June 04, 2018

Mr. Jaime Favila
California State Water Resources Control Board
Division of Water Quality
P.O. Box 100
Sacramento, CA 95812-100

Re: Application for Trash Treatment Control Device – Downstream Defender®

Dear Mr. Favila,

Hydro International® is pleased to submit this application for the Downstream Defender® for Certification as a Full Capture System - Trash Treatment Control Device. Although the Downstream Defender® is currently Certified as a Full Capture System through grandfathering, Device modifications have been made to help improve maintenance ability and accessibility. We believe recertification is beneficial. Documentation for this application is being submitted in accordance with the California State Water Resources Control Board *Trash Treatment Control Device Application Requirements* document that includes the following minimum required sections:

1. Cover Letter
2. Table of Contents
3. Physical Description
4. Installation Information
5. Operation and Maintenance Information
6. Reliability Information
7. Field/Lab Testing Information and Analysis

Please contact me with any questions or should additional information be required. Thank you for your consideration of this application.

Regards,

David Scott
Technical Product Manager
Hydro International®

1.0 COVER LETTER

1.A. A general description of the Device;

The Downstream Defender® is an Advanced Hydrodynamic Vortex Separator (AHVS) that incorporates vortex separation, sedimentation, and screening to treat stormwater for removal of sediment, trash and debris, and oil and grease from stormwater. The Device consists of a precast concrete manhole that houses internal components for conducting the treatment processes. The design of the Downstream Defender's® unique flow-modifying internal components distinguish the Downstream Defender® from conventional and simple swirl separators and prevent washout of captured pollutants across a wide treatment flow range. The flow modifying internal components used in the Downstream Defender® harness the energy from vortex flow and maximize the time for separation to occur while deflecting high scour velocities. Polluted stormwater is introduced tangentially into the side of the precast vortex chamber to establish rotational flow. A cylindrical baffle with an inner center shaft creates an outer and inner spiraling column of flow and ensures maximum residence time for pollutant travel between the inlet and outlet. Oil, trash and other floating pollutants are captured and stored on the surface of the outer spiraling column and are completely isolated from the Device outlet. Low energy vortex motion directs sediment into the protected sump region. Only after following a long three-dimensional flow path is the treated stormwater discharged from the outlet pipe. The updated version of the Downstream Defender® now incorporates a conical screen that separates the inner and outer flow columns. The screen utilized in the Downstream Defender® is made from mesh with an opening aperture that does not exceed 4.7mm in size and all flows under the listed maximum treatment capacity must pass through the screens ensuring removal and retention of all particles 5.0mm in size or larger. Maintenance ports at ground level provide access for easy inspection and clean out. The Downstream Defender® is available in five standard precast model sizes ranging from the smallest 48-inch diameter manhole footprint to the largest manhole having a footprint of 12-ft. in diameter.

1.B. The applicant's contact information and location;

California Contact:
Phil O'Neill
Regional Sales Manager
Hydro International®
109 First Street
Solvang, California 93463
(805) 350-8163
poneill@hydro-int.com

Corporate Contact:
David Scott
Technical Product Manager
Hydro International®
94 Hutchins Drive
Portland, Maine 04102
(207) 756-6200
dscott@hydro-int.com

1.C. The Devices' manufacturing location;

Hydro International® utilizes a combination of contract manufacturers and component suppliers to produce the Downstream Defender® stormwater treatment system. These partner facilities are located throughout the United States and Hydro selects the facility used based on proximity to the project as well as other factors. The facilities utilized for any particular project are selected to provide the most cost effective and convenient solution.

Hydro International® currently retains over 60 partner, manufacturing facilities. Four facilities currently provide support for the California market and these are located in San Diego, Santa Maria, Simi Valley, and Pleasanton.

1.D. A brief summary of any field/lab testing results that demonstrates the Device functions as described within the application;

The Downstream Defender® has undergone full-scale laboratory testing, in-house field monitoring, third party evaluations and Hydro International® has performed Computational fluid Dynamics all as an effort to determine the pollutant removal effectiveness and long-term performance of the Device. Many of these efforts are associated with sediment removal but several have provided good support for the Device's trash removal claims.

In 2002, a field monitoring study for Onondaga Lake Nonpoint Source Environmental Benefit Project was produced by Moffa and Associates (A Unit of Brown and Caldwell) that included a component for monitoring the Downstream Defender®. This study concluded the Downstream Defender was capable of removing 100% of trash from the storm water under the prescribed flow conditions. It should be noted that this study was performed on an earlier version of the Downstream Defender®, which did not contain a screen. Although this study and the CFD analysis support effective removal of trash without the need for a screen, Hydro International® modified the design to include a screen for complete assurance of 100% trash removal for the 5mm particle and larger.

A copy of the *Onondaga Lake Nonpoint Source Environmental Benefit Project* test report has been included in this Application in Appendix F.

1.E. A brief summary of the Device limitations, and operational, sizing, and maintenance considerations;

The Downstream Defender® is an engineered stormwater treatment system developed to meet a wide variety of applications and water quality objectives. Proper design, application, sizing, installation, operation and maintenance are critical to ensuring water quality objectives are met.

The Downstream Defender® is made from precast concrete and internal components are made from materials with long service lives. Designers should ensure application of the Device is within the strength and service limits of the precast concrete structure as well as the strength and service limits of the internal components. Adherence to Hydro International® design recommendations will ensure application within the design limits of the Downstream Defender®.

The Downstream Defender® is designed to remove sediment, trash, debris, and other gross pollutants. Sizing of the system is dependent on the targeted pollutants of concern and the federal, state, and local regulations that govern the water quality objectives. Recommended sizing guidelines have been provided in this Application but adequate sizing should be confirmed prior to finalization of design and installation.

Maintenance is a critical component of any Trash Control Program. The Downstream Defender® is an effective tool to help achieve Trash Control Program objectives but performance is dependent on routine maintenance and proper operation. The Downstream Defender® design allows for increased trash capture capacities and extended maintenance cycles. Additionally, the design of the Downstream Defender® allows for easy access for inspection and maintenance.

1.F. A description or list of locations, if any, where the Device has been installed. Include the name and contact information of as many as three municipality(s) purchasing the Device, and

Device Installation No. 1

Project: Echo Park Lake Rehabilitation
751 Echo Park Avenue, Los Angeles, CA 90026
Model: 2X DD-6 Offline
Contact: City of Los Angeles
Watershed Protection Division
(800) 974-9794
lastormwater@lacity.org

Device Installation No. 2

Project:	Temescal Canyon Park Stormwater Project – Phase 1 362 Temescal Canyon Road, Pacific Palisades, CA 90272
Model:	1X DD-12 Offline
Contact:	City of Los Angeles Watershed Protection Division (800) 974-9794 lastormwater@lacity.org

Additional installations of the Trash Capture version of this device are pending SWRCB Certification.

1.G. The certification below:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons that manage the system or those persons directly responsible for gathering the information, to the best of my knowledge and belief, the information submitted is, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

____ 06/04/2018

David Scott, Technical Product Manager Date

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2.0 TABLE OF CONTENTS

Contents

3.0 PHYSICAL DESCRIPTION

3.A. Description on how the Device works to trap all particles that are 5 mm or greater in size and how it is sized for varying flow volumes;

The Downstream Defender® is an Advanced Hydrodynamic Vortex Separator (AHVS) that incorporates vortex separation, sedimentation, and screening to treat stormwater for removal of sediment, trash and debris, and oil and grease from stormwater. The Device consists of a precast concrete manhole that houses internal components for conducting the treatment processes. The design of the Downstream Defender's® unique flow-modifying internal components distinguish the Downstream Defender® from conventional and simple swirl separators and prevent washout of captured pollutants across a wide treatment flow range. The flow modifying internal components used in the Downstream Defender® harness the energy from vortex flow and maximize the time for separation to occur while deflecting high scour velocities. Polluted stormwater is introduced tangentially into the side of the precast vortex chamber to establish rotational flow. A cylindrical baffle with an inner center shaft creates an outer and inner spiraling column of flow and ensures maximum residence time for pollutant travel between the inlet and outlet. Oil, trash and other floating pollutants are captured and stored on the surface of the outer spiraling column and are completely isolated from the Device outlet. Low energy vortex motion directs sediment into the protected sump region. Only after following a long three-dimensional flow path is the treated stormwater discharged from the outlet pipe. The updated version of the Downstream Defender® now incorporates a conical screen that separates the inner and outer flow columns. The screen utilized in the Downstream Defender® is made from mesh with an opening aperture that does not exceed 4.7mm in size and all flows under the listed maximum treatment capacity must pass through the screens ensuring removal and retention of all particles 5.0mm in size or larger. Maintenance ports at ground level provide access for easy inspection and clean out. The Downstream Defender® is available in five standard precast model sizes ranging from the smallest 48-inch diameter manhole footprint to the largest manhole having a footprint of 12-ft. in diameter.

The Downstream Defender® main product components are shown below in Figure 1. Operation of the Downstream Defender® begins when water enters the Device through the Inlet Pipe (4). The design and construction of the Inlet Pipe allow for flows to be introduced tangentially into the precast concrete manhole structure (2) which creates a rotary flow within the structure. This rotary flow is maintained when the water flow is additionally restrained by the Dip Plate Cylinder (3). The combination of the Dip Plate Cylinder and the cylindrical concrete manhole create an annulus flow path around the circumference of the Device. The flows are constrained within the annulus and continue on this rotary path. The storm water cannot begin to exit the Device until the water extends below and inside of the Dip Plate Cylinder. This creates an extended flow path in the Device, which allows finer particulate additional time to settle out of the storm water and floatables and neutrally buoyant material to surface within the annulus space. The configuration of the Dip Plate Assembly also creates a physical barrier between the Tangential Inlet Pipe and

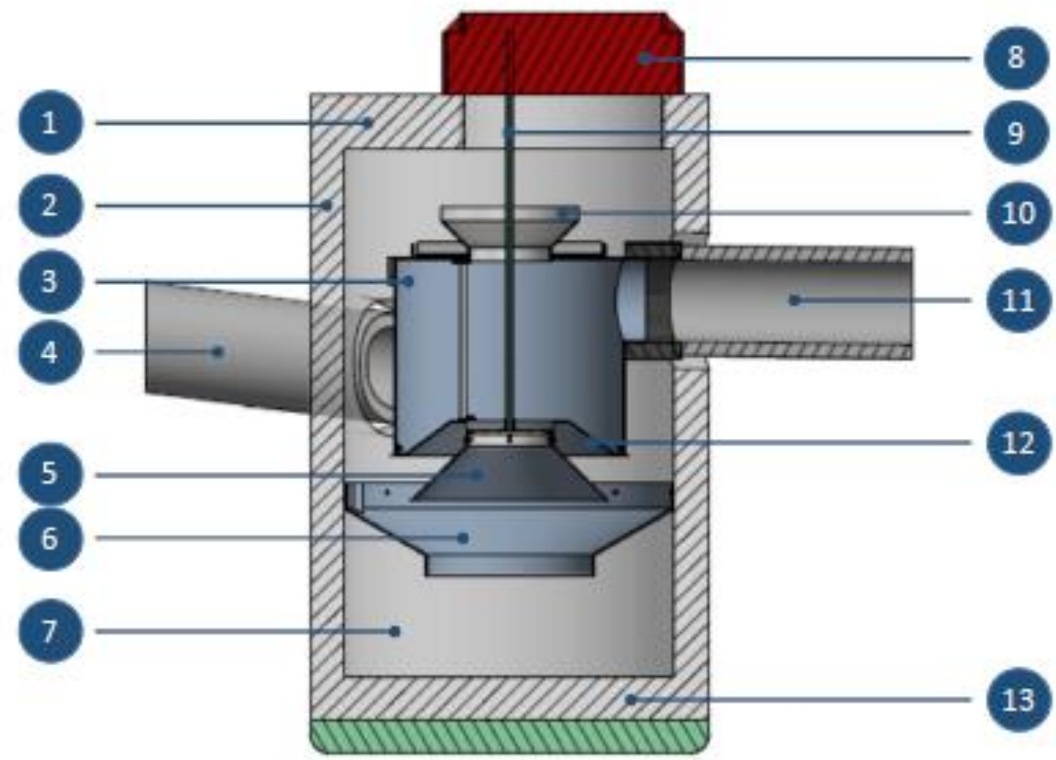


Figure 1 - Downstream Defender® Components Diagram

the Outlet Pipe (11). Floatable material such as trash and debris and non-emulsified oil is retained within the outer annulus. As the flows extend beyond the base of the Dip plate Cylinder, the water and suspended sediment encounter the Center Cone (5). Particulate sediment that is settling out of the water is directed outward and downward by the Center Cone and as the material settles further, it is then directed inward and downward by the Benching Skirt (6). The sediment is fully deposited in the Sediment Storage Sump (7). The path for the sediment to exit the Sediment Storage Sump is convoluted and the Central Cone and the Benching Skirt isolate the Sump area from disruptive flows. For these reasons, the sediment remains undisturbed and does not re-suspend into the storm water.

The storm water flows then proceed upward into the inside of the Dip Plate Cylinder. Prior to entering the Dip Plate Cylinder, the water must pass through a Conical Screen (12) which is mounted to the inside, bottom of the Dip Plate Cylinder. The screen is constructed from a perforated stainless steel material and the openings are no greater than 4.7mm in diameter. All flows under the Maximum Treatment Capacity must pass under the Dip Plate Cylinder and through the perforated screen thus ensuring Full Capture of all particles 5.0mm in size or larger.

While the presence of the screen provides assurance no particles 5.0mm or larger can exit the Device, the screen is supplementary to the Dip Plate Assembly. The Dip Plate assembly forces the floatable material to be retained within the annulus space between the Dip Plate and the Manhole inside circumference. CFD analysis and Field monitoring confirm the Dip Plate assembly used in conjunction with a submerged inlet, to maintain the water level above the crown of the outlet pipe, works to effectively capture and retain all trash and debris.

Flows in excess of the Maximum Treatment Capacity may exceed the top of the Dip Plate Assembly. The Assembly has a central opening that serves as a bypass feature in the Device. The Full Capture version of the Downstream Defender® is constructed with a conical Bypass Screen (10) that protects the central opening at the top of the Dip Plate Assembly. The screen deflects any trash or debris downward and away from the opening. The design prevents clogging and minimal bypass of trash and debris.

The Downstream Defender® requires routine and regular maintenance to remove the captured trash and debris, sediment, and oil from the Device. Access is provided to the Device for maintenance through the Manhole Access Lids (8). The Manhole Access Lid(s) are located to provide access to the Sediment Storage Sump as well as the annulus space on the outside of the Dip Plate Assembly. Larger units are provided with multiple access lids to provide for better access.

The Downstream Defender® is designed for in-line operation. While the Device may also be used in off-line applications, the hydraulics of the Device allow for maximized treatment at flows that typically well exceed the design storm and placement off-line is often not necessary. The Device does allow for internal bypass to prevent upstream flooding and adverse hydraulic conditions during the occurrence of low probability storm events.

Figure 2 illustrates the Downstream Defender® operation during three different storm event scenarios. During the design storm event the water service elevation does not exceed the crown of the outlet pipe. In the Figure, the green line represents the maximum water level during the design storm event. This level will be different based on drainage area, pipe size, and the size of the Device selected. In all instances, the design storm flows circulate around the dip-plate and then upward and under the dip-plate through the main treatment screen. Because all flows pass through the main treatment screen, Full Capture and retention of Trash is ensured during the design storm event. When designing for use of the Downstream Defender® the Typical Treatment Flow Rate in the Design Guide should always be larger than the flow generated by the design storm to ensure this scenario pertains.

The orange line in the Figure represents the water surface elevation at the Maximum Treatment Capacity of the Device. This is the water surface elevation encountered when the flow through the Device reaches the top of the bypass screen. (Note: This considers a Safety Factor) All flows must pass through either the main treatment screen or the conically shaped bypass screen. Full Capture of Trash and retention of Trash is realized at the Maximum Treatment Capacity because all flows are beneath of the top of the bypass screen.

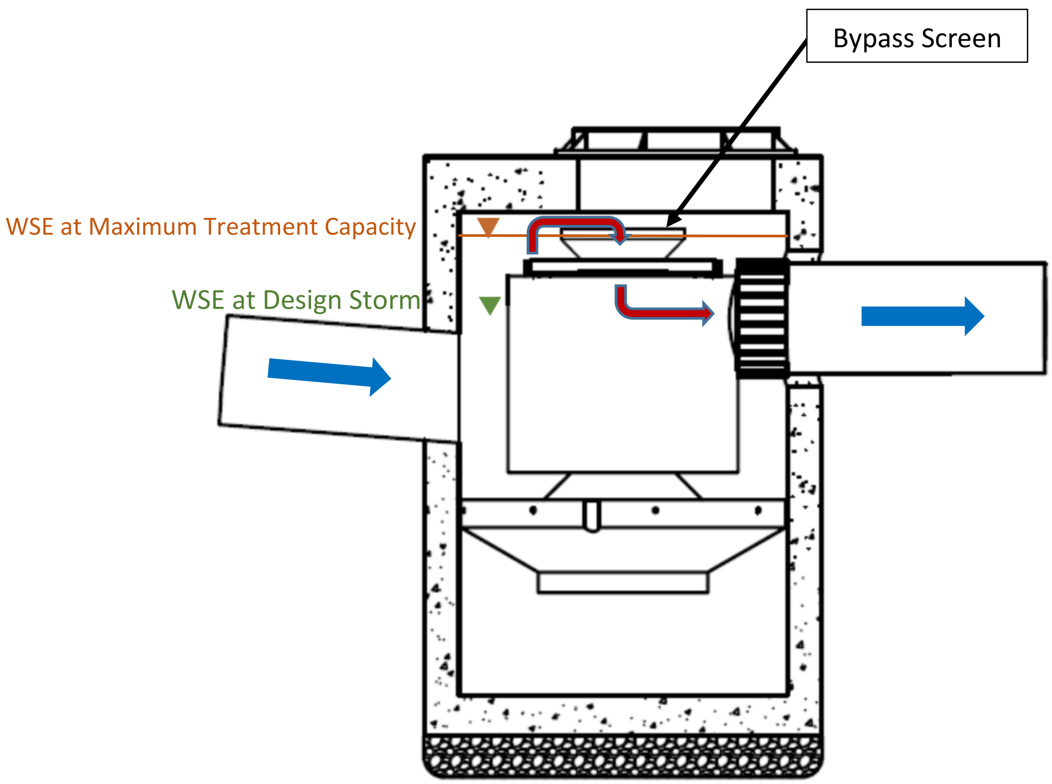


Figure 2 - Hydro DryScreen®Internal Bypass Operation

The red arrows in the Figure represents the water flow when the Device is in bypass operation. During this scenario, water will convey over the top of the bypass screen. A significant portion of the flow still passes through the screened areas of the Device but the flows in excess of the Maximum Treatment Capacity will not be screened.

Downstream Defender® Design Chart
Table 1

Model Number and Diameter		Maximum Trash Treatment Capacity[1]		Typical Treatment Flow Rate[2]		Maximum Pipe Diameter		Trash Storage Capacity		Sediment Storage Capacity	
(ft)	(m)	(cfs)	(L/s)	(cfs)	(L/s)	(in)	(mm)	(yd^3)	(m^3)	(yd^3)	(m^3)
4	1.2	3.0	85	2.20	62.4	12	300	0.35	0.26	0.70	0.53
6	1.8	8.0	227	4.96	140.3	18	450	1.07	0.82	2.10	1.61
8	2.4	15.0	425	8.82	249.6	24	600	2.67	2.04	4.65	3.56
10	3.0	25.0	708	13.73	388.8	30	750	5.20	3.97	8.70	6.65
12	3.7	38.0	1,076	19.98	565.8	36	900	8.76	6.70	14.70	11.24

This table is intended to be used as a guide for selecting standard model sizes. Contact Hydro International for custom sizing needs.

1. Maximum Trash Treatment Capacity is the maximum flow rate of the Device at which 100% removal of floatables 5mm or greater in size can be captured and retained.
2. Typical Treatment flow rate based on 80% instantaneous removal of suspended sediment with a mean particle size distribution of 75um.

3.B. Design drawings for all standard Device sizes including dimensions;

Design drawings for all standard devices are included in Appendix A.

3.C. Photographs, if any, of pre- and post-installation examples; and

Photographs of the Downstream Defender® during manufacturer, installation and operation are shown below:

Figure 3 – Benching Skirt Install and Placement

Figure 4 - Defender® Dip Plate and Cone ready for Install

Figure 5 – Close-up Side View of Dip Plate

Figure 6 – Top View of Dip Plate w/o Bypass Screen

Figure 7 - Defender® In Operation

Figure 8 - Defender® During Maintenance

3.D. Alternative configurations;

Design drawings for alternate configurations of the Downstream Defender® are included in Appendix A.

3.E. Engineering plans/diagrams for a typical installation;

Typical installation drawings and diagrams for the Downstream Defender® are included in Appendix C.

3.F. The Device maximum trash capture capacity;

Table 1 lists the Device maximum trash capture capacity (yd^3) retained by each Downstream Defender® model as "Trash Storage Capacity". The trash capture volumes listed in the table are maximum volumes that can be captured and retained without resuspension of trash and with consideration of the Maximum Treatment Capacity.

3.G. The Device hydraulic capacity (flow in cfs) at its maximum trash capture capacity for all standard Device sizes;

The maximum Device hydraulic capacity at the maximum trash capacity is listed as the "Maximum Trash Treatment Capacity" in Table 1.

3.H. Each material and material grade used to construct the Device (e.g., stainless steel, plastic, etc.);

The Downstream Defender® is constructed of industry standard materials that are suitable for the harsh environment experienced by a subsurface stormwater treatment system. A detailed Specification for the Downstream Defender® is included in Appendix B of this submittal. For convenience, a short listing of the major components and the materials used for those components is listed in this section:

- **Structure** – The Downstream Defender® main structure is made from a concrete manhole conforming to ASTM C478. The walls, floor, ceiling, and baffles are all made from concrete with a minimum 28 day compressive strength of 4,000psi or greater with aggregate per ASTM C33 and reinforcing steel per ASTM A615, Grade 60. The structure is designed to support traffic loads per AASHTO HS-25.

- **Metal Screens** – The main treatment screen and the bypass screen are made from perforated stainless steel conforming to ASTM A240, Grade 304 with perforations not greater than 4.0mm (0.156 in) in size and a total open area not less than 63%.

- **Dip Plate, Center Shaft and Cone, and Benching Skirt** – The internal components are rotationally molded from High Density Polyethylene (HDPE).

- **Structural Mounting and Securing Components** – Frames, supports, mounting hardware and securing fasteners are made from stainless steel conforming to ASTM F593 and F594, Grade 304.

- **Access Covers** – Manhole frames and covers are cast from iron in conformance with ASTM A48, CL358 and AASHTO M105. Hatches are made from aluminum. Either access system are designed to support traffic loads per AASHTO HS-25.

3.I. Conditions under which the Device re-introduces previously trapped trash;

Under normal design and operating condition the Downstream Defender® will remove and permanently retain all trash and debris that is 5.0mm in size or larger. Conditions under which the Device may re-introduce previously trapped trash are as follows:

- Maintenance of Full Capture Devices is a critical component of any trash capture program. Adherence to the recommended maintenance requirements of the Device with special consideration for the maximum trash capacity is critical in ensuring previously trapped trash is not re-introduced into the stormwater. The listed maximum trash capacity for the Downstream Defender® is the maximum manageable level the Device can hold prior to experiencing adverse conditions including re-entrainment of previously trapped trash.
- Improper Design or Installation may cause the Device to operate improperly including re-introduction of previously trapped trash.
- Routine screen maintenance to ensure screens are not broken or damaged is critical to ensuring retained trash is not re-introduced into the environment. Missing, damaged, broken, or deteriorated screens and associated components should be routinely inspected and maintained to prevent reintroduction of retained trash.

3.J. Estimated design life of the Device;

The design service life for the Downstream Defender® is dependent on the materials, design, installation, and proper operation and maintenance. The Downstream Defender® is constructed from materials with a design service life of between 50 and 100 years. The metal and plastic components are rated for the shorter span of 50 years while the concrete structure is rated for 100 years. The Device does not utilize any consumable materials.

3.K. If the Device is substantially similar to a currently listed Certified Device(s), name the Certified Device(s) and identify the substantial similarities and any minor changes in materials, material thickness, structural assembly, etc. Explain how these minor changes in your Device will impact performance as compared to the substantially similar Certified Device.

The Downstream Defender® is currently a Certified Full Capture Device and the submitted Device is substantially similar to the currently Certified Downstream Defender®. Hydro International® has modified the design of the Downstream Defender® to allow for more cost effective

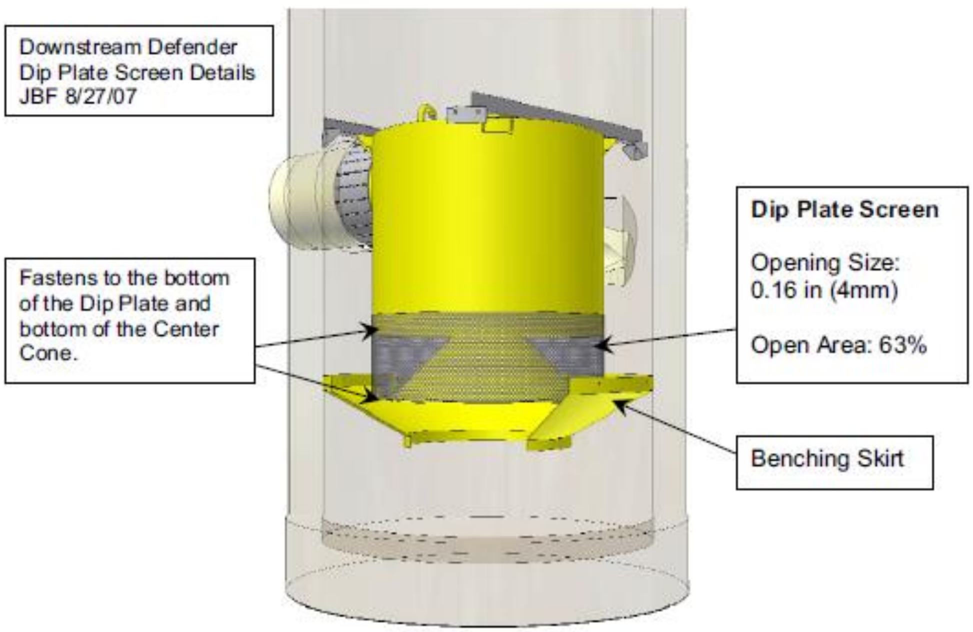


Figure 9 - Illustration of Currently Certified Downstream Defender

manufacturing, hassle free installation, and proper long-term function of the screening mechanism in the Device. All components with the exception of the screen remain unchanged. Figure 9 is an illustration of the configuration of the currently Certified Device. The two major differences between the currently Certified Device and the Device in the submitted application are the configuration of the main treatment screen and the addition of the bypass screen.

As can be seen in Figure 9, the main treatment screen was previously configured as a cylinder that connected to the bottom of the Dip-Plate and extended to the top of the central cone. The main screen in the modified design also connects to the bottom of the Dip-Plate but it is conical in shape and resides within the Dip-Plate. See Figure 1. Observation, analysis and experimentation determined the screen could be more cost effectively manufactured and in a configuration that could more securely and structurally attached to the other internal components. In addition, the top of the central cone now resides on the outside of the screen therefore eliminating any possibility of adverse sediment removal performance issues should the screen become clogged. While the current configuration operates and functions well the opportunity to optimize the operation and function was available and Hydro International® initiated the change.

The current configuration also contains no bypass screen. This can be noted in Figure 11 as compared to Figure 1. The Downstream Defender® is now configured with a bypass screen located at the top of the Dip-Plate which surrounds the central cone. Water may bypass the lower treatment area through the central cone during large storm events. While most flows will not create a water elevation within the treatment manhole to rise above the top of the Dip-Plate, the bypass screen was added in this area to prevent re-entrainment of previously captured trash from bypassing during storm events that exceed the Design Storm.

The differences in configurations will not be readily noticeable to most observers. Both configurations function well and meet the Full Capture requirements but the new configuration will only be available moving forward.

4.0 INSTALLATION INFORMATION

4.A. Device installation considerations;

The Downstream Defender® Installation Manual is included in Appendix C of this submittal and contains typical installation considerations are contained within the manual.

4.B. Device installation procedures; and

The Downstream Defender® Installation Manual is included in Appendix C of this submittal. Installation of the treatment Device is critical to ensuring a long service life for the structure and its components as well as ensuring expectations of treatment performance. The installation manual includes methods and practices for the following:

- Site Conditions
- Delivery, Offloading, & Handling
    - Pre-Inspection
    - Component Weight
    - Lifting Devices
    - Storage
- Site Preparation
    - Excavation
    - Bedding

- Installation
    - Placement
    - Jointing and Sealing
    - Pipe Connections
    - Access, Risers, & Manholes
    - Backfilling
- Installation Log

The Downstream Defender® is intended to be a turnkey Device that arrives at the construction site complete for installation. Assembly of manhole sections and access structures as well as inlet and outlet connections are required to be performed in the field as these cannot be completed at the manufacturing facility. Guidelines are provided to the Contractor to assist with installation. In all instances, Federal, State, and Local laws and regulations should be followed.

Internal components are pre-assembled and pre-installed at the factory but removed to prevent damage during shipment. Re-installation of the internal components involves only reconnection of existing hardware. In some instances, internal components may need to be installed on site. During these instances a Hydro International® representative and/or contractor will be on site for the installation of these components. At no time should a Contractor be tasked with installation of the internal components unless the Contractor has received appropriate training and certifications from Hydro International. ®

Inspection is a critical component of the installation. Inspection should occur before, during and after installation to ensure proper installation and function of the Device. An installation log is provided in the Installation Manual to document the installation of the Device. This log should be provided to Hydro International® and the Owner and a copy should be retained by the Contractor for future reference.

4.C. Methods for diagnosing and correcting installation errors.

Installation errors of the Downstream Defender® are not common provided installation is completed by a qualified Contractor and the installation is overseen by a knowledgeable Owner. Hydro International® has procedures in place to prevent installation errors but in the event an error occurs, immediate diagnosis and corrective action are required.

Prior to manufacture and delivery of the Downstream Defender®, the Contractor and Owner are provided with design drawings and fabrication drawings. These drawings provide specific details for all aspects of the design and construction of the Device. A Hydro International® representative can also be available for delivery and installation of the Downstream Defender® Device. The Hydro representative will utilize these drawings to ensure conformance with the design and installation requirements. These drawings should be utilized by the Owner and Contractor as well to help diagnose errors.

Should an error be encountered, Hydro International® should be consulted for any necessary corrective action.

5.0 OPERATION AND MAINTENANCE INFORMATION

5.A. Device inspection frequency considerations, and inspection procedures;

The Downstream Defender® *Operation and Maintenance Manual* is included with this submittal in Appendix D. The manual provides detailed information for Downstream Defender® Inspection procedures and frequency considerations. A summary of the requirements are listed below:

A thorough inspection program can be an effective practice to help ensure compliance with water quality objectives. A well-designed inspection program helps determine maintenance frequency, prevent anomalies from occurring during operation, and eliminates excessive costs from too frequent maintenance. The Downstream Defender® design allows for quick inspection from surface level and requires no entry into the vault.

Inspection Frequency

- During the first year of operation, the Downstream Defender® should be inspected every three to six months. This more frequent inspection is needed to determine the site-specific pollutant loading and is utilized to determine maintenance frequency.
- Inspection may be conducted during any season but is typically conducted prior to the start of the rainy season.

Inspection Procedures

- Set up any necessary safety equipment around the access hatches and/or manhole covers of the Downstream Defender® as required by local ordinances. Safety equipment should notify pedestrians and vehicle traffic of work in the area.
- Remove the manhole covers or access hatches.
- Without entering the structure, visually inspect the annular space around the Dip-Plate for trash, debris, and other gross pollutants. Trash levels and volumes in the chamber should be noted especially in relation to the bypass screen.
- Remove the plunger using the plunger handle. The presence of trash and debris or sediment on the plunger would indicate bypass and the need for maintenance. Using a sediment probe, measure the depth of sediment in the central sump.
- Visually inspect for signs of abnormal operation such as excessively high water levels, broken or damaged internal components, or absence of any pollutants.
- Record the date, unit location, trash and debris volumes and levels, and sediment levels measured.
- If screens are clogged or obstructed minor maintenance may be conducted to unblock the screens using the probe pole with a brush and/or net attachment.

- Securely replace the access cover/hatches.
- Remove safety equipment.
- Contact the local Mosquito and Vector Control district should mosquito or vector be present in the vault.

5.B. Maintenance frequency considerations, maintenance procedures, and a description of necessary equipment and materials for maintenance;

The Downstream Defender® *Operation and Maintenance Manual* is included with this submittal in Appendix D. The manual provides detailed information for Downstream Defender® Maintenance procedures and frequency considerations. A summary of the requirements are listed below:

Maintenance of the Downstream Defender® should occur as determined during inspection of the Device. If no inspection records have been used to determine a maintenance frequency then maintenance should occur annually or when sediment and trash levels exceed 75% of the capacity listed in the Design Table.

Maintenance Procedures

- Set up any necessary safety equipment around the access ports as stipulated by local ordinances. Safety equipment should notify passing pedestrian and road traffic that work is being done.
- Remove access lids and visually inspect the inside of the manhole. Document observations and take pictures. Estimate and record the screenings and sediment depths. Update the maintenance log.
- Remove the plunger using the plunger handle.
- Using a vactor removal system, vacuum pollutants trapped around the bypass screen and in the annular space between the Dip-Plate and the circumference of the manhole.
- Insert the vacuum tube in the central opening and vacuum sediment and liquid from the central sump. When all sediment is removed re-insert and secure the plunger in the central opening.
- Document the cleaning with photographs and by completing the maintenance log included with the *Downstream Defender® Operation and Maintenance Manual*.
- Replace the access covers/hatches and remove the safety equipment.

Recommended Maintenance Equipment and Materials

The following equipment is the minimum recommended equipment for routine maintenance of the Downstream Defender®. Additional equipment may be necessary based on unique site or installation conditions.

- PPE (Personal Protective Equipment)
- Safety and Traffic control equipment (cones, barricades, signage, flagging, etc.)
- Manhole hook or pry bar
- Flashlight
- Tape measure
- Measuring stick or sludge sampler
- Long-handled net and brush
- Confined space entry equipment
- Vacuum truck
- Digital Camera
- Inspection/Maintenance Report

5.C. Effects of delayed maintenance on Device structural integrity, performance, odors;

Generalized maintenance frequencies are included in Section 5.A. and 5.B as well as the *Operations and Maintenance Manual* in Appendix D. These generalized maintenance frequencies may be appropriate for most drainage areas. Pollutant loading is land use type and drainage area dependent. Hydro International® recommends developing a drainage area specific operation and maintenance plan. For designs meeting a Trash Full Capture requirement, it is recommended to base the design and sizing of the Device in part on the Waste Load Allocation for the drainage area. Additionally, the first year of Device operation should be closely monitored and inspected for accumulated pollutant levels to determine Device specific maintenance frequency. Maintenance activities should be reviewed annually to determine if the maintenance program is appropriate or may need adjustments.

Maintenance that is delayed or ignored may cause adverse effects in pollutant removal performance, premature bypass and release of captured pollutants, adverse hydraulic conditions such as increased HGL in the Device and upstream flooding.

5.D. Vector Control accessibility:

The Downstream Defender® is a subsurface stormwater treatment Device that maintains an accommodating environment for Mosquito and Vector. Conscious of this, Hydro International® designed the Downstream Defender® for quick and convenient access to inspect and abate for Mosquito and Vector.

The Downstream Defender® is designed to provide unobstructed visual access and manned access to all areas of the treatment manhole. While manned access is not necessary for Mosquito and Vector inspection and abatement activities, the option is available with the standard design of the Device. Access is accomplished by outfitting the Device with manhole access located directly above each of the key areas of the treatment components. Figure 10 shows a section view of a typical manhole and the relationship of the access points to the areas of exposed water. Manhole cover sizes and quantity vary based on the Device size. The smallest model (4ft Diameter) contains a single manhole access cover that spans the central opening and the outer annular space while larger models contain two or three manhole access points allowing for placement in the critical areas for access. The green arrows in the Figure represent unobstructed visual and physical access to the wet sump areas of the Device. Mosquito and Vector personnel can use these access points to visually inspect for Mosquito and Vector activity as well as mitigate by way application of larvacide pellets, briquettes or liquid spray.

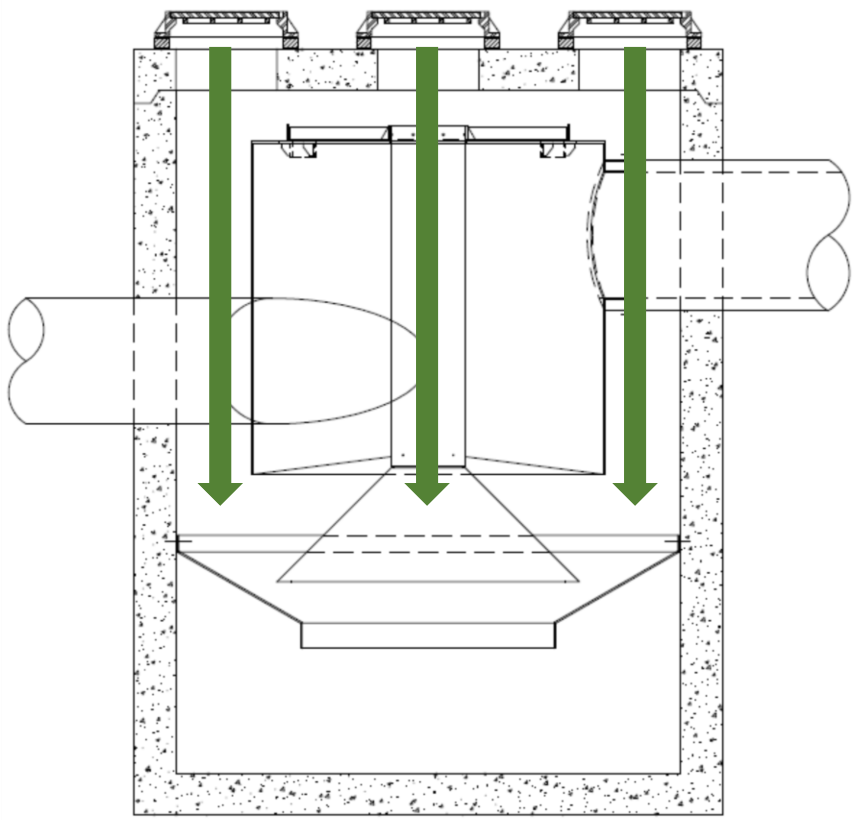


Figure 10 - Downstream Defender® Access for Mosquito/Vector Personnel

Figure 11 is a top down view of a typical Downstream Defender® manhole. The access covers are shown in this Figure as semi-transparent so that the internal components can be seen relative to the access points. As illustrated in this Figure, the totality of the components can be visually and physically accessed through the provided access points. The central access point to the sump is directly accessible from the center manhole access point and the annular space containing water and trash and debris is accessible from the outer manhole access points. Physical access is large enough for a vactor truck nozzle as well as manned entry. Should liquid or solid forms of larvacide need to be applied for Mosquito control, the visual and physical access is available.

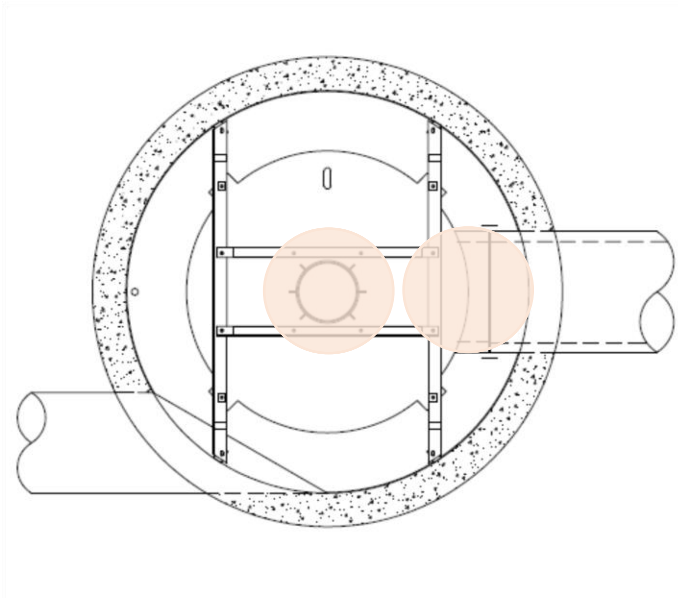


Figure 11 - Downstream Defender® Top Down View Illustrating Relation of Access Points to internal Components

Figure 12 provides the same top down view as Figure 11 but of a field-installed operational unit. The centrally located manhole access point provides access to the central channel leading to the sump. This area will contain water but if functioning properly this area should not have any trash that will visually or physically obstruct the opening. The outer manhole access points are located directly above the annular space between the internal Dip-Plate and the inside circumference of the manhole. This area contains water and will contain trash and debris. Any trash and debris that is obstructing access to the water in this area can be moved with a sampling rod.

Figure 12 - View from Manhole Access Points

While access to inspect and abate for Mosquito and Vector are key design features of the Device, the Downstream Defender® also helps prevent entry and subsequent breeding as well.

The manhole covers and access hatches utilized on the Downstream Defender® are solid and are sealed with gaskets. Small pick holes are large enough for Mosquito and other vector to enter the vault and are not recommended. Hydro International supplies all Downstream Defenders® with solid and gasket sealed covers to prevent Mosquito and Vector entry. See Figure 13, which illustrates example manhole covers with and without an open pick hole.

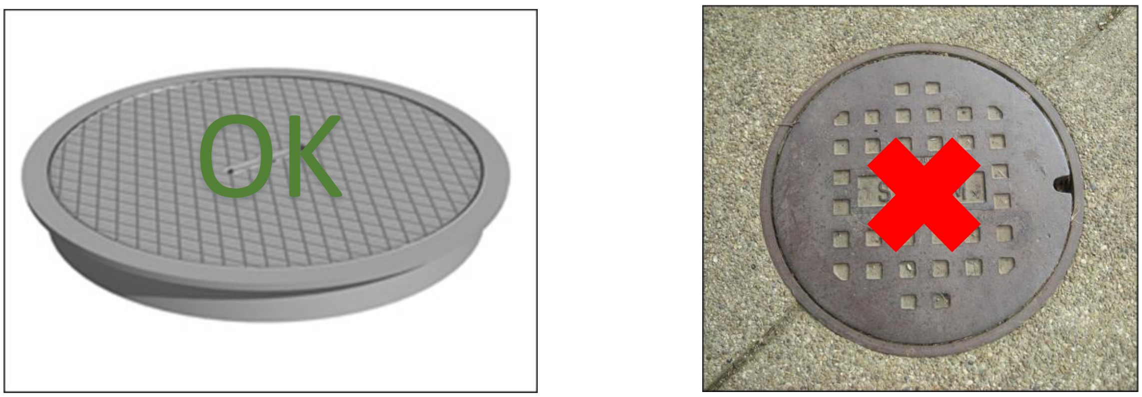


Figure 13 - Example Solid and Open Pick Hole Manhole Covers

Inlet and outlet pipes are another possible entry point to the Device for Mosquito and Vector. The Downstream Defender® is hydraulically unique from other Full Capture Devices because the inlet is submerged. The inlet of the Device enters the manhole at a lower elevation than the outlet. Because of this the inlet is always full of water. See Figure 14.

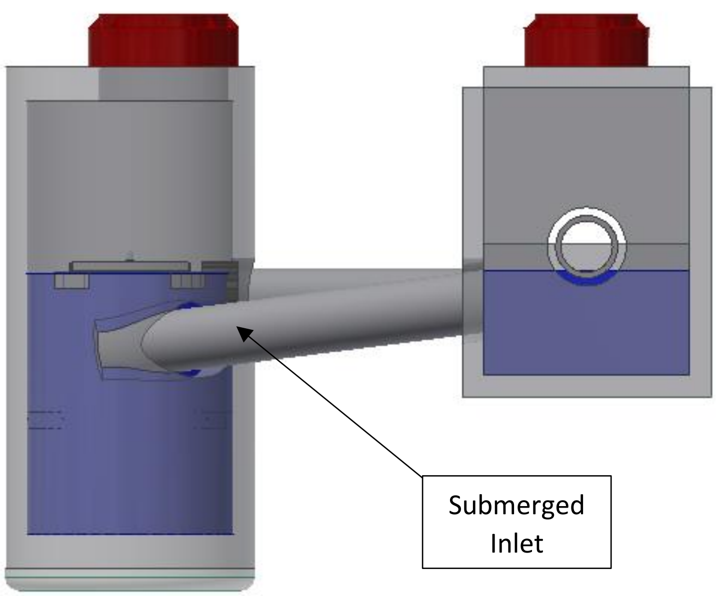


Figure 14 - Illustration of Submerged Inlet of the Downstream Defender®

With the inlet full of water, there is no opportunity for Mosquito or Vector to enter the treatment manhole. In addition, the outlet stub and pipe are isolated from the main treatment area by way of the Dip-Plate.

With entry to the treatment Device blocked at the manhole, inlet and outlet pipe, mosquito and vector are effectively excluded from the Downstream Defender®. Because of the standing water upstream of the inlet pipe, the upstream manhole must be considered a mosquito vector location however. This manhole will contain water but will be free from trash and debris, which can impede Mosquito and Vector Control activities. To prevent this manhole from access, third party exclusion devices can be considered.

Figure 15 and Figure 16 are examples of potential third party exclusion devices that may be utilized to prevent mosquito and vector from entering the upstream manhole through the inlet and outlet pipes. Both devices are considered to be check valves and function by allowing water to pass through the device in one direction. When water is not moving the valves are closed thus preventing passage of Mosquito and vector. The devices operate with low head pressure but confirmation of function within the storm drain system should be confirmed prior to application.

Figure 15 - Example Third Party Exclusion Device - Duckbill Valve

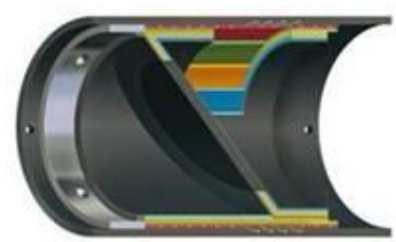


Figure 16 - Example Third Party Exclusion Device – Internal Rubber Boot Check Valve

Hydro International® should be contacted in the design phase should any third party exclusion device be a consideration for review and evaluation of compatibility.

5.E. Repair Procedures for the Device's structural components.

The design of the Downstream Defender® utilizes the entire manhole area for treatment and operation. Internal components are designed for extended service life. Minor repairs may be required and Hydro International® should be contacted in the event of a minor repair for specific repair instructions. Major repairs are not anticipated but should be evaluated by a Hydro International® representative on a case-by-case basis.

6.0 RELIABILITY INFORMATION

6.A. Estimate design life of Device components before major overhaul:

As per Section 3.J., the design service life for the Downstream Defender® is dependent on the materials, design, installation, and proper operation and maintenance. The Downstream Defender® is constructed from materials with a design service life of between 50 and 100 years. The metal and plastic components are rated for the shorter span of 50 years while the concrete structure is rated for 100 years. The Device does not utilize any consumable materials. A major overhaul would not be anticipated prior to 50 years of operation.

6.B. Device sensitivity to loadings other than trash (i.e., leaves, sediment);

The Downstream Defender® targets trash but also other pollutants such as debris, grass clippings, branches, twigs, and other gross pollutants. The vortex separation also specifically targets suspended sediment. Pollutants that are removed using the same removal mechanism, such as trash and leaves through screening, have no negative interactions with trash when encountered in the same stormwater flow. Some gross pollutant material may make the screens more susceptible to blinding and blockage and maintenance frequency may need to be adjusted based on the specific pollutant mix experienced by the Device.

The removal mechanism for sediment is unrelated to the removal mechanism for trash and therefore the Device has no dependency or sensitivity to the removal of one or the other.

6.C. Warranty Information; and

The warranty for the Downstream Defender® is a two (2) year limited warranty. A copy of the warranty is included in Appendix E.

6.D. Customer support information.

Hydro International® Stormwater has a corporate office located in Portland, Maine and representatives throughout the country.

Hydro International® Americas Stormwater Headquarters
94 Hutchins Drive
Portland, Maine 04102
Phone: (207) 756-6200
Fax: (207) 756-6212
inquiries@hydro-int.com

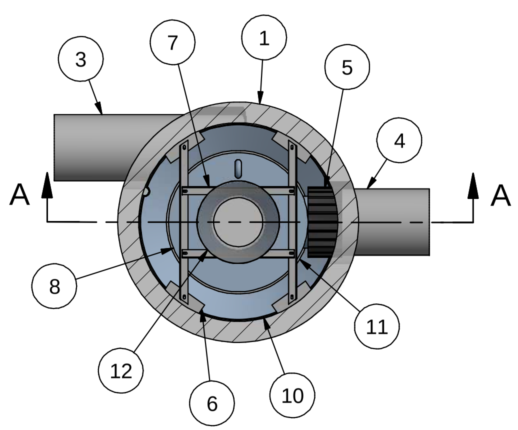
7.0 Field/Lab Testing Information and Analysis

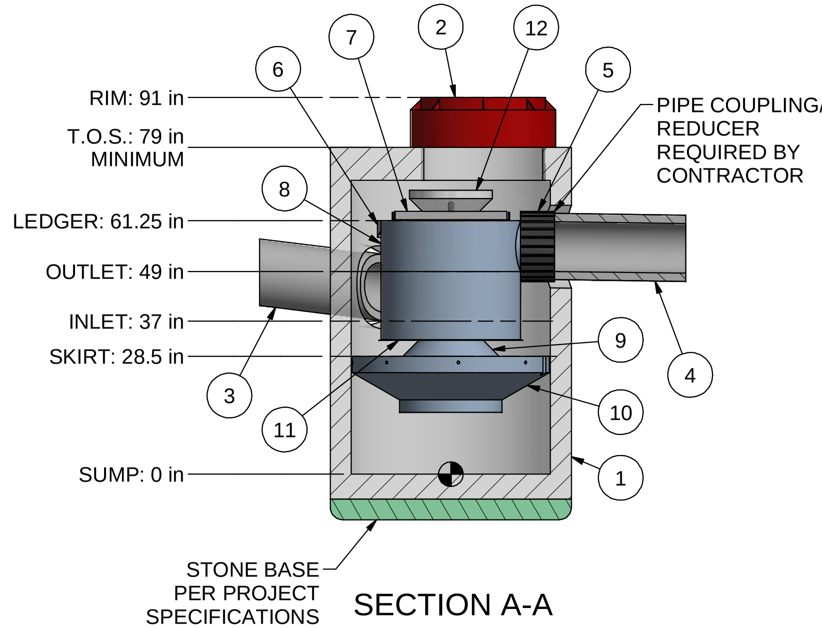
The Downstream Defender® has undergone full-scale laboratory testing, in-house field monitoring, third party evaluations and Hydro International® has performed Computational fluid Dynamics all as an effort to determine the pollutant removal effectiveness and long-term performance of the Device. Many of these efforts are associated with sediment removal but several have provided good support for the Device's trash removal claims.

In 2002, a field monitoring study for Onondaga Lake Nonpoint Source Environmental Benefit Project was produced by Moffa and Associates (A Unit of Brown and Caldwell that included a component for monitoring the Downstream Defender®. This study concluded the Downstream Defender was capable of removing 100% of trash from the storm water under the prescribed flow conditions. It should be noted that this study was performed on an earlier version of the Downstream Defender® which did not contain a screen. Although this study and the CFD analysis support effective removal of trash without the need for a screen, Hydro International® modified the design to include a screen for complete assurance of 100% trash removal for the 5mm particle and larger.

A copy of the *Onondaga Lake Nonpoint Source Environmental Benefit Project* test report has been included in this Application in Appendix F.

APPENDIX A





SECTION A-A

PARTS LIST		
ITEM	DESCRIPTION	SIZE (in)
1	PRECAST MANHOLE (BY HYDRO VIA PRECASTER)	48
2	FRAME AND COVER	30
3	INLET PIPE (BY OTHERS)	12
4	OUTLET PIPE (BY OTHERS)	12
5	PIPE COUPLING (BY OTHERS)	
6	LEDGER ANGLE	
7	SUPPORT FRAME	
8	DIP PLATE	
9	CENTER SHAFT AND CONE	
10	BENCHING SKIRT	
11	5mm SCREEN	
12	5mm BYPASS SCREEN	

DD SIZE	4'	6'	8'	10'	12'
OUTLET STUB ID	12"	18"	24"	30"	36"
OUTLET STUB OD	12.5"	18.7"	24.8"	36"	42"

EQUIPMENT PERFORMANCE

The stormwater treatment unit shall adhere to the hydraulic parameters given in the chart below and provide the removal efficiencies and storage capacities as follows:

1. Performance objectives: The unit shall be capable of treating the peak flow rate listed below.
2. Peak Hydraulic Capacity: 3.0 cfs (85 l/s)
3. Sediment Storage Capacity: 0.70 cu. yd. (0.53 cu. m)
4. Continuous Oil Storage Capacity: 70 gal. (265 liters)
5. Sediment shall be stored in a zone that is isolated from the main flow path and protected from reintrainment by a benching skirt.

PROJECTION

COMMENTS:

1. MANHOLE WALL AND SLAB THICKNESSES ARE NOT TO SCALE.
2. CONTACT HYDRO INTERNATIONAL FOR A BOTTOM OF STRUCTURE ELEVATION PRIOR TO SETTING DOWNSTREAM DEFENDER MANHOLE.
3. CONTRACTOR TO CONFIRM RIM, PIPE INVERTS, PIPE DIA. AND PIPE ORIENTATION PRIOR TO RELEASE OF UNIT TO FABRICATION.

REVISION HISTORY			
REV	BY	DESCRIPTION	DATE
-		FIRST RELEASE	

DATE: 3/29/2018 SCALE:

DRAWN BY: KDO CHECKED BY: APPROVED BY

Title: 4-ft DIAMETER DOWNSTREAM DEFENDER WITH SCREEN

GENERAL ARRANGEMENT

Hydro International
94 Hutchins Drive
Portland, ME 04102
Tel: +1 (207) 756-6200
Fax: +1 (207) 756-6212
hydro-int.com

DO NOT SCALE DRAWING

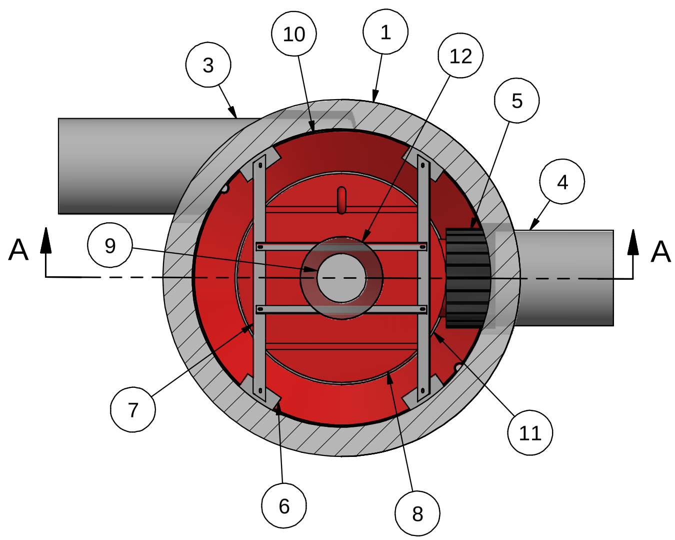
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERENCES ARE:
FRACTIONS ± 1/16
DECIMALS ± .06
ANGLES ± 1°

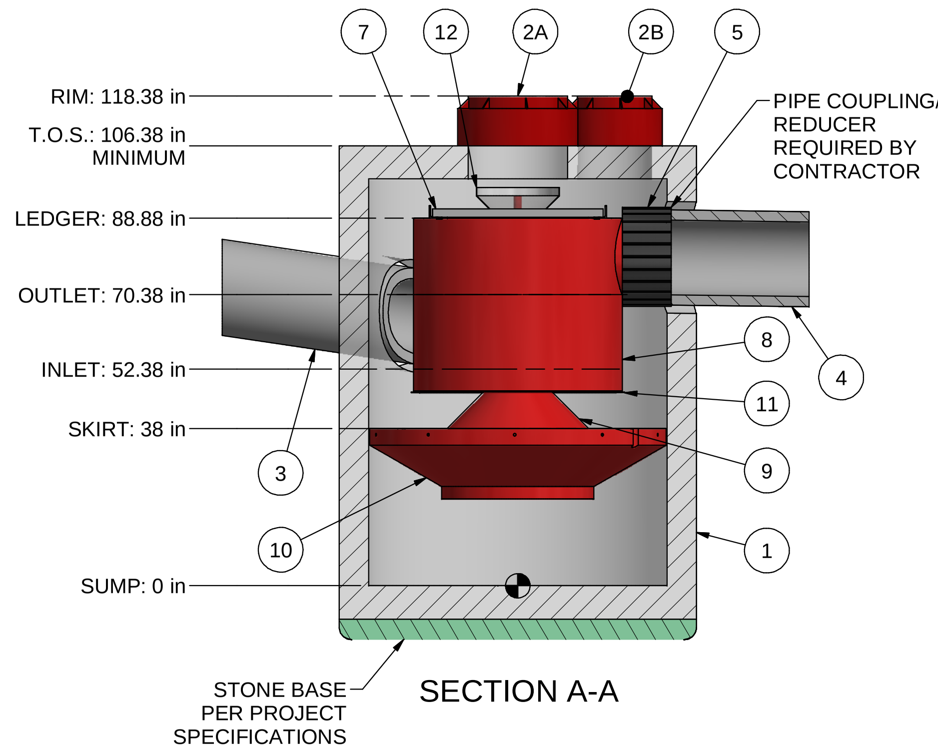
APPROX WEIGHT: N/A MATERIAL:

NEXT ASSEMBLY: -NEXT ASSY

DRAWING NO.: -DD GA

SHEET SIZE: B SHEET: 1 OF 3 Rev: -





SECTION A-A

PARTS LIST		
ITEM	DESCRIPTION	SIZE (in)
1	PRECAST MANHOLE (BY HYDRO VIA PRECASTER)	72
2A	FRAME AND COVER	24
2B	FRAME AND COVER	18
3	INLET PIPE (BY OTHERS)	18
4	OUTLET PIPE (BY OTHERS)	18
5	PIPE COUPLING (BY OTHERS)	
6	LEDGER ANGLE	
7	SUPPORT FRAME	
8	DIP PLATE	
9	CENTER SHAFT AND CONE	
10	BENCHING SKIRT	
11	5mm SCREEN	
12	5mm BYPASS SCREEN	

DD SIZE	4'	6'	8'	10'	12'
OUTLET STUB ID	12"	18"	24"	30"	36"
OUTLET STUB OD	12.5"	18.7"	24.8"	36"	42"

EQUIPMENT PERFORMANCE

The stormwater treatment unit shall adhere to the hydraulic parameters given in the chart below and provide the removal efficiencies and storage capacities as follows:

1. Performance objectives: The unit shall be capable of treating the peak flow rate listed below.
2. Peak Hydraulic Capacity: 8.0 cfs (227 l/s)
3. Sediment Storage Capacity: 2.10 cu. yd. (1.59 cu. m)
4. Continuous Oil Storage Capacity: 216 gal. (818 liters)
5. Sediment shall be stored in a zone that is isolated from the main flow path and protected from reintrainment by a benching skirt.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERENCES ARE:

FRACTIONS ± 1/16
DECIMALS ± .06
ANGLES ± 1°

PROJECTION

COMMENTS:

1. MANHOLE WALL AND SLAB THICKNESSES ARE NOT TO SCALE.
2. CONTACT HYDRO INTERNATIONAL FOR A BOTTOM OF STRUCTURE ELEVATION PRIOR TO SETTING DOWNSTREAM DEFENDER MANHOLE.
3. CONTRACTOR TO CONFIRM RIM, PIPE INVERTS, PIPE DIA. AND PIPE ORIENTATION PRIOR TO RELEASE OF UNIT TO FABRICATION.

REVISION HISTORY			
REV	BY	DESCRIPTION	DATE
-		FIRST RELEASE	

DATE: 3/29/2018	SCALE:	
DRAWN BY: KDO	CHECKED BY:	APPROVED BY

Title
6-ft DIAMETER DOWNSTREAM DEFENDER WITH SCREEN

GENERAL ARRANGEMENT

Hydro International
94 Hutchins Drive
Portland, ME 04102
Tel: +1 (207) 756-6200
Fax: +1 (207) 756-6212
hydro-int.com

APPROX WEIGHT: N/A	MATERIAL:	
NEXT ASSEMBLY: -NEXT ASSY		
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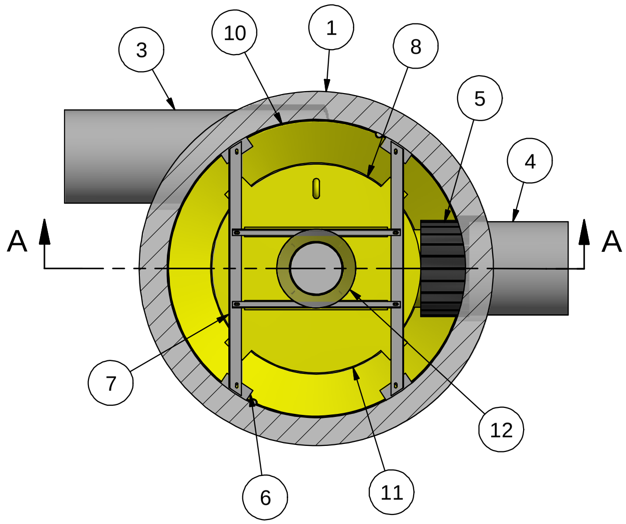
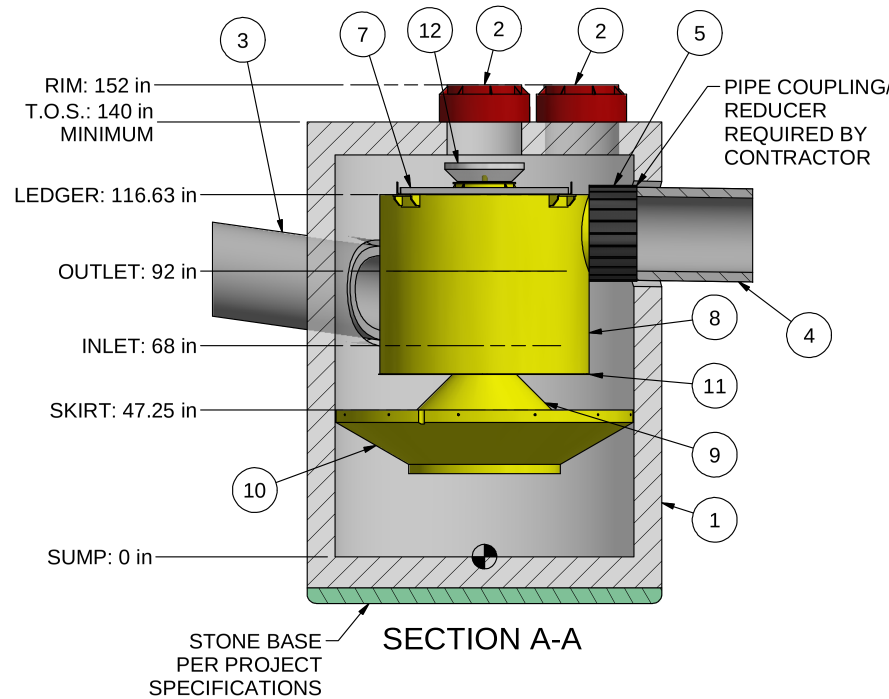
SHEET SIZE: B	SHEET: 1 OF 3	Rev: -





SECTION A-A

PARTS LIST

ITEM	DESCRIPTION	SIZE (in)
1	PRECAST MANHOLE (BY HYDRO VIA PRECASTER)	96
2	FRAME AND COVER	24
3	INLET PIPE (BY OTHERS)	24
4	OUTLET PIPE (BY OTHERS)	24
5	PIPE COUPLING (BY OTHERS)	
6	LEDGER ANGLE	
7	SUPPORT FRAME	
8	DIP PLATE	
9	CENTER SHAFT AND CONE	
10	BENCHING SKIRT	
11	5mm SCREEN	
12	5mm BYPASS SCREEN	

DD SIZE	4'	6'	8'	10'	12'
OUTLET STUB ID	12"	18"	24"	30"	36"
OUTLET STUB OD	12.5"	18.7"	24.8"	36"	42"

EQUIPMENT PERFORMANCE

The stormwater treatment unit shall adhere to the hydraulic parameters given in the chart below and provide the removal efficiencies and storage capacities as follows:

1. Performance objectives: The unit shall be capable of treating the peak flow rate listed below.
2. Peak Hydraulic Capacity: 15.0 cfs (425 l/s)
3. Sediment Storage Capacity: 4.65 cu. yd. (3.52 cu. m)
4. Continuous Oil Storage Capacity: 540 gal. (2044 liters)
5. Sediment shall be stored in a zone that is isolated from the main flow path and protected from reintrainment by a benching skirt.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERENCES ARE:
FRACTIONS ± 1/16
DECIMALS ± .06
ANGLES ± 1°

PROJECTION

COMMENTS:
1. MANHOLE WALL AND SLAB THICKNESSES ARE NOT TO SCALE.
2. CONTACT HYDRO INTERNATIONAL FOR A BOTTOM OF STRUCTURE ELEVATION PRIOR TO SETTING DOWNSTREAM DEFENDER MANHOLE.
3. CONTRACTOR TO CONFIRM RIM, PIPE INVERTS, PIPE DIA. AND PIPE ORIENTATION PRIOR TO RELEASE OF UNIT TO FABRICATION.

REVISION HISTORY

REV	BY	DESCRIPTION	DATE
-		FIRST RELEASE	

DATE: 3/29/2018 | SCALE:

DRAWN BY: KDO | CHECKED BY: | APPROVED BY

Title
8-ft DIAMETER
DOWNSTREAM DEFENDER
WITH SCREEN

GENERAL ARRANGEMENT

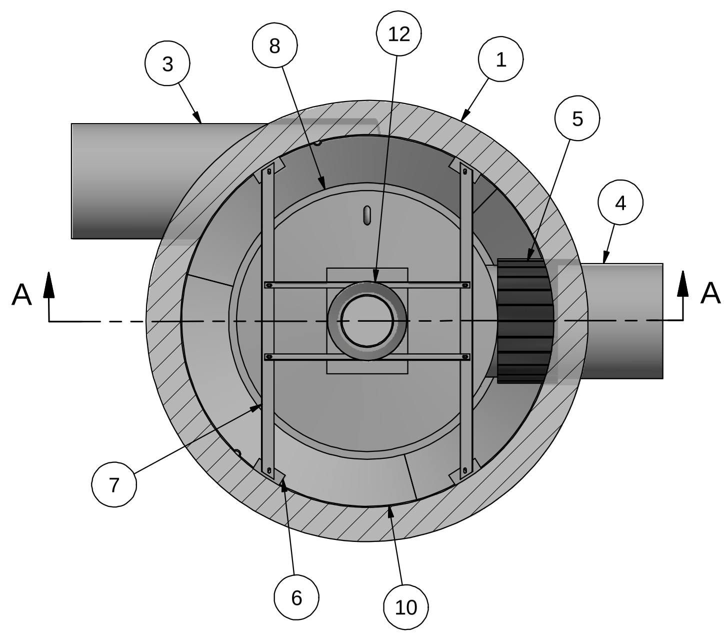
Hydro International
94 Hutchins Drive
Portland, ME 04102
Tel: +1 (207) 756-6200
Fax: +1 (207) 756-6212
hydro-int.com

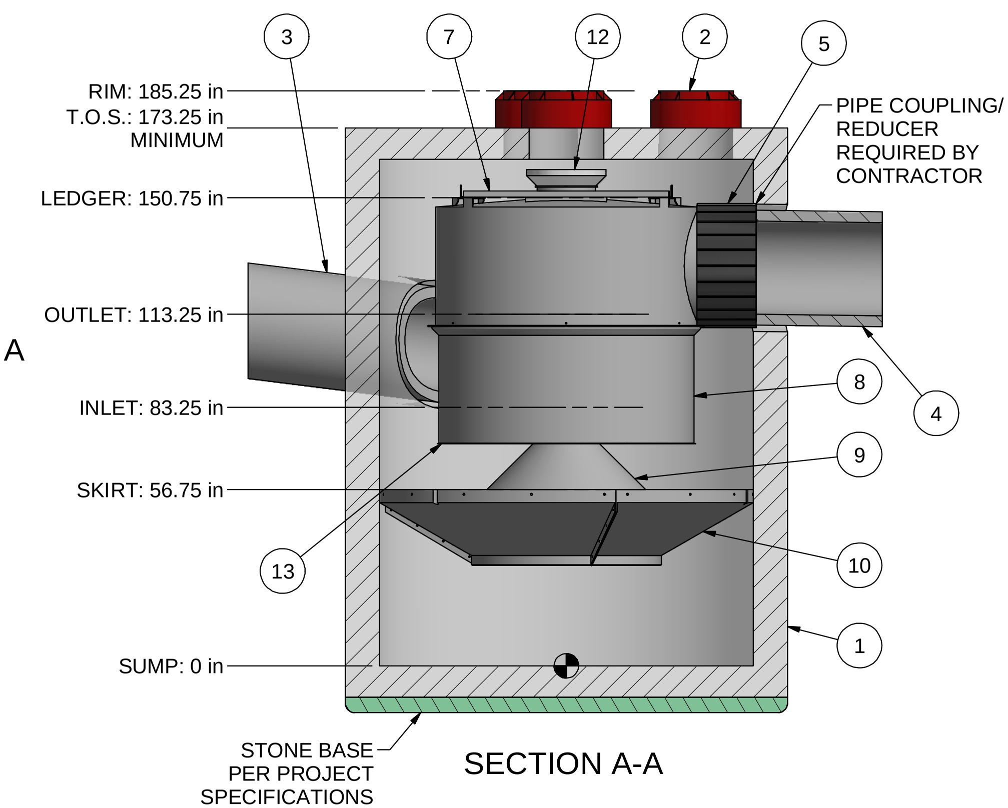
APPROX WEIGHT: N/A | MATERIAL:

NEXT ASSEMBLY: -NEXT ASSY

DRAWING NO.: -DD GA

SHEET SIZE: B | SHEET: 1 OF 3 | Rev: -





SECTION A-A

PARTS LIST		
ITEM	DESCRIPTION	SIZE (in)
1	PRECAST MANHOLE (BY HYDRO VIA PRECASTER)	120
2	FRAME AND COVER	24
3	INLET PIPE (BY OTHERS)	30
4	OUTLET PIPE (BY OTHERS)	30
5	PIPE COUPLING (BY OTHERS)	
6	LEDGER ANGLE	
7	SUPPORT FRAME	
8	DIP PLATE	
9	CENTER SHAFT AND CONE	
10	BENCHING SKIRT	
11	PIPE COLLAR	
12	5mm BYPASS SCREEN	
13	5mm SCREEN	

DD SIZE	4'	6'	8'	10'	12'
OUTLET STUB ID	12"	18"	24"	30"	36"
OUTLET STUB OD	12.5"	18.7"	24.8"	36"	42"

EQUIPMENT PERFORMANCE

The stormwater treatment unit shall adhere to the hydraulic parameters given in the chart below and provide the removal efficiencies and storage capacities as follows:

1. Performance objectives: The unit shall be capable of treating the peak flow rate listed below.
2. Peak Hydraulic Capacity: 25.0 cfs (708 l/s)
3. Sediment Storage Capacity: 8.70 cu. yd. (6.59 cu. m)
4. Continuous Oil Storage Capacity: 1050 gal. (3975 liters)
5. Sediment shall be stored in a zone that is isolated from the main flow path and protected from reintrainment by a benching skirt.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERENCES ARE:

FRACTIONS ± 1/16
DECIMALS ± .06
ANGLES ± 1°

PROJECTION

COMMENTS:

1. MANHOLE WALL AND SLAB THICKNESSES ARE NOT TO SCALE.
2. CONTACT HYDRO INTERNATIONAL FOR A BOTTOM OF STRUCTURE ELEVATION PRIOR TO SETTING DOWNSTREAM DEFENDER MANHOLE.
3. CONTRACTOR TO CONFIRM RIM, PIPE INVERTS, PIPE DIA. AND PIPE ORIENTATION PRIOR TO RELEASE OF UNIT TO FABRICATION.

REVISION HISTORY			
REV	BY	DESCRIPTION	DATE
-		FIRST RELEASE	

DATE: 3/29/2018 | SCALE:

DRAWN BY: KDO | CHECKED BY: | APPROVED BY

Title: 10-ft DIAMETER DOWNSTREAM DEFENDER WITH SCREEN

GENERAL ARRANGEMENT

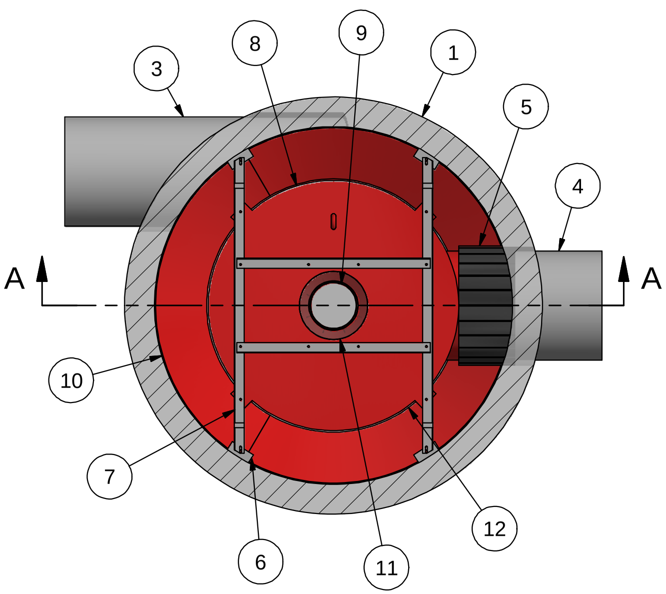
Hydro International
94 Hutchins Drive
Portland, ME 04102
Tel: +1 (207) 756-6200
Fax: +1 (207) 756-6212
hydro-int.com

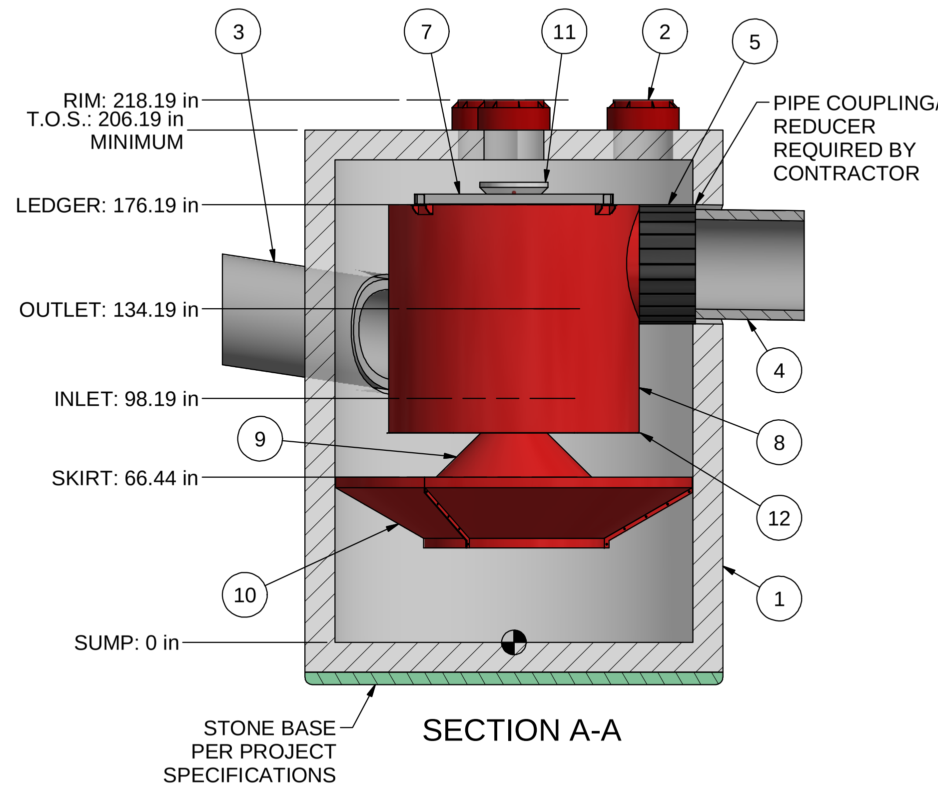
APPROX WEIGHT: N/A | MATERIAL:

NEXT ASSEMBLY: -NEXT ASSY

DRAWING NO.: -DD GA

SHEET SIZE: B | SHEET: 1 OF 3 | Rev: -





SECTION A-A

PARTS LIST		
ITEM	DESCRIPTION	SIZE (in)
1	PRECAST MANHOLE (BY HYDRO VIA PRECASTER)	144
2	FRAME AND COVER	24
3	INLET PIPE (BY OTHERS)	36
4	OUTLET PIPE (BY OTHERS)	36
5	PIPE COUPLING (BY OTHERS)	
6	LEDGER ANGLE	
7	SUPPORT FRAME	
8	DIP PLATE	
9	CENTER SHAFT AND CONE	
10	BENCHING SKIRT	
11	5mm BYPASS SCREEN	
12	5mm SCREEN	

DD SIZE	4'	6'	8'	10'	12'
OUTLET STUB ID	12"	18"	24"	30"	36"
OUTLET STUB OD	12.5"	18.7"	24.8"	36"	42"

EQUIPMENT PERFORMANCE

The stormwater treatment unit shall adhere to the hydraulic parameters given in the chart below and provide the removal efficiencies and storage capacities as follows:

1. Performance objectives: The unit shall be capable of treating the peak flow rate listed below.
2. Peak Hydraulic Capacity: 38.0 cfs (1076 l/s)
3. Sediment Storage Capacity: 14.70 cu. yd. (11.13 cu. m)
4. Continuous Oil Storage Capacity: 1770 gal. (6700 liters)
5. Sediment shall be stored in a zone that is isolated from the main flow path and protected from reintrainment by a benching skirt.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERENCES ARE:

FRACTIONS ± 1/16
DECIMALS ± .06
ANGLES ± 1°

PROJECTION

COMMENTS:

1. MANHOLE WALL AND SLAB THICKNESSES ARE NOT TO SCALE.
2. CONTACT HYDRO INTERNATIONAL FOR A BOTTOM OF STRUCTURE ELEVATION PRIOR TO SETTING DOWNSTREAM DEFENDER MANHOLE.
3. CONTRACTOR TO CONFIRM RIM, PIPE INVERTS, PIPE DIA. AND PIPE ORIENTATION PRIOR TO RELEASE OF UNIT TO FABRICATION.

REVISION HISTORY			
REV	BY	DESCRIPTION	DATE
-		FIRST RELEASE	

DATE: 3/29/2018 | SCALE:

DRAWN BY: KDO | CHECKED BY: | APPROVED BY

Title
12-ft DIAMETER DOWNSTREAM DEFENDER WITH SCREEN

GENERAL ARRANGEMENT

Hydro International®
94 Hutchins Drive
Portland, ME 04102
Tel: +1 (207) 756-6200
Fax: +1 (207) 756-6212
hydro-int.com

APPROX WEIGHT: N/A | MATERIAL:

NEXT ASSEMBLY: -NEXT ASSY

DRAWING NO.: -DD GA

SHEET SIZE: B | SHEET: 1 OF 3 | Rev: -

APPENDIX B

Hydro International® Guide Specification

Downstream Defender®
Released 05/04/2018

This product guide specification is written according to the Construction Specifications Institute (CSI) 3-Part Format, including MasterFormat, SectionFormat, and PageFormat, contained in the CSI *Manual of Practice*.

This section must be carefully reviewed and edited by the Engineer to meet the requirements of the project and local building code. Coordinate this section with other specification sections and the Plans and Drawings. Delete all "Specifier Notes" when editing this section.

Section numbers are from MasterFormat 2016 Edition. Update section number to versions if required.

Specifier Notes: This section covers the Downstream Defender® precast concrete, stormwater treatment system. The Downstream Defender® is custom designed to meet the specific requirements of the project.

Consult Hydro International® for assistance in editing this section for the specific project or application.

SECTION 33 44 36 – STORMWATER SEPARATORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Downstream Defender® precast concrete, in-line, stormwater treatment system, Advanced Hydrodynamic Vortex Separator (AHVS).

1.02 RELATED SECTIONS

A. Section 01 33 00 – Submittal Procedures
B. Section 31 00 00 – Earthwork
C. Section 03 40 00 – Precast Concrete

1.03 REFERENCE STANDARDS

A. AASHTO M105 – Gray Iron Castings
B. ASTM A48, CL.30B – Gray Iron Castings
C. ASTM A82 – Steel Wire, Plain, for Concrete Reinforcement
D. ASTM A185 – Steel Welded Wire Reinforcement, Plain for Concrete
E. ASTM A193 – Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
F. ASTM A240 – Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
G. ASTM A276 – Stainless Steel Bars and Shapes
H. ASTM A496 – Steel Wire, Deformed, for Concrete Reinforcement
I. ASTM A497 – Steel Welded Wire Reinforcement, Deformed for Concrete
J. ASTM A615 – Deformed & Plain, Carbon-Steel Bars for Concrete Reinforcement
K. ASTM C32 – Sewer and Manhole Brick (Made form Clay or Shale)
L. ASTM C33 – Concrete Aggregates
M. ASTM C139 – Concrete Masonry Units for Construction of Catch Basins and Manholes
N. ASTM C150 – Portland Cement
O. ASTM C478 – Precast Reinforced Concrete Manhole Sections
P. ASTM C497 – Standard Test Method for Concrete Pipe, Manhole Sections, or Tile
Q. ASTM C595 – Blended Hydraulic Cement
R. ASTM C990 – Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
S. ASTM C1107 – Packaged Dry, Hydraulic Cement Grout (Non-Shrink)

T. ASTM D698 – Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort

U. ASTM F593 – Stainless Steel Bolts, Hex Cap Screws, and Studs

V. ASTM F594 – Stainless Steel Nuts

W. ASTM F716 – Standard Test Methods for Sorbent Performance of Absorbents

1.04 DESIGN REQUIREMENTS

A. Precast concrete, in-line, stormwater treatment Device structure design shall comply with ASTM C478.

1. Wall thickness, and top slab thickness shall be no less than the minimum thickness necessary to sustain HS20-44 (MS18) loading requirements as determined by a Licensed Professional Engineer.
2. Wall thickness, top slab thickness and bottom slab thickness shall be no less than the minimum thickness necessary to sustain the expected soil loading based on the required burial depths for the Project as determined by a Licensed Professional Engineer.
3. Sections shall have tongue and groove or shiplap joints with a butyl mastic sealant conforming to ASTM C 990.
4. Cement shall be Type II, or III Portland cement conforming to ASTM C 150.
5. All sections shall be cured by an approved method. Sections shall not be shipped until the concrete has attained full design strength as determined by a Licensed Professional Engineer but in no case shall the compressive strength be less than 4,000 psi.
6. Pipe openings shall be sized to accept pipes of the specified size(s) and material(s), and shall be sealed by the Contractor with hydraulic cement conforming to ASTM C 595M or ASTM C1107.
7. Aggregates shall conform to ASTM C33, except that the requirement for gradation shall not apply.
8. Reinforcement shall consist of wire conforming to ASTM A82 or A496, of wire mesh conforming to ASTM A185 or A497, or Grade 40 steel bars conforming to ASTM A615.
9. Castings for manhole frames and covers shall be in accordance with ASTM A48, CL.30B and AASHTO M105. The access cover/s shall be designed for HS20-44 traffic loading and shall provide a minimum of 30-inch clear opening.
10. Brick or masonry used to build the vault frame to grade shall conform to ASTM C32 or ASTM C139 and shall be installed in conformance with all local requirements.

B. Internal structural components shall be bar, angle or similar in conformance with ASTM A276.

C. Screens shall be made from perforated Stainless Steel sheet in conformance with ASTM A240.

D. Hardware for securing and connecting structural components and screens shall be 304 stainless steel in conformance with ASTM A193, F593, and F594.

E. Dip plate, Center Shaft and Cone, and Benching Skirt shall be rotationally molded from High Density Polyethylene (HDPE).

F. The treatment system shall be sized to remove a minimum of 50% of the net annual Total Suspended Solids (TSS) load based on a d50 particle size of 67 microns for the design flows for any given drainage area as determined by a Licensed Professional Engineer. Stormwater treatment system performance shall be as verified by the NJDEP verification program

G. The treatment system shall be certified as a Full Capture Trash Treatment Control Device by the California State Water Resources Control Board (SWRCB).

1.05 QUALITY ASSURANCE

A. The manufacture of the concrete components for the stormwater treatment system shall be performed at a precast concrete facility certified by the NPCA.

B. The materials, process and finished stormwater treatment system shall be subject to inspection by the Engineer. Acceptance or rejection of the system shall be based on the Specifications contained in this section.

1.06 SUBMITTALS

A. Submittals must conform to Section 01 33 00 - Submittal Procedures.

B. Product Data: Submit manufacturer's product data, installation instructions, Operations and Maintenance Manual, Material Certifications, and Performance Certifications.

C. Record Documents:

1. Shop Drawings.

2. Operations and Maintenance Manual.

3. Installation Verification.

4. Material Certifications.

5. Performance Certifications.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

B. Storage:

1. Store in accordance with manufacturer's instructions.

2. Store in clean, dry area, out of direct sunlight.

C. Handling: Protect materials during handling and installation to prevent damage.

1.08 WARRANTY

A. The Manufacturer shall provide a minimum two (2) year limited warranty.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Hydro International, 94 Hutchins Drive, Portland, Maine 04102.
Phone: (207) 756-6200
Email: inquiries@hydro-int.com
Website: www.hydro-int.com

2.02 STORMWATER SEPARATOR

A. All material shall meet or exceed the referenced applicable standards as well as federal, state, and local requirements.

B. Stormwater Separator Vault
   1. Description: precast concrete, in-line, storm water treatment system.
   2. Type: AHVS
   3. Size: As indicated on the Plans.
   4. Concrete: A minimum compressive strength of 4,000psi at 28 days.
   5. Screens: Stainless Steel perforated mesh.

2.03 GENERAL

A. The stormwater treatment system shall be an Advanced Hydrodynamic Vortex Separator (AHVS) with flow-modifying internal components that minimize turbulence and prevent any flow from internally bypassing the separation region within the vortex chamber.

B. A tangential inlet pipe shall be used to establish rotational flow within a cylindrical vortex chamber. All polluted flow entering the vortex chamber through the inlet pipe shall follow a controlled three-dimensional flow path. Internal baffles will prevent flow entering the vortex chamber from discharging directly to the outlet pipe.

C. The tangential inlet pipe shall be positioned to convey flow into the vortex chamber beneath the internal water elevation. The AHVS shall not exceed the pressure drop (headloss) for the design flow rates specified herein as determined by ASTM C1745 / C1745M latest edition.

D. The AHVS shall fit within the limits of excavation (area and depth) as shown in the project plans and will not exceed the dimensions for the design flow rates specified herein.

E. The AHVS shall provide separate and protected storage regions for captured pollutants that float and for those that settle and shall prevent re-suspension and washout of stored pollutants for the specified flow rates. The AHVS shall not release captured floating pollutants during surcharge conditions.

F. The storage capacities for pollutants that settle (sediment) and float (trash) shall not be less than the volumes listed in Table 1. The AHVS shall operate as intended and perform as specified herein as pollutants accumulate. The storage capacity for pollutants that settle shall not reduce the volume required in the vortex chamber for separation and for preventing re-suspension and washout, or reduce the floatables storage volume capacity.

G. Minimum 24-inch openings shall provide access to the sediment storage volumes from the surface for inspection and maintenance. Two access openings shall be provided for systems larger than 4 feet in diameter. Removal of pollutants from the treatment system shall be possible without requiring confined space entry.

2.04 PERFORMANCE

A. Performance of the AHVS shall be based on independent full-scale laboratory and/or field-testing and shall adhere to the Performance Specifications listed in Table 1. The laboratory testing used as the basis of product performance shall be undertaken in accordance with testing protocols approved or endorsed by the Stormwater Equipment Manufacturers Association (SWEMA) or acceptable State agency, such as a State Department of Environmental Protection (DEP) or recognized verification agency (e.g.: ETV, NJCAT, NETE).

B. Performance of the AHVS shall be based on treating the Water Quality Flow rate (WQF without internally bypassing and without re-suspension and washout of captured pollutants (scour). The Maximum Treatment Flow Rate(s) (MTFR-50 and/or MTFR-100) shall be greater than or equal to the WQF. The AHVS shall remove greater than or equal to 80% of TSS based on the Target Particle Size (TPS) of 50 microns and/or 100 microns at MTFR-50 and MTFR-100, respectively.

C. The AHVS shall treat all flows without internally bypassing up to the Peak Treatment Flow Rate (PTFR). Full-scale independent laboratory scour testing shall demonstrate effluent control of less than or equal to 20 mg/L for all flows up to 150% of MTFR-100 without internal or external bypass.

D. The AHVS shall be capable of capturing and retaining fine silt and sand size particles. Analysis of captured sediment from full-scale field installations shall demonstrate particle sizes predominately in the 20-micron range.

E. The AHVS shall capture and retain 100% of all floating trash and debris and remove greater than 80% of hydrocarbons up to its rated storage capacities under conditions of a catastrophic spill such as might be experienced in an automobile or truck accident spill like conditions.

TABLE 1

Model Number and Diameter		Maximum Trash Treatment Capacity[1]		Typical Treatment Flow Rate[2]		Maximum Pipe Diameter		Trash Storage Capacity		Sediment Storage Capacity	
(ft)	(m)	(cfs)	(L/s)	(cfs)	(L/s)	(in)	(mm)	(yd^3)	(m^3)	(yd^3)	(m^3)
4	1.2	3.0	85	2.20	62.4	12	300	0.35	0.26	0.70	0.53
6	1.8	8.0	227	4.96	140.3	18	450	1.07	0.82	2.10	1.61
8	2.4	15.0	425	8.82	249.6	24	600	2.67	2.04	4.65	3.56
10	3.0	25.0	708	13.73	388.8	30	750	5.20	3.97	8.70	6.65
12	3.7	38.0	1,076	19.98	565.8	36	900	8.76	6.70	14.70	11.24

This table is intended to be used as a guide for selecting standard model sizes. Contact Hydro International for custom sizing needs.

1. Maximum Trash Treatment Capacity is the maximum flow rate of the Device at which 100% removal of floatables 5mm or greater in size can be captured and retained.
2. Typical Treatment flow rate based on 80% instantaneous removal of suspended sediment with a mean particle size distribution of 75um.

PART 3 – EXECUTION

3.01 Earthwork

A. Excavation, trenching, and backfilling shall be as specified in Division 31 00 00 “Earthwork.”

3.02 Identification

A. All stormwater treatment devices shall be identified at the surface level with markings indicating that they are treatment devices.

3.03 Inspection

A. General

1. Concrete, internal components, and accessories, shall be inspected prior to installation and any defective or damaged product shall be replaced.

B. Vault Sections

1. Any vault section with cracked joints shall be rejected and replaced.
2. Any vault section with a fracture or crack greater than 0.10 in. in length or 0.01 in width shall be rejected and replaced.
3. Any vault section has not had at least 7 days cure time shall be rejected and replaced.
4. Any vault section with indications of imperfections in mixing and/or molding, honeycombed, or open textured surface, shall be rejected and replaced.
5. Any vault section with indications of patches or repairs shall be rejected and replaced.
6. Any vault section with exposed reinforcing steel shall be rejected and replaced.

C. Internal Components

1. All internal components shall be free from defects and damage.
2. All mounting and securing hardware shall be present and firmly attached.
3. Screens shall be free from openings larger than 5.0mm in size and all screens shall be installed prior to operation. Screen heights shall conform to the Plans and Specifications.

3.04 Structure Installation

A. General

1. General Locations and Arrangements: Plans and Details indicate general location and arrangement of underground storm and drainage piping systems. Where specific installation procedures are not indicated in the Plans, follow the product manufacturer’s written instructions.
2. All products shall be inspected for defects and cracks before being lowered into the trench, piece by piece. Any defective, damaged or unsound structure or any product that has had its grade disturbed after laying shall be taken up and replaced. Open ends shall be protected with a pipe plug to prevent earth or other material from entering the treatment vault during construction. The interior of the treatment system shall be free from dirt, excess water and other foreign materials as the installation progresses and left clean at the completion of the installation.

3.05 Trench Excavation

A. Excavation

1. Excavate trenches to ensure that sides will be stable under all working conditions. Slope trench walls or provide supports in conformance with all federal, state, and local safety standards. Open only as much trench as can be safely maintained by available equipment. Backfill all trenches as soon as practicable, but no later than the end of each working day.
2. Where trench walls are stable or supported, provide a width sufficient, but no greater than necessary, to ensure working room to properly and safely place and compact embedment materials. The space between the treatment system and trench wall must be wider than the compaction equipment used in the compaction area.
3. When supports such as trench sheeting, trench jacks, trench shields or boxes are used, ensure that support of the treatment system and its embedment is maintained throughout installation. Ensure that sheeting is sufficiently tight to prevent washing out of the trench wall from behind the sheeting. Provide tight support of trench walls below viaducts, existing utilities, or other obstructions that restrict driving of sheeting.

B. Dewatering

1. Do not lay or embed any section of the stormwater treatment system in standing or running water. Surface runoff shall be prevented from entering the trench at all times.
2. When water is present in the work area, dewater to maintain stability of in-situ and imported materials. Maintain water level below the treatment vault bedding and foundation to provide a stable trench bottom. Use, as appropriate, sump pumps, well points, deep wells, geofabrics, perforated underdrains, or stone blankets of sufficient thickness to remove and control water in the trench. When excavating while depressing ground water, ensure the ground water is below the bottom of cut at all times to prevent washout from behind sheeting or sloughing of exposed trench walls. Maintain control of water in the trench before, during, and after the treatment vault installation and until embedment is installed and sufficient backfill has been placed to prevent flotation of the vault, attached piping or accessory drainage structures.

C. Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between exposed rock and the vault sections of at least 12 inches.

D. Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the manhole structure, as determined by the Engineer, is encountered in the bottom of a trench, such material shall be removed to at least 24 inches below bottom of the structure and replaced to the proper grade with select granular material, compacted as directed by the engineer. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Owner.

3.06 Bedding

A stable and uniform bedding shall be provided for the vault structure and any protruding features of its joint and/or fittings. The bedding shall be compacted to a minimum of 90% of maximum density per AASHTO T99, or as shown in the plans. Structure bedding shall be a minimum of 6” in thickness. The bedding surface shall provide a firm foundation of uniform density throughout the entire length of the structure.

3.07 Placing Structures

Each structure section shall be thoroughly examined before being placed; defective or damaged sections shall not be used. Structures shall be placed to the elevations as indicated on the Plans. Proper facilities shall be provided for lowering structure sections into trenches. Sections shall not be laid in water, and the sections shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches shall be provided as directed by the Engineer; see dewatering section.

3.08 Jointing

A. Joints shall be constructed as described herein and in accordance with manufacturer's installation instructions.

B. All Tongue-and-Groove vault joints shall be thoroughly cleaned. The supplied gasket or butyl mastic be installed on the tongue end with the angled surface facing toward the mating surface. Sections shall be mated with sections level and plumb.

C. Optional: Sections shall be mated and Hydraulic Cement Grout (Non-Shrink) complying with ASTM C1107 shall be applied liberally to the exterior and exterior of the joint ensuring all voids are filled completely.

3.09 Backfilling

A. General

Backfill placement and compaction shall be constructed in accordance with the specifications herein and the product manufacturer's published installation guides.

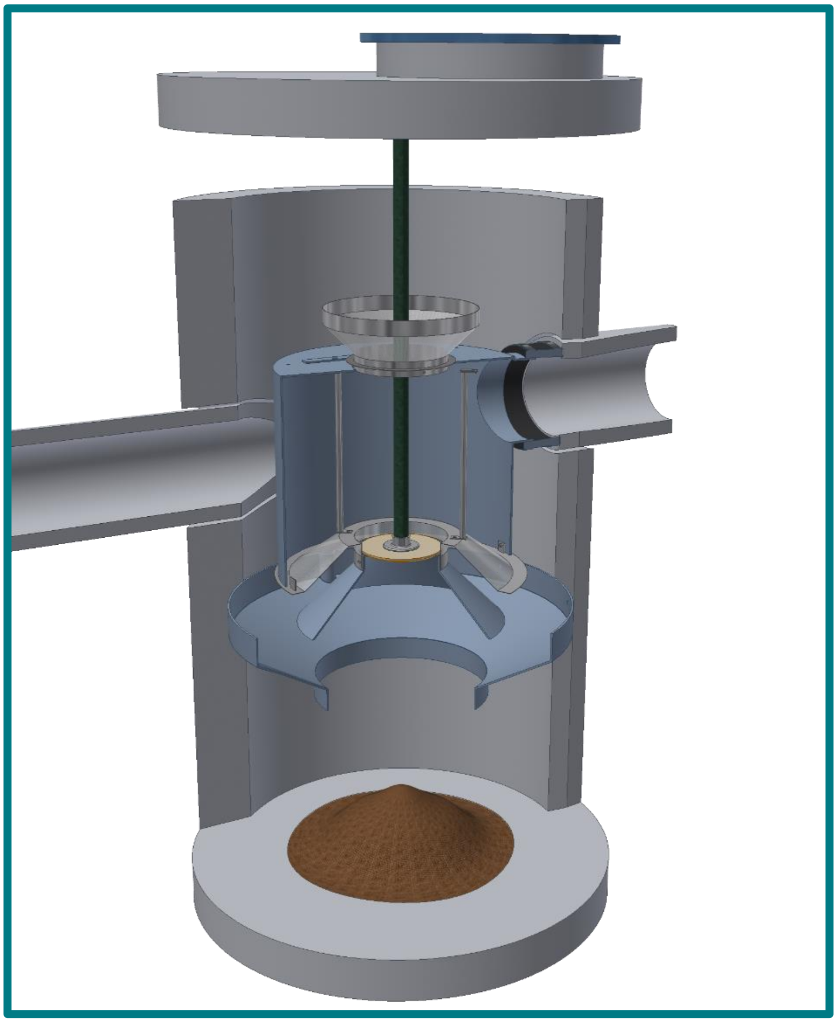
B. Backfilling Vault Sections in Trenches

After the vault sections and connecting pipes have been properly bedded, select material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along all sides of the vault in layer depths to ensure minimum compaction density is obtained evenly throughout the backfill material. The backfill shall be brought up evenly on all sides of the structure. Each layer shall be thoroughly compacted with mechanical tampers or rammers. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Engineer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

C. Movement of Construction Machinery

Movement of construction machinery over a vault structure at any stage of construction shall be at the Contractor's risk. Any damaged structure shall be replaced.

APPENDIX C



Installation Manual v1.01

Downstream Defender®

Advanced Hydrodynamic Vortex Separator

Stormwater Solutions

Turning Water Around ...®

Contents

INTRODUCTION

The Downstream Defender® is an Advanced Hydrodynamic Vortex Separator (AHVS) that incorporates vortex separation, sedimentation, and screening to treat stormwater for removal of fine, coarse and gross solids including trash and debris. The Device consists of a precast concrete manhole that houses internal components for conducting the treatment processes. There are five standard precast model sizes ranging from the smallest 48-inch diameter manhole footprint to the largest manhole having a footprint of 12-ft. in diameter. The precast manholes are made in sections that must be assembled on site. Some of the internal components are factory installed but some require assembly and installation on site. Delivery is made to the site for offloading and setting by the Contractor.

Proper installation of the Downstream Defender® is critical for maintaining the manufactured integrity of the precast concrete manhole or vault but also critical for ensuring in place structural integrity of the finished product as well ensuring storm water treatment performance. Installation should be performed in accordance with ASTM C 1821 *Standard Practice for Installation of Underground Circular Precast Concrete Manhole Structures* and the supplementary recommendations in this manual. Many problems associated with poorly performing or malfunctioning storm water treatment devices can be attributed to improper installation. Improper installation and installation methods can result in damage to the structure or safety hazards. This manual, along with the applicable ASTM standards, should be reviewed and utilized for the entirety of the installation process.

INSTALLATION PROCEDURES

SITE CONDITIONS

The construction site and installation area must be accessible to large, heavy trucks, cranes and other construction equipment. The construction area should be free of trees, overhead electrical and communications wires, and other potential obstructions that could interfere with the delivery and installation of the vault. The site and immediate area surrounding the excavation must be stable and unyielding. The area surrounding the site should be able to accommodate temporary closure during the installation.

DELIVERY, OFFLOADING, & HANDLING

PRE-INSPECTION

The Downstream Defender® structure and internal components will be delivered to the site in a condition suitable for installation. Inspection of the Downstream Defender® structure and components should occur immediately upon arrival of the delivery and prior to offloading. Inspection should include the precast concrete manhole sections as well as all internal components and necessary accessory components required for installation included with the delivery. Any damage, missing components, or non-conformance with the approved shop drawings should be noted and documented on the packing list. If concerns related to damage, missing components, or non-conformance are related to the integrity of the structure or Device, Hydro International® should be contacted immediately for consultation.

COMPONENT WEIGHT

Hydro International® shop drawings should be consulted for each components weight and lifting detail. This information should be compared to the same information as marked or permanently affixed to the precast concrete structure. Any discrepancies between the information and the drawings should be verified prior to lifting or handling any delivered material. The component weight should be considered prior to selection and use of any lifting devices and lifting equipment. Typical pick weights for the Downstream Defender® are listed in Table 1.

Table 1 - Typical Pick Weights for the Downstream Defender®

Model Number and Diameter			Approximate Heaviest Pick Weight[1]	
Model	(ft)	(m)	(tons)	(tonne)
DD-4	4	1.2	4	3.6
DD-6	6	1.8	7	6.4
DD-8	8	2.4	13	11.8
DD-10	10	3.0	18	16.3
DD-12	12	3.7	24	21.8

1. Pick Weights are approximate based on typical section heights.

LIFTING DEVICES

Lifting apparatus such as slings, cables, chains, clevis, hooks, shackles, spreader bars, etc… should be verified for adequate lifting capacity including all required safety factors and capacity reductions for site-specific conditions. The capacity for all apparatus must be clearly marked on all equipment. All apparatus and usage thereof should conform to the requirements of *OSHA Code of Federal Regulations, Title 29, Part 1926*, Current Edition as well as any applicable state and local regulations.

Slings, cables, and chains should be of adequate length to prevent contact with the concrete while still being utilized at appropriate lifting angles.

STORAGE

The Downstream Defender® Device and associated components may be installed directly into the excavation or may be stored on site for installation at a later date. Should the Downstream Defender® need to be stored on site, appropriate precautions should be taken to prevent damage to the structure and its components.

The precast structure should be placed on firm, level ground or on appropriately placed dunnage to keep the device supported and level. All components should be stored in a location to prevent damage by vehicles and equipment that have access to the construction site. Internal components should be protected, covered or kept in a location where direct exposure to the outdoor environment is limited.

SITE PREPARATION

EXCAVATION

Prior to excavation, all buried utilities should be located and identified. Excavations should be made no wider than what is necessary to safely and adequately compact the backfill material on all sides of the concrete manhole including associated piping. The excavation depth and horizontal alignment should be coordinated with the Plans and the Device design. Should the excavation bottom be unstable or yielding, over-excavation may be necessary. The excavation should be sloped, stepped, or shored as necessary to comply with all Federal, State, and Local safety laws and regulations. If the excavation requires shoring, the excavation width should be necessary to accommodate the addition of shoring.

BEDDING

Proper bedding material is necessary to ensure long-term performance of the treatment Device. The native in-situ material may be suitable for bedding provided it meets the project requirements as outlined by the Engineer. Should the native in-situ material be determined unsuitable, an imported, engineered bedding material should be utilized that will provide a uniform bearing surface and adequate soil bearing capacity for the expected load of the precast manhole or vault including all internal components while in operation. Bedding is typically designed with a minimum 6-inch sand or gravel bedding per ASTM D2321 and compacted to a minimum 90% SPD unless otherwise specified by the Engineer. The bedding should be placed uniformly and placed level.

The treatment Device should not be bedded on large boulders or rock. Excavations that encounter silty clay material in the area of the bedding or other similar material with poor bearing capacity may require a thicker bedding or different bedding material. If ground water should be encountered during excavation, the excavation should be de-watered prior to placement and compaction of the bedding. Additionally, the in-situ material should be evaluated for appropriateness.

INSTALLATION

PLACEMENT

The Device orientation should be verified prior to placement in the excavation. Placement of the Downstream Defender® is dependent on the configuration of the Device and whether the system is designed as an on-line or off-line configuration. On-line configurations typically utilize one to two structures constructed on the main conveyance storm drain conduit. Off-line configurations utilize two or more structures with the Downstream Defender® constructed on a lateral connection to the main conveyance storm drain conduit.

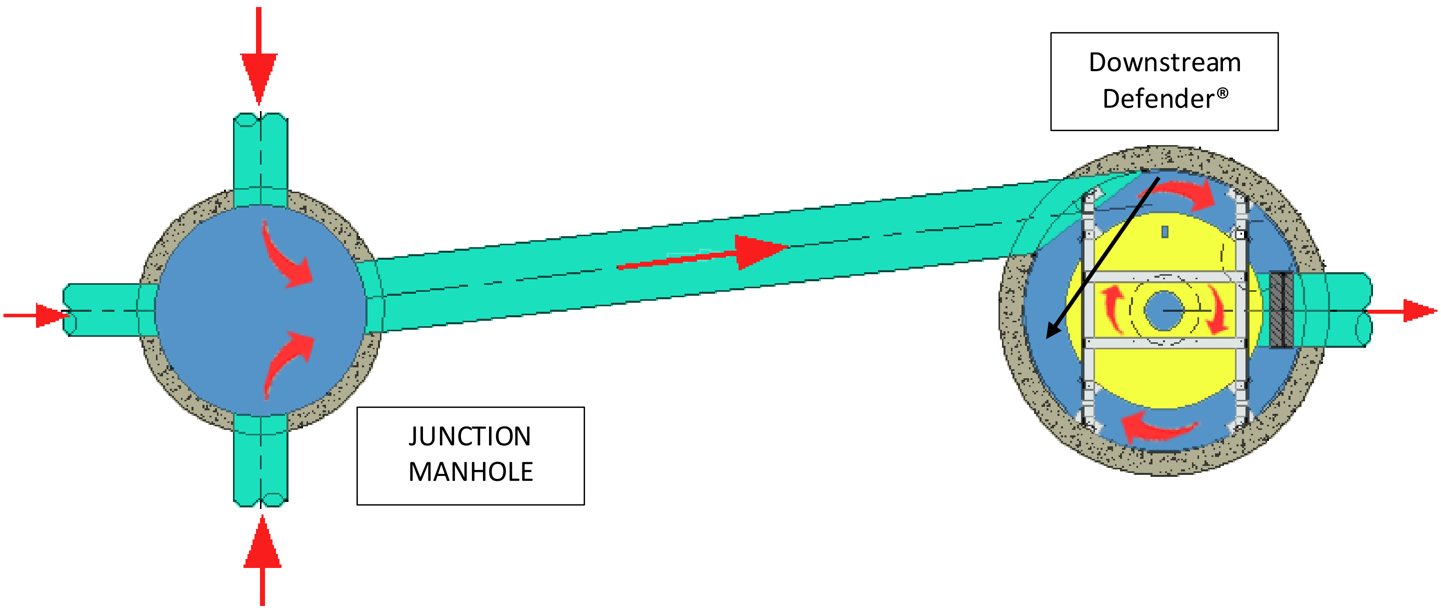


Figure 1 - Example on-line Configuration

Figure 1 is an example of an on-line configuration Downstream Defender®. The installation of this configuration places the Downstream Defender® on the main storm drain conveyance conduit. The inlet into the Downstream Defender® enters the manhole tangentially and is not aligned with the outlet. Storm drain systems collecting water from multiple drainage areas will typically utilize an upstream junction manhole to collect the flows and convey them to the Downstream Defender® in a single conduit. Excavations for on-line configurations must consider the above.

Figure 2 is an example of an off-line configuration Downstream Defender®. The installation of this configuration places the Downstream Defender® on a lateral storm drain line connected to the main storm drain conveyance conduit but isolated from the peak flows carried by the main conduit. This configuration typically includes at least two structures and in some cases three structures. A diversion/junction structure, which includes a weir to divert flows to the Downstream Defender®, is constructed on the main storm drain conveyance conduit. The Downstream Defender® is connected to the diversion/junction structure via smaller diameter lateral conduits. Off-line configurations require a larger excavation and involve additional elevations that must be accurately constructed to ensure proper operation of the Device.

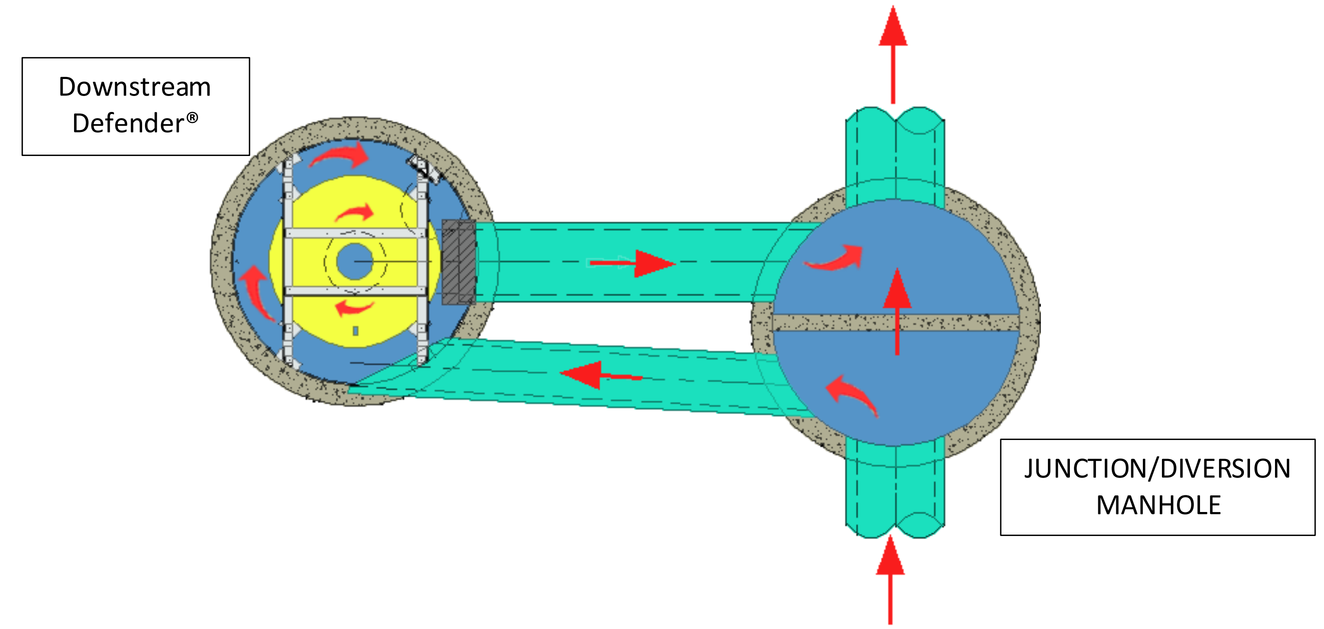


Figure 2 - Example off-line Configuration

With all installations, concrete bottom, inlet elevation, outlet elevation, weir elevation, and finished surface elevations should be verified prior to placement. Inlet and outlet alignments as well as proper flow orientation should be confirmed prior to placement as well.

The Downstream Defender® pre-cast base containing the benching skirt is the first section to be placed. Prior to placement the bedding material and compaction should be checked. After placement and prior to placement of successive manhole sections, the manhole should be checked to determine the structure is level in two opposing directions.

Figure 3 - Placement of the Pre-Cast Base with Benching Skirt

Subsequent sections of the manhole, vault, and other structures (if any) should be placed with orientation, elevations, and alignment determined the same as the base. Care should be taken to avoid damaging internal components while placing subsequent sections of the manhole.

The pre-cast manhole lid, frames and covers should not be installed until all internal components have been assembled and installed into the appropriate manhole sections.

JOINTING & SEALING

All manhole sections should be joined and sealed to ensure a watertight connection. Manhole sections will be joined with a butyl mastic material conforming to ASTM C990. Manhole sections should be sealed with a non-shrink, hydraulic grout conforming to ASTM C1107. Joints may be supplied as either shiplap or tongue and groove style.

The tongue and groove surfaces and shiplap mating surfaces should be inspected and cleaned. All mating surfaces should be free of dirt and debris. On tongue-up manhole sections, the butyl mastic material should be placed directly in the center of the of the horizontal tongue surface. On groove-up manhole sections, the butyl mastic should be placed directly in the center of the horizontal groove. On shiplap joints, the butyl mastic should be placed directly beside the vertical mating surface. Examples of butyl mastic placement can be seen in Figure 4.

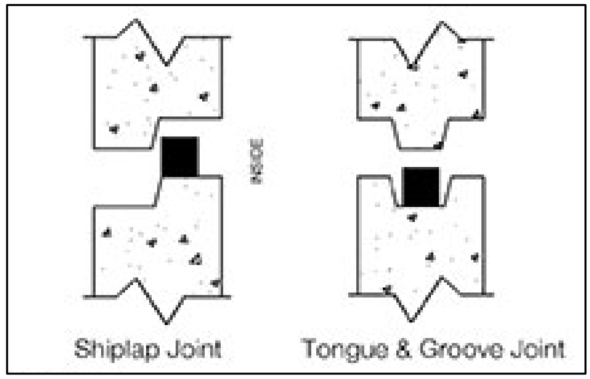


Figure 4 - Example Jointing Details

The mastic should be placed completely around the circumference of the manhole inside of the groove, on top of the tongue, or next to the vertical surface of the shiplap joint. To complete placement, the ends of the mastic should abut one another. The ends should not overlap. See Figure 5. The abutted ends should be kneaded together to form a spliced section with a depth no greater than a singular piece of mastic. All protective paper wrapping should be removed. The next section of the manhole should be carefully lowered onto the lower manhole section. The section should be checked for elevations and level.

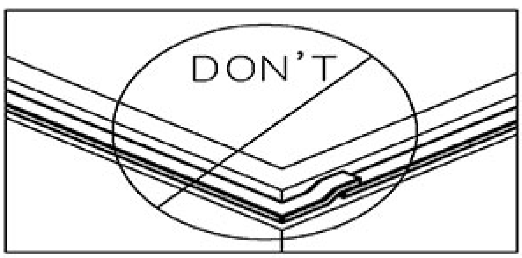


Figure 5 - Example Butyl Mastic Placement

PIPE CONNECTIONS

Pipe connections should be made per the Plans or local requirements:

- *Inlet Pipe Connection* – After the manhole riser section that contains the cone, screen and dip-plate is placed, the inlet pipe must be installed and fitted. If these components are already installed the inlet pipe cannot be installed properly.

  The inlet pipe should be inserted from the exterior of the manhole. The tangential inlet opening is oblong and will require the inlet pipe to be inserted until the pipe covers the extent of the opening. By doing so, a stub of pipe will protrude into the inside of the manhole. This stub must be placed so that the inlet pipe internal diameter is tangential to the internal diameter of the manhole section and the stub must be cut to follow the contour of the internal circumference. See Figure 6. The area between the tangential opening and the pipe outside diameter must be sealed with a watertight non-shrink grout conforming to ASTM C1107. The completed pipe and grout connection should not protrude into the manhole section and the interior should be left uniform with a smooth surface finish.

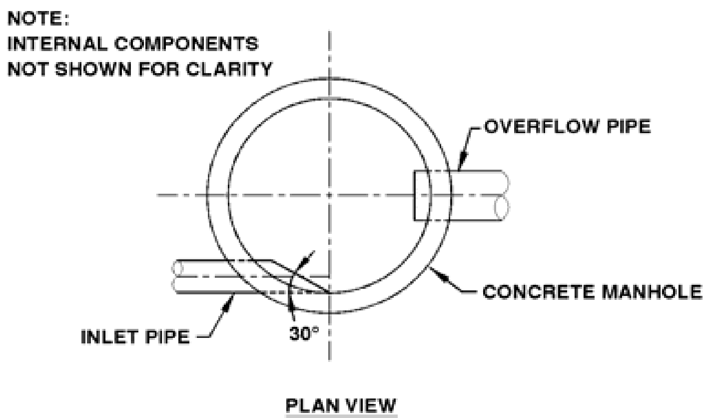


Figure 6 - Example Inlet Pipe Connection

- *Outlet Pipe Connection* – The outlet pipe connects to the overflow stub of the Downstream Defender® Dip-Plate. The connection must be made prior to installation of the pre-cast lid and frames/covers and during insertion of the internals.

  The overflow stub is made from cross-linked polyethylene and the stub outside diameter is the same as SDR35 PVC pipe of the same size. Outlet stub sizes for each Downstream Defender® are listed in Table 2. The stub must be connected to the outlet pipe utilizing a flexible coupling conforming to ASTM C1173. The flexible couplings are not provided as part of the installation kit and must be provided by the installing Contractor. A list of possible sources for the flexible couplings can be found in Table 3.

Table 2 - Dimensions of the Downstream Defender® Outlet Stub

Model Number and Diameter			Outlet Pipe Stub O.D.		Coupling Length	
Model	(ft)	(m)	(in)	(mm)	(in)	(mm)
DD-4	4	1.2	12.50	317.5	6.38	162.1
DD-6	6	1.8	18.69	474.7	9.56	242.8
DD-8	8	2.4	24.81	630.2	12.75	323.9
DD-10	10	3.0	36.00	914.4	15.25	387.4
DD-12	12	3.7	42.00	1066.8	21.5	546.1

After the correctly sized flexible coupling has been determined and sourced it can be connected. For ease of connection the coupling should be installed onto the Dip-Plate outlet stub prior to insertion of the Dip-Plate into manhole riser section. The tensioning bolts should be positioned facing upward so that they can be accessed for final tightening in the Device. The coupling should be inserted onto the stub but not tightened until the pipe connection is made.

Table 3 - Web Links for Flexible Coupling Manufacturers.

Manufacturer	Web Link
Fernco	https://www.fernco.com/plumbing/flexible-couplings
Upper Peninsula Rubber Company, Inc.	http://www.uprubber.com/rubber/
Indiana Seal	http://www.indiana-seal.com/
Marmac Construction Products	http://www.marmac.com
Pipeconx Universal Pipe Connectors	https://www.pipeconx.com/

INSTALLATION OF INTERNALS AND FINAL CONNECTIONS

The Dip-Plate assembly with Cone and Screens is pre-installed into the manhole riser section at the production facility to ensure proper alignment. The Dip-Plate support brackets attach to ledger angles that mount onto the inner walls of the manhole riser section. Once set, the Dip-Plate is removed from the ledger angles so that it is not damaged during shipping and handling. Because the ledger angles remain mounted to the manhole walls, the Dip-Plate assembly can be re-installed at the construction site in the exact location with minimal effort. Figure 7 is a picture of the Dip-Plate assembly being inserted into the manhole. The coupler has been installed prior to insertion. The Dip-Plate assembly should only be lifted from the support frame at the designated lifting points as shown in the picture. The assembly should be carefully lowered into the manhole section until it rests on the ledger angles. The overflow pipe should align with the outlet pipe opening in the manhole section and the holes on the frame should align with the mounting holes on the ledger angles. Figure 8 is a picture illustrating this step of the installation.

Figure 7 – Dip-Plate Assembly Insertion Into Manhole

Figure 8 - Dip-Plate Assembly Mounting to Manhole

The outlet pipe can now be connected to the overflow stub with the previously installed flexible coupling. The opening in the riser section should be grouted with a watertight non-shrink grout per ASTM C1107.

After installation of the internals is complete and the outlet pipe connected and sealed, the final riser sections and pre-cast lid can be installed. Installation of the riser section and pre-cast lid should be performed as detailed above. Units that contain two manhole access points should have the pre-cast lid oriented such that the second manhole access point is located directly over top of the outlet pipe.

ACCESS, RISERS & MANHOLES

Access risers and manhole risers are necessary to bring the vault to finished grade. Square and round riser manhole sections and grade rings should be utilized as necessary to reach finished grade. Sections should be placed, joined and sealed with the same methods as the vault sections. Access and manhole covers should be set in place and shimmed to finished grade and level. Gaps between the last riser section and access covers should be filled with a non-shrink, hydraulic grout with sufficient strength to handle the expected surface loads.

BACKFILLING

Backfill should be placed in uniform, mechanically compacted layers in lifts no greater than 18-inches. Backfill material should be clean and free from rocks, debris and deleterious material. Care should be taken to ensure backfill is placed and adequately compacted beneath of connecting pipes to prevent differential settlement.

INSTALLATION LOG

HYDRO INTERNATIONAL REFERENCE NUMBER:	
SITE NAME:	
SITE LOCATION:	
OWNER:	CONTRACTOR:
CONTACT NAME:	CONTACT NAME:
COMPANY NAME:	COMPANY NAME:
ADDRESS:	ADDRESS:
TELEPHONE:	TELEPHONE:
FAX:	FAX:

INSTALLATION DATE: ______________________

MODEL (CIRCLE ONE): | DD-4 | DD-6 | DD-8 | DD-10 | DD-12 |

CONFIGURATION (CIRCLE ONE): ON-LINE OFF-LINE

APPENDIX D

Operation and Maintenance Manual

Downstream Defender®

Vortex Separator for Stormwater Treatment

Turning Water Around ...®

Table of Contents

Hydro International (Stormwater), 94 Hutchins Drive, Portland ME 04102
Tel: (207) 756-6200 Fax: (207) 756-6212 Web: www.hydro-int.com

Downstream Defender® by Hydro International

The Downstream Defender® is an advanced Hydrodynamic Vortex Separator designed to provide high removal efficiencies of settleable solids and their associated pollutants, oil, and floatables over a wide range of flow rates.

The Downstream Defender® has unique, flow-modifying internal components developed from extensive full-scale testing, CFD modeling and over thirty years of hydrodynamic separation experience in wastewater, combined sewer and stormwater applications. These internal components distinguish the Downstream Defender® from simple swirl-type devices and conventional oil/grit separators by minimizing turbulence and headlosses, enhancing separation, and preventing washout of previously stored pollutants.

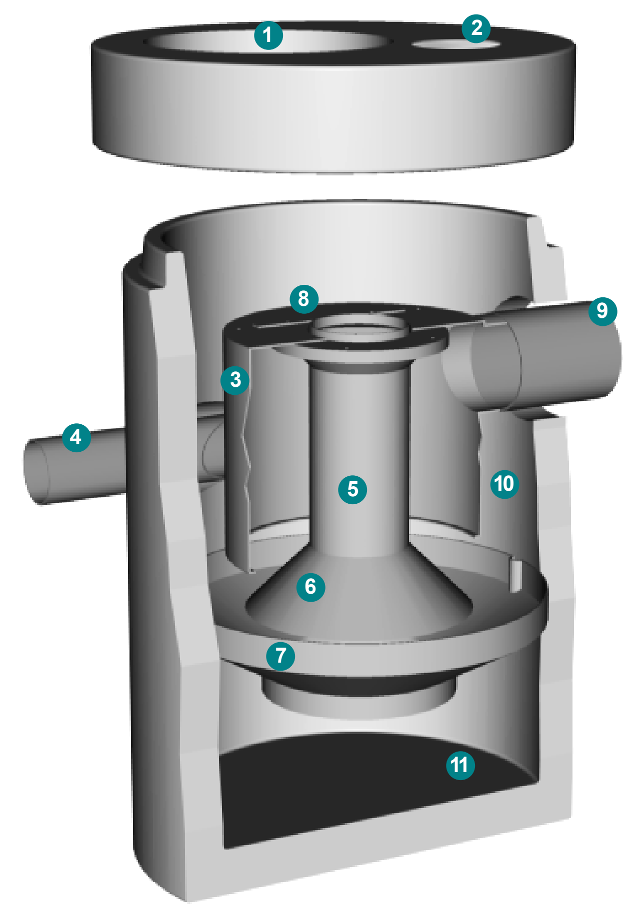
The high removal efficiencies and inherent low headlosses of the Downstream Defender® allow for a small footprint making it a compact and economical solution for the treatment of non-point source pollution.

Benefits of the Downstream Defender®

- Removes sediment, floatables, oil and grease
- No pollutant washouts
- Small footprint
- No loss of treatment capacity between clean-outs
- Low headloss
- Efficient over a wide ranges of flows
- Easy to install
- Low maintenance

Applications

- New developments and retrofits
- Utility yards
- Streets and roadways
- Parking lots
- Pre-treatment for filters, infiltration and storage
- Industrial and commercial facilities
- Wetlands protection



Downstream Defender® Components

1. Central Access Port
2. Floatables Access Port (6-ft., 8-ft. and 10-ft. models only)
3. Dip Plate
4. Tangential Inlet
5. Center Shaft
6. Center Cone
7. Benching Skirt
8. Floatables Lid
9. Outlet Pipe
10. Floatables Storage
11. Isolated Sediment Storage Zone

Hydro Maintenance Services

Hydro International has been engineering stormwater treatment systems for over 30 years. We understand the mechanics of removing pollutants from stormwater and how to keep systems running at an optimal level.

Nobody Knows our Systems Better than we do

Avoid Service Negligence

Sanitation services providers not intimately familiar with stormwater treatment systems are at risk of the following:

- Inadvertently breaking parts or failing to clean/replace system components appropriately.
- Charging you for more frequent maintenance because they lacked the tools to service your system properly in the first place.
- Billing you for replacement parts that might have been covered under your Hydro warranty plan
- Charging for maintenance that may not yet have been required.

Leave the Dirty Work to us

Trash, sediment and polluted water is stored inside treatment systems until they are removed by our team with a vactor truck. Sometimes teams must physically enter the system chambers in order to prepare the system for maintenance and install any replacement parts. Services include but are not limited to:

- Solids removal
- Removal of liquid pollutants
- Replacement media installation (when applicable)

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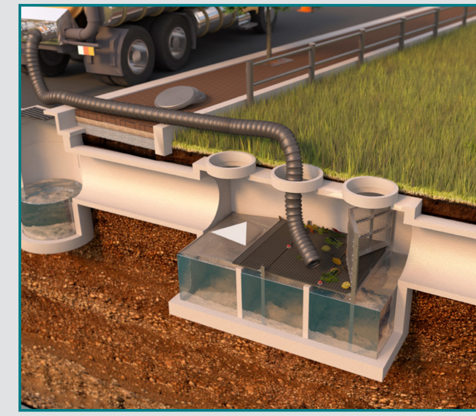
Downstream Defender® Operation and Maintenance Manual

Better Tools, Better Results

Not all vactor trucks are created equal. Appropriate tools and suction power are needed to service stormwater systems appropriately. Companies who don't specialize in stormwater treatment won't have the tools to properly clean systems or install new parts.

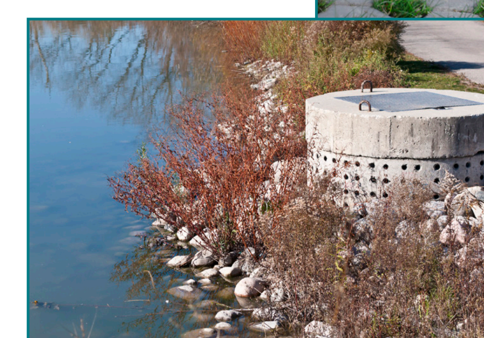


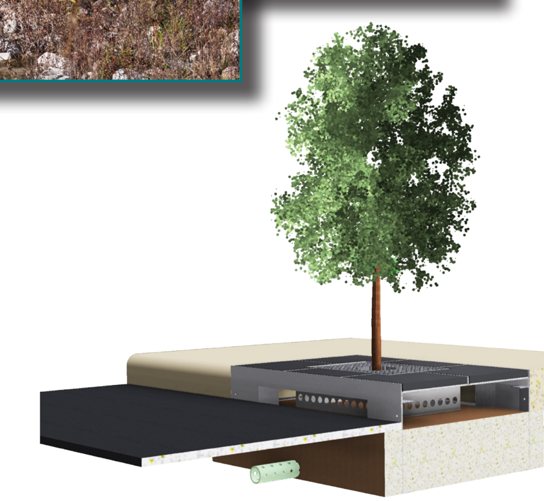
Service Warranty

Make sure you're not paying for service that is covered under your warranty plan. Only Hydro International's service teams can identify tune-ups that should be on us, not you.

Treatment Systems Serviced by Hydro:

- Stormwwater filters
- Stormwater separators
- Baffle boxes
- Biofilters/biorention systems
- Storage structures
- Catch basins
- Stormwater ponds
- Permeable pavement





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Operation

Introduction

The Downstream Defender® operates on simple fluid hydraulics. It is self-activating, has no moving parts, no external power requirement and is fabricated with durable non-corrosive components. No manual procedures are required to operate the unit and maintenance is limited to monitoring accumulations of stored pollutants and periodic clean-outs. The Downstream Defender® has been designed to allow for easy and safe access for inspection/monitoring and clean-out procedures. Entry into the unit or removal of the internal components is not necessary for maintenance, thus safety concerns related to confined-space-entry are avoided.

Pollutant Capture and Retention

The internal components of the Downstream Defender® have been designed to protect the oil, floatables and sediment storage volumes so that separator performance is not reduced as pollutants accumulate between clean-outs. Additionally, the Downstream Defender® is designed and installed into the storm drain system so that the vessel remains wet between storm events. Oil and floatables are stored on the water surface in the outer annulus separate from the sediment storage volume in the sump of the unit providing the option for separate oil disposal, and accessories such as adsorbant pads. Since the oil/floatables and sediment storage volumes are isolated from the active separation region, the potential for re-suspension and washout of stored pollutants between clean-outs is minimized.

Wet Sump

The sump of the Downstream Defender® retains a standing water level between storm events. The water in the sump prevents stored sediment from solidifying in the base of the unit. The clean-out procedure becomes more difficult and labor intensive if the system allows fine sediment to dry-out and consolidate. Dried sediment must be manually removed by maintenance crews. This is a labor intensive operation in a hazardous environment.

Blockage Protection

The Downstream Defender® has large clear openings and no internal restrictions or weirs, minimizing the risk of blockage and hydraulic losses. In addition to increasing the system headloss, orifices and internal weirs can increase the risk of blockage within the unit.

Maintenance

Overview

The Downstream Defender® protects the environment by removing a wide range of pollutants from stormwater runoff. Periodic removal of these captured pollutants is essential to the continuous, long-term functioning of the Downstream Defender®. The Downstream Defender® will capture and retain sediment and oil until the sediment and oil storage volumes are full to capacity. When sediment and oil storage capacities are reached, the Downstream Defender® will no longer be able to store removed sediment and oil. Maximum pollutant storage capacities are provided in Table 1.

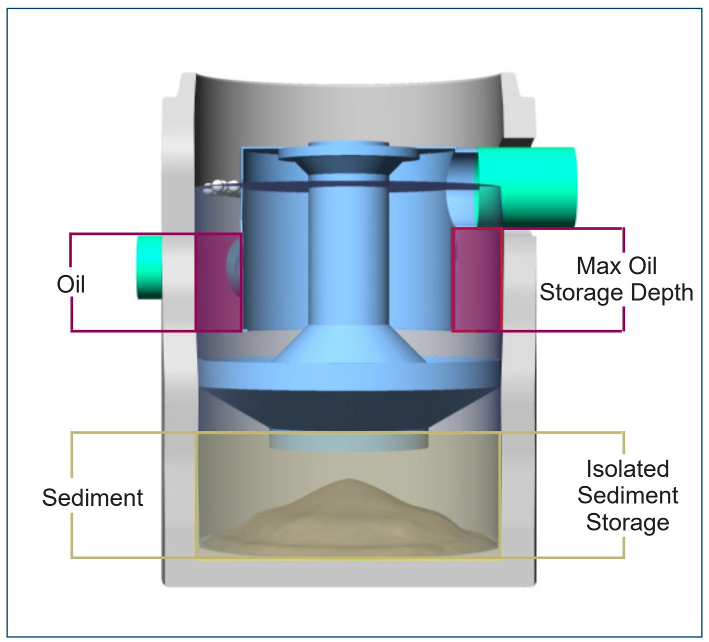

Fig.1 Pollutant storage volumes of the Downswtream Defender®.

The Downstream Defender® allows for easy and safe inspection, monitoring and clean-out procedures. A commercially or municipally owned sump-vac is used to remove captured sediment and floatables. Access ports are located in the top of the manhole. On the 6-ft, 8-ft and 10-ft units, the floatables access port is above the outlet pipe between the concrete manhole wall and the dip plate. The sediment removal access ports for all Downstream Defender® models are located directly over the hollow center shaft.

Maintenance events may include Inspection, Oil & Floatables Removal, and Sediment Removal. Maintenance events do not require entry into the Downstream Defender®, nor do they require the internal components of the Downstream Defender® to be removed. In the case of inspection and floatables removal, a vactor truck is not required. However, a vactor truck is required if the maintenance event is to include oil removal and/or sediment removal.

Determining Your Maintenance Schedule

The frequency of cleanout is determined in the field after installation. During the first year of operation, the unit should be inspected every six months to determine the rate of sediment and floatables accumulation. A simple probe such as a Sludge Judge® can be used to determine the level of accumulated solids stored in the sump. This information can be recorded in the maintenance log (see page 9) to establish a routine maintenance schedule.

The vactor procedure, including both sediment and oil/flotables removal, for a 6-ft Downstream Defender® typically takes less than 30 minutes and removes a combined water/oil volume of about 500 gallons.

Inspection Procedures

Inspection is a simple process that does not involve entry into the Downstream Defender®. Maintenance crews should be familiar with the Downstream Defender® and its components prior to inspection.

Scheduling

- It is important to inspect your Downstream Defender® every six months during the first year of operation to determine your site-specific rate of pollutant accumulation
- Typically, inspection may be conducted during any season of the year
- Sediment removal is not required unless sediment depths exceed 75% of maximum clean-out depths stated in Table 1

Recommended Equipment

- Safety Equipment and Personal Protective Equipment (traffic cones, work gloves, etc.)
- Crow bar or other tool to remove grate or lid
- Pole with skimmer or net
- Sediment probe (such as a Sludge Judge®)
- Trash bag for removed floatables
- Downstream Defender® Maintenance Log

Table 1. Downstream Defender® Pollutant Storage Capacities and Max. Cleanout Depths.

Unit Diameter	Total Oil Storage	Oil Clean-out Depth	Total Sediment Storage	Sediment Clean-out Depth	Max. Liquid Volume Removed
(feet)	(gallons)	(inches)	(gallons)	(inches)	(gallons)
4	70	<16	141	<18	384
6	216	<23	424	<24	1,239
8	540	<33	939	<30	2,884
10	1,050	<42	1,757	<36	5,546
12	1,770	<49	2,970	<42	9,460

NOTES

1. Refer to Dowmstream Defender® Clean-out Detail (Fig. 1) for measurement of depths.

2. Oil accumulation is typically less than sediment, however, removal of oil and sediment during the same service is recommended.

3. Remove floatables first, then remove sediment storage volume.

4. Sediment removal is not required unless sediment depths exceed 75% of maximum clean-out depths stated in Table 1.


Fig.4


Fig.5


Fig.6

Inspection Procedures

1. Set up any necessary safety equipment around the access port or grate of the Downstream Defender® as stipulated by local ordinances. Safety equipment should notify passing pedestrian and road traffic that work is being done.

2. Remove the lids to the manhole (Fig. 4). NOTE: The 4-ft Downstream Defender® will only have one lid.

3. Without entering the vessel, look down into the chamber to inspect the inside. Make note of any irregularities. See Fig.7 and 8 for typical inspection views.

4. Without entering the vessel, use the pole with the skimmer net to remove floatables and loose debris from the outer annulus of the chamber.

5. Using a sediment probe such as a Sludge Judge®, measure the depth of sediment that has collected in the sump of the vessel (Fig.5).

6. On the Maintenance Log (see page 9), record the date, unit location, estimated volume of floatables and gross debris removed, and the depth of sediment measured. Also note any apparent irregularities such as damaged components or blockages.

7. Securely replace the grate or lid.

8. Take down safety equipment.

9. Notify Hydro International of any irregularities noted during inspection.

Floatables and Sediment Cleanout

Floatables cleanout is typically done in conjunction with sediment removal. A commercially or municipally owned sump-vac is used to remove captured sediment and floatables (Fig.6).

Floatables and loose debris can also be netted with a skimmer and pole. The access port located at the top of the manhole provides unobstructed access for a vactor hose and skimmer pole to be lowered to the base of the sump.

Scheduling

- Floatables and sump cleanout are typically conducted once a year during any season.
- If sediment depths are greater than 75% of maximum clean-out depths stated in Table 1, sediment removal is required.
- Floatables and sump cleanout should occur as soon as possible following a spill in the contributing drainage area.


Fig.7 View over center shaft into sediment storage zone.


Fig.8 View of outer annulus of floatables and oil collection zone.

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Recommended Equipment

- Safety Equipment (traffic cones, etc)
- Crow bar or other tool to remove grate or lid
- Pole with skimmer or net (if only floatables are being removed)
- Sediment probe (such as a Sludge Judge®)
- Vactor truck (6-inch flexible hose recommended)
- Downstream Defender® Maintenance Log

1. Set up any necessary safety equipment around the access port or grate of the Downstream Defender® as stipulated by local ordinances. Safety equipment should notify passing pedestrian and road traffic that work is being done.

2. Remove the lids to the manhole (NOTE: The 4-ft Downstream Defender® will only have one lid).

3. Without entering the vessel, look down into the chamber to inspect the inside. Make note of any irregularities.

4. Using the Floatables Port for access, remove oil and floatables stored on the surface of the water with the vactor hose or the skimmer net (Fig.9).

5. Using a sediment probe such as a Sludge Judge®, measure the depth of sediment that has collected in the sump of the vessel and record it in the Maintenance Log (Pg.9).

6. Once all floatables have been removed, drop the vactor hose to the base of the sump via the Central Access Port. Vactor out the sediment and gross debris off the sump floor (Fig.6).

7. Retract the vactor hose from the vessel.

8. On the Maintenance Log provided by Hydro International, record the date, unit location, estimated volume of floatables and gross debris removed, and the depth of sediment measured. Also note any apparent irregularities such as damaged components or blockages.

9. Securely replace the grate or lid.

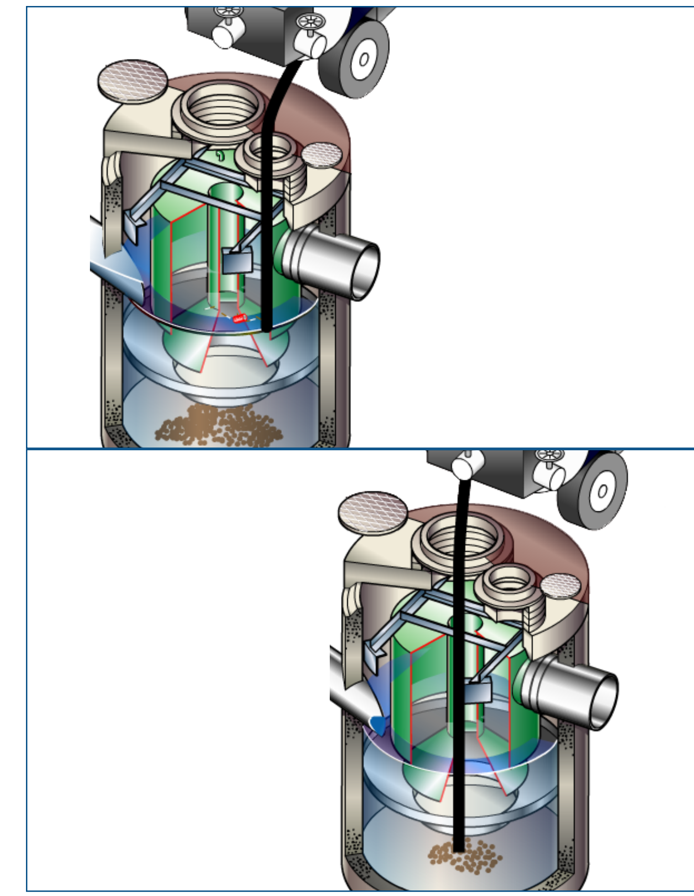
Fig.9 Floatables and sediment are removed with a vactor hose

Maintenance at a Glance

Activity	Frequency
Inspection	- Regularly during first year of installation - Every 6 months after the first year of installation
Oil and Floatables Removal	- Once per year, with sediment removal - Following a spill in the drainage area
Sediment Removal	- Once per year or as needed - Following a spill in the drainage area

NOTE: For most cleanouts it is not necessary to remove the entire volume of liquid in the vessel. Only removing the first few inches of oils/floatables and the sediment storage volume is required.

Hydro International®

Downstream Defender® Installation Log

HYDRO INTERNATIONAL REFERENCE NUMBER:	
SITE NAME:	
SITE LOCATION:	
OWNER:	CONTRACTOR:
CONTACT NAME:	CONTACT NAME:
COMPANY NAME:	COMPANY NAME:
ADDRESS:	ADDRESS:
TELEPHONE:	TELEPHONE:
FAX:	FAX:

INSTALLATION DATE: / /

MODEL (CIRCLE ONE): **4-FT** **6-FT** **8-FT** **10-FT** **CUSTOM**

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Hydro International®

Downstream Defender® Inspection and Maintenance Log

Date	Initials	Depth of Floatables and Oils	Sediment * Depth Measured	Volume of Sediment Removed	Site Activity and Comments

*Note: Sediment removal is not required unless sediment depths exceed 75% of maximum clean-out depths stated in Table 1.

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94 Hutchins Drive
Portland, ME 04102

Tel: (207) 756-6200
Fax: (207) 756-6212
stormwaterinquiry@hydro-int.com

www.hydro-int.com

Turning Water Around...®

APPENDIX E

Turning Water Around…®

Stormwater Equipment Limited Product Warranty

Hydro International's equipment including the DOWNSTREAM DEFENDER®, FIRST DEFENSE®, UP-FLO® FILTER, REG-U-FLO® Vortex Valve, HYDRO DRYSCREEN® , HYDRO BIOINFILTRATOR®, is backed by the following warranty:

Hydro International warrants all of its products to be free from defects in materials and workmanship; and will replace, repair, or reimburse at its discretion any part or parts which, after Hydro's examination, Hydro shall have determined to have failed under normal use and service by the original user within two years following initial installation. Such repair or replacement shall be free of charge for all items except for (i) those items that are consumable and normally replaced during maintenance, (ii) labor costs incurred by Hydro to obtain access to the part or unit for repair or replacement, (iii) any costs to repair or replace any surface treatment / cover after repair or replacement or (iv) other charges that Hydro may incur incident to such repair or replacement. Repair or replacement of such consumable items shall be subject to assessment of a pro-rated charge based upon Hydro International's estimate of the percentage of normal service life realized by the item. Hydro International's obligation under this Warranty is conditioned upon (a) its receiving prompt notice of claimed defects which shall in no event be later than thirty (30) days following expiration of the above warranty period and (b) owner of the product properly operating, inspecting, maintaining and caring for the product and is limited to repair or replacement as aforesaid. Purchaser agrees that the foregoing warranty is Purchaser's sole remedy under any legal theory whether pleaded in contract, tort, or otherwise.

THIS WARRANTY IS EXPRESSLY MADE BY HYDRO INTERNATIONAL AND ACCEPTED BY PURCHASER IN LIEU OF ALL OTHER WARRANTIES, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE, WHETHER WRITTEN, ORAL, EXPRESS, IMPLIED, OR STATUTORY. HYDRO INTERNATIONAL NEITHER ASSUMES, NOR AUTHORIZES ANY OTHER PERSON TO ASSUME FOR IT, ANY OTHER LIABILITIES WITH RESPECT TO ITS EQUIPMENT INCLUDING NEGLIGENCE IN DESIGN OR MANUFACTURE AND PURCHASER AGREES THAT THIS WARRANTY AND THE OBLIGATIONS OF HYDRO INTERNATIONAL SET FORTH HEREIN ARE THE SOLE REMEDIES AVAILABLE TO PURCHASER FOR THE FAILURE OF ANY PRODUCT TO PERFORM AS WARRANTED. HYDRO INTERNATIONAL SHALL NEITHER BE LIABLE FOR NORMAL WEAR AND TEAR NOR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGE DUE TO USE OR INOPERABILITY OF ITS EQUIPMENT FOR ANY REASON WHATSOEVER.

This Warranty shall not apply to equipment or parts thereof which have been altered or repaired outside of an authorized Hydro International facility or fabricator, or damaged by improper handling, installation, or application, or subject to misuse, abuse, neglect, accident or improper or inadequate maintenance. The Contractor shall inspect and provide signed acceptance of equipment prior to unloading, or notify Hydro International of any damage to equipment to effect proper remedial action.

Failure to notify Hydro International of damage to equipment prior to unloading will void all warranties pertaining to subject equipment.

APPENDIX F

Downstream Defender® Report Sections

from

Final Report
for Onondaga Lake Nonpoint
Source Environmental Benefit Project

November 2002

Submitted by
Moffa and Associates
A Unit of Brown and Caldwell
East Syracuse, NY

Moffa & Associates
A Unit of Brown and Caldwell

November 6, 2002

Pamela J. Deahl
Hydro International
94 Hutchins Drive
Portland, ME 04102

Re: Onondaga Lake Nonpoint Source Environmental Benefit Project

Dear Ms. Deahl,

As part of the above referenced project, Moffa and Associate, *a unit of Brown and Caldwell,* evaluated a four-foot diameter Downstream Defender® in Syracuse, NY.

Please find attached an electronic copy of the final report sections that pertain only to the Downstream Defender®. This version is not a complete final report. The Executive Summary is included in full to provide the reader an appreciation of the scope of the entire project.

It is our understanding that you will use these sections for marketing purposes as confirmation of a third party evaluation.

If you have any questions, please do not hesitate to call.

Very truly yours,

John J. LaGorga
Project Manager

Table of Contents

List of Tables and Figures

1 EXECUTIVE SUMMARY

1.1 Background

Nonpoint source (NPS) pollution is unlike industrial and municipal pollution; it comes from diffuse sources and is the result of rainfall or snowmelt moving over and through the ground. NPS pollution is usually associated with land use activities such as agricultural, construction and urbanization and include pollutants such as fertilizers, herbicides, pesticides, insecticides, sediment, bacteria, nutrients, oils and grease and toxic chemicals.

The objective of the Onondaga Lake Nonpoint Source Environmental Benefit Project (EBP) was to implement nonpoint source controls and management strategies to reduce nutrient inflow to Onondaga Lake from agricultural and urban practices and to evaluate the effectiveness of these controls and management strategies.

Onondaga Lake is located immediately northwest of the City of Syracuse in Onondaga County, New York. The Onondaga Lake drainage basin encompasses approximately 247 mi^2 (642 km^2) and, with the exception of 0.75 mi^2 (2 km^2) in Cortland County, lies almost entirely in the Onondaga County drainage basin. The basin includes six natural subbasins: Nine Mile Creek, Harbor Brook, Onondaga Creek, Ley Creek, Bloody Brook and Saw Mill Creek. The City of Syracuse is the region's major metropolitan center, encompassing approximately 20 square miles. The City of Syracuse together with the adjacent towns and villages have been designated an urban area by the State of New York, and thus fall under the Phase II stormwater regulations. The urban area including the City of Syracuse is approximately 100 square miles. The non-urban areas of the Onondaga Lake watershed include mostly forest and agricultural lands. The Onondaga County Soil and Water Conservation District estimated a total of 107 active farms including 67 active dairy farms in 1992. The land use attributed with these farms 37,181 cropland acres including 3,721 acres of pastureland. The current estimate of total farms is 98.

The selected agricultural sites were chosen to represent the prominent agricultural trends in New York State. Specifically, the Rohe Farm represents a typical family-owned, 100-head dairy farm that plans to continue operations as usual. The Guptill Farm is a family-owned farm that recently made the transition from dairy farming to beef cattle and heifer-livestock handling. The Leubner Farm is also a family-owned dairy farm but has expanded from a 150-head operation to more than 400-head operation.

The selected urban sites were chosen to represent typical municipal urban runoff. A stormwater vegetative filter strip was installed at the Burnet Park Zoo to treat and control runoff from a typical urban parking lot. A stormwater vortex unit was installed on East Seneca Turnpike to treat runoff from a major city street.

There were three major elements of work for the EBP: 1) *BMP design and implementation*, 2) *water quality monitoring* and 3) *effectiveness evaluation*.

BMP design and implementation included BMP identification and selection and design and construction. Working with the farmers and municipal representatives was especially important during this phase of work in order to ensure their commitment to the operation and maintenance of the BMPs. BMP design and implementation started in June 1999 and continued until November 2001.

Water quality monitoring for the agricultural sites was conducted from May 1999 to May 2000 for pre-BMP period and November 2000 to November 2001 for post-BMP period. During each period, water quality samples were collected in the receiving water adjacent to the farmstead. The intent of this sampling was to monitor the reduction of pollutants in the receiving water as a result of the group of BMPs installed on the farmstead. Water quality sampling for the urban BMPs effort began during the spring of 2001 after the BMPs were installed. For the urban BMPs, influent and effluent samples were taken during actual wet-weather events to define removal efficiency.

Effectiveness evaluation began immediately following implementation of the BMPs beginning in November 2000 and continued until March 2002. The effectiveness evaluation included site visits, farmer interviews and analysis of water quality data.

1.2 BMP Design and Implementation

The agricultural BMP selection and design process used a combination of newly established approaches and efforts that were customized to fit the nature of the project. Under this project, Tier I and II Assessments from the Agricultural Environmental Management (AEM) guide for New York State were completed to identify water quality risks and suitable BMPs. Tiers III to V Assessments were not completed since the objectives differed from those of the Soil and Water Conservation District; the EBP project was confined to farmstead-scale problems and remedies and not geared towards long-term soil management efforts. The Tier I and II Assessments led to the design and construction of BMPs, and efforts were made to have all BMPs comply with Natural Resources Conservation Service (NRCS) specifications. Based on the assessments, it was decided during the early stages of the project that targeting manure handling practices and animal pasturing adjacent to receiving waters would provide the greatest return on the investment in terms of nutrient reductions. Most of manure handling improvements were made through reengineering the manure handling stations and providing training to the farmer on proper operation. Creating a buffer zone between the receiving waters and active livestock areas and manure handling stations also provide a relatively inexpensive benefit to water quality. A simple principle was maintained throughout design and construction of BMPs: keep the clean runoff clean and divert the contaminated runoff to a treatment area.

The selected urban BMP were chosen to represent treatment for typical municipal urban runoff. A stormwater vortex unit was installed at 134 East Seneca Turnpike for the purpose of removing suspended solids and associated nutrients from the stormwater before discharge to Onondaga Creek. The catchment area serviced by this unit primarily encompasses a 1,000-feet length of East Seneca Turnpike and is approximately 1.2 acres in size. The unit is a 4-foot diameter Hydro International Downstream Defender® with a design flow of 0.75 cfs and a maximum capacity of 3.0 cfs. A stormwater vegetative filter strip was installed at the Onondaga County Burnet Park Zoo for the purpose of controlling and treating runoff from a parking lot. The original stormwater structure for this parking lot was a cobblestone-lined ditch, which was constructed around 1985 and no longer effectively conveyed stormwater. The vegetative filter strip was installed to replace the cobblestone-lined ditch. The vegetative BMP is a 160-foot long swale, which collects and conveys runoff from the parking lot. The ditch was reshaped to convey flow at rates that minimize erosion. The area was seeded with a mixture of grasses. These grasses were selected to be resilient against invading species, to grow well in a wet and dry environment and to only grow to approximately two feet tall.

1.3 Water Quality Monitoring

The EBP water quality sampling program provided data that were intended to provide only a first order approximation of farmstead and urban runoff pollutant concentrations and effectiveness of BMPs. Prior to this sampling program there were no site-specific data for urban and farmstead runoff available for the City of Syracuse and surrounding agricultural land. This sampling approach was consistent with budgetary constraints, which allocated 85% of the budget for BMP implementation and the remaining 15% for sampling and monitoring, laboratory analyses, data analyses, meetings and reporting.

Water quality analyses following USEPA approved methods were performed for Soluble Reactive Phosphorus (Ortho-Phosphorus), Total Phosphorus (Total-P), Total Kjeldahl Nitrogen (TKN), and Total Suspended Solids.

Water quality samples for the agricultural BMPs were collected in the receiving water adjacent to the farmstead once per month for one year before and after BMP implementation. Instantaneous flow measurements were taken at the same time as the water quality data. The intent of this sampling was to monitor the reduction of pollutants in the receiving water as a result of the group of BMPs installed on the farmstead. Using the water quality concentrations and the flow measurements, pounds (i.e. loads) of pollutants discharged from the farmsteads were estimated. These loads were used to identify pre- and post-BMP load reductions as well as for estimating relative loads discharging from such farmstead in the receiving waters of Onondaga Lake.

Water quality sampling for the urban BMPs effort began during the spring of 2001 after the

BMPs were installed. For the urban BMPs, influent and effluent samples were taken during actual wet-weather events to define removal efficiency. Six wet-weather events were sampled for each the vortex unit and the vegetative strip.

1.4 Effectiveness Evaluation

In the agricultural setting, pollutant concentrations significantly decreased from the pre-BMP sampling period to the post-BMP sampling period at all three farms. Pollutant concentrations from each sampling event were ranked using the Wilcoxson Rank-Sum Test. This comparison approach (alpha = 0.05, 95% confidence) indicated a significant reduction in concentration from the pre-BMP sampling to the post-BMP sampling period. Presumably the only changes at the farm were the implementation of the BMPs, which suggests the BMPs successfully reduced the concentration of pollutants discharging from the farms.

The following table provides pounds of pollutants discharged during the pre- and post-BMP periods and percent removals.

	Pre-BMP (pounds)	Post-BMP (pounds)	Percent Removal
Rohe Farm			
Total Phosphorous	865	265	70%
Total Kjeldahl Nitrogen	2,830	900	68%
Guptill Farm			
Total Phosphorous	1,700	684	61%
Total Kjeldahl Nitrogen	10,400	2,174	79%
Leubner Farm			
Total Phosphorous	799	359	55%
Total Kjeldahl Nitrogen	5,837	2,922	50%

There are approximately 50 active farms within the Onondaga Lake watershed without BMPs. If it is assumed that the three farms studied during this project are representative of the 50, than the findings from this project equate to approximately 20,000 to 50,000 pounds per year of potential total phosphorus reduction and approximately 45,000 to 410,000 pounds per year of potential TKN reduction within the watershed. Assuming that 50% of the TKN is ammonia-N, than there is approximately 22,500 to 205,000 pounds per year of potential ammonia-N reduction.

As a frame of reference, based on current Metropolitan Sewage Treatment Plant (METRO) upgrade plans, the potential total phosphorus reduction at METRO is 66,500 pounds per year and the potential ammonia-N reduction is 550,000 pounds per year.

The cost of BMP construction and implementation on each farm was approximately $45,000. This equates to approximately $45 to $112 per pound of total phosphorus removed per year and $10 to $100 per pound of ammonia-N removed per year. As a frame of reference, Onondaga County is investing approximately $125 million (1997) at METRO for phosphorus and ammonia removal during the period from 1996 to 2015. This equates to approximately $1,900 per pound of total phosphorus removed per year and $230 per pound of ammonia per year.

The stormwater vortex unit was monitored for just over a one-year period from March 2001 until May 2002, during which time approximately 40 inches of rain fell during the non-winter months. This equated to approximately 730,000 gallons of stormwater processed by the vortex unit. Also during this time approximately 100 cubic feet of material was removed from the vortex unit weighing an estimated 4,500 lbs. This equated to approximately 0.14 cubic feet or 6 lbs of material removed per 1,000 gallons of stormwater processed. Most of the material removed from the vortex unit was sand and grit and organic material such as leaves and twigs. Relatively little nutrients were removed, which was likely due to the low influent concentrations of nitrogen and phosphorus. Additionally, relatively little trash was collected as a result of the grated catchbasins, which prevent trash from entering the stormwater conveyance system. The sediment storage sump of the vortex unit is approximately 12 cubic feet; maintenance is key to the successful operation of such equipment because once the unit's sump is full, a reduction in removal efficacy is possible due to the increased risk of re-entrainment of solids deposited within the zone above the shielded sediment storage sump.

The vegetative filter strip was monitored for roughly five months from June 2001 until October 2001, during which time approximately 16.5 inches of rain fell. This equated to approximately 40,000 gallons of stormwater processed by the 160-foot long vegetative filter strip. Water quality sampling was conducted on six storm events beginning in June of 2001 and ending in October of 2001. For half the events sampled, the vegetative filter strip absorbed the stormwater and no effluent flow was apparent. During the other three sampling events, rainfall and the resulting parking lot runoff were great enough to cause flow through the vegetative filter strip. It appears that the strip could absorb about one inch of rain before effluent flow was apparent; this is equivalent to approximately 3,000 gallons of stormwater. The vegetative filter strip appeared to be effective at removing solids during a flow through condition. However, concentrations of solids were relatively low. It also appeared that the vegetative filter strip was acting as a nutrient exporter; releasing nutrients when stormwater flowed through the strip. Again, the nitrogen and phosphorus concentration in both the influent and effluent was very low. The source of the nutrient reservoir was likely from the compost bedding established for seeding.

2 URBAN BMP SELECTION AND DESIGN

Two urban BMPs were selected for this project; namely a stormwater vortex unit and a vegetative filter strip. These BMPs represent a structural and nonstructural approach, respectively.

A stormwater vortex unit was selected to represent a structural approach to controlling and treating urban stormwater.

A stormwater vortex unit is a device designed to capture settleable solids (solids such as grit and sand that settle in quiescent flow), floatables, oils and grease and incidental nutrients from stormwater runoff. The stormwater vortex unit consists of a concrete cylindrical vessel that can be installed in place of an existing catchbasin. Stormwater enters tangentially into the cylindrical vessel, which creates a circular flow path (i.e. vortex). This circular flow path minimizes turbulence and allows solids to settle into an isolated storage zone (depending on configuration) and not become re-entrained. Stormwater vortex units are generally baffled to enhance floatable and oil and grease collection. These units collect and store pollutants in the cylindrical vessel during a stormwater event, and the pollutants are removed from the unit after the stormwater event has ended.

Several companies that manufacture stormwater type vortex units provided information. This information was provided to the City of Syracuse engineers and the project team, with the approval from the city engineers, selected the Downstream Defender® manufactured by H.I.L. Technologies (Hydro International).

The City of Syracuse engineers originally recommended two sites for the stormwater vortex unit:

1. 205 Hopper Road, Syracuse, NY 13207
2. 201 East Seneca Turnpike, Syracuse, NY 13205

The site on East Seneca Turnpike was selected. After field reconnaissance the actual location of the unit was moved approximately 150 feet to the west to 134 East Seneca Turnpike. This area is depicted in Figure 7.

Due to budget constraints and sampling objectives, a 4-ft diameter Downstream Defender® with a design flow rate of 0.75 cfs was purchased for installation at the East Seneca Turnpike site, which has a catchment area of approximately 1.2 acres. Hydro International recommends a conservative approach to sizing the Downstream Defender® if no regulatory guidelines are available as in New York State. It is typically recommended to size the installation so that the design flow of the unit is greater than or equal to the peak runoff rate from a 1-year, 24-hour storm event as a minimum, with a 2-year, 24-hour storm event desirable. This conservative approach is taken because of the variability related to the first flush and TSS size distributions and particle densities.

For this project, the project team sized the Downstream Defender® much more aggressively than recommended by Hydro International. The sizing rationale for this site was based on exceeding the design flow rate of 0.75 cfs at least once or twice a month. This approach was taken in order to increase the likelihood that the site would generate flows at or above the design flow and thereby generate performance data at and beyond the unit's design flow.

Once the Downstream Defender® was located and designed, applications were submitted to the City Common Council for approval. The council adopted Ordinance No. 327 on July 10, 2000, which granted permission for the project team to construct and install the Downstream Defender®. Additionally, during field reconnaissance several residents stopped to discuss the purpose of the work and the potential impacts to their street.

3 URBAN BMP IMPLEMETATION

A stormwater vortex unit was installed at 134 East Seneca Turnpike for the purpose of removing suspended solids and associated nutrients from the stormwater before discharge to Onondaga Creek. The catchment area serviced by this unit primarily encompasses a 1,000-feet length of East Seneca Turnpike and is approximately 1.2 acres in size. The unit is a 4-foot diameter Hydro International Downstream Defender® with a design flow of 0.75 cfs and a maximum capacity of 3.0 cfs. Figure 30 shows a portion of the catchment area and Figure 31 shows the unit during installation.

Installation of the Downstream Defender® was fairly simple, considering that the location of the stormwater sewer was on the edge of a busy city street. As a result of the location of the sewer, the unit was installed off-line instead of directly in-line with the sewer. This required removing a three-foot section of the sewer and replacing it with a diversion manhole. The diversion manhole was constructed with a weir wall that diverts flow out of the stormwater sewer and into the unit. Once the flow is processed through the unit it is piped back into the diversion manhole on the other side of the weir wall where it flows back into the stormwater sewer.

In general, construction of the Downstream Defender® proceeded as planned. However, pre-cast concrete components of both the Downstream Defender® and the diversion manhole were not cast to the specified dimensions. These components were not rejected but modified in the field to meet the specifications.

4 URBAN BMP WATER QUALITY MONITORING

During a sampling event, stormwater was sampled from the influent and effluent of the Downstream Defender® at the locations illustrated in Figure 38. During the first five events, these samples were taken with a US DH-81A sampler, which was specifically designed for sampling sediment in flowing water. A photo of the US DH-81A sampler is illustrated in Figure 39. Because there was some concern that the US DH-81A sampler was not taking representative samples of the sediment load, a Van Dorn sampler was used to sample during the last event. The Van Dorn sampler is illustrated in Figure 40. Grab samples from each location were taken at approximately 15-minute intervals throughout a rain event and attempts were made to collect the first flush of stormwater from each rain event. For each pair of influent and effluent samples, the influent sample was taken first and the effluent sample was taken second with approximately 1-2 minutes between the samples.

During the first four events, each influent and effluent grab sample was analyzed for TSS, phosphorus and nitrogen. During the last two events, only TSS was analyzed because there was no clear indication of nutrient removal, and the data from the first four events provided adequate information regarding nutrient runoff in this urban stormwater. Furthermore, during the last two events the laboratory procedures for TSS were changed to reflect the industry's new understanding of laboratory bias (USGS, 2000) with respect to heavy solids and the TSS analysis. In general, the original TSS analysis allowed the laboratory to spilt the primary sample for the purpose of performing the analysis with a single filter of size 24 or 42 mm. Research has shown that splitting stormwater samples that contain solids larger than 62 micron can bias the TSS results downward by as much 50% (USGS, 2000). The new TSS method (also known as ASTM 3977 Suspended Sediment Concentration) required the laboratory to filter the entire sample and not take a split or sub-sample.

The changes made to the sampling method and solids analysis appeared to increase the concentration of solids measured. It is likely that the data collected from the first five events were biased low due to the type of sampler used and the analysis method. Further more the influent samples were likely biased more than the effluent samples because of the higher percentage of coarse grit in the influent. Based on field observations, the effects of changing the sampling method were greater than the effects of changing the solids analysis. Due to time and budget constraints, comparative sampling was not completed. As a result influent versus effluent comparisons were made only for the sixth event when both the Van Doran sampler was used and the ASTM 3977 solids analysis were used.

Flow was measured continuously in the effluent pipe of the Downstream Defender® using a

Marsh McBirney depth/velocity flow meter and data logger, Model 260C. Rain was measured continuously with a tipping rain bucket with data logger. The rain gauge was installed on the roof of St. James School approximately 200 feet from the Downstream Defender®.

5 URBAN BMP DATA ANALYSIS

The stormwater vortex unit was monitored for just over a one-year period from March 2001 until May 2002, during which time approximately 40 inches of rain fell during the non-winter months. This equated to approximately 730,000 gallons of stormwater processed by the vortex unit. Also during this time approximately 100 cubic feet of material was removed from the vortex unit weighing an estimated 4,500 lbs. This equates to approximately 0.14 cubic feet, or 6 lbs of material captured per 1,000 gallons of stormwater processed. Most of the material removed from the vortex unit was sand and grit and organic material such as leaves and twigs. Relatively little trash was collected as a result of the grated catchbasins, which prevent trash from entering the stormwater conveyance system.

The vortex stormwater unit was installed in October of 2000. Only visual inspections were made from October 2000 to March of 2001 when the first cleaning occurred. Cleaning of the unit occurred after March 2001 on an as needed basis. Table 10 shows the dates of the cleanings, the amount of stormwater volume processed between cleanings and the amount of material removed from the unit.

Water quality sampling was conducted on six storm events beginning in July of 2001 and ending in April of 2002. However, due to non-representative sampling procedures and laboratory methods only samples collected during the sixth event are considered appropriate for influent versus effluent comparisons. During events 1 through 5 samples were taken with a US DH-81A sampler, which was specifically designed for sampling sediment in flowing water. Because there was some concern that the US DH-81A sampler was not taking representative samples of the sediment load, a Van Dorn sampler was used to sample during the last event. The amount and type of material collected during the sixth event with the Van Dorn sampler appeared to be significantly different than that collected with the US DH-81A during the first five events. A photo of the solids collected with the Van Dorn sampler from the influent during event six is presented in Figure 90. Coarse, medium and fine grit (3 to 0.075 mm) were apparent in the influent while mostly fine grit (< 0.2 mm) and silt material were apparent in the effluent. In addition, the solids concentrations measured during the sixth event were the highest observed throughout the sampling effort thus suggesting that the Van Dorn sampler was collecting more solids in the sample than the US DH-81A sampler.

Figures 84 through 89 show the hyetographs and hydrographs from each of the six sampled storm events. Peak flows by event ranged from 0.3 cfs to 1.9 cfs. The peak flow of 1.9 cfs was generated from approximately 0.35 inches of rain falling in a 15 minute time period. This equates to a rain intensity of 1.4 inches per hours, which is equivalent to approximately one-half the intensity of the 1-year return frequency storm for the City of Syracuse. As a frame of reference the 4-ft diameter Downstream Defender® design flow rate is 0.75 cfs and the maximum capacity is 3.0 cfs. The design flow of 0.75 cfs was exceeded during three of the six sampled storm events. As discussed in Section 4.3.1, a 4-ft diameter unit was installed so that the design flow would be exceeded approximately once or twice a month for the purposes of sampling the unit while it operated at or near the design conditions.

Figure 89 shows the hyetograph and hydrograph for event six as well as the influent and effluent solids concentrations observed for the samples taken during this event. Flows began at approximately 9:15 am on April 25, 2002. Sampling equipment was prepared and ready for sampling in advance. Three influent/effluent sample pairs were taken at flow rates ranging from 0.4 to 0.75 cfs. As the first flows were observed, the first pair of samples were taken. As the flow rate peaked to near the design flow (0.75 cfs) the second pair of samples were taken. The third samples were taken on the falling limb of the hydrograph. Percent removal ranged from 26% to 93%. The first sample appeared to be representative of a first flush; solids concentrations in the influent were the highest observed throughout the entire sampling program. The corresponding percent removal was on the order of 93%. High percent removals are often associated with the first flush because this flush conveys waters laden with heavy solids and associated pollutants.

During events five and six floatable material (trash) was seeded into the influent. The floatable material consisted of cigarette butts, food wrappers, Styrofoam cups and milk cartons. The vortex unit was effective at removing this material; no seeded material was observed in the effluent. During the cleanings that followed events five and six all the seeded material except for the cigarette butts were recovered. This should not necessarily indicate that the unit is ineffective at capturing cigarette butts. In fact, based on field observations, the unit does capture cigarette butts, but because of their size finding cigarette butts during cleaning proved difficult.

On August 21, 2001 and September 3, 2002 solids were sampled from the sediment storage sump of the Downstream Defender®. Nine percent of the material in the sump was characterized as course sand, 53% of the material was characterized as medium sand and 38% characterized was as fine sand, silt and clay. This suggests that the majority of the material influent to this particular installation is medium sand and smaller and the material captured by this particular unit ranges from coarse to fine sized sand and smaller. This is not to say this units captures 100% of any particular size material, but rather based on the contents of the storage sump it has the ability to capture coarse to fine sized sand and smaller material. Figure 90 illustrates the type and size of material found in both the influent and effluent of the unit during testing.

Also on September 3, 2002 samples from the sediment storage sump were collected and analyzed for metals and phosphorus. These results are presented in Table 11. These results show that there are pollutants such as metals and phosphorous associated with the types of solids that the Downstream Defender® successfully captured. Pounds of associated pollutants were calculated based on the total quantity of material (solids) captured by Downstream Defender® throughout the duration of this study period and based on the assumption that this one sample was representative of the total mass of material captured. Of particular interest was chromium, cooper, lead and total phosphorus. Pounds of these pollutant removed during this study period were estimated to be:

- Chromium: 0.29 lbs
- Copper: 0.14 lbs
- Lead: 0.76 lbs
- Phosphorus: 0.95 lbs *

It is likely that the mass of phosphorus captured by the Downstream Defender® was significantly greater than 0.95 pounds. This is based on the fact that this sample represented solids captured during the summer months when nutrient concentrations are assumed to be low. It is expected that nutrient concentrations would be significantly higher if the sample were collected after the heavy autumn leaf load. During cleaning after the fall seasons, heavy layers of leaf litter were apparent.

Maintenance is key to success with any structural BMP designed to remove solids from stormwater. Onondaga County removed the solids from the unit on an as needed basis. It was a very simple operation with the vactor truck. Cleanout of the diversion manhole and the unit itself took approximately 15 minutes, which included maneuvering the truck into position near the unit, drawing material up with the suction pipe of the vactor truck and pressure washing the solids from the bottom and sides.

6 URBAN BMP LESSONS LEARNED

In the urban setting, specifically with regards to the stormwater vortex unit, measuring solids presented challenges in terms of both sampling and laboratory analysis.

The originally proposed sampling procedure relied on the use of a submersible pump to draw stormwater from the sewer to the street level where sample bottles could be filled. When selecting the pump, factors such as pumping power and transport velocity were considered. It is important that the pumping power provide a transport velocity sufficient enough to keep solids in suspension, otherwise the solids in the stormwater will not be drawn with the water to the sampling location. An additional concern with pumping stormwater for the purpose of solids sampling is the issue of solids maceration; submersible pumps can break large solids apart and bias the analytical results. After discussions with the stormwater vortex manufacturer, it was decided not to use the pumps, but instead use a US DH-81A sampler, which was specifically designed for sampling sediment in flowing water. A photo of the US DH-81A sampler is illustrated in Figure 39.

The US DH-81A sampler was used during the first five events, but concerns developed regarding the representativeness of the samples. The US DH-81A sampler is essentially a sample bottle with a specially designed nozzle that allows the bottle to be oriented in a horizontal position without losing the sample. Both the bottom of the sample bottle and the nozzle create increased flow pressure, which results in water flowing around the sample bottle and not into the bottle. As a result of the concern that the US DH-81A sampler was not taking representative samples of the sediment load, a Van Dorn sampler was used to sample during the last event. The Van Dorn sampler is illustrated in Figure 40.

The Van Dorn sampler is essentially an open tube that has two end caps that can close instantaneously. When using in a storm sewer, the end caps are in the opened position allowing water to flow freely through the tube. The end caps are then closed, trapping a sample of water within the tube. This appears to have an advantage over a sample bottle because significant pressure increases are not induced. In comparison to the submersible sampling pumps, transport velocity and solids maceration are no longer issues.

The originally proposed solids analysis was Total Suspended Solids (USEPA 160.3). However this analysis was changed to reflect the industry's new understanding of laboratory bias (USGS, 2000) with respect to heavy solids and the TSS analysis. In general, the original TSS analysis allowed the laboratory to spilt the primary sample for the purpose of performing the analysis with a single filter of size 24 or 42 mm. Research has shown that splitting stormwater samples with heavy solids can bias the TSS results downward by as much 50% (USGS, 2000). The new TSS method (also know as ASTM 3977 Suspended Sediment Concentration) required the laboratory to filter the entire sample and not take a split or sub-sample. It appears that the ASTM 3977 Suspended Sediment Concentration has an advantage over the USEPA 160.3 Total Suspended Solids method because it eliminates sampling splitting; in general the less a sample is handled and manipulated the more representative it is. Because federal and state effluent discharge permits are written to include USEPA 160.3 Total Suspended Solids, both of these analyses should be run simultaneously until enough data are collected to the presence or absence of laboratory bias.

7 URBAN BMP CONCLUSIONS

The costs of the urban stormwater vortex unit and vegetative filter strip were $34,000 and $6,000, respectively. The cost difference reflects the degree of capital improvements involved.

The urban BMPs were effective at removing solids from stormwater, but not at removing nutrients. This is likely due to the low concentration of nutrients influent to these BMPs. This may suggest that in certain urban environments, such as parking lots and city streets, nutrient runoff is not a priority pollutant.

The stormwater vortex unit worked as expected; it was easy to maintain and it collected coarse, medium and fine sized grit (4.75 mm to .075 mm) and trash. The stormwater vortex unit removed approximately 0.14 cubic feet and 6 lbs of material per 1,000 gallons of stormwater processed. The water quality-sampling program had limitations because the original sampling equipment and laboratory analysis were not appropriate for stormwater with coarse and medium sized grit content (> 0.15 mm).

The vegetative filter strip generally worked as expected; it was easy to maintain and it absorbed much of the runoff from the parking lot. However, it was a source (i.e., exporter) of nutrients. The source of the nutrients was likely the compost used to fertilize and establish vegetation. In light of the fact that the effluent nutrient concentrations were low as compared local receiving water concentrations, the increase in nutrients from influent to effluent was likely apparent because of the very low influent concentrations. The vegetative filter strip, which was approximately 150 square yards could absorb approximately 1.0 inch of rain before runoff exceeded its infiltration capacity.

8 URBAN BMP RECOMMENDATIONS

Stormwater vortex units should be installed at selected points in the urban setting to capture solids and trash. Nutrient capture may be limited due to the relatively low concentrations in the runoff from parking lots and city streets.

Consideration should be given to maximizing the size of vortex sediment storage sump to maximize storage and thereby reduce maintenance frequency. A cost analysis should be performed comparing the expense of deepening the sump versus the costs incurred by additional maintenance time.

Retrofitting a vegetative filter strip into an existing urban setting may prove difficult to site. However, constructing strips in new developments may provide many advantages including increasing green space and reducing stormwater volume through infiltration.

Measuring solids in stormwater samples presented some challenges both in terms of sampling and in analytical procedures. In the future, when heavy solids in stormwater are an issue it is recommended that a volume sampler (e.g. Van Dorn sampler) be used. Analytical procedures should also be appropriate to quantify the heavy solids.

9 REFERENCES

USGS, 2000. Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data By John R. Gray, G. Douglas Glysson, Lisa M. Turcios, and Gregory E. Schwarz. Water-Resources Investigation Report 00-4191.

Date of Cleaning	Volume of Stormwater Processed (gallons)	Volume of Material Removed (cubic feet)	Notes
March 1, 2001	NA	20	Not cleaned since installation. Filled beyond capacity. Obvious layer of leaf liter from fall foliage. Influent diversion manhole filled with heavy grit and effluent diversion manhole filled with fine silty material.
June 25, 2001	227,899	19	Unit filled to near capacity. Influent diversion manhole filled with heavy grit and effluent diversion manhole filled with fine silty material.
August 21, 2001	95,757	17	Unit filled to near capacity. Influent diversion manhole full. Effluent diversion manhole relatively clean.
November 30, 2001	184,998	19	Unit filled to near capacity. Influent diversion manhole filled with heavy grit and effluent diversion manhole filled with fine silty material.
March 13, 2002	7,965	20	Filled beyond capacity because of winter build-up of road sand. Influent diversion manhole filled with heavy grit and effluent diversion manhole filled with fine silty material.
April 8, 2002	53,219	15	Unit filled to near capacity. Influent diversion manhole full. Effluent diversion manhole relatively clean.
June 5, 2002	167,802	17	Unit filled to near capacity. Influent diversion manhole full. Effluent diversion manhole relatively clean.
Total	**737,640**	**107**	

Notes: March 1, 2001 not included in totals. Evaluation started on March 1, 2001.

The mass of the material captured (4,500 lbs) was estimated based on volume removed and specific gravity of material.

During the period from November 30, 2001 and March 13, 2002 the unit processed stormwater derived from, which was not included in the 7,965 gallons.

During this period approximately 50 inches of snow fell with a water equivalence of 3.8 inches.

Percent Passing Sieve	
#4	98
#10	91
#30	53
#40	38
#60	18
#100	9
#200	4

Parameter	Result (mg/kg)	Mass of Pollutant* (lbs)
Arsenic	2.1	0.01
Barium	30	0.13
Cadmium	2	0.01
Chromium	65	0.29
Copper	31	0.14
Lead	170	0.76
Mercury	0.2	0.00
Nickel	9	0.04
Selenium	0.8	0.00
Silver	2	0.01
Zinc	180	0.81
Total Phos	210	0.94

Note: * Mass Pollutant Captured based on 4,500 lbs total Solids Captured During Study Period

CONTRACT DRAWINGS
ONONDAGA LAKE WATERSHED
NONPOINT SOURCE
ENVIRONMENTAL BENEFIT PROJECT

EAST SENECA TURNPIKE DOWNSTREAM DEFENDER
ONONDAGA COUNTY, NEW YORK

CENTRAL NEW YORK
REGIONAL PLANNING AND DEVELOPMENT BOARD

INDEX OF DRAWINGS

DD-1 AREA MAP (TITLE SHEET)
DD-2 LAYOUT DETAILS
DD-3 MANHOLE DIVERSION DETAILS
DD-4 GENERAL ARRANGEMENT DETAILS

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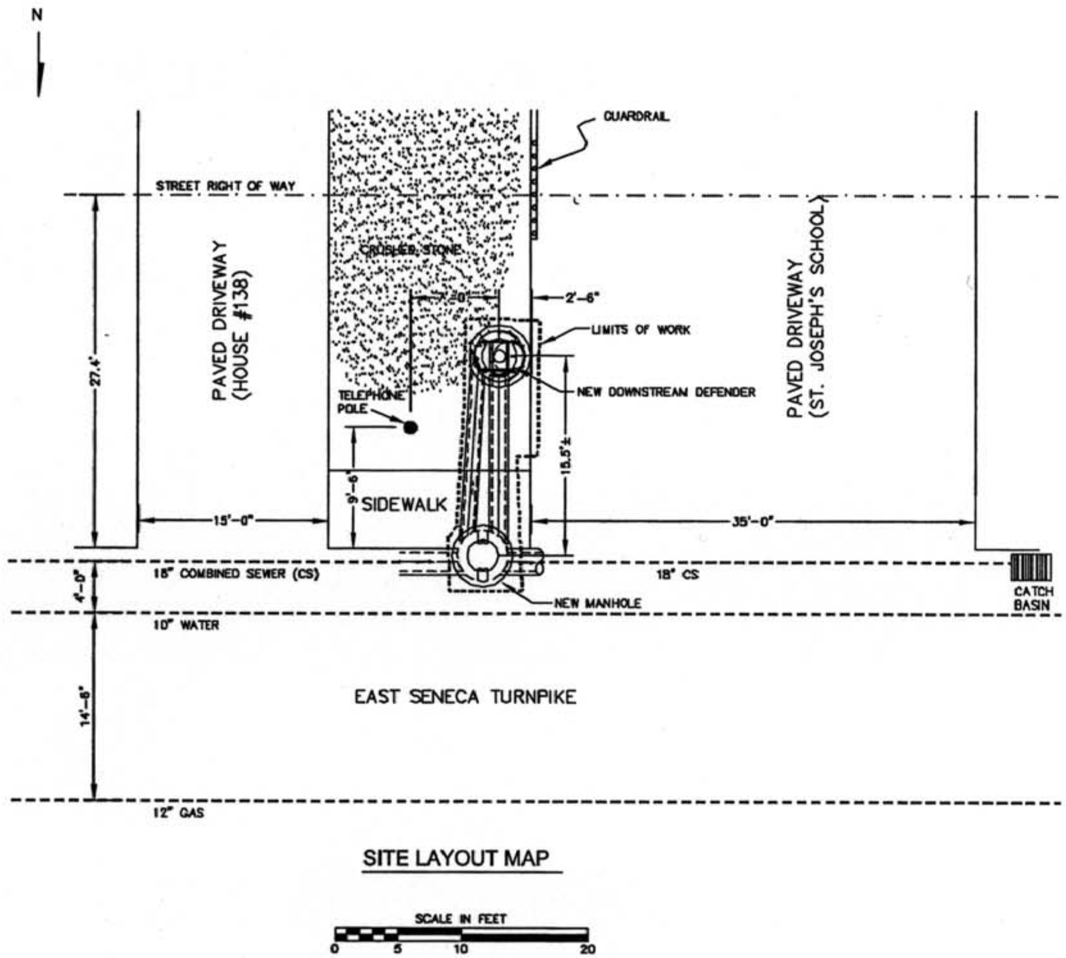


Moffa & Associates
A unit of Brown and Caldwell

Onondaga Lake Watershed, Nonpoint Source EBP
East Seneca Turnpike and Downstream Defender Location

Figure 7

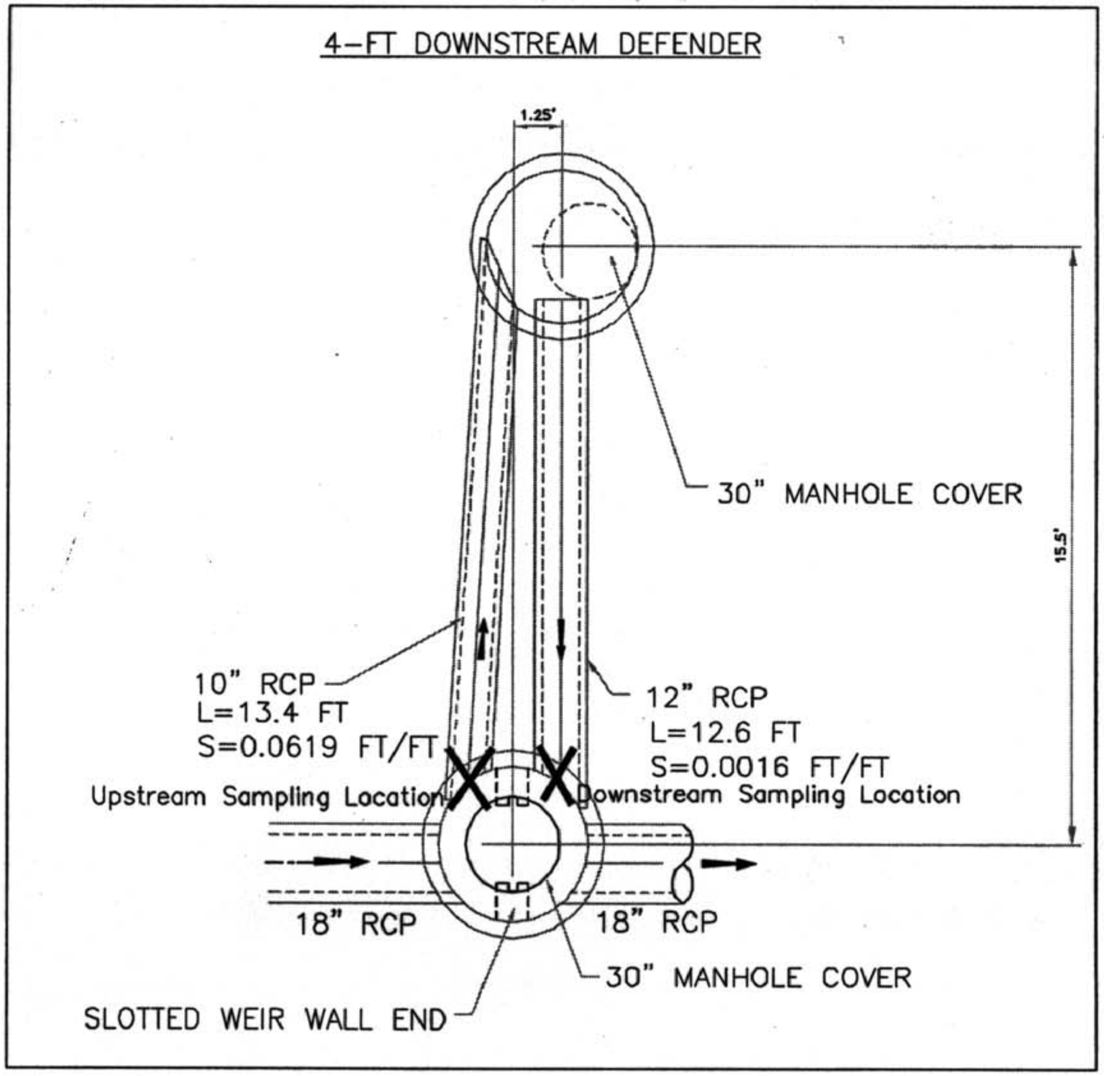
Stormwater Vortex Unit Catchment Area

Stormwater Vortex Unit Installation

Moffa & Associates
A unit of Brown and Caldwell

Onondaga Lake Watershed, Nonpoint Source EBP
Stormwater Vortex Unit Catchment Area and Unit Installation

Figures 30 & 31



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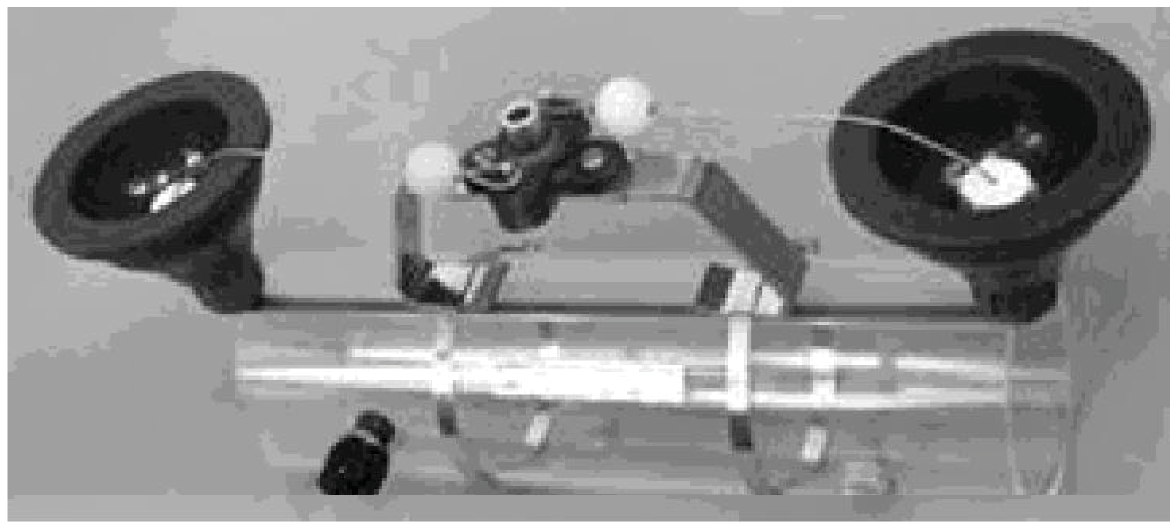
Onondaga Lake Watershed, Nonpoint Source EBP
Downstream Defender Layout with Sampling Locations

Figure 38

US DH-81A Sampler



Van Dorn Sampler

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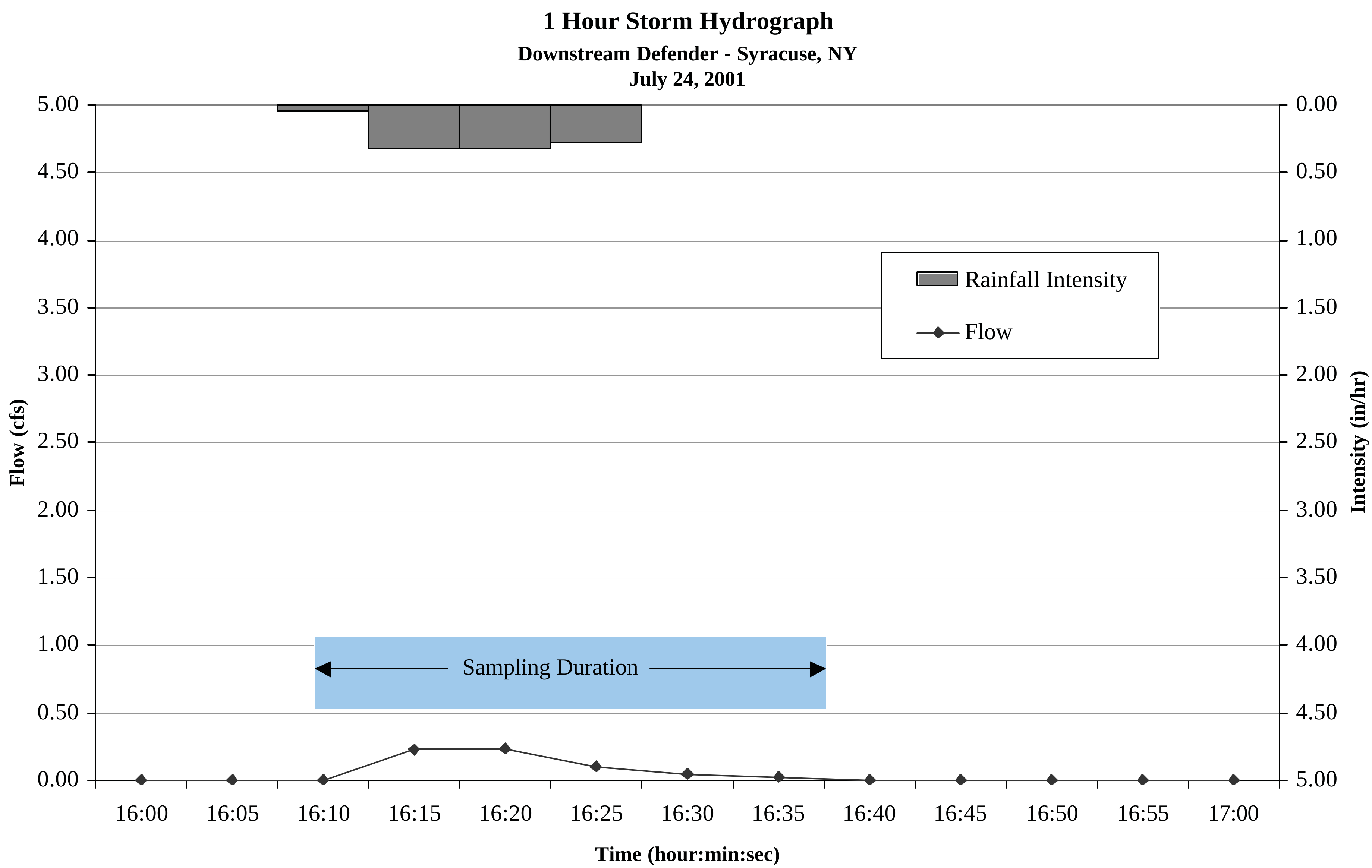
A unit of Brown and Caldwell

Onondaga Lake Watershed, Nonpoint Source EBP
US DH-81A Sampler and Van Dorn Sampler

Figures 39 & 40



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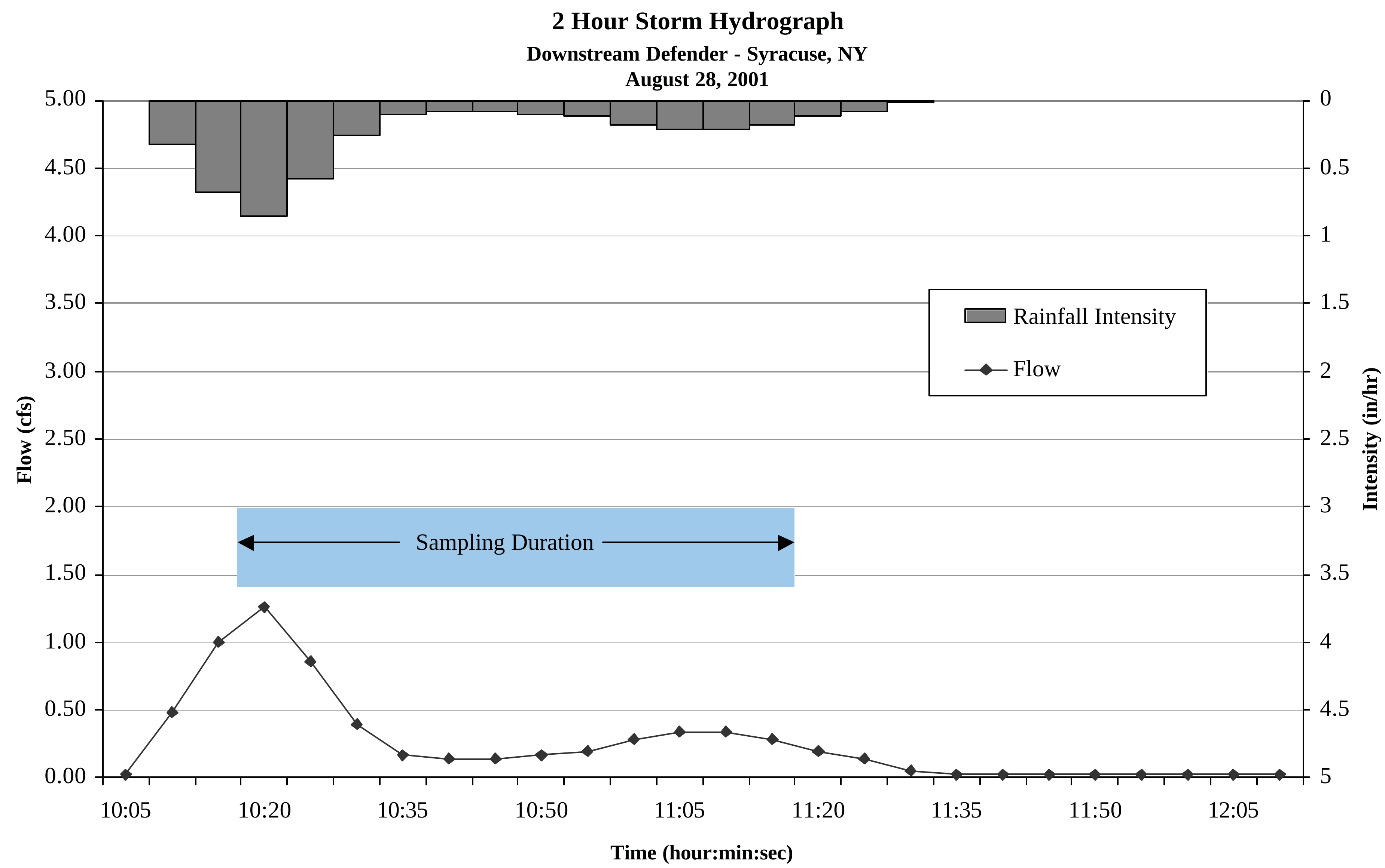
Onondaga Lake Watershed, Nonpoint Source EBP
1 Hour Storm Hydrograph-Downstream Defender - July 24, 2001

Figure 84



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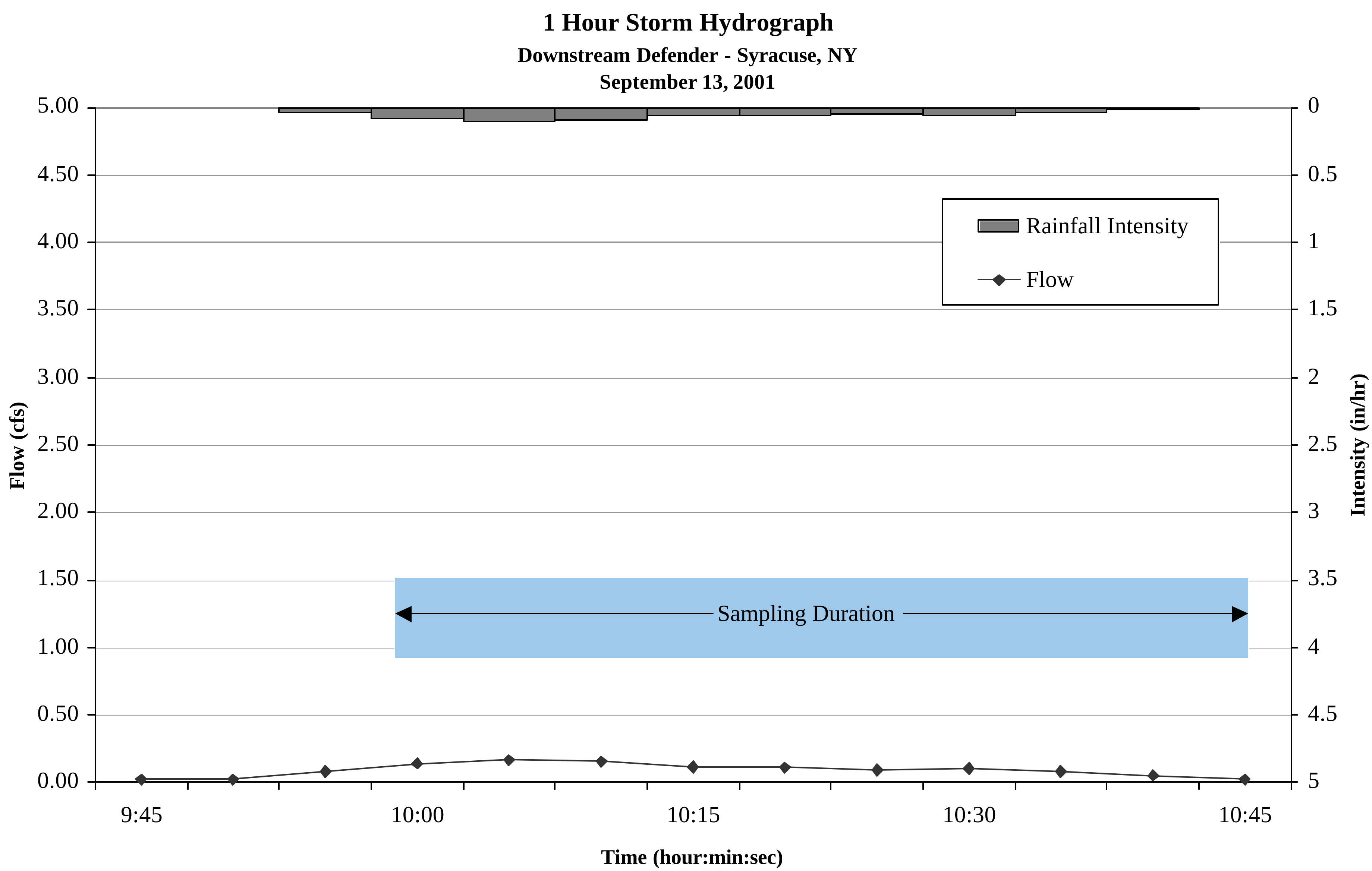
A unit of Brown and Caldwell

Onondaga Lake Watershed, Nonpoint Source EBP
2 Hour Storm Hydrograph-Downstream Defender -August 28, 2001

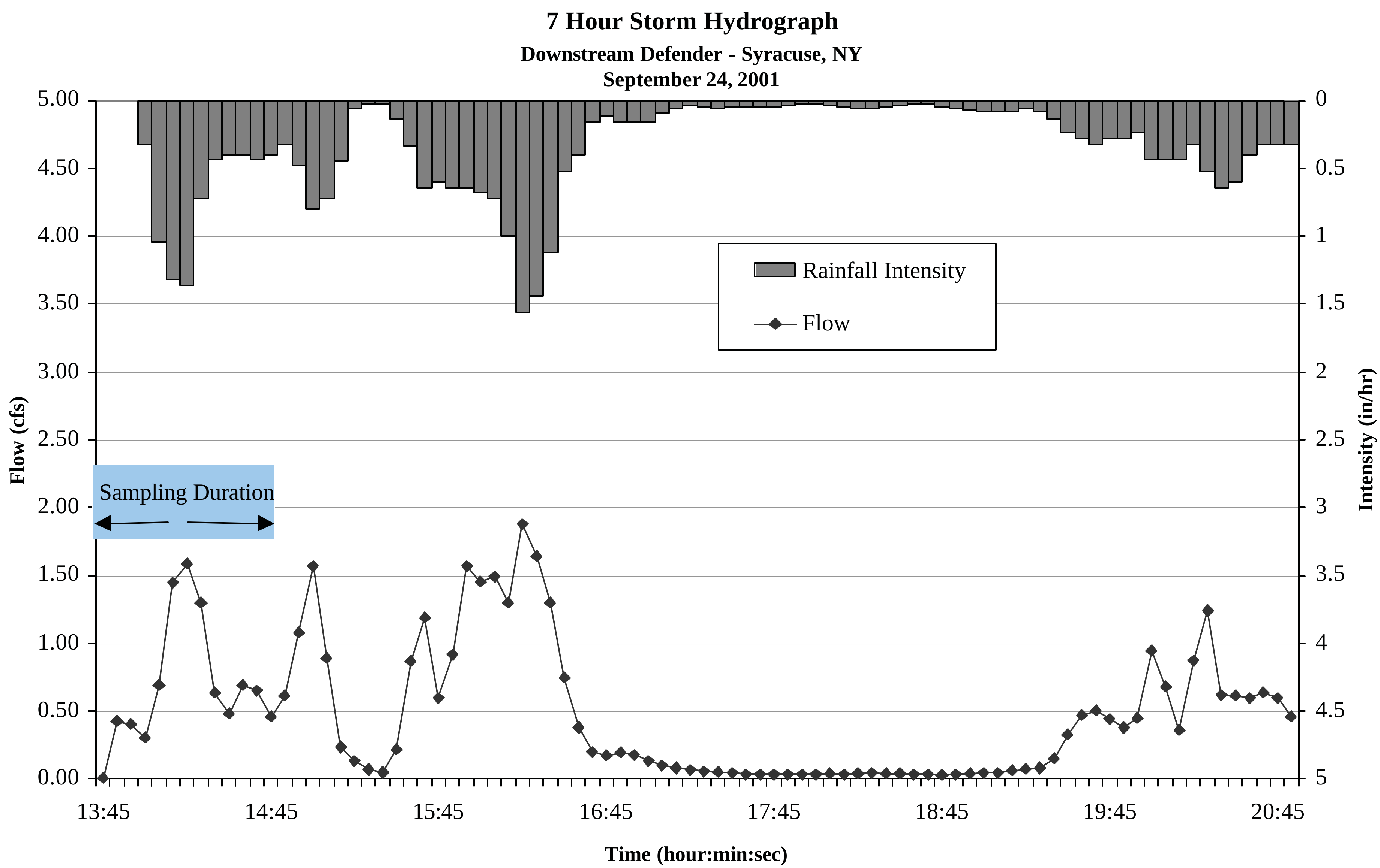
Figure 85



Moffa & Associates
A unit of Brown and Caldwell

Onondaga Lake Watershed, Nonpoint Source EBP
1 Hour Storm Hydrograph-Downstream Defender-September 13, 2001

Figure 86



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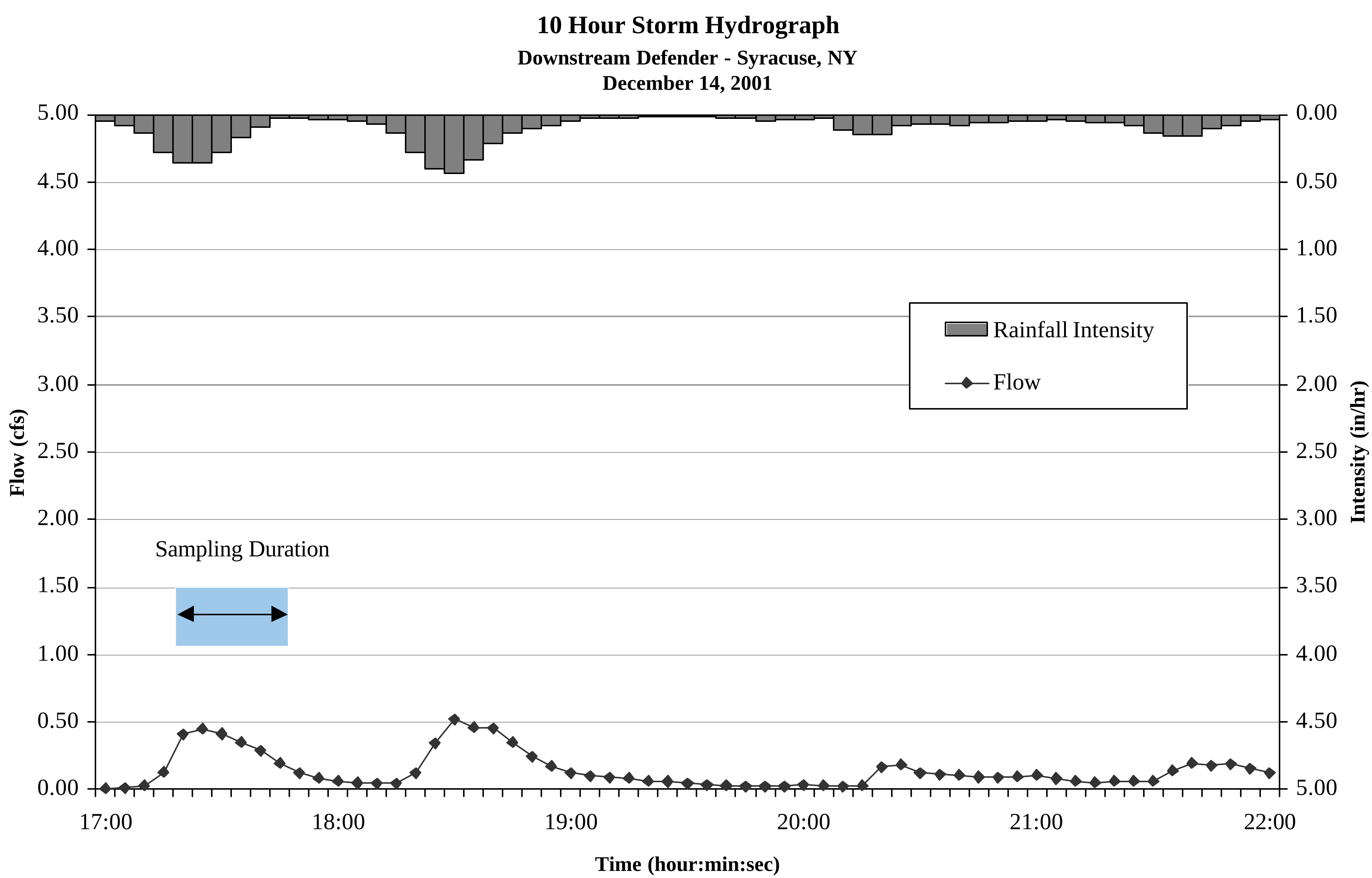
A unit of Brown and Caldwell

Onondaga Lake Watershed, Nonpoint Source EBP
7 Hour Storm Hydrograph-Downstream Defender-September 24, 2001

Figure 87



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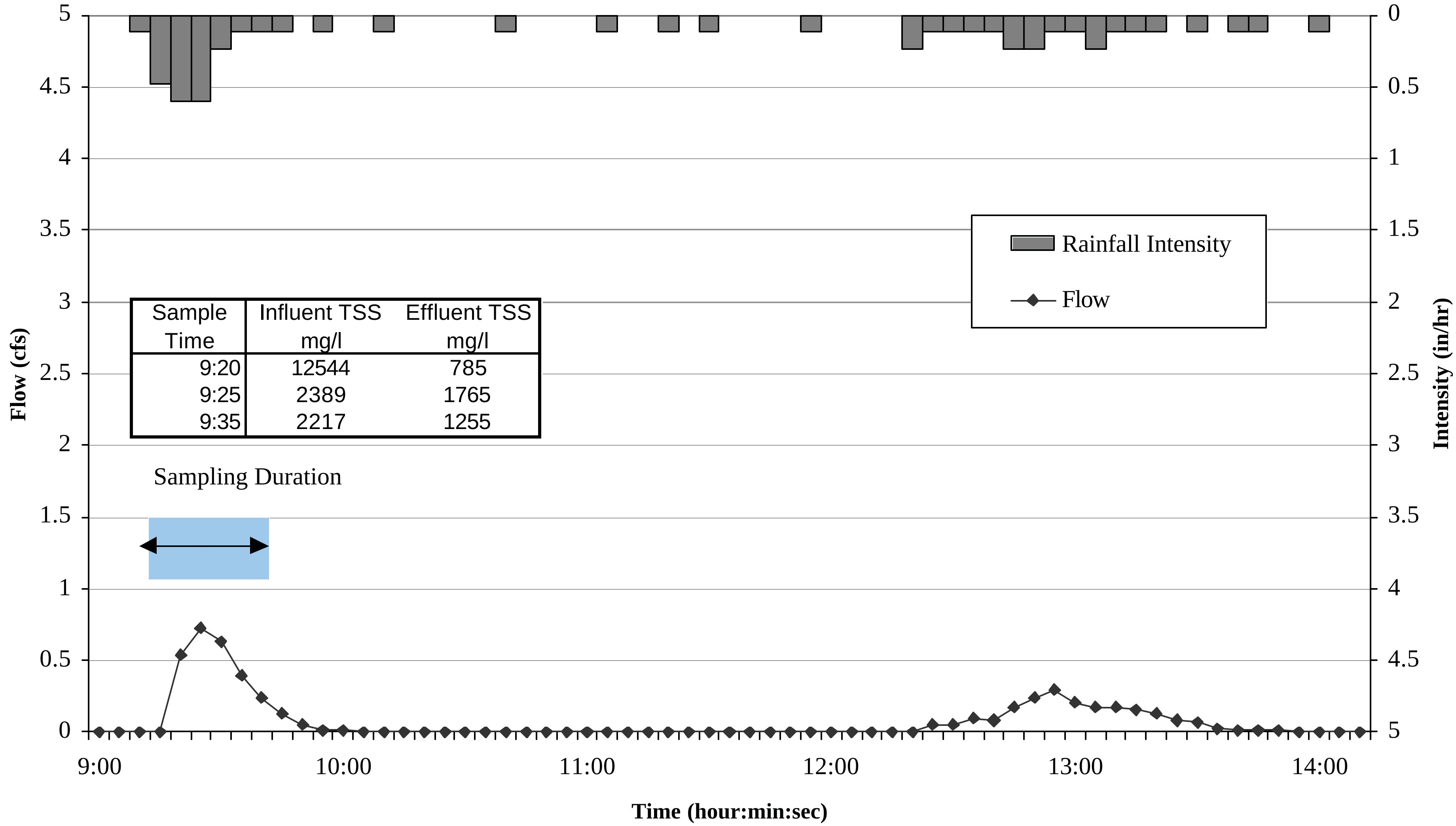
Onondaga Lake Watershed, Nonpoint Source EBP
10 Hour Storm Hydrograph-Downstream Defender-December 14, 2001

Figure 88



Sample Time	Influent TSS mg/l	Effluent TSS mg/l
9:20	12544	785
9:25	2389	1765
9:35	2217	1255

Moffa & Associates
A unit of Brown and Caldwell

Onondaga Lake Watershed, Nonpoint Source EBP
5 Hour Storm Hydrograph-Downstream Defender-April 25, 2002

Figure 89

Influent Stormwater Vortex Unit Solids Sample: Coarse to Medium Grit

Moffa & Associates
A unit of Brown and Caldwell

Onondaga Lake Watershed, Nonpoint Source EBP
Influent and Effluent Solids - Downstream Defender-April 25, 2002

Figure 90