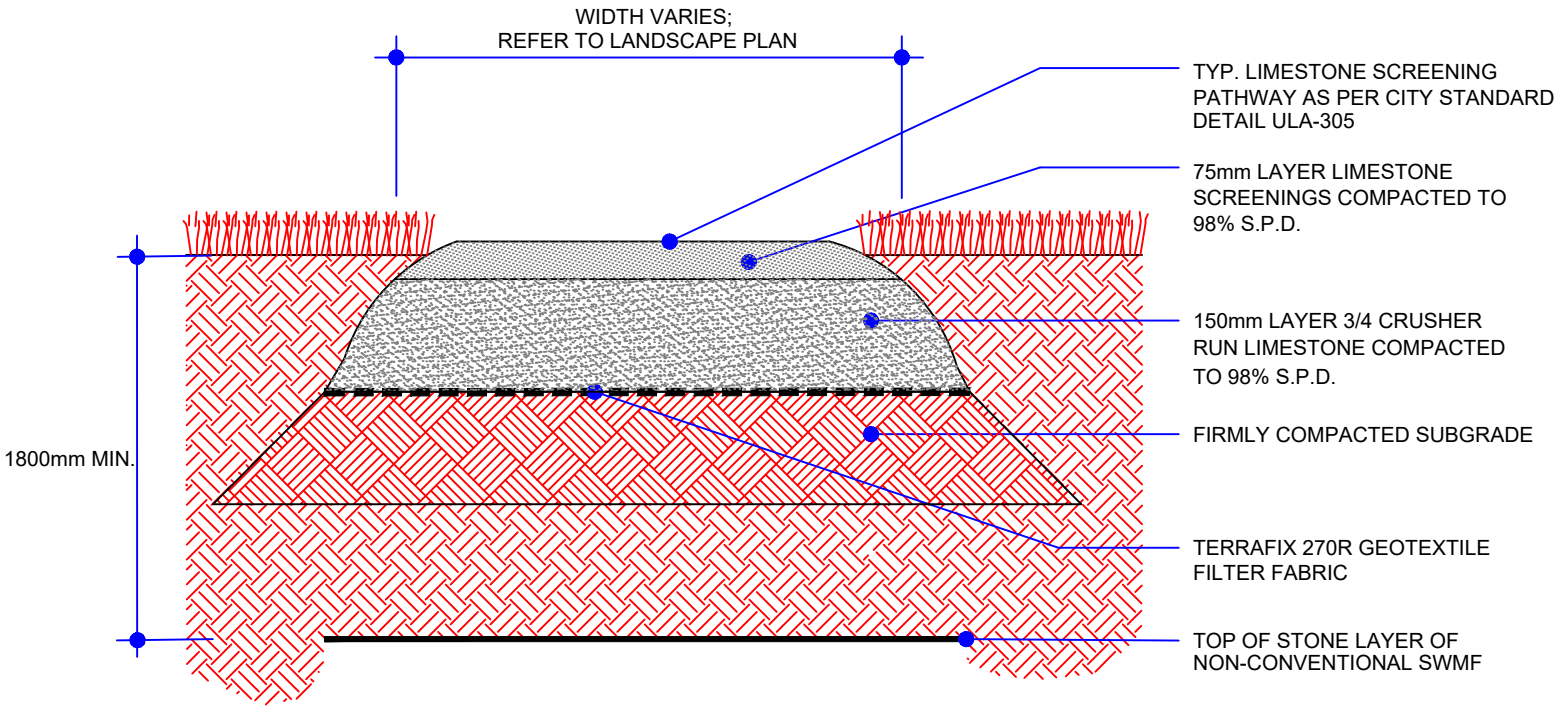
The City may also request any other details and information required by the Director of Development Engineering.

6.0 COMPLETION APPROVAL

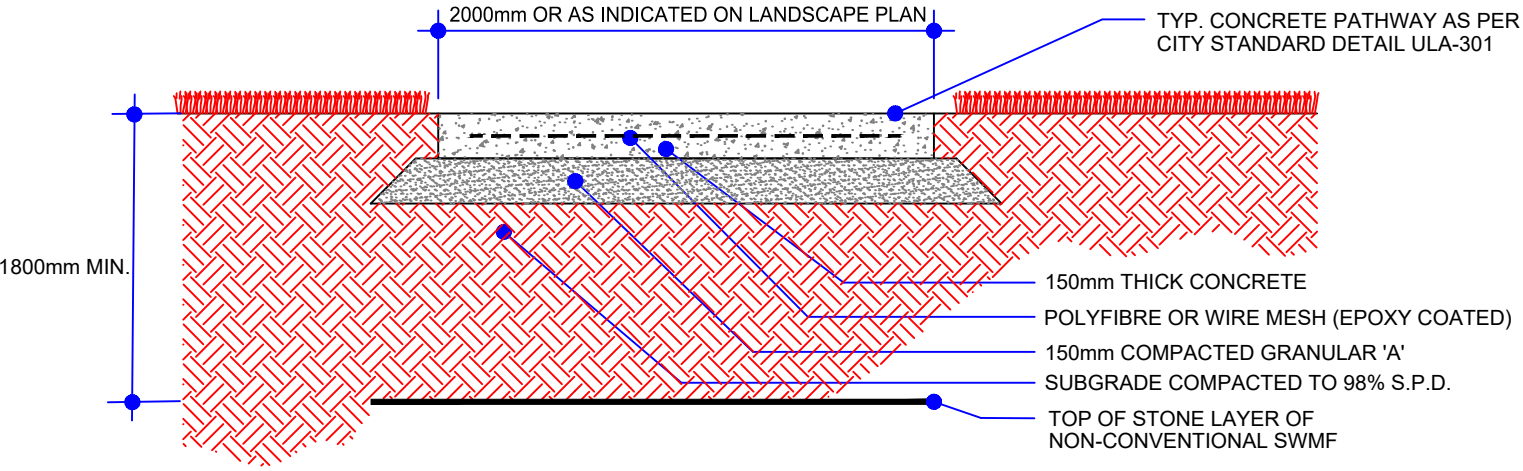
The following list is an overview of documentation required prior to, and for Completion Approval, which shall be submitted in digital format on CD-ROM or DVD disk with the final or as-constructed subdivision submission. Designs are to be in accordance with the requirements per City's Engineering Design Criteria Section 1.3.5.20 & 1.3.5.21 must be met, where applicable. Each submission shall include the applicant's contact information for comment coordination on the sufficiency of each submission.

1. New Facility Information
    a. Type
    b. Function
    c. General Description
    d. Location Description
    e. Nearest Major Intersection
    f. Municipal Address
    g. Easting
    h. Northing
    i. Access
    j. Driveway (y/n)
    k. Driveway Material
    l. Vehicle Turnaround (y/n)

   m. Gate Present (y/n)
   n. Lock Present (y/n)
   o. Adjacent Land Use (Residential/Commercial/Industrial/Rural)
   p. Land Use above facility (ROW/Park/Open Space)
   q. City Block Number
   r. Comments
2. Drawings (*.TIF)
   a. Storm sewer drainage areas plans (internal and external)
   b. Overland flow drawings
   c. All drawings related to proposed SWM facilities including section & details of facility, inlet/outlet structures, detailed plan views etc.
   d. All major & minor system design sheets
3. SWM Facility Report (PDF)
   a. SWM Facility Design Report
   b. SWM Facility Operations & Maintenance Report
4. Digital Photos of SWM Facility prior to assumption (*.JPG)
   a. All significant components
5. AutoCAD Drawing (*.DWG)
   a. Property lines associated with SWMF area.
   b. Ensure inlets and outlets are labelled.
6. GIS File Geodatabase (ESTRI File Geodatabase compatible with ArcMap 10.2.2)
   a. In NAD83 Zone 17N
7. Environmental Compliance Approval Document (ECA)
   a. Certificate of Approval OR Environmental Compliance Approval for each facility.



SECTION - LIMESTONE SCREENING PATHWAY
(DERIVED FROM CITY STANDARD DETAIL ULA-305)



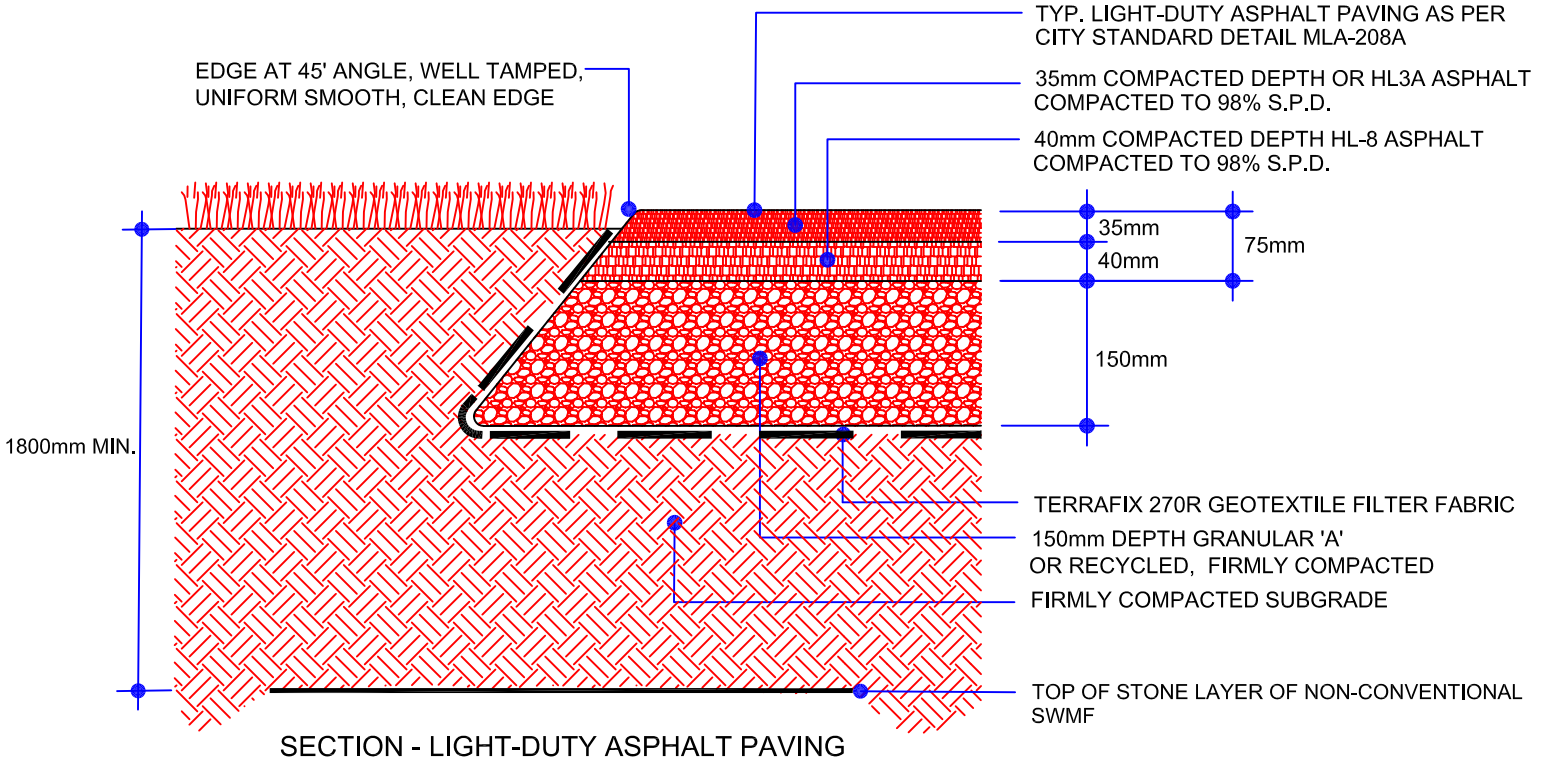
SECTION - CONCRETE PAVING PATHWAY
(DERIVED FROM CITY STANDARD DETAIL ULA-301)

NOTES:

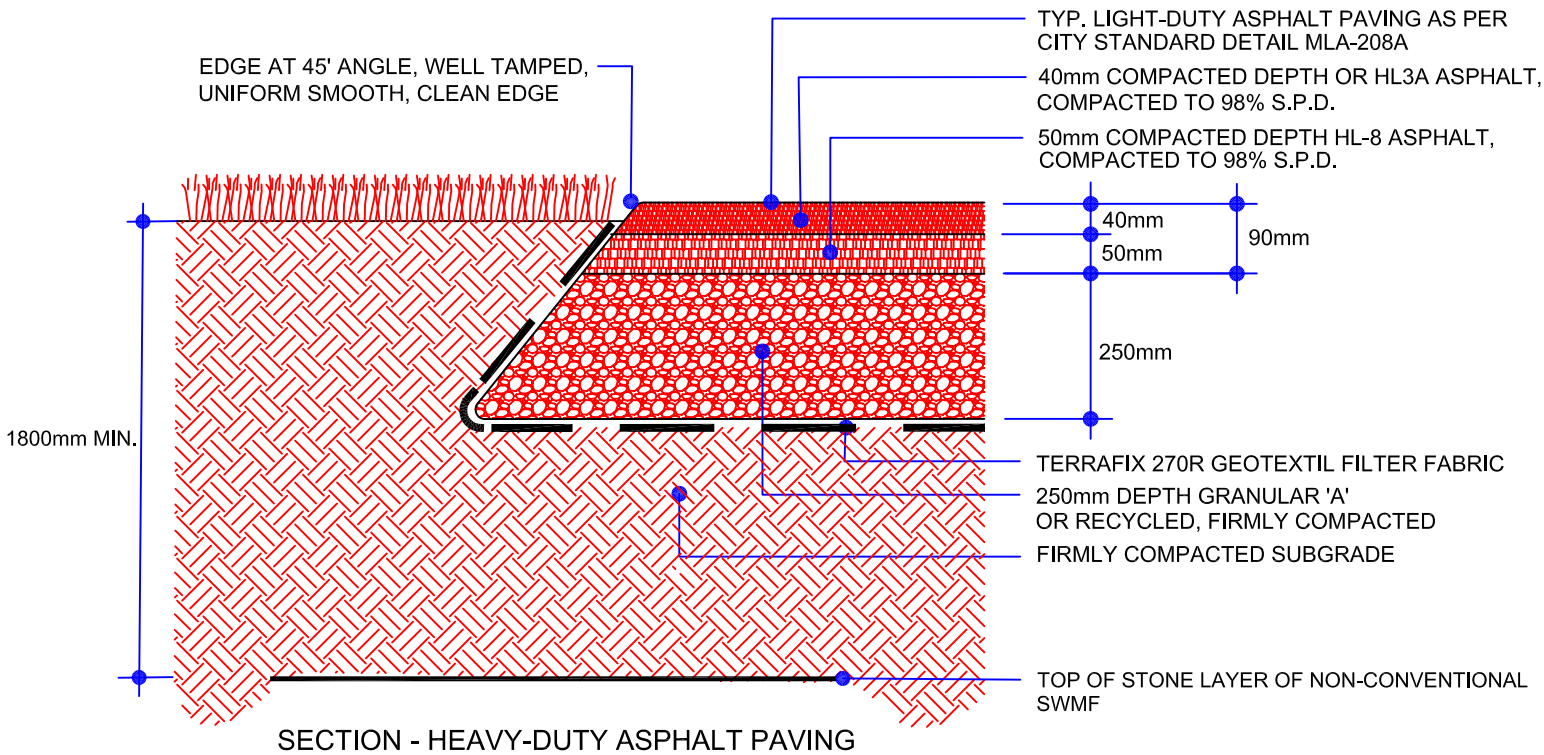
1. ALL DIMENSIONS ARE IN MILLIMETERS
2. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION
3. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO PATHWAYS ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAILS ULA 301 AND 305 FOR PAVING DETAILS

PATHWAY (TYP.) ABOVE A NON-CONVENTIONAL SWMF

SWMF - 01



SECTION - LIGHT-DUTY ASPHALT PAVING
(DERIVED FROM CITY STANDARD DETAIL MLA-208A)



SECTION - HEAVY-DUTY ASPHALT PAVING
(DERIVED FROM CITY STANDARD DETAIL MLA-209)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS
2. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION.
3. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO PATHWAYS ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAILS MLA 208A AND 209 FOR PAVING DETAILS.

ASPHALT
PATHWAYS (TYP.) ABOVE
NON-CONVENTIONAL SWMF

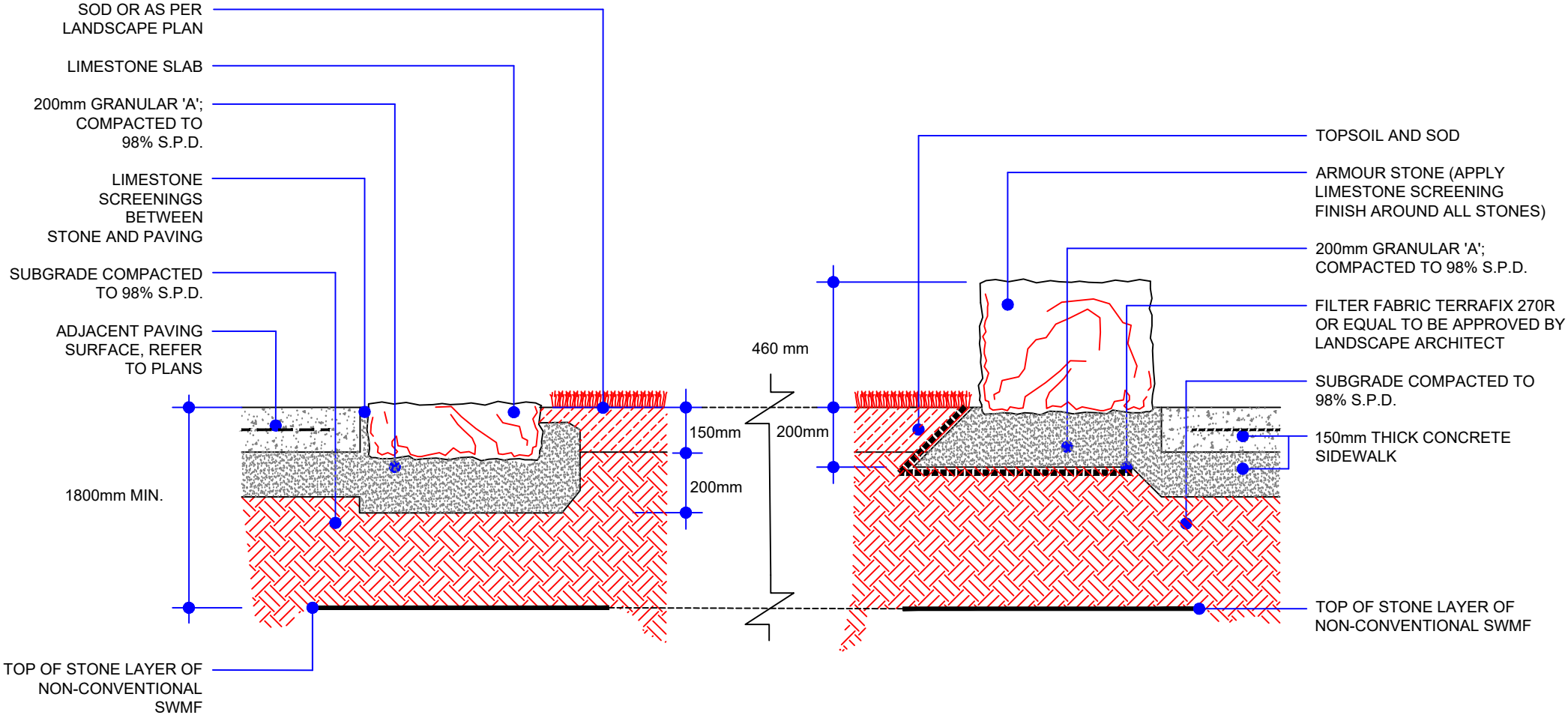
SWMF - 01A

SECTION - STEPPING STONE ADJACENT WALKWAY

(DERIVED FROM CITY STANDARD DETAIL ULA-311)

SECTION - ARMOUR STONE WITH P-I-P CONCRETE SIDEWALK

(DERIVED FROM CITY STANDARD DETAIL ULA-309)

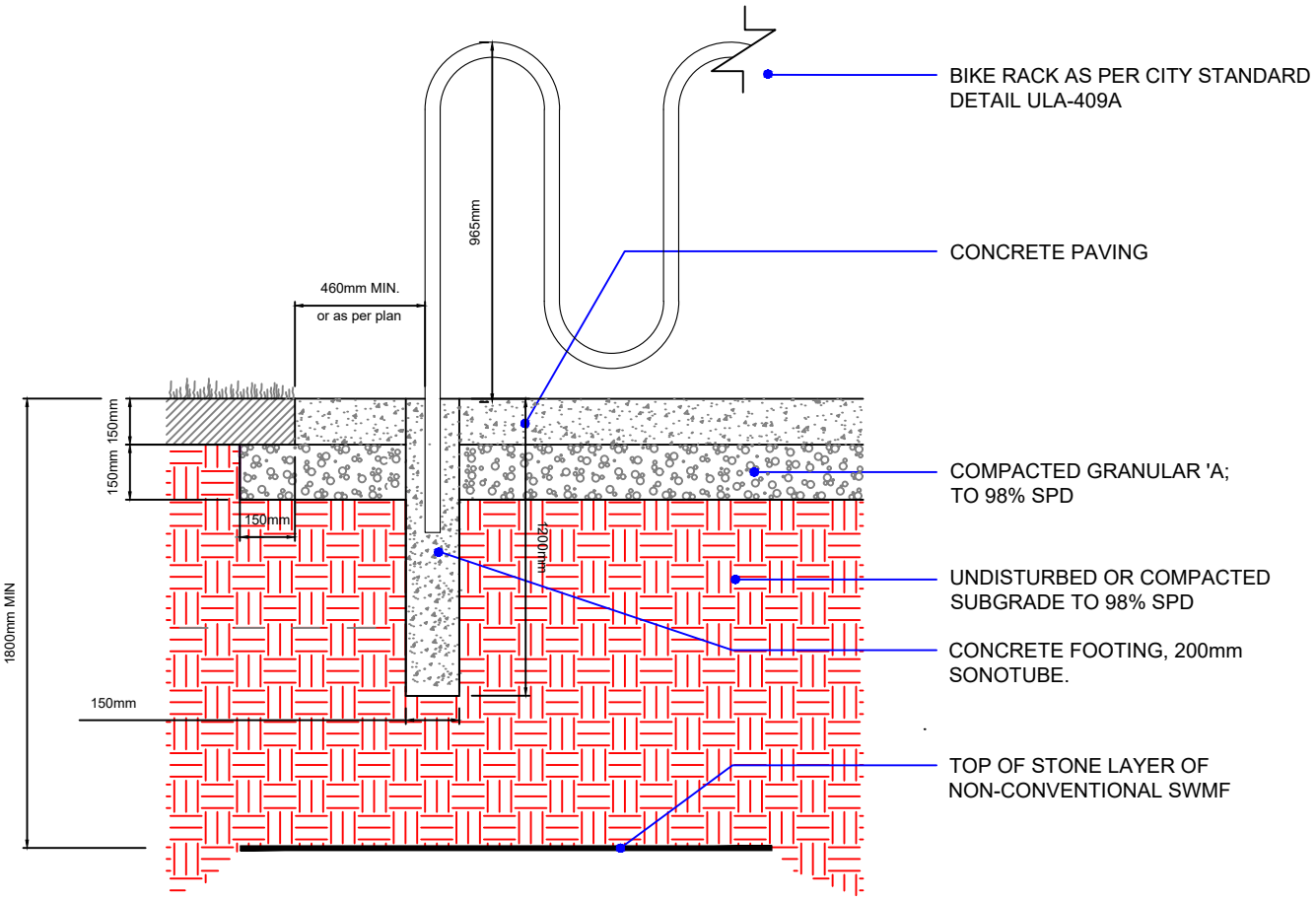


NOTES:

1. All stones to be approved by Landscape Architect prior to installation.
2. All quarry stone to have split or naturally weathered faces; no exposed drill markings.

ARMOUR STONE (TYP.) DETAIL ABOVE A NON-CONVENTIONAL SWMF

SWMF - 02



NOTES:

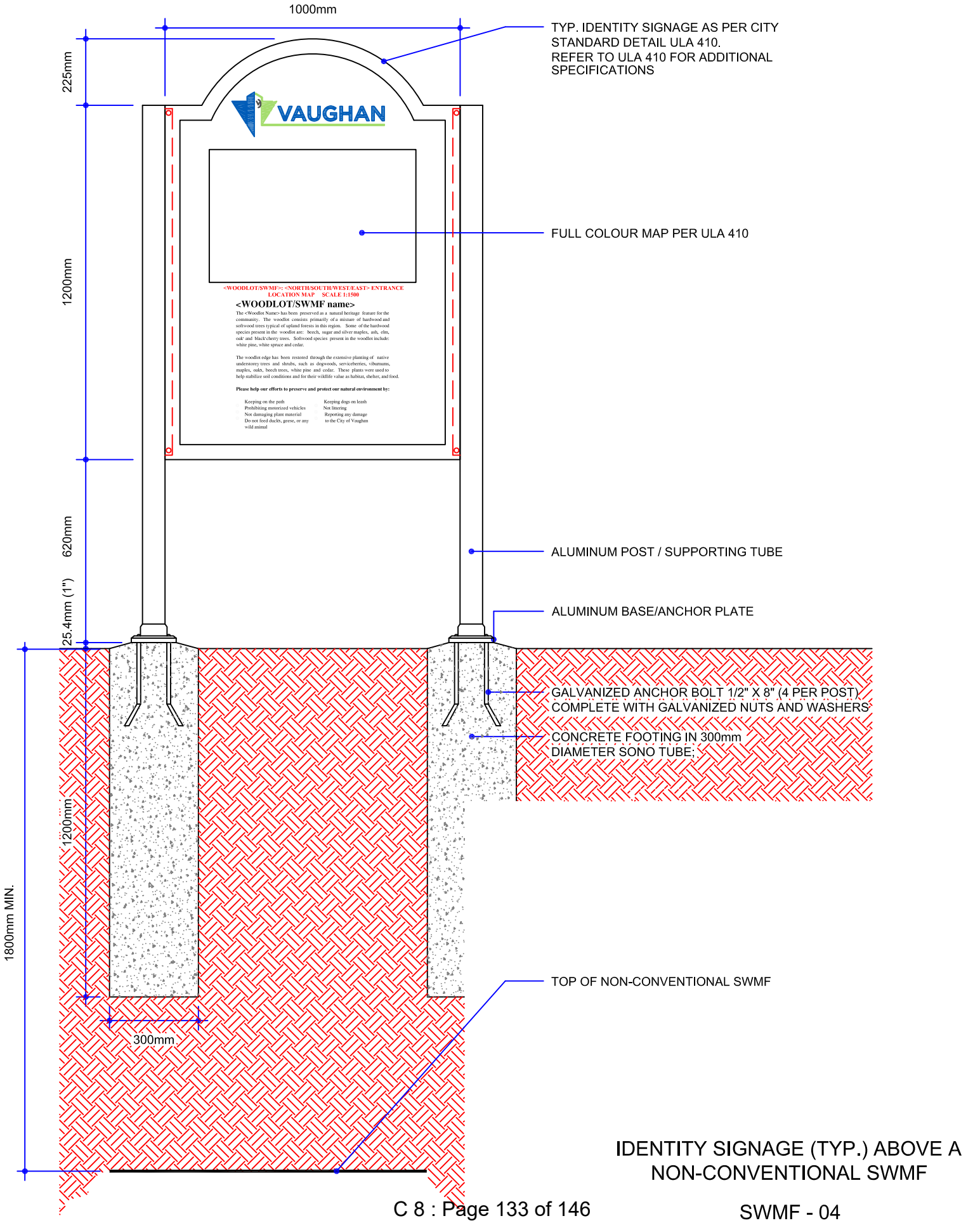
1. ALL DIMENSIONS SHOWN IN MILLIMETRES

2. REFER TO LAYOUT PLAN FOR PLACEMENT/LOCATION OF BIKE RACK

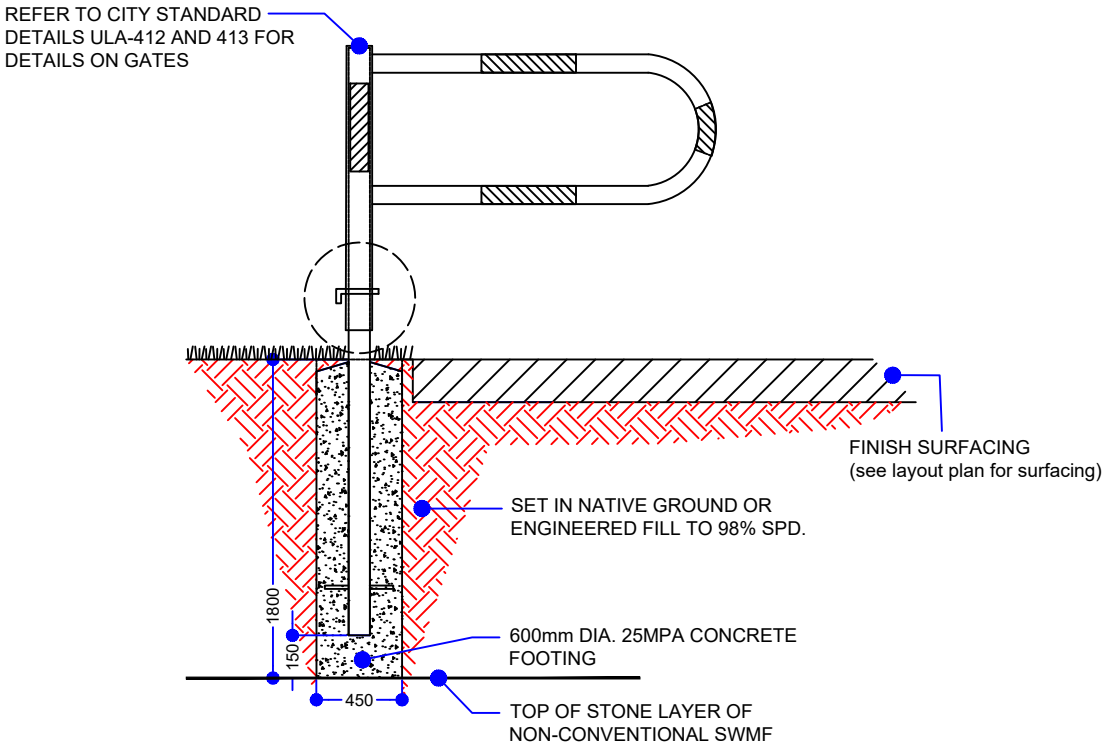
3. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION

4. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO BIKE RACKS ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAIL ULA 409A FOR BIKE RACK DETAILS

BIKE RACK DETAIL (TYP.) ABOVE A NON-CONVENTIONAL SWMF



IDENTITY SIGNAGE (TYP.) ABOVE A NON-CONVENTIONAL SWMF



NOTE:

1. ALL MEASUREMENTS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.

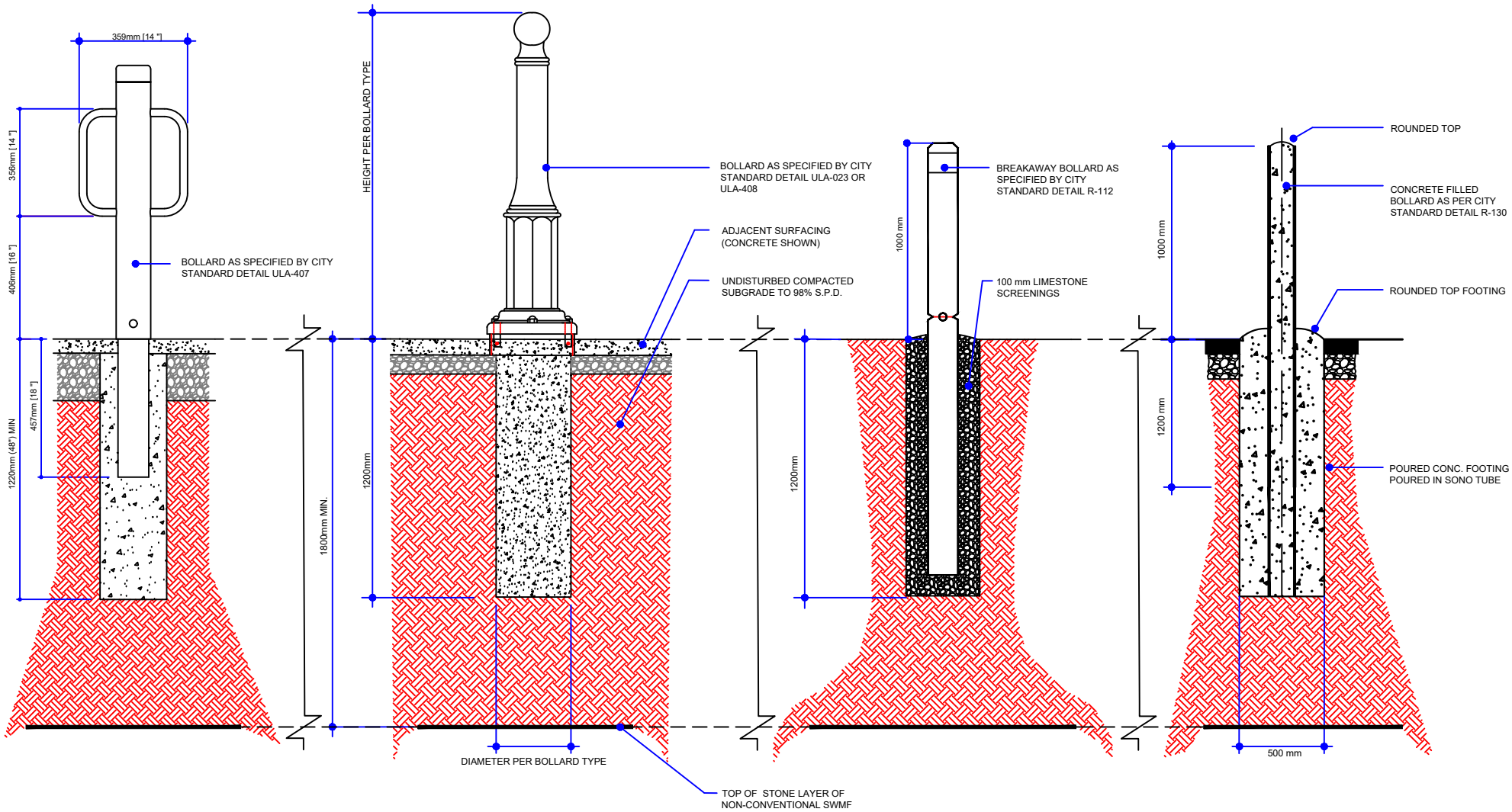
2. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION

3. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO GATES ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAILS ULA-412 AND 413 FOR GATE DETAILS

4. LOCATION TO BE FIELD STAKED AND APPROVED BY LANDSCAPE ARCHITECT PRIOR TO INSTALLATION.

5. PROTECT EXISTING PATHWAYS AND WALKWAYS FROM DAMAGE. CONTRACTOR RESPONSIBLE TO RESTORE ALL DAMAGES AT NO ADDITIONAL COST TO THE CITY.

GATE (TYP.) ABOVE A NON-CONVENTIONAL SWMF



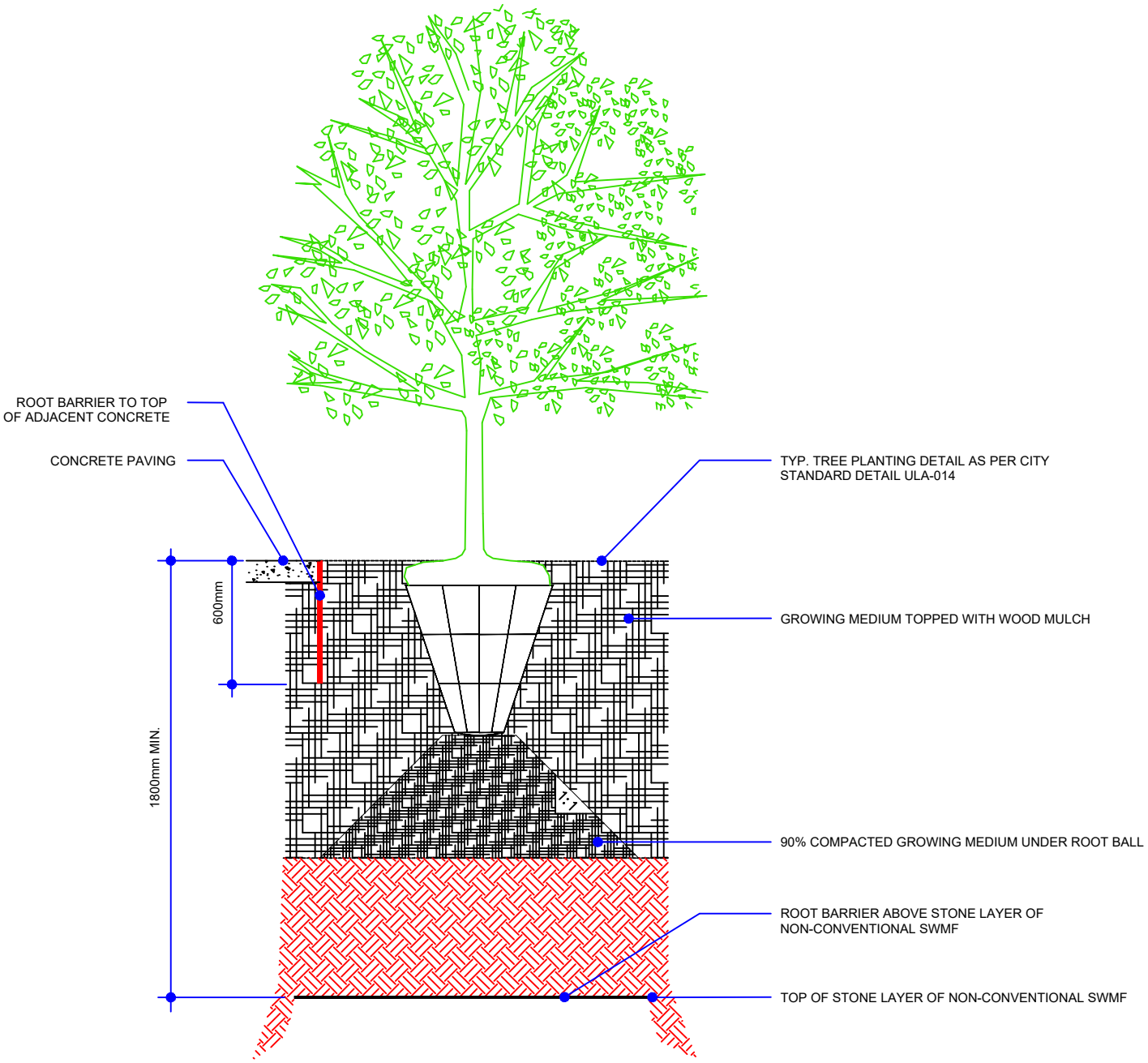
NOTES:

1. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION

2. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO BOLLARDS ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAILS ULA-023, 407 AND 408 FOR BOLLARD DETAILS. REFER TO CITY STANDARD DETAIL R-112 FOR BREAKAWAY BOLLARD DETAILS. REFER TO CITY STANDARD DETAIL R-130 FOR CONCRETE BOLLARD DETAILS

BOLLARD (TYP.) ABOVE A NON-CONVENTIONAL SWMF

SWMF - 06



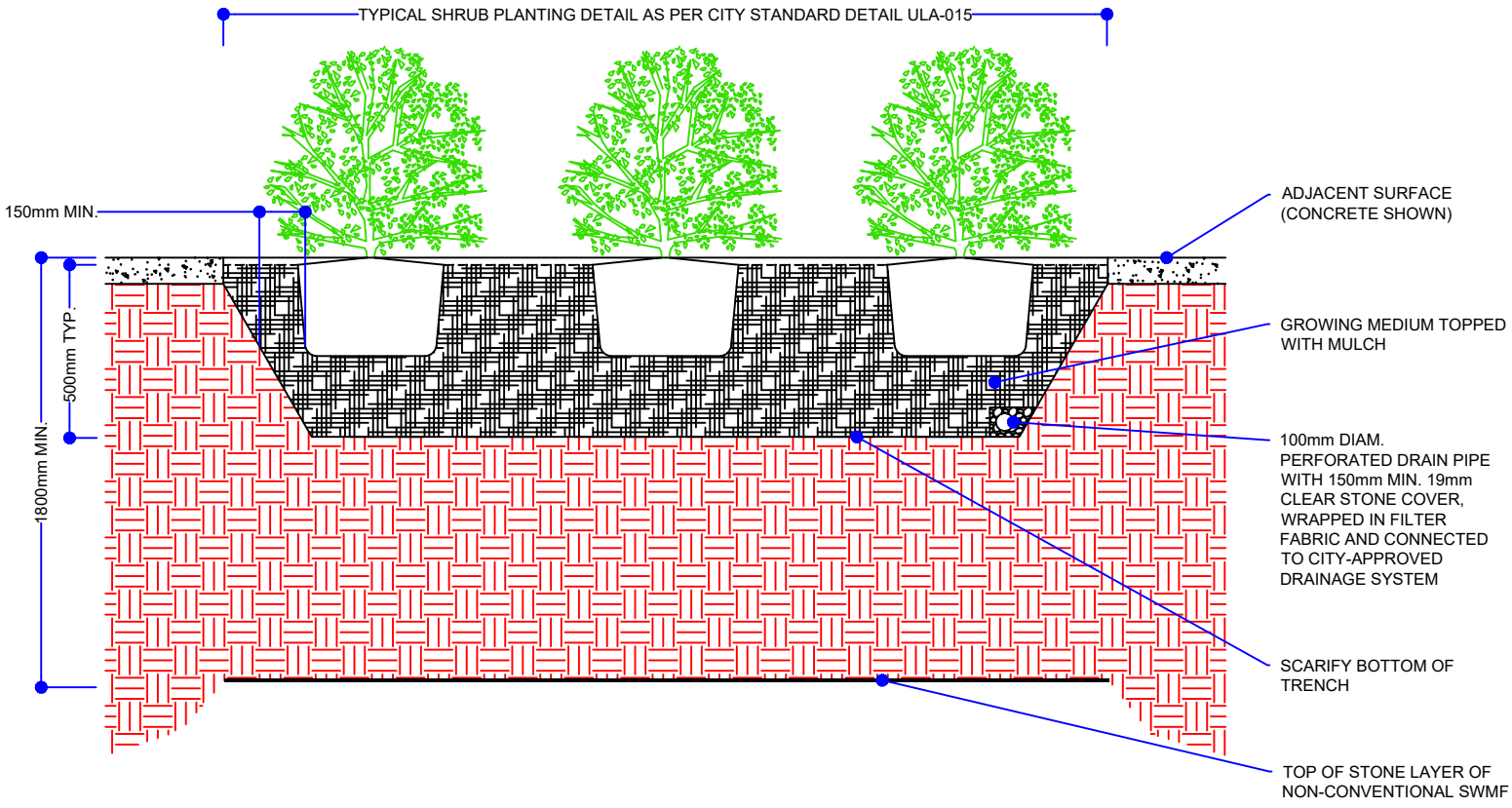
NOTES:

1. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION

2. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO TREE PLANTING ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAIL ULA-014 FOR TREE PLANTING DETAILS

TYPICAL TREE PLANTING ABOVE A NON-CONVENTIONAL SWMF

SWMF - 07



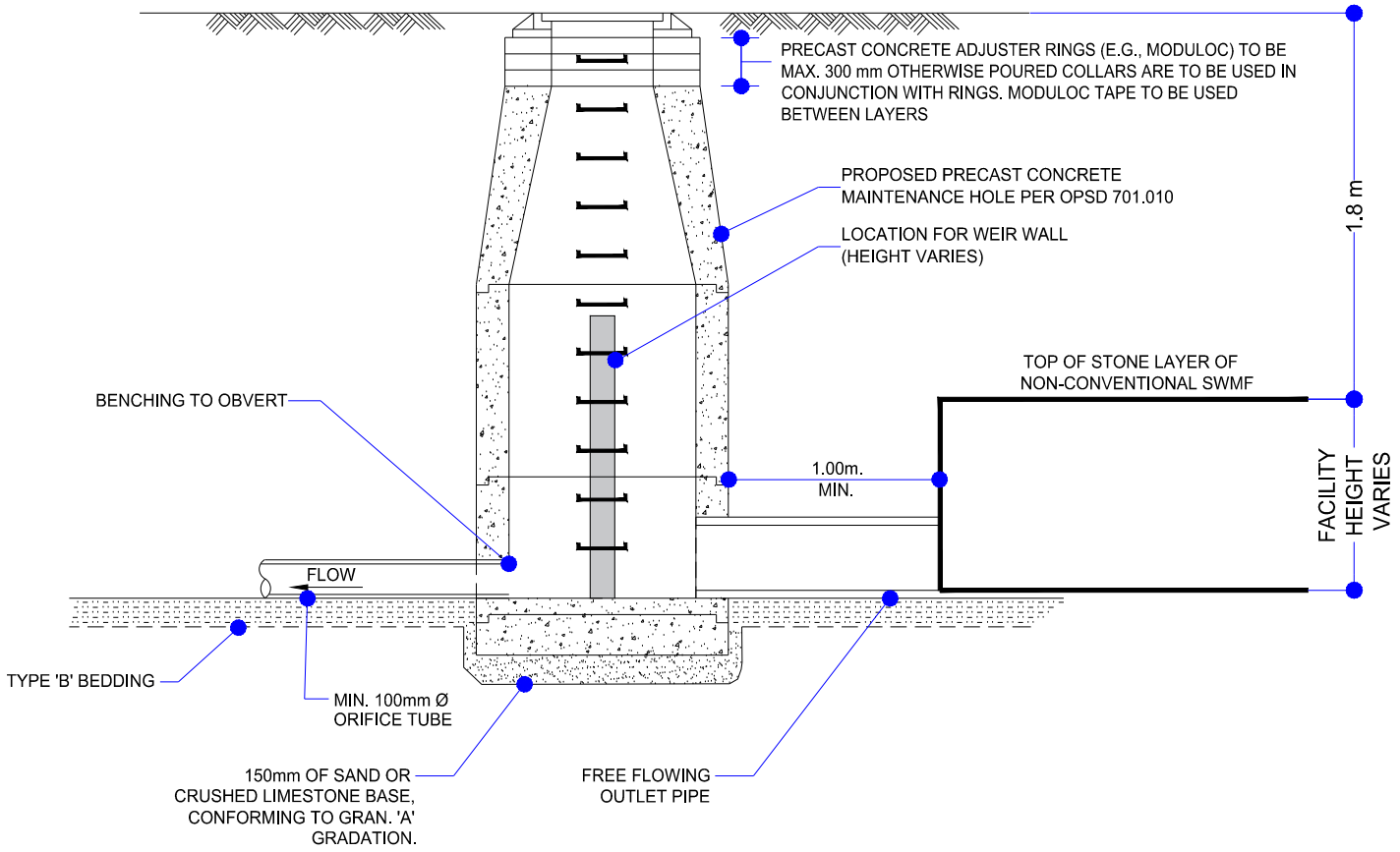
NOTES:

1. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION

2. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO SHRUB PLANTING ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAIL ULA-015 FOR SHRUB PLANTING DETAILS

TYPICAL SHRUB PLANTING ABOVE A NON-CONVENTIONAL SWMF

SWMF - 08

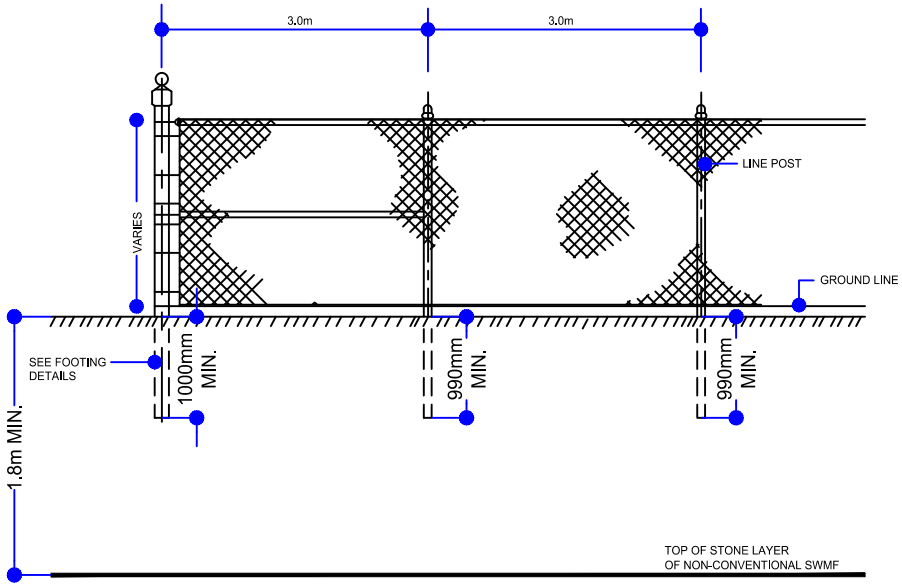


NOTE

1. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION
2. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO THE NON-CONVENTIONAL SWMF, DOWNSTREAM MANHOLE CONNECTIONS.
3. THIS DETAIL HAS BEEN DERIVED FROM CITY STANDARD DETAIL C-104.

EXAMPLE STORM CONNECTION DOWNSTREAM FROM NON-CONVENTIONAL SWMF

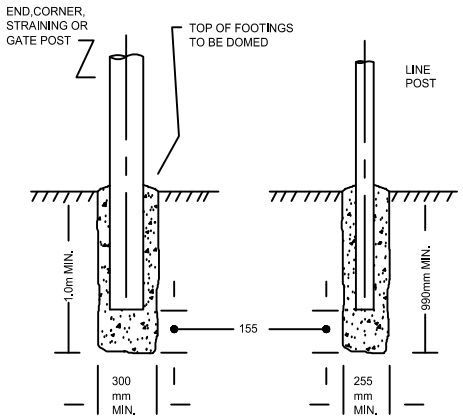
SWMF - 09



FENCE DETAILS

NOTE

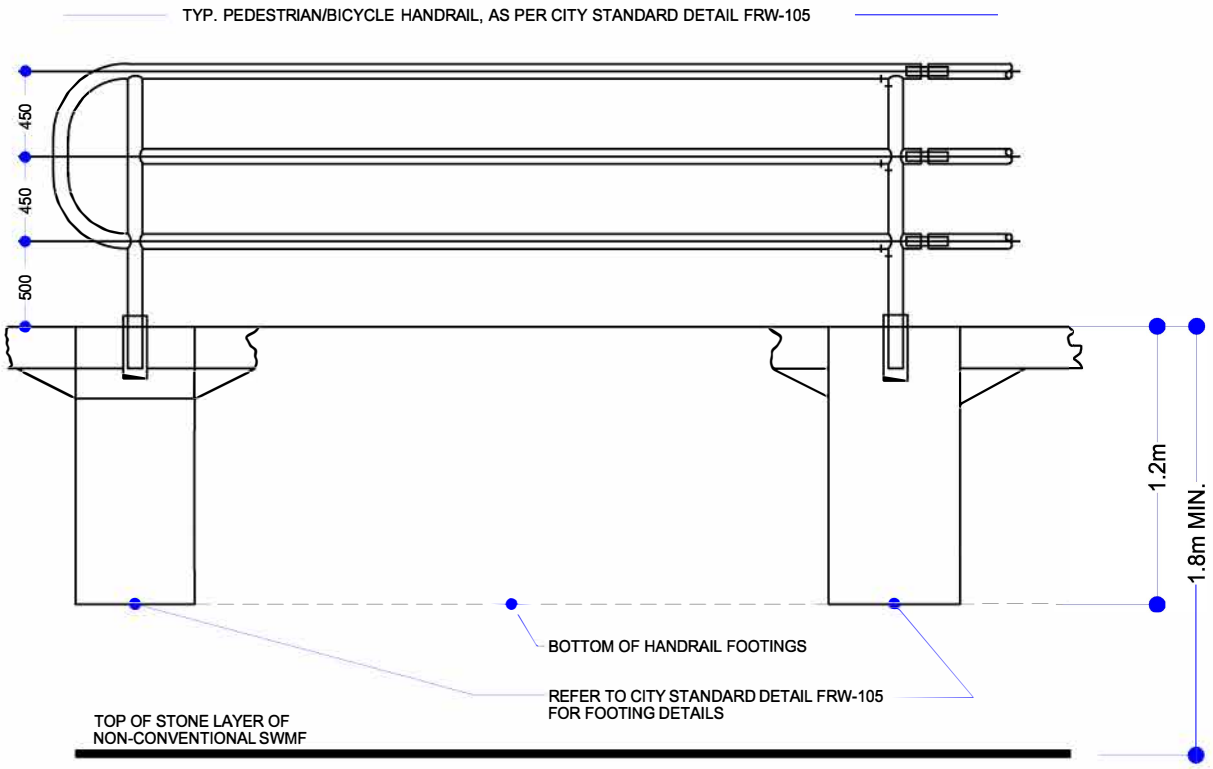
1. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION
2. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO CHAIN LINK FENCES ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAIL FRW 101 FOR ADDITIONAL SPECIFICATIONS ON CHAIN LINK FENCES



FOOTING DETAILS

CHAIN LINK SECURITY FENCE (TYP.)
ABOVE A NON-CONVENTIONAL SWMF

SWMF - 10

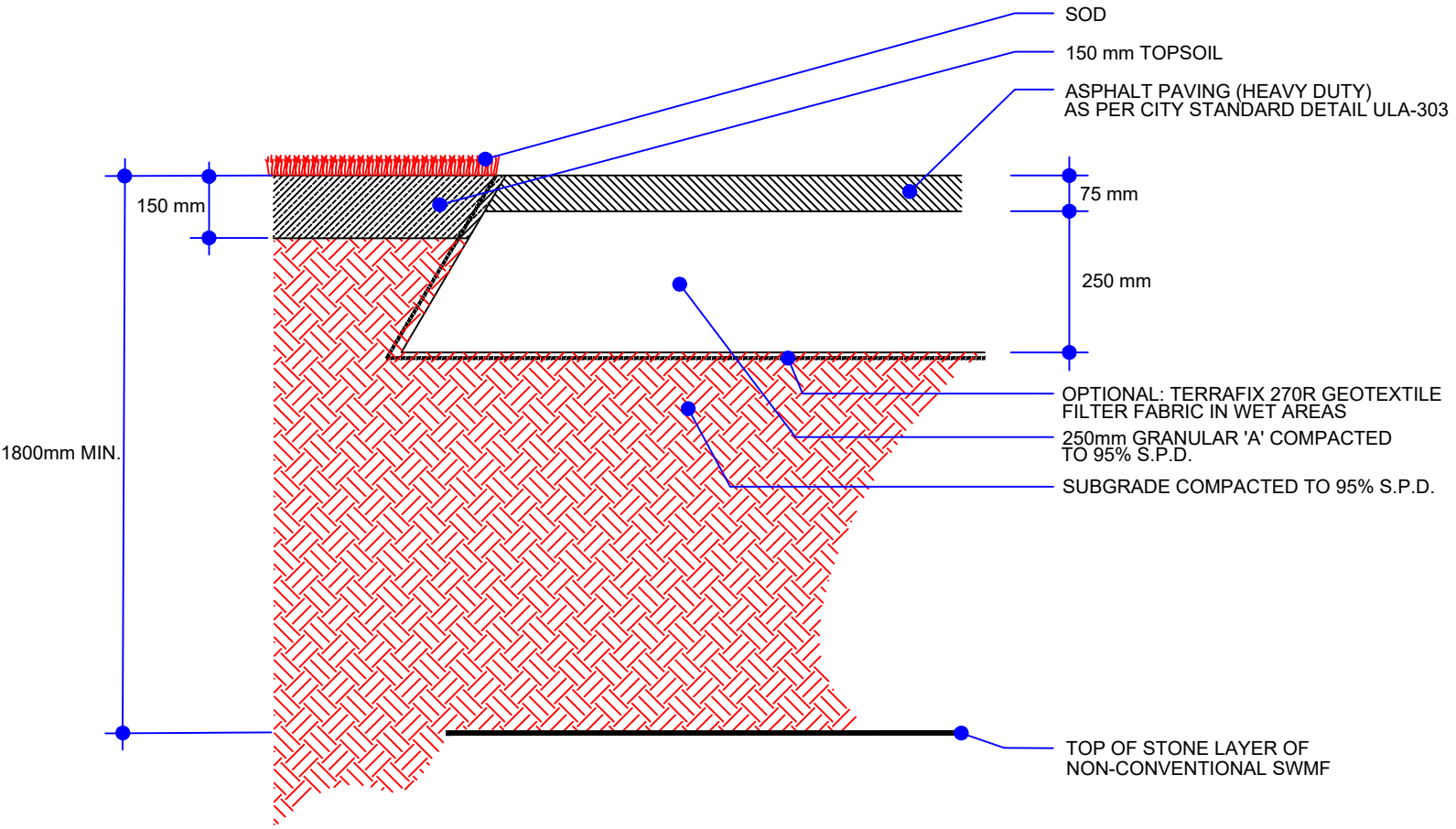


NOTE

1. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION
2. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO PEDESTRIAN/BICYCLE HANDRAILS ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAIL FRW 105 FOR ADDITIONAL SPECIFICATIONS ON HANDRAILS
3. THIS STANDARD TO BE USED IN PLACE OF OPSD 980.101 WHERE ADDITIONAL RAIL HEIGHT IS REQUIRED (SUCH AS BICYCLE TRAIL).

PEDESTRIAN / BICYCLE HAND RAIL (TYP.) DETAIL ABOVE A NON-CONVENTIONAL SWMF

SWMF - 11

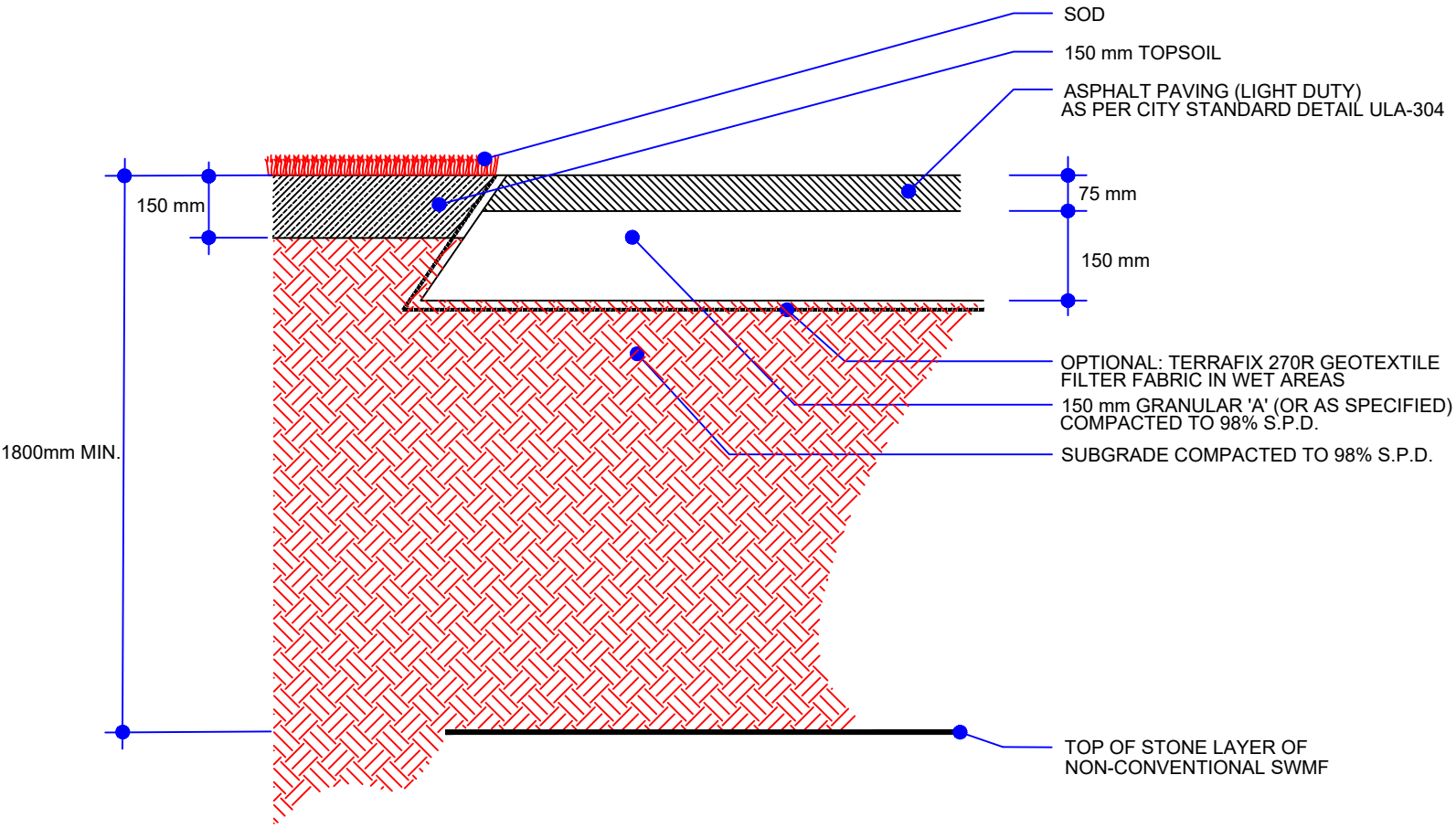


NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS
2. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION
3. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO PATHWAYS ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAIL ULA-303 FOR HEAVY-DUTY PAVING DETAILS

ASPHALT PAVING (HEAVY DUTY) (TYP.)
ABOVE A NON-CONVENTIONAL SWMF

SWMF - 12

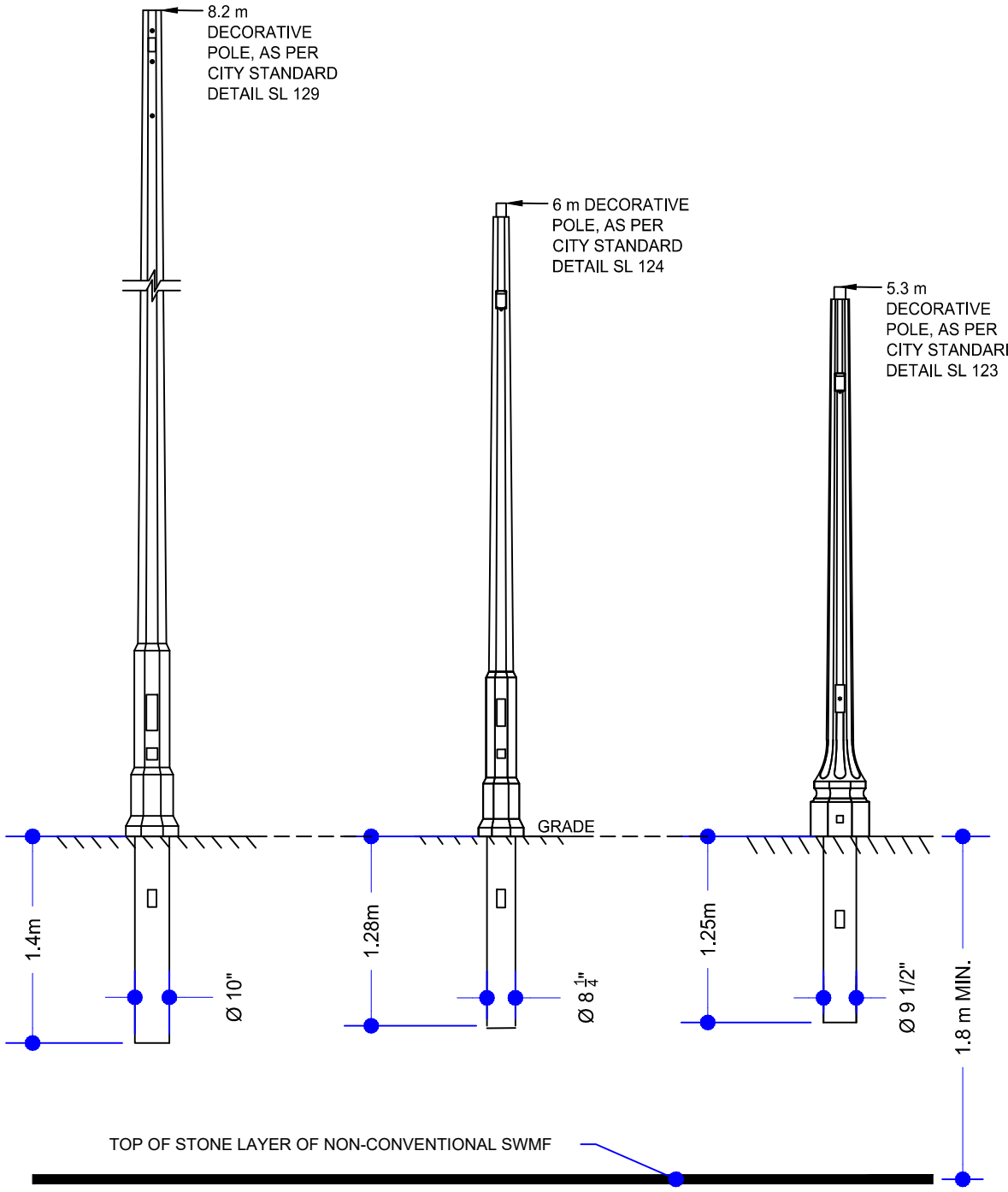


NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS
2. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION
3. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO PATHWAYS ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAIL ULA 304 FOR LIGHT-DUTY PAVING DETAILS

ASPHALT PAVING (LIGHT DUTY) (TYP.)
ABOVE A NON-CONVENTIONAL SWMF

SWMF - 13



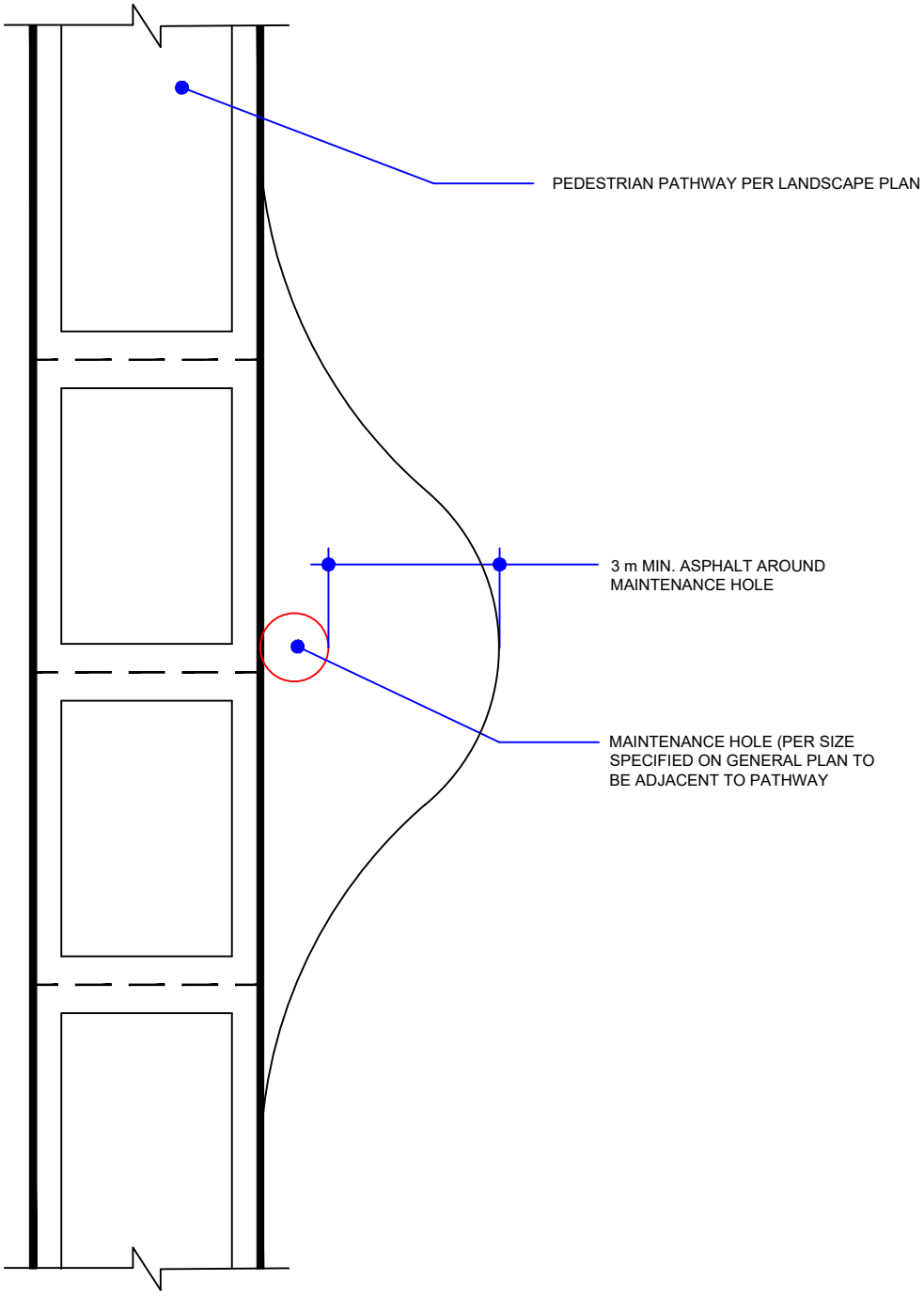
NOTES:

1. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION

2. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO DECORATIVE POLES ABOVE NON-CONVENTIONAL SWMF. REFER TO CITY STANDARD DETAILS SL 123, 124 AND 129 FOR POLE DETAILS

DECORATIVE POLE (TYP.) ABOVE A NON-CONVENTIONAL SWMF

SWMF - 14

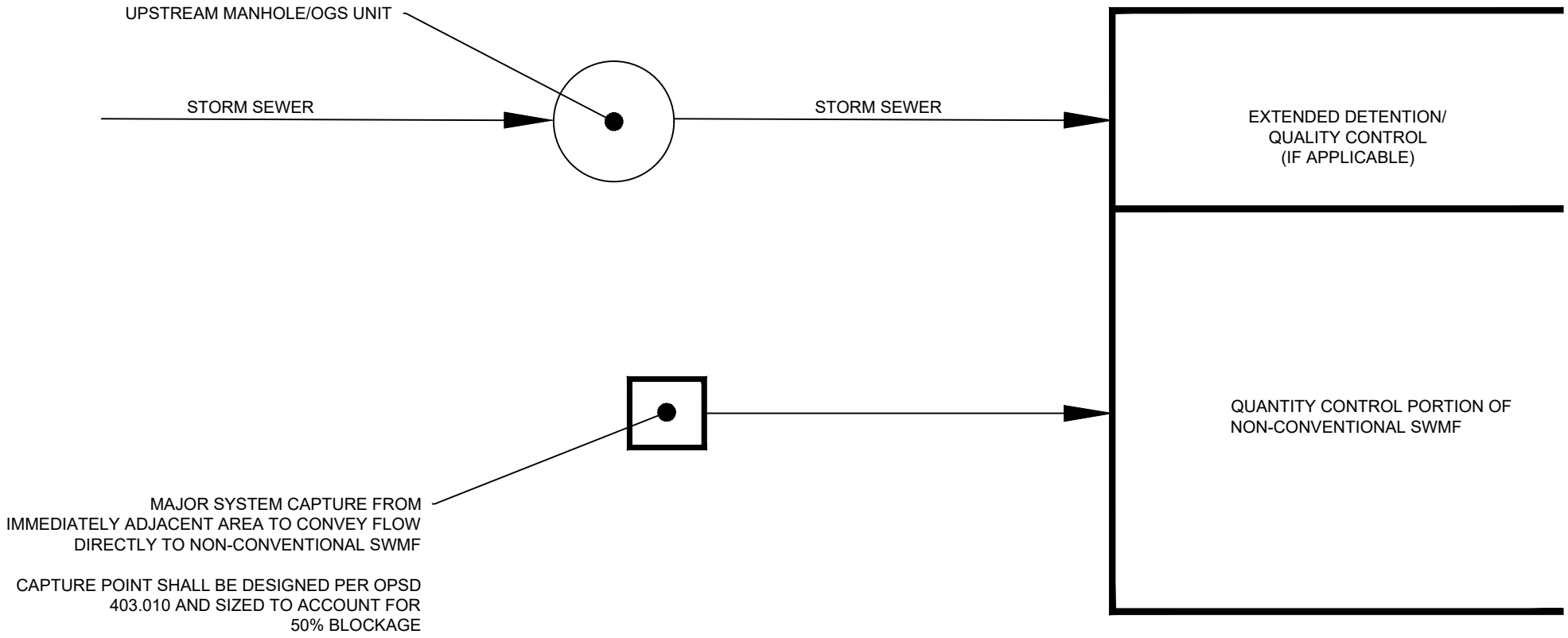


NOTES:

1. PATHWAY TYPE SHALL BE SPECIFIED IN LANDSCAPE PLAN
2. THIS TYPICAL DETAIL IS INTENDED TO CONVEY INTENT AND IS FOR REFERENCE ONLY. IT SHALL NOT BE USED AS PART OF THE CONSTRUCTION DRAWING PACKAGE OR SITE PLAN APPLICATION
3. THIS TYPICAL DETAIL IS INTENDED TO DISPLAY DETAILS WITH RESPECT TO MAINTENANCE HOLES FOR NON-CONVENTIONAL SWMF. REFER TO RELEVANT CITY STANDARDS FOR PAVING/PATHWAY DETAILS

MAINTENANCE HOLE BUMP OUT FROM PEDESTRIAN PATH FOR NON-CONVENTIONAL SWMF DETAIL

SWMF - 15



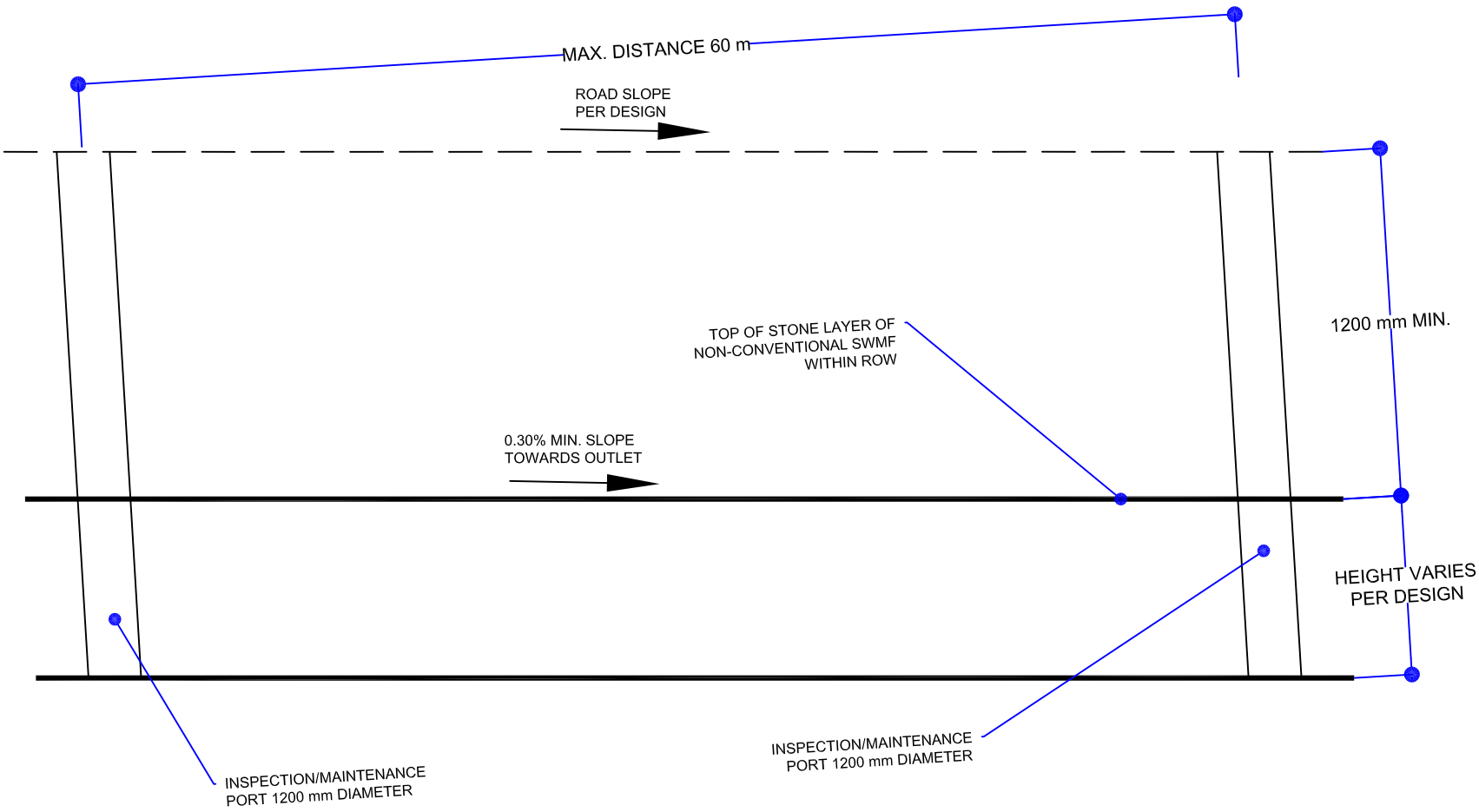
PLAN VIEW - NON-CONVENTIONAL SWMF
INLET SAMPLE CONFIGURATION

NOTES:

1. DETAIL REPRESENTS POTENTIAL CONCEPTUAL INLET CONFIGURATION TO NON-CONVENTIONAL SWMF

CONCEPTUAL STORM SEWER
CONNECTION TO NON-CONVENTIONAL
SWMF DETAIL

SWMF - 16



NOTES:

1. DETAIL REPRESENTS MAXIMUM DEPTH TO NON-CONVENTIONAL SWMF'S WITHIN PROPOSED ROW'S AND MAXIMUM INSPECTION/MAINTENANCE PORT SPACING

CONCEPTUAL NON-CONVENTIONAL
SWMF WITHIN ROW LAYOUT
SWMF - 17