TARP FIELD TEST PERFORMANCE MONITORING OF A JELLYFISH® FILTER JF4-2-1

Performance Monitoring Report for JF4-2-1 Prepared By:

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Part I: Imbrium-Supplied Information for Report

1. Company Overview and Key Contacts

Imbrium Systems has been actively engaged in the stormwater treatment industry since the introduction of its Stormceptor® product in 1992. Originally established as the Stormceptor Group of Companies, in 2006 the company changed its name to Imbrium Systems. This name change was implemented as the company expanded research and development to deliver new technologies to the stormwater treatment industry.

Imbrium Systems is a global company with U.S. headquarters (Imbrium Systems Corporation) located in Rockville, Maryland and Canadian and International headquarters (Imbrium Systems Incorporated and Imbrium International Limited) located in Toronto, Ontario, Canada, with satellite offices located across North America.

Imbrium Systems is a wholly-owned business of Monteco Ltd. Monteco is a privately-held company headquartered in Toronto, Ontario which focuses on developing innovative clean-tech solutions for application in the air, water and energy industry sectors. Monteco supports its businesses with centralized corporate services including research & development, public relations, government affairs, marketing and communication, human resources and finance.

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2. Introduction

Stormwater pollution, especially in developed urban areas is a leading cause of water quality degradation in U.S. rivers, lakes, streams, and other surface waters. Water quality problems associated with nonpoint sources of pollution, particularly stormwater, are being addressed by federal mandates that affect all states. Expansion of the National Pollutant Discharge Elimination System (NPDES) Phase II, Storm Water Regulations, requires stormwater plans from thousands of municipalities nationwide, and a renewed focus on the total maximum daily load provisions (TMDL) in the Clean Water Act brings unprecedented attention and increased resources to stormwater control issues. These programs also are predicted to have a significant influence on the rate at which new technologies enter the marketplace.

To support responsible use of stormwater treatment technologies, the Demonstration Protocol has been designed to be flexible and inclusive of both structural and nonstructural best management practices (BMPs). Additionally the Protocol has been administered following the Technology Acceptance Reciprocity Partnership (TARP) field test protocol for stormwater best management practices (BMP) for demonstrations, per the guidelines of the New Jersey Department of Environmental Protection (NJDEP).

The TARP Protocol primarily deals with the demonstration of BMPs that are designed for one or more of the following: 1) directing and distributing flows; 2) reducing erosive velocities; and 3) removing contaminants such as suspended or dissolved pollutants from collected stormwater through physical and chemical processes such as settling, media-filtering, ion-exchange, sorption, and precipitation. Current BMPs used in industrial, municipal, commercial, residential, and construction stormwater pollution control applications include vegetated swales, detention basins, infiltration basins, wet ponds, constructed wetlands, media filtration, bioretention, and sedimentation units (e.g. hydrodynamic structures, oil/sediment separators, and screen separators).

The TARP field test of Imbrium Systems' Jellyfish® Filter that is the subject of this report was conducted by the University of Florida Engineering School of Sustainable Infrastructure and Environment in Gainesville, Florida.

3. Purpose

The purpose of the TARP Protocol is to provide a uniform method for demonstrating stormwater technologies and developing test quality assurance (QA) plans for certification or verification of performance claims. The advantages of using the TARP Demonstration Protocol are numerous. Technology proponents will reduce duplicative or overlapping demonstration and performance testing of technologies; maximize return on research and development dollars; certify or verify the technology in accordance with performance claims and state regulatory standards; demonstrate effectiveness, cost, and marketability; and achieve maximum market penetration.

Since current NPDES Phase I and II regulations require industrial and municipal permittees to provide stormwater discharge control through use of BMPs, specific BMP usage is not subject to regulation. Stormwater BMPs with demonstrated capability, i.e., BMPs with reliable removal rates based on field testing, are more likely to be used in NPDES required Stormwater Pollution Prevention Plans (SWPPP) to control stormwater discharges. Obtaining certification or verification of a stormwater BMP technology from participating states can assist the technology in gaining regulatory acceptance in this application.

Imbrium Systems' Jellyfish® Filter is a BMP designed to meet federal, state, and local requirements for treating stormwater runoff in compliance with the 1972 Clean Water Act and NPDES Stormwater Amendments, and phosphorus TMDLs in critical or impaired watersheds. The Jellyfish Filter is typically comprised of a manhole or vault configuration that houses a cartridge deck and multiple high surface area membrane filtration cartridges. Stormwater from storm drains flows by gravity into the unit, where it is first pretreated by hydrodynamic separation processes then filtered through the cartridges. The combination of pretreatment and filtration treatment mechanisms is effective for the capture of floatable pollutants, coarse and fine sediments, and particulate-bound pollutants such as nutrients, toxic metals, hydrocarbons, and bacteria.

The purpose of this TARP field test of the Jellyfish Filter is to characterize the BMP's pollutant removal performance, hydraulic performance, and maintenance requirements over a long-duration monitoring period.

4. Technology Description – Jellyfish® Filter

The University of Florida Engineering School of Sustainable Infrastructure and Environment has conducted extensive hydraulic testing and field monitoring of the Jellyfish® Filter JF4-2-1 utilizing second generation Jellyfish membrane filtration cartridges. The second generation cartridge has five times the surface area of the first generation cartridge of equal length, and therefore much higher flow rate and sediment holding capacity, as well as other improved features. For example, a 54-inch long first generation cartridge (on which the original New Jersey Department of Environmental Protection Interim Certification letter for Jellyfish Filter is based) has 76 ft^2 of filtration membrane surface area, while a second generation cartridge of equal length has 381 ft^2 of filtration membrane surface area.

The following technology description information is excerpted from the **Jellyfish® Filter Technical Manual** published by Imbrium Systems:

The Jellyfish Filter is an engineered stormwater quality treatment technology featuring unique membrane filtration in a compact stand-alone treatment system that removes a high level and wide variety of stormwater pollutants. The Jellyfish Filter integrates pre-treatment and filtration with passive self-cleaning mechanisms. The system utilizes membrane filtration cartridges with very high filtration surface area and flow capacity, which provide the advantages of high sediment capacity and low filtration flux rate (flow per unit surface area) at relatively low driving head compared to conventional filter systems.

Each lightweight Jellyfish Filter cartridge consists of multiple detachable membrane-encased filter elements ("filtration tentacles") attached to a cartridge head plate. The filtration tentacles provide an extraordinarily large amount of surface area, resulting in superior flow capacity and suspended sediment removal capacity.

Jellyfish efficiently captures a high level of stormwater pollutants, including:

- Greater than 85% of the total suspended solids (TSS) load, including particles less than 5 microns
- Particulate-bound pollutants such as nutrients, toxic metals, hydrocarbons, and bacteria
- Free oil
- Floatable trash and debris

Jellyfish cartridges are passively backwashed automatically after each storm event, which removes accumulated sediment from the membranes and significantly extends the service life of the cartridges and the maintenance interval. If required, the cartridges can be easily manually backwashed without removing the cartridges. Additionally, the lightweight cartridges can be removed by hand and externally rinsed, and rinsed cartridges then re-installed. These simple maintenance options allow for cartridge regeneration, thereby minimizing cartridge replacement costs and life-cycle treatment costs while ensuring long-term treatment performance.

The Jellyfish Filter is comprised of several structural and functional components:

- A **cylindrical (manhole) or rectangular structure** constructed of either precast concrete or fiberglass, and available in a wide variety of sizes and configurations, serves as a vessel that provides long-lasting structural support for the system; provides hydraulic connections to the inlet and outlet pipes; provides surfaces for structural attachment of the cartridge deck and maintenance access wall; provides influent water storage and flow-through volume for pollutant separation and membrane filtration treatment; and provides a high-volume sump for storage of accumulated sediment.

- A rigid high-strength fiberglass **cartridge deck** separates the vessel into a lower chamber and upper chamber; houses the filter cartridges; provides a surface and flow path for treated water to the effluent pipe; provides double-wall containment of oil and other hydrocarbons below deck; and provides a platform for maintenance personnel to safely service the filter cartridges. The lower chamber provides influent water storage and flow-through volume for pollutant separation and membrane filtration treatment, and storage of accumulated sediment. The upper chamber provides above-deck clearance for inspection and maintenance service. The cartridge deck is securely attached to the vessel wall.

- A rigid high-strength fiberglass **maintenance access wall** attenuates influent water velocity; channels influent water into the lower chamber via a large opening in the cartridge deck; provides storage volume for floatable pollutants; and serves as a convenient inspection and maintenance access point for pollutant removal.

- **Cartridge receptacles** are secured to the cartridge deck and together with the cartridge lids, serve to securely anchor the filter cartridges into the cartridge deck.

- **Jellyfish membrane filtration cartridges** are inserted into the cartridge receptacles and secured with the cartridge lids. The filter cartridges treat the influent stormwater by filtering out fine suspended particulates (TSS) and particulate-bound pollutants on the membrane of each filtration tentacle. Filtered water passes through the membranes, flows up the center tube of each filtration tentacle and exits the top opening of each tentacle. Cartridges are available in various lengths and flow ratings. Filter cartridges are designated as either **hi-flo cartridges** or **draindown cartridges**, depending on their placement position within the cartridge deck. Cartridges placed within the backwash pool weir are automatically passively backwashed after each storm event, and are designated the hi-flo cartridges. Cartridges placed outside the backwash pool weir are not passively backwashed but facilitate the draindown of the backwash pool and these are designated the draindown cartridges. The design flow rate of a draindown cartridge is controlled by a cartridge lid orifice to one-half the design flow rate of a hi-flo cartridge of similar length. The lower design flow rate of the draindown cartridge reduces the likelihood of occlusion prior to scheduled maintenance.

- **Cartridge lids** are fastened onto the cartridge receptacles to securely anchor the filter cartridges into the cartridge deck. The lids are removable to allow manual backflushing or removal of the filter cartridges when required during maintenance service. Cartridge lids contain a **flow control orifice** that is specifically sized for use with hi-flo and draindown cartridges. **Blank lids** have no orifice and are used to cover unoccupied cartridge receptacles in systems that do not use the full rated flow capacity of the system.

- A **separator skirt** serves as a baffle that encloses the filtration tentacles and defines the filtration zone inside the separator skirt perimeter. The separator skirt extends the full length of the filtration tentacles and prevents contamination of the membranes with oil and floatable debris. The separator skirt has a large opening at the bottom that allows pre-treated water to enter the filtration zone under low velocity. The separator skirt is securely attached to the underside of the cartridge deck.

- A rigid fiberglass **backwash pool weir** extends 6 inches (150 mm) above the cartridge deck and encloses the hi-flo cartridges. During inflow, filtered water exiting the hi-flo cartridges forms a pool inside the weir. If sufficient driving head is available the pool overtops the weir and spills to the cartridge deck where it subsequently flows to the outlet pipe. As the inflow event subsides and forward driving head decreases, water in the backwash pool reverses flow direction and automatically passively backwashes the hi-flo cartridges, cleaning the membrane surfaces. Water in the lower chamber (below deck) is displaced through the draindown cartridges. This self-cleaning mechanism may occur multiple times during a single storm event as rainfall/runoff intensities rise and fall, thereby significantly extending the service life of the cartridges and the maintenance interval.

- **Optional internal bypass pressure relief pipe(s)** can be placed in one or multiple cartridge receptacles. The pressure relief pipe height and diameter can be varied to accommodate the design peak flow rate and system driving head requirements. When the internal bypass option is utilized, peak flow rates receive membrane filtration treatment up to the filtration design flow rate, with the balance of the peak flow receiving pre-treatment.

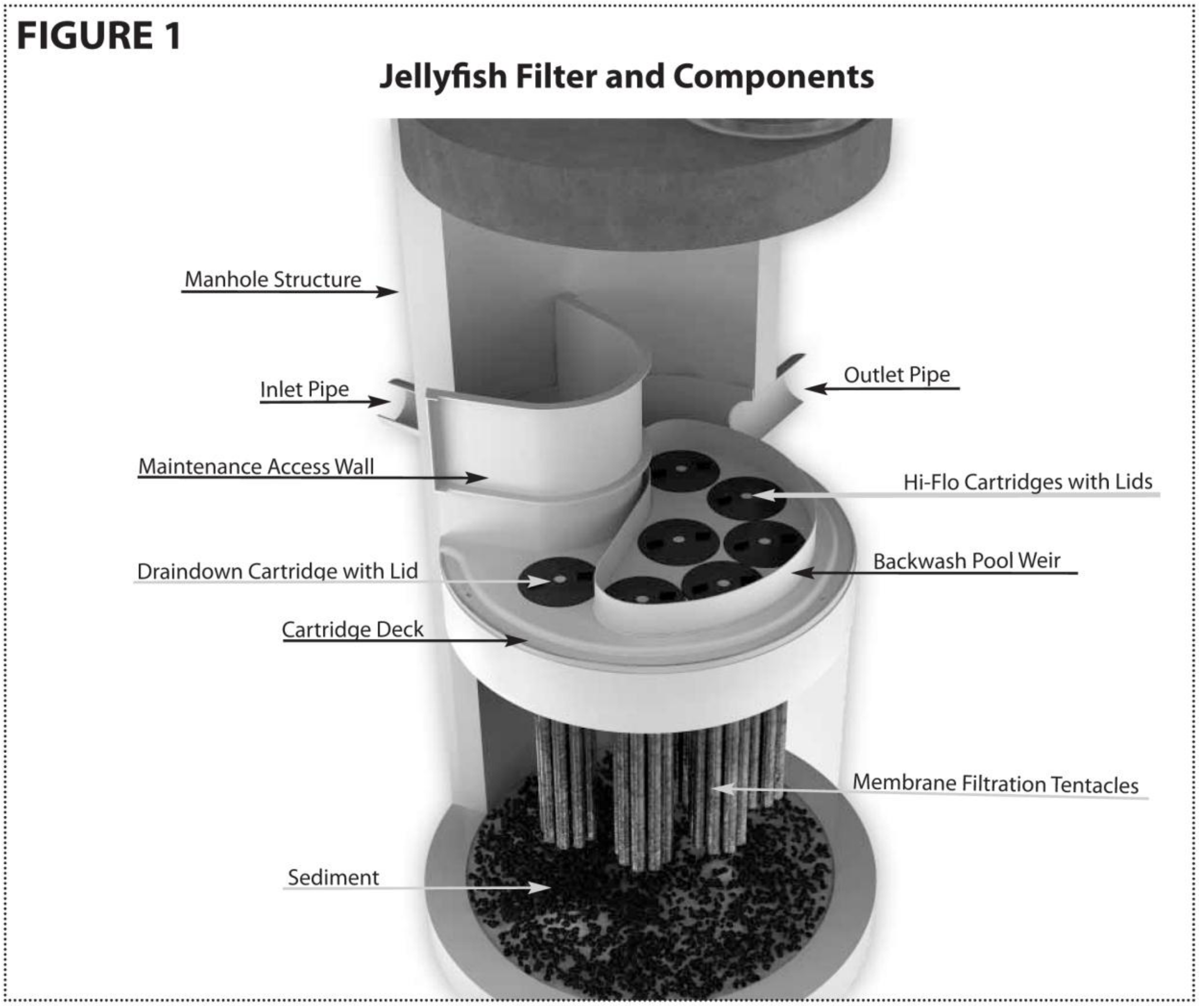
- A **deflector plate** (below-deck inlet pipe manhole configuration only) is installed across the below-deck inlet pipe opening to induce tangential water flow through the pre-treatment channel between the vessel wall and separator skirt.

- **Standard covers, rectangular hatches, or inlet grates** are installed at the surface and are removed to allow maintenance access to the system.

- **Built-in steps or ladder(s)** allow maintenance personnel to access the cartridge deck and filter cartridges.

The Jellyfish Filter and components are depicted in **Figure 1.**

Figure 1 Jellyfish Filter and Components

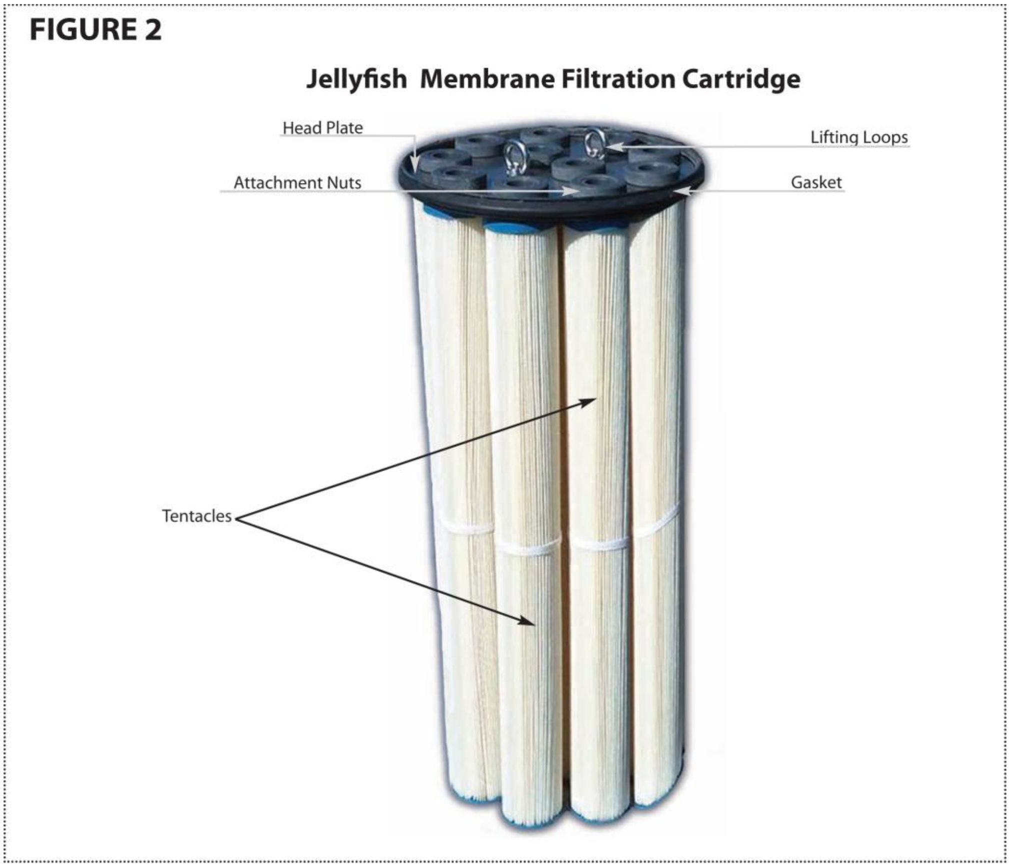


Note: Separator Skirt Not Shown

The Jellyfish Filter utilizes multiple lightweight membrane filtration cartridges. Each cartridge consists of multiple removable filter elements ("filtration tentacles") attached to a cartridge head plate. Each filtration tentacle consists of a central perforated tube surrounded by a specialized membrane. The cylindrical filtration tentacle has a threaded pipe nipple at the top and is sealed at the bottom with an end cap. A cluster of tentacles is attached to a stainless steel head plate by inserting the top pipe nipples through the head plate holes and securing with removable nuts. A removable oil-resistant polymeric rim gasket is attached to the head plate to impart a watertight seal when the cartridge is secured into the cartridge receptacle with the cartridge lid. A Jellyfish membrane filtration cartridge is depicted in **Figure 2**.

The cartridge length is typically either 27 inches (686 mm) or 54 inches (1372 mm), with options for custom lengths if required. The dry weight of a new cartridge is less than 20 pounds (9 kg), and the wet weight of a used cartridge is less than 50 pounds (23 kg), making a cartridge easy to install and remove by hand. No heavy lifting equipment is required.

Figure 2 Jellyfish Membrane Filtration Cartridge



The filtration tentacle membranes provide an extraordinarily large amount of surface area, resulting in superior flow capacity and suspended sediment removal capacity. A typical Jellyfish cartridge with eleven 54-inch (1372 mm) long filtration tentacles has 381 ft^2 (35.4 m^2) of membrane surface area. Hydraulic testing on a clean 54-inch (1372 mm) filter cartridge has demonstrated a flow rate of 180 gpm (11.3 L/s) at 18 inches (457 mm) of driving head. In addition, the filtration tentacle membrane has anti-microbial characteristics that inhibit the growth of bio-film that might otherwise prematurely occlude the pores of the membrane and restrict hydraulic conductivity.

Field testing of the Jellyfish Filter was conducted at the University of Florida over a 13-month period, and encompassed 25 monitored storm events with 15 inches of cumulative rainfall, including multiple high intensity events. Throughout the course of this study, the Jellyfish Filter demonstrated consistently high pollutant removal performance (median TSS removal efficiency 89%) as designed with a conservative Maximum Treatment Flow Rate (MTFR) of 80 gpm (5.0 L/s) for the 54-inch (1372 mm) long hi-flo cartridge and 40 gpm (2.5 L/s) for the 54-inch (1372 mm) long draindown cartridge. These values translate to a conservative design membrane filtration flux rate (flow per unit surface area) of 0.21 gpm/ft^2 (0.14 Lps/m^2) for the hi-flo cartridge and 0.11 gpm/ft^2 (0.07 Lps/m^2) for the draindown cartridge.

Laboratory hydraulic and sediment loading testing has demonstrated scalability of the membrane filtration surface area such that increases in the number and/or length of filtration tentacles contribute a uniform increase in total filter surface area and therefore flow capacity and sediment removal capacity. The flow rating of a particular Jellyfish Filter cartridge is based on the membrane filtration surface area of the cartridge and data collected from both laboratory testing and field testing.

The cartridge deck contains a receptacle for each filter cartridge. The cartridge is lowered down into the receptacle such that the cartridge head plate and rim gasket rest on the lip of the receptacle. A cartridge lid is fastened onto the receptacle to anchor the cartridge. Each cartridge lid contains a flow control orifice. The orifice in the hi-flo cartridge lid is larger than the orifice in the draindown cartridge lid.

Jellyfish Filter cartridges are designated as either hi-flo cartridges or draindown cartridges, depending on their placement position within the cartridge deck. Cartridges placed within the 6-inch (150 mm) high backwash pool weir that extends above the deck are automatically passively backwashed after each storm event and are designated as the hi-flo cartridges. Cartridges placed outside the backwash pool weir are not passively backwashed but facilitate the draindown of the backwash pool, and these are designated as the draindown cartridges. The design flow rate of a draindown cartridge is controlled by a cartridge lid orifice to one-half the design flow rate of a hi-flo cartridge of similar length. The lower design flow rate of the draindown cartridge reduces the likelihood of occlusion prior to scheduled maintenance.

Inflow events with driving head ranging from less than 1 inch (25 mm) up to the maximum design driving head will cause continuous forward flow and filtration treatment through the draindown cartridges. Inflow events with driving head that exceeds the 6-inch (150 mm) height of the backwash pool weir will cause continuous forward flow and filtration treatment through the hi-flo cartridges.

A differential in upstream and downstream water elevation during an inflow event provides the minimal driving head required to overcome the minor cumulative friction loss through the system, at which point flow-through operation of the Jellyfish Filter commences.

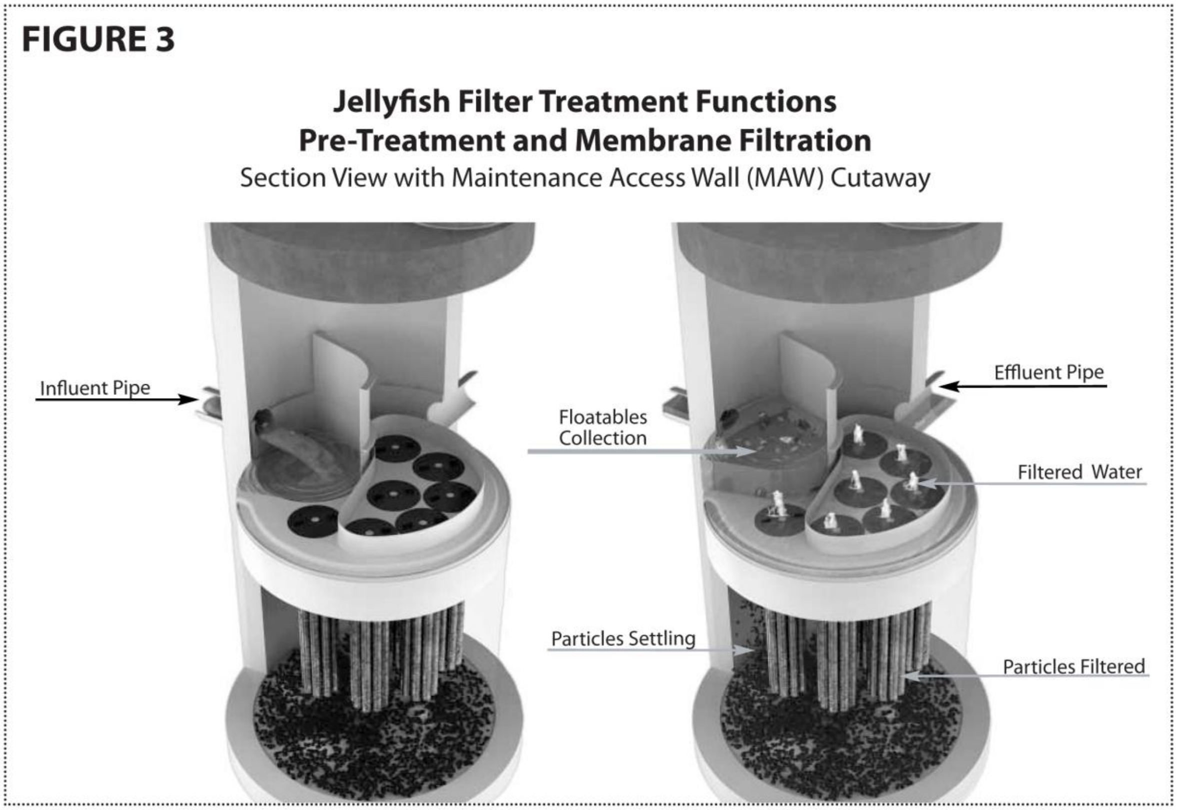
For systems using an external bypass with upstream diversion structure, the driving head is calculated as the difference in elevation between the top of the diversion structure weir and the invert of the Jellyfish Filter outlet pipe. For systems using an internal bypass, the driving head is calculated as the difference in elevation between the top of the pressure relief pipe(s) and the invert of the outlet pipe.

A minimum design driving head is selected to achieve design flow rates, while accounting for gradual increase in system head loss at the design flow rate due to long-term accumulation of sediment on the filtration membranes. A clean Jellyfish Filter cartridge has flow capacity far in excess of the cartridge design flow rate at the design driving head. This ensures that design flow capacity is maintained during the period between maintenance service operations. Typically, a minimum 18 inches (457 mm) of driving head is designed into the system but may vary from 12 to 24 inches (305 to 610 mm) depending on specific site requirements.

For systems that may experience submerged or backwater conditions due to dry weather base flow or tidal effects, driving head calculations must account for water elevation during the backwater condition. The Jellyfish Filter treatment functions will continue to operate during forward flow despite backwater conditions. An increase in the maintenance access wall height may be required to ensure floatables capture an increase in the height of the backwash pool weir may be required to ensure function of the automatic passive backwash feature.

The Jellyfish Filter provides both **pre-treatment** and **membrane filtration** treatment to remove pollutants from stormwater runoff. These functions are depicted in **Figure 3** below.

Figure 3 Jellyfish Filter Treatment Functions



Pre-treatment removes coarse sediment (particles generally > 50 microns), particulate-bound pollutants attached to coarse sediment (nutrients, toxic metals, hydrocarbons), free oil and floatable trash and debris. These pollutants are removed by gravity separation. Large, heavy particles fall to the sump (sedimentation) and low density pollutants rise to the surface (floatation) within the pre-treatment channel.

Pre-treatment begins when influent flow enters the system either through an above-deck inlet pipe (standard) or below-deck inlet pipe (optional). In the above-deck inlet pipe configuration, influent enters the maintenance access wall zone and is channeled through a large-diameter opening in the cartridge deck to the lower chamber. The large surface area of the deck opening and change in flow direction attenuate the influent flow velocity. Due to equalization of hydrostatic pressure and downstream pathway through the opening at the bottom of the separator skirt, influent flow spreads in lateral and downward directions throughout the pre-treatment channel between the vessel wall and the outer perimeter of the separator skirt. In the below-deck inlet pipe configuration, a deflector plate angled across the inlet pipe opening induces directional tangential flow in the pre-treatment channel. In either configuration, flow spreading throughout the pre-treatment channel serves to reduce the average flow velocity and enhance the separation of pollutants.

Pre-treatment for floatables occurs as buoyant pollutants rise toward the surface, with some of the floatables mass trapped beneath the cartridge deck in the pre-treatment channel. Most of the floatables mass accumulates in the maintenance access wall zone at the air-water interface. This feature allows convenient and easy inspection and maintenance for floatable contaminants. The separator skirt protects the filtration tentacles from contamination by oil and floatable debris.

Coarse sediment settles out of the pre-treatment channel to the sump. As water from the pre-treatment channel slowly flows downward and then laterally beneath the separator skirt, the combination of the large opening in the bottom of the separator skirt and a change in direction to an upward downstream flow path serves to further reduce average flow velocity and enhance particle separation. Sediment is stored in the sump until removed by vacuum during a maintenance service.

Membrane filtration treatment removes suspended particulates (generally < 50 microns) and particulate-bound pollutants (nutrients, toxic metals, hydrocarbons, and bacteria). Laboratory and field performance testing of the Jellyfish Filter have demonstrated capture of particulates as small as 2 microns.

Filtration treatment begins when pre-treated influent flows under the separator skirt and into the filtration zone through the large opening defined by the bottom edge of the separator skirt. Uniform hydraulic pressure gradient across the entire membrane surface area causes pre-treated water to penetrate the entire membrane surface area of each filtration tentacle. Water enters the membrane pores radically and deposits fine particulates on the exterior membrane surface. Filtered water flows into the perforated center drain tube of each filtration tentacle and then upward and out the top of each tentacle. Water exiting each of the tentacles of a single cartridge combines at the top of the cartridge under the cartridge lid. The combined flow then vertically exits the cartridge lid orifice with a pulsating fountain effect.

As a layer of sediment builds up on the external membrane surface, membrane pores are partially occluded which serves to reduce the effective pore size. This process, referred to as “filter ripening”, significantly improves the removal efficiency of pollutants relative to a brand new or clean membrane of some nominal pore size. Filter ripening accounts for the ability of the Jellyfish Filter to remove particles finer than the nominal pore size rating of the membranes.

The Jellyfish Filter utilizes several self-cleaning processes to remove accumulated sediment from the external surfaces of the filtration membranes, including **automatic passive backwash** of the hi-flo cartridges, **vibrational pulses**, and **gravity**. Combined, these processes significantly extend the cartridge service life, maintenance interval and reduce life-cycle costs.

Automatic passive backwash is performed on the hi-flo cartridge at the end of each runoff event and can also occur multiple times during a single storm event as intensity and driving head varies.

During inflow, filtered water exiting the hi-flo cartridges forms a pool above the cartridge deck inside the backwash pool weir. The depth and volume of the back wash pool will vary with the available driving head, ranging from some minimal quantity up to a quantity sufficient to fill and overflow the backwash pool (typical weir height is 6 inches / 150 mm). As the inflow event subsides and forward driving head decreases, water in the backwash pool reverses flow direction and automatically passively backwashes the hi-flo cartridges, removing sediment from the membrane surfaces. Water in the lower chamber (below deck) is displaced through the draindown cartridges.

Vibrational pulses occur as a result of complex and variable pressure and flow direction conditions that arise in the space between the top surface of the cartridge head plate and the underside of the cartridge lid. During forward flow a stream of filtered water exits the top of each filtration tentacle into this space and encounters resistance from the cartridge lid and turbulent pool of water within the space. Water is forced through the cartridge lid flow control orifice with a pulsating fountain effect. The variable localized pressure causes pulses that transmit vibrations to the membranes, thereby dislodging accumulated sediment. The effect appears more pronounced at higher flow rates, and applies to both hi-flo and draindown cartridges.

Gravity continuously applies a force to accumulated sediment on the membranes, both during inflow events and inter-event dry periods. As fine particles agglomerate into larger masses on the membrane surface, adhesion to the membrane surface can lessen, and a peeling effect ensues which ultimately results in agglomerates falling away from the membrane. Complex chemical and biological effects may also play a role in this process.

The Jellyfish Filter standard model numbers provide information about the manhole inside diameter (expressed in U.S. customary units) and cartridge counts for hi-flo and draindown cartridges. For example, Jellyfish Filter model number JF6-4-1 is a 6-ft diameter manhole with four hi-flo cartridges and one draindown cartridge. Standard model numbers assume the use of 54-inch (1372 mm) long cartridges. Specific designations for non-standard structures or cartridge lengths are noted in the **Jellyfish Filter Owner's Manual** published by Imbrium Systems and provided to system owners. For the field test that is the subject of this report a Jellyfish Filter JF4-2-1 was used, which is a 4-ft diameter manhole with two 54-inch long hi-flo cartridges and one 54-inch long draindown cartridge.

Design flow capacities and pollutant capacities for standard Jellyfish Filter manhole configurations are shown in **Tables 1** and **2**.

Table 1 Design Flow Capacities of the Jellyfish Filter

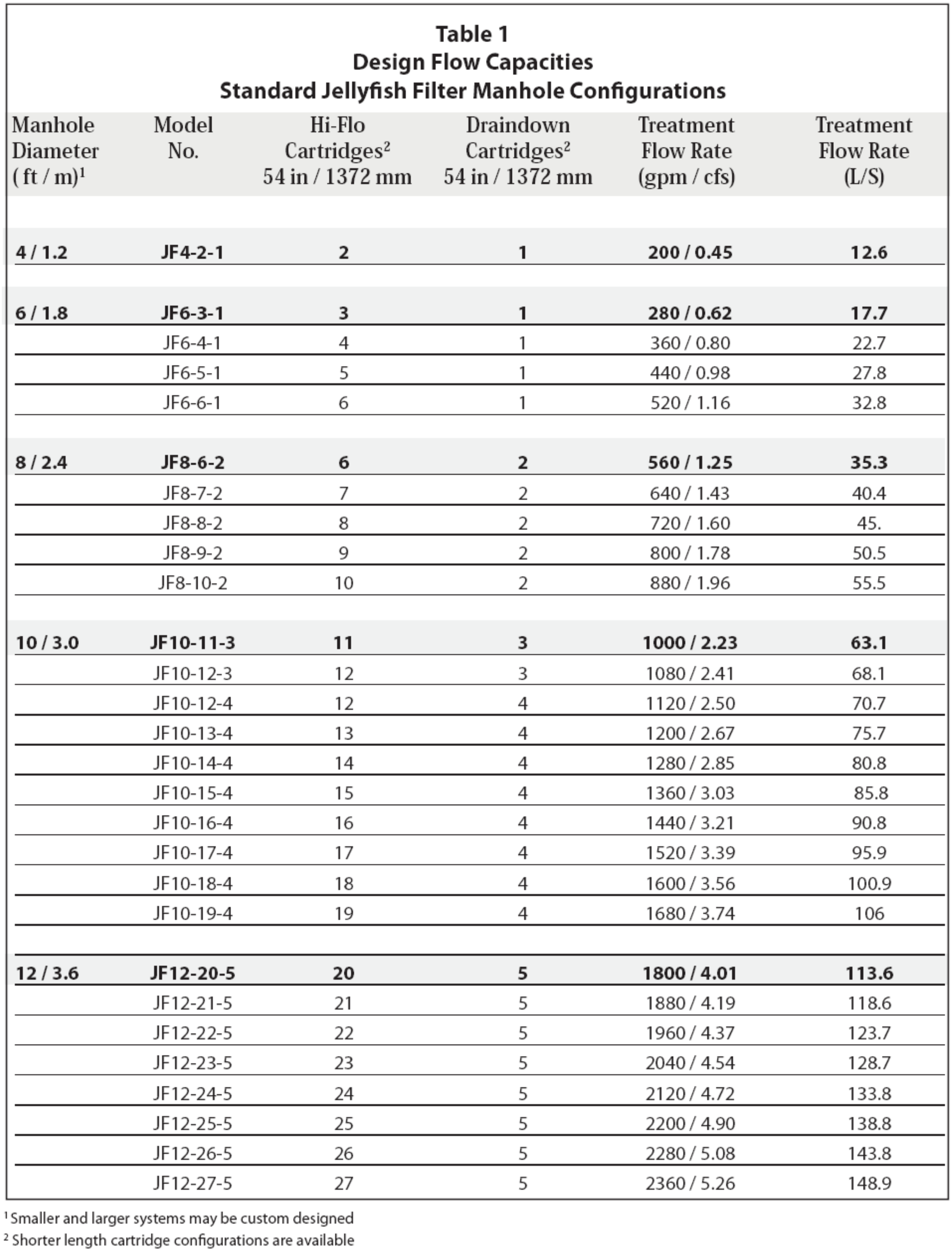


Table 1
Design Flow Capacities
Standard Jellyfish Filter Manhole Configurations

Manhole Diameter (ft / m)[1]	Model No.	Hi-Flo Cartridges[2] 54 in / 1372 mm	Draindown Cartridges[2] 54 in / 1372 mm	Treatment Flow Rate (gpm / cfs)	Treatment Flow Rate (L/S)
4 / 1.2	**JF4-2-1**	**2**	**1**	**200 / 0.45**	**12.6**
6 / 1.8	**JF6-3-1**	**3**	**1**	**280 / 0.62**	**17.7**
	JF6-4-1	4	1	360 / 0.80	22.7
	JF6-5-1	5	1	440 / 0.98	27.8
	JF6-6-1	6	1	520 / 1.16	32.8
8 / 2.4	**JF8-6-2**	**6**	**2**	**560 / 1.25**	**35.3**
	JF8-7-2	7	2	640 / 1.43	40.4
	JF8-8-2	8	2	720 / 1.60	45.
	JF8-9-2	9	2	800 / 1.78	50.5
	JF8-10-2	10	2	880 / 1.96	55.5
10 / 3.0	**JF10-11-3**	**11**	**3**	**1000 / 2.23**	**63.1**
	JF10-12-3	12	3	1080 / 2.41	68.1
	JF10-12-4	12	4	1120 / 2.50	70.7
	JF10-13-4	13	4	1200 / 2.67	75.7
	JF10-14-4	14	4	1280 / 2.85	80.8
	JF10-15-4	15	4	1360 / 3.03	85.8
	JF10-16-4	16	4	1440 / 3.21	90.8
	JF10-17-4	17	4	1520 / 3.39	95.9
	JF10-18-4	18	4	1600 / 3.56	100.9
	JF10-19-4	19	4	1680 / 3.74	106
12 / 3.6	**JF12-20-5**	**20**	**5**	**1800 / 4.01**	**113.6**
	JF12-21-5	21	5	1880 / 4.19	118.6
	JF12-22-5	22	5	1960 / 4.37	123.7
	JF12-23-5	23	5	2040 / 4.54	128.7
	JF12-24-5	24	5	2120 / 4.72	133.8
	JF12-25-5	25	5	2200 / 4.90	138.8
	JF12-26-5	26	5	2280 / 5.08	143.8
	JF12-27-5	27	5	2360 / 5.26	148.9

[1] Smaller and larger systems may be custom designed

[2] Shorter length cartridge configurations are available

Table 2 Design Pollutant Capacities of the Jellyfish Filter

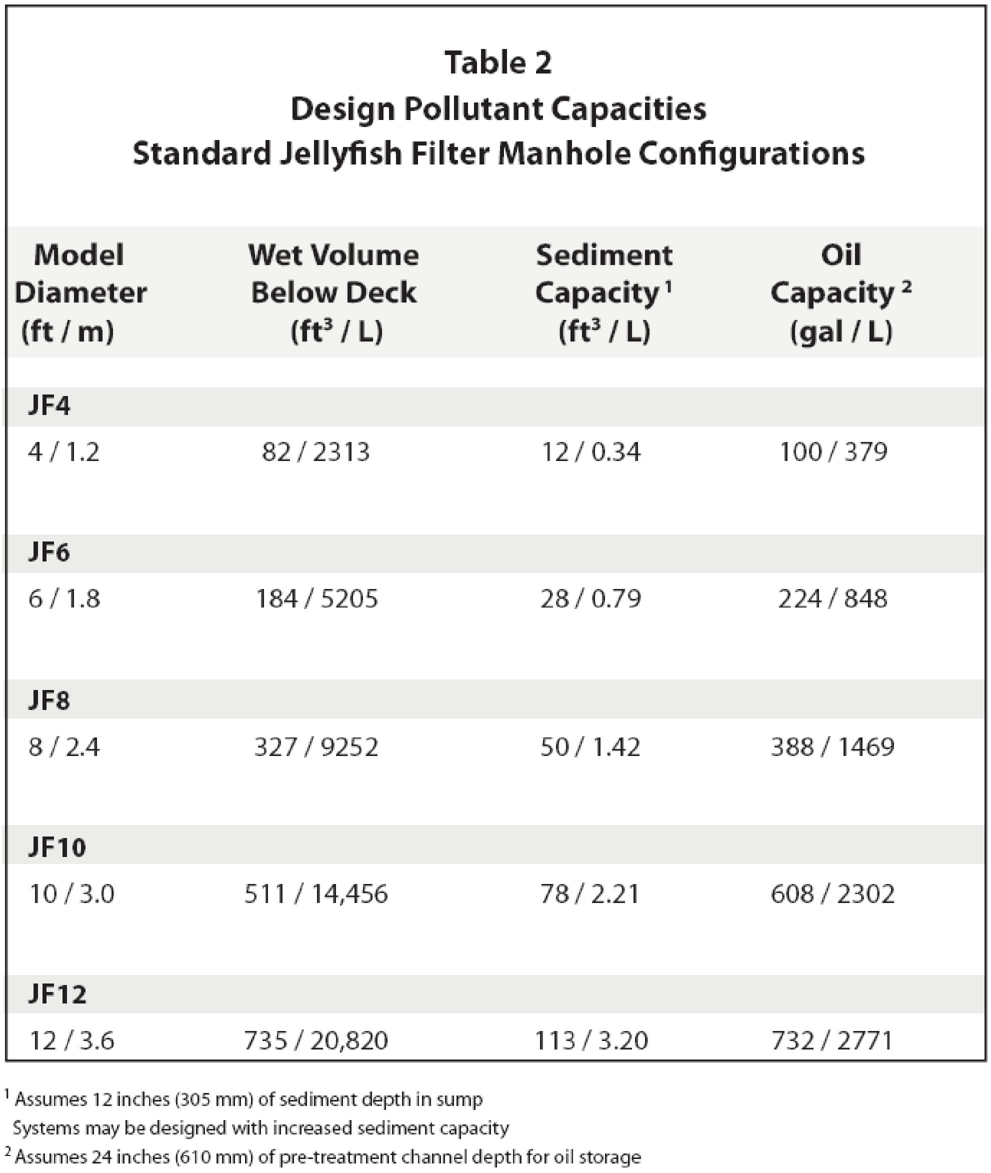


Table 2
Design Pollutant Capacities
Standard Jellyfish Filter Manhole Configurations

Model Diameter (ft / m)	Wet Volume Below Deck (ft^3 / L)	Sediment Capacity [1] (ft^3 / L)	Oil Capacity [2] (gal / L)
JF4			
4 / 1.2	82 / 2313	12 / 0.34	100 / 379
JF6			
6 / 1.8	184 / 5205	28 / 0.79	224 / 848
JF8			
8 / 2.4	327 / 9252	50 / 1.42	388 / 1469
JF10			
10 / 3.0	511 / 14,456	78 / 2.21	608 / 2302
JF12			
12 / 3.6	735 / 20,820	113 / 3.20	732 / 2771

[1] Assumes 12 inches (305 mm) of sediment depth in sump
Systems may be designed with increased sediment capacity

[2] Assumes 24 inches (610 mm) of pre-treatment channel depth for oil storage

5. Performance Claim

"The Jellyfish Filter with second-generation membrane filtration cartridges, when designed for a maximum treatment flow rate consistent with a filtration flux rate (flow per unit surface area) of 0.21 gpm/ft^2 (0.14 Lps/m^2) for the hi-flo cartridge and 0.11 gpm/ft^2 (0.07 Lps/m^2) for the draindown cartridge, demonstrated removal of 89% of TSS, 99% of SSC, 59% of Total Phosphorus, 51% of Total Nitrogen, and greater than 50% of Total Copper and Total Zinc from urban rainfall-runoff, based on median pollutant removal efficiencies developed from the field monitoring study with a duration from 28 May 2010 through 27 June 2011. "

Part II: University of Florida Supplied Report: Performance Monitoring of Jellyfish® Filter JF4-2-1

6. Executive Summary

This report details a field test performance study of Imbrium Systems' Jellyfish® Filter model JF4-2-1 with second-generation filtration cartridges, conducted in accordance with the TARP and VTAP field test protocols. The physical model monitoring campaign was carried out on the University of Florida campus by the University of Florida with the full-scale unit loaded by rainfall-runoff from an existing surface parking watershed. A total of 25 monitored storm events, with 15 inches of cumulative rainfall depth, were treated by the JF4 over the course of this study, each with varying rainfall intensity and runoff volume. Of the 25 storms treated, 2 storms generated flow rates exceeding the maximum design flow rate of 200 gpm, as designated by Imbrium Systems. No maintenance was required or conducted during the 13-month monitoring period spanning May 28, 2010 to June 27, 2011.

During each event, samples were taken pre- and post-treatment in order to assess constituent removal performance. All samples were analyzed for particle size indices, particulate matter (PM) load, total suspended solids (TSS), suspended solids concentration (SSC), volatile suspended solids (VSS), turbidity, total phosphorus, total nitrogen, total metals (including copper, zinc, lead, and chromium), and oil and grease. In addition, water chemistry parameters were measured, including pH, alkalinity, chemical oxygen demand (COD), total dissolved solids (TDS), temperature, conductivity, salinity, and dissolved oxygen (DO).

Median SSC and TSS removal efficiency results were 99% and 89%, respectively. Median removal efficiency was 59% for Total Phosphorus and 51% for Total Nitrogen. For Total Copper and Total Zinc, median removal efficiencies were 90% and 70%, respectively. The d_{50} for influent and effluent particle sizes were 82 and 3 μm, respectively. While both median and mean statistics are presented, results are primarily log-normally distributed and therefore the median values are utilized (Berretta and Sansalone 2011, Kim and Sansalone 2010, Van Buren et al., 2009)

Median head over deck level never exceeded 8.4 inches (21.4 cm) for any event and across the entire monitoring campaign the median head loss was 3.3 inches (8.3 cm). These values are below the typical design driving head value of 18 inches (45.7 cm) for the Jellyfish Filter as recommended by Imbrium Systems.

Hydraulic testing was conducted on the clean system with fresh filter cartridges prior to commencement of the monitoring campaign, and was repeated at the conclusion of the field study on the system with dirty cartridges. Curves of head loss versus flow rate were nearly identical for the system with fresh cartridges and dirty cartridges, indicating no loss of hydraulic capacity despite the capture of approximately 166 pounds of dry basis particulate matter (PM) mass by the JF4 equipped with 3 cartridges. The system had a volumetric capacity to retain a significantly larger mass of PM. Median and peak head losses were driven predominately by flow rate and to a much lesser degree by filter cartridge ripening which was muted.

At the completion of the monitoring campaign, a mass balance was obtained by collecting all of the retained particulate matter separated by the unit, weighing the total dry mass of PM recovered and adding this separated mass to the mass of PM in the effluent in order to compare this summed PM mass to the influent PM mass. A 90% PM mass recovery is required for a defensible monitoring campaign for any unit operation or process. By measurement the mass balance error is 5% (95% mass recovery) which validates the testing methods used throughout this study.

The results obtained in this field study (Part II of the TARP report) as developed and as exclusively-written by the University of Florida demonstrates that the Jellyfish Filter's particulate removal performance is reasonably insensitive to incoming particle size distribution (PSD) and runoff event duration. Results are summarized in the following manufacturer's performance claim:

"The Jellyfish Filter with second-generation filtration cartridges, when designed for a maximum treatment flow rate consistent with a filtration flux rate (flow per unit surface area) of 0.21 gpm/ft^2 (0.14 Lps/m^2) for the hi-flo cartridge and 0.11 gpm/ft^2 (0.07 Lps/m^2) for the draindown cartridge, demonstrated removal of 89% of TSS, 99% of SSC, 59% of Total Phosphorus, 51% of Total Nitrogen, and greater than 50% of Total Copper and Total Zinc from rainfall-runoff, based on median constituent removal efficiencies developed from the field monitoring study with a duration from 28 May 2010 through 27 June 2011. "

The results provided by the manufacturer's performance claim represent the results obtained in this physical modeling field study (Part II of the TARP report dated 01 November 2011) as developed and as written by the University of Florida.

List of Nomenclature

BDL: Below Detection Limit
CRD: Cumulative rainfall depth
DCOD: Dissolved Chemical Oxygen Demand
DO: Dissolved Oxygen
d_{rain}: Rainfall depth
EMC: Event Mean Concentration
EMV: Event mean values
IPRT: Initial pavement residence time
$i_{rain-max}$: Maximum rainfall intensity
MPN: Most Probable Number
n_{eff}: Number of effluent samples
n_{inf}: Number of influent samples
NJCAT: New Jersey Corporation for Advanced Technology
NJDEP: New Jersey Department of Environmental Protection
PDH: Previous dry hours
PM: Particulate Matter
PR: Percent Removal
PSD: particle size distribution
Q_{med}: Median flow rate
Q_p: Maximum flow rate
SSC: Suspended Sediment Concentration
TARP: Technology Acceptance Reciprocity Partnership
TCOD: Total Chemical Oxygen Demand
TDN: Total Dissolved Nitrogen
TDP: Total Dissolved Phosphorus
TDS: Total Dissolved Solids
TN: Total Nitrogen
TP: Total Phosphorus
t_{rain}: Event duration
TSS: Total Suspended Solids
VA DCR: Virginia Department of Conservation and Recreation
V_{runoff}: Runoff volume
VSS: Volatile Suspended Solids
VTAP: Virginia Technology Assessment Protocol
ΔM: Treatment efficiency

7. Quality Assurance Project Plan (QAPP)

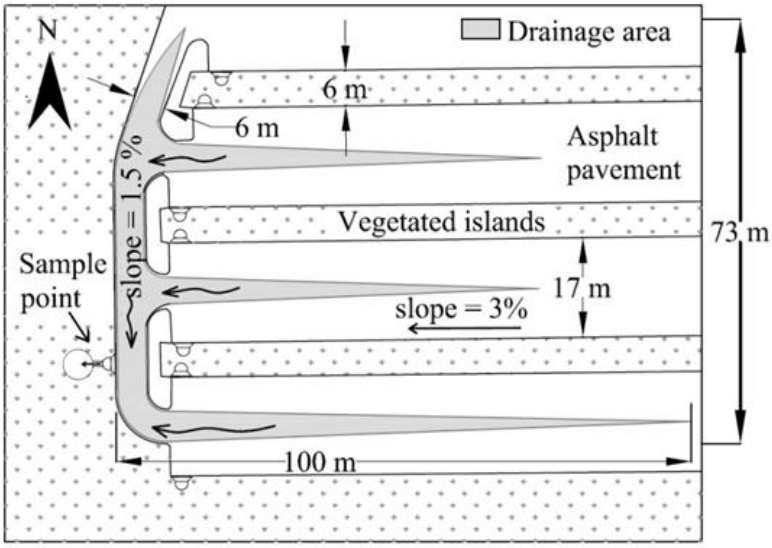
Prior to initiating the field test at the University of Florida, the source area rainfall and pollutant characteristics and University analytical processes were reviewed with NJCAT and NJDEP and confirmed as acceptable for performing a TARP field study.

UF-ESSIE prepared a Quality Assurance Project Plan (QAPP) for the proposed field study. The QAPP was submitted to NJCAT for review and was subsequently approved. The QAPP adheres to guidelines established in **EPA Requirements for Quality Assurance Project Plans** (EPA QA/R-5), the **TARP Protocol for Stormwater Best Management Practice Demonstrations**, and the **VTAP Guidance for Evaluating Stormwater Manufactured Treatment Devices**.

8. Test Site Description and BMP Installation

The Reitz Union parking lot at the University of Florida – Gainesville was the field study site. It is an asphalt-paved source area that functions as a primary parking facility for the University of Florida. The parking lot was built in the 1990s and is designed to provide adequate conveyance of runoff during wet weather events with storm runoff considered with respect to adequate surface drainage. Raised vegetated islands separate parking aisles and drain to the impervious asphalt-paved surface which drains by gravitationally-driven sheet flow to curb and gutter leading to regularly-spaced catch-basins. The total area of island is 24.39 % of the entire parking lot and the percentage of pavement is 75.61 %. The islands are mainly planted with magnolia trees, an occasional sycamore tree and grass. These catch-basins concentrate and collect gutter flow and provide entry of runoff into a storm sewer pipe system on the University of Florida campus. All the collected runoff discharges to Lake Alice about 2000 ft away from the parking lot. The combination of impervious asphalt pavement and raised vegetated islands, a very common design for surface parking across North America (Berretta and Sansalone 2011), provides substantial loads of nitrogen, phosphorus, metals, and particulate matter (PM) to runoff from the site.

Figure 4(a) illustrates the drainage for the contributing area and (b) provides an aerial view of the watershed.



4(b) Aerial photo of the Reitz Union surface parking facility at the University of Florida in Gainesville, illustrating the contributing drainage area and influent appurtenance (Inlet A) serving as the feed to the JF4-2-1. North is towards the top of the page. The NW intersection is Museum Road at Center Drive.

Depending on the storm event intensity and wind direction the drainage area can vary from 5,400 to 8,600 ft^2 (0.12 to 0.20 acres) of pavement. The catchment drains to inlet A as shown in **Figure 4(b) and 4(a)**. Runoff captured by inlet A is the source of influent to the downstream Jellyfish Filter.

Data from a 2009 monitoring study (Berretta and Sansalone, 2011) at this identical test site was useful in the selection of a properly sized Jellyfish Filter for the site. The study included runoff flow rate data from 15 storm events. Two of those storms generated peak runoff flow rates that exceeded 200 gpm. Based on this actual historical data, the Jellyfish Filter model JF4-2-1 with 54-inch long filtration cartridges was installed for field testing. The JF4-2-1 is a 4-ft diameter manhole configuration with two hi-flo cartridges, each rated at 80 gpm, and a single draindown cartridge rated at 40 gpm, for a total Maximum Treatment Flow Rate (MTFR) of 200 gpm at 18 inches of driving head. The historical runoff data suggested that over the course of a minimum 20-storm monitoring campaign, several storms would generate peak flow rates that meet or exceed the treatment unit's MTFR. This was indeed the case, as two storms generated peak flow rates exceeding 200 gpm during the Jellyfish Filter monitoring period.

Since the University required a temporary installation of the treatment unit, a fiberglass JF4-2-1 was provided and installed above-ground on a hillside just below the catchment area. The above-ground installation facilitated much easier site construction and minimal site disturbance, and provided advantages for the monitoring personnel in terms of access to sampling points and instrumentation, and direct observation of flow dynamics within the treatment unit. A profile view schematic of the site set-up is shown in **Figure 5** and a corresponding photo in **Figure 6**. The unit was equipped with a side manway to facilitate manual removal of accumulated PM as well as system inspection at the conclusion of the study.

The JF4-2-1 was configured with a below-deck inlet pipe and deflector plate, which are standard options for the Jellyfish Filter. The test unit contained a circular maintenance access pipe, a feature that has been replaced in later designs by a horseshoe-shaped maintenance access wall. The test unit also contained a pressure relief pipe that could potentially function as an internal bypass, however this feature was rendered nonfunctional by the installation of an external bypass. External bypass piping was configured around the unit such that influent flows attaining a water elevation exceeding 18 inches above deck elevation would be externally bypassed to the downstream drop box where effluent samples were taken. The invert of the horizontal run of bypass piping was set at 18 inches above deck elevation to insure that the design driving head of 18 inches was provided to the Jellyfish Filter. Top view photos of the JF4-2-1 cartridge deck are shown in **Figures 7** and **8**.

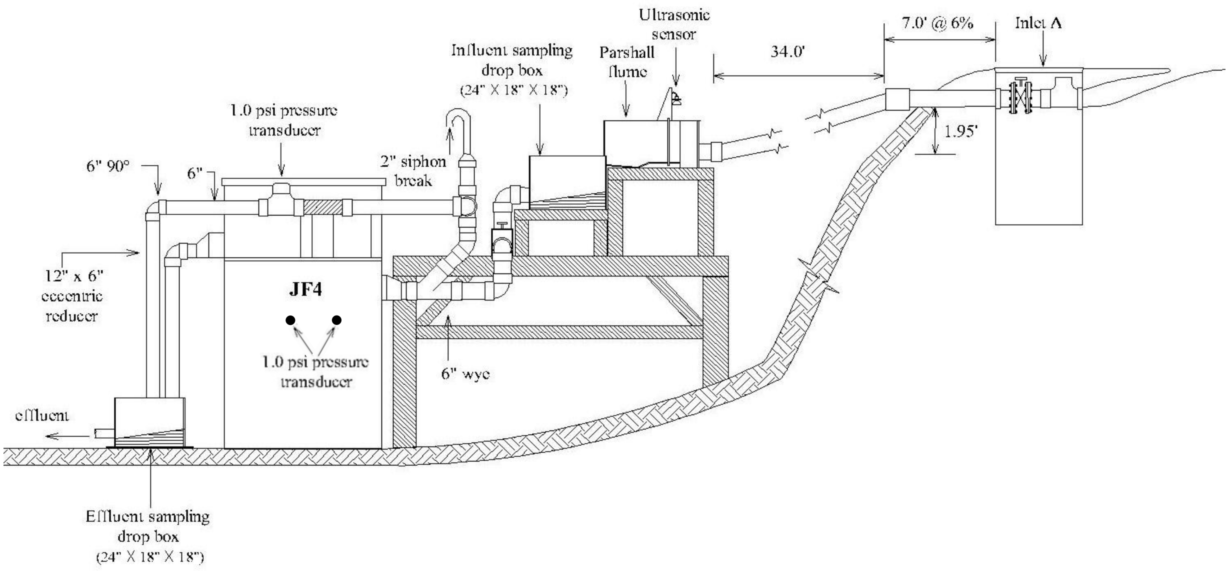


Figure 5 Profile view schematic of the field set-up for the Jellyfish Filter JF4-2-1.

Figure 6 **Photo of field test set-up for the Jellyfish Filter JF4-2-1. Below-deck inlet pipe enters the right side of the vessel and outlet pipe (invert at deck level) exits the left side of the vessel. External bypass piping has invert of horizontal section 18 inches above deck level.**

Figure 7 **Top view photos of the Jellyfish Filter JF4-2-1 deck with two hi-flo cartridges and one draindown cartridge installed with cartridge lids off (upper left image) and cartridge lids on (upper right image). The backwash pool weir encloses the hi-flo cartridge. Also shown are the maintenance access pipe (large), pressure relief pipe (small), and the outlet opening (lower right in each image).**

Figure 8 **Top view photo of the Jellyfish Filter JF4-2-1 during operation. Filtered water exits the cartridge lid orifice as a pulsating fountain.**

9. Test Methods, Procedures, and Equipment

Field monitoring system design for the Jellyfish Filter JF4-2-1 included the following:

Monitoring and collection of rainfall-runoff were performed for 25 storm events. Runoff samples were collected manually on a time basis with physical, hydrologic and radar observations. Manual sampling with flow weighting was used. Samples of the whole influent and effluent flows were collected manually at 2-10 minute intervals, depending on storm duration. Manual sampling of the whole flow has a distinct advantage over auto-sampling of a small portion of the cross-section of flow, since sampling of the whole flow provides a more accurate representation of the actual pollutant load transported in the runoff. The flow rate at the time of sampling, and throughout the storm duration, was recorded automatically by the flowmeter, and therefore the flow volume is known for each time interval during the storm. Once the storm event ended, the samples taken at timed intervals across the hydrograph were transported to the laboratory and composited. Compositing was flow volume-weighted based on the volume of runoff corresponding to each respective time interval on the hydrograph. After compositing, analysis was performed.

During events, runoff was conveyed from the catchment to the treatment system after collection by catch basin inlet A. The distance from inlet A to the treatment system was 34 feet. Influent samples were collected at the influent drop box upstream of the treatment unit and effluent samples were collected at the effluent drop box downstream of the unit. The influent sample location was 4 feet upstream, and the effluent sample location was 2 feet downstream, of the unit.

Flow rate measurement utilized a 1 inch (25.4 mm) Parshall flume equipped with an ultrasonic sensor (model Shuttle Level Transmitter) connected to a data logger (model EasyLog EL-USB). Flow from the flume discharged into the influent drop box, creating a free well-defined discharge for representative manual sampling. The Parshall flume calibration curve is shown in **Figure 9.**

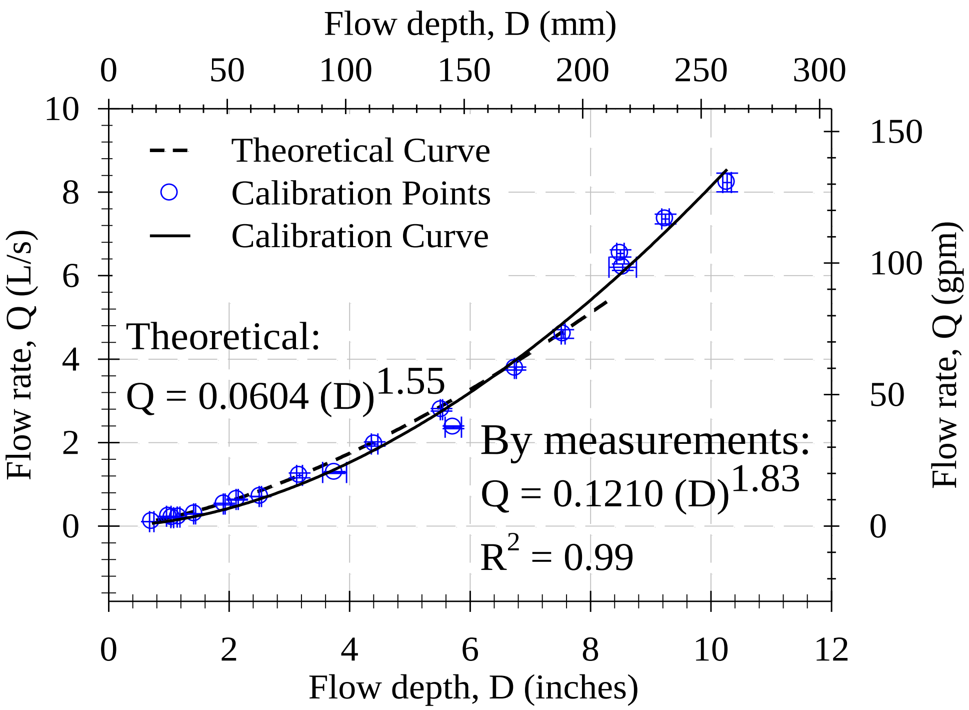


Figure 9 Parshall flume calibration curve

Rainfall measurement utilized a tipping bucket rain gauge manufactured by ISCO Inc. (0.01-inch bucket capacity) equipped with data logger installed on the roof of the Unit Operations building located 150 meters south of the monitored site. Rainfall data was recorded every five minutes by the data logger.

Head loss measurements utilized monitoring of water pressure/elevation in the inlet and outlet pipes of the treatment unit with two 1-psi pressure transducers (model PDCR 1830 1 psig, manufactured by DRUCK Inc.) connected to a data logger (model CR1000, manufactured by Campbell Scientific Inc.).

pH, conductivity, and temperature measurement utilized a YSI 600XLM-M Multi-Parameter Water Quality Logger installed in the treatment unit's inlet for continuous automatic monitoring.

Sample analyses were performed in the University of Florida analytical labs, which is a NJDEP certified environmental laboratory, and the certification is included in **Appendix A**. Samples were transported to the labs immediately after each storm and all time-sensitive analyses were performed within sample holding times. All samples were handled in accordance with chain-of-custody procedures and analyzed in accordance with Standard Method protocols. A summary of lab analyses is given in **Table 3**.

Table 3 Summary of Analytical Tests

	Analysis	Test Methods
Water Chemistry Analysis	pH	S.M[1].4500-H^+ B
	Conductivity/TDS/Salinity	S.M.2510
	Oxidation-Reduction Potential	S.M.2580
	Temperature	S.M.2550
	Alkalinity	S.M.2320
Particulate Matter (PM) Analysis	Sediment PM	Sansalone and Kim., (2008)[2]
	Settleable PM	S.M.2540-F
	Suspended PM (as TSS)	S.M.2540-D
	Volatile Suspended PM (VSS)	S.M.2540-E
	Total PM (as SSC)	ASTM D-3977-97
	Turbidity	S.M.2130
	PSD	S.M.2560-D
Phosphorus Analysis	Total Phosphorus (TP)	S.M.4500-P-B Acid Hydrolysis
Nitrogen Analysis	Total Nitrogen (TN)	Persulfate Digestion Method
Metals Analysis	Total Metals (Cu, Cr, Pb, Zn)	S.M.3030 B
Oil and Grease	Total O&G	S.M. 5520
COD	Total COD	Reactor Digestion Method

[1] S.M. : Standard Method

[2] J. Sansalone and J-Y Kim, "Transport of Particulate Matter Fractions in Urban Source Area Pavement Surface Runoff", ***J. Environmental Quality***, 37:1883–1893 2008.
[2.] J-Y Kim and J. Sansalone, "Event-Based Size Distributions of Particulate Matter Transported During Urban Rainfall-Runoff Events", ***Water Research***, 42(10-11), 2756-2768, May 2008.

10. Data and Analysis

Hydrology

Event-based hydrologic indices including previous dry hours (PDH), event duration, peak flow rate, median flow rate, mean flow rate, total runoff volume, rainfall depth, initial pavement residence time (IPRT), and runoff coefficient were monitored for a total of 25 TARP and VTAP qualifying storm events occurring over the 13-month period spanning May 28, 2010 to June 27, 2011. Cumulative rainfall depth was 15 inches. Data are shown in **Tables 4** and **5**. Individual storm event summaries with hydrographs and hyetographs are detailed in **Appendix B**.

Monitored storm events across the field test program varied in duration from 26 to 691 minutes. Previous dry hours range from 10 to 910 hours. Rainfall ranged from 0.3 to 5.0 cm (0.10 to 1.98 inches). IPRT ranged from 1 to 34 minutes. Runoff volume ranged from 206 to 13,229 liters (54 to 3495 gpm). Peak rainfall intensity ranged from 5 to 137 mm/hr (0.2 to 5.4 in/hr). Peak runoff flow rate ranged from 0.5 to 14.3 L/s (7 to 226 gpm), median flow rate ranged from 0.01 to 5.5 L/s (0.1 to 86.7 gpm). Two storms (July 15 and August 1) generated peak flow rates that exceeded the Maximum Treatment Flow Rate of 200 gpm for the Jellyfish Filter JF4-2-1.

Particle Size Distributions

Particle size distribution was analyzed for all 25 storm events using laser diffraction and M1e scattering theory (Dickenson and Sansalone 2009, Garofalo and Sansalone 2011). The % finer by mass, d_{10}, d_{50}, and d_{90}, are shown in **Table 6**. The d_{50} represents the particle diameter for which 50 percent of the particles by mass are smaller than or the same size as that diameter. Similarly, the d_{10} and the d_{90} represent the particle diameters for which 10 and 90 percent of the particles by mass are smaller than or the same size as those diameters. For the 25 events monitored in this study, influent runoff d_{10} ranges from 2 to 54 µm with a median of 9 µm. Effluent runoff d_{10} ranges from <1 to 2 µm with a median of 1 µm. Influent runoff d_{50} ranges from 22 to 263 µm with a median of 82 µm. Effluent runoff d_{50} ranges from 1 to 11 µm with a median of 3 µm. Influent runoff d_{90} ranges from 173 to 1016 µm with a median of 401 µm. Effluent runoff d_{90} ranges from 2 to 52 µm with a median of 12 µm.

Recognizing that intensity is only one parameter (others are deposition, volume, previous dry hours …) impacting the complexity of transport, it was generally observed that larger particles were mobilized during the more intense rain events of 14 May 2011, 21 June and 1 August 2010, with peak rainfall intensities of 137.2, 121.9, and 127.0 mm/hr (5.4, 4.8 and 5.0 in/hr) and median flows of 0.02, 5.4 and 4.7 L/s (0.4, 87 and 75 gpm), respectively. The 21 June event had the largest influent d_{10} and d_{50} values of 54 and 263 µm, respectively. The least intense events were 23 August, 26 September, 2010, 9 March and 20 April, 2011 with peak rain intensities of 15.0, 5.1, 15.0 and 15.0 mm/hr (0.6, 0.2, 0.6 and 0.6 in/hr) and median flow rates of 0.01, 0.26, 0.1 and 0.006 L/s (0.2, 4.1, 1.6 and 0.1 gpm), respectively. The 20 April 2011 event had the smallest influent d_{10} and d_{50} values of 2 and 22 µm, respectively.

Particulate Matter Fractions and Removal Efficiency

Removal efficiencies for event-based particulate matter (PM) fractions including turbidity, PM < 25µm, TSS, PM < 500 µm, PM < 1000 µm, PM < 2000 µm, and SSC were measured for all 25 storm events as shown in **Table 7** and **Table 8**. Detailed methods of granulometric separation and mass balance are in Sansalone and Kim (2008), Kim and Sansalone (2008) and Sansalone et. al. (2009).

For the 25 qualifying storms, TSS removal efficiency ranged 71-98% with a median of 89%, and SSC removal efficiency ranged 89-100% with a median of 99%. Turbidity removal efficiency ranged 34-98% with a median of 85%. Influent runoff turbidity ranged from 5 to 171 NTU with a median of 33 NTU. Effluent runoff turbidity ranged from 1 to 14 NTU with a median of 5 NTU.

Total Phosphorus and Total Nitrogen

The event-based concentrations of Total Phosphorus (TP) and Total Nitrogen (TN) for the 25 events are presented in **Table 9**. For the 25 qualifying storms, TP removal efficiency ranged 11-92% with a median of 59%. TN removal efficiency ranged from (-11) to 88% with a median of 51%.

Total Metals

The event-based influent and effluent concentrations and removal efficiencies of Total Chromium, Total Copper, Total Lead, and Total Zinc for the 25 events are presented in **Table 10**. For the 25 qualifying storms, Total Chromium removal efficiency ranged from (-24) to 98% with a median of 36%. Total Copper removal efficiency ranged from 55 to 100% with a median of 90%. Total Lead removal efficiency ranged from (-27) to100% with a median of 81%. Total Zinc removal efficiency ranged from 4 to 99% with a median of 70%.

Oil and Grease

The event-based influent and effluent concentrations and removal efficiencies of Total Oil and Grease for the 25 events are presented in **Table 11**. For the 25 qualifying storms, Total Oil and Grease removal efficiency ranged from 0 to 100% with a median of 62%.

Runoff water chemistry

Event-based water chemistry indices including pH, redox potential, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), alkalinity, and total chemical oxygen demand (COD) were measured for a total of 25 storm events as shown in **Tables 8** and **12**. Raw influent and treated effluent samples were analyzed. Additionally, pH, redox potential, conductivity, salinity, and TDS inside the treatment unit were also continuously monitored during each storm event. Influent runoff pH ranges from 6.5 to 7.5 with a median of 7.1, and the effluent pH ranges from 6.2 to 7.2 with a median of 6.8.

Redox potential is a measure of a chemical species' tendency to acquire electrons and be reduced. Water with a high potential tends to gain electrons from new species introduced to the system and water with a low potential can lose electrons to new species; both paths are important for speciation. For the 25 events monitored in this study, influent runoff redox ranges from 285 to 443 mV with a median of 366 mV. Effluent runoff redox ranges from 291 to 488 mV with a median of 364 mV.

Electrical conductivity is a measure of the ability of water to transmit an electric current. Influent runoff conductivity ranges from 18.9 to 186.7 µS/cm with a median of 56.6 µS/cm. Conductivity is nearly doubled during treatment due to contact with stored runoff in the JF4-2-1, which has high conductivity. Effluent runoff conductivity ranges from 41.2 to 422.6 µS/cm with a median of 97.8 µS/cm. Given that TDS is highly correlated to conductivity, TDS follows the same pattern. Influent runoff TDS ranges from 9.3 to 91.3 mg/L with a median of 29.8 mg/L. Effluent runoff TDS ranges from 20.1 to 206.9 mg/L with a median of 48.5 mg/L.

Influent runoff alkalinity ranges from 3.1 to 47.3 mg/L as $CaCO_3$ with a median of 21.5 mg/L as $CaCO_3$. An increase in alkalinity is observed during treatment again due to contact with stored runoff in the JF4-2-1, which has high alkalinity. Effluent runoff alkalinity ranges from 6.7 to 125.1 mg/L as $CaCO_3$ with a median of 41.1 mg/L as $CaCO_3$.

Influent runoff total COD ranges from 14.3 to 486.1 mg/L with a median of 80.9 mg/L. Effluent runoff total COD ranges from 12.4 to 96.1 mg/L with a median of 51.6 mg/L. Influent runoff DO ranges from 3.3 to 8.4 mg/L with a median of 6.7 mg/L. Effluent runoff DO ranges from 2.8 to 8.4 mg/L with a median of 4.7 mg/L.

Head Loss and Hydraulic Testing

The peak and median driving head over the Jellyfish Filter JF4-2-1 deck level for each event is tabulated in **Table 13**. As shown, the driving head increases as the flow rate increases. For the 25 qualifying events, the median value of event-based median driving head over deck level is 83 mm (3.25 inches), and the median value of event-based peak driving head over deck level is 204 mm (8.05 inches). No water was bypassed around the treatment unit during the entire monitoring period, including during the two storms events which generated peak flow rates slightly in excess of the Maximum Treatment Flow Rate of 200 gpm.

Hydraulic testing was conducted on the clean system with fresh filter cartridges prior to commencement of the monitoring campaign, and was repeated at the conclusion of the field study on the system with dirty cartridges. Curves of head loss versus flow rate were nearly identical for the system with fresh cartridges and dirty cartridges, indicating no loss of hydraulic capacity despite the capture of 166 pounds of dry basis PM mass by the JF4 equipped with 3 cartridges. These results suggest the combination of very high cartridge surface area, vertical configuration and self-cleaning mechanisms are effective in maintaining hydraulic capacity. The system had a volumetric capacity for PM that was large and not exceeded during the period of this study.

Results of hydraulic testing of the Jellyfish Filter JF4-2-1 prior to commissioning (new filter cartridges) and at the conclusion of the monitoring period (dirty filter cartridges) are detailed in **Appendix C**.

Maintenance

No maintenance was required or carried out during the 13-month monitoring period spanning May 28, 2010 to June 27, 2011.

PM Recovery and Mass Balance

Mass balance result showed a 95% mass recovery rate for the 25 qualifying events. The theoretical mass is calculated by the difference of influent and effluent mass, which is 79.9 kg for the 25 qualifying events. The actual mass is calculated by summing the mass recovered from the sump and the filter cartridges, which are 72.0 kg (158 lbs) and 3.6 kg (8 lbs), respectively, in this project.

Table 4 Monitored rainfall-runoff event hydrologic data

Event Date	t_{rain} (min)	d_{rain} (in)	$i_{rain-max}$ (inch/hr)	IPRT (min)	V_{inf} (gal)	V_{eff} (gal)	Runoff Reduction %	Q_p (gpm)	Q_{med} (gpm)	n_{inf}	n_{eff}	TARP& VTAP Qualified
28 May 2010	112	0.81	3.0	10	1972	974	51%	68	15.5	19	8	Yes
16 June	61	0.63	2.4	18	1323	1234	7%	85	10.3	11	10	Yes
21 June	43	0.92	4.8	6	2297	2238	3%	118	86.7	10	10	Yes
30 June	50	0.52	3.0	8	1442	1410	2%	145	52.3	11	11	Yes
15 July	28	0.38	3.6	8	953	872	8%	210	22.9	10	10	Yes
1 August	36	1.18	5.0	5	3163	3089	3%	226	75.1	10	10	Yes
6 August	104	0.14	2.0	5	368	271	27%	108	0.2	10	8	Yes
7 August	48	0.34	2.4	7	693	672	3%	131	6.8	10	10	Yes
23 August	42	0.11	0.6	20	82	51	38%	20	0.2	10	10	Yes
12 September	52	0.27	2.0	18	434	399	8%	61	1.6	10	10	Yes
26 September	78	0.14	0.2	1	298	221	26%	7	4.1	10	10	Yes
27 September	388	0.60	3.6	20	1015	996	2%	173	0.7	10	10	Yes
4 November	43	0.19	1.8	5	263	135	49%	56	1.8	11	11	Yes
16 November	34	0.13	1.0	8	81	44	46%	28	0.3	11	11	Yes
5 January 2011	125	0.84	4.2	3	1532	1309	15%	117	2.6	10	10	Yes
10 January	26	0.20	3.6	4	298	277	7%	53	0.2	8	8	Yes
25 January	389	1.74	0.7	5	3273	3268	0%	65	6.2	10	10	Yes
7 February	306	1.29	1.2	8	3495	3420	2%	35	12.1	11	11	Yes
9 March	691	1.15	0.6	10	2656	2594	2%	50	1.6	12	12	Yes
28 March	66	0.10	1.3	7	138	112	19%	16	0.9	12	10	Yes
30 March	179	0.60	3.0	34	979	973	2%	89	1.6	12	12	Yes
20 April	61	0.14	0.6	9	54	30	44%	52	0.1	12	12	Yes
14 May	295	1.98	5.4	5	2974	2830	2%	119	0.4	19	19	Yes
6 June	69	0.16	0.9	4	254	194	24%	25	0.1	10	10	Yes
27 June	50	0.45	1.7	2	894	840	6%	53	2.0	10	10	Yes
Sum		15.01			30931	28453						

*Differences between influent and effluent volume :2478 gal.

PDH: Previous dry hours
t_{rain}: Event duration
d_{rain}: Rainfall depth
$i_{rain-max}$: Maximum rainfall intensity
IPRT: Initial pavement residence time
V_{runoff}: Runoff volume

Q_p: Maximum flow rate
Q_{med}: Median flow rate
n_{inf}: Number of influent samples
n_{eff}: Number of effluent samples
CRD: Cumulative rainfall depth

Table 5 Rainfall-runoff data collection requirements

Event Date	Sampling Coverage (nearest 10%)	Number of Composited samples	d_{rain} (in)	PDH (hr)	V_{runoff} (gal)	Q_p (gpm)	% of Treatment Design at Q_p	TARP& VTAP Qualified
28 May 2010	100	27(19i) (8e)	0.81	96	1972	68	34	Yes
16 June	100	21(11i) (10e)	0.63	288	1323	85	43	Yes
21 June	100	20(10i) (10e)	0.92	96	2297	118	59	Yes
30 June	100	22(11i) (11e)	0.52	288	1442	145	72	Yes
15 July	100	20(10i) (10e)	0.38	96	953	210	105	Yes
1 August	100	20(10i) (10e)	1.18	24	3163	226	113	Yes
6 August	100	18(10i) (8e)	0.14	120	368	108	54	Yes
7 August	100	20(10i) (10e)	0.34	24	693	131	65	Yes
23 August	100	20(10i) (10e)	0.11	48	82	20	10	Yes
12 September	100	20(10i) (10e)	0.27	172	434	61	30	Yes
26 September	100	20(10i) (10e)	0.14	40	298	7	4	Yes
27 September	100	20(10i) (10e)	0.60	10	1015	173	87	Yes
4 November	100	22(11i) (11e)	0.19	910	263	56	28	Yes
16 November	100	22(11i) (11e)	0.13	286	81	28	14	Yes
5 January 2011	100	20(10i) (10e)	0.84	72	1532	117	58	Yes
10 January	100	16(8i) (8e)	0.20	106	298	53	26	Yes
25 January	100	20(10i) (10e)	1.74	365	3273	65	32	Yes
7 February	100	22(11i) (11e)	1.29	12	3495	35	18	Yes
9 March	100	24(12i) (12e)	1.15	79	2656	50	25	Yes
28 March	100	22(12i) (10e)	0.10	438	138	16	8	Yes
30 March	100	24(12i) (12e)	0.60	48	979	89	44	Yes
20 April	100	24(12i) (12e)	0.14	196	54	52	26	Yes
14 May	100	38(19i) (19e)	1.98	188	2974	119	60	Yes
6 June	100	20(10i) (10e)	0.16	541	254	25	12	Yes
27 June	100	20(10i) (10e)	0.45	88	894	53	27	Yes
Sum			15.01		30931			

(“i” stands for influent, “e” stands for effluent)

Table 6   Event-based particle size distributions (PSD)

Event Date	Influent PSD (μm)			Effluent PSD (μm)		
	d_{10}	d_{50}	d_{90}	d_{10}	d_{50}	d_{90}
28 May 2010	7	69	915	2	11	34
16 June	28	242	1016	1	6	16
21 June	54	263	769	1	6	34
30 June	8	75	271	1	5	17
15 July	40	225	628	2	6	17
1 August	26	213	693	2	6	17
6 August	16	231	984	1	3	18
7 August	19	186	737	1	4	12
23 August	14	190	714	2	4	40
12 September	9	89	328	1	2	8
26 September	4	35	173	1	3	52
27 September	15	136	723	1	3	11
4 November	3	68	401	1	2	9
16 November	5	51	610	1	2	12
5 January 2011	15	110	794	1	3	12
10 January	8	117	227	1	2	6
25 January	7	63	308	0	1	2
7 February	7	68	369	1	3	18
9 March	6	57	278	1	3	7
28 March	4	32	200	1	3	8
30 March	6	44	176	1	3	7
20 April	2	22	310	0	1	8
14 May	10	80	705	1	3	8
6 June	10	99	345	1	2	7
27 June	10	82	310	1	6	14
Mean	13	114	519	1	4	16
Median	9	82	401	1	3	12
Std. dev.	12	74	270	0	2	12

Table 7 Removal efficiencies for particulate matter (PM) fractions

Event Date	**PM < 25 µm**			**TSS**			**%Volatile**		**Particulate Matter, PM Fractions**							**SSC**		
									< 500 µm			**< 1000 µm**		**< 2000 µm**				
	EMC$_i$ [mg/L]	**EMC$_e$ [mg/L]**	**PR (%)**	**EMC$_i$ [mg/L]**	**EMC$_e$ [mg/L]**	**PR (%)**	**EMV$_i$ (%)**	**EMV$_e$ (%)**	**EMC$_i$ [mg/L]**	**EMC$_e$ [mg/L]**	**PR (%)**	**EMC$_i$ [mg/L]**	**EMC$_e$ [mg/L]**	**EMC$_i$ [mg/L]**	**EMC$_e$ [mg/L]**	**EMC$_i$ [mg/L]**	**EMC$_e$ [mg/L]**	**PR (%)**
28 May 2010	43.7	11.9	87	89.3	18.7	90	49.0	59.8	261.0	11.3	96	383.4	13.3	525.0	15.4	532.3	15.4	99
16 June	40.2	19.7	53	79.3	21.7	74	34.9	73.6	240.4	13.9	94	534.9	16.0	868.2	18.1	1401.7	18.1	99
21 June	18.4	9.9	48	105.5	15.2	86	21.3	72.6	209.2	5.5	97	374.6	6.5	556.2	7.4	1162.9	7.4	99
30 June	12.2	5.8	53	25.2	7.4	71	15.9	66.9	233.8	4.0	98	289.5	4.7	345.8	5.4	444.5	5.4	99
15 July	23.7	6.9	73	91.8	8.3	92	25.3	34.1	276.6	6.4	98	451.2	7.4	640.7	8.4	812.2	8.4	99
1 August	18.5	6.9	64	130.2	15.4	89	70.5	52.7	83.9	5.5	93	120.6	6.6	161.0	7.7	245.1	7.7	97
6 August	48.0	12.1	82	77.5	15.0	86	51.3	0.3	95.3	5.4	94	145.1	6.4	203.3	7.3	308.4	7.3	98
7 August	13.1	7.0	49	45.3	12.2	74	42.3	30.8	25.0	10.8	57	37.2	12.4	50.6	13.9	117.1	13.9	89
23 August	38.3	5.0	92	74.2	8.2	93	69.1	46.9	265.1	3.5	99	392.6	4.1	532.8	4.7	555.8	4.7	100
12 September	45.2	11.6	76	91.2	15.7	84	56.3	40.7	106.0	4.6	96	143.2	5.2	183.4	5.8	261.5	5.8	98
26 September	11.2	2.2	85	16.3	4.7	79	58.5	80.0	61.3	3.8	94	84.1	4.4	107.0	5.0	117.9	5.0	97
27 September	44.5	5.0	89	51.1	3.2	94	55.1	37.9	312.2	4.7	98	484.7	5.3	669.8	6.0	765.1	6.0	99
4 November	93.6	6.7	96	39.9	4.2	95	46.2	53.0	226.5	8.3	96	294.1	9.3	367.5	10.4	477.1	10.4	99
16 November	119.6	9.2	96	261.0	11.8	98	42.6	11.4	303.5	11.9	96	409.8	12.0	524.8	12.2	543.6	12.2	99
5 January 2011	68.6	13.0	84	152.2	15.9	91	69.4	52.2	170.6	6.7	96	234.6	7.7	307.3	8.7	693.2	8.7	99
10 January	20.7	3.1	86	80.7	6.6	92	68.0	24.8	86.1	2.4	97	131.5	2.7	179.4	3.0	211.1	3.0	99
25 January	32.3	3.5	89	69.8	7.1	90	68.1	30.1	48.1	3.7	92	64.8	3.9	82.4	4.1	105.8	4.1	96
7 February	20.4	4.4	79	34.8	5.3	85	75.8	54.5	128.7	6.3	95	202.7	6.9	285.9	7.6	438.3	7.6	98
9 March	22.0	4.3	81	30.5	8.3	73	57.8	31.2	29.4	2.3	92	38.8	2.6	48.7	2.8	78.2	2.8	97
28 March	56.5	11.6	84	68.4	12.7	86	54.5	24.8	64.8	3.5	95	83.3	4.5	102.8	5.6	102.8	5.6	96
30 March	44.9	5.1	89	104.5	7.3	93	60.2	5.6	206.7	5.7	97	278.6	6.5	361.6	7.3	443.7	7.3	98
20 April	65.7	7.9	93	143.7	11.4	96	44.7	22.8	343.0	4.6	99	466.5	5.3	606.7	6.1	921.7	6.1	100
14 May	33.9	11.3	67	77.1	12.5	84	65.7	10.2	255.9	5.3	98	357.9	5.3	470.6	5.3	487.3	5.3	99
6 June	54.2	10.6	85	85.6	13.2	88	54.9	25.4	93.5	5.4	94	125.1	5.9	158.9	6.4	237.5	9.0	97
27 June	54.3	10.1	82	131.4	12.8	91	62.5	29.6	297.8	7.4	98	391.5	8.6	487.5	9.8	591.7	9.8	98
Mean	41.7	8.2	78	86.3	11.0	87	52.8	38.9	177.0	6.1	94	260.8	6.9	353.1	7.8	482.3	7.9	98
Median	40.2	7.0	84	79.3	11.8	89	55.1	34.1	206.7	5.4	96	278.6	6.4	345.8	7.3	444.5	7.3	99
Std. dev.	25.9	4.0	15	51.4	4.8	8	15.8	21.8	100.9	3.0	8	156.3	3.4	225.5	3.8	338.3	3.8	2

Table 8 Event-based values for alkalinity, COD, and turbidity

Event Date	Alkalinity [mg/L as $CaCO_3$]		Total COD [mg/L]		Turbidity (NTU)		
	EMV_i	**EMV_e**	**EMV_i**	**EMV_e**	**EMV_i**	**EMV_e**	**PR%**
28 May 2010	29.2	22.7	80.9	68.2	35.6	14.1	60%
16 June	21.5	34.5	93.3	63.7	32.7	10.7	67%
21 June	12.6	19.1	27.5	21.8	4.7	3.0	36%
30 June	9.1	24.8	14.3	20.6	9.8	6.5	34%
15 July	17.0	42.8	56.3	34.0	31.2	7.1	77%
1 August	5.9	17.0	37.8	30.1	14.8	3.9	74%
6 August	26.0	42.2	94.1	14.4	51.9	1.4	97%
7 August	14.6	29.8	20.8	41.9	15.6	3.8	76%
23 August	28.5	83.5	95.8	38.7	46.6	5.3	89%
12 September	23.3	79.6	99.3	51.8	27.9	3.6	87%
26 September	39.6	84.1	132.2	48.0	21.4	3.3	85%
27 September	27.1	42.2	51.4	53.1	14.1	5.1	64%
4 November	36.5	125.1	135.7	55.3	82.5	5.5	93%
16 November	45.2	102.9	486.1	51.6	171.0	10.8	94%
5 January 2011	18.2	41.1	40.7	51.9	65.7	10.1	85%
10 January	15.9	38.9	66.6	26.7	38.0	3.3	91%
25 January	21.3	20.2	21.5	12.4	28.2	6.8	76%
7 February	13.5	18.1	39.3	23.9	30.0	5.9	80%
9 March	23.1	36.4	34.9	24.8	19.4	2.4	88%
28 March	47.3	114.4	459.4	51.6	61.1	3.5	94%
30 March	22.3	50.2	118.1	53.6	70.7	4.6	93%
20 April	6.5	30.4	364.3	58.9	112.2	2.4	98%
14 May	3.1	6.7	58.7	57.6	19.9	5.6	72%
6 June	9.7	89.3	219.3	96.1	38.4	3.7	90%
27 June	32.0	119.2	344.6	74.2	63.8	3.4	95%
Mean	22.0	52.6	127.7	45.0	44.3	5.4	80%
Median	21.5	41.1	80.9	51.6	32.7	4.6	85%
Std. dev.	11.9	35.8	137.5	20.3	36.7	3.1	17%

Table 9 Event-based values for Total Phosphorus and Total Nitrogen

Event Date	TN			TP		
	EMV_i [µg/L]	EMV_e [µg/L]	PR (%)	EMV_i [µg/L]	EMV_e [µg/L]	PR (%)
28 May 2010	4906	3378	66	2405	762	84
16 June	3110	1610	51	3256	876	74
21 June	4818	1885	62	5883	472	92
30 June	1885	1751	9	1216	619	50
15 July	2716	2202	26	3548	731	81
1 August	2033	1234	41	2342	920	62
6 August	5503	1566	79	2040	920	67
7 August	1170	763	37	1407	955	35
23 August	3424	2112	62	1570	883	65
12 September	2520	2628	4	2135	1537	34
26 September	2716	1647	55	3035	1485	64
27 September	2265	760	67	3063	1730	45
4 November	3401	1122	83	5011	2409	76
16 November	5695	1252	88	8793	2574	84
5 January 2011	1879	553	75	3947	2104	54
10 January	1238	1118	16	3853	2496	39
25 January	1399	733	48	4497	1146	75
7 February	1182	816	32	2952	1177	60
9 March	1300	1195	10	887	806	11
28 March	6511	2955	64	7056	3751	58
30 March	4024	1345	67	4364	2474	44
20 April	10479	6500	66	6504	4769	59
14 May	3940	2202	45	2994	1480	51
6 June	4305	4388	23	2769	2368	35
27 June	5564	6579	-11	3228	2758	20
Mean	3519	2092	47	3550	1688	57
Median	3110	1610	51	3063	1480	59
Std. dev.	2161	1614	27	1914	1060	21

Table 10 Event-based values for Total Metals

Event Date	Total Zinc			Total Copper			Total Lead			Total Chromium		
	EMC$_i$ [µg/L]	**EMC$_e$** [µg/L]	**PR** (%)	**EMC$_i$** [µg/L]	**EMC$_e$** [µg/L]	**PR** (%)	**EMC$_i$** [µg/L]	**EMC$_e$** [µg/L]	**PR** (%)	**EMC$_i$** [µg/L]	**EMC$_e$** [µg/L]	**PR** (%)
28 May 2010	BDL	BDL	----	BDL	BDL	----	24.0	37.6	22	BDL	BDL	----
16 June	BDL	BDL	----	20.9	BDL	----	26.8	35.9	-27	BDL	BDL	----
21 June	1100	11	99	646.6	24.8	96	118.0	23.5	81	BDL	BDL	----
30 June	100	68	32	75.0	BDL	----	23.0	BDL	----	2.6	1.9	30
15 July	1500	BDL	----	880.4	BDL	----	114.1	BDL	----	8.2	BDL	----
1 August	100	2	98	7.2	0.3	96	8.6	3.5	60	7.1	1.8	75
6 August	1500	345	77	361.0	0.1	100	98.4	5.0	96	5.7	0.2	98
7 August	700	217	69	149.6	0.1	100	38.9	2.0	95	1.6	0.2	89
23 August	1500	375	75	5.5	0.1	99	19.1	4.4	86	42.3	44.1	35
12 September	2000	880	56	3.1	0.1	96	9.4	1.5	86	55.5	55.3	8
26 September	6400	640	90	14.6	BDL	----	3.9	4.6	12	33.9	30.7	33
27 September	1200	1116	7	56.6	4.7	92	46.9	6.1	87	104.9	99.4	8
4 November	1600	400	75	79.5	0.4	100	71.7	4.5	97	49.7	41.4	58
16 November	1500	420	72	77.8	18.2	87	13.1	4.1	83	28.7	11.8	78
5 January 2011	2600	702	73	112.1	48.5	63	75.1	91.1	-6	122.5	108.5	23
10 January	3000	2760	8	46.5	14.1	72	34.9	9.3	75	42.9	29.6	36
25 January	4400	528	88	619.0	6.9	99	150.1	93.1	38	105.9	94.6	11
7 February	1300	793	39	113.7	51.3	55	104.5	62.8	40	78.0	97.3	-24
9 March	1500	450	70	366.5	44.7	88	20.1	0.1	100	82.8	65.8	23
28 March	1100	715	35	133.2	35.4	79	24.6	4.8	85	88.6	59.7	46
30 March	7600	760	90	85.2	13.3	85	120.2	9.4	92	117.7	66.3	44
20 April	1600	1536	4	197.3	20.4	94	249.1	127.8	72	157.9	105.2	63
14 May	600	270	55	57.5	17.7	70	27.8	6.5	77	96.2	56.9	42
6 June	1300	507	61	100.6	39.8	70	71.3	76.1	19	95.0	103.1	18
27 June	600	546	9	72.7	18.1	77	120.4	3.8	97	70.3	33.6	55
Mean	1948	638	58	178.4	17.9	86	64.6	26.8	64	63.5	52.7	40
Median	1500	518	70	82.4	15.9	90	38.9	6.1	81	62.9	55.3	36
Std. dev.	1852	594	31	231.4	17.5	14	58.4	37.0	37	45.0	37.9	30

Table 11 Event-based values for Total Oil and Grease

Event Date	Total Oil and Grease		
	EMC_i [mg/L]	**EMC_e [mg/L]**	**PR (%)**
28 May 2010	0.20	0.08	62
16 June	0.93	0.43	54
21 June	0.35	0.35	0
30 June	0.64	0.62	2
15 July	1.10	0.35	68
1 August	0.96	0.55	43
6 August	1.04	0.47	55
7 August	0.73	0.55	25
23 August	0.20	0.00	100
12 September	0.61	0.00	100
26 September	0.44	0.00	100
27 September	0.99	0.08	92
4 November	0.46	0.00	100
16 November	0.93	0.00	100
5 January 2011	0.61	0.00	100
10 January	0.55	0.16	72
25 January	0.64	0.00	100
7 February	1.04	0.00	100
9 March	1.56	1.45	7
28 March	4.06	1.17	71
30 March	2.34	2.32	1
20 April	1.74	0.78	55
14 May	1.74	1.56	10
6 June	1.74	0.78	55
27 June	1.16	0.78	33
Mean	1.07	0.50	60
Median	0.93	0.35	62
Std. dev.	0.82	0.60	37

Table 12 Event-based water chemistry values (all results are not concentrations, but are values)

Event Date	pH		Redox (mV)		DO (mg/L)		Temperature (°C)		Conductivity (µS/cm)		TDS (mg/L)	
	EMV_i	EMVe	EMV_i	EMVe	EMV_i	EMVe	EMV_i	EMVe	EMV_i	EMVe	EMV_i	EMVe
28 May 2010	7.0	7.0	391	386	6.1	6.3	23.9	24.1	60.5	69.1	29.8	33.9
16 June	7.1	6.7	368	366	4.5	3.6	25.0	25.0	49.5	81.9	24.2	40.2
21 June	7.1	6.6	383	438	6.7	4.7	23.4	24.6	24.2	43.1	11.9	21.1
30 June	6.9	6.5	376	376	5.7	4.4	25.7	25.3	23.9	57.3	11.9	28.0
15 July	7.3	6.8	355	355	7.2	5.8	27.7	26.2	32.6	96.3	15.8	43.6
1 August	6.5	6.5	366	364	7.5	7.1	25.7	25.6	18.9	42.4	9.3	20.6
6 August	7.3	6.5	386	393	6.3	4.2	27.6	26.7	69.2	87.9	33.9	43.3
7 August	7.0	6.5	386	360	7.1	4.3	25.7	26.0	34.6	71.7	16.9	35.1
23 August	7.0	6.8	340	329	6.4	4.2	26.7	25.7	74.1	177.7	36.3	88.0
12 September	7.4	6.8	407	431	6.8	5.0	27.0	26.2	62.1	174.2	30.3	85.3
26 September	6.6	6.7	422	488	3.3	2.8	24.5	24.5	107.6	182.9	52.6	89.6
27 September	7.1	6.7	443	465	6.6	5.4	23.6	23.8	54.0	98.9	26.2	48.5
4 November	7.2	7.0	366	412	6.6	4.5	22.0	21.9	103.5	298.7	50.6	127.7
16 November	7.2	6.8	352	376	7.1	4.4	22.1	22.6	174.0	225.0	85.5	110.3
5 January 2011	7.5	6.7	399	364	8.3	7.4	21.4	22.1	38.6	107.1	18.9	52.5
10 January	7.2	6.8	331	350	8.3	5.0	19.8	20.2	47.0	97.8	32.9	68.0
25 January	7.1	7.0	336	323	8.1	7.6	18.8	19.9	48.4	65.7	26.7	25.5
7 February	7.2	7.2	353	356	8.3	8.4	22.2	23.1	30.6	41.2	15.2	20.1
9 March	7.4	7.1	357	366	8.4	8.3	17.8	17.8	40.6	86.7	20.1	42.6
28 March	7.1	7.1	321	315	7.2	5.3	22.8	22.3	186.7	257.3	91.3	126.0
30 March	7.2	7.0	379	321	7.5	6.1	21.8	21.7	62.1	121.5	30.3	60.1
20 April	6.9	6.5	375	384	5.5	4.4	24.3	23.0	159.8	422.6	78.3	206.9
14 May	7.4	7.2	352	363	4.6	4.3	24.8	23.9	56.6	88.9	27.8	43.4
6 June	7.2	7.0	303	300	6.7	4.7	26.7	26.2	109.2	391.5	53.5	191.7
27 June	7.0	6.2	285	291	6.3	4.3	26.4	25.6	95.0	322.9	46.6	158.2
Mean	7.1	6.8	365	371	6.7	5.3	23.9	23.8	70.5	148.4	35.1	72.4
Median	7.1	6.8	366	364	6.7	4.7	24.3	24.1	56.6	97.8	29.8	48.5
Std. dev.	0.2	0.3	35	48	1.3	1.5	2.7	2.3	46.6	110.8	22.7	53.4

Table 13 Event-based driving head over deck level

Event Date	Median head over deck level (inch)	Median head over deck level (mm)	Peak head over deck level (inch)	Peak head over deck level (mm)
28 May 2010	1.56	40	6.22	158
16 June	4.23	108	7.79	198
21 June	6.67	170	9.89	251
30 June	2.01	51	15.55	395
15 July	5.78	147	16.89	429
1 August	8.41	214	20.92	531
6 August	5.75	146	12.04	306
7 August	4.58	116	12.23	311
23 August	1.47	37	4.58	116
12 September	2.07	53	6.17	157
26 September	1.45	37	2.48	63
27 September	1.16	30	15.70	399
4 November	3.08	78	6.72	171
16 November	1.77	45	6.82	173
5 January 2011	2.40	61	11.72	298
10 January	1.49	38	8.05	204
25 January	3.25	83	6.88	175
7 February	5.43	138	12.18	309
9 March	2.73	69	7.23	184
28 March	3.36	85	6.02	153
30 March	6.96	177	15.69	398
20 April	4.59	117	6.42	163
14 May	4.25	108	19.65	499
6 June	0.65	16	6.56	167
27 June	5.61	143	16.76	426
Mean	3.63	92	10.45	265
Median	3.25	83	8.05	204
Std. dev.	2.11	54	5.06	129

11. Data Quality Assessment

Data was analyzed using statistical methods in accordance with guidelines in the **TARP Protocol for Stormwater Best Management Practice Demonstrations**, and the **VTAP Guidance for Evaluating Stormwater Manufactured Treatment Devices**. Data was examined by statistical and regression analysis, ANOVA statistics, non-parametric analysis, correlations, probability distributions of data, normality testing, standards, and physical data replication.

Data integrity in the laboratory was addressed in a multi-level review process for all analyses conducted. The initial step in this review process was conducted by each lab analyst as tests were conducted. Calibration values and procedures were checked against previous tests to alert the analyst to in case of malfunction in equipment or test errors.

The second level of review was conducted by the lab director who collected results and entered these values into the tabular spreadsheets for each test. Each of the results was checked for accuracy of input as well as to appropriateness for the samples which were analyzed. All results were overseen or conducted personally by the lab manager. All preliminary calculations were reviewed.

The final level of review was conducted by the project manager who reviewed all results generated within the laboratory.

12. Conclusions

Field testing of an Imbrium Systems' Jellyfish® Filter model JF4-2-1 with second-generation filtration cartridges was conducted in accordance with the TARP and VTAP field test protocols. The physical modeling campaign was carried out on the University of Florida campus with the full-scale unit loaded by rainfall-runoff from a surface parking watershed. A total of 25 monitored storm events, with 15 inches of cumulative rainfall depth, were treated by the JF4 during this study. Of the 25 storms treated, two storms generated flows exceeding the maximum design flow of 200 gpm. No maintenance was required or conducted during the 13-month monitoring period from May 28, 2010 to June 27, 2011.

Treatment results generated median SSC and TSS removal efficiency results of 99% and 89%, respectively. Median removal efficiency was 59% for Total Phosphorus and 51% for Total Nitrogen. For Total Copper, Zinc, Lead and Chromium median removal efficiencies were 90, 70, 81, and 36%, respectively. The d_{50} for influent and effluent particle sizes were 82 and 3 μm, respectively. Median head loss never exceeded 8.4 inches (21.4 cm) for any event and across the entire monitoring campaign the median head loss was 3.3 inches (8.3 cm). Dry basis particulate matter (PM) recovered from the treatment unit totaled 166 pounds, and the JF4-2-1 had a volumetric capacity to retain a significantly larger mass of PM. Median and peak head losses were driven predominately by flow rate and to a much lesser degree by filter cartridge ripening which was muted. At the completion of the monitoring campaign, a 95% mass balance was obtained on particulate matter (PM) which validates the testing methods used throughout this study. This mass balance on PM is an independent requirement to validate the influent and effluent monitoring and validates the most rigorous unit operation and process physical modeling available. The results obtained in this field study demonstrate that the Jellyfish Filter's particulate removal performance is reasonably insensitive to incoming particle size distribution (PSD) and runoff event duration.

APPENDIX A

New Jersey Environmental Laboratory Certification

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Office of Quality Assurance
401 East State Street
P.O. Box 420, Mail Code 401-02D
Trenton, New Jersey 08625-0420
Tel: (609) 292-3950
Fax: (609) 777-1774

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

February 28, 2011

Dr. Gaoxiang Ying
UF-EES UNIT OPERATIONS AND PROCESS LAB
110 BLACK HALL UNIVERSITY OF FLORIDA
GAINESVILLE, FL 32611

Lab ID # FL017

Dear Laboratory Manager:

New Jersey's Environmental Laboratory Certification Program (Program) is currently accepting renewal applications for Fiscal Year 2012 (FY2012). The Program includes both New Jersey Environmental Laboratory Certification using standards published at N.J.A.C. 7:18, "Regulations Governing the Certification of Laboratories and Environmental Measurements" and New Jersey National Environmental Laboratory Accreditation using the 2003 NELAC Standard and incorporated by reference at N.J.A.C. 7:18-1.5(d). All laboratories holding either of these approvals are required to annually renew their status. Renewals are for the annual period, which runs concurrent to the state's fiscal year of July 1 through June 30.

Also, please note that within the next year, New Jersey plans to eliminate the use of the 2003 NELAC Standard and adopt the TNI Standards in its place.

Enclosed is a FY2012 Program renewal application package. Instructions to complete the application are enclosed.

Renewal applications are due back to the Office of Quality Assurance by March 31, 2011. All companies that have submitted a complete application by that date will receive a 2012 Certificate and Annual Certified Parameter List (ACPL) by July 1, 2011. For companies submitting after March 31, 2011, there may be a period of time after July 1, 2011, during which the company is without a 2012 Certificate and ACPL. During this period a company cannot conduct business or present itself as a New Jersey Certified Environmental Laboratory or Environmental Measurement Business. Companies not renewing certification by July 1, 2011 will be required to submit an initial application and fee to be granted certification. Renewal application due dates have been established based on the policies given at N.J.A.C. 7:18-2.7(a) 4.

If you have any questions please contact either Michael DiBalsi or Evelyn Nazario at (609) 292-3950.

Sincerely,

Joseph F Aiello

Joseph F. Aiello, Manager

APPENDIX B

Individual Storm Event Summaries with Hydrographs and Hyetographs

Table B1: JF4 Summary: 28 May 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	28 May 2010	Influent Volume:	7465 L (1972 gal)
Previous Dry Hours:	96	Event Duration:	112 min
Maximum Flow Rate:	4.30 L/s (68.2 gpm)	Number of Influent Samples:	19
Median Flow Rate:	0.98 L/s (15.5 gpm)	Number of Effluent Samples:	8
Mean Flow Rate:	1.12 L/s (17.8 gpm)	Peak Rainfall Intensity:	76 mm/hr (3.0 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	21 mm (0.81 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

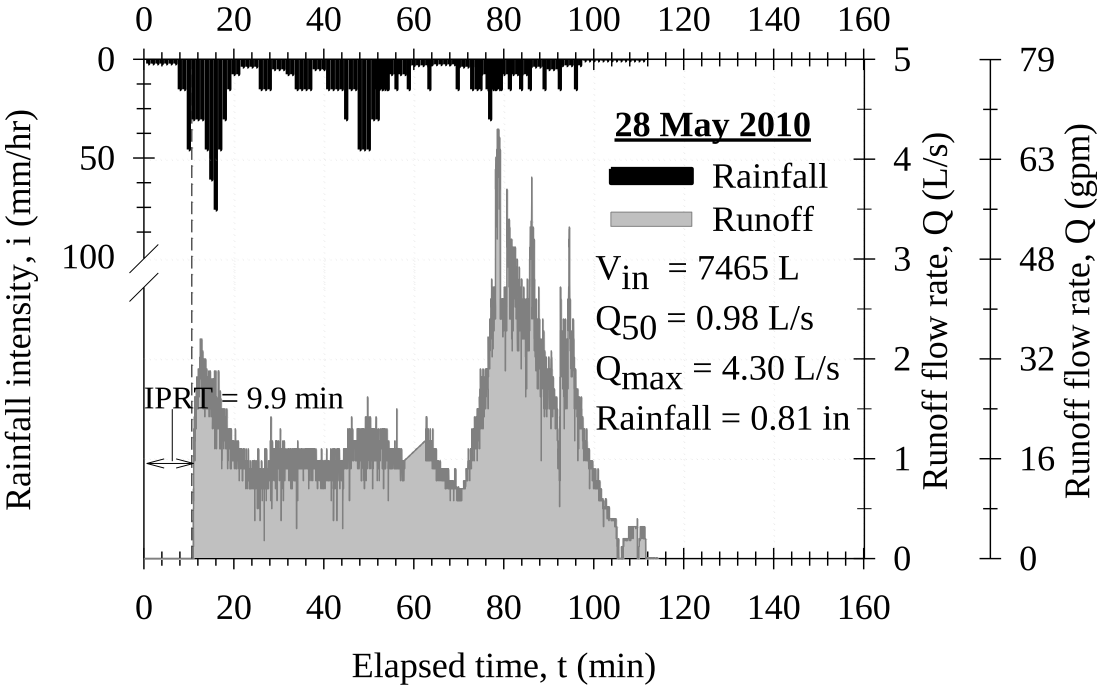


Figure B1: Hydrograph and hyetograph for 28 May 2010 event

On May 28, 2010, the Jellyfish Filter JF4-2-1 at the University of Florida parking lot site treated its first rainfall-runoff event, starting with a clean empty unit. The event occurred after 96 dry hours. The peak rainfall intensity is 3.0 in/hr and rainfall depth is 0.81 inches. The storm lasted approximately 112 minutes. The maximum, median, and mean runoff flow rates are 68 gpm, 16 gpm, and 18 gpm, respectively. The influent runoff volume is 1,972 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 19 and 8, respectively. Fewer effluent than influent samples are collected since the JF4 unit is filling up for a substantial part of the storm. The influent and effluent TSS is 89.3 mg/L and 18.7 mg/L, respectively, and the removal efficiency is 90%. The influent and effluent SSC is 532.3 mg/L and 15.4 mg/L, respectively, and the removal efficiency is 99%.

Table B2: JF4 Summary: 16 June 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	16 June 2010	Influent Volume:	5008 L (1323 gal)
Previous Dry Hours:	288	Event Duration:	61 min
Maximum Flow Rate:	5.36 L/s (85.0 gpm)	Number of Influent Samples:	11
Median Flow Rate:	0.65 L/s (10.3 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	2.21 L/s (35.1 gpm)	Peak Rainfall Intensity:	61 mm/hr (2.4 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	16 mm (0.63 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

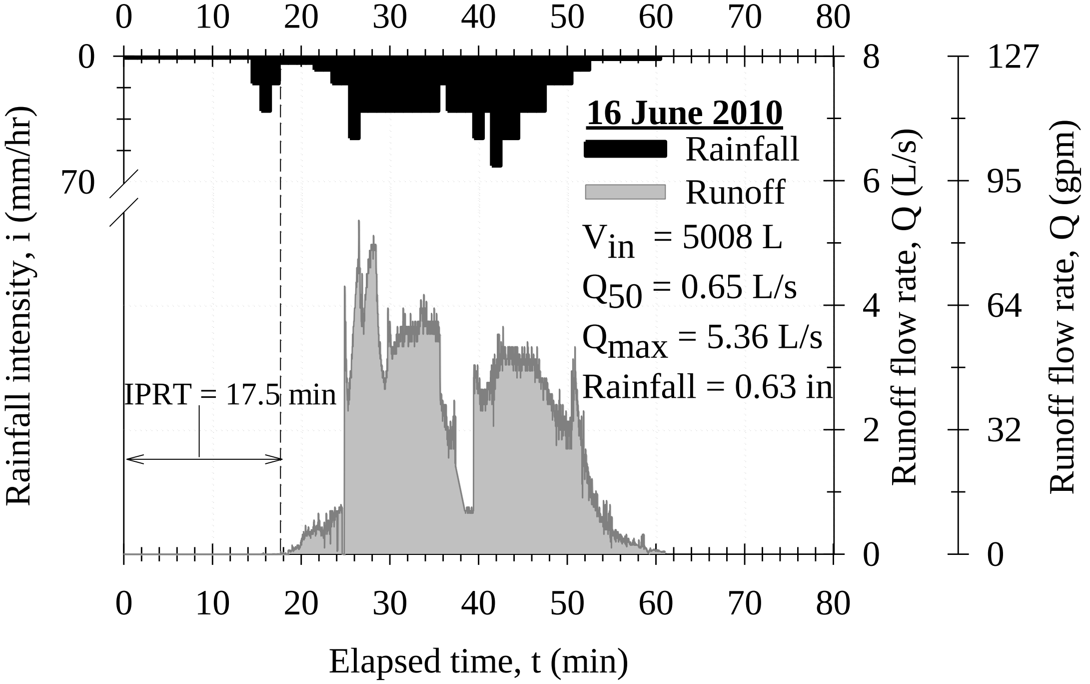


Figure B2: Hydrograph and hyetograph for 16 June 2010 event

On June 16, 2010, the JF4 unit treated its second rainfall-runoff event. The event occurred after 288 dry hours. The peak rainfall intensity is 2.4 in/hr and rainfall depth is 0.63 inches. The storm lasted approximately 61 minutes. The maximum, median, and mean runoff flow rates are 85 gpm, 10 gpm, and 35 gpm, respectively. The influent runoff volume is 1,323 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 11 and 10, respectively. The influent and effluent TSS is 79.3 mg/L and 21.7 mg/L, respectively, and the removal efficiency is 74%. The influent and effluent SSC is 1401.7 mg/L and 18.1 mg/L, respectively, and the removal efficiency is 99%.

Table B3: JF4 Summary: 21 June 2010 Hydrology

Event Information		**JF4 Unit Treatment Run information**	
Event Date:	21 June 2010	Influent Volume:	8695 L (2297 gal)
Previous Dry Hours:	96	Runoff Duration:	43 min
Maximum Flow Rate:	7.46 L/s (118.3 gpm)	Number of Influent Samples:	10
Median Flow Rate:	5.47 L/s (86.7 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	5.09 L/s (80.7 gpm)	Peak Rainfall Intensity:	122 mm/hr (4.8 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	23 mm (0.92 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

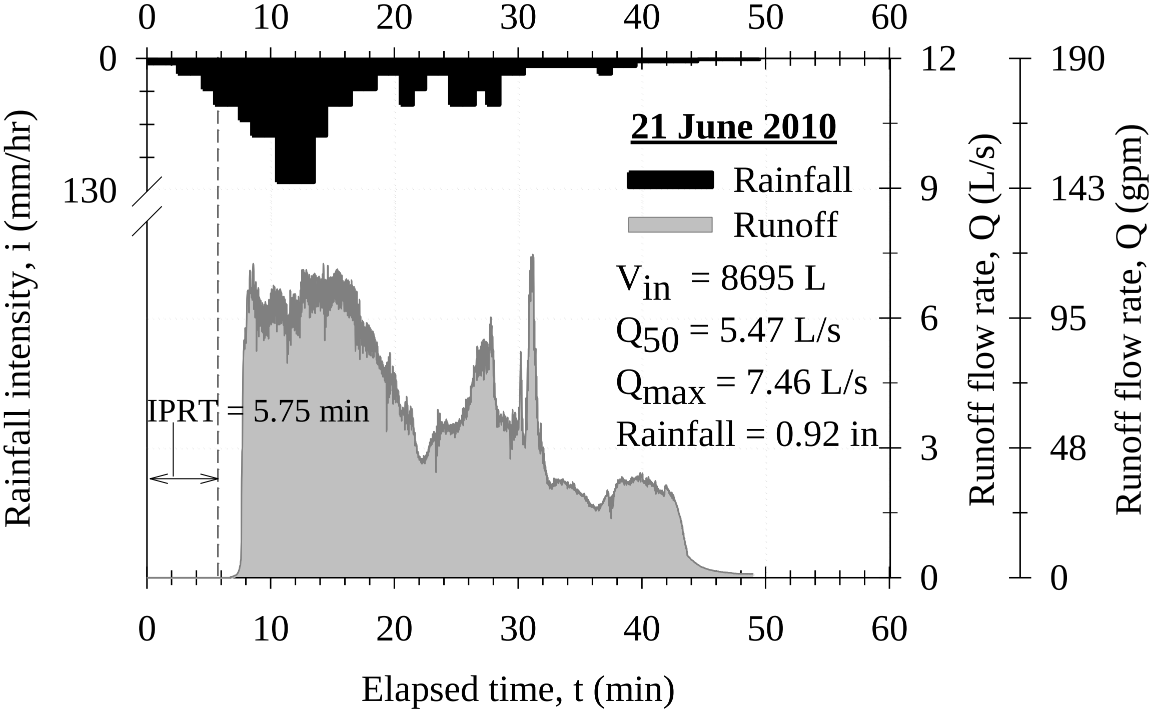


Figure B3: Hydrograph and hyetograph for 21 June 2010 event

On June 21, 2010, the JF4 unit treated its third rainfall-runoff event. The event occurred after 96 previous dry hours. The peak rainfall intensity is 4.8 in/hr and rainfall depth is 0.92 inches. The storm lasted approximately 43 minutes. The maximum, median, and mean runoff flow rates are 118 gpm, 87 gpm, and 81 gpm, respectively. The influent runoff volume is 2297 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 105.5 mg/L and 15.2 mg/L, respectively, and the removal efficiency is 86%. The influent and effluent SSC is 1162.9 mg/L and 7.4 mg/L, respectively, and the removal efficiency is 99%.

Table B4: JF4 Summary: 30 June 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	30 June 2010	Influent Volume:	5459 L (1442 gal)
Previous Dry Hours:	288	Runoff Duration:	50 min
Maximum Flow Rate:	9.13 L/s (144.8 gpm)	Number of Influent Samples:	11
Median Flow Rate:	3.30 L/s (52.3 gpm)	Number of Effluent Samples:	11
Mean Flow Rate:	3.95 L/s (62.6 gpm)	Peak Rainfall Intensity:	76 mm/hr (3.0 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	13 mm (0.52 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

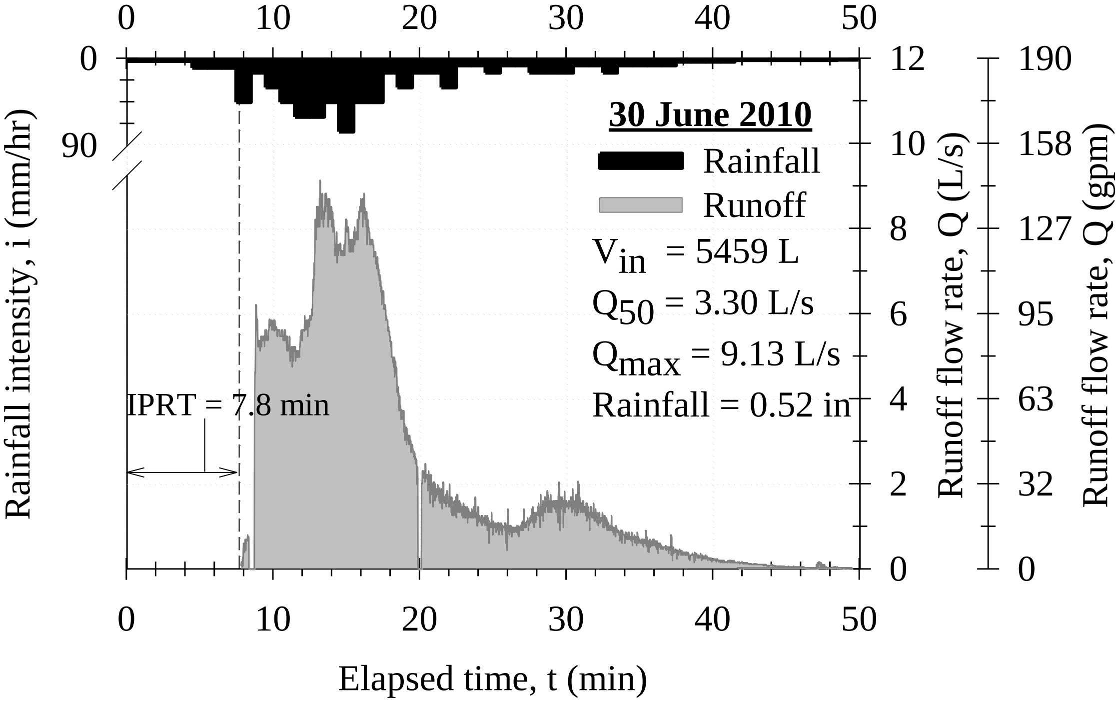


Figure B4: Hydrograph and hyetograph for 30 June 2010 event

On June 30, 2010, the JF4 unit treated its fourth rainfall-runoff event. The event occurred after 288 dry hours. The peak rainfall intensity is 3 in/hr and rainfall depth is 0.52 inches. The storm lasted approximately 50 minutes. The maximum, median, and mean runoff flow rates are 145 gpm, 52 gpm, and 63 gpm, respectively. The influent runoff volume is 1442 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 11 and 11, respectively. The influent and effluent TSS is 25.2 mg/L and 7.4 mg/L, respectively, and the removal efficiency is 71%. The influent and effluent SSC is 444.5 mg/L and 5.4 mg/L, respectively, and the removal efficiency is 99%.

Table B5: JF4 Summary: 15 July 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	15 July 2010	Influent Volume:	3608 L (953 gal)
Previous Dry Hours:	96	Runoff Duration:	28 min
Maximum Flow Rate:	13.26 L/s (210.2 gpm)	Number of Influent Samples:	10
Median Flow Rate:	1.44 L/s (22.9 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	3.12 L/s (49.4 gpm)	Peak Rainfall Intensity:	91 mm/hr (3.6 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	10 mm (0.38 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

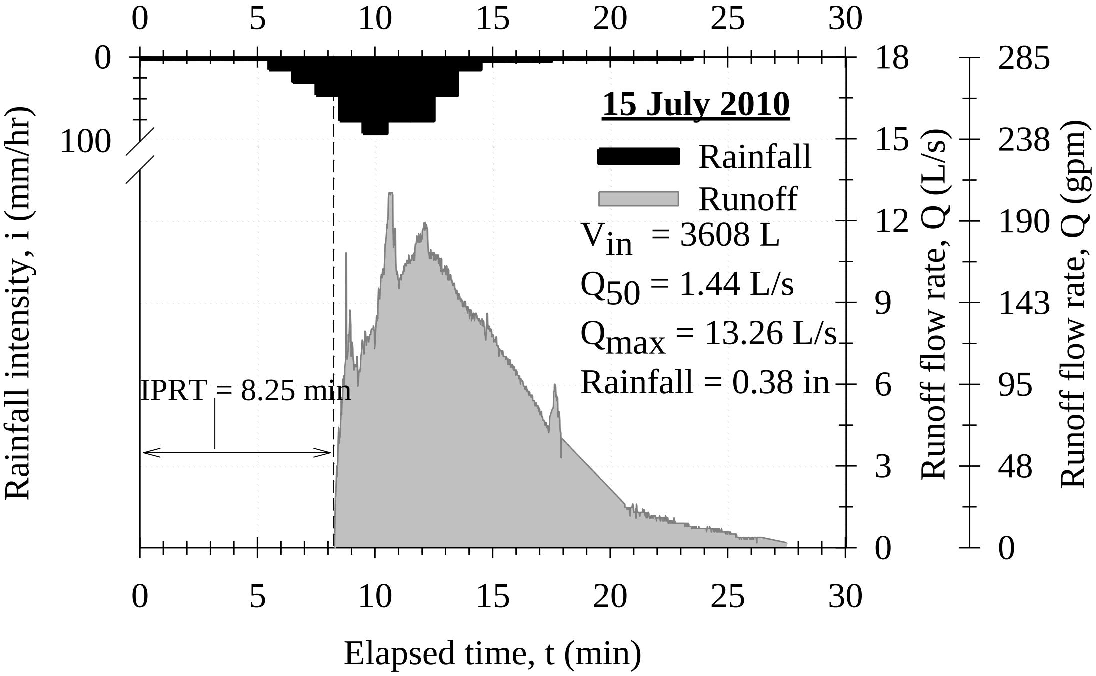


Figure B5: Hydrograph and hyetograph for 15 July 2010 event

On July 15, 2010, the JF4 unit treated its fifth rainfall-runoff event. The event occurred after 96 dry hours. The peak rainfall intensity is 3.6 in/hr and rainfall depth is 0.38 inches. The storm lasted approximately 28 minutes. The maximum, median, and mean runoff flow rates are 210 gpm, 23 gpm, and 49 gpm, respectively. The influent runoff volume is 953 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 91.8 mg/L and 8.3 mg/L, respectively, and the removal efficiency is 92%. The influent and effluent SSC is 812.2 mg/L and 8.4 mg/L, respectively, and the removal efficiency is 99%.

Table B6: JF4 Summary: 1 August 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	01 August 2010	Influent Volume:	11973 L (3163 gal)
Previous Dry Hours:	24	Event Duration:	36 min
Maximum Flow Rate:	14.25 L/s (225.9 gpm)	Number of Influent Samples:	10
Median Flow Rate:	4.74 L/s (75.1 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	5.47 L/s (86.7 gpm)	Peak Rainfall Intensity:	127 mm/hr (5.0 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	30 mm (1.18 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

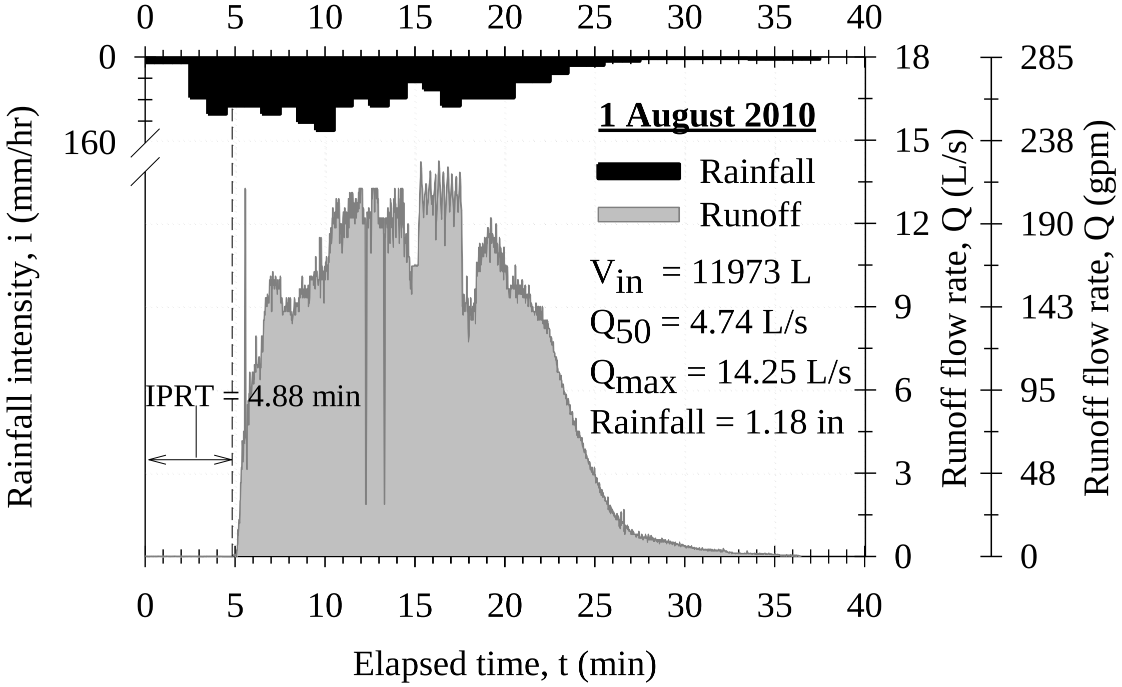


Figure B6: Hydrograph and hyetograph for 1 August 2010 event

On August 1, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 24 dry hours. The peak rainfall intensity is 5.0 in/hr and rainfall depth is 1.18 inches. The storm lasted approximately 36 minutes. The maximum, median, and mean runoff flow rates are 226 gpm, 75 gpm, and 87 gpm, respectively. The influent runoff volume is 3163 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 130.2 mg/L and 15.4 mg/L, respectively, and the removal efficiency is 89%. The influent and effluent SSC is 245.1 mg/L and 7.7 mg/L, respectively, and the removal efficiency is 97%.

Table B7: JF4 Summary: 6 August 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	6 August 2010	Influent Volume:	1393 L (368 gal)
Previous Dry Hours:	120	Event Duration:	104 min
Maximum Flow Rate:	6.80 L/s (107.8 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.01 L/s (0.2 gpm)	Number of Effluent Samples:	8
Mean Flow Rate:	0.27 L/s (4.3 gpm)	Peak Rainfall Intensity:	51 mm/hr (2.0 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	4 mm (0.14 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

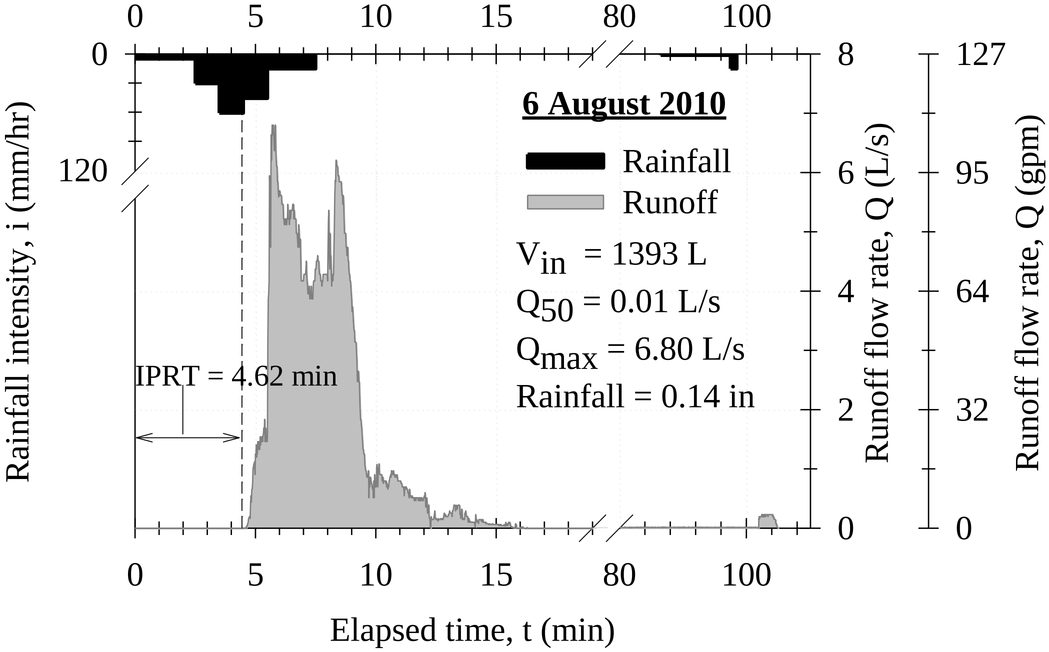


Figure B7: Hydrograph and hyetograph for 6 August 2010 event

On August 6, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 120 dry hours. The peak rainfall intensity is 2.0 in/hr and rainfall depth is 0.14 inch. The storm lasted approximately 104 minutes. The maximum, median, and mean runoff flow rates are 108 gpm, 0.2 gpm, and 4.3 gpm, respectively. The influent runoff volume is 368 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 8 , respectively. The influent and effluent TSS is 77.5 mg/L and 15.0 mg/L, respectively, and the removal efficiency is 86%. The influent and effluent SSC is 308.4 mg/L and 7.3 mg/L, respectively, and the removal efficiency is 98%.

Table B8: JF4 Summary: 7 August 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	7 August 2010	Influent Volume:	2622 L (693 gal)
Previous Dry Hours:	24	Runoff Duration:	48 min
Maximum Flow Rate:	8.24 L/s (130.6 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.43 L/s (6.8 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.90 L/s (14.3 gpm)	Peak Rainfall Intensity:	61 mm/hr (2.4 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	9 mm (0.34 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

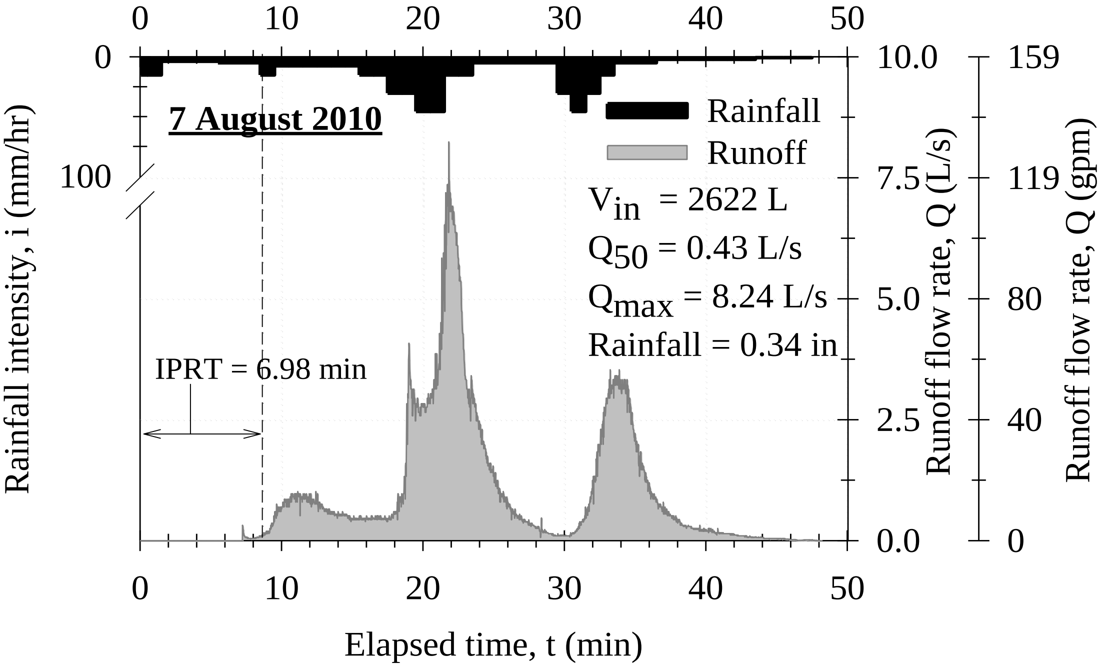


Figure B8: Hydrograph and hyetograph for 7 August 2010 event

On August 7, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 24 dry hours. The peak rainfall intensity is 2.4 in/hr and rainfall depth is 0.34 inch. The storm lasted approximately 48 minutes. The maximum, median, and mean runoff flow rates are 131 gpm, 7 gpm, and 14 gpm, respectively. The influent runoff volume is 693 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 45.3 mg/L and 12.2 mg/L, respectively, and the removal efficiency is 74%. The influent and effluent SSC is 117.1 mg/L and 13.9 mg/L, respectively, and the removal efficiency is 89%.

Table B9: JF4 Summary: 23 August 2010 Hydrology

Event Information		**JF4 Unit Treatment Run information**	
Event Date:	23 August 2010	Influent Volume:	312 L (82 gal)
Previous Dry Hours:	48	Runoff Duration:	42 min
Maximum Flow Rate:	1.25 L/s (19.8 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.01 L/s (0.2 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.12 L/s (2.0 gpm)	Peak Rainfall Intensity:	15 mm/hr (0.6 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	3 mm (0.11 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

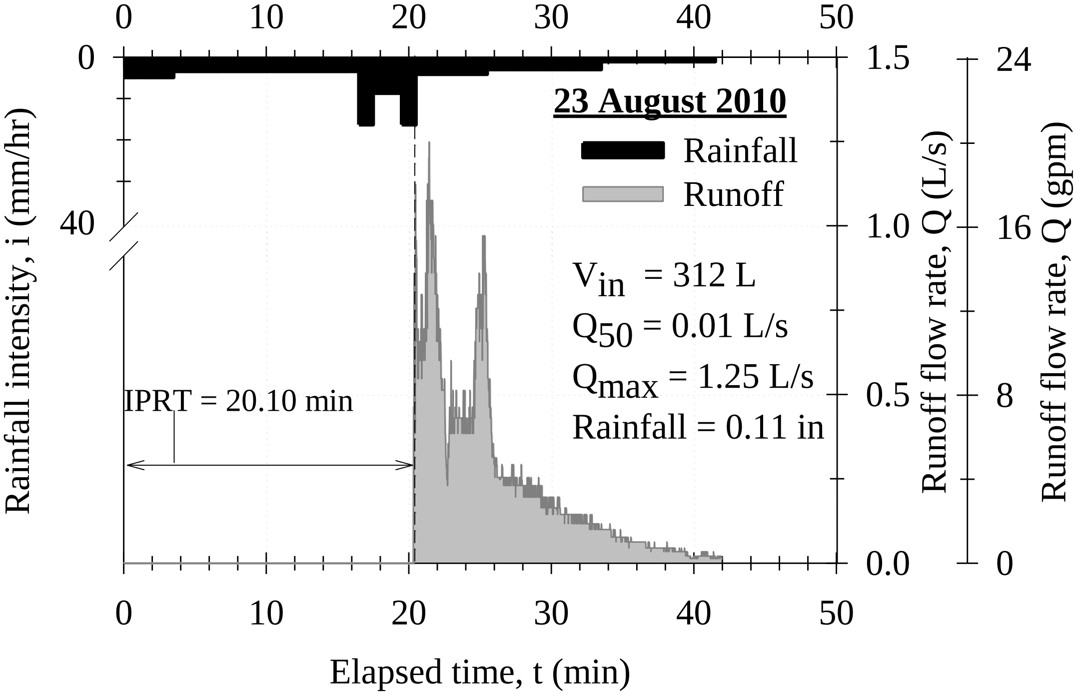


Figure B9: Hydrograph and hyetograph for 23 August 2010 event

On August 23, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 48 dry hours. The peak rainfall intensity is 0.6 in/hr and rainfall depth is 0.11 inch. The storm lasted approximately 42 minutes. The maximum, median, and mean runoff flow rates are 20 gpm, 0.2 gpm, and 2 gpm, respectively. The influent runoff volume is 82 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 74.2 mg/L and 8.2 mg/L, respectively, and the removal efficiency is 93%. The influent and effluent SSC is 555.8 mg/L and 4.7 mg/L, respectively, and the removal efficiency is 100%.

Table B10: JF4 Summary: 12 September 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	12 September 2010	Influent Volume:	1643 L (434 gal)
Previous Dry Hours:	172	Runoff Duration:	52 min
Maximum Flow Rate:	3.85 L/s (61.0 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.10 L/s (1.6 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.53 L/s (8.4 gpm)	Peak Rainfall Intensity:	51 mm/hr (2.0 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	7 mm (0.27 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

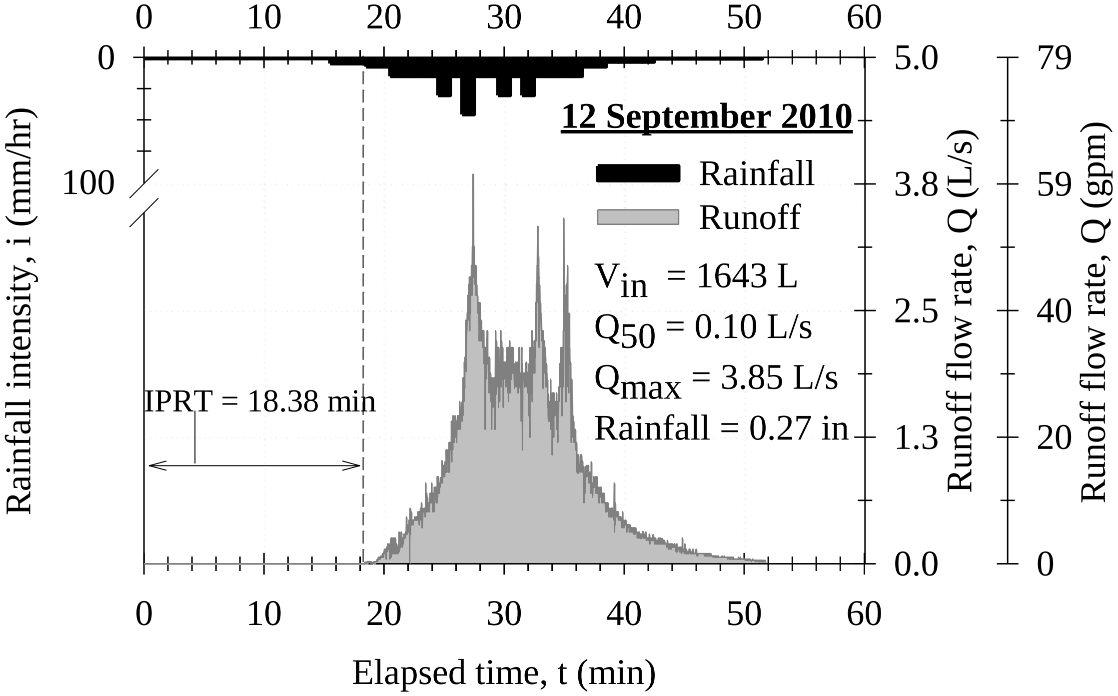


Figure B10: Hydrograph and hyetograph for 12 September 2010 event

On September 12, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 172 dry hours. The peak rainfall intensity is 2.0 in/hr and rainfall depth is 0.27 inch. The storm lasted approximately 52 minutes. The maximum, median, and mean runoff flow rates are 61 gpm, 2 gpm, and 8 gpm, respectively. The influent runoff volume is 434 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 91.2 mg/L and 15.7 mg/L, respectively, and the removal efficiency is 84%. The influent and effluent SSC is 261.5 mg/L and 5.8 mg/L, respectively, and the removal efficiency is 98%.

Table B11: JF4 Summary: 26 September 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	26 September 2010	Influent Volume:	1129 L (298 gal)
Previous Dry Hours:	40	Runoff Duration:	78 min
Maximum Flow Rate:	0.45 L/s (7.1 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.26 L/s (4.1 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.24 L/s (3.8 gpm)	Peak Rainfall Intensity:	5 mm/hr (0.2 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	4 mm (0.14 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

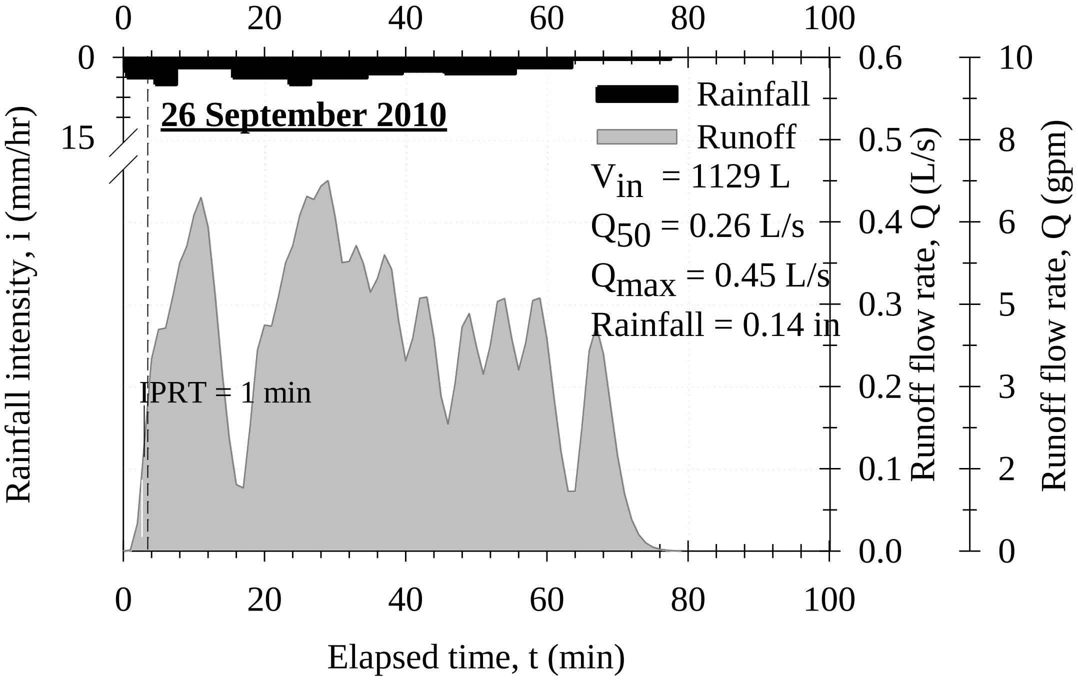


Figure B11: Hydrograph and hyetograph for 26 September 2010 event

On September 26, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 40 dry hours. The peak rainfall intensity is 0.2 in/hr and rainfall depth is 0.14 inch. The storm lasted approximately 78 minutes. The maximum, median, and mean runoff flow rates are 7 gpm, 4 gpm, and 4 gpm, respectively. The influent runoff volume is 298 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 16.3 mg/L and 4.7 mg/L, respectively, and the removal efficiency is 79%. The influent and effluent SSC is 117.9 mg/L and 5.0 mg/L, respectively, and the removal efficiency is 97%.

Table B12: JF4 Summary: 27 September 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	27 September 2010	Influent Volume:	3841 L (1015 gal)
Previous Dry Hours:	10	Runoff Duration:	388 min
Maximum Flow Rate:	10.94 L/s (173.4 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.04 L/s (0.7 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.16 L/s (2.6 gpm)	Peak Rainfall Intensity:	91 mm/hr (3.6 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	15 mm (0.6 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

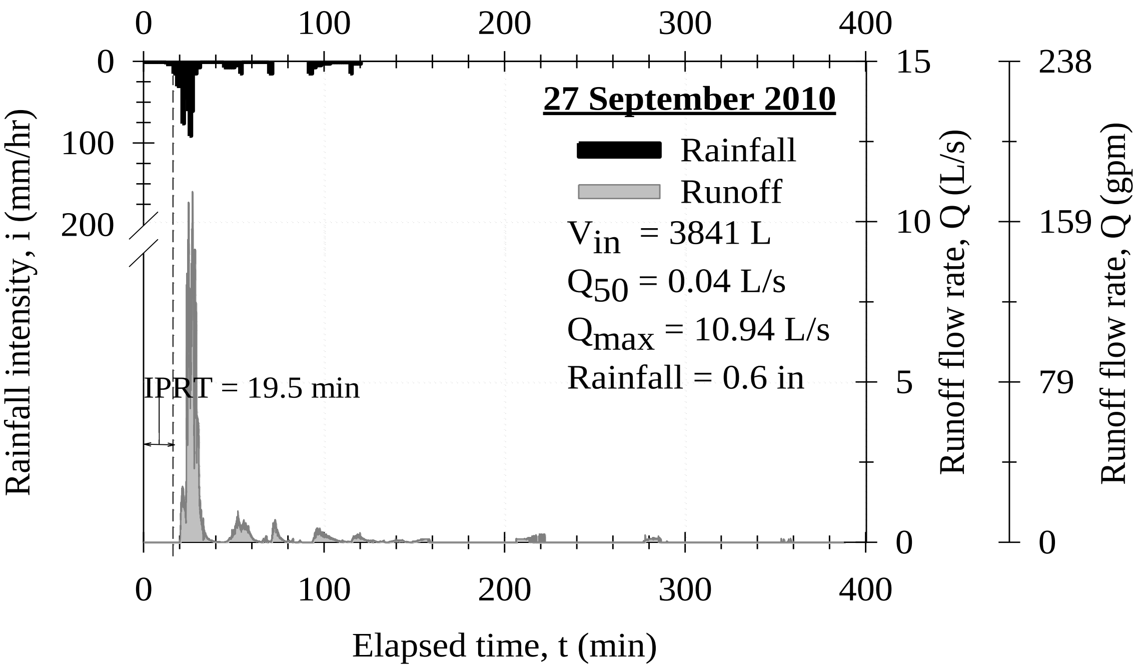


Figure B12: Hydrograph and hyetograph for 27 September 2010 event

On September 27, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 10 dry hours. The peak rainfall intensity is 3.6 in/hr and rainfall depth is 0.60 inch. The storm lasted approximately 388 minutes. The maximum, median, and mean runoff flow rates are 173 gpm, 0.7 gpm, and 2.6 gpm, respectively. The influent runoff volume is 1015 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 51.1 mg/L and 3.2 mg/L, respectively, and the removal efficiency is 94%. The influent and effluent SSC is 765.1 mg/L and 6.0 mg/L, respectively, and the removal efficiency is 99%.

Table B13: JF4 Summary: 4 November 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	4 November 2010	Influent Volume:	994 L (263 gal)
Previous Dry Hours:	910	Runoff Duration:	43 min
Maximum Flow Rate:	3.53 L/s (56.0 gpm)	Number of Influent Samples:	11
Median Flow Rate:	0.12 L/s (1.8 gpm)	Number of Effluent Samples:	11
Mean Flow Rate:	0.38 L/s (6.0 gpm)	Peak Rainfall Intensity:	46 mm/hr (1.8 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	5 mm (0.19 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

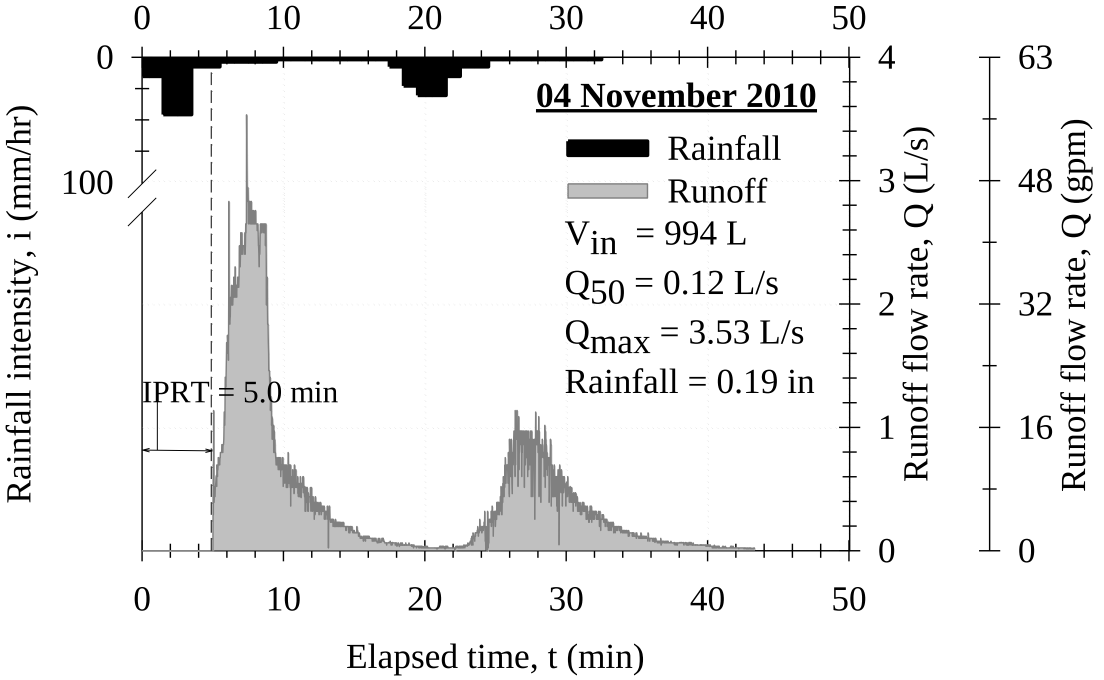


Figure B13: Hydrograph and hyetograph for 4 November 2010 event

On November 4, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 910 dry hours. The peak rainfall intensity is 1.8 in/hr and rainfall depth is 0.19 inch. The storm lasted approximately 43 minutes. The maximum, median, and mean runoff flow rates are 56 gpm, 2 gpm, and 6 gpm, respectively. The influent runoff volume is 263 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 11 and 11, respectively. The influent and effluent TSS is 39.9 mg/L and 4.2 mg/L, respectively, and the removal efficiency is 95%. The influent and effluent SSC is 477.1 mg/L and 10.4 mg/L, respectively, and the removal efficiency is 99%.

Table B14: JF4 Summary: 16 November 2010 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	16 November 2010	Influent Volume:	305 L (81 gal)
Previous Dry Hours:	286	Runoff Duration:	34 min
Maximum Flow Rate:	1.75 L/s (27.7 gpm)	Number of Influent Samples:	11
Median Flow Rate:	0.02 L/s (0.3 gpm)	Number of Effluent Samples:	11
Mean Flow Rate:	0.13 L/s (2.1 gpm)	Peak Rainfall Intensity:	25 mm/hr (1.0 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	3 mm (0.13 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

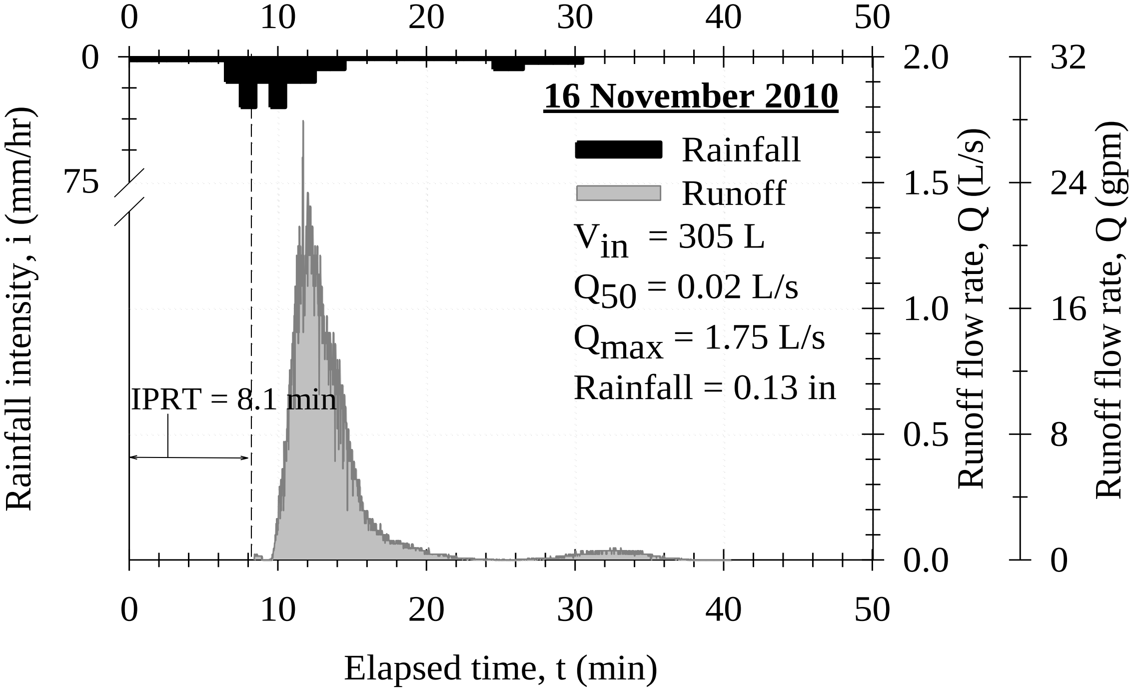


Figure B14: Hydrograph and hyetograph for 16 November 2010 event

On November 16, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 286 dry hours. The peak rainfall intensity is 1.0 in/hr and rainfall depth is 0.13 inch. The storm lasted approximately 34 minutes. The maximum, median, and mean runoff flow rates are 28 gpm, 0.3 gpm, and 2 gpm, respectively. The influent runoff volume is 81 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 11 and 11, respectively. The influent and effluent TSS is 261.0 mg/L and 11.8 mg/L, respectively, and the removal efficiency is 98%. The influent and effluent SSC is 543.6 mg/L and 12.2 mg/L, respectively, and the removal efficiency is 99%.

Table B15: JF4 Summary: 5 January 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	05 January 2011	Influent Volume:	5800 L (1532 gal)
Previous Dry Hours:	72 hr	Event Duration:	125 min
Maximum Flow Rate:	7.36 L/s (116.7 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.16 L/s (2.6 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	1.14 L/s (18.1 gpm)	Peak Rainfall Intensity:	107 mm/hr (4.2 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	21 mm (0.84 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

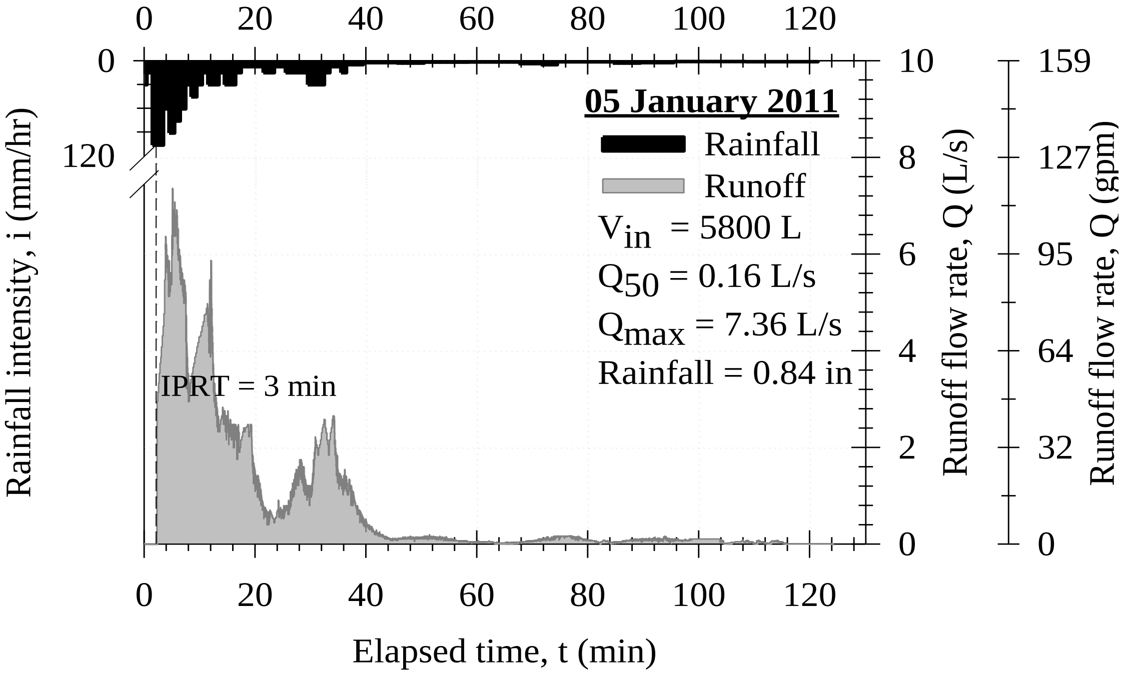


Figure B15: Hydrograph and hyetograph for 5 January 2011 event

On January 5, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 72 dry hours. The peak rainfall intensity is 4.2 in/hr and rainfall depth is 0.84 inches. The storm duration is 125 minutes. The maximum, median, and mean runoff flow rates are 117 gpm, 3 gpm, and 18 gpm, respectively. The influent runoff volume is 1532 gallons. Sampling occurred during the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. This is a The influent and effluent TSS is 152.2 mg/L and 15.9 mg/L, respectively, and the removal efficiency is 91%. The influent and effluent SSC is 693.2 mg/L and 8.7 mg/L, respectively, and the removal efficiency is 99%.

Table B16: JF4 Summary: 10 January 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	10 January 2011	Influent Volume:	1129 L (298 gal)
Previous Dry Hours:	106 hr	Event Duration:	26 min
Maximum Flow Rate:	3.32 L/s (52.6 gpm)	Number of Influent Samples:	8
Median Flow Rate:	0.1 L/s (1.6 gpm)	Number of Effluent Samples:	8
Mean Flow Rate:	0.41 L/s (6.5 gpm)	Peak Rainfall Intensity:	91 mm/hr (3.6 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	5 mm (0.20 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

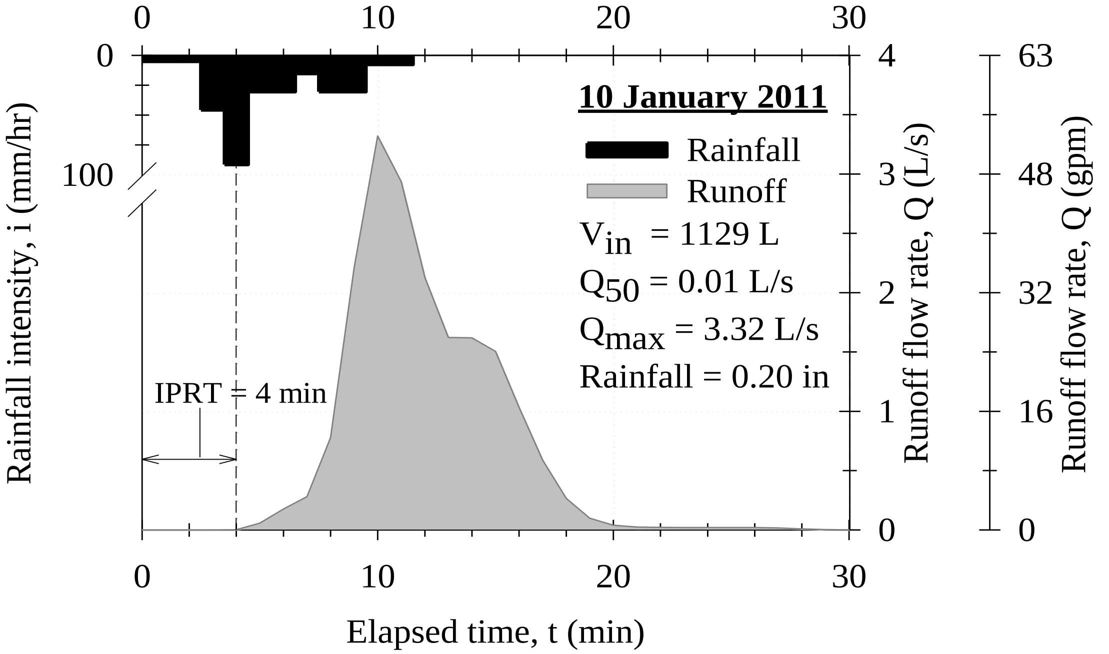


Figure B16: Hydrograph and hyetograph for 10 January 2011 event

On January 10, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 106 dry hours. The peak rainfall intensity is 3.6 in/hr and rainfall depth is 0.20 inch. The storm lasted approximately 26 minutes. The maximum, median, and mean runoff flow rates are 53 gpm, 0.2 gpm, and 7 gpm, respectively. The influent runoff volume is 298 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 8 and 8, respectively. The influent and effluent TSS is 80.7 mg/L and 6.6 mg/L, respectively, and the removal efficiency is 92%. The influent and effluent SSC is 211.1 mg/L and 3.0 mg/L, respectively, and the removal efficiency is 99%.

Table B17: JF4 Summary: 25 January 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	25 January 2011	Influent Volume:	12387 L (3273 gal)
Previous Dry Hours:	365 hr	Runoff Duration:	389 min
Maximum Flow Rate:	4.09 L/s (64.8 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.39 L/s (6.2 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.53 L/s (8.4 gpm)	Peak Rainfall Intensity:	18 mm/hr (0.7 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	44 mm (1.74 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

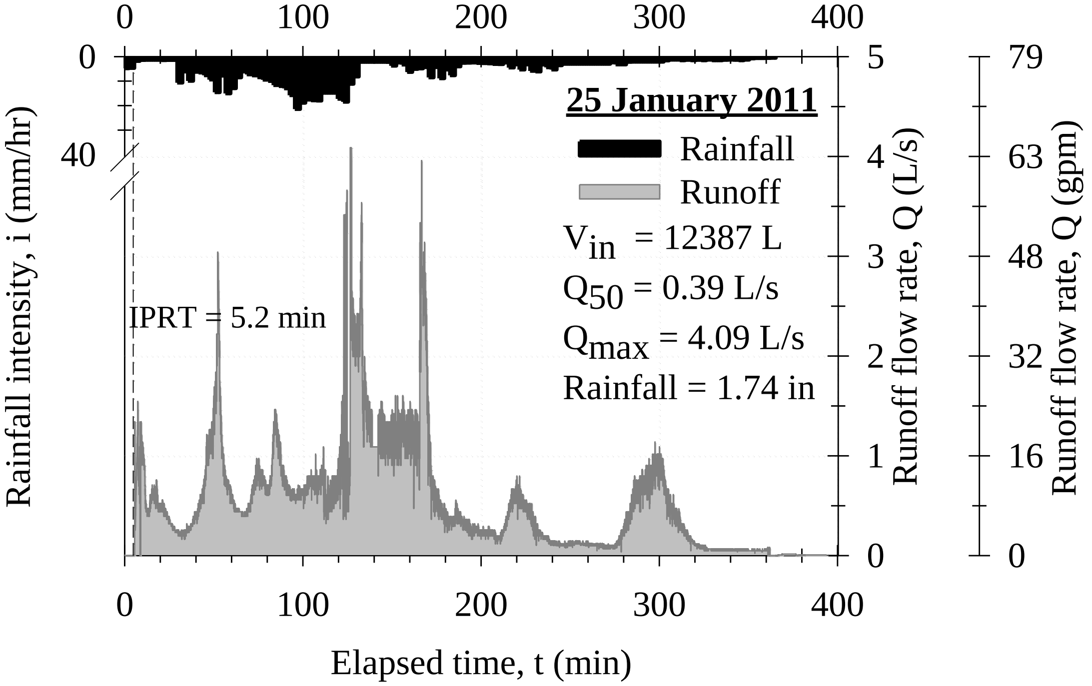


Figure B17: Hydrograph and hyetograph for 25 January 2011 event

On January 25, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 365 dry hours. The peak rainfall intensity is 0.7 in/hr and rainfall depth is 1.74 inch. The storm lasted approximately 389 minutes. The maximum, median, and mean runoff flow rates are 65 gpm, 6 gpm, and 8 gpm, respectively. The influent runoff volume is 3273 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 69.8 mg/L and 7.1 mg/L, respectively, and the removal efficiency is 90%. The influent and effluent SSC is 105.8 mg/L and 4.1 mg/L, respectively, and the removal efficiency is 96%.

Table B18: JF4 Summary: 7 February 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	07 February 2011	Influent Volume:	13229 L (3495 gal)
Previous Dry Hours:	12 hr	Runoff Duration:	306 min
Maximum Flow Rate:	2.22 L/s (35.2 gpm)	Number of Influent Samples:	11
Median Flow Rate:	0.77 L/s (12.1 gpm)	Number of Effluent Samples:	11
Mean Flow Rate:	0.71 L/s (11.2 gpm)	Peak Rainfall Intensity:	30 mm/hr (1.2 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	32.8 mm (1.29 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

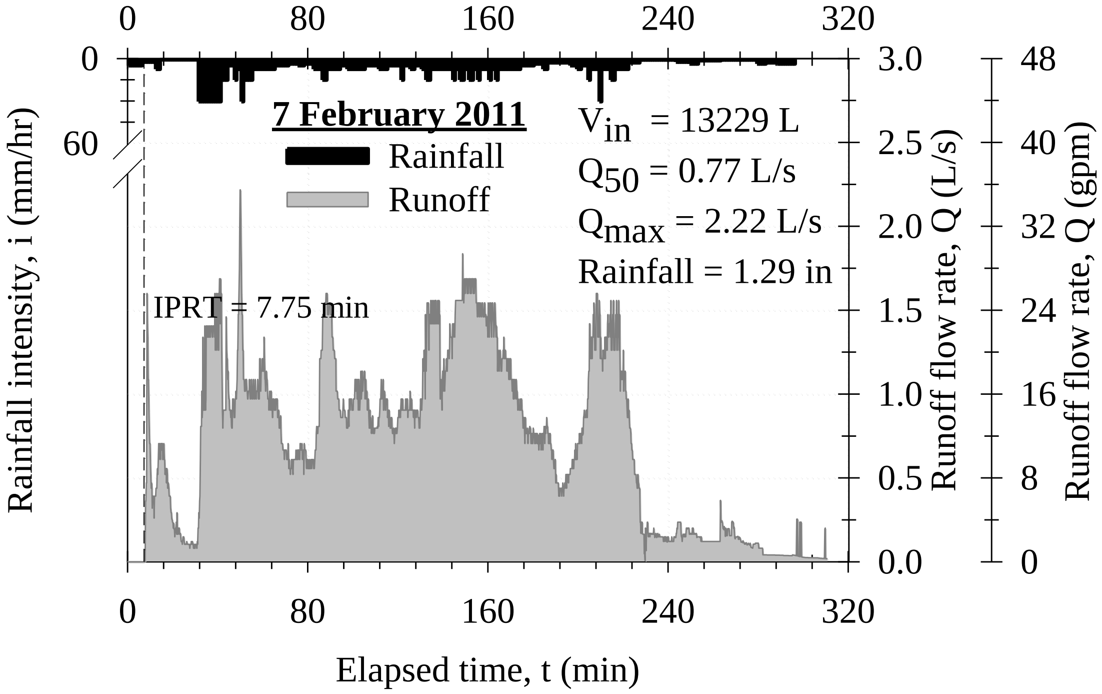


Figure B18: Hydrograph and hyetograph for 7 February 2011 event

On February 7, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 12 dry hours. The peak rainfall intensity is 1.2 in/hr and rainfall depth is 1.29 inch. The storm lasted approximately 306 minutes. The maximum, median, and mean runoff flow rates are 35 gpm, 12 gpm, and 11 gpm, respectively. The influent runoff volume is 3495 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 11 and 11, respectively. The influent and effluent TSS is 34.8 mg/L and 5.3 mg/L, respectively, and the removal efficiency is 85%. The influent and effluent SSC is 438.3 mg/L and 7.6 mg/L, respectively, and the removal efficiency is 98%.

Table B19: JF4 Summary: 9 March 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	09 March 2011	Influent Volume:	10051 L (2656 gal)
Previous Dry Hours:	79 hr	Runoff Duration:	691 min
Maximum Flow Rate:	3.13 L/s (49.7 gpm)	Number of Influent Samples:	12
Median Flow Rate:	0.10 L/s (1.6 gpm)	Number of Effluent Samples:	12
Mean Flow Rate:	0.24 L/s (3.8 gpm)	Peak Rainfall Intensity:	15 mm/hr (0.6 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	29.2 mm (1.15 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

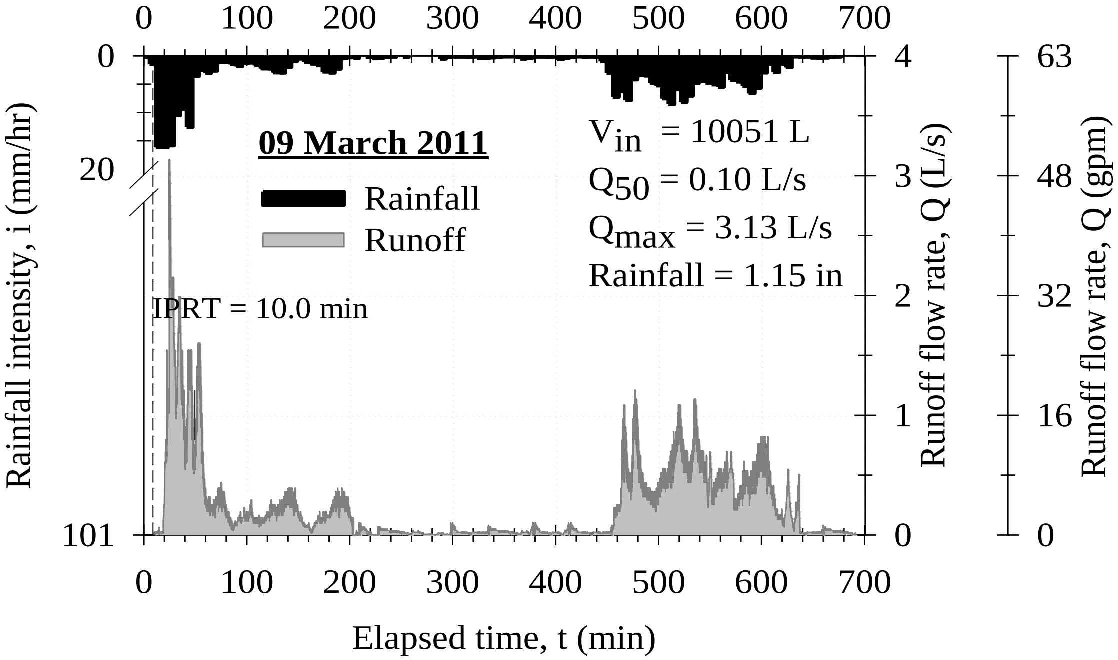


Figure B19: Hydrograph and hyetograph for 9 March 2011 event

On March 9, 2010, the JF4 unit treated a rainfall-runoff event. The event occurred after 79 dry hours. The peak rainfall intensity is 0.6 in/hr and rainfall depth is 1.15 inch. The storm lasted approximately 691 minutes. The maximum, median, and mean runoff flow rates are 50 gpm, 2 gpm, and 4 gpm, respectively. Influent volume is 2656 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 12 and 12, respectively. The influent and effluent TSS is 30.5 mg/L and 8.3 mg/L, respectively, and the removal efficiency is 73%. The influent and effluent SSC is 78.2 mg/L and 2.8 mg/L, respectively, and the removal efficiency is 97%.

Table B20: JF4 Summary: 28 March 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	28 March 2011	Influent Volume:	522 L (138 gal)
Previous Dry Hours:	438 hr	Event Duration:	66 min
Maximum Flow Rate:	1.03 L/s (16.4 gpm)	Number of Influent Samples:	12
Median Flow Rate:	0.06 L/s (0.9 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.13 L/s (2.1 gpm)	Peak Rainfall Intensity:	33 mm/hr (1.3 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	2.5 mm (0.10 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

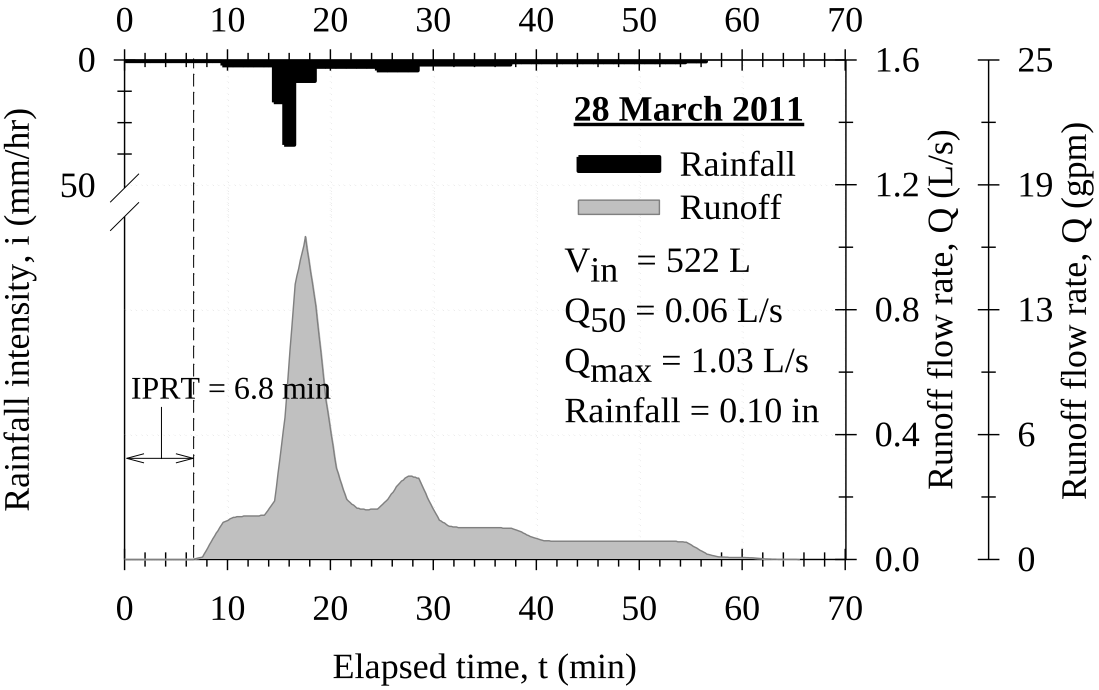


Figure B20: Hydrograph and hyetograph for 28 March 2011 event

On March 28, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 438 dry hours. The peak rainfall intensity is 1.3 in/hr and rainfall depth is 0.10 inch. The storm lasted approximately 66 minutes. The maximum, median, and mean runoff flow rates are 16 gpm, 1 gpm, and 2 gpm, respectively. The influent runoff volume is 138 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 12 and 10, respectively. The influent and effluent TSS is 68.4 mg/L and 12.7 mg/L, respectively, and the removal efficiency is 86%. The influent and effluent SSC is 102.8 mg/L and 5.6 mg/L, respectively, and the removal efficiency is 96%.

Table B21: JF4 Summary: 30 March 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	30 March 2011	Influent Volume:	3707L (979 gal)
Previous Dry Hours:	48 hr	Event Duration:	179 min
Maximum Flow Rate:	5.61 L/s (89.0 gpm)	Number of Influent Samples:	12
Median Flow Rate:	0.10 L/s (1.6 gpm)	Number of Effluent Samples:	12
Mean Flow Rate:	0.29 L/s (4.5 gpm)	Peak Rainfall Intensity:	76 mm/hr (3.0 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	15 mm (0.60 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

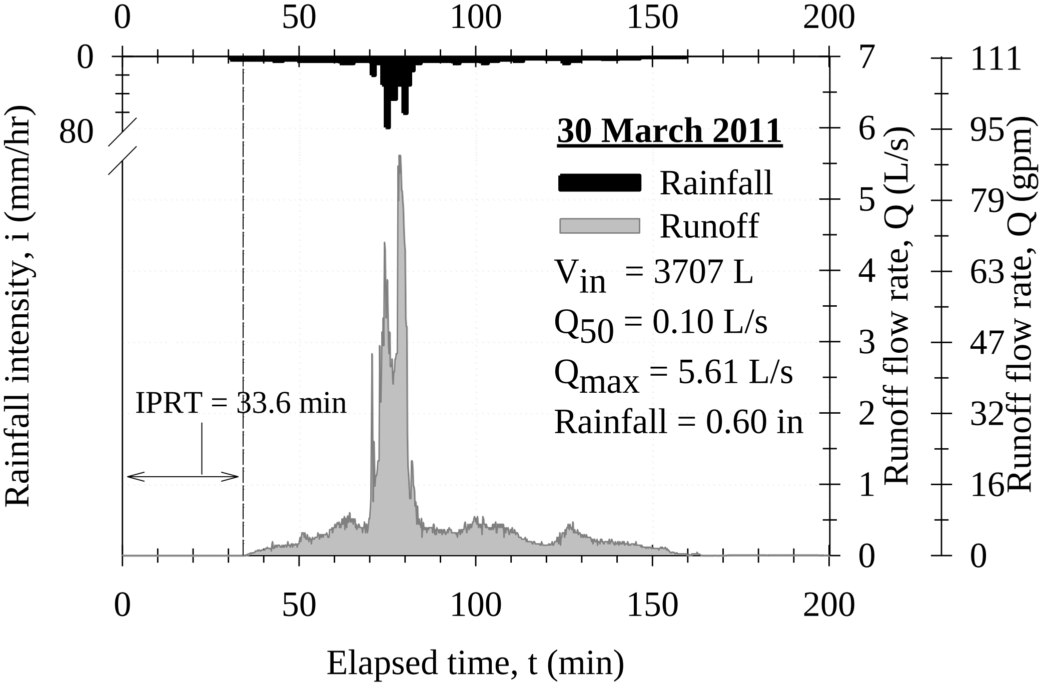


Figure B21: Hydrograph and hyetograph for 30 March 2011 event

On March 30, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 48 dry hours. The peak rainfall intensity is 3 in/hr and rainfall depth is 0.60 inch. The storm lasted approximately 179 minutes. The maximum, median, and mean runoff flow rates are 89 gpm, 2 gpm, and 5 gpm, respectively. The influent runoff volume is 979 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 12 and 12, respectively. The influent and effluent TSS is 104.5 mg/L and 7.3 mg/L, respectively, and the removal efficiency is 93%. The influent and effluent SSC is 443.7 mg/L and 7.3 mg/L, respectively, and the removal efficiency is 98%.

Table B22: JF4 Summary: 20 April 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	20 April 2011	Influent Volume:	206 L (54 gal)
Previous Dry Hours:	196 hr	Event Duration:	61 min
Maximum Flow Rate:	3.28 L/s (52.0 gpm)	Number of Influent Samples:	12
Median Flow Rate:	0.01 L/s (0.1 gpm)	Number of Effluent Samples:	12
Mean Flow Rate:	0.06 L/s (0.9 gpm)	Peak Rainfall Intensity:	15 mm/hr (0.6 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	4 mm (0.14 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

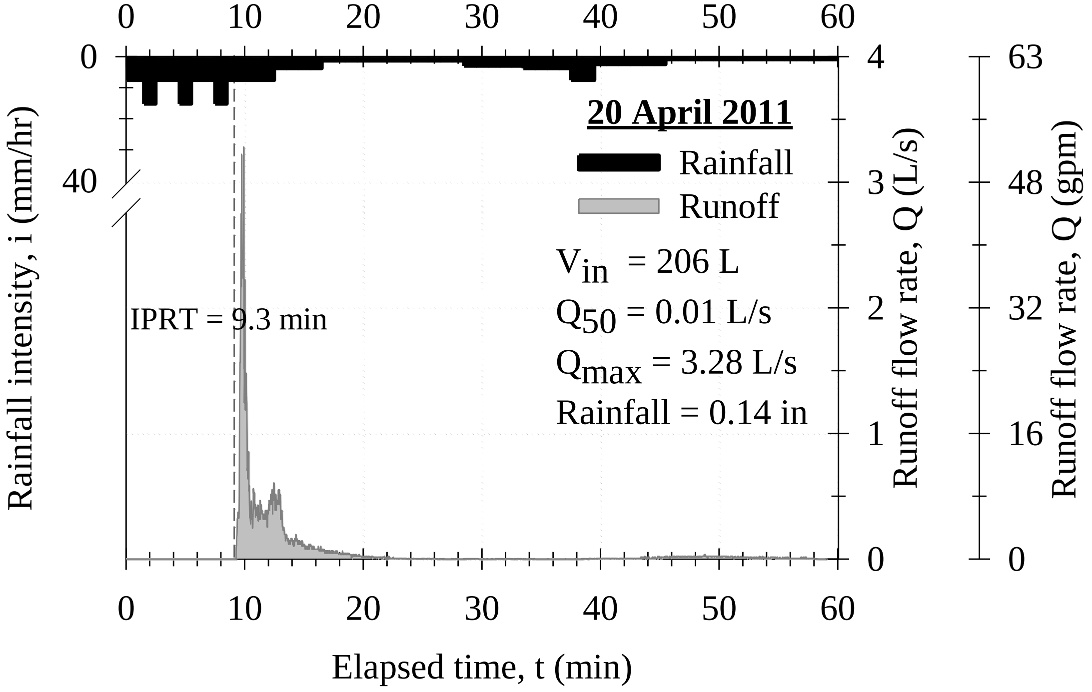


Figure B22: Hydrograph and hyetograph for 20 April 2011 event

On April 20, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 196 dry hours. The peak rainfall intensity is 0.6 in/hr and rainfall depth is 0.14 inch. The storm lasted approximately 61 minutes. The maximum, median, and mean runoff flow rates are 52 gpm, 0.1 gpm, and 0.9 gpm, respectively. The influent runoff volume is 54 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 12 and 12, respectively. The influent and effluent TSS is 143.7 mg/L and 11.4 mg/L, respectively, and the removal efficiency is 96%. The influent and effluent SSC is 921.7 mg/L and 6.1 mg/L, respectively, and the removal efficiency is 100%.

Table B23: JF4 Summary:14 May 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	14 May 2011	Influent Volume:	11256 L (2974 gal)
Previous Dry Hours:	188 hr	Event Duration:	295 min
Maximum Flow Rate:	7.53 L/s (119.3 gpm)	Number of Influent Samples:	19
Median Flow Rate:	0.02 L/s (0.36 gpm)	Number of Effluent Samples:	19
Mean Flow Rate:	0.63 L/s (9.98 gpm)	Peak Rainfall Intensity:	137 mm/hr (5.4 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	50 mm (1.98 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

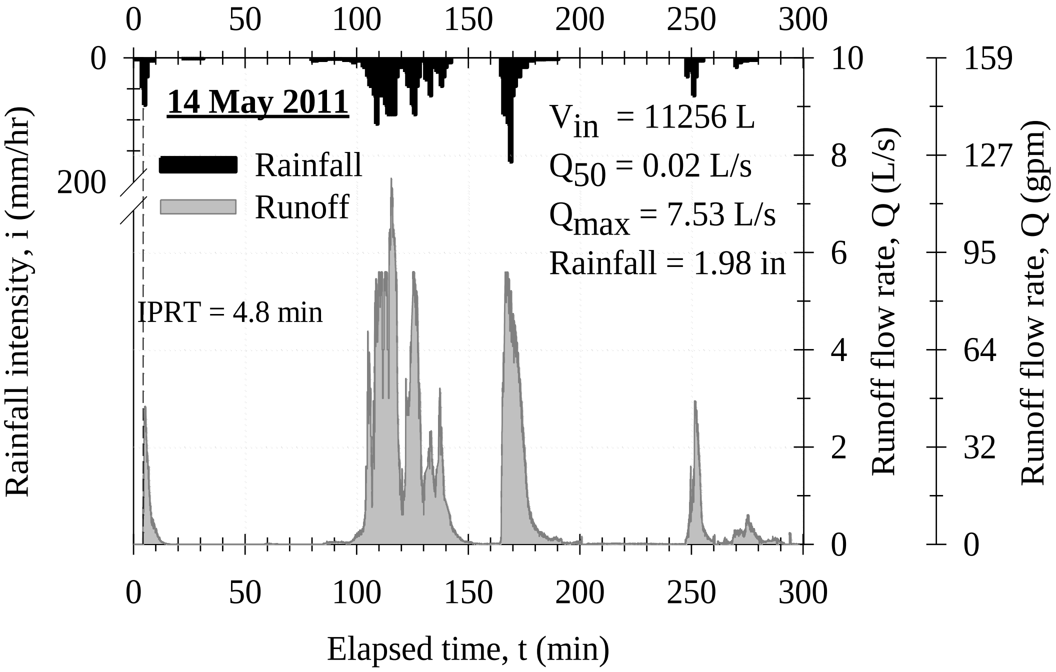


Figure B23: Hydrograph and hyetograph for 14 May 2011 event

On May 14, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 188 dry hours. The peak rainfall intensity is 5.4 in/hr and rainfall depth is 1.98 inch. The storm lasted approximately 295 minutes. The maximum, median, and mean runoff flow rates are 119.3 gpm, 0.4 gpm, and 10.0 gpm, respectively. The influent runoff volume is 2,974 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 19 and 19, respectively. The influent and effluent TSS is 77.1 mg/L and 12.5 mg/L, respectively, and the removal efficiency is 84%. The influent and effluent SSC is 487.3 mg/L and 5.3 mg/L, respectively, and the removal efficiency is 99%.

Table B24: JF4 Summary:6 June 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	6 June 2011	Influent Volume:	960 L (254 gal)
Previous Dry Hours:	541 hr	Event Duration:	69 min
Maximum Flow Rate:	1.55 L/s (24.5 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.01 L/s (0.1 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.23 L/s (3.7 gpm)	Peak Rainfall Intensity:	23 mm/hr (0.9 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	4 mm (0.16 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

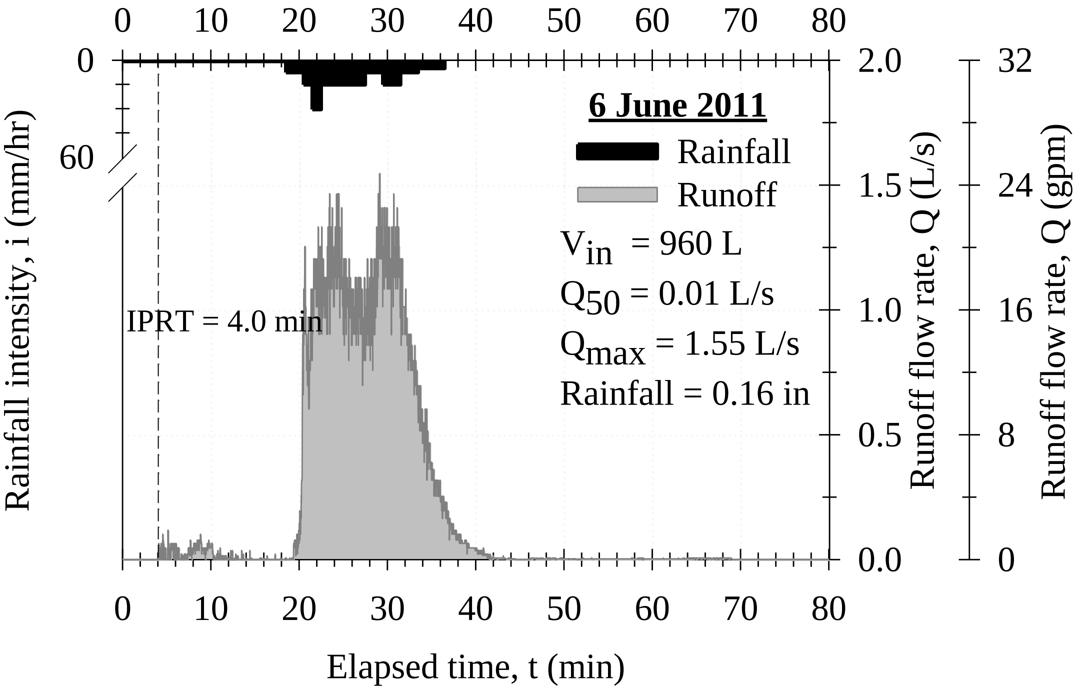


Figure B24: Hydrograph and hyetograph for 6 June 2011 event

On June 6, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 541 dry hours. The peak rainfall intensity is 0.9 in/hr and rainfall depth is 0.16 inch. The storm lasted approximately 69 minutes. The maximum, median, and mean runoff flow rates are 24.5 gpm, 0.1 gpm, and 3.7 gpm, respectively. The influent runoff volume is 254 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 85.6 mg/L and 13.2 mg/L, respectively, and the removal efficiency is 88%. The influent and effluent SSC is 237.5 mg/L and 9.0 mg/L, respectively, and the removal efficiency is 97%.

Table B25: JF4 Summary: 27 June 2011 Hydrology

Event Information		JF4 Unit Treatment Run information	
Event Date:	27 June 2011	Influent Volume:	3383 L (894 gal)
Previous Dry Hours:	88 hr	Event Duration:	50 min
Maximum Flow Rate:	3.35 L/s (53.2 gpm)	Number of Influent Samples:	10
Median Flow Rate:	0.12 L/s (2.0 gpm)	Number of Effluent Samples:	10
Mean Flow Rate:	0.64 L/s (10.1 gpm)	Peak Rainfall Intensity:	43 mm/hr (1.7 inch/hr)
Experimental Site:	UF Engineering Surface Parking	Rainfall Depth:	11 mm (0.45 inch)
TARP Qualifying:	YES	Site Location:	Gainesville, FL

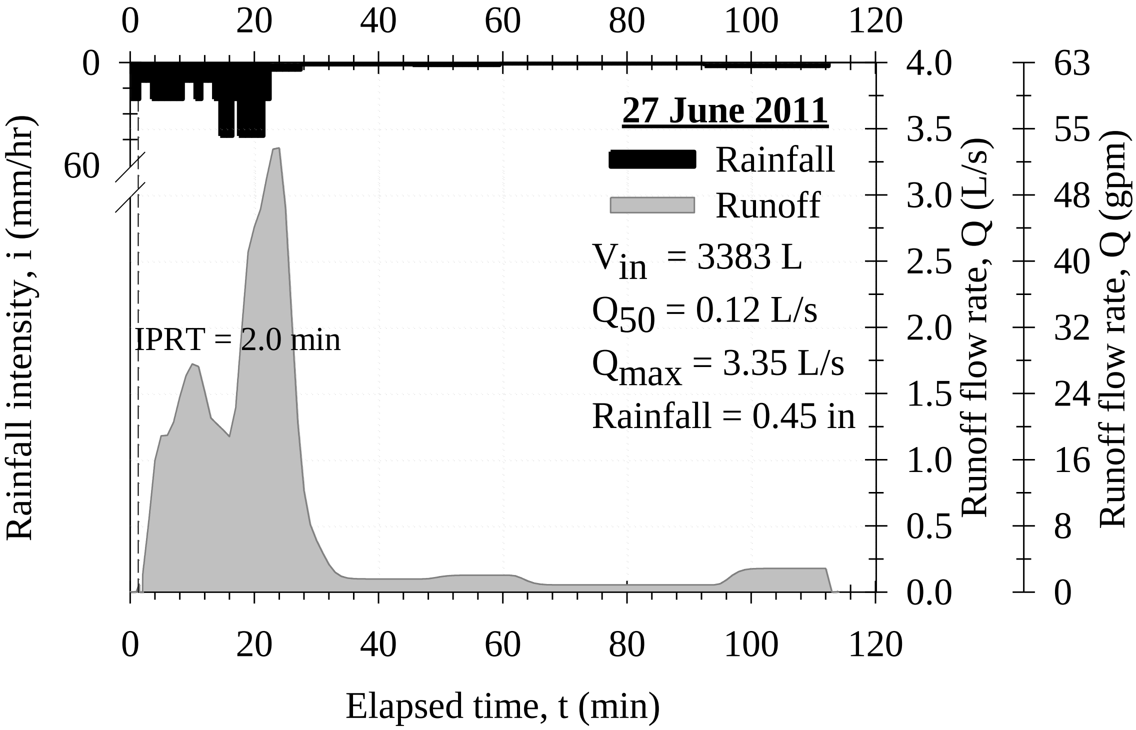


Figure B25: Hydrograph and hyetograph for 27 June 2011 event

On June 27, 2011, the JF4 unit treated a rainfall-runoff event. The event occurred after 88 dry hours. The peak rainfall intensity is 1.7 in/hr and rainfall depth is 0.45 inch. The storm lasted approximately 50 minutes. The maximum, median, and mean runoff flow rates are 53 gpm, 2 gpm, and 10 gpm, respectively. The influent runoff volume is 894 gallons. Sampling occurred throughout the entire duration of the storm and the number of influent and effluent samples taken is 10 and 10, respectively. The influent and effluent TSS is 131.4 mg/L and 12.8 mg/L, respectively, and the removal efficiency is 91%. The influent and effluent SSC is 591.7 mg/L and 9.8 mg/L, respectively, and the removal efficiency is 98%.

APPENDIX C

Hydraulic Testing of the Jellyfish® Filter JF4-2-1

Extensive hydraulic testing was conducted at the University of Florida on a new clean 54-inch long Jellyfish® filtration cartridge with various orifice sizes in the cartridge lid. Hydraulic testing was also been conducted on the Jellyfish Filter JF4-2-1 with the standard 70 mm lid orifice on each of the two hi-flo cartridges and the standard 35 mm lid orifice on the single draindown cartridge, and was performed on the system with clean cartridges prior to commissioning as well as with dirty cartridges at the conclusion of the monitoring period (25 monitored storm events and 15 inches of cumulative rainfall).

Figure C1 depicts the hydraulic response curve for a new clean 54-inch Jellyfish filtration cartridge with a very large orifice in the cartridge lid, in this case an 11-inch diameter orifice. The very large opening in the cartridge lid allowed determination of the hydraulic response of the cartridge itself with essentially no flow restriction from the lid orifice. Test results demonstrate a clean-cartridge flow capacity of 180 gpm at 18 inches of driving head, which is much higher than the design treatment flow rate of a hi-flo cartridge (80 gpm with 70 mm lid orifice) or a draindown cartridge (40 gpm with 35 mm orifice) at 18 inches of driving head. The cartridge has capacity to tolerate a significant degree of particulate matter (PM) loading and occlusion while maintaining design flow rate at design driving head.

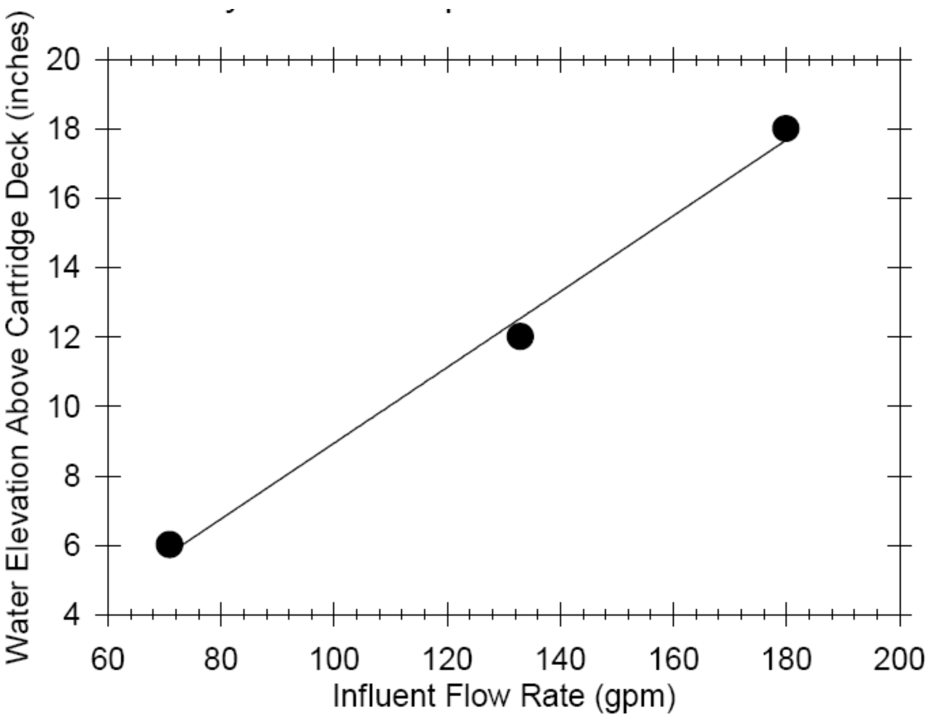


Figure C1: Hydraulic response of a clean 54-inch long Jellyfish filtration cartridge with an 11-inch diameter lid orifice. Assuming no flow restriction from the very large lid orifice, this is essentially the hydraulic response of the clean cartridge itself.

Figure C2 depicts the hydraulic response curve for a new clean 54-inch Jellyfish filtration cartridge with a 35 mm orifice in the cartridge lid, which is the standard lid orifice for the draindown cartridge. Test results demonstrate a flow capacity of 44 gpm at 18 inches of driving head. Imbrium Systems assigns a design treatment flow rate of 40 gpm to the draindown cartridge used in the Jellyfish Filter JF4-2-1.

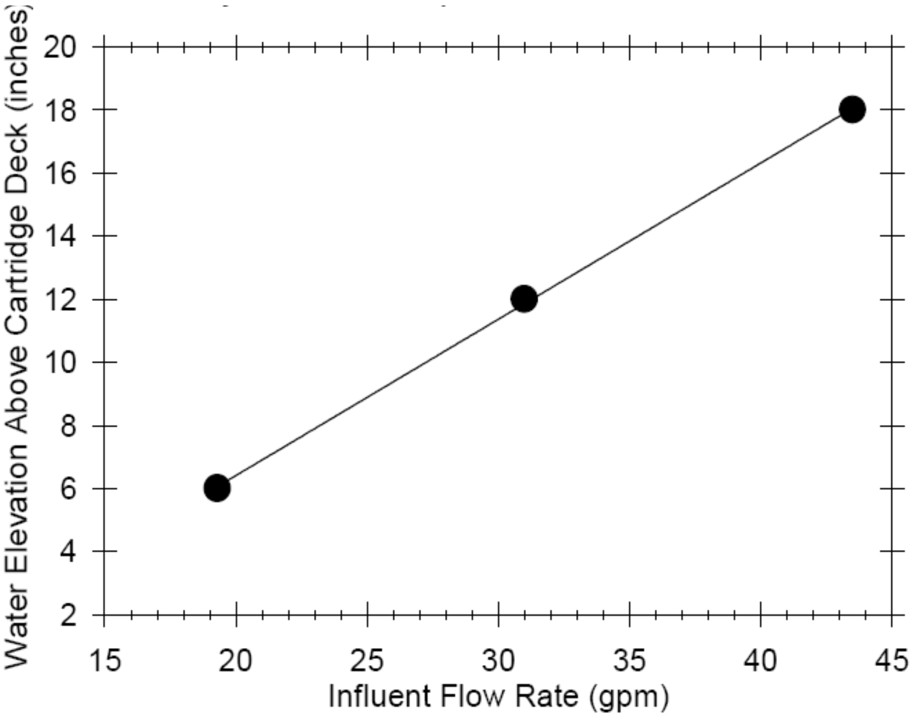


Figure C2: Hydraulic response of a clean 54-inch long Jellyfish filtration cartridge with a 35 mm lid orifice, used as the draindown cartridge in the JF4-2-1.

Figure C3 depicts the hydraulic response curve for a new clean 54-inch Jellyfish filtration cartridge with a 70 mm orifice in the cartridge lid, which is the standard lid orifice for each of the hi-flo cartridges. Test results demonstrate a flow capacity of 116 gpm at 18 inches of driving head and 88 gpm at 12 inches of driving head. Since each hi-flo cartridge is located within the 6-inch high backwash pool weir, the net available driving head for the hi-flo cartridge is 12 inches. Imbrium Systems assigns a design treatment flow rate of 80 gpm to each hi-flo cartridge used in the Jellyfish Filter JF4-2-1.

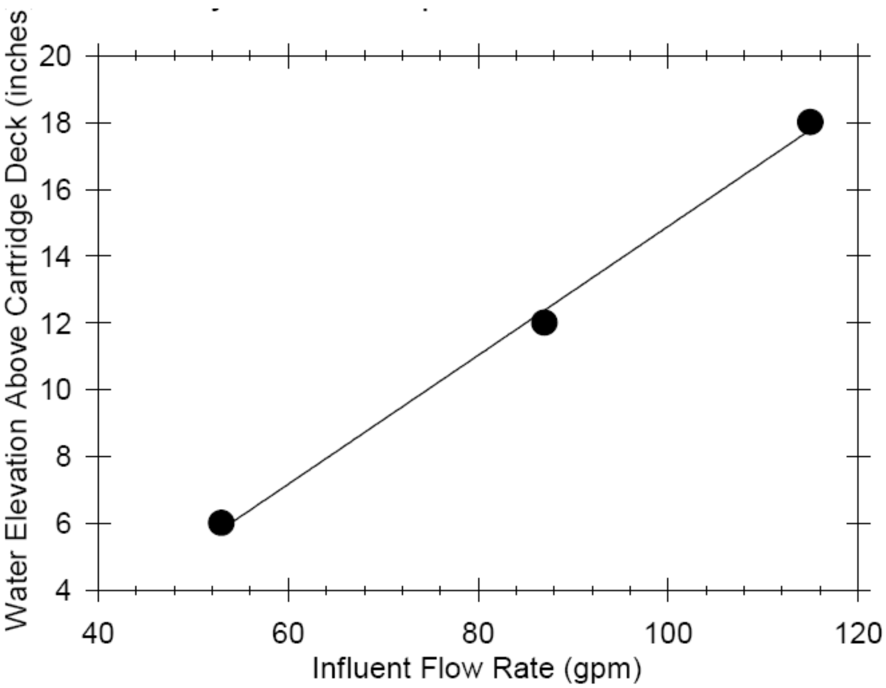


Figure C3: Hydraulic response of a clean 54-inch long Jellyfish filtration cartridge with a 70 mm lid orifice, used for each hi-flo cartridge in the JF4-2-1.

Figure C4 depicts the hydraulic response curves for the Jellyfish Filter JF4-2-1, which uses three 54-inch long Jellyfish filtration cartridges, one deployed as the draindown cartridge and two deployed as hi-flo cartridges. Hydraulic testing was performed with clean new cartridges prior to commissioning the system for field testing, and with dirty cartridges at the conclusion of monitoring after 25 storm events and 15 inches of cumulative rainfall. Test results demonstrate a flow capacity of 200 gpm at 18 inches of driving head for the JF4-2-1 with clean cartridges, which is the design treatment flow rate of the system. The hydraulic response curves are virtually identical for the system with clean cartridges and with dirty cartridges up to 18 inches of driving head, despite the capture of 166 pounds (dry basis) of PM mass during the monitoring period. These results indicate that the system has volumetric capacity to capture a much greater PM load.

The divergence of the curves beyond 18 inches of driving head is attributed to a difference in the height of the pressure relief pipe during the hydraulic tests. During hydraulic testing with clean cartridges prior to commissioning the system, the pressure relief pipe height was 18 inches. At driving head greater than 18 inches, the pressure relief pipe began to overflow, resulting in a relatively flat response curve from that point forward as flow rate increased. The pressure relief pipe height was subsequently increased to 24 inches prior to commissioning the system in order to eliminate any possibility of internal bypassing of water during the monitoring period, An external bypass was installed around the treatment unit and configured to begin bypassing influent if driving head exceeded 18 inches during a storm event. Hydraulic testing was performed on the JF4-2-1 with the dirty cartridges after the external bypass was disassembled and with the 24-inch high pressure relief pipe intact, resulting in a response curve with gradually increasing slope as flow rate increased with driving head between 18 and 24 inches.

After completing hydraulic testing on the JF4-2-1 with dirty cartridges, the draindown time of water within the 6-inch high backwash pool weir was measured, ranging 101-120 seconds. The backwash pool is designed as a passive self-cleaning mechanism, and provides a reverse flow of water through the hi-flo cartridges when influent flow ceases. Water below the cartridge deck is displaced through the draindown cartridge and discharged to the top of the cartridge deck and subsequently to the outlet pipe. The backwash pool draindown time of approximately 2 minutes indicates that the degree of PM occlusion on the dirty hi-flo and draindown cartridges did not appear to significantly impede water flow through the cartridges during passive backwash.

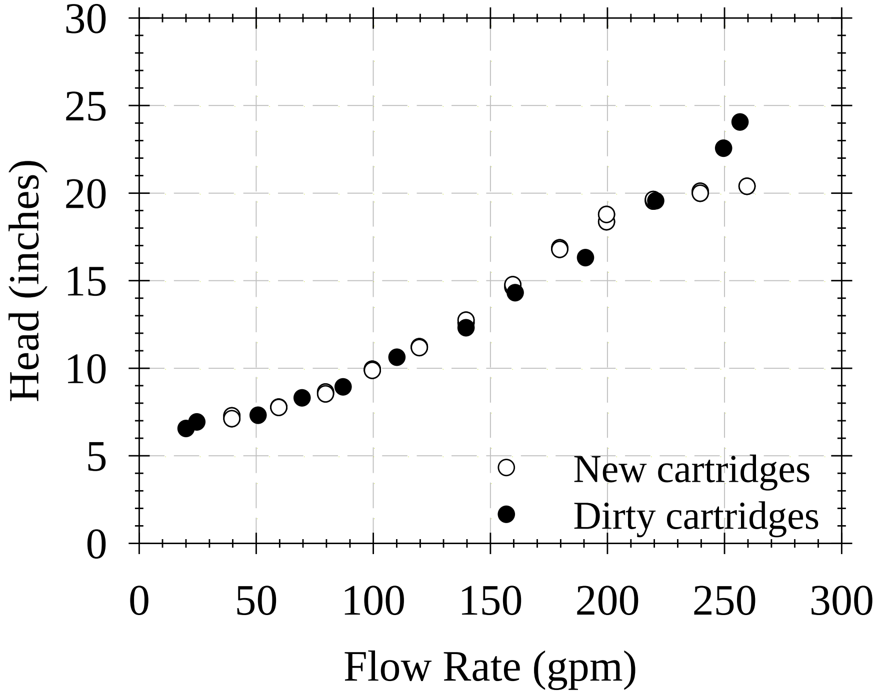


Figure C4: Hydraulic response of the Jellyfish Filter JF4-2-1 with clean cartridges prior to commissioning and with dirty cartridges after the monitoring period (25 storm events, 15 inches of cumulative rainfall, 28,453 gallons of treated runoff, and 166 pounds of captured PM mass)

After completing hydraulic testing of the JF4-2-1 with the dirty cartridges, a manual backflush of the dirty cartridges was performed using a Jellyfish® Cartridge Backflush Pipe to simulate a typical annual maintenance activity. The backflush pipe is a 40-inch tall, 12-inch diameter hollow tube fitted with a flush valve and flapper on the inside bottom, and a compressible gasket on the lower end. In order to manually backflush a cartridge, the cartridge lid is removed and the backflush pipe is placed over the cartridge receptacle with the compressible gasket resting squarely on the receptacle. The pipe is filled with clean water using a hose, and the weight of the water causes the compressible gasket to form a water-tight seal on the receptacle. A wire connected to the internal flapper valve is then pulled, which raises the flapper and allows the contents of the pipe to drain out and backflush the cartridge. Since the pipe is 40 inches tall, the head of backflush water is significantly higher than the typical 18 inches of driving head that a cartridge might experience during peak treatment forward flow. The pipe is designed to provide a significant backflush volume and relatively high backflush flow rate in order to effectively remove accumulated sediment from the filter surfaces. The backflush pipe holds approximately 18 gallons of water when full, with 14 gallons of that total in the uppermost 30 inches of pipe, which is the distance from the top of the pipe to the top of the flapper valve when in the open position.

The time to drain the uppermost 30 inches of backflush pipe volume (14 gallons) was measured for all three cartridges and determined to be approximately 8 seconds in each case, which equates to an average backflush flow rate of approximately 105 gpm for each cartridge. Hydraulic testing was subsequently performed on the JF4-2-1 with the manually backflushed cartridges. As expected, the hydraulic response curve was virtually identical to the system with clean new cartridges and with dirty cartridges as determined earlier. This indicates that the degree of sediment occlusion on the dirty cartridges was not significant enough to result in an increase in hydraulic capacity after manual backflushing. Prior to manual backflushing of the cartridges, 158 pounds of dry basis pollutant mass was recovered from the sump. After manual backflushing of the cartridges, a very small amount of additional pollutant mass (0.1 pounds dry basis) was recovered from the sump. This indicates that each dirty cartridge contained sufficient porosity to allow passage of a relatively high backflush flow rate such that minimal PM was dislodged from the cartridges, despite the presence of 2.6 pounds of PM mass on each cartridge (established by later manual rinsing of each cartridge as described below).

After completing hydraulic testing of the JF4-2-1 with manually backwashed cartridges, the cartridges were removed from the system and rinsed with a garden hose sprayer as part of the PM mass recovery and to simulate a typical maintenance activity. Accumulated PM was easily removed from the cartridges with rinsing, and a pollutant mass of 2.6 pounds (dry basis) was recovered from each cartridge, for a total of approximately 8 pounds. PM mass recovered from the sump was 158 pounds, for a total dry basis PM mass recovery of 166 pounds. The uniform and relatively low quantity of pollutant mass found on the cartridges indicates that self-cleaning mechanisms are effective in removing accumulated PM from both the hi-flo cartridges and the draindown cartridge.

Hydraulic testing was subsequently performed on the JF4-2-1 with the manually rinsed cartridges. As expected, the hydraulic response curve was virtually identical to the system with clean new cartridges, with dirty cartridges, and with manually backwashed cartridges as determined earlier. This indicates that the degree of sediment occlusion on the dirty cartridges was not significant enough to result in an increase in hydraulic capacity after manual backflushing. Figure C5 depicts the hydraulic response curves of the JF4-2-1 with manually backflushed cartridges and with manually rinsed cartridges.

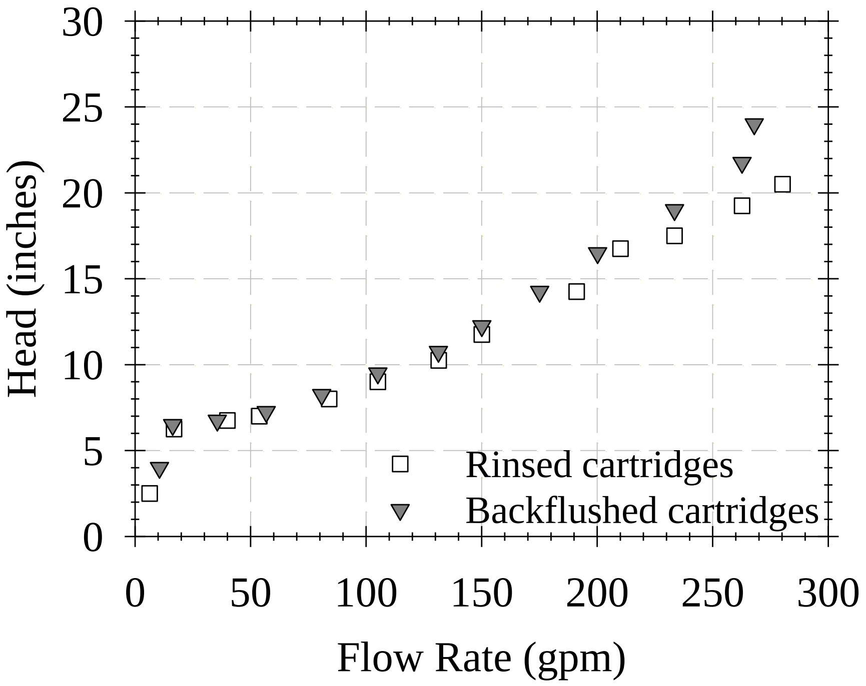


Figure C5: Hydraulic response of the JF4-2-1 with manually backflushed cartridges and with manually rinsed cartridges

APPENDIX D

Methodology for Determining Particulate Matter Removal Efficiency

EMC Calculations (Event basis):

$$\text{Influent EMC} = \frac{\text{Influent Mass (g)}}{\text{Influent Volume (L)}} \qquad (1)$$

$$\text{Effluent EMC} = \frac{\text{Effluent Mass(mg)}}{\text{Effluent Volume (L)}} \qquad (2)$$

$$\text{Effluent Volume} = \text{Influent Volume} - \text{Required Fill Volume} \qquad (3)$$

% Removal Calculations Based on Event Summation of Loads (as a % removal, PR):

$$\text{PR (\%Mass)} = \frac{\text{Influent Mass} - \text{Effluent Mass}}{\text{Influent Mass}}(100) \qquad (4)$$

Note that Δ Mass represents the change in mass on an event basis, therefore the % removal based on change in mass Equation (4) can be further expanded into the following form when using EMC and event flow volumes:

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$$\text{PR(\% Mass)} = \frac{(\text{Influent EMC})(\text{Influent Volume}) - (\text{Effluent EMC})(\text{Effluent Volume})}{(\text{Influent EMC})(\text{Influent Volume})}(100)$$

Removal efficiencies (Percent Removal, PR) summarized in the tables in this report are calculated using Equation 4, assuming that PR is the assessment metric utilized to evaluate a BMP. The influent and effluent mass values used in this equation are based on calculations of concentration, flow and time. Note that concentration is mass normalized to flow volume; for example [mg/L] and that flow volume is determined by integrating increments of flow with time. The only way to check the results of a monitoring campaign is to carry out a separate accounting of mass with a complete mass balance at the end of the campaign, which entails recovery and measurement of the total captured mass from the BMP. This recovery and measurement process is a part of the University of Florida monitoring and analytical and performance verification methodology.

If the EMCs are used directly to calculate percent removal, an assumption has to be made that influent volume is equal to effluent volume, and therefore cancels out of the equation. Note that the expanded equation below Equation 4 is equivalent to Equation 4 but explicitly accounts for a difference in influent and effluent volume for an event. For the University of Florida JF4-2-1 monitoring campaign the effluent volume is usually not equal to the influent volume. Evaporation between events is common, and this phenomenon generates a change in volume stored. Whatever volume is required to fill the unit at the start of an event is subtracted from the influent volume to yield the effluent volume. This “fill volume” is more significant in small events where it represents a larger percentage of the influent volume, and in events following a longer dry period where evaporation from the JF4-2-1 between events is greater. Seasonality (temperature) also plays a role in this evaporation. It is frequently observed in the field that a finite volume of runoff has to be generated, and influent samples taken, before any effluent is generated. For the 25 events, the cumulative evaporated volume is 2478 gallons, which accounts for 8% of total influent runoff volume (30931 gallons).

Calculations of percent removal using EMCs alone in instances where influent volume is not equal to effluent volume can misrepresent the actual mass removal, and therefore are inappropriate for reporting removal efficiency in the JF4-2-1 monitoring campaign.

It should also be noted that the distribution of constituent concentration during an event is not a normal distribution. As expected, the constituent distribution is log-normal and therefore the representative statistic is the median and not the mean (Van Buren et al. 1997; Berretta and Sansalone 2011; Liu and Sansalone 2010; Strecker et al. 2001; Kim and Sansalone 2010). However, because of reporting requirements the University of Florida is reporting a mean (EMC).

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Sample Calculation of SSC percent removal (PR) for 16 June 2010 event

Step 1: Calculate Influent Mass

$$V_{inf} = 1323\, gal * \frac{3.7854\, L}{gal} = 5008.1\, L$$

$$Influent\ Mass = EMC_{inf} * V_{inf} = 1401.7\ \frac{mg}{L} * 5008.1\, L = 7019853.8\, mg$$

Step 2: Calculate Effluent Mass

$$V_{eff} = 1234\, gal * \frac{3.7854\, L}{gal} = 4671.1\, L$$

$$Effluent\ Mass = EMC_{eff} * V_{eff} = 18.1\ \frac{mg}{L} * 4671.1\, L = 84546.9\, mg$$

Step 3: Calculate Percent Removal

$$PR = \frac{Influent\ Mass - Effluent\ Mass}{Influent\ Mass} * 100 = \frac{7019853.8 - 84546.9}{7019853.8} * 100$$

PR = 99%

Sample Calculation of TSS percent removal (PR) for 6 August 2010 event

Step 1: Calculate Influent Mass

$$V_{inf} = 368\, gal * \frac{3.7854\, L}{gal} = 1393.0\, L$$

$$Influent\ Mass = EMC_{inf} * V_{inf} = 77.5\ \frac{mg}{L} * 1393.0\, L = 107959.6\, mg$$

Step 2: Calculate Effluent Mass

$$V_{eff} = 271\, gal * \frac{3.7854\, L}{gal} = 1025.8\, L$$

$$Effluent\ Mass = EMC_{eff} * V_{eff} = 15.0\ \frac{mg}{L} * 1025.8\, L = 15387.7\, mg$$

Step 3: Calculate Percent Removal

$$PR = \frac{Influent\ Mass - Effluent\ Mass}{Influent\ Mass} * 100 = \frac{107959.6 - 15387.7}{107959.6} * 100$$

PR = 86%

APPENDIX E

Nutrient accounting in the monitoring campaign PR%, based on PM mass balance

Based on the PM mass recovery there is 5% of PM that remained physically unaccounted for in the mass balance analysis that required representative monitoring of the influent, the effluent and a full cleaning and recovery of all material from the unit. The gradation of that PM loading the unit ranges from sediment-size to suspended-size PM. However, since we do not know the PSD of the 5 % of PM mass since this PM was not recovered, this appendix assumes that this PM is similar to the influent PM and that only the finer fraction of suspended PM of this PSD is not present since this finer suspended PM is eluted from the unit. By adding this amount of PM mass to the recovered material, the cumulative PR% of TN and TP can be adjusted once the PM-phase concentration of TN and TP were determined by acid-digestion and spectrophotometer. Since TN concentration ranges from 1.32 to 9.61 mg/g across the suspended, settleable and sediment PM fractions and using the weighted influent PSD the adjusted PR% could be 53% for TN if the 5% of PM were considered. Similarly, Since TP concentration ranges from 2.71 to 13.89 mg/g, and using the weighted influent PSD the adjusted PR% could be 61% for TP.

For treatment devices that are not designed to remove the dissolved fraction of constituents such as nutrients and metals, it is not unusual to observe a negative percent removal for such pollutants for some of the treated storms during a monitoring campaign. The JF4 is designed to remove PM and the associated particulate-bound fraction of such constituents. Within a storm flow, and within a treatment unit such as the JF4, there is a complex and dynamic combination of chemical, biological, and physical (advection and dispersion) as well as kinetics phenomena that affect the partitioning of constituents between the particulate-bound and dissolved phases. In most urban areas the source materials for nutrients are anthropogenic or biogenic PM that partition into solution as a function of time.

There is a hetero-disperse distribution of PM sizes in the influent. Each of these PM size fractions has an initial concentration [mg/g] of particulate-bound nitrogen, phosphorus, or metal associated with it. This concentration varies by PM size fraction due to the varying surface area per unit mass of different PM size fractions. The kinetics of partitioning are such that there is a mass transfer of nitrogen, phosphorus, or metal from the particulate-bound phase to the dissolved phase when the flow enters a treatment unit. The process of partitioning occurs in the opposite direction as well, back to the particulate-bound phase that favors a higher concentration of constituent on the smaller PM fractions that have higher surface area per unit mass. In this way the finer suspended and colloidal PM fractions become preferentially enriched. These enriched fine PM size fractions are more readily flushed from any treatment unit by subsequent intra-event flows and subsequent storms (inter-event re-distribution keeps occurring).

Additionally, all treatment units sustain varying microbial populations, and microbial cells are both enriched with nitrogen, and of small size; by comparison in the fine suspended-size range and of a specific gravity not much greater than 1.0. High microbe concentration eluted in the effluent, relative to the influent, would therefore tend to decrease the percent removal of nitrogen and in part depend on the hydrology, inter-event microbial competition and water chemistry within the treatment unit. In comparison, phosphorus has much more rapid kinetics than TN and partitions back to PM, typically of a larger size range and of much more inorganic nature and therefore with a specific gravity in the range of 2 to 2.7. As a consequence the JF4 demonstrates a significantly higher removal for TP across the entire monitoring campaign and does not exhibit any event-based negatives. While there is phosphorus uptake by the microbial population, once phosphorus re-partitions back to the PM size distribution, TP is far more stable, less leachable, less reactive through microbial mediation, and less mobile as compared to TN in such a complex and temporally-varying environment of a treatment unit.

Table E-1 Mass balance results

	g	lb
Mass difference between influent and effluent	79956	176
Mass recovered from the JF4	75559	166
Mass not recovered	4397	10

Table E-2 TN, TP concentration based on influent PSD

	Suspended	Settleable	Sediment	total
mass fraction based on influent PSD	12%	13%	75%	100%
N fraction concentration (mg/g)	9.16	5.01	1.32	
N concentration weighed by PSD (mg/g)	1.10	0.65	0.99	2.74
P fraction concentration (mg/g)	13.89	5.04	2.71	
P concentration weighed by PSD (mg/g)	1.67	0.66	2.03	4.35

Table E-3 Adjusted PR% for TN and TP

	TN	TP
N/P-mass-influent (mg)	315882	364461
N/P-mass-effluent (mg)	154650	149457
PM mass not recovered (g)	4397	4397
N/P concentration weighed by PSD (mg/g)	2.74	4.35
N/P-mass-not recovered (g)	12	19
Original PR% based on flow monitoring	51%	59%
Adjusted PR%	**53%**	**61%**

Table E-4 Mass balance results utilizing measured functional and granulometric fractions of sediment, settleable and suspended PM

Rainfall-runoff Event	Influent									Effluent								
	Vol.	Sediment PM		Settleable PM		Suspended PM		Total PM		Vol.	Sediment PM		Settleable PM		Suspended PM		Total PM	
		EMC	Mass	EMC	Mass	EMC	Mass	EMC	Mass		EMC	Mass	EMC	Mass	EMC	Mass	EMC	Mass
	L	mg/L	g	mg/L	g	mg/L	g	mg/L	g	L	mg/L	g	mg/L	g	mg/L	g	mg/L	g
28-May-10	7454	435.9	3249.6	45.4	338.6	43.7	325.9	525.1	3914.2	3682	6.2	22.9	6.9	25.2	11.9	43.8	25.0	91.9
16-Jun	4997	1333.5	6663.5	66.9	334.5	67.9	339.3	1468.3	7337.3	4665	7.1	33.2	2.0	9.4	20.1	93.6	29.2	136.2
21-Jun	8683	1781.6	15469.0	22.2	192.5	13.7	119.2	1817.5	15780.7	8460	5.6	47.6	1.8	15.1	9.9	83.7	17.3	146.4
30-Jun	5451	504.0	2747.3	20.6	112.5	19.2	104.9	543.9	2964.7	5330	8.0	42.5	1.5	8.2	5.7	30.5	15.2	81.2
15-Jul	3602	938.6	3381.1	68.2	245.6	23.7	85.3	1030.5	3712.0	3296	5.2	17.0	1.4	4.6	6.9	22.9	13.5	44.5
1-Aug	11990	243.2	2916.0	22.8	272.8	18.5	222.2	284.5	3411.0	11676	4.8	55.9	8.4	98.4	6.9	80.9	20.1	235.2
6-Aug	1395	390.3	544.4	29.5	41.2	48.0	66.9	467.8	652.5	1024	13.1	13.5	2.9	3.0	12.0	12.3	28.1	28.7
7-Aug	2620	222.5	582.9	32.3	84.5	13.1	34.3	267.9	701.8	2540	1.6	4.0	5.1	13.1	6.9	17.5	13.6	34.5
23-Aug	310	533.9	165.5	41.9	13.0	44.6	13.8	620.4	192.3	193	2.6	0.5	3.1	0.6	4.7	0.9	10.4	2.0
12-Sep	1641	165.0	270.7	68.7	112.7	67.4	110.6	301.2	494.1	1508	2.7	4.1	4.1	6.2	11.5	17.4	18.4	27.7
26-Sep	1126	224.5	252.9	0.9	1.0	2.0	2.2	227.4	256.1	835	7.9	6.6	2.2	1.8	2.0	1.7	12.1	10.1
27-Sep	3837	875.1	3357.4	50.0	192.0	44.5	170.8	969.6	3720.2	3765	3.2	11.9	2.1	7.8	5.0	18.7	10.2	38.4
4-Nov	994	486.4	483.5	38.6	38.4	92.8	92.3	617.8	614.2	510	3.7	1.9	2.9	1.5	6.5	3.3	13.1	6.7
16-Nov	306	318.4	97.5	131.9	40.4	118.2	36.2	568.6	174.1	166	18.0	3.0	2.4	0.4	8.4	1.4	28.9	4.8
5-Jan-11	5791	841.4	4872.3	49.8	288.4	40.9	236.8	932.1	5397.5	4948	3.2	15.7	2.8	14.1	12.9	63.9	18.9	93.7
10-Jan	1126	454.0	511.4	60.1	67.7	20.8	23.4	534.9	602.5	1047	1.4	1.5	3.6	3.8	3.1	3.2	8.1	8.5
25-Jan	12387	410.6	5085.8	37.7	467.3	32.4	401.8	480.7	5954.9	12353	1.1	14.0	2.1	25.4	2.0	24.6	5.2	64.0
7-Feb	13211	738.5	9756.9	16.7	221.2	23.0	304.4	778.3	10282.5	12928	2.4	31.1	0.8	10.8	4.2	54.7	7.5	96.6
9-Mar	10036	69.6	699.0	8.5	85.6	13.3	133.5	91.5	918.1	9805	0.5	5.3	0.6	5.8	0.9	9.1	2.1	20.2
28-Mar	522	65.4	34.1	13.0	6.8	36.4	19.0	114.8	59.9	423	1.9	0.8	2.1	0.9	8.0	3.4	12.0	5.1
30-Mar	3761	386.9	1455.3	54.3	204.3	34.0	127.7	475.2	1787.3	3678	0.8	3.0	1.8	6.6	4.6	16.7	7.2	26.4
20-Apr	204	1010.4	206.2	30.9	6.3	24.8	5.1	1066.1	217.6	113	1.8	0.2	2.6	0.3	7.1	0.8	11.5	1.3
14-May	10864	790.9	8591.9	59.6	647.5	44.5	483.6	895.0	9723.0	10697	2.0	21.2	1.3	14.0	11.2	119.5	14.5	154.7
6-Jun	964	307.6	296.5	30.8	29.7	53.3	51.4	391.7	377.6	733	1.1	0.8	2.5	1.8	10.4	7.6	13.9	10.2
27-Jun	3379	514.8	1739.7	67.6	228.6	47.6	161.0	630.1	2129.3	3175	4.6	14.6	2.3	7.3	8.9	28.2	15.8	50.1

Total influent PM	= 81.4 kg (179 lb)
Total effluent PM	= 1.4 kg (3 lb)
Mass difference between influent and effluent	= 79.9 kg (176 lb)
Independent PM Recovery based on cleaning out and backwashing unit and recovering PM	= 75.5 kg (166 lb)
% mass recovery	= 94.5% (above the standard 90% recovery)

Notes : Sediment PM includes all biogenic material including leaves, sticks, detritus.
Settleable PM based on SM 2540F.
Suspended PM based on 60 min. quiescent settling in Imhoff cone (this is the formal and correct definition of suspended and is not TSS!).

References for details: Sansalone and Kim (2008), Kim and Sansalone (2008) and Sansalone et. al. (2009)