Submitted to

Stephen Braun & Hal Stratford

CB Shield Inc.

Performance Assessment of SWM Shield Infrastructure

Final Report

Submitted by:

Aquafor Beech Ltd.

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Table of Contents

Appendices

List of Figures

List of Tables

1.0 Introduction

This study aims to assess the performance of four (4) SWM Shield™ units, two installed in the City of Vaughan and the other two in the City of Brampton by the Region of Peel, both located in Ontario, Canada. This assessment is intended to determine the operational efficiency of this infrastructure in real-world operations. The insights gained from this evaluation will highlight the potential advantages of integrating SWM Shield™ into municipal stormwater management (SWM) strategies by assessing their functionality and efficacy. The aim is to support informed decision-making for future infrastructure improvements and to enhance overall stormwater management practices.

1.1 Background

SWM Shield™ is a specialized stormwater management device designed to capture and retain sediment and associated pollutants, including phosphorous, from surface runoff before it enters stormwater management facilities (SWMF) (i.e. wet ponds). Designed by CB Shield Inc., this device is typically installed at the inlet of stormwater ponds. SWM Shield™ is designed to act as a pre-treatment and sediment capture device, intercepting sediment-laden runoff at the inlet and trapping particulates that would otherwise accumulate in the forebay or main pond. Not only does the sediment capture capability aim to enhance the water quality performance of SWMFs, but it also aims to reduce the frequency and cost of pond maintenance by limiting the sediment buildup within the permanent pool areas of the pond [1]. SWM Shield™ is engineered to handle varying runoff conditions and drainage areas (runoff volumes and sediment loads), making them adaptable to different land uses and environmental conditions. By maintaining the capacity of stormwater ponds and reducing pollutant loads, SWM Shield™ is designed to contribute to sustainable stormwater management and improved ecosystem health [1].

Along with offering adaptability to environmental conditions, SWM Shield™ can be arranged and configured in a variety of ways to accommodate differing SWM designs and capacity considerations. **Figure 1** illustrates the conceptual design of six SWM Shield™ units installed at the inlet of a pond. This configuration ensures that stormwater passes through the SWM Shield™ before entering the pond.

Figure 1 – Conceptual SWM Shield™ Installation at the Forebay Inlet [1]

Figure 2 depicts eight SWM Shield™ units arranged in parallel (two rows of four units) during the construction phase of a SWM pond, and is designed to service a greater volume of runoff.

Figure 2 - SWM Shield™ During the SWM Pond Construction

1.2 Study Objectives

Assessing the performance of a project post-installation is crucial for understanding its real-world efficacy and identifying areas for improvement. This evaluation aims to determine whether the SWM Shields™ are performing as designed, providing data-driven insights into their operational effectiveness, sediment and phosphorous capture capabilities and identifying potential strengths and areas for improvement.

The primary goal of SWM Shield™ performance assessment is to provide municipalities and industry comprehensive data on the:

- Annual sediment loading,
- Sediment characteristics,
- Phosphorus removal, and
- Total sediment capture capabilities of SWM Shield™.

This evaluation will consider operational efficiency, maintenance requirements, and financial implications to offer a holistic understanding of the infrastructure's performance.

1.3 Previous Studies

Following a collaborative meeting between Aquafor Beech Limited and CB Shield Inc., it was agreed to employ the same monitoring and assessment methodology used by the University of Toronto Masters student, Punreet Brar, in the report entitled CB Shield Testing Report [2].

The CB Shield Field Testing Final Report evaluated the performance of the CB Shield™[1], a proprietary catch basin inserts designed by CB Shield™ to improve stormwater management by retaining sediments within catch basins and preventing their downstream transport. The yearlong study, conducted at the University of Toronto, involved field testing under real hydraulic and sediment loading conditions. It compared shielded and unshielded catch basins for sediment retention and assessed parameters such as phosphorus, heavy metals, nutrients, particle size distribution, and general chemistry. The findings demonstrated that the CB Shield™ significantly enhanced sediment retention, reduced pollutant discharge, and maintained catch basin hydraulics. Recommendations were made for periodic maintenance, long-term monitoring, and potential scalability for municipal stormwater management systems [2].

[1] The CB Shield is an innovative catch basin insert designed to prevent stormwater sediment and grit accumulated in the catch basin sump from being washed downstream, effectively acting as a protective barrier.

Figure 3 - Conceptual design of a CB Shield™ illustrating its sediment retention mechanism within a catch basin [1].

By aligning with the "CB Shield Field Testing Final Report" research methodologies, the SWM Shield Performance Assessment aims to ensure robust, reliable, and actionable insights that can inform future stormwater management practices and infrastructure investments.

1.4 Site Overview and Key Characteristics

The four (4) facilities and associated infrastructure evaluated under this study demonstrated significant variations in existing site conditions, design considerations, and catchment characteristics, reflecting adaptations to specific environmental and operational needs. The following sections provide an overview of each site, specifically:

1. Villa Park SWMF (City of Vaughan)
2. Harmonia SWMF (City of Vaughan)
3. Heart Lake SWMF (Region of Peel – City of Brampton)
4. Kennedy SWMF (Region of Peel – City of Brampton)

Table 1 provides a comprehensive summary of each site's key characteristics of SWM Shield™ units installed. This information offers valuable context for understanding the specific environmental and structural factors influencing SWM Shield™ performance at each site.

Table 1 - Site Summary Description

Site Name	Location (Owner)	Year of Construction	Drainage Area (ha)	Imperviousness	Number of SWM Shield™ units at the site	SWM Shield™ Configuration	Proposed Maintenance Cycle (years)	Est. TSS Capture Rate *
Villa Park SWMF	City of Vaughan (Vaughan)	2023	29	53%	8	Parallel (2 rows of 4 units)	6	58%
Harmonia SWMF	City of Vaughan (Vaughan)	2023	11.2	50%	3	In-series	6	57%
Heart Lake SWMF	Region of Peel (City of Brampton)	2018	10.29	45%	3	In-series	5.7	55%
Kennedy SWMF	Region of Peel (City of Brampton)	2018	9.02	58%	3	In-series	4	55%

* Provided by CB Shield Inc and discussed below

1.4.1 Villa Park SWMF (City of Vaughan)

The **Villa Park Stormwater Management Facility**, located at the northwest corner of Villa Park Drive and Pine Valley Drive in Vaughan, Ontario, has undergone significant upgrades to enhance its stormwater management capabilities. Initially designed as a dry pond, it was converted into a wet pond with a permanent pool to improve sediment capture and water quality. These upgrades included the installation of 8 (eight) SWM Shield™ units at the inlet, pond excavation, realignment of the inlet channel, construction of maintenance access roads, and modifications to the outlet structure to enhance flood control [3].

The facility became operational in August 2023, servicing a drainage area of 29 hectares with an imperviousness of approximately 53%. The SWM Shield™ units installed at the site were provided by CB Shield Inc.

Figure 4 provides an aerial view of the Villa Park Stormwater Management Facility in Vaughan, Ontario. The SWM Shield™ units were installed at the pond inlet, upstream of the forebay, serving as a pre-treatment system before stormwater enters the main pond.

Figure 4 - Aerial Image of Villa Park SWMF Pond - Vaughan

1.4.1.1 Sizing of the SWM Shield™

Detailed calculations for the sizing of the SWM Shield™ are provided in **Appendix A.** For the Villa Park SWMF, based on the CB Shield Inc. report [4], the calculated requirement was 6.9 units. However, due to space constraints associated with the site and layout, it was recommended that the SWM Shield™ units be installed in two rows. As such, the number was rounded up to 8 to facilitate an even distribution. This configuration allowed for two equal rows of four units each, which was considered by CB Shield Inc. as the optimal arrangement for this site, ensuring both operational efficiency and structural balance [4].

Figure 5 presents an isometric view of the SWM Shield™ units installed at the Villa Park Stormwater Management Facility. The units are arranged in parallel (two rows of four).

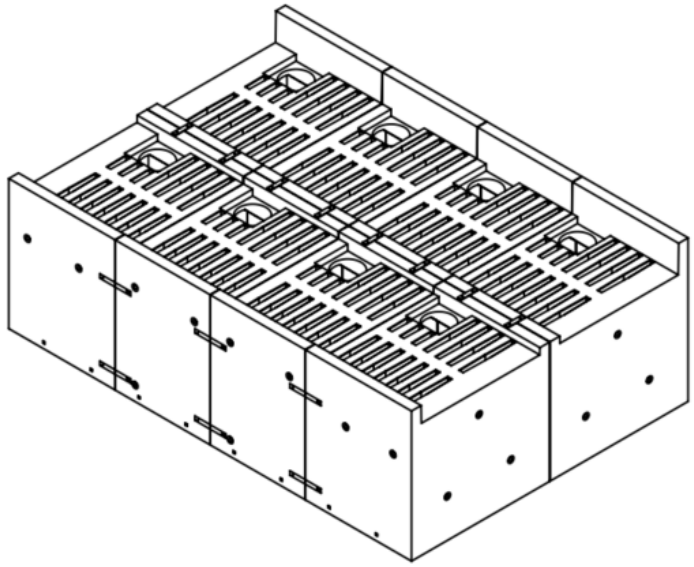

Figure 5 - Isometric View of the SWM Shields™, Villa Park, Vaughan [5]

1.4.1.2 Predicted Performance

The predicted performance evaluated by CB Shield Inc. for Villa Park indicated a long-term sediment capture rate of 58% TSS removal assuming the Environmental Technology Verification (ETV) particle size distribution (PSD) [4]. This estimate was determined by modeling the catchment area in PCSWMM, utilizing long-term continuous rainfall data from the Bloor Street meteorological station.

In terms of the maintenance cycle, it was estimated during design phases by CB Shield Inc. the that the SWM Shield™ at the Villa Park site be cleaned every 6 (six) years [4]. This schedule was based on the target accumulated sediment height, which is set at maximum 1.8 meters within the SWM Shield™ units, representing 75% of the total 2.4-meter capacity of the SWM Shield [4].

The maintenance cycle for the SWM Shield™ at the Villa Park SWMF was calculated based on sediment accumulation rates. According to the CB Shield Inc. calculations, the SWM Shield™ was designed to capture sediment at a rate of 6.7 m^3/year. It is noted that the MECP 2003 Guideline document (Table 6.3) estimates the annual sediment load (with a capture rate of 58%) at 27 m^3/year. CB Shield Inc. used an average of these two values, an annual sediment accumulation rate of 16.9 m^3/year, to determine the cleaning period. For the Villa Park SWMF site, it has been established that the SWM Shield™ should be cleaned every 6 (six) years [4].

Figure 6 provides a view of the Villa Park Stormwater Management Facility as seen from the pond inlet, highlighting the SWM Shield™ units.

Figure 6 - Villa Park SWMF, Vaughan

1.4.2 Harmonia SWMF (City of Vaughan)

The **Harmonia Stormwater Management Facility**, located southeast of Harmonia Crescent and northeast of Dunstan Crescent in Vaughan, Ontario, has undergone significant upgrades to enhance its stormwater management capabilities. Initially designed as a dry pond, it was converted into a wet pond with a permanent pool to improve sediment capture and water quality. These upgrades included the installation of 3 (three) SWM Shield™ units installed in series at the inlet, pond excavation, realignment of the inlet storm sewer and swale, construction of maintenance access roads, and spillway installation [3].

The facility became operational in August 2023, servicing a drainage area of 11.2 hectares with an imperviousness of approximately 50%. The SWM Shield™ units installed at the site were provided by CB Shield Inc.

Figure 7 provides an aerial view of the Harmonia Stormwater Management Facility in Vaughan, Ontario. The SWM Shield™ units were installed at the pond inlet, upstream of the forebay, serving as a pre-treatment system before stormwater enters the main pond.

Figure 7 - Aerial Image of Harmonia SWMF Pond – Vaughan

1.4.2.1 Sizing of the SWM Shield™

Detailed calculations for the sizing of the SWM Shield™ are provided in Appendix 7.1. For the Harmonia SWMF, the calculated sizing requirement was 2.68 units. The number was rounded up to 3 units for this site [4].

Figure 8 presents an isometric view of the SWM Shield™ units installed at the Harmonia Stormwater Management Facility. The units are arranged in series (one row of three).

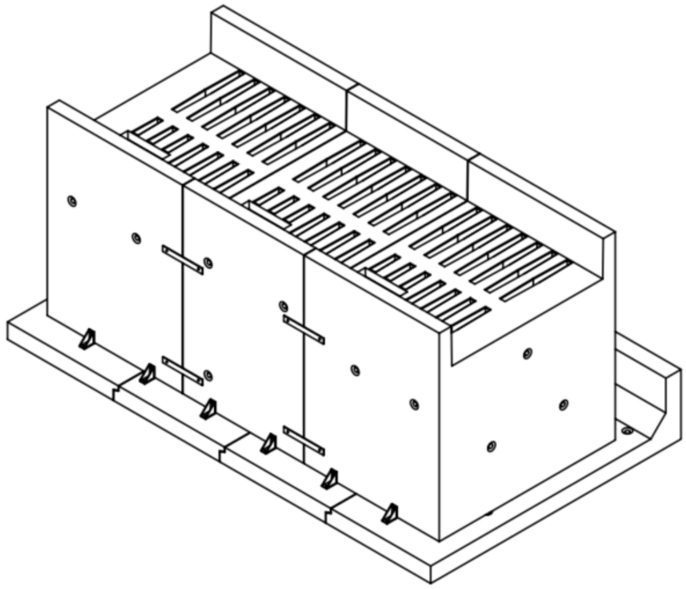

Figure 8 - Isometric View of the SWM Shield™, Harmonia, Vaughan

1.4.2.2 Predicted Performance

The predicted performance evaluated by CB Shield Inc. for Villa Park indicated a long-term sediment capture rate of 57% TSS removal assuming the ETV PSD. This estimate was determined by modeling the catchment area in PCSWMM, utilizing long-term continuous rainfall data from the Bloor Street meteorological station [4].

The maintenance cycle for the SWM Shield™ at the Harmonia SWMF was calculated based on sediment accumulation rates. According to the CB Shield Inc. calculations, the SWM Shield™ was designed to capture sediment at a rate of 2.6 m^3/year. It is noted that the MECP 2003 Guideline document (Table 6.3) estimates the annual sediment load (with a capture rate of 57%) at 10 m^3/year. By averaging these two values, an annual sediment accumulation rate of 6.3 m^3/year was used to determine the cleaning period. For the Harmonia site, it has been established that the SWM Shield™ should be cleaned every 6 (six) years. This schedule is based on a target sediment height of 1.8 meters, which represents 75% of the total 2.4-meter capacity of the SWM Shield™ [4].

Figure 9 provides a view of the Harmonia Stormwater Management Facility as seen from the pond inlet, highlighting the SWM Shield™ units.

Figure 9 - Harmonia SWMF, City of Vaughan

1.4.3 Heart Lake SWMF (Region of Peel – City of Brampton)

The Heart Lake SWMF is in the City of Brampton and was installed by the Region of Peel. Located at the intersection of Mayfield Road and Heart Lake Road. This facility has been operational since 2018, with the SWM Shield™ installed at the forebay [6]. The total drainage area of the site is 10.29 hectares, with an imperviousness of 45%, as provided by CB Shield Inc. A distinctive feature of this site is the 10-meter channel (**Figure 10**), covered with riprap, which connects the pond inlet to the SWM Shield™, offering additional sediment retention before flow reaches the Shield units [6].

Figure 10 - Heart Lake SWMF, Region of Peel, (City of Brampton)

Figure 11 provides an aerial view of the Heart Lake Stormwater Management Facility in Brampton, Ontario. The SWM Shield™ units were installed at the pond inlet, upstream of the forebay, serving as a pre-treatment system before stormwater enters the main pond.

Figure 11 - Aerial Image of Heart Lake SWMF, Region of Peel, (City of Brampton)

1.4.3.1 Sizing of the SWM Shield™

No detailed methodology for sizing considerations of the SWM Shield™ at the Heart Lake site was provided by CB Shield Inc. However, it has been confirmed that 3 (three) SWM Shield™ units were installed in series at this location.

1.4.3.2 Predicted Performance

The performance of the SWM Shield™ at Heart Lake was evaluated by CB Shield Inc., which predicted a long-term sediment capture rate of 55%. Maintenance requirements for the SWM Shield™ have been calculated based on MECP 2003 Guideline document. According to CB Shield Inc., the SWM Shield™ in the Heart Lake SWMF was designed to capture sediment at a rate of 2.3 m^3/year. Additionally, the MECP 2003 Guideline document (Table 6.3) estimates an annual sediment load of 7.0 m^3/year with a capture rate of 55%. Using this annual sediment accumulation rate, it has been determined that the SWM Shield™ should be cleaned approximately every 5.7 years. This cleaning cycle is based on a target sediment height of 1.8 meters, which corresponds to 75% of the SWM Shield™ total capacity of 2.4 meters [6].

1.4.4 Kennedy SWMF (Region of Peel – City of Brampton)

The Kennedy SWMF is in the City of Brampton, Region of Peel, at the intersection of Mayfield Road and Kennedy Road. This facility has been operational since 2018, with the SWM Shield™ installed at the forebay. The total drainage area of the site is 9.02 hectares, with an imperviousness of 45%, as provided by CB Shield Inc. A distinctive feature of this site is that the SWM Shield™ was designed to be in a submerged condition (under 10 cm of water).

Figure 12 provides an aerial view of the Kennedy Stormwater Management Facility in Brampton, Ontario. The SWM Shield™ units are installed at the pond inlet, upstream of the forebay, serving as a pre-treatment system before stormwater enters the main pond.

Figure 12 - Aerial Image of Kennedy SWMF Pond, Region of Peel, (City of Brampton)

1.4.4.1 Sizing of the SWM Shield™

No detailed methodology for sizing the SWM Shield™ at the Kennedy SWMF Pond site was provided by CB Shield Inc. However, it has been confirmed that 3 (three) SWM Shield™ units were installed at this location.

1.4.4.2 Predicted Performance

The performance of the SWM Shield™ at the Kennedy SWMF was evaluated by CB Shield™ Inc., which predicted a long-term sediment capture rate of 54%. Maintenance requirements for the SWM Shield™ have been calculated based on MECP 2003 Guideline document. According to CB Shield Inc., the SWM Shield ™ was designed to capture sediment at a rate of 2.4 m^3/year. Additionally, the MECP 2003 Guideline document (Table 6.3) estimates an annual sediment load of 10.0 m^3/year with a capture rate of 55%. Using this annual sediment accumulation rate, it has been determined that the SWM Shield™ should be cleaned approximately every 4.0 years. This cleaning cycle is based on a target sediment height of 1.8 meters, which corresponds to 75% of the SWM Shield™ total capacity of 2.4 meters [6].

1.5 Scope of Work

A detailed scope of work for the monitoring and assessment program was developed following the meeting with CB Shield Inc. The following work plan was agreed upon and implemented to ensure replicability and accuracy:

1. **Background Review:** A comprehensive review of all background documentation provided by CB Shield Inc., including drawings and reports, was conducted Additional relevant information was acquired were necessary. The background review included:
   a) CB Shield Field Testing Final Report [2]
   b) City of Vaughan Sites (2): Documentation provided by Aquafor Beech including: 1) IFT Design Drawings for Sites 3 and 8; 2) Considerations of upstream and adjacent (catchment) land use.
   c) Region of Peel Sites (2): Documentation provided by CB Shield™ including: 1) IFT Design Drawings and/or As-Built Drawings; 2) Considerations of upstream and adjacent (catchment) land use

2. **Site Inventory and Investigation:** Field activities including on-site inspections of the SWM Shield™, topographic/bathymetric surveys, sediment sampling, and elevation checks to assess the current conditions of the SWM Shields™ were completed.
   a) **On-site Inspections:** Visual inspections were conducted to identify features noted in the available design drawings, as well as opportunities and constraints of the design(s) for reporting purposes.
   b) **Bathymetric Surveys:** Bathymetric surveys were conducted to accurately evaluate the volume of sediment accumulated within the SWM Shield™ over its operational period i.e. since installation. This was achieved by capturing precise geodetic elevation data at the top and bottom of the sediment layer using survey techniques, allowing for a clear determination of sediment depth and distribution with each SWM Shield™ installation/ site.
   c) **Sediment Sampling**: To evaluate the sediment and nutrient removal efficiency of the SWM Shield™, samples were collected along the length of each of the four (4) SWM Shield™ locations to provide insights into the quantity of sediment, sediment characteristics and nutrients captured, specifically phosphorous, from runoff by the SWM Shields™. Sediment was submitted to an accredited laboratory for analysis, as discussed below.

3. **Performance Assessment and Analysis:** A technical memorandum outlining survey results and findings including confirmation of the existing sediment quantity and quality storage and removal, and general performance observations was prepared, represented by this document and the findings within.

2.0 Sampling Methodology

The methodology implemented in this study was confirmed by CB Shield Inc. on July 10, 2024 following the submission of the SWM Shield Sediment Sampling Methodology Memo (**Appendix C**). The memo outlined detailed methodological approaches including bathymetric surveys, sediment sampling and laboratory analysis and constituents to assess the performance of SWM Shield™ in regard to sediment and phosphorus retention. Key highlights of the methodology include:

1. **Bathymetric Surveys**: A geo-referenced bathymetric survey was completed using Sokkia iM 55 Total Station and Sokkia GCX3 GNSS GPS receiver and tied into local benchmark(s) established as a part of the standardized survey approach and/or as provided within existing drawing files. Bathymetric survey efforts were limited to the sediment within the SWM Shield with the primary objective of determining the quantity of sediment. Predetermined grids for each SWM shield™ were designed and agreed upon, with these grids provided in **Appendix B**. This ensured sufficient survey detail such that an accurate sediment quantity estimate could be determined. Bathymetric

surveys used a traditional rod and disc approach, with bottom of sediment survey points estimated by pushing the survey rod into the sediment until its termination point and top of sediment points estimated by resting the rod tip/disc on the top of the accumulated sediment. Additional survey points were gathered to confirm the base elevation of the SWM Shield™. These surveys were used to inform Digital Terrain Modeling in AutoCAD Civil 3D to calculate sediment volumes by comparing the top and bottom of sediment surfaces.

2. **Sediment Sampling:** In order to determine the sediment quality and quantify the nutrients removed from runoff and stored within the SWM Shield, sediment samples were collected across all sites following a systematic approach, as detailed in **Appendix B** and summarized below.

Samples were systematically collected along the SWM Shield™, using sediment coring where possible. In cases where coring was ineffective due to the concrete base of SWM Shield™ a PONAR dredge (Figure 13) was used to capture the sediment layer.

Figure 13 - AMS Bottom Grab Dredge Sampler (PONAR dredge) [7]

The samples were submitted for laboratory analysis of the following:

1. Particle Size Distribution by Sieve Analysis (<5mm)/Sample (D6913)
2. Particle Size Distribution by Sieve Analysis (>5mm)/Sample (D6913)
3. Particle Size Distribution - Hydrometer Analysis - 8 Point/Sample (D7928)
4. Materials Finer than 75um (#200) by Washing/Sample (ASTM C117/CSA A23.2 - 5A)
5. Phosphorus, Total (Colorimetric, Low Level)
6. Phosphorus, Total Dissolved (Colorimetric, Low Level)
7. Sampling constituents were selected to remain consistent with the parameters evaluated in the CB Shield Testing Report [2].

To ensure the sediment sampling properly represented the SWM Shield™ performance, two sampling strategies were used:

a. Parameters a-d (three (3) samples total):
    1. one sample was collected from the inlet area

2. one sample was collected from the outlet area
3. one sample was collected from multiple sample locations available within the SWM Shield™ to represent a composite sample

b. Parameters e-f (three (3) samples total):
   1. all three samples will be composites to represent the average amount of phosphorous contained throughout the SWM Shield™. Composites will be made up of equal parts from three sampling areas. A field sheet is developed to organize and reference sample locations for each SWM shield, see Section 3.0.

Sample preparation closely followed the CB Shield Testing Report [2] and as recommended by the accredited lab. Samples were shipped to AGAT Laboratories where they underwent appropriate analysis. Additional samples were collected for density analysis, discussed below.

2. **Sediment Density**: The density of dried sediment samples was calculated by dividing their weight by the volume, measured using water displacement in a 1000 mL beaker at the university of Guelph Environmental Laboratory by the study team.

This methodology ensured a robust evaluation of SWM Shield™ performance in capturing sediment and nutrients under varying conditions. Full details of the sampling methodology, including specific procedures are provided in **Appendix B**, with performance calculations provided in **Appendix C**.

Results are discussed hereafter.

3.0 Results

The results from the sampling conducted as part of the study are detailed in the sections below.

3.1 Sediment Quality Results

The bathymetric survey data, including top and bottom sediment elevations, were imported into Civil 3D to determine sediment accumulation within each SWM Shield™ over the operational period. By comparing these elevations, the total volume of sediment accumulated in each SWM Shield™ was calculated, allowing for an accurate assessment of sediment capture.

To calculate the total sediment weight, the sediment volume was multiplied by its wet density, yielding the overall weight of the accumulated sediment. This data is essential for evaluating the long-term effectiveness of the SWM Shield™ in capturing and retaining sediment.

In addition to volume, sediment density was measured from the collected samples to estimate the total weight of sediment by multiplying the wet density of material to the volume of material in each site specifically. This weight measurement provides further insight into the mass of material each SWM Shield™ has retained, which was used to ascertain the amount of accumulated nutrients, including phosphorus.

Sediment volume, wet density of sediment, total sediment weight, predicted time of clean-out, annual sediment weight per year and annual sediment weight per hectare for each site are summarized in **Table 2** offering a comprehensive overview of sediment accumulation across the facilities.

According to the information provided by CB Shield Inc., "the maximum recommended sediment accumulation depth is 1.8m, typically reached within an average period of 6 -7 years". The total sediment volume for each site, as shown in **Table 2**, remains below this threshold, indicating that the SWM Shields™ have not yet reached their sediment capacity.

Table 2 - Summary of Sediment Characteristics

Site Name	Drainage Area (ha)	Starting Year of Operation	Accumulated Sediment Volume (m^3)	Wet Density (Kg/m^3)	Weight (Kg)
Villa Park (Vaughan)	29	2023	6.36	1,890	12,020
Harmonia (Vaughan)	11.2	2023	1.38	1,765	2,436
Heart Lake (Brampton)	10.29	2018	3.53	1,702	6,008
Kennedy (Brampton)	9.02	2018	5.61	1,569	8,802

Table 3 summarizes the chemical analysis of sediment samples collected from SWM Shields™ at the four sites: Villa Park, Harmonia, Kennedy, and Heart Lake. The results include phosphorus concentrations, leachate metal levels, and other water quality parameters. Phosphorus concentrations, a primary focus of this study, ranged from 531 mg/kg to 798 mg/kg, reflecting nutrient retention across all sites. Most leachate parameters, such as arsenic, barium, boron, cadmium, chromium, copper, lead, mercury, selenium, silver, uranium, zinc, fluoride, nitrate, and nitrite, were below detectable levels (<RDL). Cyanide levels showed slight variability, with the highest concentration detected at the Kennedy site (0.648 mg/L).

While the data provides insights into sediment composition, it cannot directly measure the nutrient retention efficiency of the SWM Shield™. To evaluate efficiency, the difference in nutrient concentrations between SWM Shield™ inflow and outflow must be analyzed as this was not included in the current study scope.

Table 3 - The Chemical Analysis of Sediment Samples

Parameter	Unit	RDL	Site Name																O. Reg. 297/17: GENERAL WASTE MANAGEMENT Concentration (mg/L TCLP)
			Villa Park				Harmonia				Kennedy				Heart Lake				
			(P1)	(P2)	(P3)	**Average**	(P1)	(P2)	(P3)	**Average**	(P1)	(P2)	(P3)	**Average**	(P1)	(P2)	(P3)	**Average**	
Phosphorus	mg/kg	**10**	798	744	745	**762.3**	598	677	531	**602**	626	633	707	**655.3**	652	644	612	**636**	**-**
Arsenic - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**2.5**
Barium - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**100**
Boron - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**500**
Cadmium - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**0.5**
Chromium - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**5**
Copper - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**NA**
Lead - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**5**
Mercury - Leachate (SWEP)	mg/L	**0.1**	<0.1	<0.1	<0.1	**<0.1**	<0.1	<0.1	<0.1	**<0.1**	<0.1	<0.1	<0.1	**<0.1**	<0.1	<0.1	<0.1	**<0.1**	**0.1**
Selenium - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**1**
Silver - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**5**
Uranium - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**10**
Zinc - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**NA**
Fluoride - Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**150**
Nitrate, Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	**1000**
Nitrite, Leachate (SWEP)	mg/L	**0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	<0.5	<0.5	<0.5	**<0.5**	
Cyanide - SWEP	mg/L	**0.02**	0.003	<0.002	0.008	**NA**	0.005	0.006	0.004	**0.005**	0.648	0	0.37	**0.3**	0.099	0.417	0.397	**0.30**	**20**

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3.2 Particle Size Distribution Results

The Particle Size Distribution (PSD) analysis provides insights into the size distribution of sediment particles within the SWM Shield™. Results from the PSD are provided in **Table 4**. The PSD curves, plotted on a logarithmic scale for particle size against a linear scale for percent passing, illustrate the proportions of coarse, medium, and fine particles in each sample (**Figure 14** to **Figure 17**).

For this analysis, particle gradation was conducted according to ASTM standards (ASTM D6913 & D7928). Three samples were collected from each SWM Shield™ site, labelled as follows:

- **S1 (Inlet):** Collected from the point nearest to the inlet of the SWM Shield™, representing sediment entering the system.
- **S2 (Outlet)**: Collected from the point nearest to the outlet of the SWM Shield™, reflecting sediment that has passed through.
- **S3 (Composite):** A composite sample taken from multiple locations across the SWM Shield™ (inlet, outlet, and middle) to provide a comprehensive representation of the sediment profile.

The PSD parameters calculated by the AGAT Laboratory for each sample include key particle sizes and grading coefficients:

- **D_{60} (Particle Size at 60% Passing)**: Indicates the particle size at which 60% of the sample passes, used to determine coarseness and calculate the uniformity coefficient (C_u).
- **D_{30} (Particle Size at 30% Passing)**: Represents the particle size at 30% passing, utilized with D_{60} and D_{10} to calculate the coefficient of curvature (C_c).
- **D_{10} (Effective Particle Size)**: The particle size at which 10% of the sample passes.
- **C_u (Uniformity Coefficient)**: Calculated as $C_u = \frac{D_{60}}{D_{10}}$, this coefficient measures the range of particle sizes. Higher C_u values indicate a well-graded soil with a variety of particle sizes.
- **Cc (Coefficient of Curvature)**: Calculated as $C_c = \frac{(D_{30})^2}{(D_{10} \times D_{60})}$ this coefficient assesses the soil gradation shape. A Cc between 1 and 3 typically signifies well-graded soil, while values outside this range suggest poor grading.

For sample collection locations for each site, refer to **Appendix B**.

Table 4 - Particle Size Distribution Characteristics

Site Name	Sample Location	Percentage of soil fractions (%)					Soil Grading Coefficients				
		Cobble	Gravel	Sand	Silt	Clay	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	C_u	C_c
Villa Park (Vaughan)	S1	0	11.9	82.1	4.8	1.2	2.408	0.938	0.184	13	2
	S2	0	6.1	16.8	47.4	29.7	0.014	0.002	NA	NA	NA
	S3 (Composite)	**0**	**21**	**59.4**	**13.2**	**6.4**	**2.642**	**0.389**	**0.007**	**380**	**8**
Harmonia (Vaughan)	S1	0	11.1	77.9	8.3	2.7	0.8	0.278	0.075	11	1
	S2	0	3.8	47.9	39.5	8.8	0.151	0.024	0.003	52	1
	S3 (Composite)	**0**	**4.3**	**70.3**	**21.2**	**4.2**	**0.408**	**0.107**	**0.011**	**39**	**3**
Heart Lake (Peel)	S1	0	0	30.1	52.1	17.9	0.053	0.007	NA	NA	NA
	S2	0	0.3	19.5	60.2	20.1	0.02	0.007	NA	NA	NA
	S3 (Composite)	**0**	**0.1**	**15.8**	**65.9**	**18.1**	**0.025**	**0.007**	**NA**	**NA**	**NA**
Kennedy (Peel)	S1	0	0	21.1	60.3	18.6	0.026	0.005	NA	NA	NA
	S2	0	0	9.8	69.3	20.9	0.01	0.006	NA	NA	NA
	S3 (Composite)	**0**	**0**	**25.3**	**58.1**	**16.5**	**0.031**	**0.009**	**NA**	**NA**	**NA**

As shown in **Table 4**, the fraction of gravel and sand in the Kennedy and Heart Lake SWM Shield™ are notably lower (2x to 3x lower) than those in the Harmonia and Villa Park SWM Shield™, whereas the silt and clay fractions within the Kennedy and Heart Lake SWM Shield™ are notably lower (2x to 3x lower) than Harmonia and Villa Park SWM Shield™. This discrepancy suggests:

- that some coarser sediment may not be reaching the SWM Shield™. The unique configurations of the Kennedy and Heart Lake SWM Shield™ may be impacting the sediment composition reaching these facilities. i.e. coarser sediment may have settled within the upstream rip-rap channel in the case of the Heart Lake site.
- that some coarser sediment may be bypassing the SWM Shield™ without full capture, as may be the case in the Kennedy Site.

However, it is equally possible that local or regional factors between sites Brampton and Vaughan may be influencing particle size distribution results. These may include but are not limited to: drainage area characteristics, land-use, winter maintenance practices, catch-basin cleanout frequencies, drainage systems design standards, native surficial geology (i.e. native soil types) and/or rainfall distributions and intensities. Furthermore, facility age and/or the time each facility has been in service may also contribute to the results observed. Further analysis of specific factors and future sampling may assist in greater understanding.

From **Table 4** and as shown in **Figures 14-17**, it is also noted that in general, the Kennedy and Heart Lake SWM Shield™ sites demonstrate more uniformity in the sediment captured as compared to the Harmonia and Villa Park SWM Shields™ sites.

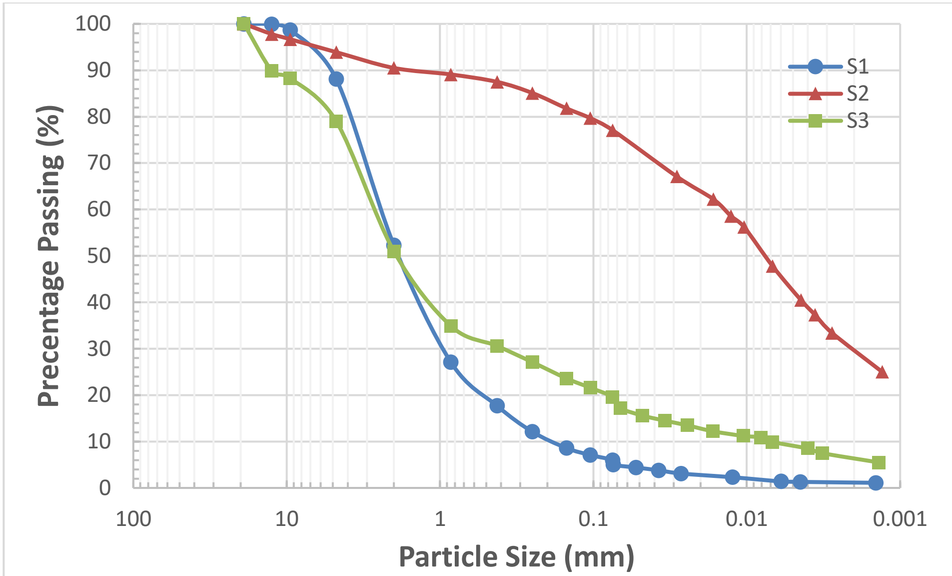

Figure 14 - Particle Size Distribution (PSD) Curve for SWM Shield™ - Villa Park Site

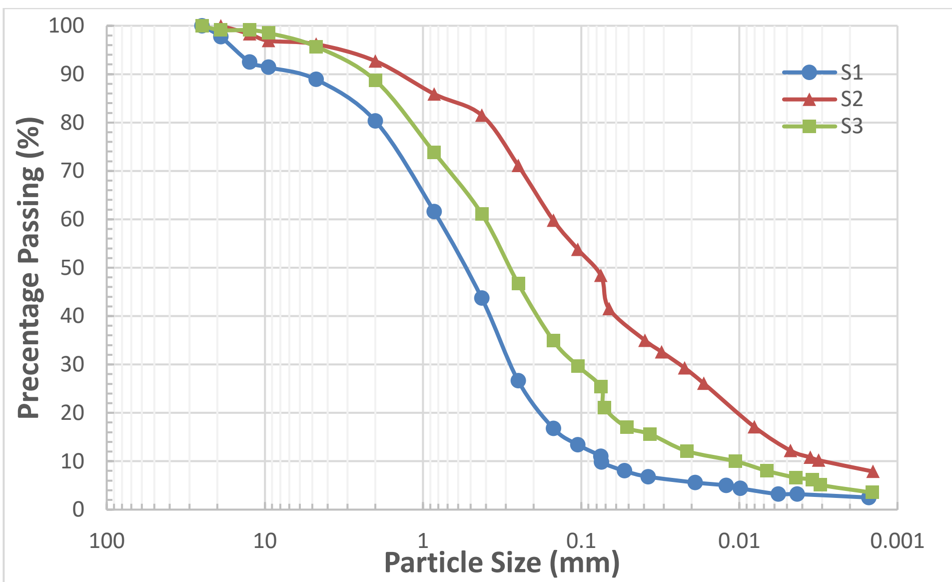

Figure 15 – Particle Size Distribution (PSD) Curve for SWM Shield™ – Harmonia Site

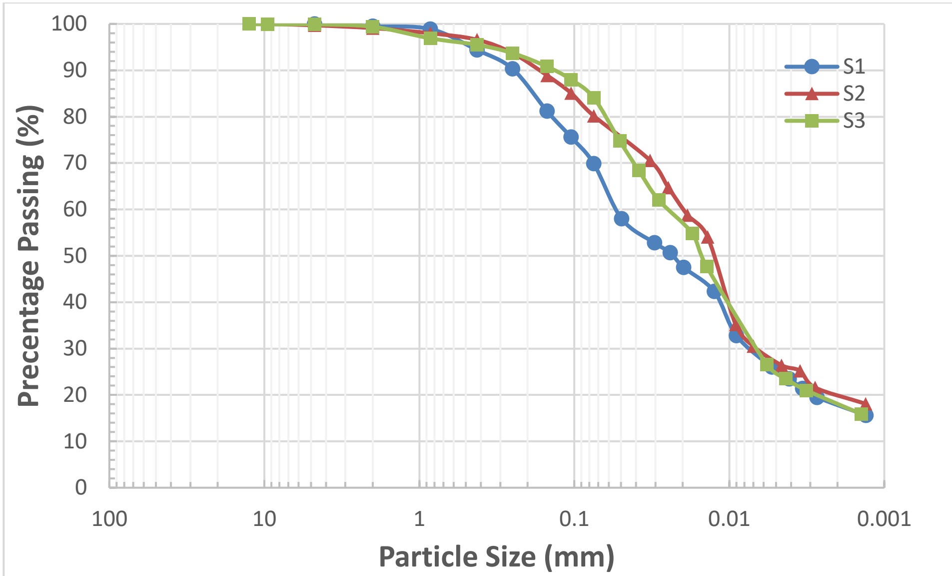

Figure 16 - Particle Size Distribution (PSD) Curve for SWM Shield™ – Heart Lake Site

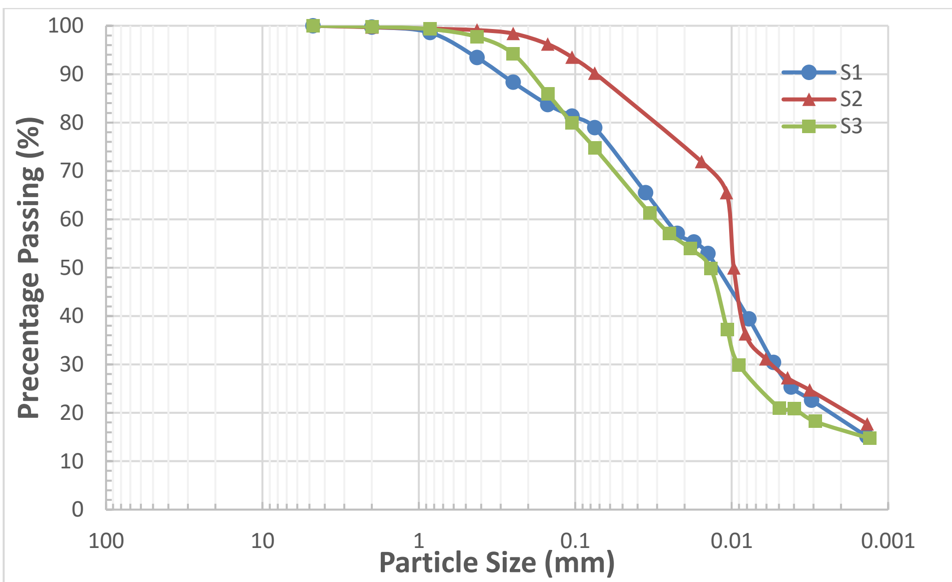

Figure 17 - Particle Size Distribution (PSD) Curve for SWM Shield™ - Kennedy Site

3.2.1 Summary of Sediment Capture rate and Comparison with ETV PSD Curve

Figure 18 illustrates the particle size distribution (PSD) of sediments captured within the SWM Shield™ across the four study sites, compared against the particle size distribution recommended by the Canadian Environmental Technology Verification (ETV) Program [2] for laboratory testing of Oil-Grit Separators. The ETV curve serves as a theoretical benchmark, for comparison of the sediment characteristics under field conditions at the four sites.

The PSD curves shown are based on composite samples (S3) from each site, providing a comprehensive view of the particle size distribution. The data reveal distinct trends among the sites:

- **Villa Park and Harmonia SWMFs** exhibit a similar PSD trend, though Harmonia captures a higher proportion of larger particles, with approximately 50% of materials ranging between 1-10 mm. In contrast, Villa Park captures around 25% of materials within this size range.
- **Kennedy and Heart Lake SWMFs** share a similar PSD pattern, demonstrating higher efficiency in capturing finer particles (0.1-0.01 mm), retaining approximately 60% of these smaller materials. However, both sites are largely ineffective at capturing particles larger than 0.9 mm.

The ETV PSD curve falls near the middle of the four PSD curves obtained from each facility through field sampling in this study, suggesting variability in type/ size of sediment captured from each drainage area and SWMF.

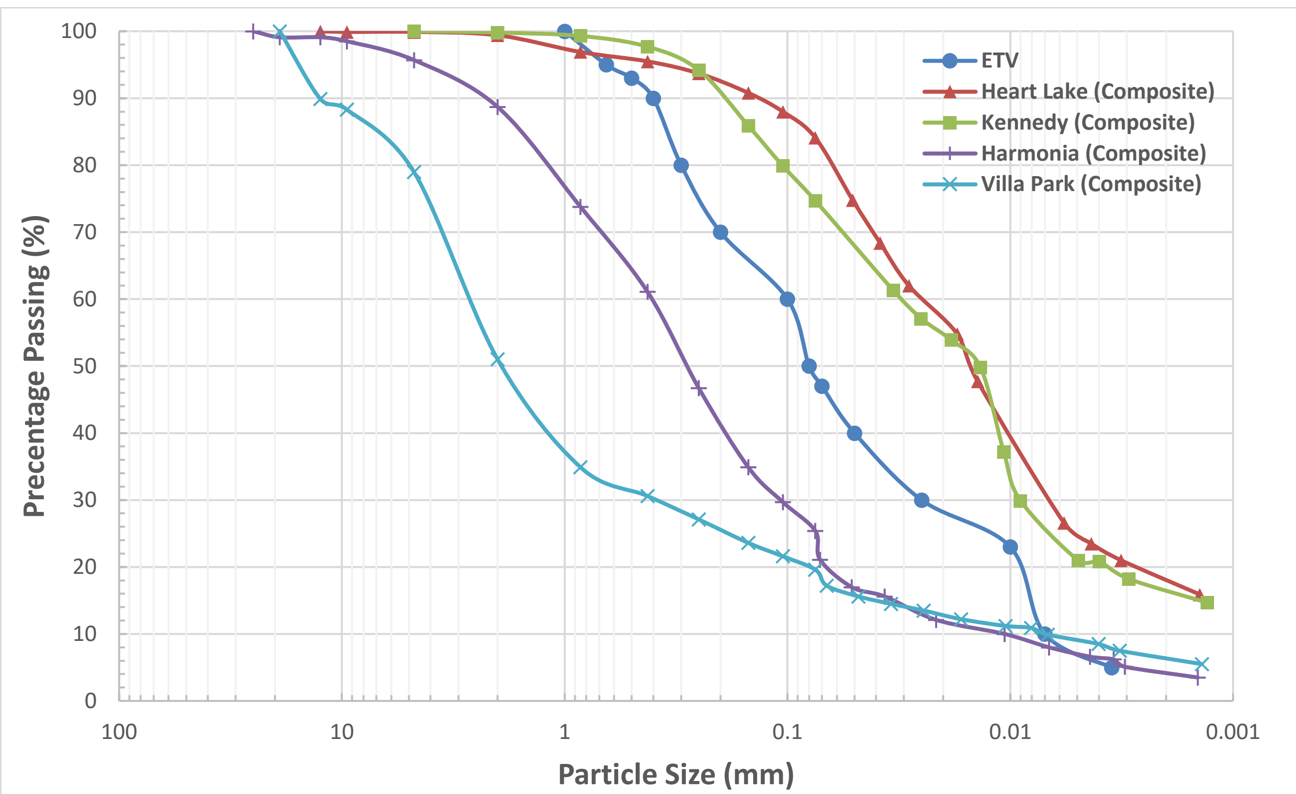

Figure 18 - Summary of Particle Size Distribution Curve

3.3 Sediment Capture Results

The sediment capture rate for this study was determined using the sediment volume and weight data presented in **Table 2**. The annual sediment volume was calculated by dividing the total sediment volume accumulated at each site by the years of operation.

- For the Vaughan sites (Villa Park and Harmonia), the facilities have been operational since 2023, resulting in an operational period of 1 year at the time of field activity.
- For the Brampton sites (Heart Lake and Kennedy), the SWMFs have been operational since 2018, giving them a 6-year operational period.

To obtain the annual sediment weight, the annual sediment volume was multiplied by the sediment density specific to each site. For normalized results, both annual sediment volume and sediment weight were further divided by the drainage area of each site, ensuring consistency across sites. This information is summarized in **Table 5**, along with maintenance cycle observations discussed below.

3.3.1 The Maintenance Cycle

The maintenance cycle was assessed using the background information provided by CB Shield Inc., which specifies a maximum sediment storage capacity corresponding to a sediment depth of 1.8 m within each SWM Shield™ unit. The maintenance cycle was calculated by dividing the maximum sediment storage volume by the annual sediment volume for each site, yielding the predicted time to reach capacity.

The results of this calculation indicate the following maintenance cycles (in years):

- Villa Park: 16 years
- Harmonia: 28 years
- Heart Lake: 66 years
- Kennedy: 41 years

It must be noted that both Villa Park and Harmonia were operational for only a short duration (approx. 1-year) and as such have only limited data available. Irrespective of the short operational duration, the normalized sediment capture volume (m^3/year/ha) are similar between Harmonia (approx. 1-year of operation) and Heart Lake (more than 6-years of operation) and in general the normalized sediment capture volume amongst all four (4) sites varied between 0.06 - 0.22 m^3/year/ha.

These values provide insight into the long-term operational efficiency of the SWM Shield™ and are also presented in **Table 5**. This analysis highlights the differences in sediment accumulation rates across sites due to varying operational timelines and drainage area characteristics

Table 5 - Sediment Capture Rates, Annual Values, and Predicted Maintenance Cycles for SWM Shield™

Site Name	Drainage Area (ha)	Maximum Sediment Storage Capacity (m^3)	Starting Year of Operation	Accumulated Sediment Volume (m^3)	Wet Density (Kg/m^3)	Weight (Kg)	Annual Sediment Volume (m^3/year)	Annual Sediment Volume per hectare (m^3/year /ha)	Annual Sediment Weight (Kg/year)	Annual Sediment Weight per Hectare (Kg/year/ha)	Predicted Time to Clean-out (years)
Villa Park (Vaughan)	29	108	2023	6.36	1,890	12,020	6.36	0.22	12,020	414.5	16
Harmonia (Vaughan)	11.2	40.5	2023	1.38	1,765	2,436	1.38	0.12	2,436	217.5	28
Heart Lake (Brampton)	10.29	40.5	2018	3.53	1,702	6,008	0.59	0.06	1,001	97.3	66
Kennedy (Brampton)	9.02	40.5	2018	5.61	1,569	8,802	0.93	0.10	1,467	162.6	41

Figure 19 shows the relationship between annual sediment volume captured by SWM Shield™ and the drainage area size at the study sites. A strong linear correlation ($R^2 = 0.9879$) was observed, confirming that sediment accumulation volume is directly related to the size of the drainage area. Villa Park, with the largest drainage area of 29 hectares, exhibited the highest annual sediment capture volume of 6.36 m^3/year. Conversely, sites with smaller drainage areas, such as Kennedy with 9 hectares, recorded significantly lower volumes (0.93 m^3/year). This data highlights the role of drainage area in determining the sediment capture volumes within SWM Shield™.

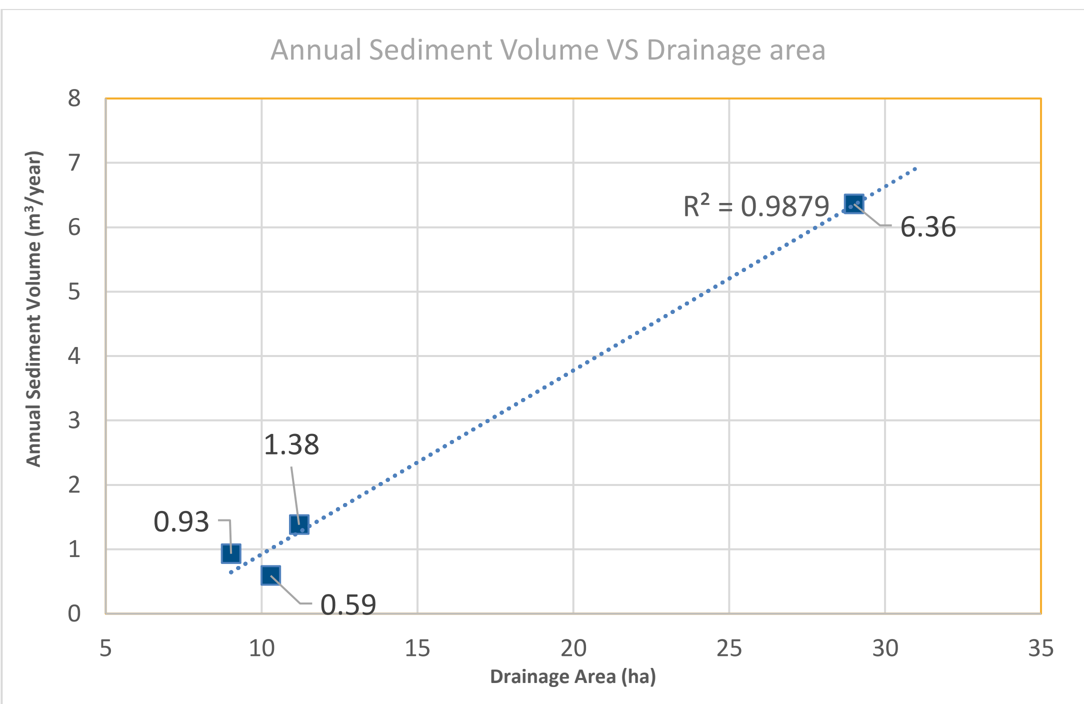

Figure 19 - Annual Sediment Volume versus Drainage Area

3.4 Phosphorus Results

Table 6 presents the phosphorus concentrations at each SWM Shield™. At each site, three (3) composite samples (labeled P1, P2, and P3) were collected from each SWM Shield™ to ensure comprehensive spatial coverage.

A composite sample from the SWM Shield™ is a representative sediment sample collected from multiple locations within the units, including the inlet, outlet, and central areas. This approach ensured analysis by combining sediment from different sections, providing an accurate depiction of the overall sediment characteristics and distribution within the SWM Shield™ system. This approach accounted for variability across the SWM Shield™, ensuring that the sampling reflected a view of phosphorus levels, providing reliable data for performance assessment.

The inclusion of the Lake Simcoe Phosphorus Offsetting Policy in this report reflects the potential alignment of SWM Shield™ performance with the funding criteria established by the Lake Simcoe Region Conservation Authority (LSRCA). The objective is to assess whether the SWM Shield™ qualifies for funding under this policy by demonstrating its effectiveness in capturing and retaining phosphorus, thereby reducing nutrient loads to sensitive water bodies.

Table 6 - Phosphorus Concentrations in SWM Shield™

Site Name	Location Sample	Unit	RDL	Phosphorus Concentration	Average Phosphorous concentration
Villa Park (Vaughan)	P1 (Composite)	mg/kg	10	798	**762.3**
	P2 (Composite)	mg/kg	10	744	
	P3 (Composite)	mg/kg	10	745	
Harmonia (Vaughan)	P1 (Composite)	mg/kg	10	598	**602**
	P2 (Composite)	mg/kg	10	677	
	P3 (Composite)	mg/kg	10	531	
Heart Lake (Peel)	P1 (Composite)	mg/kg	10	652	**636**
	P2 (Composite)	mg/kg	10	644	
	P3 (Composite)	mg/kg	10	612	
Kennedy (Peel)	P1 (Composite)	mg/kg	10	626	**655.3**
	P2 (Composite)	mg/kg	10	633	
	P3 (Composite)	mg/kg	10	707	

Under the Lake Simcoe Phosphorus Offsetting Policy (LSPOP), phosphorus entering Lake Simcoe must be controlled to protect aquatic life. Effective phosphorus retention within SWM Shield™ contributes to this goal by capturing phosphorus before it reaches the lake. According to the LSRCA Phosphorus Offsetting Policy (May 2023), the offset value is $35,770 per kilogram per year. The average phosphorus concentration and total phosphorus amount, annual phosphorus amount and total amount of Phosphorous per year per hectare for each site are presented in the **Table 7**.

Table 7 - Total Weight of Phosphorus in SWM Shield™

Site Name	Average Phosphorus Concentration (mg/kg)	Drainage Area (ha)	Total Weight of Sediment (kg)	Total Weight of Phosphorus in SWM Shield™ (Kg)	Total Weight of Phosphorus in SWM Shield™ per year (Kg/Year)	Total Weight of Phosphorus in SWM Shield™ per year per hectare (Kg/Year/ha)
Villa Park (City of Vaughan)	762	29.00	12,020	**9.16**	**9.16**	**0.32**
Harmonia (City of Vaughan)	602	11.20	2,346	**1.47**	**1.47**	**0.13**
Heart Lake (Region of Peel)	636	10.30	6,008	**3.82**	**0.64**	**0.06**
Kennedy (Region of Peel)	655	9.02	8,802	**5.77**	**0.96**	**0.11**

Figure 20 illustrates the relationship between annual phosphorus retention within the SWM Shield™ and the drainage area across the study sites. A very strong correlation ($R^2 = 0.9952$) was found, indicating that the phosphorus capture is closely tied to the drainage area size. Villa Park, having the largest drainage area of 29 hectares, demonstrated the highest annual phosphorus retention (9.16 kg/year), while smaller sites like Kennedy, with 9 hectares, retained significantly lower phosphorus amounts (0.96 kg/year). This trend emphasizes the significant influence of drainage area on phosphorus capture within the SWM Shield™.

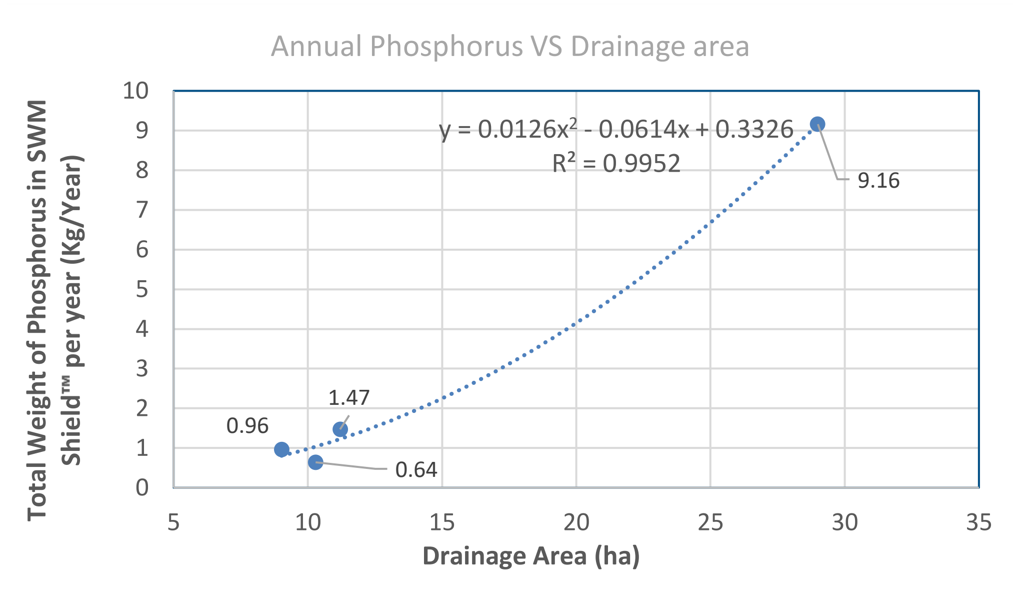

Figure 20 - Annual phosphorus retention versus drainage area

3.1 Summary of Findings

Table 8 provides a comprehensive summary of the key findings for SWM Shield™ across the four study sites: Villa Park, Harmonia, Heart Lake, and Kennedy. It includes critical information such as total sediment volume, density of material, phosphorus concentrations, and annual sediment loading.

Table 8 - Summary of Findings

Site Name	Starting Yeat of Operation	Drainage Area (ha)	% Imperviousness	Phosphorus Concentration (mg/kg)	Sediment Volume in SWM Shield™ (m^3)	Density of Material (kg/m^3)	Total Weight of the Sediment (Kg)	Annual Sediment Volume (m^3/year)	Annual Sediment Volume per hectare(m^3/year/ha)	Annual Sediment Loading (Kg/year)	Sediment Loading (Kg/year/ha)	Total Phosphorus in the site (kg)	Annual Phosphorus Weight (kg/year)	Annual Phosphorus Weight per Area (kg/year/ha)
Villa Park (Vaughan)	2023	29.0	53%	762	6.36	1,890	12,020	6.36	0.22	12,020	414.5	9.16	9.16	0.32
Harmonia (Vaughan)	2023	11.2	50%	602	1.38	1,765	2,436	1.38	0.12	2,436	217.5	1.47	1.47	0.13
Heart Lake (Brampton)	2018	10.3	45%	636	3.53	1,702	6,008	0.59	0.06	1,001	97.3	3.82	0.64	0.06
Kennedy (Brampton)	2018	9.0	58%	655	5.61	1,560	8,802	0.93	0.10	1,467	162.6	5.77	0.96	0.11

Table 9 presents a comprehensive overview of the economic valuation of phosphorus removal, calculated in alignment with the Lake Simcoe Protection Plan. It highlights the cost implications per kilogram of phosphorus captured, based on the guidelines established in the Lake Simcoe Region Conservation Authority's offsetting policy. This table serves as a valuable reference for evaluating the financial benefits of phosphorus retention achieved through SWM Shield™ installations at the assessed sites, reinforcing their role in supporting sustainable stormwater management and nutrient reduction objectives.

Table 9 - Phosphorus Offsetting Values Based on the Lake Simcoe Protection Plan

Site Name	Year of Construction	Drainage Area (ha)	Phosphorus Concentration (mg/kg)	Sediment Volume in SWM Shields (m^3)	Density of Material (kg/m^3)	Total Weight of the Sediment (Kg)	Total Phosphorus in the site (Kg)	Offset Value ($/kg/year)	Phosphorus Weight (kg/year)	Offset Calculation ($/year)	(Offset Calculation ($/year/ha)
Villa Park (Vaughan)	2023	29.0	762	6.36	1,890	12,020	**9.16**	$ 35,770	**9.16**	**$ 327,637**	$ 11,298
Harmonia (Vaughan)	2023	11.2	602	1.38	1,765	2,436	**1.47**		**1.47**	**$ 52,456**	$ 4,684
Heart Lake (Peel)	2018	10.3	636	3.53	1,702	6,008	**3.82**		**0.64**	**$ 22,780**	$ 2,212
Kennedy (Peel)	2018	9.0	655	5.61	1,560	8,802	**5.77**		**0.96**	**$ 34,371**	$ 3,819

4.0 Conclusions and Discussions

The SWM Shield™ performance assessment across the four sites—Villa Park, Harmonia, Heart Lake, and Kennedy—provides quantitative insights into the efficiency of these devices under varying environmental and operational conditions. The following sections highlight the key findings:

4.1 Sediment Assessment

4.1.1 Sediment Volume and Weight

The study quantified sediment accumulation at each site. Villa Park captured 6.36 m^3/year with a weight of 12,020 kg/year. Harmonia retained 1.38 m^3/year, weighing 2,436 kg/year. Heart Lake captured 0.59m^3/year with a weight of 1,001 kg/year, and Kennedy retained 0.935 m^3/year, weighing 1,467 kg/year.

4.1.2 Sediment Capture Performance

The sediment capture rates across the four (4) sites ranged between 0.06 (m^3/year/ha) (Heart Lake) and 0.22 (m^3/year/ha) (Villa Park). It must be noted that both Villa Park and Harmonia were operational for only a short duration (approx. 1-year). Irrespective of the short operational duration, the normalized sediment capture volume (m^3/year/ha) are close between Harmonia (0.12 m^3/year/ha after approx. 1-year of operation) and Kennedy (0.10 m^3/year/ha after more than 6-years of operation). In general, the normalized sediment capture volume amongst all four (4) sites showed minimal variation, ranging between 0.06 - 0.22 (m^3/year/ha), suggesting the SWM Shields™ captured sediment consistently and effectively across the sites.

The differences in sediment accumulation across sites appear to be attributed to variations in drainage area size and unique characteristics of each drainage area. For instance, while the drainage area of Villa Park is three times larger than that of Harmonia, the sediment accumulation at Villa Park is approximately 4.6 times greater. This highlights the significant influence of drainage area characteristics on sediment transport and accumulation within the infrastructure.

Additionally, site-specific factors such as the presence of a rip-rap channel upstream of Heart Lake may impact the sediment capture efficiency at these facilities. In-situ observations at Heart Lake in the form of vegetation establishment in the channel suggest that voids in the rip rap have intercepted and accumulated sediment, allowing for rooting and establishment of Phragmites. Sediment capture rates do not support this however, with a higher sediment capture rate at Kennedy (0.10 m^3/year/ha) when compared to its neighbor, Heart Lake (0.06 m^3/year/ha). This difference may suggest that other site-specific factors, such as the submerged conditions at Kennedy, may impact capture rates to a greater extent.

4.1.3 Sediment Quality and Phosphorous

The chemical analysis of sediment samples collected from SWM Shields™ across four study sites—Villa Park, Harmonia, Kennedy, and Heart Lake—demonstrates key findings on sediment composition and phosphorus retention. As noted above in **Section 4.1.2**, the SWM Shield™ infrastructure demonstrated consistent and efficient sediment capture performance. Sediment represents a vehicle for a number of constituents including phosphorus. Phosphorus concentrations ranged between 531 mg/kg and 798 mg/kg, with average values of **762.3 mg/kg** at **Villa Park**, **602 mg/kg** at **Harmonia**, **636 mg/kg** at **Heart Lake**, and

655 mg/kg at **Kennedy.** Across all sites, a median value of 645.5 mg/kg and a mean value of 663.8 mg/kg was demonstrated. The greatest variation from the median and mean values was observed at Villa Park at 116.5 mg/kg greater than the median and 98.3 mg/kg greater than the mean, further supporting the influence of drainage area size and unique characteristics of each drainage area on capture rates. Despite this variability, all sites were within +98.25 mg/kg (Villa Park) and -61.75 mg/kg (Harmonia) of the median phosphorus concentration, highlighting consistent concentrations and the SWM Shields™' effectiveness in capturing phosphorus from stormwater runoff.

Leachate metal levels for elements such as arsenic, barium, boron, cadmium, chromium, copper, lead, mercury, selenium, silver, uranium, and zinc were all below detectable limits (<RDL), suggesting that the captured sediment did not pose significant metal contamination risks. Similarly, parameters such as fluoride, nitrate, and nitrite were also below detectable levels, while cyanide levels showed slight variability, with the highest concentration recorded at Kennedy (0.648 mg/L).

These results provide valuable insights into sediment composition and nutrient retention by SWM Shield™. However, direct nutrient retention efficiency could not be assessed due to the absence of inflow and outflow nutrient data which is out of the scope of this study.

4.2 Particle Size Distribution

The Particle Size Distribution (PSD) analysis highlights significant differences in sediment characteristics across the study sites. Villa Park and Harmonia demonstrate greater effectiveness in capturing coarser materials, with gravel and sand fractions accounting for **80.4% and 74.6%**, respectively. In contrast, Heart Lake and Kennedy retained significantly lower proportions of coarser material, with gravel and sand contributing only **15.9% and 25.3%**, respectively.

Conversely, the finer material fractions (silt and clay) dominated the sediment composition in Heart Lake and Kennedy, accounting for **84% and 74.6%**, respectively, compared to **19.6% in Villa Park and 25.4% in Harmonia**. This suggests that while Villa Park and Harmonia were more effective in capturing coarser sediments, Heart Lake and Kennedy predominantly retained finer sediments. This is supported by the PSD curves displayed in **Figure 18**.

When comparing results at the four sites, as summarized in **Figure 18** and **Table 4**, the greatest influence on PSD results appears to be upstream catchment characteristics, primarily soil conditions. Kennedy and Heart Lake facilities demonstrated nearly identical PSD curves, likely due to their proximity and therefore shared drainage area characteristics. This nearly identical PSD curve was demonstrated despite the site-specific condition differences (i.e. upstream rip-rap channel and submerged conditions). Villa Park and Harmonia on the other hand demonstrated opposite PSD curves when compared to Heart Lake and Kennedy, likely due to their location and varying drainage area conditions. Between the two sites, even further variation was observed between the PSD curves, with the two sites separated by 2.5 km and on opposite sides of the Humber River. These site-specific factors underline the importance of considering design and operational conditions when evaluating SWM Shield™ performance in sediment retention.

4.3 Maintenance Cycle

The proposed maintenance cycles for Villa Park, Harmonia, Heart Lake, and Kennedy are 6, 6, 5.7, and 4 years, respectively. However, based on the sediment captured in the SWM Shield™ and the corresponding volume to a maximum sediment depth of 1.8 m, the calculated cleaning cycles are significantly longer, at 16, 22, 66.1, and 41.6 years, respectively.

Notably, the specific characteristics of Heart Lake and Kennedy, such as their site configurations, potentially contribute to longer-than-expected maintenance cycles. Regular surveys remain essential to monitor sediment accumulation and ensure accurate assessments of their long-term performance.

Additionally, further surveys are recommended for Villa Park and Harmonia to improve the precision of sediment loading estimates, as determining long-term maintenance cycles based on one year of performance introduces significant uncertainty. Additional surveys are recommended to be undertaken in 3-5 years time.

4.4 Financial Considerations

4.4.1 Clean-Out Costs

The clean-out costs for SWM Shield™ units, which includes decanting excess water into the adjacent ponds, hydro-vacuuming sediment, and offsite disposal of debris, were provided by a local contractor [8]. Clean-out costs were determined using the minimum threshold design details, or the clean-out volume trigger when the sediment height reaches 1.2 meters, such that costing represented a conservative value. That is, the sediment volume for each site at which 50% of the total 2.4-meter capacity of the SWM Shield™ [4] is reached.

For the SWM Shield™ sites analyzed in this study, the sediment volumes and clean-out costs are as follows:

- **Villa Park**: Sediment volume of 70 m³ with a clean-out cost of $40,320, resulting in a cost of $576 per cubic meter.
- **Harmonia**: Sediment volume of 26 m³ with a clean-out cost of $14,976, resulting in a cost of $576 per cubic meter.
- **Heart Lake**: Sediment volume of 26 m³ with a clean-out cost of $14,976, resulting in a cost of $576 per cubic meter.
- **Kennedy**: Sediment volume of 26 m³ with a clean-out cost of $14,976, resulting in a cost of $576 per cubic meter.

In comparison, analysis of recent sediment removal projects for traditional pond clean-outs in Brantford, Waterloo, and Richmond Hill and others, indicate an average cleaning cost of $700 per cubic meter for projects removing between 0-750 m³ of sediment. This cost excludes expenses related to engineering, permitting, or project design.

The integration of SWM Shield™ units as a pre-treatment system may offer additional advantages by reducing or even eliminating the need for design, engineering, and permitting and compliance requirement pursuant to the Excess Soil regulations O.Reg. 416/19 as sediment removed from SWM Shield™ would be characterized as liquid waste and therefore exempt. By avoiding these additional steps, proponents may realize additional cost savings and efficiencies in clean-out programs, which may reduce the cost variance on a per cubic meter basis.

4.4.2 LSRCA phosphorus offsetting policy

The economic value of phosphorus offsetting was calculated using the Lake Simcoe Region Conservation Authority (LSRCA) phosphorus offsetting policy, which assigns a cost of **$35,770/kg/year**. Based on phosphorus retention rates, the economic benefit ranged from **$2,212 to $11,298/ha/year** across the study sites.

5.0 Site-Specific Challenges

- At Heart Lake, the 10-meter riprap channel affected sediment transport, requiring adjustments to capture efficiency calculations.
- Kennedy's submerged configuration reduced the effectiveness of sediment capture.
- Sampling limitations, such as distinguishing sediment layers and core sampling issues, underscore the need for improved survey techniques and equipment.

6.0 Recommendations

Regular Bathymetric Monitoring: Given that the long-term sediment capture rates for SWM Shield™ have been calculated by CB Shield Inc., it is recommended to conduct bathymetric surveys every 3-5 years to monitor sediment accumulation effectively. This recommendation is particularly relevant as the Vaughan sites have been operational for only one year, while the Peel sites have been functioning for nearly six years. Regular surveys at five-year intervals will provide valuable data on the volume of sediment retained in the SWM Shield™, enabling better assessment of their performance and ensuring timely maintenance to optimize their efficiency.

7.0 References

[1] C. Inc., "SWM Shield™," 29 November 2024. [Online]. Available: https://www.cbshield.com/copy-of-cb-shield.

[2] P. Brar, "CB Shield Field Testing: Final Report," Toronto, Ontario, 2016.

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[4] Stephen Braun, c. Mark Smith, "Vaughan SWM Facilities Retrofit (Sites 3 & 8), Predicted Performance of SWM Shield Units," CB Shield Inc, Bradford, On, 2021.

[5] C. C. PIPE, "22-2189 Villa Park and Harmonia Stormwater Mtg Pond CUSTOMER: Green Infrastructure Partners Inc.," Puslinch, Ontario, 2023.

[6] S. Braun, "Re: SWM Shield sites - Sediment Sampling and Monitoring Program," CB Shield Inc. , 2024.

[7] "Rentals, AMS Bottom Grab Dredge Sampler," Field Environmental Instruments, Inc, 2024. [Online]. Available: https://www.fieldenvironmental.com/equipment-rentals/soil/sampling-equipment/ams-bottom-grab-dredge-sampler.html.

[8] W. Groves, "SWM Shield™ Cleanout Quotation," Wm.GROVES LIMITED, Hamilton, Ontario, 2024.

[9] M. o. Environment, "Stormwater Management Planning and," Province of Ontario , 2003 .

[10] C. W. Stats, "Total Precipitation - Monthly data for Vaughan," 29 November 2024. [Online]. Available: https://vaughan.weatherstats.ca/charts/precipitation-monthly.html.

[11] Mohammad Nayeb Yazdi, Durelle Scott, David J. Sample, Xixi Wang , "Efficacy of a retention pond in treating stormwater nutrients and sediment," *Journal of Cleaner Production,* vol. 290, 2021.

Appendix A – SWM Shield™ Sizing

$$SWM\ Shield\ Area\ (m^2) = Area\ of\ CB\ Shield\ Grate\ (m^2)\ \times 5\ CB's/ha\ \times Total\ Drainage\ Area\ (ha)$$

Using this approximation, the number of standard precast SWM Shield™ lengths required can be determined to meet the calculated surface area. Each standard SWM Shield™ section is typically sized as follows:

- **Dimensions:** 3.0 m x 2.5 m = 7.5 m^2 per SWM Shields™ section

Calculating the approximate number of box sections required

$$Number\ of\ Box\ Sections = \frac{SWM\ Shield^{™}\ Treatment\ Area\ (m^2)}{SWM\ Shield\ ^{™}\ Surface\ Area}$$

Table 10 - SWM Shield™ Sizing for Villa Park and Harmonia

SWMF	Total Drainage Area (ha)	Area of CB Shield Grate (m^2)	SWM Shield™ Area (m^2)	SWM Shield™ Area per Section (m^2)	Number of Calculated SWM Shields™ per Site	Number of Installed SWM Shields™ per Site
Villa Park (City of Vaughan)	29	0.36	52.2	7.5	6.96	8
Harmonia (City of Vaughan)	11.2	0.36	20.16	7.5	2.68	3

Appendix B – SWM Shield™ Sediment Sampling Methodology Memo

June 26, 2024

To: **Stephen Braun & Hal Stratford**
CB Shield

From: **Graham Eby and Chris Denich, M.Sc., P.Eng., Aquafor Beech Ltd.**

Re: **Professional Services for the Performance Assessment of Four (4) SWM Shields**

Aquafor Beech Limited (Aquafor) is pleased to provide a memo for the updated methodology proposed to conduct the Performance Assessment of Four (4) SWM Shields, as discussed during the Pre-Consultation Meeting on March 12th, 2024. As such, please review the following memo outlining this updated methodology and recommendations.

1.0 Project Understanding

It is understood that the Client wishes to conduct assessment of four (4) SWM Shields installed at two (2) locations in Vaughan and Peel respectively. The following SWM Shields were selected by the Client in consultation with Aquafor Beech and were confirmed as a part of the project scope during the initiation meeting:

1. Kennedy SWMP (Peel)
2. Heart Lake SWMP (Peel)
3. SWMP 87 – Villa Park Pond (Vaughan)
4. SWMP 130 – Harmonia Pond (Vaughan)

All four (4) SWM shields are to be assessed using the methodologies consistent with the scope of works and CB Shield Field Testing: Final Report (Brar, 2016). Updated methodology for the Site Inventory and Investigation is outlined below. SWM Shield-specific methodologies are outlined in **Section 3.0**.

2.0 Site Inventory and Investigation

2.1 On-site Inspection

Visual on-site inspections will be completed to identify features noted in available design drawings, as well as opportunities and constraints of the design(s) for reporting purposes. All field investigations will occur during favorable weather conditions such that all facility elements may be investigated.

2.2 Bathymetric Survey

A geo-referenced bathymetric survey will be undertaken of the subject SWM Shield using Total Station survey equipment and/or GPS survey equipment and will be tied into local benchmark(s) established as a part of the standardized survey approach and/or as provided within existing drawing files. All surveys will be referenced to UTM NAD83 datum. This survey will provide horizontal and vertical controls suitable for subsequent analysis. Bathymetric survey efforts will be limited to the sediment within the SWM Shield with the primary objective of determining the quantity of sediment. Predetermined grids for each SWM shield are included in **Section 3.0**. This will ensure sufficient survey detail will be obtained to provide an accurate sediment quantity estimate. Bathymetric surveys will use a traditional rod and disc approach. Survey points will also be gathered to confirm the base elevation of the SWM Shields. Bottom of sediment survey points will be estimated by pushing the survey rod into the sediment until its termination point. It is assumed that access to the internal chamber will be provided either through available manholes or through the top of the grate. Confined spaces entry has not been included in the scope of work.

In addition, the SWM Shield structure will be geo-referenced to develop a 3D sediment volume model (heat map) for each site. Available control points (benchmarks, manholes, inlet elevations, etc) will be used to support the surveying.

2.3 Sediment Sampling

In order to determine the sediment quality and quantify the nutrients removed from runoff and stored within the SWM Shield, sediment samples will be collected across all sites. Aquafor will collect three (3) sediment samples/ site along the length of each SWM Shield selected for assessment. To retrieve the samples, a sediment core will be used where manhole lids can be opened. This will allow the entire column of sediment to be sampled. However, the sediment core is designed for use on a clay liner, so the concrete bottom of the SWM Shield may inhibit its ability to take a complete sample. If the sediment core cannot be reliably used, a PONAR Dredge will be used instead at all sample locations. It is noted that the PONAR dredge is biased towards the top 15-20cm of the sediment layer and will not represent the entire column when the sediment depth is greater than 20cm. The samples will be submitted for laboratory analysis of the following:

a. Particle Size Distribution by Sieve Analysis (<5mm)/Sample (D6913)
b. Particle Size Distribution by Sieve Analysis (>5mm)/Sample (D6913)
c. Particle Size Distribution - Hydrometer Analysis - 8 Point/Sample (D7928)
d. Materials Finer than 75um (#200) by Washing/Sample (ASTM C117/CSA A23.2 - 5A)
e. Phosphorus, Total (Colorimetric, Low Level)
f. Phosphorus, Total Dissolved (Colorimetric, Low Level)

Sampling constituents were selected to remain consistent with the parameters evaluated in the CB Shield Field Testing: Final Report (Brar, 2016).

To ensure the sediment sampling properly represents the SWM Shield's performance, two sampling strategies will be used:

- Parameters a-d (three (3) samples total):
    1) one sample will be collected from the inlet area
    2) one sample will be collected from the outlet area
    3) one sample will be a composite from multiple sample locations available within the SWM Shield
- Parameters e-f (three (3) samples total):
    1) all three samples will be composites to represent the average amount of phosphorous contained throughout the SWM Shield. Composites will be made up of equal parts from three sampling areas. A field sheet is developed to organize and reference sample locations for each SWM shield, see **Section 3.0**.

Sample preparation will closely follow the CB Shield Field Testing: Final Report (Brar, 2016). Sediment samples will be directly put into clean plastic containers/bags from the sampling equipment. If required, a 30-micron filter and associated device will be sought out to remove excess water. Sample bottles will be filled with excess water removed but not completely dried and submitted to the accredited laboratory for analysis where, they will accept the wet sample. The sample is to be washed through a sieve then transferred to an evaporating dish. The washed sample is then dried at 100°C, then transferred into a pre-weighed sieve and retaining pan. The dried sample is shaken for 10 minutes. Following shaking, the sieve is re-weighed and the grain size distribution can be calculated. Multiple sieve sizes can be used if required by the individual client.

For the phosphorous samples (e-f), a volume-based and weight-based value for phosphorous levels in the sediment will be found. To accomplish this, sample jars will be weighed with a scale and measured prior to being filled. After being filled with dry sediment, a dry-weight of the sample can be calculated by weighing the jar again and subtracting the jar weight. Lab-provided sample jars will be filled to the top to ensure the full volume of the jar is reached, allowing a consistent volume across the samples. This will allow the amount of phosphorous retained by the SWM Shields to be quantified in terms of weight and volume of sediment once lab results are received. Samples will be shipped to AGAT Laboratories where they will also provide a dry weight to be used in analysis.

3.0 SWM Shield-specific Methodology

Specific methodology is developed based on each SWM Shield's characteristics. To account for differences in size and number of manholes, bathymetric grids and sampling sequences are altered to best represent each SWM Shield.

3.1 Kennedy SWMP (Peel)

The proposed bathymetric survey grid is shown in **Figure 3-1**.

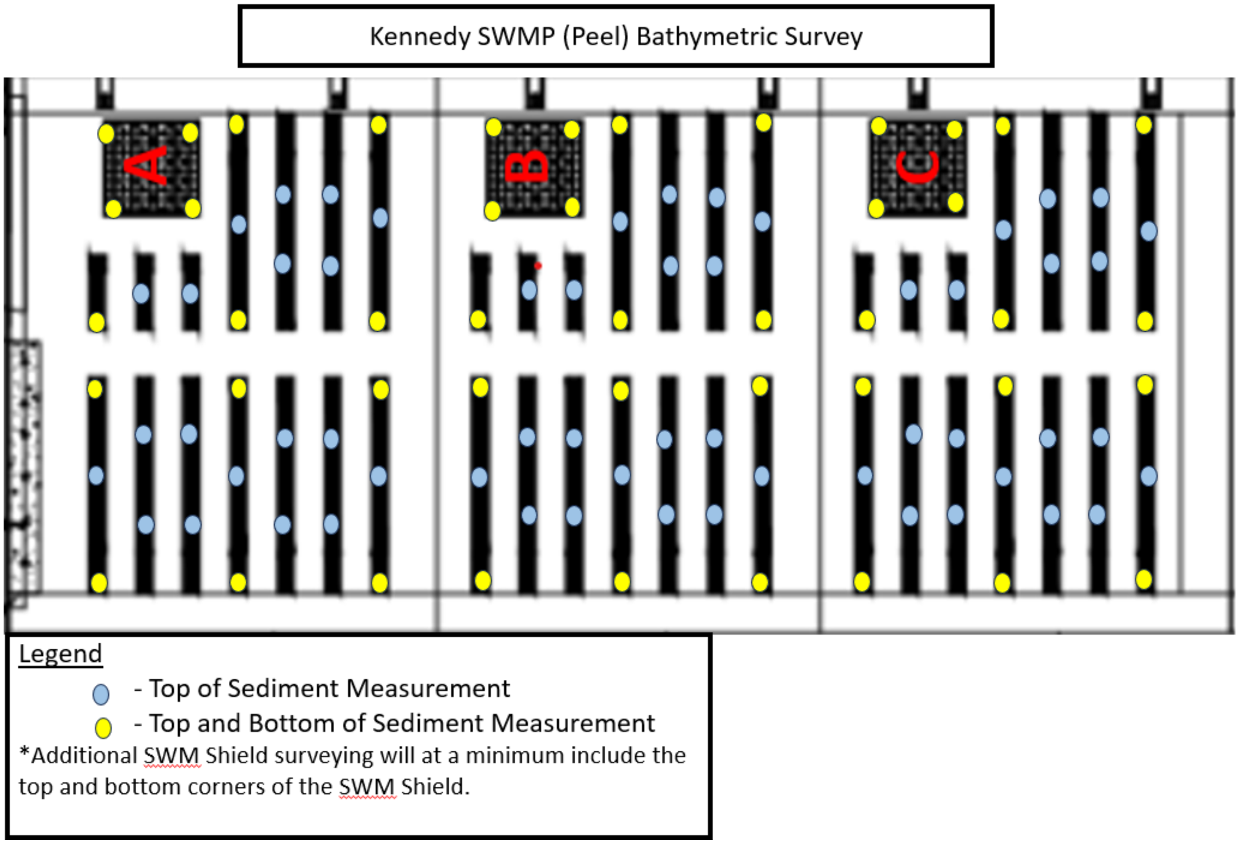
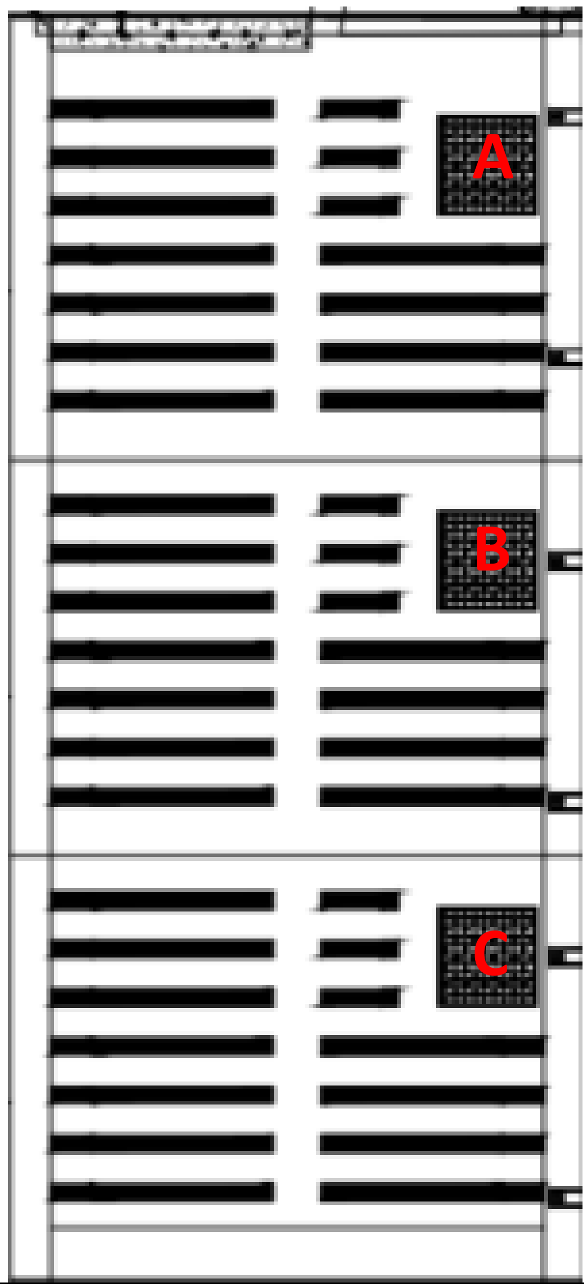


Figure 3-1 - Kennedy SWMP (Peel) Bathymetric Survey Grid.

The sampling sequence is summarized in **Table 3-1**.

Table 3-1 – Kennedy SWMP (Peel) Sediment Sampling Field Sheet.



Sample Details: Particle Size (Parameters a-d)	
Sample Number	Location Notes
1. Sediment 1: Inlet	A
2. Sediment 2: Outlet	C
3. Sediment 3: Composite	A
	B
	C
Sample Details: Phosphorous (Parameters e-f)	
Sample Number	Location Notes
1. Phosphorous Composite 1	A
	B
	C
2. Phosphorous Composite 2	A
	B
	C
3. Phosphorous Composite 3	A
	B
	C
Notes:	

3.2 Heart Lake SWMP (Peel)

The proposed bathymetric survey grid is shown in **Figure 3-2**.

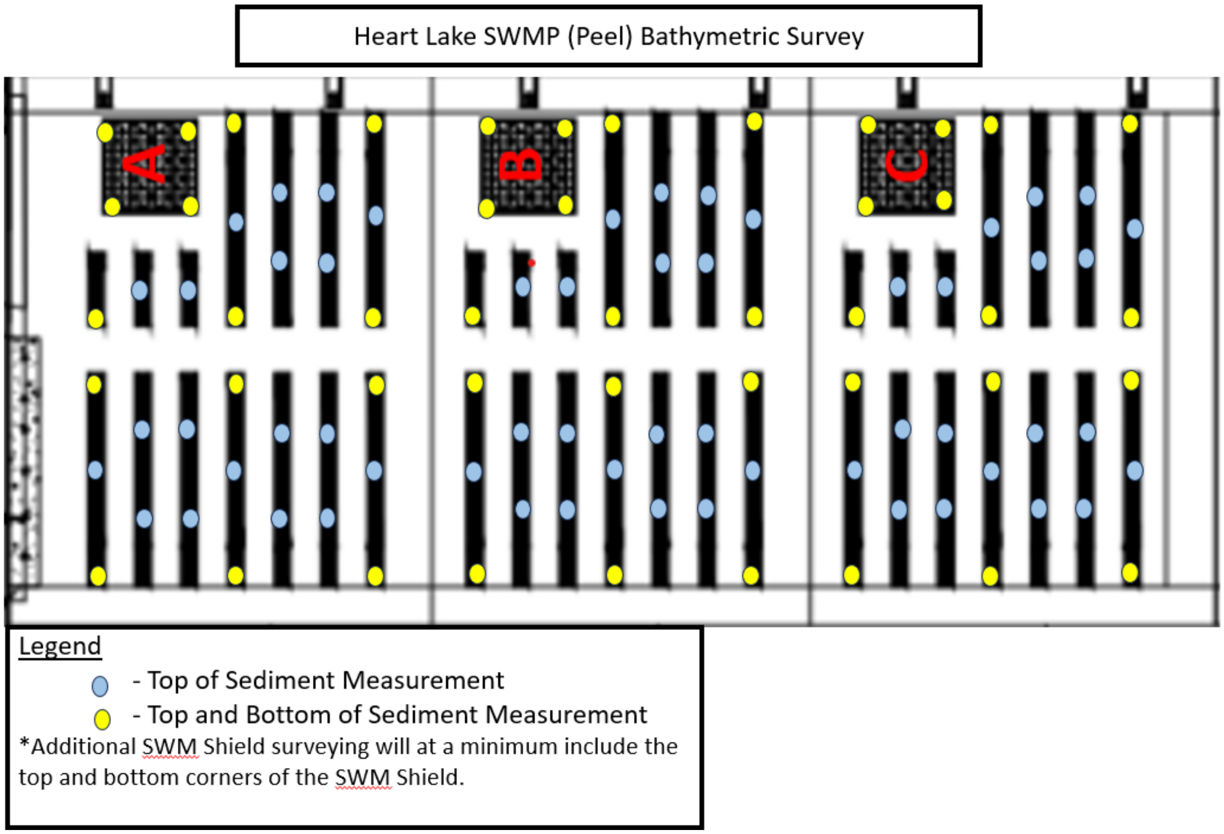
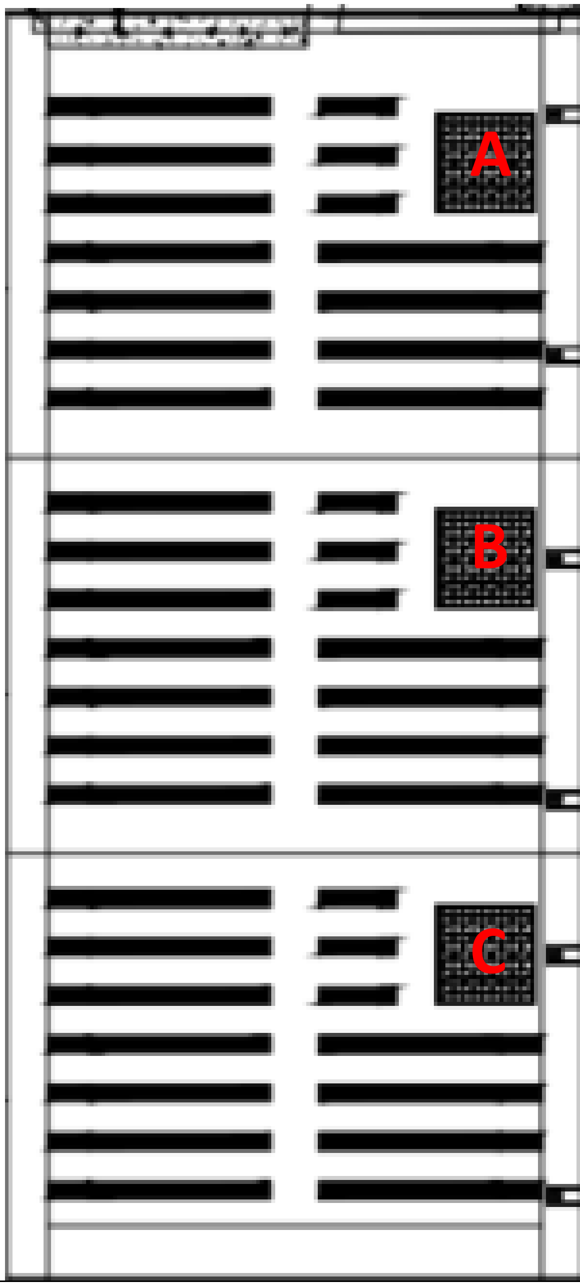


Figure 3-2 - Heart Lake SWMP (Peel) Bathymetric Survey Grid

The sampling sequence is summarized in **Table 3-2**.

Table 3-2 - Heart Lake SWMP (Peel) Sediment Sampling Field Sheet.



Sample Details: Particle Size (Parameters a-d)	
Sample Number	Location Notes
1. Sediment 1: Inlet	A
2. Sediment 2: Outlet	C
3. Sediment 3: Composite	A
	B
	C
Sample Details: Phosphorous (Parameters e-f)	
Sample Number	Location Notes
1. Phosphorous Composite 1	A
	B
	C
2. Phosphorous Composite 2	A
	B
	C
3. Phosphorous Composite 3	A
	B
	C
Notes:	

3.3 SWMP 87 – Villa Park Pond (Vaughan)

The proposed bathymetric survey grid is shown in **Figure 3-3**.

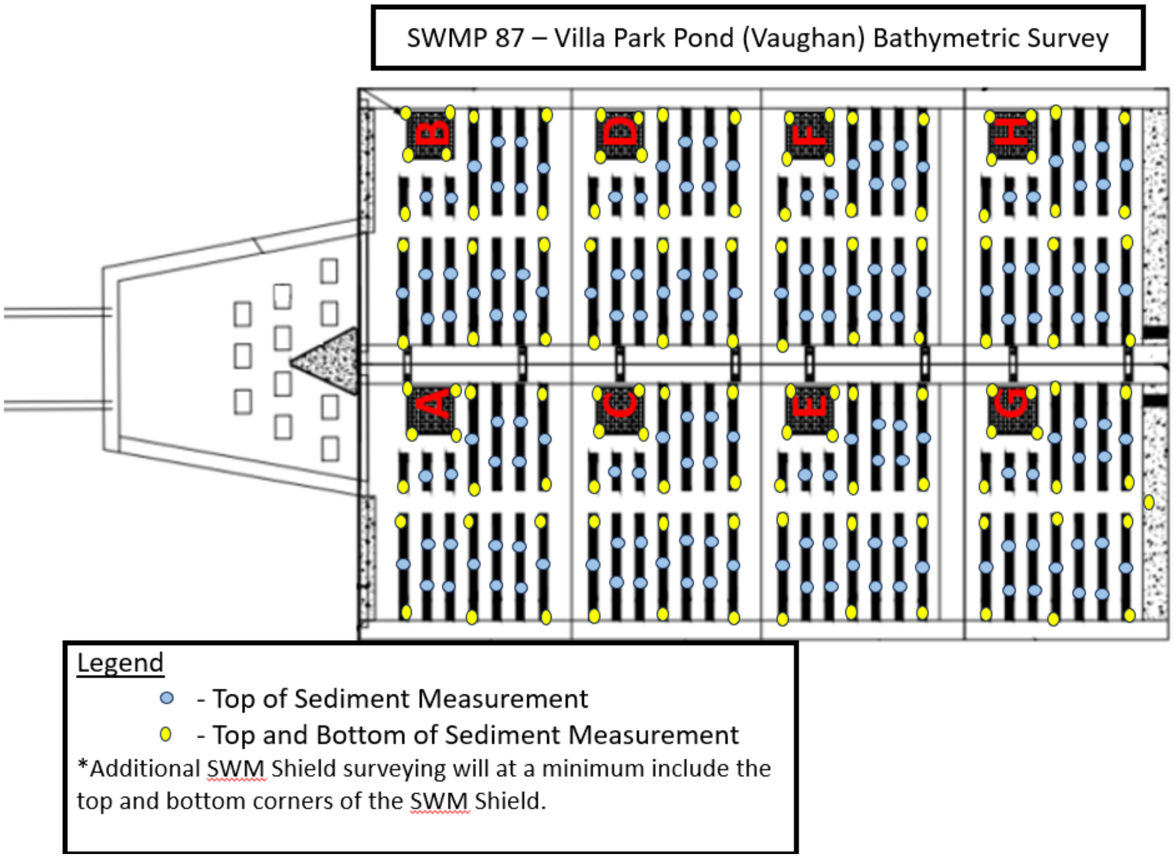
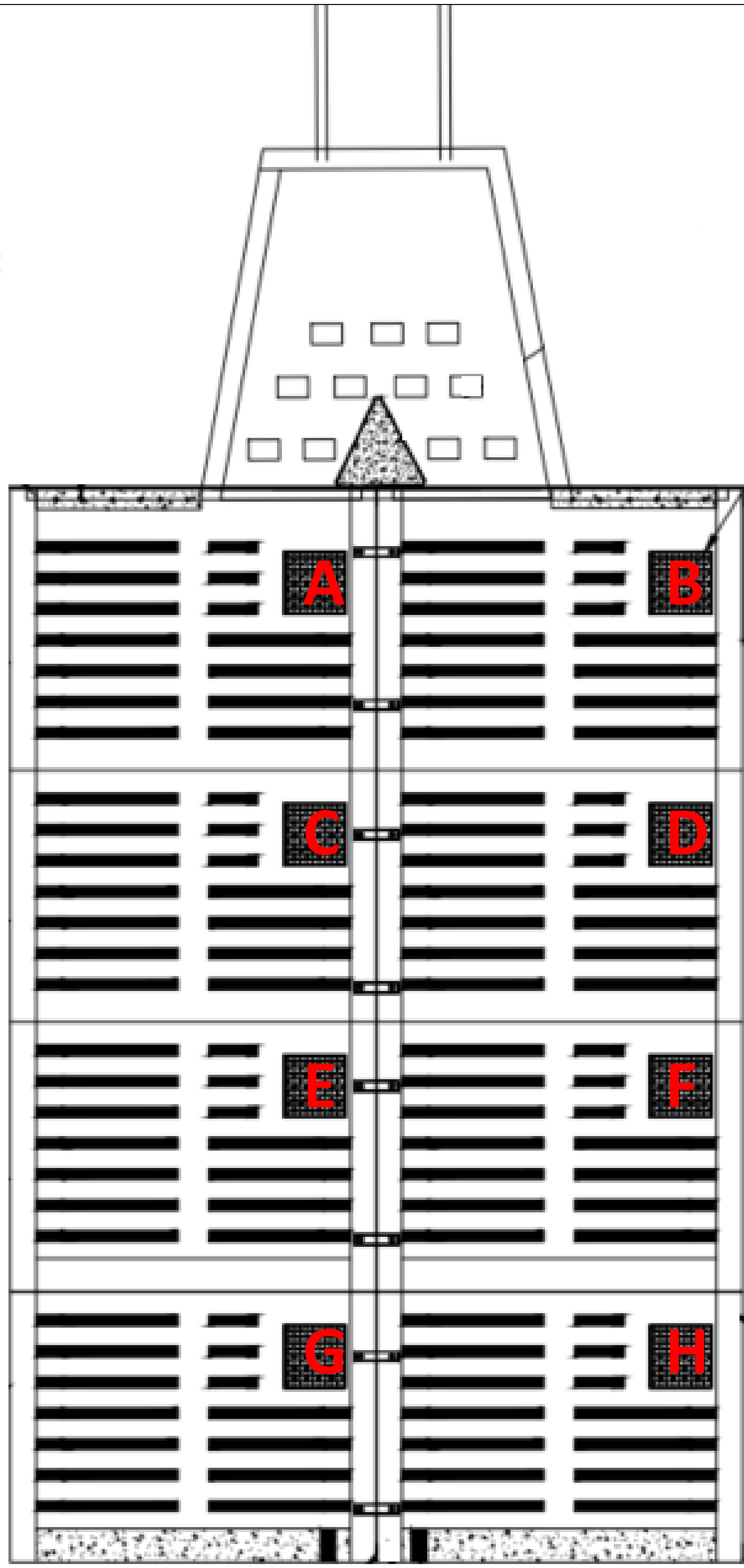


Figure 3-3 - SWMP 87 - Villa Park Pond (Vaughan) Bathymetric Survey Grid.

The sampling sequence is summarized in **Table 3-3**.

Table 3-3 - SWMP 87 - Villa Park Pond (Vaughan) Sediment Sampling Field Sheet.



Sample Details: Particle Size (Parameters a-d)

Sample Number	Location Notes
1. Sediment 1: Inlet	A
	B
2. Sediment 2: Outlet	G
	H
3. Sediment 3: Composite	B
	C
	F
	G

Sample Details: Phosphorous (Parameters e-f)

Sample Number	Location Notes
1. Phosphorous Composite 1	A
	D
	G
2. Phosphorous Composite 2	B
	C
	F
3. Phosphorous Composite 3	B
	E
	H

Notes:

3.4 SWMP 130 – Harmonia Pond (Vaughan)

The proposed bathymetric survey grid is shown in **Figure 3-4**.

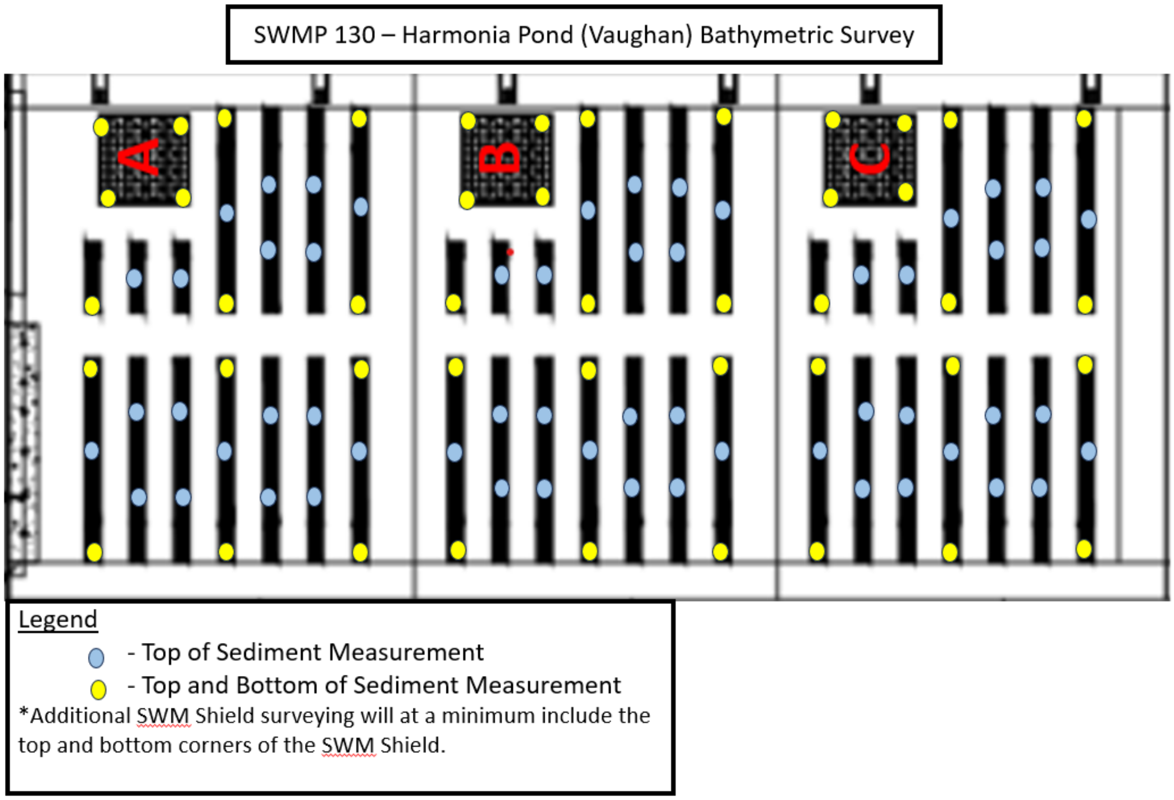
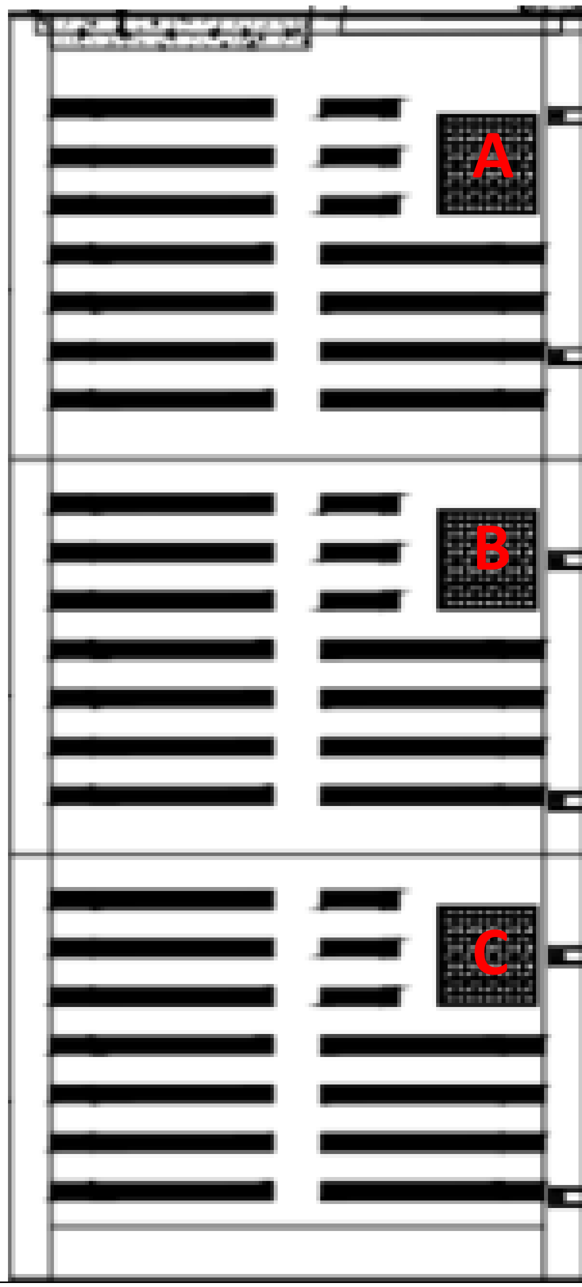


Figure 3-4 - SWMP 130m - Harmonia Pond (Vaughan) Bathymetric Survey Grid.

The sampling sequence is summarized in **Table 3-4**.

Table 3-4 - SWMP 130 - Harmonia Pond (Vaughan) Sediment Sampling Field Sheet.



Sample Details: Particle Size (Parameters a-d)

Sample Number	Location Notes
1. Sediment 1: Inlet	A
2. Sediment 2: Outlet	C
3. Sediment 3: Composite	A
	B
	C

Sample Details: Phosphorous (Parameters e-f)

Sample Number	Location Notes
1. Phosphorous Composite 1	A
	B
	C
2. Phosphorous Composite 2	A
	B
	C
3. Phosphorous Composite 3	A
	B
	C

Notes:

4.0 Anticipated Schedule

Upon confirmation of this methodology by the Client, all field work will be completed in late June/early July while SWMP levels are low. As discussed in the proposal, a draft submission is expected by September 30th, 2024.

Aquafor Beech Limited will conduct all of the aforementioned work along with reporting and analysis within the discussed upset limit, as authorized by the Client. We ask that you please contact us to confirm these considerations and discuss any further questions.

Appendix C – SWM Shield™ Annual Sediment Capture Calculations

This procedure for calculating the annual sediment loading was developed using background information provided by CB Shield Inc. to Aquafor Beech Ltd.

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m³)	Annual Loading (m³/ha)
35%	770	1,230	0.6
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

SWM Planning & Design Manual **- 6-13 -** ***Operation, Maintenance and Monitoring***

Villa Park SWMF Pond (City of Vaughan)

- Predicted Long-term Capture: 58%

1. Total Volume of Stormwater and Annual Loading

- **Precipitation**: Approximately of **792 mm** for City of Toronto
- **Runoff Coefficient**: **50%** (for imperviousness values of 53%)
- Stormwater **Suspended Solids** Concentration: **125 mg/L** of total.
- Stormwater Sediment **Density**: **1.23 kg/L** (per MOECC)

Sediment loading (kg/yr) = 29 (ha) X 792 (mm) X 50% runoff Coefficient X 125 mg/L

Sediment loading (kg/yr) = 14,355 (kg/year)

Sediment capture = 14,355 (kg/year) X 58% capture rate = 8326 (kg/year)

Sediment volume captured = 8326 (kg/year) / 1.23 (kg/L) = **6.7 (m^3/year)**

2. Annual Sediment Loading based on MECP 2003 Guidelines Document

1. Annual sediment loading (m^3/yr) = 1.6 (m^3/ha/yr) X 29 (ha) = **46 (m^3/year)**
2. Annual sediment captured (times 58% capture rate) = **27 (m^3/year)**

- Two Method Sediment Accumulation Average: **16.9 (m^3/year)**

Harmonia SWMF Pond (City of Vaughan)

- Predicted Long-term Capture: 57%

1. Total Volume of Stormwater and Annual Loading

- **Precipitation**: Approximately of **792 mm** for City of Toronto
- **Runoff Coefficient**: **50%** (for imperviousness values of 50%)
- Stormwater **Suspended Solids** Concentration: **125 mg/L** of total.
- Stormwater Sediment **Density**: **1.23 kg/L** (per MOECC)

Sediment loading (kg/yr) = 11.2 (ha) X 792 (mm) X 50% runoff Coefficient X 125 mg/L

Sediment loading (kg/yr) = 5,544 (kg/year)

Sediment capture = 5,544 (kg/year) X 57% capture rate = 3160 (kg/year)

Sediment volume captured = 3160 (kg/year) / 1.23 (kg/L) = **2.6 (m^3/year)**

2. Annual Sediment Loading based on MECP 2003 Guidelines Document

3. Annual sediment loading (m^3/yr) = 1.6 (m^3/ha/yr) X 11 (ha) = **17.6 (m^3/year)**
4. Annual sediment captured (times 58% capture rate) = **10 (m^3/year)**

- Two Method Sediment Accumulation Average: **6.3 (m^3/year)**

Heart Lake SWMF Pond (City of Brampton, Region of Peel)

- Predicted Long-term Capture: 55%

1. Total Volume of Stormwater and Annual Loading

- **Precipitation**: Approximately of **792 mm** for City of Toronto
- **Runoff Coefficient**: **50%** (for imperviousness values of 45%)
- Stormwater **Suspended Solids** Concentration: **125 mg/L** of total.
- Stormwater Sediment **Density**: **1.23 kg/L** (per MOECC)

Sediment loading (kg/yr) = 10.29 (ha) X 792 (mm) X 50% runoff Coefficient X 125 mg/L

Sediment loading (kg/yr) = 5,094 (kg/year)

Sediment capture = 5,094 (kg/year) X 55% capture rate = 2802 (kg/year)

Sediment volume captured = 2802 (kg/year) / 1.23 (kg/L) = **2.3 (m^3/year)**

2. Annual Sediment Loading based on MOECC

Annual sediment loading (kg/yr) = 1,535 (kg/ha) X 10.29 (ha) = 15,795 (kg/year)

Annual sediment captured (55% capture rate) = 15,795 (kg/yr) X 55% capture rate = 8,687 (kg/year)

Sediment Volume Capture = 8687 (kg/year) /1.23 (kg/L) = **7.0 (m3/year)**

Kennedy SWMF Pond (City of Brampton, Region of Peel)

- Predicted Long-term Capture: 54%

1. Total Volume of Stormwater and Annual Loading

- **Precipitation**: Approximately of **792 mm** for City of Toronto
- **Runoff Coefficient**: **60%** (for imperviousness values of 58%)
- Stormwater **Suspended Solids** Concentration: **125 mg/L** of total.
- Stormwater Sediment **Density**: **1.23 kg/L** (per MOECC)

Sediment loading (kg/yr) = 9.02 (ha) X 792 (mm) X 60% runoff Coefficient X 125 mg/L

Sediment loading (kg/yr) = 5,5,358 (kg/year)

Sediment capture = 5,538 (kg/year) X 54% capture rate = 2893 (kg/year)

Sediment volume captured = 2893 (kg/year) / 1.23 (kg/L) = **2.4 (m^3/year)**

2. Annual Sediment Loading based on MOECC

Annual sediment loading (kg/yr) = 2,539 (kg/ha) X 9.02 (ha) = 22,902 (kg/year)

Annual sediment captured (55% capture rate) = 22,902 (kg/yr) X 54% capture rate = 12,367 (kg/year)

Sediment Volume Capture = 12,367 (kg/year) /1.22 (kg/L) = **10.0 (m3/year)**