WATER YEAR 2007 DATA REPORT

High Point Phase I Block Scale Monitoring

Prepared for

Seattle Public Utilities

April 2008

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Prepared for

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April 4, 2008

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Introduction

Seattle Public Utilities (SPU) is implementing a large scale Natural Drainage System (NDS) project in conjunction with the redevelopment project for the High Point neighborhood in West Seattle (Figure 1). NDS swales are part of what is termed a "Low Impact Development" (LID) approach to managing stormwater runoff. The goal of the LID approach is to minimize the effect that changes in land use associated with urbanization can have on the natural hydrology within a given catchment. As opposed to conventional stormwater systems that route runoff directly to storm drains, the NDS swales first route runoff through a vegetated/compost amended swale, slowing runoff and allowing for infiltration into the groundwater. Excess runoff is then routed to a conventional stormwater conveyance system. The end result is improved stormwater quality and decreased erosion in downstream receiving waters. The High Point NDS swales, unlike previous NDS swales constructed by SPU, have been constructed to provide shallow surface ponding (3 to 10 inches), with 3 to 4 feet of biorention soil and an underdrain collection system.

Herrera Environmental Consultants, Inc. (Herrera) is currently working with SPU to implement a block-scale monitoring program of NDS swales that have been installed at the High Point project site. The project is being funded by SPU, the Washington State Department of Ecology (Ecology), and U.S. Environmental Protection Agency (U.S. EPA) with the goals of quantifying the water quality treatment and flow retention performance of the NDS swales in order to:

- Provide a basis for potential design refinements
- Improve NDS performance
- Reduce installation costs.

To achieve these goals, the following monitoring activities are being performed in association with a representative NDS swale in the High Point neighborhood:

- Continuous measurements of ponding depth on the swale's surface
- Continuous measurements of discharge within the swale's underdrain system
- Collection of water quality samples before and after treatment within the swale
- Implementation of controlled infiltration tests on the swale's surface
- Continuous measurements of precipitation in the immediate vicinity of the swale.

The specific monitoring procedures that are being implemented in connection with these activities were documented previously in the Quality Assurance Project Plan (QAPP) for the monitoring program (Herrera 2007a). As described in the QAPP, the monitoring for this project will occur over a three year period beginning in December 2006 and ending in September 2009. Annual data reports are to be prepared at the end of each water year. (A water year begins at the beginning of October and concludes at the end of September in the subsequent year.) This document represents the data report for water year 2007 and specifically summarizes results from the monitoring activities described above. The presentation of these results is organized under the following section headings:

- Experimental Design
- Methods
- Results and Discussion
- Conclusions.

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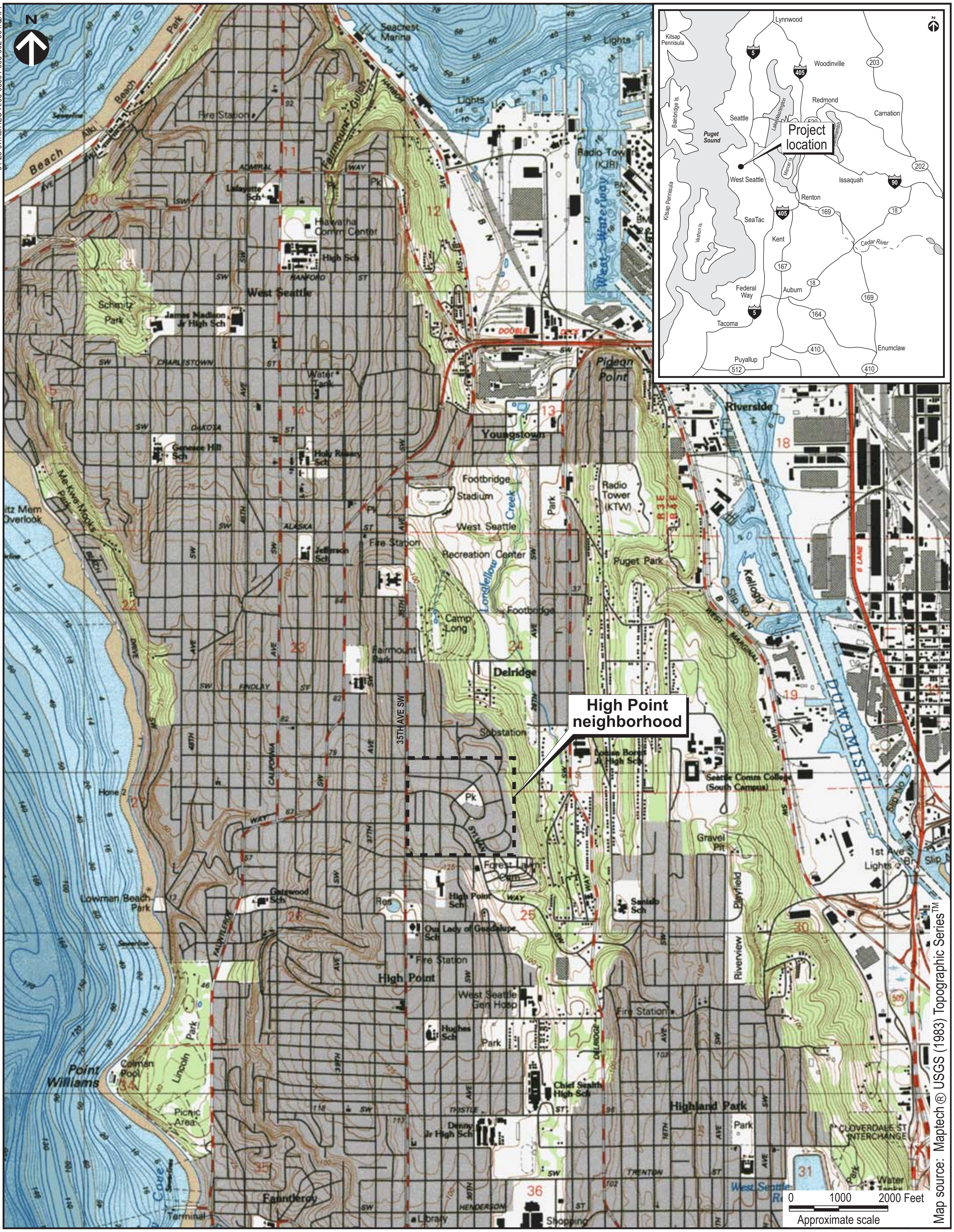


Figure 1. Vicinity map for the High Point redevelopment project site in Seattle, Washington.

Experimental Design

The NDS swales in the High Point neighborhood have five primary components (also see Figure 2):

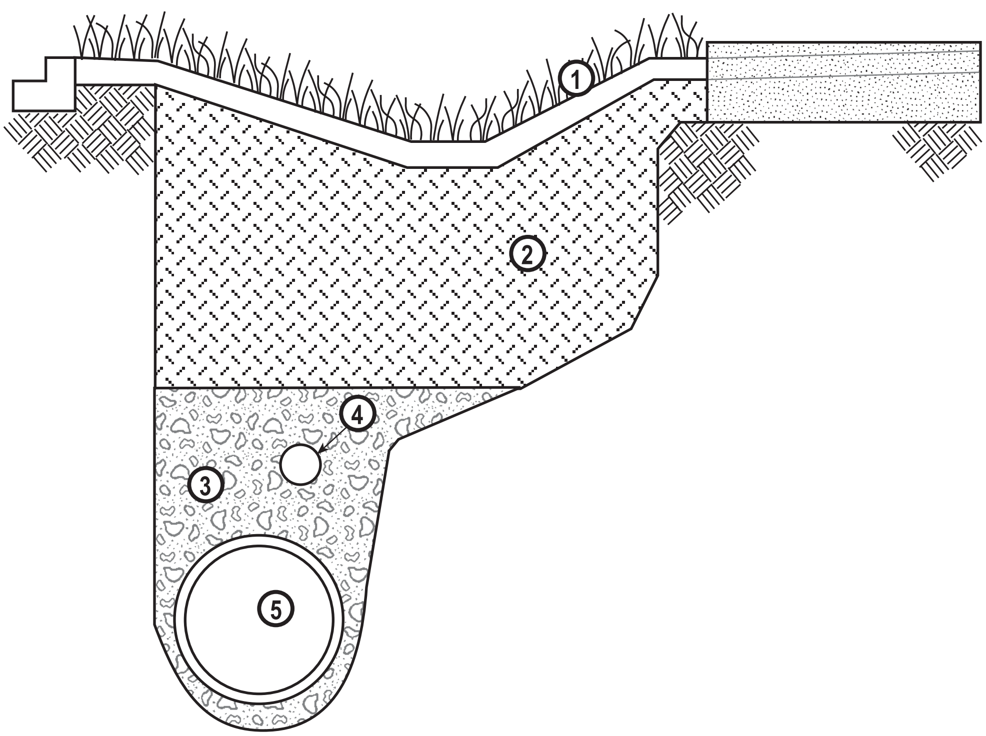
- Grass or vegetated planting strip
- Engineered soil layer, a gravel drain layer
- Perforated underdrain pipe
- Solid-walled conveyance pipe.

During operation, stormwater runoff from the surrounding drainage basin enters the planting strip via sheetflow where it is retained for a sufficient period of time to allow for infiltration to the underlying engineered soil layer. Absorption and filtration processes within the engineered soil layer then provide water quality treatment. Storage within the engineered soil layer also serves to attenuate stormwater runoff flow rates and volumes. Under saturated conditions, stormwater will infiltrate from the engineered soil layer down to the gravel drain layer. The gravel drain layer provides additional storage for attenuating stormwater runoff flow rates and volumes. Overflow from the gravel drain layer is first collected in the 8-inch perforated underdrain pipe and then discharged to the solid-walled pipe (via a public storm drain manhole [PSDMH]) for conveyance out of the NDS swale.

As noted above, the goals of this study are to obtain data for evaluating the water quality treatment and flow control benefits of NDS swales in the High Point neighborhood. These data will then provide a basis for design refinements that might be considered to improve performance, and/or reduce installation costs. To meet these goals, monitoring is being conducted in a representative NDS swale (hereafter referred to as the NDS test swale) that was constructed in 2004 and 2005 as part of Phase I of the High Point neighborhood redevelopment project. Figure 3 shows the specific location of the NDS test swale on the project site. In conjunction with this study, water inputs and outputs from the NDS test swale are being recorded over a three-year monitoring period, extending from December 2006/January 2007 through September 2009. In addition, infiltration rates on the surface of the NDS test swale are being measured through controlled testing procedures on three occasions. Finally, water quality samples are being collected for pollutants in stormwater before and after treatment in the NDS test swale.

The subsections below provide a more detailed description of the experimental design for the four primary components of this study:

- Hydrologic Simulation Program – Fortran (HSPF) model calibration monitoring
- Continuous hydrologic monitoring
- Controlled infiltration tests
- Water quality monitoring.



KEY

1. Grass or vegetated planting strip
2. Engineered soil layer
3. Gravel drain layer
4. 8" perforated underdrain pipe
5. Solid-wall conveyance pipe

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Figure 2. Schematic diagram of a typical NDS swale cross-section.

12-18-07/rtb/HEC-R/06-03304-050-002-001/IWater Yr '07 Data

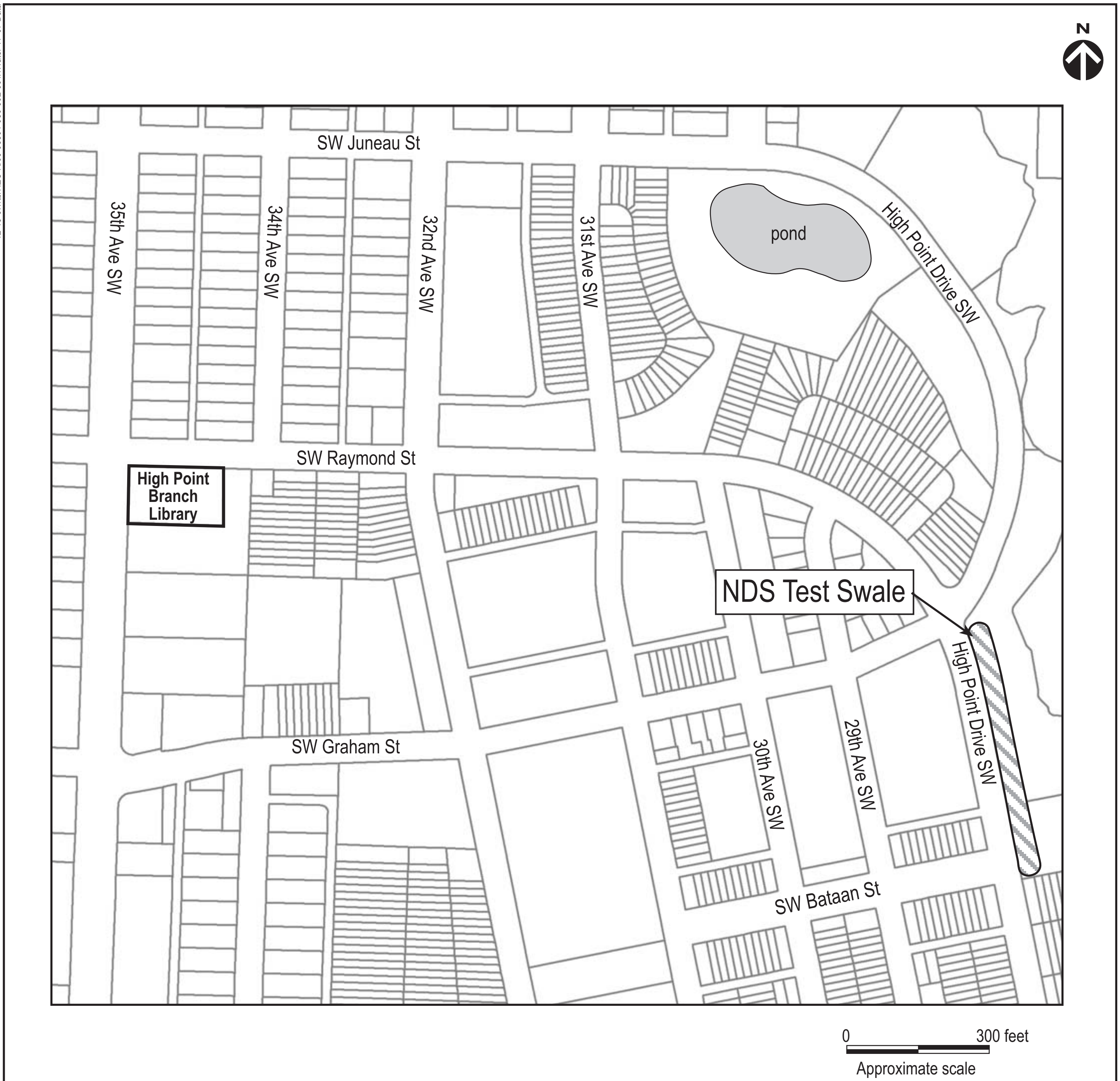

Figure 3. Site map for the High Point redevelopment project site showing the location of the natural drainage system (NDS) test swale.

The purpose and general location of the monitoring stations associated with these study components also are summarized in Table 1. The specific location of the monitoring stations is also shown in Figure 4.

Table 1. Location, purpose, and sampling frequency for monitoring stations established for the High Point Phase I Block Scale Monitoring project.

Station	Station Type	Station Location	Station Purpose	Sampling Frequency
D1	Discharge	NDS test swale overflow drain located on Highpoint Way SW approximately mid-block between SW Bataan Street and SW Graham Street	Monitor stormwater inputs to the NDS test swale during discrete storm events. Data to be used for HSPF model calibration	Monitoring during six discreet storm events
D2	Discharge	PSDMH 5.60 located on Highpoint Way SW approximately mid-block between SW Bataan Street and SW Graham Street	Continuous monitoring of stormwater outputs from the NDS test swale	Continuous monitoring was initiated in January 2007 and will conclude in September of 2009
D3	Discharge	PSDMH 5.50 located near the intersection of Highpoint Way SW and SW Graham Street	Continuous monitoring of stormwater outputs from the NDS test swale	Continuous monitoring was initiated in December 2006 and will conclude in September of 2009
WL1	Water Level	NDS test swale overflow drain located on Highpoint Way SW approximately mid-block between SW Bataan Street and SW Graham Street	Continuous monitoring of ponding depth at the surface of the NDS test swale and record the occurrence of overflow events	Continuous monitoring was initiated in January 2007 and will conclude in September of 2009
WQ1	Water Quality	NDS test swale overflow drain located on Highpoint Way SW approximately mid-block between SW Bataan Street and SW Graham Street	Monitor influent stormwater quality for NDS test swale	Monitoring during six discreet storm events
WQ2	Water Quality	PSDMH 5.50 located near the intersection of Highpoint Way SW and SW Graham Street	Monitor effluent stormwater quality for NDS test swale	Monitoring during six discreet storm events
RG1	Precipitation	High Point Public Library at 3411 SW Raymond Street	Continuous monitoring of precipitation depth	Continuous monitoring was initiated in January 2007 and will conclude in September of 2009

PSDMH: Public storm drain manhole.

HSPF Calibration Monitoring

Because stormwater enters the NDS test swale as highly diffuse sheet flow, the direct measurement of influent discharge rates and volumes is not practical over the long-term. Therefore, influent to the NDS test swale will ultimately be estimated using output from an HSPF model. However, this HSPF model will not be developed until year 2 or 3 of the study,

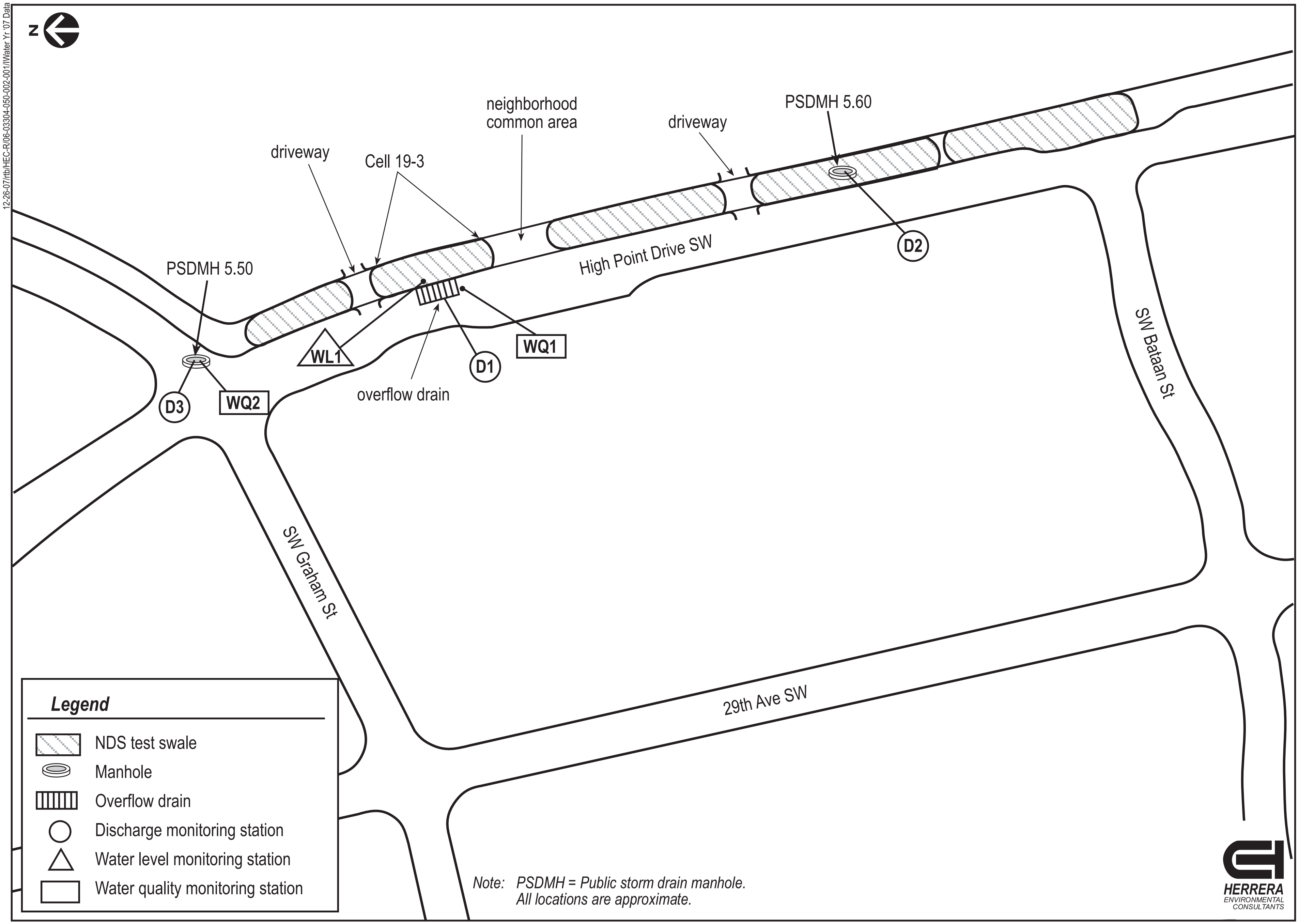

Figure 4. Plan view of NDS test swale and monitoring station locations for the High Point Phase I Block Scale monitoring.

pending the collection of sufficient calibration data for the model. In order to obtain these calibration data, influent discharge rates to the NDS test swale are being monitored during up to six discrete storm events. This monitoring is specifically targeting storms of sufficient size to produce measurable quantities of runoff into the NDS test swale while not exceeding the 6-month, 24-hour storm event. During these events, a temporary monitoring station (designated D1 in Figure 4) is established in association with the test swale where runoff from the surrounding drainage basin is concentrated at a single collection point. Monitoring equipment installed at this station is then used to continuously record discharge rates. These data are then processed for use in subsequent HSPF model calibration efforts.

Continuous Hydrologic Monitoring

Continuous hydrologic monitoring is being performed to track the outputs of stormwater from the perforated underdrain pipe for the NDS test swale over the three-year monitoring period. In addition, automated instrumentation has been installed on the surface of the NDS test swale to continuously measure the ponding depth near the overflow drain. This instrumentation is also being used to record the occurrence (i.e., presence or absence) and duration of overflow events. Finally, precipitation is also being monitored continuously to provide data for interpreting the other monitoring results. In order to facilitate this monitoring, the following stations have been established in association with the NDS test swale:

- A precipitation monitoring station (designated RG1) was established on the roof of the High Point Branch Public Library at 3411 SW Raymond Street (see Figure 3). A rain gauge and data logger installed at this station is being used to continuously monitor precipitation over the duration of the project.

- Flow monitoring stations were established in two separate PSDMHs that collect water from sections of perforated underdrain pipe within the gravel layer of the NDS test swale (see Figure 2). (Water discharged from the underdrain pipes is then routed to the solid-walled conveyance pipe shown in Figure 2 within these same PSDMHs.) One station (designated D2 in Figure 4) was established in PSDMH 5.60 that is located at approximately the midpoint of the NDS test swale. This station receives flow from approximately a 250-foot-long section of perforated underdrain pipe that extends south from PSDMH 5.60 to the intersection of SW Bataan Street and Highpoint Way SW. The other station (designated D3 in Figure 4) was established in PSDMH 5.50 near the intersection of SW Graham Street and Highpoint Way SW. This station receives flow from approximately a 250-foot-long section of perforated underdrain pipe that extends south from PSDMH 5.50 to PSDMH 5.60. Automated flow monitoring equipment was installed in association with each of these stations to continuously monitor stormwater outputs from the NDS test swale.

- One water level monitoring station (designated WL1 in Figure 4) was established on the surface of the NDS test swale near the overflow drain. Automated equipment was installed at this station to continuously record ponding depth and the occurrence and duration of overflow events.

This monitoring instrumentation was installed in December 2006 and January 2007 and will operate continuously through the end of September 2009.

Data from these instruments and the HSPF model will ultimately be used to track stormwater inputs and outputs from the NDS test swale. This information will then be used to evaluate whether the NDS swales are meeting requirements for flow attenuation and water quality treatment that were established for Phase I of the High Point neighborhood redevelopment project (Herrera and R.W. Beck 2004). Pursuant to these requirements, the stormwater treatment systems on the project site must attenuate the 2-year, 24-hour storm to pre-developed pasture conditions. Similarly, the NDS swales must provide water quality treatment for the 6-month, 24-hour storm. However, it should be noted that these treatment requirements are to be applied to the entire project site, taking into account all of the associated stormwater systems. Therefore, it is not possible to assess these treatment goals directly using only the monitoring data obtained from the NDS test swale. However, if it can be shown that the NDS test swale is meeting these goals, it may be inferred that other NDS swales on the project site are performing similarly and these treatment goals are likely being met on a system-wide basis.

Controlled Infiltration Tests

Three controlled infiltration tests are being performed in conjunction with this study to measure surface water infiltration rates within the NDS test swale. Specifically, two initial infiltration tests were conducted during the first and second months of the three-year monitoring program. A final test is scheduled to be performed at the end of the third year of the monitoring program.

Each infiltration test is being performed using procedures promulgated by Ecology (2005) for pilot infiltration testing. The pilot infiltration test is a relatively large-scale infiltration test that is typically performed during the design phase of a project to estimate infiltration rates for a proposed stormwater infiltration facility. It specifically involves excavating a test pit to the depth proposed for the infiltration facility. Water is then added at a variable rate to maintain a constant water level within the pit. During this process, a rotameter is used to measure the flow rate of this water. After this flow rate has remained stabile (i.e., constant) for a period of time, the water is turned off and the rate of infiltration (in inches per hour) is recorded until the pit is empty. The pilot infiltration test was modified for use in the NDS test swale according to the procedures described in the Methods section of this document.

Water Quality Monitoring

Stormwater quality sampling is also being conducted in association with the NDS test swale during six separate storm events to characterize stormwater pollutant concentrations before and after treatment. Pollutant concentrations are being characterized based on grab samples collected at representative influent and effluent discharge points for stormwater entering and leaving the NDS test swale. The influent monitoring station (designated WQ1 in Figure 4) is located at the point where stormwater runoff from Highpoint Way SW concentrates near the overflow drain for the NDS test swale. The effluent monitoring station (designated WQ2 in Figure 4) is located at the point where the section of perforated underdrain pipe discharges into PSDMH 5.50 (see description in Continuous Hydrologic Monitoring section above). Each collected sample is analyzed for total suspended solids, suspended sediment concentration, total phosphorus, soluble reactive phosphorus, hardness, total copper, dissolved copper, total zinc, and dissolved zinc, fecal coliform bacteria, and *Escherichia coli* (*E. coli*).

Methods

This section provides an overview of the sampling, measurement, data management, and data analysis procedures that are being used for this project. These procedures are summarized below and described in more detail in the QAPP (Herrera 2007a) that was prepared previously for the project.

Sampling Procedures

Field sampling procedures that are being utilized for this study are described herein. This information is organized under separate subsections for each of the four primary components of this study that were identified earlier in the Experimental Design section of this document.

HSPF Calibration Monitoring

Temporary monitoring station D1 (see Figure 4) is established in association with the NDS test swale to facilitate HSPF calibration monitoring during six separate storm events. Prior to each storm event, field personnel block the curb cuts that convey water into the NDS test swale from Highpoint Drive SW. Each curb cut is blocked with a combination of 4-foot-long tube sand bags, impermeable plastic garbage bags, and plywood barriers that are fitted with weather stripping to form a seal with the curb and street. With the curb cuts blocked, all stormwater that would normally enter the NDS test swale is concentrated at the low point in the street where the overflow drain for the system is located.

In conjunction with blocking the curb cuts, field personnel also install a primary measuring device in the overflow drain. The primary measuring device is incorporated into a custom fabricated box made of ¾-inch marine plywood having the following interior dimensions: length = 23 inches; width = 8.25 inches; depth = 20 inches. This box is temporarily mounted at the top of the overflow drain where it collects all of the stormwater that is diverted from the blocked curb cuts. A two-stage weir cut into one side of the box allows flow estimates to be derived from water level measurements within the box. The two-stage weir consists of a 45-degree v-notch for use during low to moderate flows (i.e., 0.02 to 0.50 cubic feet per second [cfs]) and a 23-inch rectangular weir (without end constrictions) for use during high flows (i.e., 0.50 to 1.2 cfs). A more detailed description of the primary measuring device is provided in the QAPP that was prepared previously for the project (Herrera 2007a).

Automated monitoring equipment is then installed inside the primary measuring device to facilitate the continuous monitoring of discharge. More specifically, a Campbell Scientific CS445-L submersible pressure transducer is fitted to the bottom of the box to measure the depth of water over the two-stage weir. The pressure transducer is integrated with a Campbell Scientific CR200 datalogger that is programmed to record water level measurements with a 1-minute logging interval. Data from the datalogger is downloaded after each storm event and subsequently exported to an Excel spreadsheet for data management and archiving purposes. The water level measurements are then be converted to estimates of discharge based on standard hydrologic equations (Grant and Dawson 1997).

During the actual HSPF calibration monitoring, field personnel visit the NDS test swale at 2-to 4-hour intervals throughout the storm event to ensure that flows are properly routed through the primary measuring device and that the monitoring equipment is functioning correctly. Field personnel also make manual measurements within the primary measuring device to check the calibration of the automated monitoring equipment.

Continuous Hydrologic Monitoring

Continuous hydrologic monitoring for this study involves the collection of precipitation, discharge, and water level data at those stations shown in Figure 4 and discussed in the Experimental Design section. The specific procedures that are used to collect each type of data are described in the following subsections.

Precipitation Data

As described above, monitoring station RG1 was established at the High Point Branch Public Library (see Figure 3) to continuously measure precipitation amounts over the duration of the project. To facilitate this monitoring, a Hydrologic Services TB3 tipping bucket rain gauge was affixed to the library's roof on a 10-foot pole and leveled in accordance with the manufacture's specifications. The rain gauge was interfaced with a Campbell Scientific CR200 Datalogger that is programmed to record precipitation depths with a 15-minute logging interval. The datalogger is housed in a locking, vandal resistant enclosure that is hidden from public view.

Field personnel perform monthly site visits to upload data from the datalogger, check and replace the battery pack as necessary, and visually inspect all system components. Any operational problems identified during these site visits are addressed immediately. Field personnel record detailed notes to describe any equipment maintenance or repairs that are required during these site visits.

Discharge Data

As described above, stations D2 and D3 (see Figure 4) were established to measure discharge from the perforated underdrain pipe sections for the NDS test swale. In order to facilitate this monitoring, DataGator® flow metering systems from Renaissance Instruments were installed in the perforated underdrain pipe sections at their point of discharge into PSDMH 5.50 and PSDMH 5.60.

Each DataGator flow metering system has two components: a modified Venturi flow tube with three strategically positioned pressure transducers to measure flow; and a data logger that allows the continuous recording of flow measurements. In accordance with the manufacturer's instructions, the flow tubes were securely fastened to each 8-inch perforated underdrain pipe with a stainless steel mounting base and leveled with threaded leveling rods. The dataloggers were attached to a ladder rung at the top of each PSDMH using short sections of cable and then interfaced with the pressure transducers in the flow tubes using manufacturer supplied communication cables. Finally, the dataloggers were programmed to continuously record discharge measurements from the flow tubes with a 15-minute logging interval.

Field personnel perform monthly site visits to upload data from the DataGator flow metering systems, check and replace batteries as necessary, and visually inspect all system components from the top of the manhole. Any operational problems that are identified during these site visits are addressed immediately. During all site visits, field personnel record detailed notes to describe any equipment maintenance or repairs that are required. On the day following each site visit, data from the flow metering systems are exported to an Excel spreadsheet for data management and archiving purposes. At that time, the data also undergo a quality assurance audit. Any operational problems identified through this review are addressed immediately.

Water Level Data

Monitoring station WL1 (see Figure 4) was established to continuously monitor water levels on the surface of the NDS test swale near the overflow drain. To facilitate this monitoring, a Campbell Scientific CS445-L submersible pressure transducer was installed at a low point within the NDS test swale. The pressure transducer was integrated with a Campbell Scientific CR200 datalogger that is programmed to continuously record water levels in the swale with a 15-minute logging interval. Both the pressure transducer and datalogger are housed in vandal resistant enclosures that are hidden from public view.

Field personnel perform monthly site visits to upload data from the datalogger, check and replace the battery pack as necessary, and visually inspect all system components. Any operational problems that are identified during these site visits are addressed immediately. During all site visits, field personnel record detailed notes to describe any equipment maintenance or repairs that are required. On the day following each site visit, data from the water level monitoring equipment are exported to an Excel spreadsheet for data management and archiving purposes. At that time, the data also undergo a quality assurance audit. Any operational problems identified through this review are addressed immediately.

In conjunction with the water level monitoring equipment described above, a staff gauge was also installed in the NDS test swale near the overflow drain. Survey equipment was then used to reference the elevation of both the pressure transducer and overflow drain to the datum on the staff gauge. Using this relationship, the data from the automated monitoring equipment can be used to track the occurrence and duration of overflow events at the surface of the NDS test swale.

Controlled Infiltration Tests

As described earlier in the Experimental Design section, surface infiltration rates to the NDS test swale are measured using procedures promulgated by Ecology (2005) for pilot infiltration testing. The specific field procedures that are implemented in connection with the NDS test swale are as follows:

1. Culverts immediately up-gradient and down-gradient of the overflow drain for the swale are blocked with inflatable plugs (Figure 5). These culverts convey water beneath a neighborhood common area and driveway, respectively, which cross the swale at two locations on Highpoint Way SW. This isolates a 72.4 foot section of the swale with an approximate surface area of 391 square feet. All subsequent activities related to this test are performed on this section of the swale.

2. Water from a nearby fire hydrant (see Figure 5) is discharged to the swale using approximately 300 feet of 4-inch fire hose. A rotameter is attached to the hose to measure the discharge rate of this water. To reduce potential soil erosion at the point of discharge for this water in the swale, the end of the fire hose is placed in a makeshift flow diffuser consisting of a 40-gallon plastic garbage can perforated with numerous 1.5-inch holes.

3. The discharge rate from the hose is varied up or down to maintain a constant water depth in the swale. Every 15 to 30 minutes, the discharge rate for water entering the swale and water level in the swale are manually recorded. A pressure transducer and data logger are also installed in the swale near the overflow drain (Figure 5) and programmed continuously record water levels during the test, with a 1-minute logging interval.

4. After the discharge rate required for maintaining the target water depth in the swale stabilizes and remains constant for a period of 60 minutes, the flow of water to the swale is turned off. The time required for water remaining in the swale to infiltrate is then measured until there is no longer any visible standing water.

Water Quality Monitoring

Water quality samples are being collected during six separate storm events at the monitoring stations depicted in Figure 4 (i.e., WQ1 and WQ2). The following conditions serve as guidelines for defining the acceptability of specific storm events for sampling:

- **Precipitation total**: A minimum of 0.25 inches of precipitation in a 24-hour period

- **Antecedent dry period**: A period of at least 12 hours preceding the event with less than 0.01 inches of precipitation

- **End of storm dry period**: A continuous 12-hour period with no measurable rainfall.

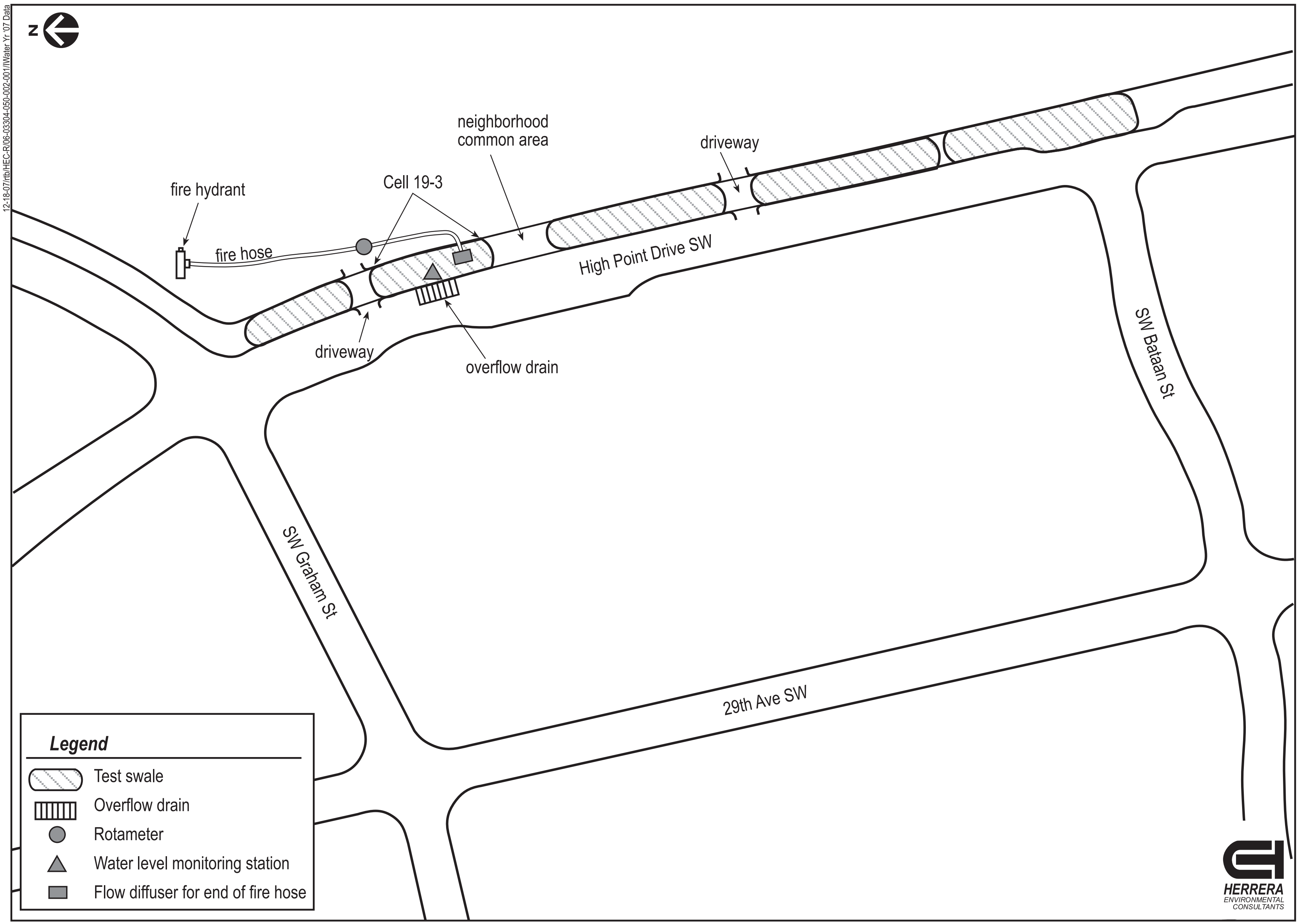

Figure 5. **Plan view of natural drainage system test swale and controlled infiltration test monitoring station location for the High Point Phase I Block Scale Monitoring project.**

The storm depth criterion was established to target only those storms that will provide substantial runoff from the High Point development while the antecedent conditions criterion was established to allow some time for pollutant buildup on impervious surfaces between storm events. These criteria were adapted from Ecology's *Guidance for Evaluating Emerging Stormwater Technologies: Technology Assessment Protocol – Ecology* (TAPE) (Ecology 2002).

Precipitation forecasts from the Center for Ocean Land-Atmosphere Studies (http://wxmaps.org/pix/meteograms.html) are reviewed on a weekly basis to determine if specific storm events should be targeted for sampling. Immediately prior to sampling, incoming storms are tracked using Doppler radar images for the region that can be accessed via the King 5 weather website (http://www.king5.com/weather/doppler/?seattle). To the extent possible, the timing of sample collection from each monitoring station is targeted to capture the rising limb of the storm hydrograph.

Sample collection at each monitoring station follow those procedures identified in *Recommended Protocols for Measuring Conventional Water Quality Variables and Metals in Fresh Water of the Puget Sound Region* (U.S. EPA 1991). Samples from station WQ1 (see Figure 4) are collected by submerging pre-cleaned bottles supplied by the laboratory in stormwater that has concentrated along the street curb near the point of discharge into the overflow drain. If the flow at this location is too shallow for the bottles to be fully submerged, a clean, wide-mouth bottle is used to collect the water and then to fill the required sample bottles. Samples from station WQ2 (see Figure 4) are collected by mounting the bottles on an extendable pole and then lowering them into PSDMH 5.50. At this location, the sample bottles are then be positioned to capture water that is discharging from the perforated underdrain pipe and allowed to fill.

Following collection, each sample bottle is placed in a cooler with ice and kept at 4°C for transport to the laboratory. All samples are delivered to the laboratory within 12 hours of collection. A completed chain-of-custody record is submitted with each batch of samples. Each collected sample is then analyzed for total suspended solids, suspended sediment concentration, total phosphorus, soluble reactive phosphorus, hardness, total copper, dissolved copper, total zinc, and dissolved zinc, fecal coliform bacteria, and *E. coli*.

Measurement Procedures

Laboratory measurement procedures for water quality samples follow those methods approved by the U.S. Environmental Protection Agency (APHA et al. 1992; U.S. EPA 1983, 1984). The analytical methods, preservation methods, container specifications, holding times, and detection limits are presented in Table 2. The analytical methods were selected to provide low enough detection limits to enable reliable comparisons to applicable surface water quality standards.

The laboratory identified for this project (Aquatic Research, Inc.) is certified by Ecology and participates in audits and interlaboratory studies conducted by Ecology and the U.S. EPA. The adequacy of the standard operating procedures in the laboratory has been verified by these performance and system audits.

Table 2. Methods and detection limits for laboratory measurement procedures.

Parameter	Bottle Type	Preservation Method	Analytical Method	Method Number [a]	Reporting Limit [b]	Sample Holding Times
Total suspended solids	1L, P	Cool, 4°C	Gravimetric, 103°C	EPA 160.2	0.50 mg/L	7 days
Suspended sediment concentration	1L, P	Cool, 4°C	Wet sieving filtration Gravimetric, 103°C	ASTM D 3977-97C	0.50 mg/L (sand) 0.50 mg/L (fines)	7 days
Total phosphorus	500 ml, P	Cool, 4°C; H_2SO_4 to pH<2	Automated ascorbic acid	EPA 365.1	0.002 mg/L	28 days
Soluble reactive phosphorus	500 ml, P	Cool, 4°C; filtration, 0.45 µm	Automated ascorbic acid	EPA 365.1	0.001 mg/L	48 hours [c]
Hardness	500ml, P	Cool, 4°C; HNO_3 to pH<2	EDTA titrimetric	SM 2340C	2 mg/L as $CaCO_3$	6 months
Copper, dissolved	500 ml, P	Cool, 4°C; filtration, 0.45 µm; HNO_3 to pH<2	GFAA	EPA 220.2	0.001 mg/L	14 days [c]
Copper, total	500 ml, P	Cool, 4°C; HNO_3 to pH<2	GFAA	EPA 220.2	0.001 mg/L	6 months
Zinc, dissolved	500 ml, P	Cool, 4°C; filtration, 0.45 µm; HNO_3 to pH<2	ICP	EPA 200.7	0.005 mg/L	6 months [c]
Zinc, total	500 ml, P	Cool, 4°C; HNO_3 to pH<2	ICP	EPA 200.7	0.005 mg/L	6 months
Fecal coliform bacteria	300 ml, G	Cool, 4°C	Membrane filter	SM 9222D	2 CFU/100 ml	12 hours
Escherichia coli (*E. coli*)	300 ml, G	Cool, 4°C	Membrane filter	EPA 10029	2 CFU/100 ml	12 hours

[a] SM method numbers are from APHA et al. 1992; EPA method numbers are from U.S. EPA 1983; 1984.
[b] Reporting limit refers to the practical quantitation limit.
[c] Sample filtration and/or preservation will occur within 12 hours of sample collection.
EDTA = ethylenediaminetetracetic acid.
GFAA = graphite furnace atomic absorption.
ICP = inductively coupled plasma.
mg/L = milligrams per liter.
P = polyethylene, polypropylene, fluoropolymer.

Within 30 days of receiving the samples, the laboratory reports the analytical results in standardized reports that include sample and quality control data. The reports are suitable for evaluating the project data and also include a case narrative that summarizes any problems encountered during the analyses.

Data Management Procedures

This section describes the data management procedures that are being used in connection with this study. The presentation of this information is generalized under separate subsections for hydrologic and water quality data that are collected through the four primary components of this study identified previously in the Experimental Design section.

Continuous Hydrologic Data

Data from the automated instruments at each station are uploaded at monthly intervals (or after discrete storm events for HSPF calibration monitoring) using a laptop computer in the field. If appropriate, manual measurements are made on site for equipment calibration purposes in accordance with the schedule identified in the QAPP for the project (Herrera 2007a). On the day following each site visit, uploaded data from each monitoring station are transferred to Microsoft Excel spreadsheets to facilitate all subsequent data management, analysis, and archiving activities. At that time, the data also undergo a quality assurance audit. Any operational problems that are identified through this audit are addressed immediately through a follow-up site visit, if necessary.

Based on manufacturer recommendations, post processing of the data from the DataGator flow metering systems at stations D2 and D3 is also performed to eliminate noise from sensor readings that are below lower thresholds for accuracy. Specifically, the DataGator flow metering systems are constructed with three separate pressure transducers that are positioned at the inlet, throat, and outlet of a Venturi flow tube. Data from the inlet and outlet pressure transducers are processed according to the flow chart in Appendix A to remove spurious values in the flow data record relating to pressure readings that are below the manufacturer's recommended threshold of 0.005 pounds per square for accuracy.

Water level measurements from station WL1 are also adjusted to reflect the ponding depth relative to the staff gauge at the station and the overflow drain for the NDS test swale. In this way, the data from station WL1 can be used to track the occurrence and duration of overflow events at the surface of the NDS test swale.

At the end of each water year, the hydrologic data from all stations undergo a final data quality assurance review prior to analysis to ensure they conform to specific method quality objectives that are specified in the QAPP for the project (Herrera 2007a). The data quality assurance review procedures and results from the current water year are described in a data quality assurance review memorandum that is presented in Appendix B.

Water Quality Data

After each storm sampling event, water quality analytical results are received from the laboratory and entered into Microsoft Excel spreadsheets for all subsequent data management, analysis, and archiving purposes. Data audits are performed within 7 days of receiving the analytical results to ensure they are complete and include all required quality control information. At the end of each water year, a final quality assurance review is also performed on the analytical results prior to their evaluation and analysis by comparing the associated quality control information to specific method quality objectives that are identified in the QAPP for the project (Herrera 2007a). The data quality assurance review procedures and results from the current water year are presented in a data quality assurance review memorandum that is presented in Appendix C.

Data Analysis Methods

The following subsections describe the data analysis procedures used for evaluating data obtained from the four primary components of this study:

HSPF Calibration Monitoring

Discharge and precipitation data from the HSPF calibration monitoring are summarized using tabular and graphical formats to assess their suitability for use in subsequent HSPF model calibration efforts.

Continuous Hydrologic Monitoring

Hydrologic data in this study are being collected to determine if stormwater treatment goals that were established for Phase I of the High Point redevelopment project are being met. Specifically, the stormwater treatment systems on the site must attenuate the 2-year, 24-hour storm to pre-developed pasture conditions and provide water quality treatment for the 6-month, 24-hour storm. These treatment requirements are to be applied to the entire project site, taking into account all of the associated stormwater systems. If, as noted previously, it can be shown that the NDS test swale is meeting these goals, it may be inferred that other NDS swales on the project site are also performing similarly and these treatment goals are also likely being met on a system-wide basis.

To facilitate the evaluation of the NDS test swale's performance relative to these treatment goals, hydrologic data collected in this study are processed to compile the following information for each storm that occurred during the monitoring period:

- Storm precipitation depth from station RG1
- Storm duration from station RG1
- Storm average intensity from station RG1
- Storm peak intensity from station RG1

- Storm antecedent dry period from station RG1
- Peak water level at station WL1
- Peak effluent discharge rate at stations D2 and D3
- Effluent volume at stations D2 and D3.

(Note that storms are delineated in this analysis based on a minimum 12-hour period of no precipitation between each event.)

The characteristics of storm events that produce measurable effluent discharge volumes at stations D2 and D3 are then summarized in order to provide a general assessment of the NDS test swale's treatment performance relative to design expectations. Similarly, the characteristics of storm events that produce overflow events in the NDS swale, as measured at station WL1, are also characterized and compared to these treatment goals. However, it should be noted that more detailed analyses of the NDS test swale's treatment performance cannot be performed at this time pending the development and calibration of the HSPF model (described earlier in the Experimental Design section). Once this model is fully developed, influent discharge rates for the NDS swale can be estimated and compared to effluent discharge rates measured at station D2 and D3 in order to determine if flows from the 2-year, 24-hour storm are being attenuated to pre-developed pasture conditions. This model will be finalized when additional calibration data are obtained through the HSPF calibration monitoring described above.

Controlled Infiltration Tests

Data from controlled infiltration tests are processed to compute an average surface infiltration rate for the NDS test swale using the following formula:

$$IR = \frac{\Delta L}{\Delta T}$$

where: IR = Infiltration rate (inches/hour)

ΔL = Change in water level (in inches) from the point at which water inputs are turned off to the point where no standing water is present

ΔT = Change in time (in hours) from the point at which water inputs are turned off to the point where no standing water is present.

Water Quality Monitoring

Water quality data from this study are being collected at stations WQ1 and WQ2 to characterize stormwater pollutant concentrations before and after treatment, respectively, in the NDS test swale. To facilitate this characterization, basic summary statistics (i.e., average, minimum, and maximum) are computed from the data to describe their central tendency and variation. Where undetected values present in the data, the method detection limit was used in all of these calculations.

Because stations WQ1 and WQ2 are located within a stormwater conveyance system and not an actual waterbody, they are technically not subject to state water quality standards. However, comparisons of the collected data to these standards were performed to provide a general assessment of stormwater quality at each station. As defined in WAC 172-201A, state water quality standards vary depending on specific designated uses that have been established for the associated water body. The High Point neighborhood is located within the watershed for Longfellow Creek which has the following designated uses for aquatic life and recreation:

- Salmonid spawning, rearing, and migration
- Primary contact recreation.

Applicable water quality standards for these designated uses are summarized in Table 3 for the specific monitoring parameters that are targeted in this study. In addition, the U.S. EPA (2000) has recommended ambient water quality criteria that are intended to address the adverse effects of excessive nutrients on streams and rivers. Recommended criteria that are applicable to Longfellow Creek are also summarized in Table 3 for the specific parameters targeted in this study. Study results are compared to these surface water standards/criteria, although they are not directly applicable to stormwater.

Table 3. Applicable water quality standards and criteria for monitoring parameters targeted by the High Point Phase I Block Scale Monitoring project.

Parameter	Standard	Criteria	Source
Total Phosphorus	NA	0.0195 mg/L	U.S. EPA (2000)
Dissolved Copper [a]	Acute[b]: 4.6 µg/L Chronic[c]: 3.5 µg/L	NA	WAC 173-201A
Dissolved Zinc [a]	Acute[b]: 35 µg/L Chronic[c]: 32 µg/L	NA	WAC 173-201A
Fecal Coliform Bacteria	Not to exceed geometric mean value of 100 colonies/ 100 mL with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100 mL.	NA	WAC 173-201A

[a] Standards vary with water hardness. Values presented are based on a median hardness of 25 mg/L as CaCO3 for western Washington (Herrera 2006).
[b] A 1-hour average concentration not to be exceeded more than once every 3 years on average.
[c] A 4-day average concentration not to be exceeded more than once every 3 years on average.
NA: not applicable.
µg/L: microgram/liter.
mL: milliliter.

Results and Discussion

Monitoring results for water year 2007 are summarized and discussed herein. The presentation of this information is organized under separate subsections for the four primary components of this study identified earlier in the Experimental Design section.

HSPF Calibration Monitoring

During water year 2007, HSPF calibration monitoring was performed during three separate storm events that began on March 9, March 23, and September 29. Precipitation and discharge data collected from stations RG1 and D1, respectively, during these events are presented in Figures 6, 7, and 8, and summary statistics computed from these data are presented in Table 4. These data indicated that precipitation totals for the three storm events ranged from 0.72 inches for the March 23 storm to 1.10 inches for the September 29 storm. Average precipitation intensities ranged from 0.014 inches/hour for the March 9 storm to 0.042 inches/hour for the September 29 storm.

Predictably, the lowest flow volume discharged to the NDS test swale (3,355 gallons) was measured coincident with the storm having the smallest precipitation total (i.e., the March 23 storm). Flow volumes to the NDS test swale during the March 9 and September 29 storms were substantially higher (5,863 and 5,018 gallons, respectively). Maximum discharge rates to the NDS test swale ranged from 12.6 gallons/minute (gal/min) during the September 29 storm to 28.4 gal/min during the March 9 storm.

The HSPF calibration monitoring is specifically targeting storms of sufficient size to produce measurable quantities of runoff in the NDS test swale while not exceeding the 6-month, 24-hour event (1.08 inches). Based on the data results presented in Table 4, the sampled storm events generally conformed to this goal. In the coming water year, HSPF calibration monitoring will be performed during three additional storms. The data from all the storm events will then be used in HSPF model calibration efforts.

Continuous Hydrologic Monitoring

Monitoring results for continuous hydrologic monitoring are summarized and discussed herein. The presentation of this information is organized under separate subsections for precipitation, discharge, and water level data.

Precipitation Data

Precipitation monitoring for this study initiated on January 17, 2007 with the establishment of station RG1 at the High Point Public Library (see Figure 3). However, monitoring at other

Table 4. Summary of precipitation and discharge data collected from stations RG1 and D1, respectively, during HSFP calibration monitoring in water year 2007.

Storm Start Date and Time	Storm End Date and Time	Storm Duration (hours)	Storm Antecedent Dry Period (hours)	Storm Precipitation Depth (inches)	Storm Maximum Precipitation Intensity (inches/15minutes)	Storm Average Precipitation Intensity (inches/hour)	Flow Volume to NDS Test Swale (gallons)	Maximum Discharge to NDS Test Swale (gal/min)
3/9/07 20:30	3/12/07 11:00	62.50	20.00	0.86	0.040	0.014	5,863	28.4
3/23/07 11:30	3/25/07 8:45	45.25	20.00	0.72	0.020	0.016	3,355	14.1
9/29/07 21:45	10/1/07 0:00	26.25	43.25	1.10	0.030	0.042	5,018	12.6

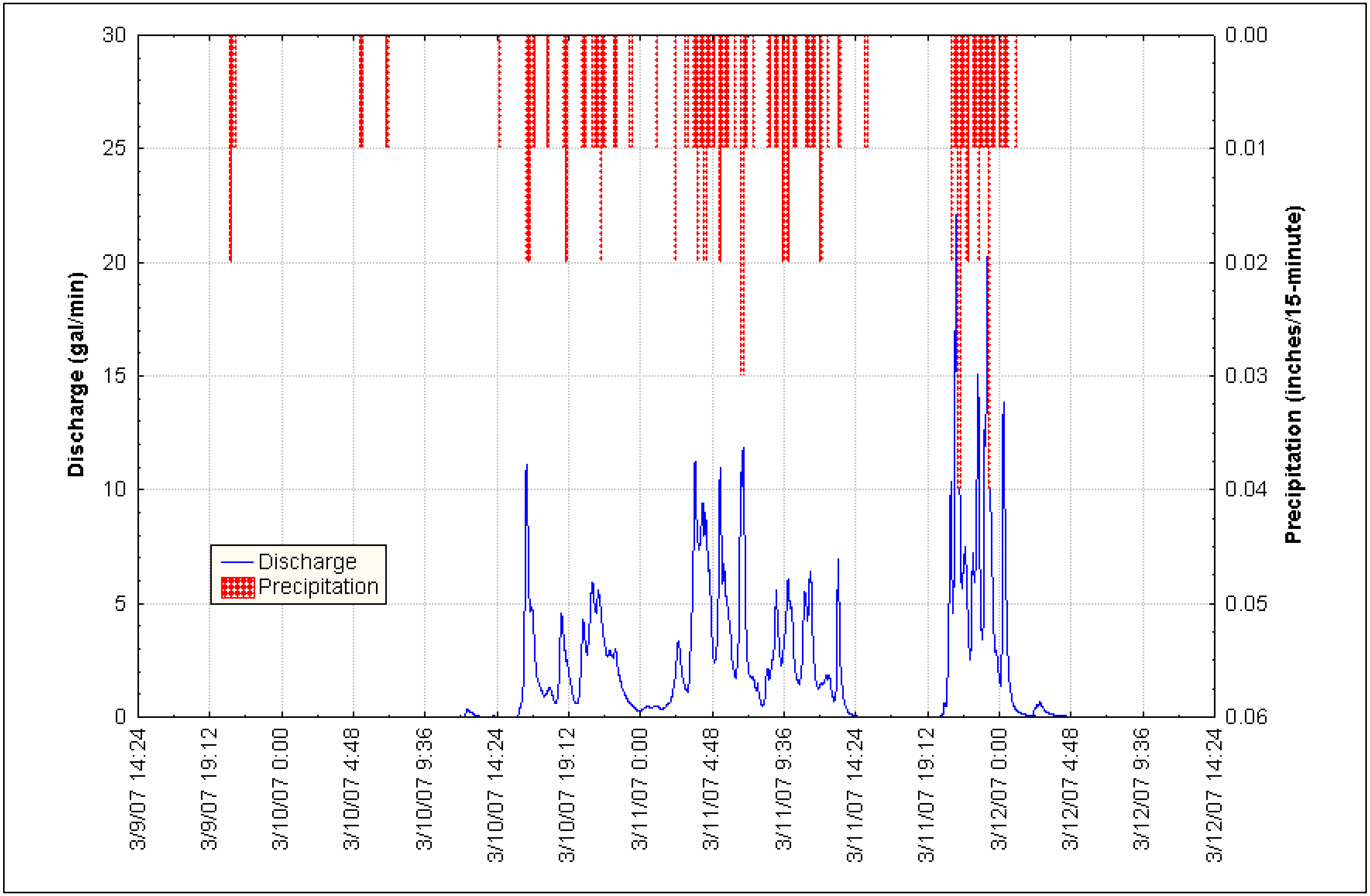

Figure 6. **Precipitation and discharge data collected during the March 9, 2007 storm event for HSPF calibration monitoring related to the High Point Phase I Block Scale Monitoring project.**

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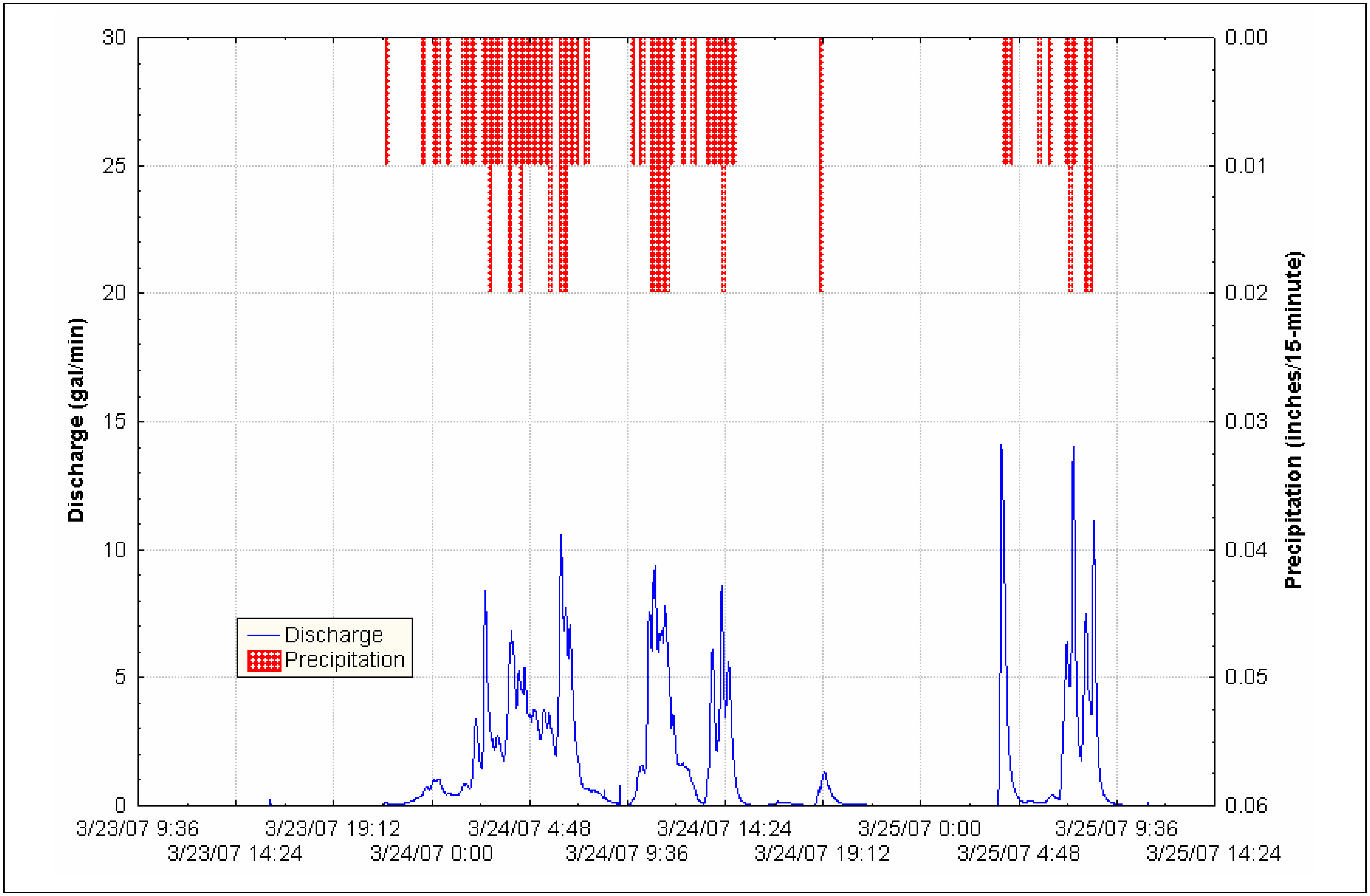

Figure 7. Precipitation and discharge data collected during the March 23, 2007 storm event for HSPF calibration monitoring related to the High Point Phase I Block Scale Monitoring project.

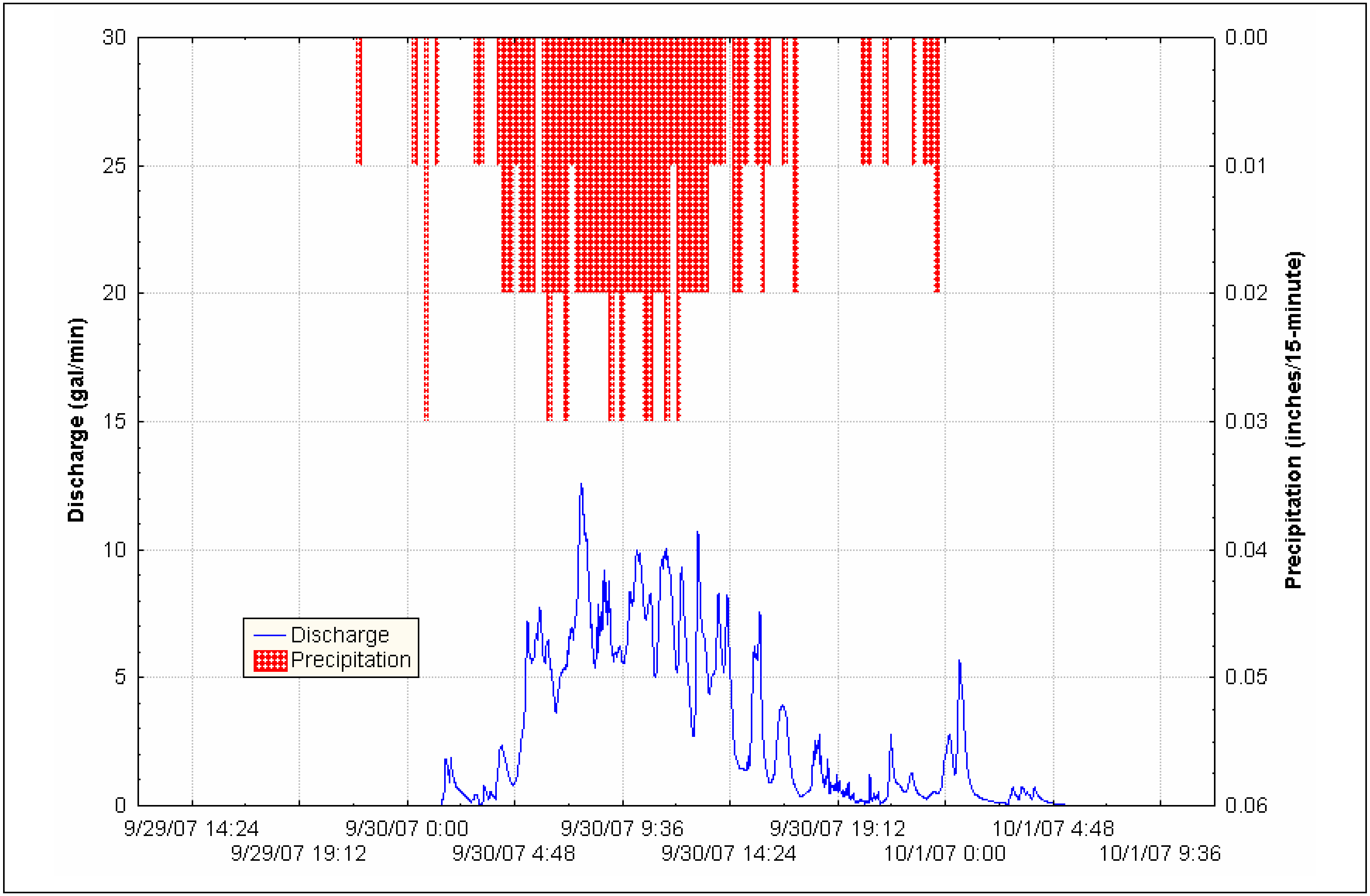

Figure 8. Precipitation and discharge data collected during the September 29, 2007 storm event for HSPF calibration monitoring related to the High Point Phase I Block Scale Monitoring project.

stations established in connection with this study was initiated as early as December 29, 2006. To facilitate the interpretation of data from these stations, precipitation data for the period extending from December 29 through January 16 were obtained from other monitoring stations that are maintained by SPU. Specifically, precipitation data for the period extending from December 29 through December 31 were obtained from SPU’s station RG18, which is located approximately 7 miles due east of station RG1. Similarly, precipitation data for the period extending from January 1 through January 16 were obtained from SPU’s station RG14, which is located approximately 3 miles due north of station RG1.

The data obtained from all of these stations were subsequently combined and used for the analyses presented herein. The raw precipitation data from these stations are summarized graphically in Figure 9. In addition, Table D1 in Appendix D presents detailed summary data from individual storm events including the date and time for the storm beginning and end, the storm duration, antecedent dry period, precipitation total, maximum intensity, and average intensity. More general summary statistics were computed from these data and are provided in Table 5. Finally, forms that were completed in conjunction with routine quality assurance audits of the data from station RG1 are presented in Appendix E, while results from the formal verification and validation review of these data are summarized in the hydrologic data quality assurance review memorandum that is presented in Appendix B.

Table 5. Summary statistics for storm events measured over the period from December 29, 2006 through September 30, 2007.

	Minimum	Median	Maximum
Precipitation Total (inches)	0.01	0.10	1.36
Storm Duration (hours)	0.25	7.00	62.50
Antecedent Dry Period (hours)	12.25	37.50	322.00
Average Intensity (inches/hour)	0.003	0.02	0.36
Maximum Intensity (inches/15 minutes)	0.01	0.02	0.15

Based on these data, a total of 89 storm events occurred over the period extending from December 29, 2006 through September 30, 2007. Twelve of these storms had precipitation totals that exceeded 0.50 inches, 16 had totals between 0.50 and 0.25 inches, and 61 had totals that were less than 0.25 inches. The median precipitation total across all the storms was 0.10 inches. The three highest precipitation totals (1.39, 1.15, and 1.10 inches) occurred coincident with storm events that initiated on May 20, January 1, and October 1, respectively. These were the only three storms with precipitation totals exceeding the threshold (1.08 inches) corresponding to the 6-month, 24-hour design storm for water quality treatment. The precipitation total for the May 20 storm also exceeded the threshold (1.68 inches) corresponding to the 2-year, 24-hour design storm for flow control. However, it should be noted that total duration of the May 20 and January 1 storms was much longer than 24 hours. For example, the May 20 storm lasted 39.5 hours and the January 1 storm lasted 42.0 hours. The October 1 storm lasted only 26.5 hours and is therefore generally considered representative of the 6-month, 24-hour design storm.

The median storm duration was 7 hours while the range was 0.25 to 62.50 hours. Similarly, the median storm antecedent dry period was 37.5 hours while the range was 12.25 to 322 hours. The storm with the highest average intensity (0.36 inches/hour) began on May 4 and lasted only 1 hour. The storm with the highest maximum intensity (0.15 inches/15 minutes) began on January 8, 2007 and lasted 0.5 hours.

To provide some context for interpreting these data, it should be noted that water year 2007 was substantially wetter than normal based on analyses performed by the National Weather Service (2007) using data from Sea-Tac Airport. For example, the precipitation total for water year 2007 from these data was 47.16 inches, whereas the historical average is approximately 37.07 inches.

Discharge Data

Discharge monitoring at stations D2 and D3 began on January 19, 2007 and December 29, 2006, respectively. (The start of monitoring at station D2 was delayed relative to station D3 due to the presence of a cap on the associated underdrain pipe that complicated installation of the required monitoring equipment.) The raw discharge data, including inflow to the swale and discharge from the swale's underdrain as measured at Station D3, are presented in Figure 9. In addition, Table D2 in Appendix D presents summary data from each station for individual storm events including the total flow volume, maximum discharge rate, and flow duration. Finally, forms that were completed in conjunction with routine quality assurance audits of these data are presented in Appendix E, while the results from the formal verification and validation review of these data are summarized in the hydrologic data quality assurance review memorandum that is presented in Appendix B.

Excluding periods when no data were collected due to equipment malfunctions or when water was being diverted away from the NDS test swale to facilitate HSPF calibration monitoring, discharge data were collected over 72 and 83 storm events at stations D2 and D3, respectively (see Appendix D, Table D2). However, these data indicate that stormwater was rarely discharged from the underdrain pipes that are associated with each monitoring station (see Figure 9). For example, substantial quantities of stormwater were observed during only three storm events at station D2. The associated storm events began on May 20, September 3, and September 27. As noted previously, the May 20 storm had the highest precipitation total (1.36 inches) out of all the storms in the current monitoring period and lasted 39.5 hours. The September 3 storm produced 0.72 inches of precipitation in 10.25 hours, while the September 27 storm produced 0.27 inches in 7 hours. Total flow volumes measured at station D2 in conjunction with these storms were relatively small. For example, the total flow volume measured during each storm ranged from 116.7 gallons during the May 20 storm to 150.9 gallons during the September 3 storm. Maximum discharge rates were similarly low, ranging from 0.9 gal/min during the May 20 storm to 1.3 gal/min during the September 3 storm. The total flow duration for all three storms was also relatively short (<5 hours).

Substantial quantities of stormwater were observed at station D3 during only two storm events that began on January 1 and September 3 (see Figure 9 and Appendix D, Table D2). As noted

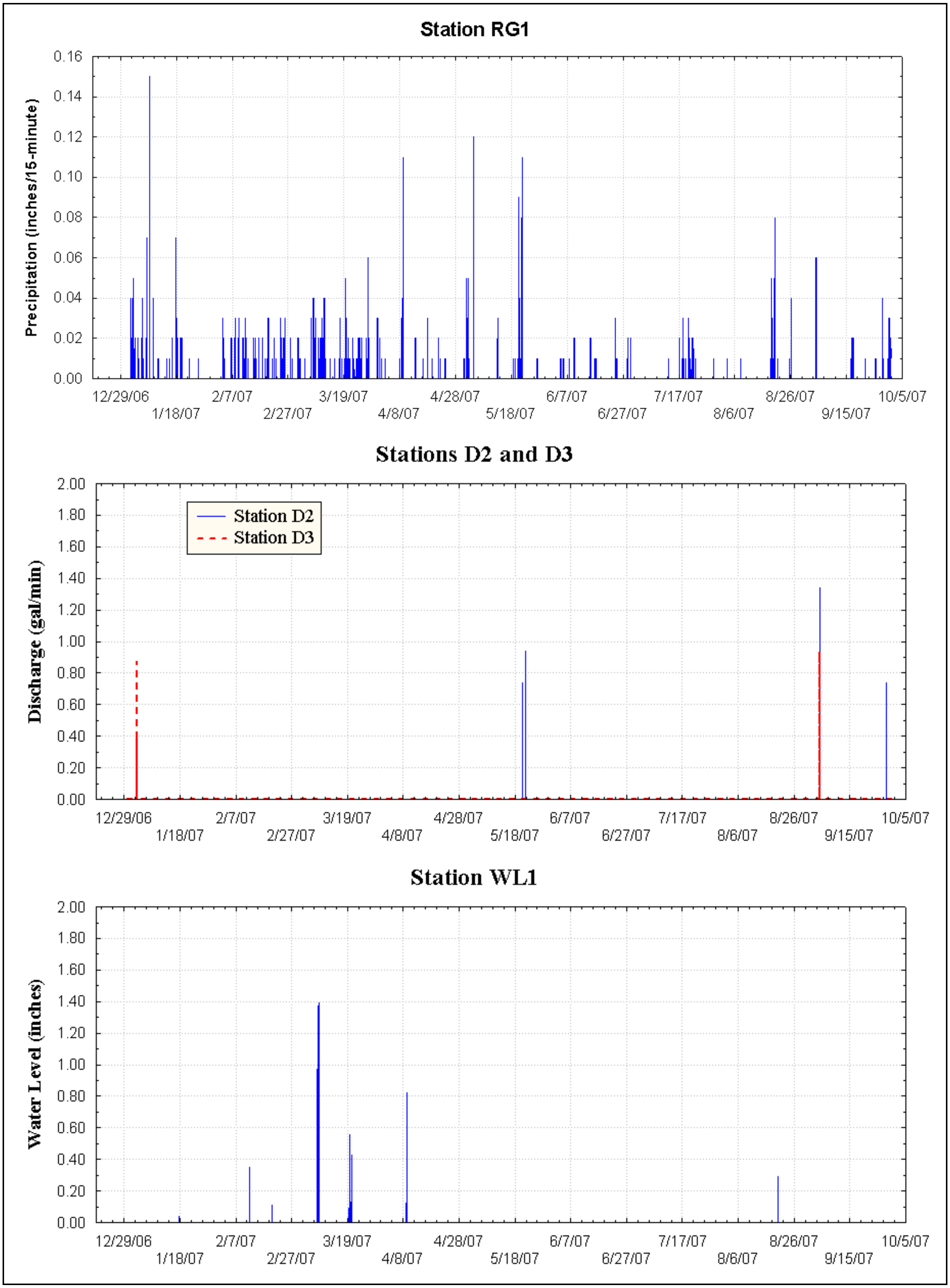

Figure 9. Precipitation, discharge, and water level data measured using continuous hydrologic monitoring for the High Point Phase I Block Scale Monitoring project.

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previously, the January 1 storm had the second highest precipitation total (1.15 inches) out of all the storms in the current monitoring period and lasted 42.0 hours. (Note that station D2 was not installed until January 17; therefore, no data are available from this station for the January 1 storm.) Characteristics of the September 3 storm event are described above in conjunction with the station D2 data. Similar to station D2, the flow volumes measured at station D3 during these storms were relatively low (60.3 and 77.4 gallons, respectively). Likewise, the maximum discharge rate for both storms (0.9 gal/min) was barely above levels that can be accurately quantified using the equipment employed for this study.

Considered collectively, the data from stations D2 and D3 indicate the NDS test swale effectively treated all runoff from storm events with precipitation totals below the 6-month, 24-hour and 2-year, 24-hour design storms for water quality treatment and flow control, respectively. Even when measured precipitation totals exceeded the corresponding thresholds for these design storms, flow volumes and maximum discharge rates measured in the underdrain system of the NDS test swale were extremely low. However, it should be noted that more detailed analyses of the NDS test swale's performance relative to the design goals will be performed in subsequent phases of the project once influent discharge rates are available from the HSPF model.

Water Level Data

Water level monitoring at stations WL1 began on January 17, 2007. The raw water level data from this station are presented in Figure 9. In addition, Table D3 in Appendix D presents summary data from each station for individual storm events including the average water depth, maximum water depth, and ponding duration. Forms that were completed in conjunction with routine quality assurance audits of these data are presented in Appendix E, while the results from the formal verification and validation review process are summarized in the hydrologic data quality assurance review memorandum that is presented in Appendix B.

Excluding periods when no data were collected due to equipment malfunctions or when water was being diverted away from the NDS test swale to facilitate HSPF calibration monitoring, water level data were collected at station WL1 over 83 storm events (see Appendix D, Table D2). However, substantial ponding within the NDS test swale was only observed during five of these events (see Figure 9). At no time did water levels within the NDS test swale exceed the depth threshold (13.32 inches) that would result in a discharge to the overflow drain. The highest measured water level at station WL1 (2.1 inches) occurred coincident with a storm event that began on April 8 and produced 0.51 inches of precipitation in 13.5 hours. The second highest water level (1.4 inches) occurred coincident with a storm event that began on March 7 and produced 0.68 inches of precipitation in 43.25 hours. However, a controlled infiltration test was performed in the hours immediately leading up to this storm (see discussion in next section). Because the NDS test swale was artificially saturated during this test, the relatively high water level measured during the March 7 storm may be an anomaly. Water levels measured at station WL1 during all other monitored storm events were below 1 inch.

Finally, it should be noted that the HSPF calibration monitoring described above took place during three of the largest storms to occur during the current monitoring period (see Table 4 and Appendix D, Table D1). Ponding in the NDS test swale was precluded during these events because all runoff was diverted to station D1 and the overflow drain to facilitate the HSPF calibration monitoring. Therefore, it is possible that additional ponding might have been measured during the current monitoring period had the runoff from these three large storms been allowed to enter the NDS test swale.

In general, frequent ponding and high water levels in the NDS test swale may be precluded during all but the largest storms due to the relatively high infiltration rates that have been measured for water on the surface of the swale (see discussion below).

Controlled Infiltration Tests

Three controlled tests are to be performed for this study to measure infiltration rates on the surface of the NDS test swale. The first and second tests were completed on March 7, 2007 and April 11, 2007, respectively. (The third test is to be performed during the third and final year of the monitoring project.) Results from these tests were documented in detail in two previous data reports (Herrera 2007b, 2007c). For convenience, these reports are reproduced in Appendices F and G, respectively, and the results are briefly summarized herein.

Graphs summarizing the water depth and discharge data collected during the March 7 and April 11 infiltration tests are presented in Figure 10. These graphs show the water level increase that occurred with the initial introduction of water into the NDS test swale at the onset of each test, the period of steady state water level and discharge towards the end of each test, and the final period of draw down after the inflow of water has been cut off.

Based on these data, the calculated infiltration rate for the NDS test swale from the March 7 test was 4.22 inches/hour. Similarly, the calculated infiltration rate for NDS test swale from the April 11 test was 6.11 inches/hour. To provide some perspective for interpreting these results, an infiltration rate of 2 inches/hour was assumed for the surface of the High Point NDS swales during the design phase of the project (Herrera and R.W. Beck 2004).

Water Quality Monitoring

Water quality samples were collected during three separate storm events during the current monitoring period. However, due to the lack of discharge from the underdrain system for the NDS test swale (see results in Continuous Hydrologic Monitoring section above), field personnel were unable to collect samples at the effluent monitoring station (WQ2). Therefore, results are only presented herein for the inlet monitoring station (WQ1).

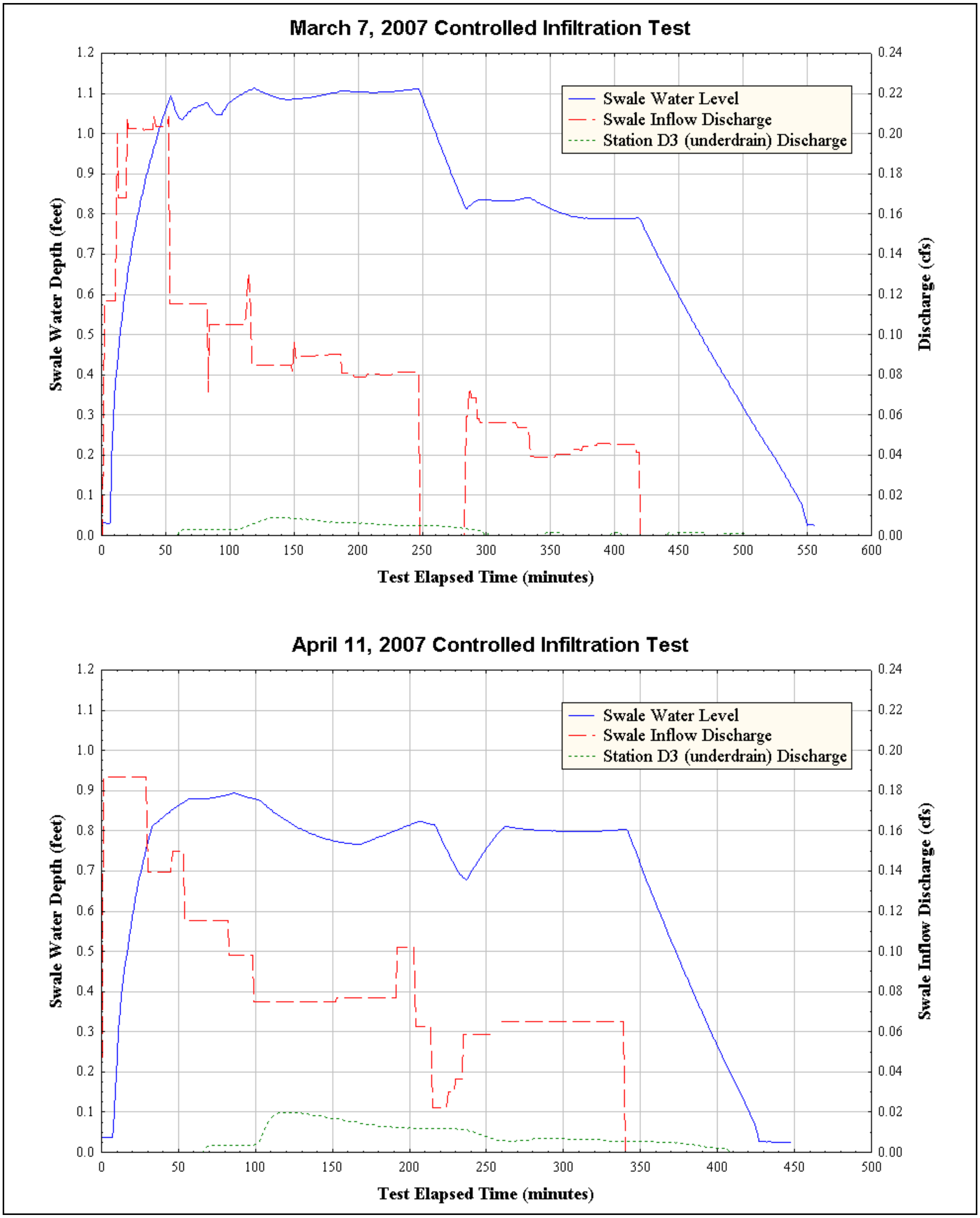

Figure 10. NDS test swale water depth and discharge data from the March 7 and April 11, 2007 controlled infiltration tests.

Summary statistics for precipitation that occurred in association with each sampled storm event are provided in Table 6, while summary statistics for the water quality data are presented in Table 7. To facilitate the interpretation of these data, Table 7 also presents median stormwater pollutant concentrations for selected parameters based on stormwater samples collected in residential areas through the National Urban Runoff Program (NURP) (Burton and Pitt 2002). In addition, Table 7 presents theoretical background or "irreducible" concentrations for stormwater pollutants that represent the lowest concentration that can be achieved through treatment using conventional stormwater controls (Winer 2000). Finally, results from the formal verification and validation review of the water quality data are summarized in the water quality data quality assurance review memorandum in Appendix C, and laboratory reports, chain-of-custody records, and data quality assurance audit forms from these data are presented in Appendix H.

Table 6. Summary statistics for precipitation measured in association with storm events that were sampled for water quality in water year 2007.

Storm Start Time	Storm End Time	Storm Precipitation Depth (inches)	Storm Antecedent Dry Period (hours)	End of Storm Dry Period (hours)
6/9/2007 9:30	6/10/2007 19:00	0.26	43.00	128.50
9/27/2007 19:30	9/28/2007 2:15	0.27	51.75	43.25
9/29/2007 21:45	9/30/2007 23:45	1.10	43.25	21.00

As described in the Methods Section of this document, guidelines were established for defining the acceptability of specific storm events for water quality sampling based on storm precipitation total, antecedent dry period, and end of storm dry period. These guidelines were adopted to ensure the quality of the influent and effluent to the NDS test swale will be characterized during representative storm conditions. Based on the data presented in Table 6, all three of the sampled storms met the established guidelines.

Comparisons of the data presented in Table 7 indicate that the maximum pollutant concentrations for the following parameters in runoff from the High Point neighborhood were lower than the median values from the NURP data set: total suspended solids, soluble reactive phosphorus, total phosphorus, total copper, and total zinc. In addition, concentrations of total copper and total zinc in runoff from the High Point neighborhood were at levels that are considered irreducible based on other research (Winer 2000).

Because stations WQ1 and WQ2 are located within a stormwater conveyance system and not an actual waterbody, they are technically not subject to state water quality standards. However, as described in the Methods sections, comparisons of the collected data to these standards were performed to provide a general assessment of stormwater quality at each station. Results from theses comparisons showed that concentrations of several parameters in runoff from the High Point neighborhood exceeded applicable state water quality standards or federal criterion (see Table 3). For example, based on the median hardness concentration from samples collected for this study (22.3 mg/L as $CaCO_3$), the median and maximum concentrations for dissolved copper

(0.0075 and 0.0086 mg/L, respectively) exceeded the applicable water quality standard for this metal (i.e., 0.0042 mg/L). In addition, the average and maximum concentrations for fecal coliform bacteria (1,180 and 2,200 colony forming units [CFU]/100 ml, respectively) exceeded the applicable water quality standard (200 CFU/100 ml). Finally, the minimum concentration for total phosphorus (0.140 mg/L) exceeded the applicable federal criterion for this parameter (0.0195 mg/L).

Table 7. Summary statistics for water quality data obtained from samples collected at station WQ1 in water year 2007.

Parameter	n	Minimum Concentration	Maximum Concentration	Median Concentration	Median Concentration from NURP [b]	Irreducible Concentration Range [c]
Total Suspended Solids (mg/L)	3	17	31	25	101	11 - 28
Soluble Reactive Phosphorus (mg/L)	3	0.032 J	0.120 J	0.069	0.143	0.003 – 0.13
Total Phosphorus (mg/L)	3	**0.140**	**0.220**	**0.143**	0.383	0.05 – 0.20
SSC – Coarse Fraction (mg/L)	3	1.6	22	1.7	ND	ND
SSC – Fine (mg/L)	3	10	19	15	ND	ND
Total Copper (mg/L)	3	0.0030	0.0101	0.0088	0.033	0.0048 - 0.010
Dissolved Copper (mg/L)	3	0.0011 J	**0.0086**	**0.0075 J**	ND	ND
Total Zinc (mg/L)	3	0.034	0.035	0.035	0.135	0.021 – 0.098
Dissolved Zinc (mg/L)	3	0.012 J	0.021	0.017 J	ND	ND
Hardness (mg/L as $CaCO_3$)	2[a]	9.58	35.0	22.3	ND	ND
Fecal (CFU/100 ml)	2[a]	160	**2,200 J**	**1,180**	ND	ND
E. Coli (CFU/100 ml)	2[a]	160	2,200 J	1,180	ND	ND

Values in **bold** exceed applicable state water quality standards or federal criteria (see Table 3). Water quality standards for dissolved copper and zinc were computed based on the average hardness concentration (22.29 mg/L as $CaCO_3$) from Table 7.

[a] Hardness, fecal coliform bacteria, and *Escherichia coli* (*E. coli*) bacteria were added to the list of targeted parameters in this study after the first sampling event. Therefore, only two samples were collected for these parameters.

[b] Source: Burton and Pitt (2002).

[c] Source: Winer (2000).

CFU/100 ml: colony forming units per 100 milliliters.
J: estimated value.
mg/L: milligrams per liter.
ND: no data.
SSC: suspended sediment concentration.

Conclusions

Major conclusions from the monitoring data collected during water year 2007 for the High Point Phase I Block Scale Monitoring project are summarized below.

- Storms captured for the HSPF calibration monitoring generally conformed to the goal of producing measurable quantities of runoff into the NDS test swale while not exceeding the 6-month, 24-hour event. Once additional monitoring has been completed for this component of the study, the data from all the storm events will be used in the HSPF model calibration efforts.

- Continuous hydrologic data collected during the monitoring period indicated that precipitation totals for three storms exceeding the threshold corresponding to the 6-month, 24-hour design storm for water quality treatment. The precipitation total for one storm also exceeded the threshold corresponding to the 2-year, 24-hour design storm for flow control. However, the total duration of two of these storms was longer than 24 hours.

- Continuous hydrologic data collected during the monitoring period indicated that the NDS test swale effectively treated all runoff from storm events with precipitation totals below the 6-month, 24-hour and 2-year, 24-hour design storms for water quality treatment and flow control, respectively. Even when measured precipitation totals exceeded the corresponding thresholds for these design storms, flow volumes and maximum discharge rates measured in the underdrain system of the NDS test swale were relatively low. More detailed analyses of the NDS test swale's performance relative to design goals will be performed in subsequent phases of the project to further evaluate and verify these results.

- Continuous hydrologic data collected during the monitoring period indicated that ponding within the NDS test swale was rarely observed. At no time did water levels within the NDS test swale exceed the depth threshold that would result in a discharge to the overflow drain. However, it is possible that additional ponding might have occurred during the monitoring period had the runoff from several large storms not been diverted from the NDS test swale to facilitate the three HSPF calibration monitoring events.

- Measured infiltration rates for the NDS test swale were 4.22 and 6.11 inches/hour from the two controlled infiltration tests performed during the monitoring period. These infiltration rates were substantially higher than the rate that was assumed for the design phase of the High Point NDS swales.

- Pollutant concentrations in runoff arising from the High Point neighborhood were generally lower than concentrations measured in national studies for the same land use (Burton and Pitt 2002). In addition, concentrations of metals were at levels that are considered irreducible using conventional stormwater controls.

References

APHA, AWWA, and WEF. 1992. Standard Methods for the Examination of Water and Wastewater. 18th edition. Edited by A.E. Greenberg, American Public Health Association; A.D. Eaton, American Water Works Association; and L.S. Clesceri, Water Environment Federation.

Burton, G.A. and R.E. Pitt. 2002. Stormwater Effects Handbook: A Toolbox for Watershed Managers, Scientists, and Engineers. Lewis Publishers, Boca Raton, Florida.

Ecology. 2002. Guidance for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol – Ecology (TAPE). Publication No. 02-10-037. Washington State Department of Ecology, Olympia, Washington.

Ecology. 2005. Stormwater Management in Western Washington – Volume III: Hydrologic Analysis and Flow Control Design/BMPs. Publication No. 05-10-31 (a revision of Publication No. 99-13). Washington State Department of Ecology, Water Quality Program, Olympia, Washington. February 2005.

Grant, D.M. and B.D. Dawson. 1997. ISCO Open Channel Flow Measurement Handbook. Fifth Edition. ISCO Inc., Lincoln, Nebraska.

Herrera and R.W. Beck. 2004. Hydrologic Modeling for High Point Revitalization, Seattle, Washington. Appendix C to High Point Drainage Plan Report by SvR Design Company. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., and R.W. Beck, Seattle, Washington. May 5, 2004.

Herrera. 2007a. High Point Phase I Block Sacke Monitoring: Quality Assurance Project Plan. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., Seattle, Washington. August 13, 2007.

Herrera. 2007b. Data Report: First Controlled Infiltration Test for the High Point Phase I Block Scale Monitoring Project. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., Seattle, Washington. April 10, 2007.

Herrera. 2007c. Data Report: Second Controlled Infiltration Test for the High Point Phase I Block Scale Monitoring Project. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., Seattle, Washington. May 24, 2007.

National Weather Service. 2007. Water Year 2007 Climate Charts for Seattle-Tacoma Airport. Obtained December 10, 2007 from National Weather Service website: <http://www.wrh.noaa.gov/climate/yeardisp.php?stn=KSEA&wfo=sew&year=2006&span=Water+Year>.

U.S. EPA. 1983. Methods for Chemical Analysis of Water and Wastes. EPA 600/4-79-020. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

U.S. EPA. 1984. Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act; Final Rule and Interim Final Rule. U.S. Environmental Protection Agency. Code of Federal Regulations Part 136. October 26, 1984.

U.S. EPA. 2000. Ambient Water Quality Criteria Recommendations: Rivers and Streams in Ecoregion II. EPA 822-B-00-015. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Prepared for the U.S. Environmental Protection Agency by the Center for Watershed Protection, Ellicott City, Maryland. June 2000.

APPENDIX A

Data Post Processing Procedures for DataGator Flow Metering Systems

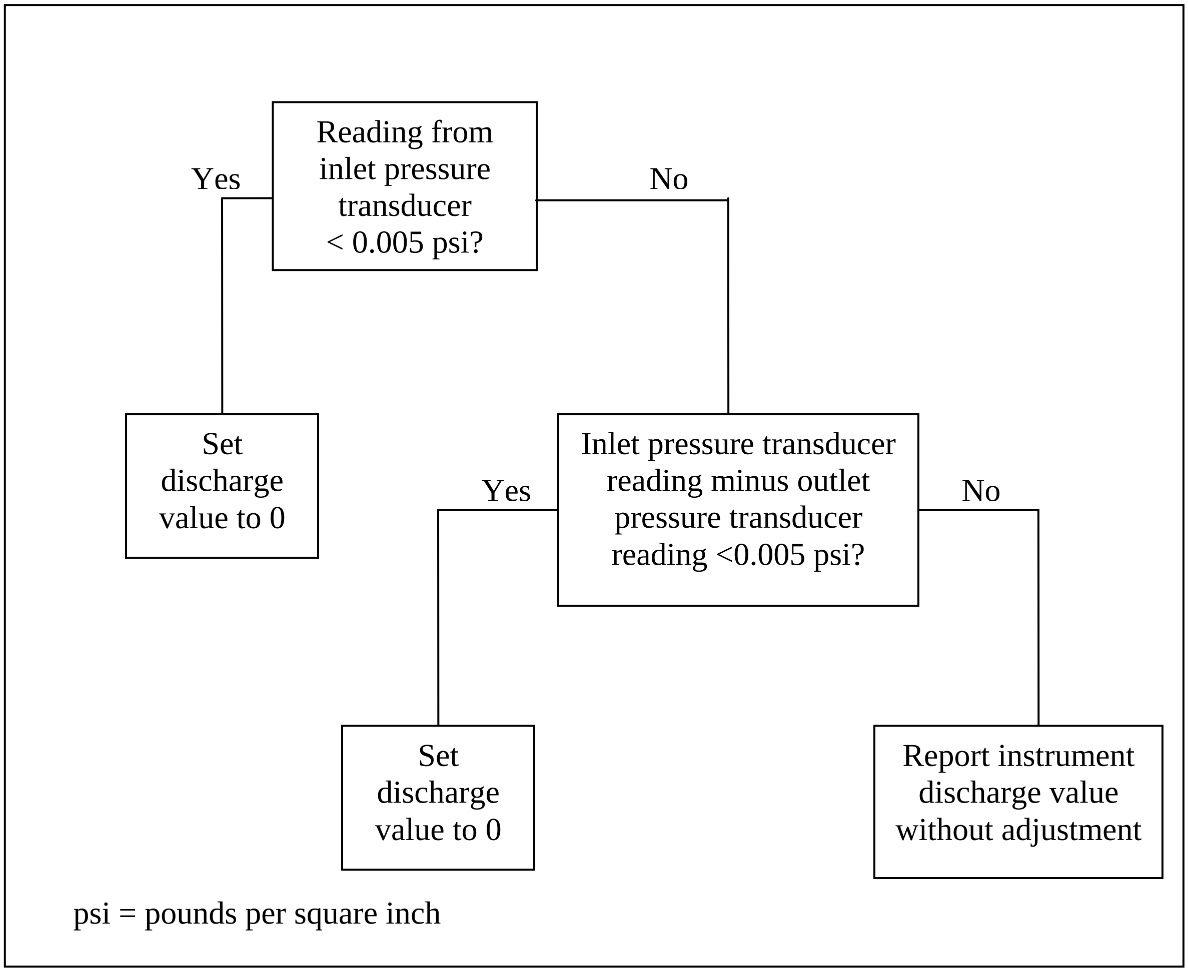

Figure A1. Data processing procedures for DataGator flow metering systems installed at stations D2 and D3 for the High Point Phase I Block Scale monitoring project.

APPENDIX B

Hydrologic Data Quality Assurance Review Memorandum

Herrera Environmental Consultants, Inc.

Memorandum

To	Project File 06-03304-050
From	Elizabeth Woodcock and John Lenth, Herrera Environmental Consultants
Date	December 14, 2007
Subject	Water Year 2007 Hydrologic Data Validation Review for the High Point Phase I Block Scale Monitoring Project

This memorandum presents the results from a quality assurance review of the continuous hydrologic monitoring data that were collected for the High Point Phase I Block Scale Monitoring project over water year 2007. This review specifically examined water level data from station WL1, precipitation data from station RG1, and discharge data from stations D2 and D3. Detailed descriptions of these stations and their associated monitoring equipment are provided in the Quality Assurance Project Plan (QAPP) that was prepared for the project (Herrera 2007).

As outlined in the QAPP, the goal of the data quality assurance review is to ensure that the data collected through this study are scientifically and legally defensible. To meet this goal, the collected hydrologic data were evaluated relative to specific Measurement Quality Objectives (MQOs) that were defined in the QAPP for the following quality assurance measures: bias, representativeness, completeness, and comparability. Separate subsections below describe the the MQOs for each quality assurance measure, the methods used to evaluate each MQOs, and the results from each evaluation.

Bias

Bias is the systematic or persistent distortion of a measurement process which causes errors in one direction (i.e., the expected measurement is different from the true value). Bias is assessed based on a comparison of monitoring equipment readings to an independently measured “true” value. As defined in the QAPP, the MQOs for discharge measurements is a difference of no more than 10 percent between the instrument reading and the independently measured value. For water level and precipitation depth measurements, the difference between the instrument reading and the independently measured value will be within 5 percent. For reference, Table 1 shows the theoretical accuracy of hydrologic monitoring equipment to be used in for this project based on measurements that were made by the manufacturers under controlled conditions.

The specific MQOs for bias are assessed in the following subsections for water level data from station WL1, precipitation data from station RG1 (as well as SPU stations RG14 and RG18 from SPU), and discharge data from stations D2 and D3.

Table 1. Hydrologic monitoring equipment accuracy based on manufacturer specifications.

Monitoring Equipment	Measurement Type	Accuracy
DataGator	Discharge	Open Channel: ±3 percent [a] Full Pipe: ±3 percent [a] Full Pipe Below Transition: ±10 percent [a] Full Pipe Below Transition: ±5 percent [a]
Campbell Scientific CS445-L submersible pressure transducer	Water Level	±0.1% of full span or ±0.01 feet
Hydrologic Services TB3 tipping bucket rain gauge	Precipitation Depth	±2% for rainfall intensities ranging from 1 to 28 inches/hour

[a] Accuracy is expressed as a percentage of maximum discharge.

Station WL1 Water Level Data

As noted above, the MQO for water level measurements at station WL1 is a difference of no more than 5 percent between the instrument's readings and an independently measured value. In this case, the independently measured value is derived by reading a staff gauge that was installed in association with the monitoring station at the onset of the project. Pursuant to the QAPP for the project (Herrera 2007), these measurements are to be made six times annually. However, field crews were unable to collect simultaneous measurements from the staff gauge and instrument in the course of routine monitoring in water year 2007 because standing water was rarely observed at station WL1.

Due to this consideration, the MQO was assessed based on repeated measurements made during controlled infiltration tests that were performed on March 7 and April 11, 2007. These data are summarized in Table 2 and include the staff gauge readings, raw readings from station WL1's pressure transducer, and adjusted pressure transducer readings to facilitate comparison to the staff gauge. The adjusted readings were derived by subtracting a constant value (0.05 feet) from the raw pressure transducer readings based on the calculated elevation difference between the staff gauge and pressure transducer.

The percent difference between the repeated staff gauge and adjusted pressure transducer readings were subsequently calculated based on the following equation:

$$\%D = \frac{(M - T) \text{ x } 100\%}{T}$$

where: %D = percent difference
S = measured value from instrument
T = independently measured value.

Table 2. Comparison of staff gauge and pressure transducer reading for station WL1 during controlled infiltration tests performed on March 7 and April 11, 2007.

Date	Time	Staff Gauge Readings (feet)	Station WL1 Raw Pressure Transducer Readings (feet)	Station WL1 Adjusted Pressure Transducer Readings [a] (feet)	Difference Between Staff Gauge and Adjusted Pressure Transducer Readings (%)
3/7/2007	9:26	0.46	0.480	0.430	-6.5
3/7/2007	9:33	0.58	0.618	0.568	-2.1
3/7/2007	9:34	0.62	0.660	0.610	-1.6
3/7/2007	9:46	0.80	0.850	0.800	0.0
3/7/2007	9:47	0.82	0.867	0.817	-0.4
3/7/2007	9:54	0.90	0.955	0.905	0.6
3/7/2007	9:55	0.92	0.967	0.917	0.2
3/7/2007	10:05	1.00	1.068	1.018	1.8
3/7/2007	10:06	1.01	1.070	1.020	1.0
3/7/2007	10:36	1.02	1.069	1.019	-0.1
3/7/2007	10:37	1.02	1.064	1.014	-0.6
4/11/2007	9:05	0.75	0.820	0.770	2.7
Average:					-0.4

[a] The adjusted pressure transducer readings were derived by subtracting a constant value (0.05 feet) from the raw pressure transducer readings based on the calculated elevation difference between the staff gauge and pressure transducer.

The resultant values are also shown in Table 2. The average percent difference between the staff gauge readings and adjusted pressure transducer readings was then calculated. This result (-0.4 percent) indicates that the MQO for bias was met for water level measurements collected at station WL1 over water year 2007.

Station RG1 Precipitation Data

As noted above, the MQO for precipitation measurements at station RG1 is a difference of no more than 5 percent between the instrument's readings and an independently measured true value. In this case, the true value is the factory specified volume that is required to trip either one of the two tipping buckets that are associated with the rain gauge installed at station RG1. To evaluate the MQO, field personnel made replicate measurements (10 for each tipping bucket, for a total of 20 measurements) of the actual volume required to trip the tipping buckets. Pursuant to the QAPP for the project (Herrera 2007), these measurements are to be made annually through the duration of the project. The rain gauge was installed on December 29, 2006 and these measurements were made on December 8, 2007. The associated results are summarized in Table 3.

Based on these measurements, the average volume required to trip the tipping buckets was 7.1 milliliters (ml). The percent difference between this value and the factory specified volume for tripping the tipping buckets (6.47 ml) was subsequently calculated based on the equation described in the preceding subsection. The result from this calculation (10.0 percent different) suggests that the MQO for bias was not met for precipitation measurements collected at station WL1 over water year 2007.

Table 3. Results from rain gauge calibration measurements made at station RG1 on December 8, 2007.

Replicate	Tipping Bucket #	Volume to Required to Trip Tipping Bucket (ml)
1	1	7.2
1	2	6.5
2	1	7.2
2	2	6.5
3	1	7.5
3	2	6.7
4	1	8.4
4	2	7.5
5	1	7.4
5	2	7.5
6	1	7.3
6	2	6.4
7	1	7.3
7	2	7.4
8	1	7.5
8	2	6.8
9	1	7.0
9	2	6.0
10	1	7.0
10	2	7.2
Average:		7.1

However, there are several factors that can affect the accuracy of the calibration measurements when made under uncontrolled conditions in the field (e.g., temperature, wind, etc.). Therefore, these results will be verified using a different calibration procedure. Specifically, the calibration check will be repeated using a more precise field calibration kit that provided by the manufacturer. The results from this follow-up calibration check will be documented in separate memorandum with a corrective actions identified as necessary.

Stations D2 and D3 Discharge Data

As noted above, the MQO for discharge measurements at stations D2 and D3 is a difference of no more than 10 percent between the instrument's readings and an independently measured value. In this case, the independently measured value is derived by making a manual measurement of discharge at each station. More specifically, a calibrated is bucket positioned to capture the discharge from the underdrains associated with each station. A stopwatch is then used to determine the time required to collect a known volume of water in the bucket. Pursuant to the QAPP for the project (Herrera 2007), these measurements are to be made twice annually. However, field crews were unable to collect these measurements in the course of routine monitoring in water year 2007 because water was rarely observed discharging from the underdrains associated with stations D2 and D3.

Due to this consideration, the MQO was assessed based on three repeated measurements made at station D3 during the controlled infiltration test that was performed on April 11, 2007. These data are summarized in Table 4 and include the discharge rate from the flow monitoring equipment installed at station D3 and the manual measurement of discharge obtained from the calibrated bucket measurements. The percent difference between these values was subsequently calculated based on the equation described in the subsection above for station WL1 (see Table 4).

Table 4. Comparison of manual and instrument discharge readings from station D3 WL1 during the controlled infiltration tests performed on April 11, 2007.

Date	Time	Discharge (GPM) from Manual Meas.	Discharge (GPM) from Instrument	Difference Between Manual and Instrument Readings (%)
4/11/2007	14:35	2.47	2.33	-5.7
4/11/2007	14:45	1.86	2.06	10.8
4/11/2007	15:02	.22	1.21	450

These results showed a pattern related to the magnitude of discharge that was present at the station at the time of the measurement. Specifically, the percent difference for the two measurements made at 2 gallons per minute (gal/min) were relatively low (-5.7 and 10.8 percent), while the percent difference for the one measurement made at 0.22 gal/min was substantially larger (450 percent). However, according to the manufacturer, discharge rates below approximately 1 gal/min cannot be accurately measured by the instrument installed at station D3 (Natarajan 2007). If only the two measurements above 1 gal/min are considered, the MQO for bias was generally met for discharge measurements collected at station D3 over water year 2007. However, it should be noted that the MQO for station D2 could not be assessed because no discharge was observed at this station during the controlled infiltration test performed on April 11, 2007.

Representativeness

Representativeness is the degree to which the data accurately describe the conditions being evaluated based on the selected sampling locations, sampling frequency, and sampling methods. To ensure the representativeness of the hydrologic data collected through this project, a test NDS swale was selected at the onset of the project with typical design features for High Point project site. Furthermore, rainfall patterns, stormwater conveyance features, and surrounding land uses were also considered in the identification of monitoring locations and sampling frequencies to ensure representative data for the target conditions of this study are obtained.

Based on anecdotal observations made by field personnel over water year 2007, the test NDS swale selected for this study does not appear anomalous relative to others NDS swales in the High Point neighborhood. Similarly, the monitoring locations and procedures identified for this study appear to be providing representative data for characterizing the performance of the test NDS swale.

Completeness

Completeness is the amount of valid data obtained from the measurement system. Completeness is assessed based on the occurrence of gaps that occurred in the data record for all monitoring equipment. The associated MQO is less than 5 percent of the total data record missing due to equipment malfunctions or other operational problems.

Table 5 summarizes the percentage of missing data from each monitoring station relative to the anticipated amount that should have been collected over the period extending from the inception of monitoring through the end of water year 2007 (i.e., September 30, 2007). The specific flags that were assigned to the missing data are also summarized in Table 5. (These data flags were derived from a list of codes provided by Seattle Public Utilities for use with the Hydstra database [see Table 6]). The data in Table 5 indicate the goal identified above for completeness was met at all stations except WL1. All of the missing data for station WL1 were related to a single equipment malfunction (premature battery failure) that occurred over the period from September 3–25, 2007. However, it should be noted that only three storm events occurred over this period. Precipitation totals for two of these storms were relatively small (0.01 and 0.28 inches), while the precipitation total for one storm was more substantial (0.72 inches). Based on these considerations, this gap in the data record for station WL1 is not expected to have a significant impact on the overall usability of the data.

Table 5. Summary statistics for missing data in water year 2007 for stations RG1, D2, D3, and WL1.

Station RG1	Total Missing Data: 0.0%
Station D2	Total Missing Data: 4.6%
	No Data (Hydstra Code #255): 4.4%
	Suspect data that requires further analysis (Hydstra Code #8): 0.2%
Station D3	Total Missing Data: 2.0%
	No Data (Hydstra Code #255): 2.0%
Station WL1	Total Missing Data: 8.0%
	Power failure or clock altered. No data recorded. (Hydstra Code #254): 8.0%

See Table 6 for a complete list of Hydstra codes.

Table 6. Data quality assurance codes for use with Seattle Public Utilities Hydstra database.

Code	Description
1	Good continuous records
2	Good quality edited data
3	Data transposed from a nearby rain gauge
5	Valid data that has undergone screening level review
6	Provisional and subject to change - data not yet reviewed
7	Vaid data adjusted for calibration
8	Suspect data that requires further analysis
26	Good daily read records
27	Time corrected
28	Data valid based on reviewer's comment
29	Transposed suspect data
30	Irregular Time Rate Data - weekly/monthly read.
31	Transposed missing data
32	Transposed reject data
51	Data interpolated between points 5 min interval
75	Interpolation
76	Reliable interpolation
77	Correlation with other station - same variable
79	Records partly estimated
80	Accumulated
81	Wet day within accumulated rainfall period
82	Linear interpolation across gap in records.
90	Excellent (within 2% of actual discharge)
91	Good (within 5% of actual discharge)
92	Fair (within 8% of actual discharge)
93	Poor (within 10% of actual discharge)
99	Downstream control failed
100	Suspected downstream blockage - level not corrected.
101	Velocity data out of bounds - replaced with estimated velocity
102	Level too low for accurate velocity reading
103	Level too low for accurate level reading
104	Records estimated
105	Data transposed from different time period - same gage.
106	Downstream blockagage caused level to rise - correct level estimated
107	Sensor not completely anchored
108	Turbulent flow causing significant variation in current meter revolutions
109	Significant variation between velocities of adjacent flow measurement cells
110	Abnormal velocity distributions
111	Very slow velocities
112	More than 10% of flow in some sections

Table 6 (continued). Data quality assurance codes for use with Seattle Public Utilities Hydstra database.

Code	Description
113	Poor flow measurement cross-section
114	Angular flow through flow measurement cross-section
115	Negative depth at 0 velocity - depth set to 0
116	Velocity negative at depth below sensor limits - velocity set to 0
117	Velocity negative - sensor error - velocity set to 0
118	Velocity estimated based on velocity rating
140	Data not yet checked
141	Data QA/QC-ed by consultant.
150	Rating table extrapolated due to inadequate gauging information
151	Data Missing
152	Data exceeds control limits
160	Bad data - not usable
161	Maximum recordable level exceeded
162	Rating table exceeded.
163	Logger adjusted incorrectly - human error
164	Gage unstable immediately after installation
170	Data may be salvageable, but requires further review.
201	Data not recorded
202	Power failure
203	Data missing because input sensor damaged or not connected
204	Not enough particles in water for sensor to read velocity or level
248	Reserved
249	Data not measured
250	Data overflow
251	Record gap error
252	Record deleted
253	Point created for comment
254	Power failure or clock altered. No data recorded.
255	No data.

Comparability

Comparability is the ability to compare data from the current project to data from other similar projects, regulatory requirements, and historical data. The goal of data comparability was met by using standard units of measurement and reporting conventions in the data report that was prepared for water year 2007. For example, precipitation totals from station RG1 were reported in inches, flow volumes and discharge rates from stations D2 and D3 were reported in gallons and gallons per minute, respectively, and water level data from station WL1 were reported in inches. Summary statistics computed from these data were also presented in standardized tables and figures within the data report to facilitate their comparisons to other data sets with relative ease.

References

Herrera. 2007. Quality Assurance Project Plan: High Point Phase I Block Scale Monitoring. Draft. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Seattle, Washington. September 13, 2007.

Natarajan, Raj. 2007. Personal communication (telephone conversation with John Lenth, Herrera Environmental Consultants concerning low level pressure transducer readings and lower threshold for instrument accuracy). Renaissance Instruments, Round Rock, Texas. December 10, 2007.

APPENDIX C

Water Quality Data Quality Assurance Review Memorandum

Herrera Environmental Consultants, Inc.

Memorandum

To	Project File 06-03304-050
cc	John Lenth, Herrera Environmental Consultants
From	Gina Catarra, Herrera Environmental Consultants
Date	December 4, 2007
Subject	Data Quality Assurance Review of High Point Phase I Block Scale Monitoring Water Quality Data

This memorandum presents a review of data quality for three surface water samples collected for performance monitoring of natural drainage system (NDS) swales at the High Point Phase I block scale monitoring site in June and September 2007. Aquatic Research Incorporated of Seattle, Washington analyzed the samples for:

- Total suspended solids by EPA Method 160.2
- Total phosphorus by EPA Method 365.1
- Hardness by Standard Method 2340C
- Soluble reactive phosphorus (SRP) by EPA Method 365.1
- Suspended sediment concentration by Standard Method 3977-97C
- Total and dissolved copper by EPA 220.2
- Total and dissolved zinc by EPA Method 200.7
- Coliform bacteria by Standard Method 9222D
- *Escherichia coli (E. coli)* by EPA Method 10029

The laboratory's performance was reviewed in accordance with quality control (QC) criteria outlined in the *High Point Phase I Block Scale Monitoring Quality Assurance Project Plan* (QAPP) (SPU 2007).

Quality control data summaries submitted by the laboratories were reviewed; raw data were not submitted by the laboratories. Data quality assurance worksheets summarizing the quality assurance and quality control (QA/QC) review were completed for each sampling event and are included with the data. Data qualifiers (flags) were added to the sample results in the laboratory reports. Data validation results are summarized below, followed by definitions of data qualifiers.

Custody, Preservation, Holding Times, and Completeness—Acceptable with Qualification

The samples were properly preserved and sample custody was maintained from sample collection to receipt at the laboratories. With the exception noted below, all samples were filtered and preserved within the required holding times (Table 1). All samples were analyzed within the required holding times. The laboratory reports were complete and contained results for all samples and tests requested on the chain-of-custody (COC) forms.

Table 1. Summary of sample collection requirements.

Parameter	Analytical Method	Bottle	Preservative	Holding Time
Hardness	SM 2340C	500 mL poly	Nitric acid to pH<2, cool to 4°C	6 months
Total suspended solids	EPA 160.2	1 L poly	Cool to 4°C	7 days
Suspended sediment concentration	SM 3977-97C	1 L poly	Cool to 4°C	7 days
Total phosphorus	EPA 365.1	250 mL poly	Sulfuric acid to pH<2, cool to 4°C	28 days
Soluble reactive phosphorus	EPA 365.1	250 mL poly	Cool to 4°C, filtration within 12 hours	48 hours
Dissolved metals	EPA 220.2 /	500 mL poly	Cool to 4°C, filtration within 12 hours, nitric acid to pH <2.	6 months
Total metals	EPA 200.7/200.8	500 mL poly	Nitric acid to pH<2, cool to 4°C	6 months
Fecal coliform bacteria	SM 9222D	300 mL glass	Cool to 4°C	12 hours
Escherichia coli (E. coli)	EPA 10029	300 mL glass	Cool to 4°C	12 hours

The soluble reactive phosphorus, dissolved copper, and dissolved zinc results for samples collected on 6/9/2007 and 9/30/2007 were qualified as estimated (J) because samples were not filtered and preserved with 12 hours of sample collection (see Table 2).

Table 2. Summary of sample results qualified due to exceedance of filtration holding time.

Sample ID	Sample Date	Parameter	Qualifier
WQ-1	6/9/2007	Soluble reactive phosphorus	J
WQ-1	6/9/2007	Dissolved copper	J
WQ-1	6/9/2007	Dissolved zinc	J
WQ-1 Dupe	6/9/2007	Soluble reactive phosphorus	J
WQ-1 Dupe	6/9/2007	Dissolved copper	J
WQ-1 Dupe	6/9/2007	Dissolved zinc	J
WQ-1	9/30/2007	Soluble reactive phosphorus	J
WQ-1	9/30/2007	Dissolved copper	J
WQ-1	9/30/2007	Dissolved zinc	J

The sample collected in June 2007 was not analyzed for hardness, fecal coliform bacteria, and *E. coli* because the final list of project parameters had not been finalized at this time.

Laboratory Reporting Limits—Acceptable

The laboratory reporting limits and QAPP specified reporting limits are provided in Table 3. The laboratory reporting limits met the QAPP specified reporting limits for all analyses. No data were qualified based on laboratory reporting limits.

Table 3. Summary of QAPP and laboratory reporting limits.

Parameter	QAPP Reporting Limit	Laboratory Reporting Limit
Hardness	2 mg/L as $CaCO_3$	2 mg/L as $CaCO_3$
Total suspended solids	0.50 mg/L	0.05 mg/L
Suspended sediment concentration	0.50 mg/L	0.50 mg/L
Total phosphorus	0.002 mg/L	0.002 mg/L
Soluble reactive phosphorus	0.001 mg/L	0.001 mg/L
Total and dissolved copper	0.001 mg/L	0.001 mg/L
Total and dissolved zinc	0.005 mg/L	0.005 mg/L
Fecal coliform bacteria	2 CFU/100 mL	2 CFU/100 mL
Escherichia coli (E. coli)	2 CFU/100 mL	2 CFU/100 mL

Blank Analysis—Acceptable

Method Blanks

Method blanks were analyzed at the required frequency. Method blanks did not contain levels of target analytes above the laboratory reporting limits.

Rinsate Blanks

Rinsate blanks were not required for this project.

Laboratory Control Sample Analysis—Acceptable

Laboratory control samples were analyzed at the required frequency. The percent recovery values for all sampling events met the QAPP criteria (90 to 110 percent) for all analyses.

Matrix Spike Analysis—Acceptable

Matrix spike (MS) samples were analyzed for total phosphorus, soluble reactive phosphorus, hardness, and metals at the required frequency. The percent recovery values for the MS analyses met the control limits (75 to 125 percent) established by the QAPP.

Laboratory Duplicate Analysis—Acceptable

Laboratory duplicates were analyzed at the required frequency. The relative percent difference (RPD) was calculated for each analyte where both duplicate values were greater than five times the reporting limit (RL). The difference between duplicate values was calculated if the detected compound concentration was less than five times the RL in either the sample or the field duplicate. A control limit of less than 20 percent RPD (25 percent for total suspended solids, suspended sediment solids, fecal coliform bacteria, and *E. coli*) was established in the QAPP and a control limit of two times the RL was used to evaluate difference values. The relative percent difference (RPD) values met the control limits established by the QAPP, and all difference values were less than two times the RL.

Field Duplicates—Acceptable with Discussion

One field duplicate was collected with the first sample event and analyzed for all parameters. However, because hardness, fecal coliform bacteria, and E. coli were not analyzed for the first storm event, these parameters were not evaluated for field duplicate precision.

The QAPP specified that a field duplicate sample be collected during the first and third sample event (66 percent of sampling events). As shown in Table 4, field duplicates were not collected at the required frequency. No data were qualified because of field duplicate sampling frequency.

Table 4. Frequency of Field Duplicate Sample Collection.

Number of Events	Number of Field Duplicates Collected	Percentage of Events Sampled
3	1	33

Data Quality Assessment Summary

In general, the data quality for all parameters was found to be acceptable based on holding time, reporting limit, method blank, control standard, matrix spike, laboratory duplicate, and field duplicate criteria. Holding time criterion was exceeded for samples collected on June 9, 2007 and September 30, 2007 for soluble reactive phosphorus, dissolved metals, and coliform (September sample only). These results were qualified as estimated (J) due to potential bias.

Usability of the data is based on the guidance documents previously noted. Upon consideration of the information presented here, the data are acceptable as qualified.

Definition of Data Qualifiers

The following data qualifier definitions were used to evaluate project data:

J The associated value is an estimated quantity.

References

SPU. 2007. High Point Phase I Block Scale Monitoring Quality Assurance Project Plan. Prepared for Seattle Public Utilities. September 2007.

APPENDIX D

Summary Statistic for Hydrologic Monitoring Data from Individual Storm Events

Table D1. Summary statistics for precipitation data collected at station RG1 during individual storm events in water year 2007.

Storm ID:	Storm Start Date and Time	Storm End Date and Time	Station RG1[a] Storm Duration (hours)	Station RG1[a] Storm Antecedent Dry Period (hours)[a]	Station RG1[a] Storm Precipitation Depth (inches)[a]	Station RG1[a] Maximum Precipitation Intensity (inches/15-minutes)[a]	Station RG1[a] Average Precipitation Intensity (inches/hour)[a]
1	1/1/07 15:15	1/3/07 9:15	42.00	131.75	1.15	0.05	0.027
2	1/4/07 3:00	1/4/07 15:45	12.75	17.75	0.05	0.02	0.004
3	1/5/07 13:15	1/6/07 1:30	12.25	21.50	0.55	0.04	0.045
4	1/6/07 23:45	1/7/07 9:15	9.50	22.25	0.44	0.07	0.046
5	1/8/07 11:15	1/8/07 11:45	0.50	26.00	0.16	0.15	0.320
6	1/9/07 14:15	1/9/07 15:45	1.50	26.50	0.13	0.04	0.087
7	1/11/07 11:30	1/11/07 14:00	2.50	43.75	0.05	0.01	0.020
8	1/14/07 11:30	1/14/07 11:45	0.25	69.50	0.01	0.01	0.040
9	1/15/07 11:45	1/15/07 14:00	2.25	24.00	0.02	0.01	0.009
10	1/16/07 11:15	1/16/07 11:30	0.25	21.25	0.02	0.02	0.080
11	1/17/07 17:15	1/18/07 11:30	18.25	29.75	0.41	0.07	0.022
12	1/19/07 7:00	1/19/07 21:45	14.75	19.50	0.11	0.02	0.007
13	1/22/07 16:00	1/22/07 16:15	0.25	66.25	0.01	0.01	0.040
14	1/25/07 17:45	1/25/07 18:00	0.25	73.50	0.01	0.01	0.040
15	2/3/07 11:45	2/4/07 6:15	18.50	209.75	0.24	0.03	0.013
16	2/6/07 11:00	2/6/07 20:15	9.25	52.75	0.06	0.02	0.006
17	2/7/07 22:00	2/8/07 0:45	2.75	25.75	0.10	0.03	0.036
18	2/9/07 5:00	2/9/07 11:30	6.50	28.25	0.10	0.03	0.015
19	2/10/07 20:15	2/11/07 21:15	25.00	32.75	0.27	0.03	0.011
20	2/12/07 13:00	2/12/07 13:15	0.25	15.75	0.01	0.01	0.040
21	2/14/07 13:30	2/15/07 12:45	23.25	48.25	0.12	0.02	0.005
22	2/16/07 15:00	2/16/07 16:30	1.50	26.25	0.04	0.02	0.027
23	2/17/07 19:45	2/17/07 21:15	1.50	27.25	0.09	0.02	0.060
24	2/18/07 20:45	2/18/07 21:00	0.25	23.50	0.01	0.01	0.040
25	2/19/07 13:30	2/20/07 3:00	13.50	16.50	0.47	0.03	0.035
26	2/21/07 11:30	2/22/07 3:00	15.50	32.50	0.08	0.02	0.005
27	2/22/07 15:30	2/22/07 15:45	0.25	12.50	0.01	0.01	0.040
28	2/24/07 5:00	2/26/07 0:30	43.50	37.25	0.66	0.03	0.015
29	2/27/07 18:45	2/28/07 8:30	13.75	42.25	0.05	0.02	0.004
30	3/2/07 9:15	3/3/07 11:00	25.75	48.75	0.31	0.02	0.012
31	3/5/07 2:00	3/5/07 4:00	2.00	39.00	0.04	0.01	0.020
32	3/7/07 5:15	3/9/07 0:30	43.25	49.25	0.68	0.04	0.016
33	3/9/07 20:30	3/12/07 11:00	62.50	20.00	0.86	0.04	0.014
34	3/13/07 22:15	3/13/07 22:30	0.25	35.25	0.01	0.01	0.040

Table D1. Summary statistics for precipitation data collected at station RG1 during individual storm events in water year 2007.

Storm ID:	Storm Start Date and Time	Storm End Date and Time	Station RG1[a] Storm Duration (hours)	Station RG1[a] Storm Antecedent Dry Period (hours)[a]	Station RG1[a] Storm Precipitation Depth (inches)[a]	Station RG1[a] Maximum Precipitation Intensity (inches/15-minutes)[a]	Station RG1[a] Average Precipitation Intensity (inches/hour)[a]
35	3/15/07 18:45	3/15/07 19:00	0.25	44.25	0.01	0.01	0.040
36	3/17/07 11:00	3/17/07 18:15	7.25	40.00	0.15	0.03	0.021
37	3/18/07 8:45	3/18/07 9:00	0.25	14.50	0.01	0.01	0.040
38	3/19/07 9:00	3/21/07 1:15	40.25	24.00	0.53	0.05	0.013
39	3/22/07 6:15	3/22/07 15:30	9.25	29.00	0.09	0.02	0.010
40	3/23/07 11:30	3/25/07 8:45	45.25	20.00	0.72	0.02	0.016
41	3/26/07 23:45	3/27/07 19:30	19.75	39.00	0.31	0.06	0.016
42	3/30/07 21:15	3/31/07 5:45	8.50	73.75	0.27	0.03	0.032
43	3/31/07 21:30	3/31/07 22:15	0.75	15.75	0.04	0.02	0.053
44	4/1/07 14:00	4/1/07 15:15	1.25	15.75	0.01	0.01	0.008
45	4/2/07 16:15	4/2/07 16:30	0.25	25.00	0.01	0.01	0.040
46	4/7/07 21:00	4/7/07 23:30	2.50	124.50	0.05	0.01	0.020
47	4/8/07 14:30	4/9/07 4:00	13.50	15.00	0.51	0.11	0.038
48	4/13/07 12:00	4/13/07 19:00	7.00	104.00	0.15	0.02	0.021
49	4/16/07 11:30	4/16/07 12:00	0.50	64.50	0.02	0.01	0.040
50	4/17/07 20:30	4/18/07 1:15	4.75	32.50	0.10	0.03	0.021
51	4/19/07 14:45	4/19/07 15:00	0.25	37.50	0.01	0.01	0.040
52	4/21/07 19:00	4/21/07 23:30	4.50	52.00	0.09	0.02	0.020
53	4/22/07 13:30	4/22/07 13:45	0.25	14.00	0.01	0.01	0.040
54	4/24/07 2:15	4/24/07 9:15	7.00	36.50	0.06	0.01	0.009
55	4/30/07 19:30	5/1/07 2:30	7.00	154.25	0.13	0.01	0.019
56	5/1/07 22:45	5/2/07 18:00	19.25	20.25	0.30	0.05	0.016
57	5/4/07 8:00	5/4/07 9:00	1.00	38.00	0.36	0.12	0.360
58	5/13/07 0:15	5/13/07 1:00	0.75	207.25	0.05	0.03	0.067
59	5/18/07 19:45	5/19/07 6:00	10.25	138.75	0.03	0.01	0.003
60	5/20/07 9:15	5/22/07 0:45	39.50	27.25	1.36	0.11	0.034
61	5/27/07 5:30	5/27/07 13:30	8.00	124.75	0.04	0.01	0.005
62	6/4/07 12:15	6/4/07 19:15	7.00	190.75	0.02	0.01	0.003
63	6/5/07 8:00	6/5/07 22:00	14.00	12.75	0.04	0.01	0.003
64	6/7/07 14:15	6/7/07 14:30	0.25	40.25	0.01	0.01	0.040
65	6/9/07 9:30	6/9/07 19:15	9.75	43.00	0.26	0.02	0.027
66	6/15/07 3:45	6/15/07 10:00	6.25	128.50	0.15	0.02	0.024
67	6/16/07 18:30	6/17/07 7:30	13.00	32.50	0.06	0.01	0.005
68	6/24/07 3:00	6/24/07 16:45	13.75	163.50	0.11	0.03	0.008

Table D1. Summary statistics for precipitation data collected at station RG1 during individual storm events in water year 2007.

Storm ID:	Storm Start Date and Time	Storm End Date and Time	Station RG1[a] Storm Duration (hours)	Station RG1[a] Storm Antecedent Dry Period (hours)[a]	Station RG1[a] Storm Precipitation Depth (inches)[a]	Station RG1[a] Maximum Precipitation Intensity (inches/15-minutes)[a]	Station RG1[a] Average Precipitation Intensity (inches/hour)[a]
69	6/28/07 9:00	6/28/07 21:30	12.50	88.25	0.10	0.02	0.008
70	6/29/07 13:30	6/29/07 17:30	4.00	16.00	0.07	0.02	0.018
71	7/13/07 3:30	7/13/07 3:45	0.25	322.00	0.01	0.01	0.040
72	7/17/07 2:45	7/17/07 6:00	3.25	95.00	0.10	0.02	0.031
73	7/18/07 4:30	7/18/07 18:45	14.25	22.50	0.29	0.03	0.020
74	7/19/07 10:30	7/19/07 10:45	0.25	15.75	0.01	0.01	0.040
75	7/20/07 7:45	7/21/07 4:45	21.00	21.00	0.34	0.03	0.016
76	7/21/07 17:00	7/23/07 3:00	34.00	12.25	0.59	0.02	0.017
77	7/29/07 11:00	7/29/07 11:15	0.25	152.00	0.01	0.01	0.040
78	8/3/07 4:15	8/3/07 5:45	1.50	113.00	0.02	0.01	0.013
79	8/8/07 2:45	8/8/07 3:00	0.25	117.00	0.01	0.01	0.040
80	8/18/07 20:45	8/19/07 16:45	20.00	257.75	0.46	0.05	0.023
81	8/20/07 5:30	8/20/07 11:15	5.75	12.75	0.31	0.08	0.054
82	8/21/07 7:30	8/21/07 9:00	1.50	20.25	0.02	0.01	0.013
83	8/25/07 15:45	8/26/07 4:30	12.75	102.75	0.15	0.04	0.012
84	9/3/07 22:45	9/4/07 9:00	10.25	210.25	0.72	0.06	0.070
85	9/16/07 13:00	9/17/07 13:30	24.50	292.00	0.28	0.02	0.011
86	9/21/07 18:30	9/21/07 18:45	0.25	101.00	0.01	0.01	0.040
87	9/25/07 11:00	9/25/07 15:45	4.75	88.25	0.02	0.01	0.004
88	9/27/07 19:30	9/28/07 2:30	7.00	51.75	0.27	0.04	0.039
89	9/29/07 21:45	10/1/07 0:00	26.25	43.25	1.10	0.03	0.042

[a] Station RG1 was installed on January 17, 2007. Data presented in this table from storms prior to this date were obtained from SPU stations RG14 and RG18. See discussion in text.

Table D2. Summary statistics for discharge data collected at stations D2 and D3 during individual storm events in water year 2007.

Storm ID:	Storm Start Date and Time	Storm End Date and Time	Station D2 Flow Volume (gallons)	Station D2 Maximum Discharge Rate (gal/min)	Station D2 Flow Duration (hours)	Station D3 Flow Volume (gallons)	Station D3 Maximum Discharge Rate (gal/min)	Station D3 Flow Duration (hours)
1	**1/1/07 15:15**	**1/3/07 9:15**	**ND**	**ND**	**ND**	**60.3**	**0.9**	**1.50**
2	1/4/07 3:00	1/4/07 15:45	ND	ND	ND	0.0	0.0	0.00
3	1/5/07 13:15	1/6/07 1:30	ND	ND	ND	0.0	0.0	0.00
4	1/6/07 23:45	1/7/07 9:15	ND	ND	ND	0.0	0.0	0.00
5	1/8/07 11:15	1/8/07 11:45	ND	ND	ND	0.0	0.0	0.00
6	1/9/07 14:15	1/9/07 15:45	ND	ND	ND	0.0	0.0	0.00
7	1/11/07 11:30	1/11/07 14:00	ND	ND	ND	0.0	0.0	0.00
8	1/14/07 11:30	1/14/07 11:45	ND	ND	ND	0.0	0.0	0.00
9	1/15/07 11:45	1/15/07 14:00	ND	ND	ND	0.0	0.0	0.00
10	1/16/07 11:15	1/16/07 11:30	ND	ND	ND	0.0	0.0	0.00
11	1/17/07 17:15	1/18/07 11:30	ND	ND	ND	0.0	0.0	0.00
12	1/19/07 7:00	1/19/07 21:45	0.0	0.0	0.00	0.0	0.0	0.00
13	1/22/07 16:00	1/22/07 16:15	0.0	0.0	0.00	0.0	0.0	0.00
14	1/25/07 17:45	1/25/07 18:00	0.0	0.0	0.00	0.0	0.0	0.00
15	2/3/07 11:45	2/4/07 6:15	0.0	0.0	0.00	0.0	0.0	0.00
16	2/6/07 11:00	2/6/07 20:15	0.0	0.0	0.00	0.0	0.0	0.00
17	2/7/07 22:00	2/8/07 0:45	0.0	0.0	0.00	0.0	0.0	0.00
18	2/9/07 5:00	2/9/07 11:30	0.0	0.0	0.00	0.0	0.0	0.00
19	2/10/07 20:15	2/11/07 21:15	0.0	0.0	0.00	0.0	0.0	0.00
20	2/12/07 13:00	2/12/07 13:15	0.0	0.0	0.00	0.0	0.0	0.00
21	2/14/07 13:30	2/15/07 12:45	0.0	0.0	0.00	0.0	0.0	0.00
22	2/16/07 15:00	2/16/07 16:30	0.0	0.0	0.00	0.0	0.0	0.00
23	2/17/07 19:45	2/17/07 21:15	0.0	0.0	0.00	0.0	0.0	0.00
24	2/18/07 20:45	2/18/07 21:00	0.0	0.0	0.00	0.0	0.0	0.00
25	2/19/07 13:30	2/20/07 3:00	0.0	0.0	0.00	0.0	0.0	0.00
26	2/21/07 11:30	2/22/07 3:00	0.0	0.0	0.00	0.0	0.0	0.00
27	2/22/07 15:30	2/22/07 15:45	0.0	0.0	0.00	0.0	0.0	0.00
28	2/24/07 5:00	2/26/07 0:30	0.0	0.0	0.00	0.0	0.0	0.00
29	2/27/07 18:45	2/28/07 8:30	0.0	0.0	0.00	0.0	0.0	0.00
30	3/2/07 9:15	3/3/07 11:00	0.0	0.0	0.00	0.0	0.0	0.00
31	3/5/07 2:00	3/5/07 4:00	0.0	0.0	0.00	0.0	0.0	0.00
32	3/7/07 5:15	3/9/07 0:30	0.0	0.0	0.00	0.0	0.0	0.00
33	3/9/07 20:30	3/12/07 11:00	NA	NA	NA	NA	NA	NA
34	3/13/07 22:15	3/13/07 22:30	0.0	0.0	0.00	0.0	0.0	0.00
35	3/15/07 18:45	3/15/07 19:00	0.0	0.0	0.00	0.0	0.0	0.00
36	3/17/07 11:00	3/17/07 18:15	0.0	0.0	0.00	0.0	0.0	0.00
37	3/18/07 8:45	3/18/07 9:00	0.0	0.0	0.00	0.0	0.0	0.00

Table D2. Summary statistics for discharge data collected at stations D2 and D3 during individual storm events in water year 2007.

Storm ID:	Storm Start Date and Time	Storm End Date and Time	Station D2 Flow Volume (gallons)	Station D2 Maximum Discharge Rate (gal/min)	Station D2 Flow Duration (hours)	Station D3 Flow Volume (gallons)	Station D3 Maximum Discharge Rate (gal/min)	Station D3 Flow Duration (hours)
38	3/19/07 9:00	3/21/07 1:15	0.0	0.0	0.00	0.0	0.0	0.00
39	3/22/07 6:15	3/22/07 15:30	0.0	0.0	0.00	0.0	0.0	0.00
40	3/23/07 11:30	3/25/07 8:45	NA	NA	NA	NA	NA	NA
41	3/26/07 23:45	3/27/07 19:30	0.0	0.0	0.00	0.0	0.0	0.00
42	3/30/07 21:15	3/31/07 5:45	0.0	0.0	0.00	0.0	0.0	0.00
43	3/31/07 21:30	3/31/07 22:15	0.0	0.0	0.00	0.0	0.0	0.00
44	4/1/07 14:00	4/1/07 15:15	0.0	0.0	0.00	0.0	0.0	0.00
45	4/2/07 16:15	4/2/07 16:30	0.0	0.0	0.00	0.0	0.0	0.00
46	4/7/07 21:00	4/7/07 23:30	0.0	0.0	0.00	0.0	0.0	0.00
47	4/8/07 14:30	4/9/07 4:00	0.0	0.0	0.00	0.0	0.0	0.00
48	4/13/07 12:00	4/13/07 19:00	0.0	0.0	0.00	0.0	0.0	0.00
49	4/16/07 11:30	4/16/07 12:00	0.0	0.0	0.00	0.0	0.0	0.00
50	4/17/07 20:30	4/18/07 1:15	0.0	0.0	0.00	0.0	0.0	0.00
51	4/19/07 14:45	4/19/07 15:00	0.0	0.0	0.00	0.0	0.0	0.00
52	4/21/07 19:00	4/21/07 23:30	0.0	0.0	0.00	0.0	0.0	0.00
53	4/22/07 13:30	4/22/07 13:45	0.0	0.0	0.00	0.0	0.0	0.00
54	4/24/07 2:15	4/24/07 9:15	0.0	0.0	0.00	0.0	0.0	0.00
55	4/30/07 19:30	5/1/07 2:30	0.0	0.0	0.00	0.0	0.0	0.00
56	5/1/07 22:45	5/2/07 18:00	0.0	0.0	0.00	0.0	0.0	0.00
57	5/4/07 8:00	5/4/07 9:00	0.0	0.0	0.00	0.0	0.0	0.00
58	5/13/07 0:15	5/13/07 1:00	0.0	0.0	0.00	0.0	0.0	0.00
59	5/18/07 19:45	5/19/07 6:00	0.0	0.0	0.00	0.0	0.0	0.00
60	**5/20/07 9:15**	**5/22/07 0:45**	**116.7**	**0.9**	**3.25**	**0.0**	**0.0**	**0.00**
61	5/27/07 5:30	5/27/07 13:30	0.0	0.0	0.00	0.0	0.0	0.00
62	6/4/07 12:15	6/4/07 19:15	0.0	0.0	0.00	0.0	0.0	0.00
63	6/5/07 8:00	6/5/07 22:00	0.0	0.0	0.00	0.0	0.0	0.00
64	6/7/07 14:15	6/7/07 14:30	0.0	0.0	0.00	0.0	0.0	0.00
65	6/9/07 9:30	6/9/07 19:15	0.0	0.0	0.00	0.0	0.0	0.00
66	6/15/07 3:45	6/15/07 10:00	0.0	0.0	0.00	0.0	0.0	0.00
67	6/16/07 18:30	6/17/07 7:30	0.0	0.0	0.00	0.0	0.0	0.00
68	6/24/07 3:00	6/24/07 16:45	0.0	0.0	0.00	0.0	0.0	0.00
69	6/28/07 9:00	6/28/07 21:30	0.0	0.0	0.00	0.0	0.0	0.00
70	6/29/07 13:30	6/29/07 17:30	0.0	0.0	0.00	0.0	0.0	0.00
71	7/13/07 3:30	7/13/07 3:45	0.0	0.0	0.00	0.0	0.0	0.00
72	7/17/07 2:45	7/17/07 6:00	0.0	0.0	0.00	0.0	0.0	0.00
73	7/18/07 4:30	7/18/07 18:45	0.0	0.0	0.00	0.0	0.0	0.00
74	7/19/07 10:30	7/19/07 10:45	0.0	0.0	0.00	0.0	0.0	0.00

Table D2. Summary statistics for discharge data collected at stations D2 and D3 during individual storm events in water year 2007.

Storm ID:	Storm Start Date and Time	Storm End Date and Time	Station D2 Flow Volume (gallons)	Station D2 Maximum Discharge Rate (gal/min)	Station D2 Flow Duration (hours)	Station D3 Flow Volume (gallons)	Station D3 Maximum Discharge Rate (gal/min)	Station D3 Flow Duration (hours)
75	7/20/07 7:45	7/21/07 4:45	0.0	0.0	0.00	0.0	0.0	0.00
76	7/21/07 17:00	7/23/07 3:00	0.0	0.0	0.00	0.0	0.0	0.00
77	7/29/07 11:00	7/29/07 11:15	0.0	0.0	0.00	0.0	0.0	0.00
78	8/3/07 4:15	8/3/07 5:45	0.0	0.0	0.00	0.0	0.0	0.00
79	8/8/07 2:45	8/8/07 3:00	0.0	0.0	0.00	0.0	0.0	0.00
80	8/18/07 20:45	8/19/07 16:45	ND	ND	ND	0.0	0.0	0.00
81	8/20/07 5:30	8/20/07 11:15	ND	ND	ND	0.0	0.0	0.00
82	8/21/07 7:30	8/21/07 9:00	ND	ND	ND	0.0	0.0	0.00
83	8/25/07 15:45	8/26/07 4:30	0.0	0.0	0.00	0.0	0.0	0.00
84	**9/3/07 22:45**	**9/4/07 9:00**	**150.9**	**1.3**	**2.50**	**77.4**	**0.9**	**1.50**
85	9/16/07 13:00	9/17/07 13:30	0.0	0.0	0.00	0.0	0.0	0.00
86	9/21/07 18:30	9/21/07 18:45	0.0	0.0	0.00	0.0	0.0	0.00
87	9/25/07 11:00	9/25/07 15:45	0.0	0.0	0.00	ND	ND	ND
88	**9/27/07 19:30**	**9/28/07 2:30**	**133.8**	**0.7**	**4.50**	**ND**	**ND**	**ND**
89	9/29/07 21:45	10/1/07 0:00	NA	NA	NA	NA	NA	NA

ND: No data are available for the indicated storm.
NA: Data collected during storm for HSPF calibration purposes. Because all runoff is routed to the NDS test swale's overflow drain during this process, data from stations WL1, D2, and D3 are not accurate.
gal/min: gallons per minute
Storm events with a measurable discharge at station D2 and/or station D3 are shown in **boldface** for emphasis.

Table D3. Summary statistics for water level data collected at station WL1 during individual storm events in water year 2007.

Storm ID:	Storm Start Date and Time	Storm End Date and Time	Station WL1 Average Water Depth (inches)	Station WL1 Maximum Water Depth (inches)	Station WL1 Ponding Duration (hours)
1	1/1/07 15:15	1/3/07 9:15	0.0	0.0	0.00
2	1/4/07 3:00	1/4/07 15:45	0.0	0.0	0.00
3	1/5/07 13:15	1/6/07 1:30	0.0	0.0	0.00
4	1/6/07 23:45	1/7/07 9:15	0.0	0.0	0.00
5	1/8/07 11:15	1/8/07 11:45	0.0	0.0	0.00
6	1/9/07 14:15	1/9/07 15:45	0.0	0.0	0.00
7	1/11/07 11:30	1/11/07 14:00	0.0	0.0	0.00
8	1/14/07 11:30	1/14/07 11:45	0.0	0.0	0.00
9	1/15/07 11:45	1/15/07 14:00	0.0	0.0	0.00
10	1/16/07 11:15	1/16/07 11:30	0.0	0.0	0.00
11	**1/17/07 17:15**	**1/18/07 11:30**	**0.0**	**0.0**	**5.75**
12	1/19/07 7:00	1/19/07 21:45	0.0	0.0	0.00
13	1/22/07 16:00	1/22/07 16:15	0.0	0.0	0.00
14	1/25/07 17:45	1/25/07 18:00	0.0	0.0	0.00
15	2/3/07 11:45	2/4/07 6:15	0.0	0.0	0.00
16	2/6/07 11:00	2/6/07 20:15	0.0	0.0	0.00
17	2/7/07 22:00	2/8/07 0:45	0.0	0.0	0.00
18	2/9/07 5:00	2/9/07 11:30	0.0	0.0	0.00
19	**2/10/07 20:15**	**2/11/07 21:15**	**0.3**	**0.4**	**0.50**
20	2/12/07 13:00	2/12/07 13:15	0.0	0.0	0.00
21	2/14/07 13:30	2/15/07 12:45	0.0	0.0	0.00
22	2/16/07 15:00	2/16/07 16:30	0.0	0.0	0.00
23	2/17/07 19:45	2/17/07 21:15	0.0	0.0	0.00
24	2/18/07 20:45	2/18/07 21:00	0.0	0.0	0.00
25	**2/19/07 13:30**	**2/20/07 3:00**	**0.1**	**0.1**	**0.25**
26	2/21/07 11:30	2/22/07 3:00	0.0	0.0	0.00
27	2/22/07 15:30	2/22/07 15:45	0.0	0.0	0.00
28	2/24/07 5:00	2/26/07 0:30	0.0	0.0	0.00
29	2/27/07 18:45	2/28/07 8:30	0.0	0.0	0.00
30	3/2/07 9:15	3/3/07 11:00	0.0	0.0	0.00
31	3/5/07 2:00	3/5/07 4:00	0.0	0.0	0.00
32	**3/7/07 5:15**	**3/9/07 0:30**	**0.7**	**1.4**	**7.25**
33	3/9/07 20:30	3/12/07 11:00	NA	NA	NA
34	3/13/07 22:15	3/13/07 22:30	0.0	0.0	0.00
35	3/15/07 18:45	3/15/07 19:00	0.0	0.0	0.00
36	3/17/07 11:00	3/17/07 18:15	0.0	0.0	0.00
37	3/18/07 8:45	3/18/07 9:00	0.0	0.0	0.00
38	**3/19/07 9:00**	**3/21/07 1:15**	**0.2**	**0.6**	**3.75**
39	3/22/07 6:15	3/22/07 15:30	0.0	0.0	0.00
40	3/23/07 11:30	3/25/07 8:45	NA	NA	NA
41	3/26/07 23:45	3/27/07 19:30	0.0	0.0	0.00
42	3/30/07 21:15	3/31/07 5:45	0.0	0.0	0.00
43	3/31/07 21:30	3/31/07 22:15	0.0	0.0	0.00
44	4/1/07 14:00	4/1/07 15:15	0.0	0.0	0.00
45	4/2/07 16:15	4/2/07 16:30	0.0	0.0	0.00
46	4/7/07 21:00	4/7/07 23:30	0.0	0.0	0.00
47	**4/8/07 14:30**	**4/9/07 4:00**	**1.1**	**2.1**	**0.75**
48	4/13/07 12:00	4/13/07 19:00	0.0	0.0	0.00
49	4/16/07 11:30	4/16/07 12:00	0.0	0.0	0.00

Table D3. Summary statistics for water level data collected at station WL1 during individual storm events in water year 2007.

Storm ID:	Storm Start Date and Time	Storm End Date and Time	Station WL1 Average Water Depth (inches)	Station WL1 Maximum Water Depth (inches)	Station WL1 Ponding Duration (hours)
50	4/17/07 20:30	4/18/07 1:15	0.0	0.0	0.00
51	4/19/07 14:45	4/19/07 15:00	0.0	0.0	0.00
52	4/21/07 19:00	4/21/07 23:30	0.0	0.0	0.00
53	4/22/07 13:30	4/22/07 13:45	0.0	0.0	0.00
54	4/24/07 2:15	4/24/07 9:15	0.0	0.0	0.00
55	4/30/07 19:30	5/1/07 2:30	0.0	0.0	0.00
56	5/1/07 22:45	5/2/07 18:00	0.0	0.0	0.00
57	5/4/07 8:00	5/4/07 9:00	0.0	0.0	0.00
58	5/13/07 0:15	5/13/07 1:00	0.0	0.0	0.00
59	5/18/07 19:45	5/19/07 6:00	0.0	0.0	0.00
60	5/20/07 9:15	5/22/07 0:45	0.0	0.0	0.00
61	5/27/07 5:30	5/27/07 13:30	0.0	0.0	0.00
62	6/4/07 12:15	6/4/07 19:15	0.0	0.0	0.00
63	6/5/07 8:00	6/5/07 22:00	0.0	0.0	0.00
64	6/7/07 14:15	6/7/07 14:30	0.0	0.0	0.00
65	6/9/07 9:30	6/9/07 19:15	0.0	0.0	0.00
66	6/15/07 3:45	6/15/07 10:00	0.0	0.0	0.00
67	6/16/07 18:30	6/17/07 7:30	0.0	0.0	0.00
68	6/24/07 3:00	6/24/07 16:45	0.0	0.0	0.00
69	6/28/07 9:00	6/28/07 21:30	0.0	0.0	0.00
70	6/29/07 13:30	6/29/07 17:30	0.0	0.0	0.00
71	7/13/07 3:30	7/13/07 3:45	0.0	0.0	0.00
72	7/17/07 2:45	7/17/07 6:00	0.0	0.0	0.00
73	7/18/07 4:30	7/18/07 18:45	0.0	0.0	0.00
74	7/19/07 10:30	7/19/07 10:45	0.0	0.0	0.00
75	7/20/07 7:45	7/21/07 4:45	0.0	0.0	0.00
76	7/21/07 17:00	7/23/07 3:00	0.0	0.0	0.00
77	7/29/07 11:00	7/29/07 11:15	0.0	0.0	0.00
78	8/3/07 4:15	8/3/07 5:45	0.0	0.0	0.00
79	8/8/07 2:45	8/8/07 3:00	0.0	0.0	0.00
80	8/18/07 20:45	8/19/07 16:45	0.0	0.0	0.00
81	**8/20/07 5:30**	**8/20/07 11:15**	**0.3**	**0.3**	**0.25**
82	8/21/07 7:30	8/21/07 9:00	0.0	0.0	0.00
83	8/25/07 15:45	8/26/07 4:30	0.0	0.0	0.00
84	9/3/07 22:45	9/4/07 9:00	ND	ND	ND
85	9/16/07 13:00	9/17/07 13:30	ND	ND	ND
86	9/21/07 18:30	9/21/07 18:45	ND	ND	ND
87	9/25/07 11:00	9/25/07 15:45	0.0	0.0	0.00
88	9/27/07 19:30	9/28/07 2:30	0.0	0.0	0.00
89	9/29/07 21:45	10/1/07 0:00	NA	NA	NA

ND: No data are available for the indicated storm.
NA: Data collected during storm for HSPF calibration purposes. Because all runoff is routed to the NDS test swale's overflow drain during this process, data from stations WL1, D2, and D3 are not accurate.
Storm events with measurable ponding at station WL1 are shown in **boldface** for emphasis.

APPENDIX E

Quality Assurance Audit Forms for Hydrologic Monitoring Data

Automated Data Collection
Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 11/21/07 Page 1 of 1

Site Name/Location: Supplemental Data from SPU – RG14, RG17, RG18

Checked: initials JC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 12/18/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
12/26/07 – 01/17/07	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 2/23//07 Page 1 of 1

Site Name/Location: High Point Library Roof, RG1

Checked: initials JC

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

date 9/4/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/17/0/ - 2/22/07	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 2/23/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Checked: initials JL

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

date 9/4/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/17/07 - 2/22/07	NONE		NONE	

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Date 2/23/07 Page 1 of 1

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/31/07 – 2/22/07	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 1/18/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials TL

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date 9/4/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/1/07 – 1/17/07	None		Negative values during six different time spans	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By: Niklas Christensen

Date: 2/23/07 Page 1 of 1

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments NORTH DataGator – D3

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
1/17/07 – 2/22/07	NONE		One set of negative values on 2/15	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

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Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Date 4/13/07 Page 1 of 1

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point Library Roof, RG1

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
2/22/0/ - 4/11/07	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 4/13/07 Page 1 of 1

Checked: initials Sc

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
2/22/07 - 4/11/07	3/7/07 900 – 3/7/07 1845 Infiltration Test #1 The infiltration test used an artificial input of water to the NDS swale, so pressure transducer readings during this time should be discarded	Values in timeseries left blank	3/8/07 Small precipitation causes increase in water surface since ground is saturated from previous days infiltration test	Original values left in timeseries
	3/10/07 1100 - 3/12/07 1030 HSPF test #1, transducer monitored water level in weir and was not monitoring water level in NDS swale.	Precipitation occurred during this period while inputs (curb cuts) to the NDS swale were blocked. There is a possibility the sensor would of measure water levels in the NDS swale so the data gap is left blank.		
	3/23/07 1700 - 3/25/07 1230 HSPF test #2, transducer monitored water level in weir and was not monitoring water level in NDS swale.	Precipitation occurred during this period while inputs (curb cuts) to the NDS swale were blocked. There is a possibility the sensor would of measure water levels in the NDS swale so the data gap is left blank.		

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By Niklas Christensen

Date 4/13/07

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
2/22/07 – 4/11/07	NONE		Negative values during eleven different time spans	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 5/22/07 Page 1 of 1

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments NORTH DataGator – D3

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
2/22/07 – 4/11/07	3/7/07 900 – 3/7/07 1845 Infiltration Test #1 . The infiltration test used an artificial input of water to the NDS swale, so DataGator readings during this time should be discarded	Data values left blank	20 sets of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)
	3/10/07 1100 - 3/12/07 1030 HSPF test #1, curb cuts letting water into the NDS swale were blocked during this period so data should be left blank	Data values left blank		
	3/23/07 1700 - 3/25/07 1230 HSPF test #1, curb cuts letting water into the NDS swale were blocked during this period so data should be left blank	Data values left blank		

NOTES:

Automated Data Collection Quality Assurance Worksheet

By: Niklas Christensen
Date: 5/23/07 Page 1 of 1
Checked: initials 54
date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU
Site Name/Location: High Point Library Roof, RG1
Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
4/11/07 – 5/22/07	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 5/23/07 Page 1 of 1

Checked: initials SC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
4/11/07 – 5/22/07	4/11/07 0830 – 4/11/07 1530 Infiltration Test #2 The infiltration test used an artificial input of water to the NDS swale, so pressure transducer readings during this time should be discarded	Values in timeseries left blank	None	

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By: Niklas Christensen

Date: 5/23/07 Page 1 of 1

Checked: initials ZC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
4/11/07 – 5/22/07	NONE		Negative Values on 4/11/07	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By: Niklas Christensen

Date: 5/22/07 Page 1 of 1

Checked: initials JL

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments NORTH DataGator – D3

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
4/11/07 – 5/22/07	4/11/07 – 4/11/07 Infiltration Test #2 The infiltration test used an artificial input of water to the NDS swale, so DataGator readings during this time should be discarded	Data values left blank	Five spans of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By: Niklas Christensen
Date: 6/27/07 Page 1 of 1
Checked: initials TC
date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU
Site Name/Location: High Point Library Roof, RG1
Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
5/22/07 – 6/26/07	NONE		NONE	NONE

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Date 6/27/07 Page 1 of 1

Checked: initials SL

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
5/22/07 – 6/26/07	NONE		NONE	

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 6/27/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

date 9/4/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
5/22/07 – 6/26/07	NONE		Negative Values during 3 different time spans. Six positive values that are at or near instrument threshold of measurement during times of no precipitation.	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0) Values are left in record

NOTES:

Automated Data Collection Quality Assurance Worksheet

By: Niklas Christensen

Date: 6/27/07 Page 1 of 1

Checked: initials JL

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments NORTH DataGator – D3

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
5/22/07 – 6/26/07	NONE		One set of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 7/19/07 Page 1 of 1

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point Library Roof, RG1

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
6/26/07 – 7/17/07	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 7/19/07 Page 1 of 1

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
6/26/07 – 7/17/07	NONE		NONE	

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By Niklas Christensen

Date 7/19/07 Page 1 of 1

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
6/26/07 – 7/17/07	NONE		Eight time spans of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)
			Eight time spans of positive values during times of no precipitation	Values left in data record

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 7/19/07 Page 1 of 1

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments NORTH DataGator – D3

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
6/26/07 – 7/17/07	NONE		None	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 8/24/07 Page 1 of 1

Checked: initials 3C

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point Library Roof, RG1

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
7/17/07 – 8/23/07	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Date 8/24/07 Page 1 of 1

Checked: initials Sr

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
7/17/07 – 8/23/07	NONE		NONE	

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 8/24/07 Page 1 of 1

Checked: initials ЗC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
7/17/07 – 8/23/07	8/12/07 – 8/23/07 Power failure (bad battery)	Values left blank		
			One time span of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)
			One time span of positive values during time of no precipitation	Values left in data record

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 8/24/07

Checked: initials JC

date 9/4/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments NORTH DataGator – D3

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
7/17/07 – 8/23/07	NONE		3 time spans of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 9/27/07 Page 1 of 1

Checked: initials JC

date 9-28-07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point Library Roof, RG1

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
8/23/07 – 9/25/07	NONE		NONE	

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 9-27-07 Page 1 of 1

Checked: initials: SC

date: 9-28-07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
8/23/07 - 9/25/07	9/3/07 19:45 – 9/25/07 Battery drawn down too far, no measurements taken	Values left blank Called Campbell Scientific technical support and was told that battery can be drawn to 10 Volts before it needs to be changed. Plotted up a timeseries of voltage (attached) that shows rapid draw down starting at 11 volts. **** Change this battery every second visit to stay within a 45 day margin of safety.		

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection Quality Assurance Worksheet

By: Niklas Christensen

Date: 9/27/07 Page 1 of 1

Checked: initials JC

date 9-28-07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
8/23/07 – 9/25/07			Multiple time span of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)
			Systematic throat pressure drift to unrealistic positive values.	Contacted Raj at RI. Throat pressure readings are used only for backwater events so data quality is not affected by "zeroing" the throat coefficients. Throat coefficients will be zeroed at next data upload.

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By Niklas Christensen

Date 9/27/07 Page 1 of 1

Checked: initials JC

date 9-28-07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments NORTH DataGator – D3

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
8/23/07 – 9/25/07	NONE		8 time spans of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)

NOTES:

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 10/27/07 Page 1 of 1

Checked: initials JL

date 12/18/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point Library Roof, RG1

Site Sensor: Hydrologic Services tipping bucker rain gauge & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
9/25/07 – 10/26/07	NONE		NONE	

NOTES:

HERRERA ENVIRONMENTAL CONSULTANTS

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 10/29/07 Page 1 of 1

Checked: initials SL

date 12-18-07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between SW Graham and Bataan St.

Site Sensor: Campbell Scientific CS445-L submersible pressure transducer & CR200 data logger

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
9/26/07 - 10/26/07	9/29/70- 10/1/07 HSPF Calibration	Values flagged and left blank	NONE	

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Date: 10/27/07 Page 1 of 1

Checked: initials SC

date 12/18/07

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Site Sensor: Renaissance Instruments DataGator SOUTH, station D2

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
9/25/07 – 10/26/07	NONE		Multiple time span of negative values	Values set to zero, assigned flag 117 (Velocity negative - sensor error - velocity set to 0)
			Systematic throat pressure drift to unrealistic positive values.	Meeting RI field technician on site on 12/7/07 to replace pressure transducer

NOTES:

NK o:\proj\y2006\06-03304-050\data\data audit\datagators - d2 & d3\data qa audit form dg2 south - 092507-102607.doc

Automated Data Collection
Quality Assurance Worksheet

By: Niklas Christensen

Project Name/No./Client: High Point Phase I Block Scale Monitoring / 06-03304-050 / SPU

Date: 12/3/07 Page 1 of 1

Site Name/Location: High Point NDS Test Swale on High Point Dr between Graham and Bataan St.

Checked: initials JC

Site Sensor: Renaissance Instruments NORTH DataGator – D3

date: 12/18/07

Data Upload Time Span	Data Gaps		Data Anomalies	
	Description/Time Span	Corrective Action	Description/Time Span	Corrective Action
9/25/07 – 10/29/07	9/25/2007 – 10/29/2007 Instrument Failure	Data Logger was sent back to RI to try to recover any data. They were unable to, so values have been flagged and left blank in the data record		

NOTES:

APPENDIX F

Data Report from March 7, 2007 Controlled Infiltration Test

DATA REPORT

First Controlled Infiltration Test for the High Point Phase I Block-Scale Monitoring Project

Prepared for

Seattle Public Utilities
700 Fifth Avenue
Seattle, Washington 98101

Prepared by

Herrera Environmental Consultants
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206/441-9080

April 10, 2007

Background

Seattle Public Utilities (SPU) is implementing a large-scale natural drainage system (NDS) project in conjunction with the redevelopment project for the High Point neighborhood in West Seattle (Figure 1). NDS swales are part of what is termed a *low-impact development* approach to managing stormwater runoff. The goal of this approach is to minimize the potential effect of land use changes on the natural hydrograph that can result from urbanization. In contrast to conventional stormwater systems that route runoff directly to storm drains, the NDS swales route runoff first through a vegetated and compost-amended swale, reducing the rate of flow and allowing the runoff to infiltrate into the ground. The excess runoff is then routed to the conventional stormwater system. This approach increases infiltration, decreases the rate and volume of runoff, and improves water quality. The end result is decreased erosion, stabilized water temperatures, and improved downstream habitat.

As part of this NDS project, Seattle Public Utilities is implementing a block-scale monitoring project for NDS swales that have been installed on the High Point redevelopment site. The goal of the monitoring program is to quantify the treatment performance of the NDS swales in order to provide a basis for potential design refinements that might improve performance or reduce installation costs or both. The specific monitoring activities that will be performed to meet this goal are described in a quality assurance project plan (QAPP) that was prepared earlier for the project (Herrera 2006). In general, the QAPP describes hydrologic and water quality monitoring activities to be performed in association with an NDS test swale on the High Point redevelopment site over a 3-year period, beginning in winter 2006 and ending in September 2009.

As described in the QAPP, a specific component of this monitoring project is the implementation of three controlled tests to measure infiltration rates on the surface of the NDS test swale. The first and second tests are to be conducted during the first and second months, respectively, of the monitoring project, and the third test is to be performed during the third and final year of the monitoring project.

This report documents the results of the first controlled infiltration test which was conducted on March 7, 2007. It describes the study location and the procedures that were used during the test process. It also summarizes the results of the test using graphical representations of the data as necessary. The raw data from the test are provided in an appendix.

Study Location

The study location was the High Point redevelopment site in West Seattle (Figure 1). The site lies within the Longfellow Creek drainage basin and is generally bordered on the north by SW Juneau Street, on the west by 34th Avenue SW, on the south by SW Myrtle Street, and on the east by a designated steep-sloped greenbelt. The infiltration test was conducted in a representative NDS swale (NDS test swale) that parallels Highpoint Drive SW between SW Graham and SW Bataan Street (Figure 2).

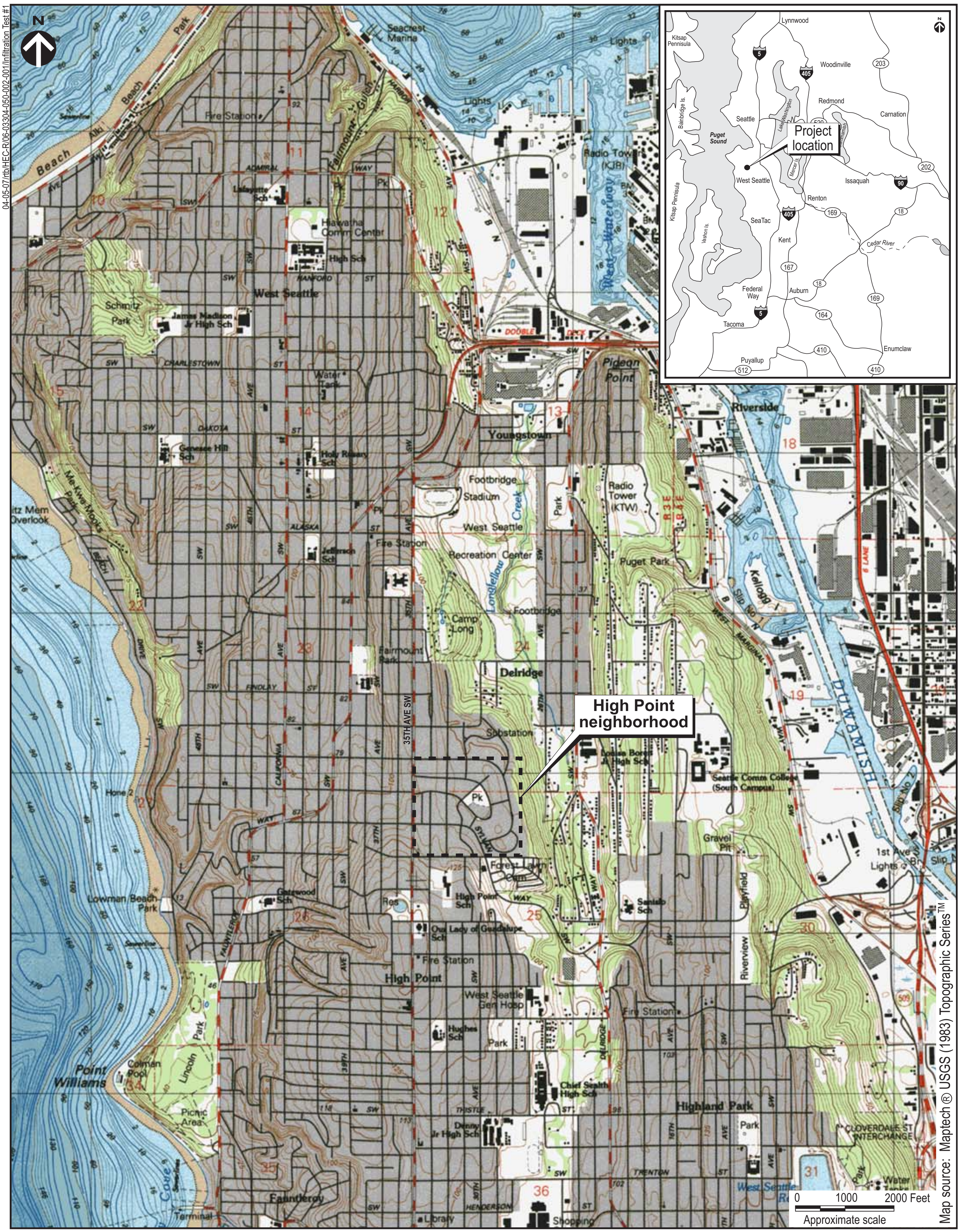


Figure 1. Vicinity map for the High Point redevelopment project site in Seattle, Washington.

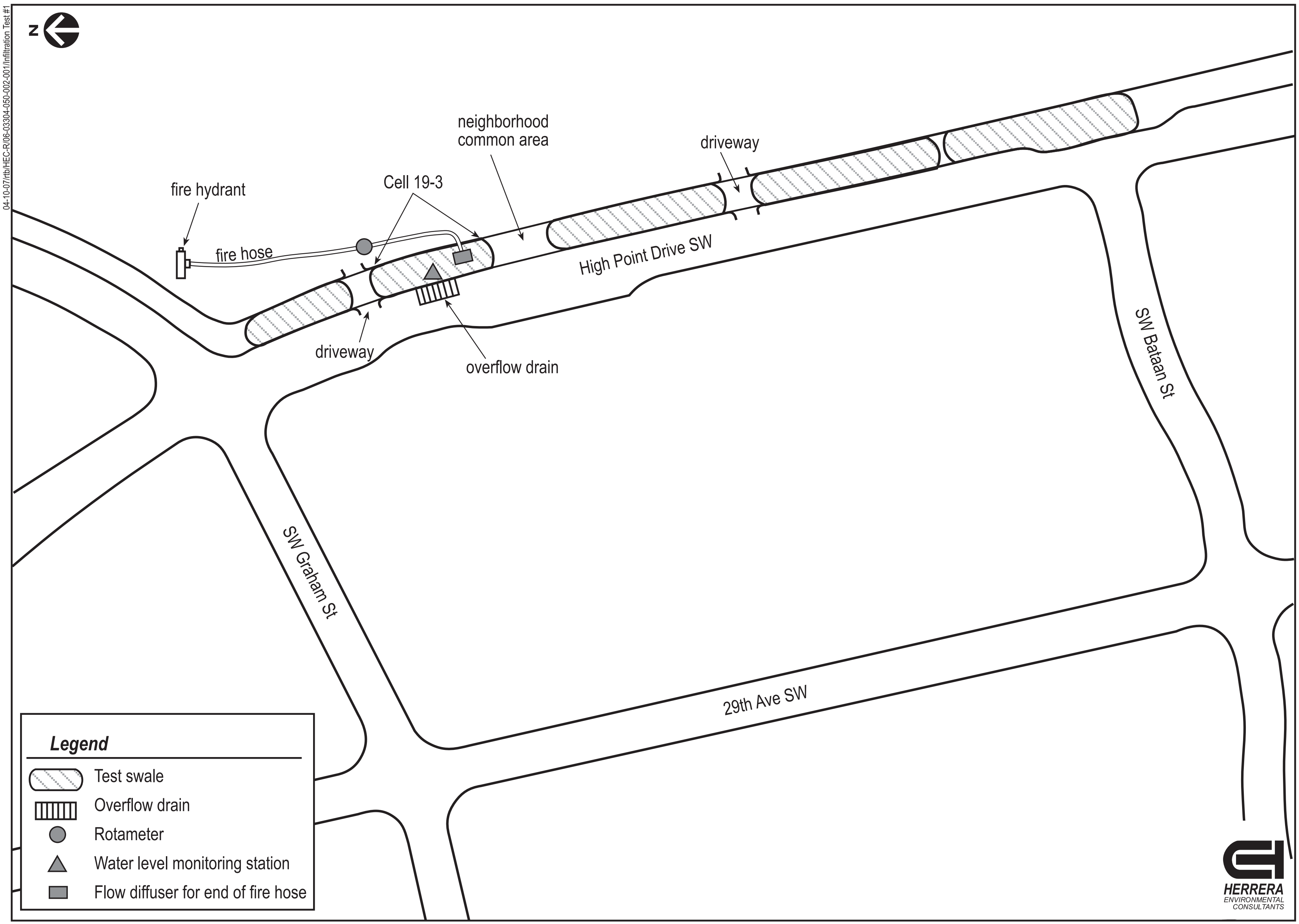


Figure 2. Plan view of natural drainage system test swale and controlled infiltration test monitoring station location for the High Point Phase I Block-scale Monitoring project.

Methods

Surface infiltration rates in the NDS test swale were measured using procedures adopted from the Washington State Department of Ecology's (2005) pilot infiltration test. The pilot infiltration test is a relatively large-scale infiltration test that is typically performed during the design phase of a project to estimate infiltration rates for a proposed stormwater infiltration facility. It specifically involves excavating a test pit to the same depth as that of the proposed infiltration facility. Water is then introduced to the pit at a variable rate to maintain a constant water level in the pit. During this process, a rotameter is used to measure the flow rate of this water. After the flow rate has remained stable (i.e., constant) for 60 minutes, the water is turned off and the rate of infiltration (in inches per hour) is recorded until the pit is empty. This method has been shown to provide the most accurate estimates of infiltration rates for large-scale infiltration facilities (Seattle University 2004).

The pilot infiltration test method was modified for use in the NDS test swale as follows:

1. Culverts immediately upgradient and downgradient of the overflow drain for the swale were blocked with inflatable plugs. These culverts convey water beneath a neighborhood common area and driveway, which cross the swale at two locations on High Point Drive SW. This isolated a 72.4-foot section of the swale with an approximate surface area of 391 square feet. This section of the swale (which is identified as Cell 19-3 in the drainage plans for the project) represents approximately 20 percent of the total surface area of the swale. All subsequent activities related to this test were performed on this section of the swale.

2. Water from a nearby fire hydrant (Figure 2) was discharged to the swale using approximately 300 feet of 4-inch-diameter fire hose. A rotameter was attached to the hose to measure the water discharge rate. To reduce potential soil erosion at the point of discharge, the end of the fire hose was placed in a makeshift flow diffuser consisting of a 40-gallon garbage can perforated with numerous 1.5-inch holes.

3. The discharge rate from the hose was varied to maintain a water depth of 0.79 feet in the swale. (Through the first several hours of the test, the water depth was maintained at 1.1 feet; however, at this water depth, water was observed discharging into the overflow drain for the swale through a joint in the associated concrete casing. Therefore, the discharge rate was subsequently adjusted to maintain a water depth of only 0.79 feet throughout the remainder of the test to prevent this overflow.) Every 15 to 30 minutes, the discharge rate of water entering the swale and the water depth in the swale were manually recorded. A pressure transducer and data logger were also installed in the swale near the overflow drain

(Figure 2) and programmed with a 1-minute logging interval to continuously record water depth during the test.

4. After the discharge rate required for maintaining the target water depth (0.79 feet) in the swale stabilized and remained constant for 60 minutes, water flow to the swale was turned off. The time required for water remaining in the swale to infiltrate the soil was then measured until there was no longer any standing water.

5. The infiltration rate for the swale was then computed using the following formula:

$$IR = \frac{\Delta L}{\Delta T}$$

where:

IR = infiltration rate (inches/hour)

ΔL = change in water depth (in inches) from point when water inputs are turned off to point when no standing water is present

ΔT = change in time (in hours) from point when water inputs are turned off to point when no standing water is present

Photographs documenting the implementation of these procedures during the actual test are provided in Appendix A.

Results

A graph of the water depth and discharge data collected during this test is provided in Figure 3. The field measurements recorded during the test are provided in Appendix B.

After setting up the required equipment, the infiltration test began at 9:14 a.m. with the first discharge of water into the NDS test swale. The prevailing weather at this time, overcast with sun breaks, generally persisted through the end of the test. However, approximately 0.22 inches of precipitation was measured at the site in the 24-hour period preceding the test. This rainfall resulted in nearly saturated conditions in the soils associated with the swale.

At the beginning of the test, the discharge rate for water entering the swale was initially ramped up to approximately 0.2 cubic feet per second (cfs) (Figure 3). After approximately 60 minutes of elapsed time, the ponding depth in the swale reached 1.1 feet, a level just below the invert for the swale’s overflow drain. However, as noted above, at this water depth, water was observed discharging into the overflow drain for the swale through a joint in the associated concrete casing. Therefore, after 248 minutes of elapsed test time, the water discharge to the swale was

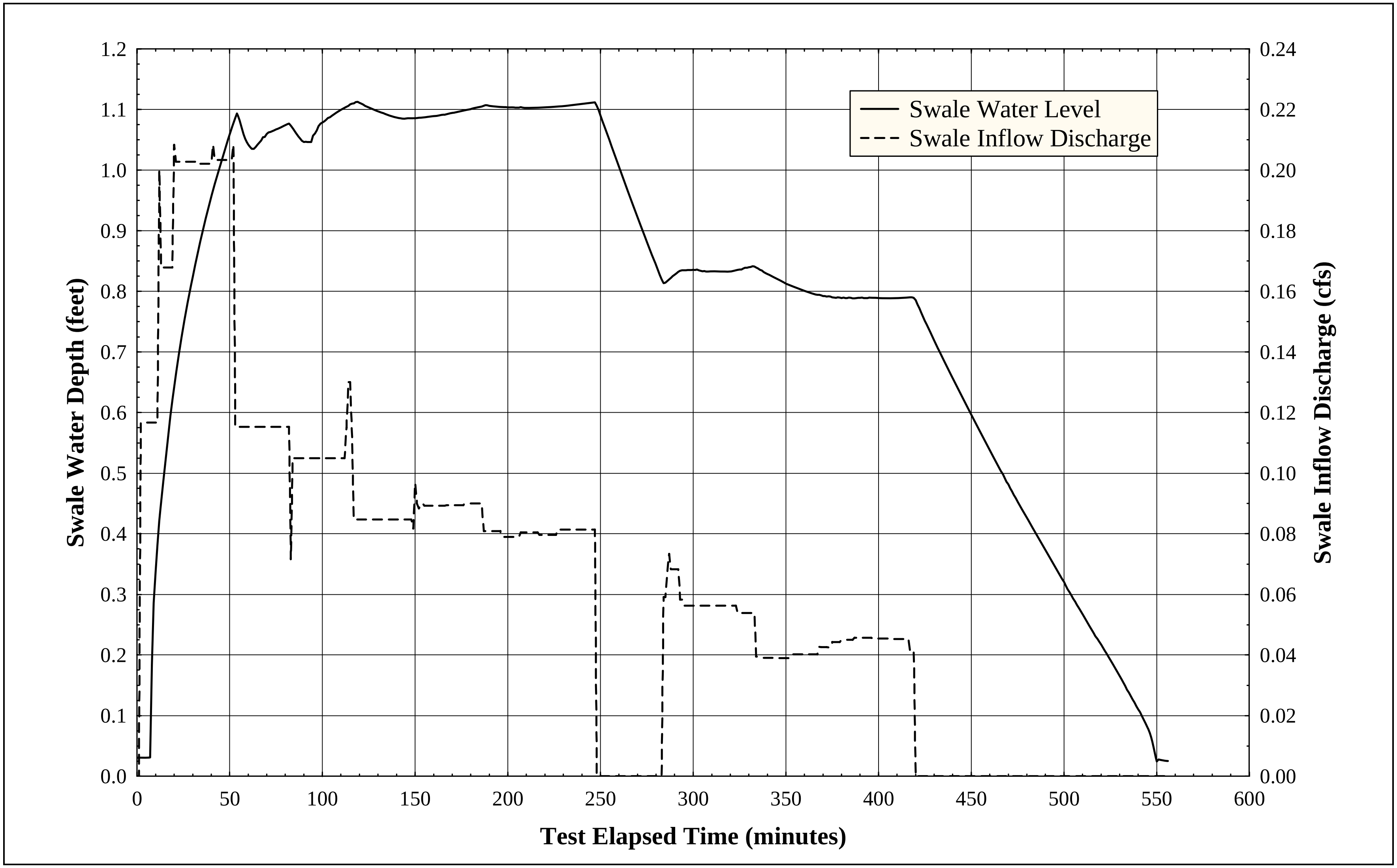


Figure 3. Inflow discharge rates and water depths measured during the controlled infiltration test on March 7, 2007, for the High Point Phase I Block-Scale Monitoring project.

wp4 06-03304-050 infiltration test #1.doc turned off for approximately 30 minutes to allow the water depth to decrease to the new target of 0.79 feet. The inflow rate was then adjusted (primarily reduced) to maintain this water depth for the next 73 minutes (Figure 3).

After approximately 360 minutes of elapsed test time, the discharge rate required to maintain the target water depth in the swale stabilized at approximately 0.045 cfs. This discharge rate was then maintained for approximately 60 minutes, or until 420 minutes of elapsed test time, at which point the water input to the swale was turned off. The water depth then dropped steadily over the next 130 minutes (2.17 hours) from the target depth of 0.79 feet until there was no appreciable standing water left in the swale (Figure 3). The total elapsed time for the test at this point was 550 minutes. At the end of the test, the final water depth in the swale was 0.024 feet, which corresponds to a 0.762-foot (9.135-inch) change in water depth from the time when the flow to the swale was turned off. Based on these data, the calculated infiltration rate for the swale is 9.135 inches/2.17 hours or 4.216 inches/hour. To provide some perspective for interpreting these results, an infiltration rate of 2 inches/hour was assumed for the surface of the High Point NDS swales during the design phase of the project (Herrera and R.W. Beck 2004).

References

Ecology. 2005. Stormwater Management in Western Washington. Volume III, Hydrologic Analysis and Flow Control Design/BMPs. Publication 05-10-31 (a revision of Publication 99-13). Washington State Department of Ecology, Water Quality Program, Olympia, Washington. February 2005.

Herrera. 2006. Quality Assurance Project Plan: High Point Phase I Block Scale Monitoring. Draft. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Seattle, Washington. September 13, 2006.

Herrera and R.W. Beck. 2004. Hydrologic Modeling for High Point Revitalization, Seattle, Washington. Appendix C to High Point Drainage Plan Report by SvR Design Company. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., and R.W. Beck, Seattle, Washington. May 5, 2004.

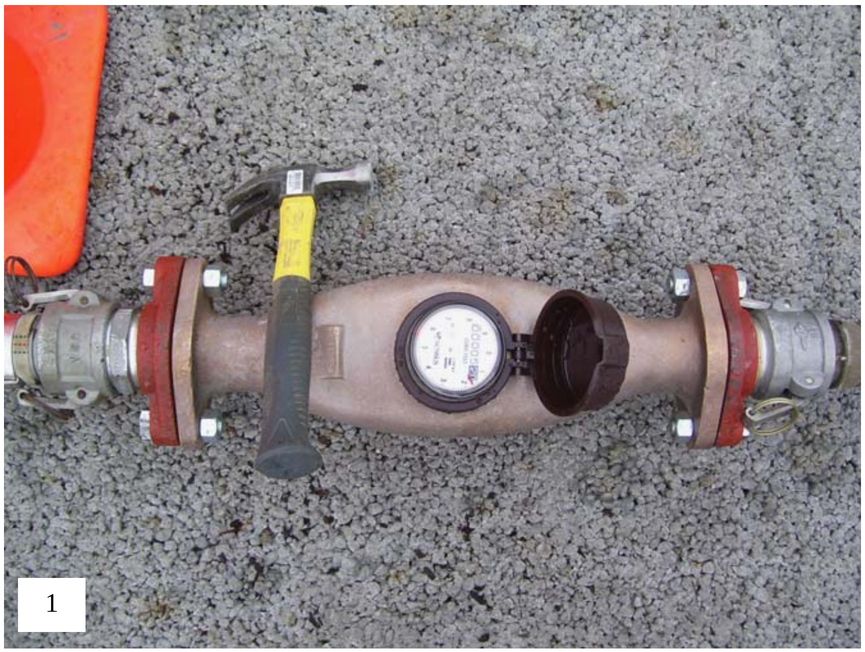
Seattle University. 2004. Soil Stormwater Detention Monitoring Method. Prepared for Seattle Public Utilities by Seattle University, School of Science and Engineering, Seattle, Washington. May 25, 2004.

APPENDIX A

Photographic Documentation of Field Measurement Procedures for March 7, 2007 Controlled Infiltration Test

Controlled Infiltration Test on March 7, 2007
High Point Block-Scale Monitoring Program
Photographic Log

Photo Number	Photo Description
1	Rotameter used to measure inflow discharge rates to the natural drainage system test swale
2	Pressure transducer used to measure water level in the natural drainage system test swale
3	Downgradient inflatable plug used to isolate Cell 19-3 of the natural drainage system test swale
4	Upgradient inflatable plug used to isolate Cell 19-3 of the natural drainage system test swale
5	Flow diffuser used for water entering the natural drainage system test swale
6	Flow diffuser used for water entering the natural drainage system test swale
7	Ponding in natural drainage system test swale during infiltration test
8	Ponding in natural drainage system test swale during infiltration test
9	Ponding near overflow drain for natural drainage system test swale during infiltration test



1

2

3

4

5


NO PARKING


7


8


9

APPENDIX B

Field Measurements from Controlled Infiltration Test on March 7, 2007

Table B1. Field measurements from controlled infiltration test on March 7, 2007.

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	9:14:00	0	0.031	0.000
3/7/2007	9:15:00	1	0.031	0.000
3/7/2007	9:16:00	2	0.031	0.117
3/7/2007	9:17:00	3	0.031	0.117
3/7/2007	9:18:00	4	0.031	0.117
3/7/2007	9:19:00	5	0.031	0.117
3/7/2007	9:20:00	6	0.031	0.117
3/7/2007	9:21:00	7	0.031	0.117
3/7/2007	9:22:00	8	0.184	0.117
3/7/2007	9:23:00	9	0.286	0.117
3/7/2007	9:24:00	10	0.339	0.117
3/7/2007	9:25:00	11	0.382	0.117
3/7/2007	9:26:00	12	0.420	0.200
3/7/2007	9:27:00	13	0.452	0.168
3/7/2007	9:28:00	14	0.481	0.168
3/7/2007	9:29:00	15	0.511	0.168
3/7/2007	9:30:00	16	0.541	0.168
3/7/2007	9:31:00	17	0.568	0.168
3/7/2007	9:32:00	18	0.594	0.168
3/7/2007	9:33:00	19	0.618	0.168
3/7/2007	9:34:00	20	0.642	0.208
3/7/2007	9:35:00	21	0.664	0.203
3/7/2007	9:36:00	22	0.685	0.203
3/7/2007	9:37:00	23	0.705	0.203
3/7/2007	9:38:00	24	0.724	0.203
3/7/2007	9:39:00	25	0.742	0.203
3/7/2007	9:40:00	26	0.760	0.203
3/7/2007	9:41:00	27	0.777	0.203
3/7/2007	9:42:00	28	0.793	0.203
3/7/2007	9:43:00	29	0.809	0.203
3/7/2007	9:44:00	30	0.824	0.203
3/7/2007	9:45:00	31	0.839	0.203
3/7/2007	9:46:00	32	0.853	0.203
3/7/2007	9:47:00	33	0.867	0.202
3/7/2007	9:48:00	34	0.881	0.202
3/7/2007	9:49:00	35	0.894	0.202
3/7/2007	9:50:00	36	0.908	0.202
3/7/2007	9:51:00	37	0.920	0.202
3/7/2007	9:52:00	38	0.932	0.202
3/7/2007	9:53:00	39	0.944	0.202

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	9:54:00	40	0.955	0.202
3/7/2007	9:55:00	41	0.967	0.208
3/7/2007	9:56:00	42	0.978	0.203
3/7/2007	9:57:00	43	0.988	0.203
3/7/2007	9:58:00	44	0.999	0.203
3/7/2007	9:59:00	45	1.009	0.203
3/7/2007	10:00:00	46	1.020	0.203
3/7/2007	10:01:00	47	1.030	0.203
3/7/2007	10:02:00	48	1.039	0.203
3/7/2007	10:03:00	49	1.049	0.203
3/7/2007	10:04:00	50	1.058	0.203
3/7/2007	10:05:00	51	1.068	0.203
3/7/2007	10:06:00	52	1.077	0.208
3/7/2007	10:07:00	53	1.086	0.115
3/7/2007	10:08:00	54	1.094	0.115
3/7/2007	10:09:00	55	1.086	0.115
3/7/2007	10:10:00	56	1.075	0.115
3/7/2007	10:11:00	57	1.064	0.115
3/7/2007	10:12:00	58	1.055	0.115
3/7/2007	10:13:00	59	1.047	0.115
3/7/2007	10:14:00	60	1.043	0.115
3/7/2007	10:15:00	61	1.038	0.115
3/7/2007	10:16:00	62	1.035	0.115
3/7/2007	10:17:00	63	1.035	0.115
3/7/2007	10:18:00	64	1.038	0.115
3/7/2007	10:19:00	65	1.042	0.115
3/7/2007	10:20:00	66	1.045	0.115
3/7/2007	10:21:00	67	1.049	0.115
3/7/2007	10:22:00	68	1.054	0.115
3/7/2007	10:23:00	69	1.055	0.115
3/7/2007	10:24:00	70	1.060	0.115
3/7/2007	10:25:00	71	1.062	0.115
3/7/2007	10:26:00	72	1.063	0.115
3/7/2007	10:27:00	73	1.064	0.115
3/7/2007	10:28:00	74	1.066	0.115
3/7/2007	10:29:00	75	1.067	0.115
3/7/2007	10:30:00	76	1.069	0.115
3/7/2007	10:31:00	77	1.069	0.115
3/7/2007	10:32:00	78	1.071	0.115
3/7/2007	10:33:00	79	1.072	0.115

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	10:34:00	80	1.074	0.115
3/7/2007	10:35:00	81	1.076	0.115
3/7/2007	10:36:00	82	1.077	0.115
3/7/2007	10:37:00	83	1.073	0.072
3/7/2007	10:38:00	84	1.069	0.105
3/7/2007	10:39:00	85	1.064	0.105
3/7/2007	10:40:00	86	1.060	0.105
3/7/2007	10:41:00	87	1.056	0.105
3/7/2007	10:42:00	88	1.052	0.105
3/7/2007	10:43:00	89	1.048	0.105
3/7/2007	10:44:00	90	1.046	0.105
3/7/2007	10:45:00	91	1.047	0.105
3/7/2007	10:46:00	92	1.046	0.105
3/7/2007	10:47:00	93	1.046	0.105
3/7/2007	10:48:00	94	1.046	0.105
3/7/2007	10:49:00	95	1.057	0.105
3/7/2007	10:50:00	96	1.060	0.105
3/7/2007	10:51:00	97	1.066	0.105
3/7/2007	10:52:00	98	1.072	0.105
3/7/2007	10:53:00	99	1.077	0.105
3/7/2007	10:54:00	100	1.078	0.105
3/7/2007	10:55:00	101	1.080	0.105
3/7/2007	10:56:00	102	1.083	0.105
3/7/2007	10:57:00	103	1.086	0.105
3/7/2007	10:58:00	104	1.087	0.105
3/7/2007	10:59:00	105	1.090	0.105
3/7/2007	11:00:00	106	1.092	0.105
3/7/2007	11:01:00	107	1.094	0.105
3/7/2007	11:02:00	108	1.096	0.105
3/7/2007	11:03:00	109	1.097	0.105
3/7/2007	11:04:00	110	1.100	0.105
3/7/2007	11:05:00	111	1.101	0.105
3/7/2007	11:06:00	112	1.103	0.105
3/7/2007	11:07:00	113	1.104	0.115
3/7/2007	11:08:00	114	1.106	0.130
3/7/2007	11:09:00	115	1.108	0.130
3/7/2007	11:10:00	116	1.110	0.112
3/7/2007	11:11:00	117	1.110	0.085
3/7/2007	11:12:00	118	1.112	0.085
3/7/2007	11:13:00	119	1.113	0.085

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	11:14:00	120	1.111	0.085
3/7/2007	11:15:00	121	1.110	0.085
3/7/2007	11:16:00	122	1.108	0.085
3/7/2007	11:17:00	123	1.106	0.085
3/7/2007	11:18:00	124	1.105	0.085
3/7/2007	11:19:00	125	1.103	0.085
3/7/2007	11:20:00	126	1.102	0.085
3/7/2007	11:21:00	127	1.100	0.085
3/7/2007	11:22:00	128	1.099	0.085
3/7/2007	11:23:00	129	1.098	0.085
3/7/2007	11:24:00	130	1.097	0.085
3/7/2007	11:25:00	131	1.096	0.085
3/7/2007	11:26:00	132	1.095	0.085
3/7/2007	11:27:00	133	1.094	0.085
3/7/2007	11:28:00	134	1.092	0.085
3/7/2007	11:29:00	135	1.091	0.085
3/7/2007	11:30:00	136	1.090	0.085
3/7/2007	11:31:00	137	1.089	0.085
3/7/2007	11:32:00	138	1.088	0.085
3/7/2007	11:33:00	139	1.087	0.085
3/7/2007	11:34:00	140	1.086	0.085
3/7/2007	11:35:00	141	1.086	0.085
3/7/2007	11:36:00	142	1.085	0.085
3/7/2007	11:37:00	143	1.085	0.085
3/7/2007	11:38:00	144	1.085	0.085
3/7/2007	11:39:00	145	1.085	0.085
3/7/2007	11:40:00	146	1.085	0.085
3/7/2007	11:41:00	147	1.085	0.085
3/7/2007	11:42:00	148	1.085	0.085
3/7/2007	11:43:00	149	1.085	0.082
3/7/2007	11:44:00	150	1.085	0.097
3/7/2007	11:45:00	151	1.086	0.090
3/7/2007	11:46:00	152	1.086	0.088
3/7/2007	11:47:00	153	1.086	0.090
3/7/2007	11:48:00	154	1.087	0.090
3/7/2007	11:49:00	155	1.087	0.089
3/7/2007	11:50:00	156	1.087	0.089
3/7/2007	11:51:00	157	1.088	0.089
3/7/2007	11:52:00	158	1.088	0.089
3/7/2007	11:53:00	159	1.088	0.089

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	11:54:00	160	1.089	0.089
3/7/2007	11:55:00	161	1.089	0.089
3/7/2007	11:56:00	162	1.090	0.089
3/7/2007	11:57:00	163	1.090	0.089
3/7/2007	11:58:00	164	1.091	0.089
3/7/2007	11:59:00	165	1.091	0.089
3/7/2007	12:00:00	166	1.091	0.089
3/7/2007	12:01:00	167	1.092	0.090
3/7/2007	12:02:00	168	1.093	0.089
3/7/2007	12:03:00	169	1.094	0.090
3/7/2007	12:04:00	170	1.094	0.089
3/7/2007	12:05:00	171	1.095	0.090
3/7/2007	12:06:00	172	1.095	0.089
3/7/2007	12:07:00	173	1.096	0.090
3/7/2007	12:08:00	174	1.097	0.089
3/7/2007	12:09:00	175	1.097	0.090
3/7/2007	12:10:00	176	1.098	0.089
3/7/2007	12:11:00	177	1.099	0.090
3/7/2007	12:12:00	178	1.099	0.090
3/7/2007	12:13:00	179	1.100	0.090
3/7/2007	12:14:00	180	1.101	0.090
3/7/2007	12:15:00	181	1.102	0.090
3/7/2007	12:16:00	182	1.102	0.090
3/7/2007	12:17:00	183	1.103	0.090
3/7/2007	12:18:00	184	1.104	0.090
3/7/2007	12:19:00	185	1.104	0.090
3/7/2007	12:20:00	186	1.105	0.090
3/7/2007	12:21:00	187	1.106	0.081
3/7/2007	12:22:00	188	1.107	0.081
3/7/2007	12:23:00	189	1.107	0.081
3/7/2007	12:24:00	190	1.106	0.081
3/7/2007	12:25:00	191	1.105	0.081
3/7/2007	12:26:00	192	1.105	0.081
3/7/2007	12:27:00	193	1.105	0.081
3/7/2007	12:28:00	194	1.105	0.081
3/7/2007	12:29:00	195	1.104	0.081
3/7/2007	12:30:00	196	1.104	0.081
3/7/2007	12:31:00	197	1.104	0.079
3/7/2007	12:32:00	198	1.104	0.079
3/7/2007	12:33:00	199	1.104	0.079

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	12:34:00	200	1.103	0.079
3/7/2007	12:35:00	201	1.103	0.079
3/7/2007	12:36:00	202	1.103	0.079
3/7/2007	12:37:00	203	1.103	0.079
3/7/2007	12:38:00	204	1.103	0.079
3/7/2007	12:39:00	205	1.103	0.079
3/7/2007	12:40:00	206	1.103	0.079
3/7/2007	12:41:00	207	1.104	0.080
3/7/2007	12:42:00	208	1.103	0.080
3/7/2007	12:43:00	209	1.103	0.081
3/7/2007	12:44:00	210	1.103	0.080
3/7/2007	12:45:00	211	1.103	0.080
3/7/2007	12:46:00	212	1.102	0.081
3/7/2007	12:47:00	213	1.103	0.080
3/7/2007	12:48:00	214	1.102	0.080
3/7/2007	12:49:00	215	1.102	0.080
3/7/2007	12:50:00	216	1.103	0.081
3/7/2007	12:51:00	217	1.103	0.080
3/7/2007	12:52:00	218	1.103	0.080
3/7/2007	12:53:00	219	1.103	0.080
3/7/2007	12:54:00	220	1.103	0.080
3/7/2007	12:55:00	221	1.104	0.080
3/7/2007	12:56:00	222	1.104	0.080
3/7/2007	12:57:00	223	1.104	0.080
3/7/2007	12:58:00	224	1.104	0.080
3/7/2007	12:59:00	225	1.105	0.080
3/7/2007	13:00:00	226	1.105	0.080
3/7/2007	13:01:00	227	1.105	0.081
3/7/2007	13:02:00	228	1.105	0.081
3/7/2007	13:03:00	229	1.105	0.081
3/7/2007	13:04:00	230	1.106	0.081
3/7/2007	13:05:00	231	1.106	0.081
3/7/2007	13:06:00	232	1.106	0.081
3/7/2007	13:07:00	233	1.106	0.081
3/7/2007	13:08:00	234	1.107	0.081
3/7/2007	13:09:00	235	1.107	0.081
3/7/2007	13:10:00	236	1.108	0.081
3/7/2007	13:11:00	237	1.108	0.081
3/7/2007	13:12:00	238	1.108	0.081
3/7/2007	13:13:00	239	1.109	0.081

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	13:14:00	240	1.109	0.081
3/7/2007	13:15:00	241	1.109	0.081
3/7/2007	13:16:00	242	1.110	0.081
3/7/2007	13:17:00	243	1.110	0.081
3/7/2007	13:18:00	244	1.111	0.081
3/7/2007	13:19:00	245	1.111	0.081
3/7/2007	13:20:00	246	1.111	0.081
3/7/2007	13:21:00	247	1.112	0.081
3/7/2007	13:22:00	248	1.106	0.000
3/7/2007	13:23:00	249	1.099	0.000
3/7/2007	13:24:00	250	1.090	0.000
3/7/2007	13:25:00	251	1.082	0.000
3/7/2007	13:26:00	252	1.073	0.000
3/7/2007	13:27:00	253	1.065	0.000
3/7/2007	13:28:00	254	1.056	0.000
3/7/2007	13:29:00	255	1.048	0.000
3/7/2007	13:30:00	256	1.039	0.000
3/7/2007	13:31:00	257	1.031	0.000
3/7/2007	13:32:00	258	1.023	0.000
3/7/2007	13:33:00	259	1.014	0.000
3/7/2007	13:34:00	260	1.006	0.000
3/7/2007	13:35:00	261	0.997	0.000
3/7/2007	13:36:00	262	0.989	0.000
3/7/2007	13:37:00	263	0.981	0.000
3/7/2007	13:38:00	264	0.972	0.000
3/7/2007	13:39:00	265	0.964	0.000
3/7/2007	13:40:00	266	0.955	0.000
3/7/2007	13:41:00	267	0.947	0.000
3/7/2007	13:42:00	268	0.938	0.000
3/7/2007	13:43:00	269	0.930	0.000
3/7/2007	13:44:00	270	0.922	0.000
3/7/2007	13:45:00	271	0.914	0.000
3/7/2007	13:46:00	272	0.906	0.000
3/7/2007	13:47:00	273	0.898	0.000
3/7/2007	13:48:00	274	0.890	0.000
3/7/2007	13:49:00	275	0.882	0.000
3/7/2007	13:50:00	276	0.874	0.000
3/7/2007	13:51:00	277	0.866	0.000
3/7/2007	13:52:00	278	0.858	0.000
3/7/2007	13:53:00	279	0.850	0.000

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	13:54:00	280	0.843	0.000
3/7/2007	13:55:00	281	0.835	0.000
3/7/2007	13:56:00	282	0.827	0.000
3/7/2007	13:57:00	283	0.820	0.000
3/7/2007	13:58:00	284	0.814	0.059
3/7/2007	13:59:00	285	0.814	0.059
3/7/2007	14:00:00	286	0.817	0.067
3/7/2007	14:01:00	287	0.820	0.073
3/7/2007	14:02:00	288	0.822	0.068
3/7/2007	14:03:00	289	0.825	0.068
3/7/2007	14:04:00	290	0.827	0.068
3/7/2007	14:05:00	291	0.830	0.068
3/7/2007	14:06:00	292	0.832	0.068
3/7/2007	14:07:00	293	0.834	0.058
3/7/2007	14:08:00	294	0.835	0.058
3/7/2007	14:09:00	295	0.835	0.056
3/7/2007	14:10:00	296	0.835	0.056
3/7/2007	14:11:00	297	0.835	0.056
3/7/2007	14:12:00	298	0.835	0.056
3/7/2007	14:13:00	299	0.835	0.056
3/7/2007	14:14:00	300	0.835	0.056
3/7/2007	14:15:00	301	0.835	0.056
3/7/2007	14:16:00	302	0.836	0.056
3/7/2007	14:17:00	303	0.835	0.056
3/7/2007	14:18:00	304	0.834	0.056
3/7/2007	14:19:00	305	0.833	0.056
3/7/2007	14:20:00	306	0.833	0.056
3/7/2007	14:21:00	307	0.833	0.056
3/7/2007	14:22:00	308	0.833	0.056
3/7/2007	14:23:00	309	0.833	0.056
3/7/2007	14:24:00	310	0.833	0.056
3/7/2007	14:25:00	311	0.833	0.056
3/7/2007	14:26:00	312	0.833	0.056
3/7/2007	14:27:00	313	0.833	0.056
3/7/2007	14:28:00	314	0.833	0.056
3/7/2007	14:29:00	315	0.833	0.056
3/7/2007	14:30:00	316	0.833	0.056
3/7/2007	14:31:00	317	0.833	0.056
3/7/2007	14:32:00	318	0.833	0.056
3/7/2007	14:33:00	319	0.832	0.056

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	14:34:00	320	0.832	0.056
3/7/2007	14:35:00	321	0.833	0.056
3/7/2007	14:36:00	322	0.834	0.056
3/7/2007	14:37:00	323	0.835	0.056
3/7/2007	14:38:00	324	0.836	0.054
3/7/2007	14:39:00	325	0.836	0.054
3/7/2007	14:40:00	326	0.836	0.054
3/7/2007	14:41:00	327	0.838	0.054
3/7/2007	14:42:00	328	0.839	0.054
3/7/2007	14:43:00	329	0.839	0.054
3/7/2007	14:44:00	330	0.840	0.054
3/7/2007	14:45:00	331	0.840	0.054
3/7/2007	14:46:00	332	0.841	0.054
3/7/2007	14:47:00	333	0.841	0.054
3/7/2007	14:48:00	334	0.839	0.039
3/7/2007	14:49:00	335	0.837	0.039
3/7/2007	14:50:00	336	0.835	0.039
3/7/2007	14:51:00	337	0.834	0.039
3/7/2007	14:52:00	338	0.832	0.039
3/7/2007	14:53:00	339	0.830	0.039
3/7/2007	14:54:00	340	0.829	0.039
3/7/2007	14:55:00	341	0.827	0.039
3/7/2007	14:56:00	342	0.825	0.039
3/7/2007	14:57:00	343	0.824	0.039
3/7/2007	14:58:00	344	0.822	0.039
3/7/2007	14:59:00	345	0.821	0.039
3/7/2007	15:00:00	346	0.819	0.039
3/7/2007	15:01:00	347	0.818	0.039
3/7/2007	15:02:00	348	0.816	0.039
3/7/2007	15:03:00	349	0.815	0.039
3/7/2007	15:04:00	350	0.813	0.039
3/7/2007	15:05:00	351	0.812	0.039
3/7/2007	15:06:00	352	0.810	0.039
3/7/2007	15:07:00	353	0.809	0.039
3/7/2007	15:08:00	354	0.808	0.040
3/7/2007	15:09:00	355	0.806	0.040
3/7/2007	15:10:00	356	0.805	0.040
3/7/2007	15:11:00	357	0.804	0.040
3/7/2007	15:12:00	358	0.803	0.040
3/7/2007	15:13:00	359	0.802	0.040

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	15:14:00	360	0.801	0.040
3/7/2007	15:15:00	361	0.800	0.040
3/7/2007	15:16:00	362	0.799	0.040
3/7/2007	15:17:00	363	0.798	0.040
3/7/2007	15:18:00	364	0.797	0.040
3/7/2007	15:19:00	365	0.796	0.040
3/7/2007	15:20:00	366	0.795	0.040
3/7/2007	15:21:00	367	0.794	0.040
3/7/2007	15:22:00	368	0.794	0.043
3/7/2007	15:23:00	369	0.793	0.043
3/7/2007	15:24:00	370	0.792	0.043
3/7/2007	15:25:00	371	0.792	0.043
3/7/2007	15:26:00	372	0.791	0.043
3/7/2007	15:27:00	373	0.792	0.042
3/7/2007	15:28:00	374	0.791	0.043
3/7/2007	15:29:00	375	0.790	0.044
3/7/2007	15:30:00	376	0.790	0.044
3/7/2007	15:31:00	377	0.789	0.044
3/7/2007	15:32:00	378	0.790	0.044
3/7/2007	15:33:00	379	0.790	0.044
3/7/2007	15:34:00	380	0.789	0.045
3/7/2007	15:35:00	381	0.790	0.045
3/7/2007	15:36:00	382	0.789	0.045
3/7/2007	15:37:00	383	0.789	0.045
3/7/2007	15:38:00	384	0.790	0.045
3/7/2007	15:39:00	385	0.789	0.045
3/7/2007	15:40:00	386	0.788	0.045
3/7/2007	15:41:00	387	0.789	0.046
3/7/2007	15:42:00	388	0.789	0.046
3/7/2007	15:43:00	389	0.789	0.046
3/7/2007	15:44:00	390	0.789	0.046
3/7/2007	15:45:00	391	0.790	0.046
3/7/2007	15:46:00	392	0.789	0.046
3/7/2007	15:47:00	393	0.789	0.046
3/7/2007	15:48:00	394	0.789	0.046
3/7/2007	15:49:00	395	0.790	0.046
3/7/2007	15:50:00	396	0.789	0.046
3/7/2007	15:51:00	397	0.789	0.046
3/7/2007	15:52:00	398	0.790	0.046
3/7/2007	15:53:00	399	0.789	0.046

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	15:54:00	400	0.789	0.046
3/7/2007	15:55:00	401	0.789	0.046
3/7/2007	15:56:00	402	0.789	0.046
3/7/2007	15:57:00	403	0.789	0.045
3/7/2007	15:58:00	404	0.788	0.046
3/7/2007	15:59:00	405	0.788	0.046
3/7/2007	16:00:00	406	0.788	0.046
3/7/2007	16:01:00	407	0.789	0.045
3/7/2007	16:02:00	408	0.789	0.045
3/7/2007	16:03:00	409	0.789	0.045
3/7/2007	16:04:00	410	0.789	0.045
3/7/2007	16:05:00	411	0.789	0.045
3/7/2007	16:06:00	412	0.789	0.045
3/7/2007	16:07:00	413	0.789	0.045
3/7/2007	16:08:00	414	0.789	0.045
3/7/2007	16:09:00	415	0.790	0.045
3/7/2007	16:10:00	416	0.790	0.045
3/7/2007	16:11:00	417	0.790	0.042
3/7/2007	16:12:00	418	0.790	0.042
3/7/2007	16:13:00	419	0.789	0.042
3/7/2007	16:14:00	420	0.786	0.000
3/7/2007	16:15:00	421	0.778	0.000
3/7/2007	16:16:00	422	0.772	0.000
3/7/2007	16:17:00	423	0.765	0.000
3/7/2007	16:18:00	424	0.758	0.000
3/7/2007	16:19:00	425	0.752	0.000
3/7/2007	16:20:00	426	0.746	0.000
3/7/2007	16:21:00	427	0.738	0.000
3/7/2007	16:22:00	428	0.732	0.000
3/7/2007	16:23:00	429	0.726	0.000
3/7/2007	16:24:00	430	0.719	0.000
3/7/2007	16:25:00	431	0.713	0.000
3/7/2007	16:26:00	432	0.706	0.000
3/7/2007	16:27:00	433	0.700	0.000
3/7/2007	16:28:00	434	0.693	0.000
3/7/2007	16:29:00	435	0.688	0.000
3/7/2007	16:30:00	436	0.681	0.000
3/7/2007	16:31:00	437	0.675	0.000
3/7/2007	16:32:00	438	0.669	0.000
3/7/2007	16:33:00	439	0.663	0.000

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	16:34:00	440	0.656	0.000
3/7/2007	16:35:00	441	0.651	0.000
3/7/2007	16:36:00	442	0.645	0.000
3/7/2007	16:37:00	443	0.639	0.000
3/7/2007	16:38:00	444	0.633	0.000
3/7/2007	16:39:00	445	0.626	0.000
3/7/2007	16:40:00	446	0.621	0.000
3/7/2007	16:41:00	447	0.614	0.000
3/7/2007	16:42:00	448	0.608	0.000
3/7/2007	16:43:00	449	0.603	0.000
3/7/2007	16:44:00	450	0.596	0.000
3/7/2007	16:45:00	451	0.591	0.000
3/7/2007	16:46:00	452	0.585	0.000
3/7/2007	16:47:00	453	0.579	0.000
3/7/2007	16:48:00	454	0.573	0.000
3/7/2007	16:49:00	455	0.567	0.000
3/7/2007	16:50:00	456	0.561	0.000
3/7/2007	16:51:00	457	0.555	0.000
3/7/2007	16:52:00	458	0.550	0.000
3/7/2007	16:53:00	459	0.544	0.000
3/7/2007	16:54:00	460	0.538	0.000
3/7/2007	16:55:00	461	0.532	0.000
3/7/2007	16:56:00	462	0.526	0.000
3/7/2007	16:57:00	463	0.521	0.000
3/7/2007	16:58:00	464	0.515	0.000
3/7/2007	16:59:00	465	0.510	0.000
3/7/2007	17:00:00	466	0.503	0.000
3/7/2007	17:01:00	467	0.498	0.000
3/7/2007	17:02:00	468	0.492	0.000
3/7/2007	17:03:00	469	0.486	0.000
3/7/2007	17:04:00	470	0.481	0.000
3/7/2007	17:05:00	471	0.475	0.000
3/7/2007	17:06:00	472	0.470	0.000
3/7/2007	17:07:00	473	0.464	0.000
3/7/2007	17:08:00	474	0.459	0.000
3/7/2007	17:09:00	475	0.453	0.000
3/7/2007	17:10:00	476	0.448	0.000
3/7/2007	17:11:00	477	0.442	0.000
3/7/2007	17:12:00	478	0.437	0.000
3/7/2007	17:13:00	479	0.432	0.000

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	17:14:00	480	0.426	0.000
3/7/2007	17:15:00	481	0.421	0.000
3/7/2007	17:16:00	482	0.416	0.000
3/7/2007	17:17:00	483	0.410	0.000
3/7/2007	17:18:00	484	0.405	0.000
3/7/2007	17:19:00	485	0.400	0.000
3/7/2007	17:20:00	486	0.394	0.000
3/7/2007	17:21:00	487	0.389	0.000
3/7/2007	17:22:00	488	0.384	0.000
3/7/2007	17:23:00	489	0.378	0.000
3/7/2007	17:24:00	490	0.373	0.000
3/7/2007	17:25:00	491	0.368	0.000
3/7/2007	17:26:00	492	0.362	0.000
3/7/2007	17:27:00	493	0.357	0.000
3/7/2007	17:28:00	494	0.352	0.000
3/7/2007	17:29:00	495	0.347	0.000
3/7/2007	17:30:00	496	0.342	0.000
3/7/2007	17:31:00	497	0.336	0.000
3/7/2007	17:32:00	498	0.331	0.000
3/7/2007	17:33:00	499	0.326	0.000
3/7/2007	17:34:00	500	0.321	0.000
3/7/2007	17:35:00	501	0.315	0.000
3/7/2007	17:36:00	502	0.309	0.000
3/7/2007	17:37:00	503	0.304	0.000
3/7/2007	17:38:00	504	0.298	0.000
3/7/2007	17:39:00	505	0.293	0.000
3/7/2007	17:40:00	506	0.288	0.000
3/7/2007	17:41:00	507	0.283	0.000
3/7/2007	17:42:00	508	0.278	0.000
3/7/2007	17:43:00	509	0.273	0.000
3/7/2007	17:44:00	510	0.267	0.000
3/7/2007	17:45:00	511	0.262	0.000
3/7/2007	17:46:00	512	0.257	0.000
3/7/2007	17:47:00	513	0.252	0.000
3/7/2007	17:48:00	514	0.247	0.000
3/7/2007	17:49:00	515	0.241	0.000
3/7/2007	17:50:00	516	0.237	0.000
3/7/2007	17:51:00	517	0.231	0.000
3/7/2007	17:52:00	518	0.227	0.000
3/7/2007	17:53:00	519	0.222	0.000

Table B1 (continued). Field measurements from controlled infiltration test on March 7, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
3/7/2007	17:54:00	520	0.217	0.000
3/7/2007	17:55:00	521	0.212	0.000
3/7/2007	17:56:00	522	0.207	0.000
3/7/2007	17:57:00	523	0.202	0.000
3/7/2007	17:58:00	524	0.197	0.000
3/7/2007	17:59:00	525	0.192	0.000
3/7/2007	18:00:00	526	0.187	0.000
3/7/2007	18:01:00	527	0.181	0.000
3/7/2007	18:02:00	528	0.176	0.000
3/7/2007	18:03:00	529	0.171	0.000
3/7/2007	18:04:00	530	0.166	0.000
3/7/2007	18:05:00	531	0.160	0.000
3/7/2007	18:06:00	532	0.155	0.000
3/7/2007	18:07:00	533	0.149	0.000
3/7/2007	18:08:00	534	0.143	0.000
3/7/2007	18:09:00	535	0.138	0.000
3/7/2007	18:10:00	536	0.132	0.000
3/7/2007	18:11:00	537	0.127	0.000
3/7/2007	18:12:00	538	0.121	0.000
3/7/2007	18:13:00	539	0.116	0.000
3/7/2007	18:14:00	540	0.111	0.000
3/7/2007	18:15:00	541	0.105	0.000
3/7/2007	18:16:00	542	0.099	0.000
3/7/2007	18:17:00	543	0.094	0.000
3/7/2007	18:18:00	544	0.087	0.000
3/7/2007	18:19:00	545	0.081	0.000
3/7/2007	18:20:00	546	0.074	0.000
3/7/2007	18:21:00	547	0.064	0.000
3/7/2007	18:22:00	548	0.051	0.000
3/7/2007	18:23:00	549	0.037	0.000
3/7/2007	18:24:00	550	0.024	0.000
3/7/2007	18:25:00	551	0.028	0.000
3/7/2007	18:26:00	552	0.027	0.000
3/7/2007	18:27:00	553	0.026	0.000
3/7/2007	18:28:00	554	0.026	0.000
3/7/2007	18:29:00	555	0.025	0.000
3/7/2007	18:30:00	556	0.025	0.000
3/7/2007	18:31:00	557	0.025	0.000
3/7/2007	18:32:00	558	0.025	0.000

APPENDIX G

Data Report from April 11, 2007 Controlled Infiltration Test

DATA REPORT

Second Controlled Infiltration Test for the High Point Phase I Block-Scale Monitoring Project

Prepared for

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May 24, 2007

Background

Seattle Public Utilities (SPU) is implementing a large-scale natural drainage system (NDS) project in conjunction with the redevelopment project for the High Point neighborhood in West Seattle (Figure 1). NDS swales are part of what is termed a *low-impact development* approach to managing stormwater runoff. The goal of this approach is to minimize the potential effect of land use changes on the natural hydrograph that can result from urbanization. In contrast to conventional stormwater systems that route runoff directly to storm drains, the NDS swales route runoff first through a vegetated and compost-amended swale, reducing the rate of flow and allowing the runoff to infiltrate into the ground. The excess runoff is then routed to the conventional stormwater system. This approach increases infiltration, decreases the rate and volume of runoff, and improves water quality. The end result is decreased erosion, stabilized water temperatures, and improved downstream habitat.

As part of this NDS project, Seattle Public Utilities is implementing a block-scale monitoring project for NDS swales that have been installed on the High Point redevelopment site. The goal of the monitoring program is to quantify the treatment performance of the NDS swales in order to provide a basis for potential design refinements that might improve performance or reduce installation costs or both. The specific monitoring activities that will be performed to meet this goal are described in a quality assurance project plan (QAPP) that was prepared earlier for the project (Herrera 2006). In general, the QAPP describes hydrologic and water quality monitoring activities to be performed in association with an NDS test swale on the High Point redevelopment site over a 3-year period, beginning in winter 2006 and ending in September 2009.

As described in the QAPP, a specific component of this monitoring project is the implementation of three controlled tests to measure infiltration rates on the surface of the NDS test swale. The first and second tests are to be conducted during the first and second months, respectively, of the monitoring project, and the third test is to be performed during the third and final year of the monitoring project.

This report documents the results of the second controlled infiltration test which was conducted on April 11, 2007. (The first infiltration test was conducted on March 7, 2007.) It describes the study location and the procedures that were used during the test process. It also summarizes the results of the test using graphical representations of the data, as necessary. The raw data from the test are provided in an appendix.

Study Location

The study location was the High Point redevelopment site in West Seattle (Figure 1). The site lies within the Longfellow Creek drainage basin and is generally bordered on the north by SW Juneau Street, on the west by 34th Avenue SW, on the south by SW Myrtle Street, and on the east by a designated steep-sloped greenbelt. The infiltration test was conducted in a representative NDS swale (NDS test swale) that parallels Highpoint Drive SW between SW Graham and SW Bataan Street (Figure 2).

04-05-07/rtb/HEC-R/06-03304-050-002-001/Infiltration Test #1

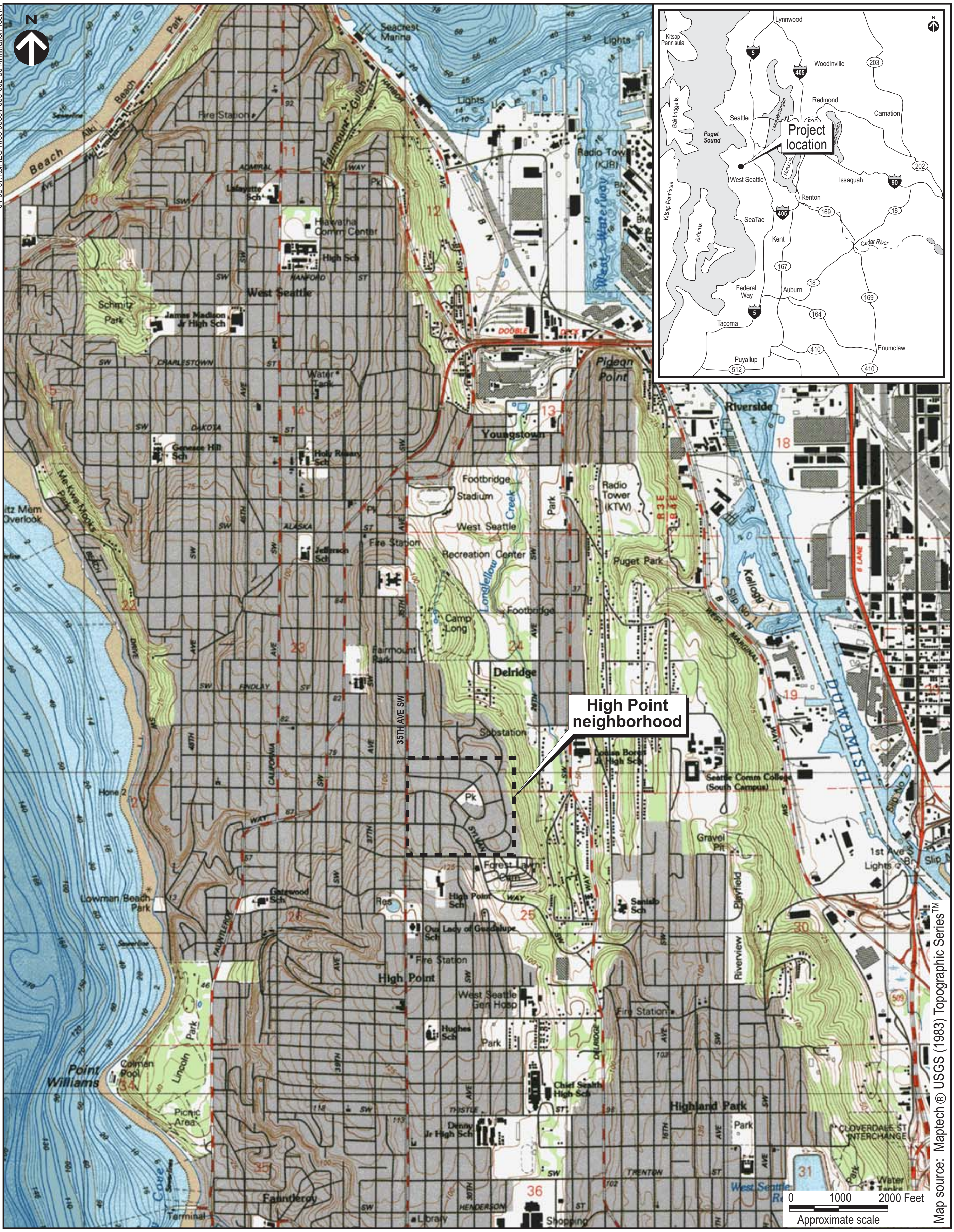

Figure 1. Vicinity map for the High Point redevelopment project site in Seattle, Washington.

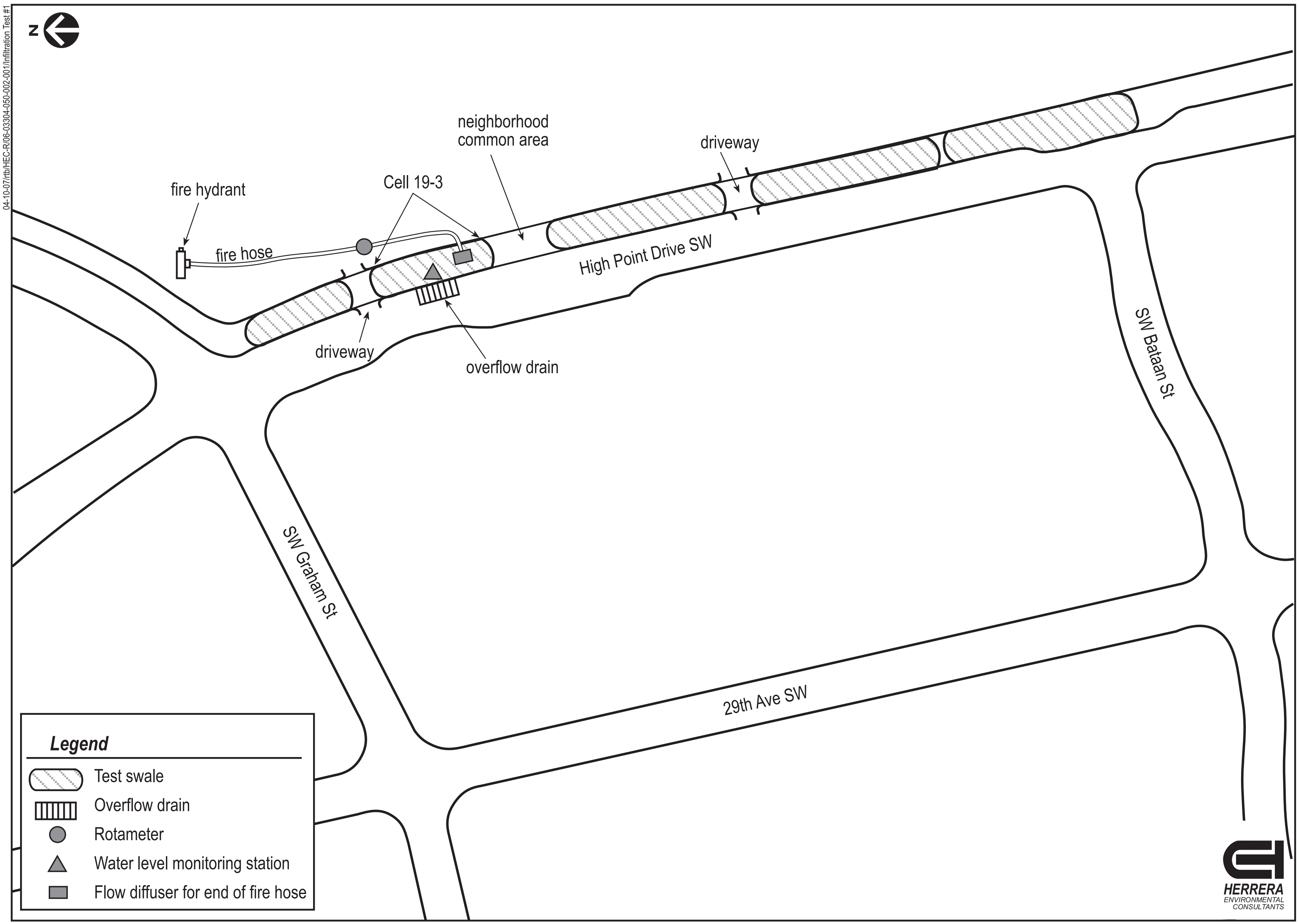

Figure 2. Plan view of natural drainage system test swale and controlled infiltration test monitoring station location for the High Point Phase I Block-scale Monitoring project.

Methods

Surface infiltration rates in the NDS test swale were measured using procedures adopted from the Washington State Department of Ecology's (2005) pilot infiltration test. The pilot infiltration test is a relatively large-scale infiltration test that is typically performed during the design phase of a project to estimate infiltration rates for a proposed stormwater infiltration facility. It specifically involves excavating a test pit to the same depth as that of the proposed infiltration facility. Water is then introduced to the pit at a variable rate to maintain a constant water level in the pit. During this procedure, a rotameter is used to measure the flow rate of the introduced water. After the flow rate has remained stable (i.e., constant) for 60 minutes, the water is turned off and the rate of infiltration (in inches per hour) is recorded until the pit is empty. This method has been shown to provide the most accurate estimates of infiltration rates for large-scale infiltration facilities (Seattle University 2004).

The pilot infiltration test method was modified for use in the NDS test swale as follows:

1. Culverts immediately upgradient and downgradient of the overflow drain for the swale were blocked with inflatable plugs. These culverts convey water beneath a neighborhood common area and driveway that crosses the swale at two locations on High Point Drive SW. This isolated a 72.4-foot section of the swale with an approximate surface area of 391 square feet. This section of the swale (which is identified as Cell 19-3 in the drainage plans for the project) represents approximately 20 percent of the total surface area of the swale. All subsequent activities related to this test were performed on this section of the swale.

2. Water from a nearby fire hydrant (Figure 2) was discharged to the swale using approximately 300 feet of 4-inch-diameter fire hose. A rotameter was attached to the hose to measure the water discharge rate. To reduce potential soil erosion at the point of discharge, the end of the fire hose was placed in a makeshift flow diffuser consisting of a plastic 40-gallon garbage can perforated with numerous 1.5-inch holes.

3. The discharge rate from the hose was varied to maintain a water depth of 0.80 feet in the swale. This target depth was identified during the first infiltration test and represents the maximum ponding depth that can be maintained within the swale without loosing water to the overflow drain. Every 15 to 30 minutes, the discharge rate of water entering the swale and the water depth in the swale were manually recorded. A pressure transducer and data logger were also installed in the swale near the overflow drain (Figure 2) and programmed with a 1-minute logging interval to continuously record water depth during the test.

4. After the discharge rate that was required for maintaining the target water depth (0.80 feet) in the swale stabilized and remained constant for 60 minutes, water flow to the swale was turned off. The time required for water remaining in the swale to infiltrate the soil was then measured until there was no longer any standing water.

5. The infiltration rate for the swale was then computed using the following formula:

$$IR = \frac{\Delta L}{\Delta T}$$

where:

IR = infiltration rate (inches/hour)

ΔL = change in water depth (in inches) from the time when water inputs are turned off to the time when no standing water is present

ΔT = change in time (in hours) from the time when water inputs are turned off to the time when no standing water is present

Photographs documenting the implementation of these procedures during the actual test are provided in Appendix A.

Results

A graph of the water depth and discharge data recorded during this test is provided in Figure 3. The field measurements recorded during the test are provided in Appendix B.

After setting up the required equipment, the infiltration test began at 8:36 a.m. with the first discharge of water into the NDS test swale. The prevailing weather at the time (i.e., clear skies) generally persisted through the end of the test. These conditions also persisted over the three days leading up to the test and resulted in a low initial water content in the soils associated with the swale.

At the beginning of the test, the discharge rate for water entering the swale was initially ramped up to approximately 0.19 cubic feet per second (cfs) (Figure 3). After approximately 33 minutes of elapsed time, the ponding depth in the swale reached the target depth of 0.80 feet. The inflow rate was then adjusted (primarily reduced) to maintain a water depth greater than or equal to 0.80 feet until 279 minutes of elapsed time in the test, at which point the discharge rate required to maintain this depth stabilized at 0.065 cfs (Figure 3). This discharge rate was maintained for approximately 60 minutes, or until 339 minutes of elapsed test time, at which point the water input to the swale was turned off. The water depth then dropped steadily over the next 91 minutes (1.52 hours) from the target depth of 0.80 feet until there was no appreciable standing

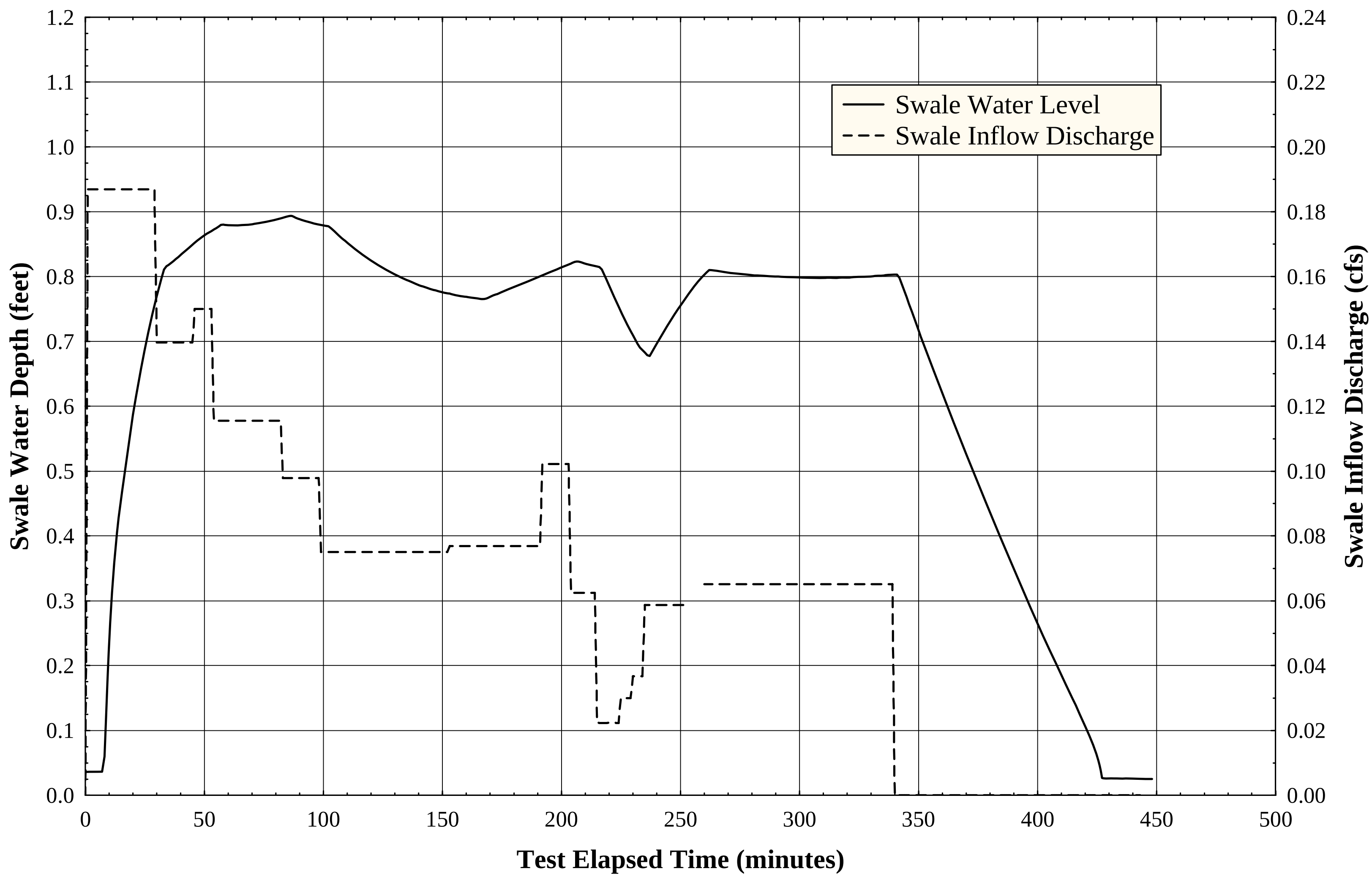

Figure 3. Inflow discharge rates and water depths measured during the controlled infiltration test on April 11, 2007, for the High Point Phase I Block-Scale Monitoring project.

lt 06-03304-050 infiltration test #2.doc water remaining in the swale (Figure 3). The total elapsed time for the test at this point was 430 minutes. At the end of the test, the final water depth in the swale was 0.026 feet, which corresponds to a 0.774-foot (9.228-inch) change in water depth from the time when the flow to the swale was turned off. Based on these data, the calculated infiltration rate for the swale is 9.228 inches/1.52 hours or 6.111 inches/hour.

To provide some perspective for interpreting these results, an infiltration rate of 2 inches/hour was assumed for the surface of the High Point NDS swales during the design phase of the project (Herrera and R.W. Beck 2004). Furthermore, the rate measured during the first infiltration test that was performed in connection with this project was 4.216 inches/hour. The difference in the measured infiltration rates between the first and second infiltration tests (i.e., 1.895 inches/hour) may be attributed to differences in the soil moisture content of the test swale leading up to the tests (it rained prior to the first infiltration test); however, maintaining a steady state discharge rate for 60 minutes prior to measuring the infiltration rate is meant to ensure saturated soil conditions persist in the test swale regardless of antecedent conditions. Therefore, differences in the initial soil moisture content should not be a significant factor contributing to the differences in infiltration rates between the first and second tests.

References

Ecology. 2005. Stormwater Management in Western Washington. Volume III, Hydrologic Analysis and Flow Control Design/BMPs. Publication 05-10-31 (a revision of Publication 99-13). Washington State Department of Ecology, Water Quality Program, Olympia, Washington. February 2005.

Herrera. 2006. Quality Assurance Project Plan: High Point Phase I Block Scale Monitoring. Draft. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Seattle, Washington. September 13, 2006.

Herrera and R.W. Beck. 2004. Hydrologic Modeling for High Point Revitalization, Seattle, Washington. Appendix C to High Point Drainage Plan Report by SvR Design Company. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., and R.W. Beck, Seattle, Washington. May 5, 2004.

Seattle University. 2004. Soil Stormwater Detention Monitoring Method. Prepared for Seattle Public Utilities by Seattle University, School of Science and Engineering, Seattle, Washington. May 25, 2004.

APPENDIX A

Photographic Documentation of Field Measurement Procedures for April 11, 2007 Controlled Infiltration Test

Controlled Infiltration Test on April 11, 2007
High Point Block-Scale Monitoring Program
Photographic Log

Photo Number	Photo Description
1	Rotameter used to measure inflow discharge rates to the natural drainage system test swale
2	Pressure transducer used to measure water level in the natural drainage system test swale
3	Upgradient inflatable plug used to isolate Cell 19-3 of the natural drainage system test swale
4	Downgradient inflatable plug used to isolate Cell 19-3 of the natural drainage system test swale
5	Flow diffuser used for water entering the natural drainage system test swale
6	Ponding in natural drainage system test swale during infiltration test
7	Ponding in natural drainage system test swale during infiltration test
8	Fire hydrant and 4” hose used to deliver water to the natural drainage system test swale
9	Field book and datalogger near natural drainage system test swale overflow drain


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04 11 2007


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APPENDIX B

Field Measurements from Controlled Infiltration Test on April 11, 2007

Table B1. Field measurements from controlled infiltration test on April 11, 2007.

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	8:36:00	0	0.036	0.000
4/11/2007	8:37:00	1	0.036	0.187
4/11/2007	8:38:00	2	0.036	0.187
4/11/2007	8:39:00	3	0.036	0.187
4/11/2007	8:40:00	4	0.036	0.187
4/11/2007	8:41:00	5	0.036	0.187
4/11/2007	8:42:00	6	0.036	0.187
4/11/2007	8:43:00	7	0.036	0.187
4/11/2007	8:44:00	8	0.060	0.187
4/11/2007	8:45:00	9	0.152	0.187
4/11/2007	8:46:00	10	0.236	0.187
4/11/2007	8:47:00	11	0.306	0.187
4/11/2007	8:48:00	12	0.351	0.187
4/11/2007	8:49:00	13	0.393	0.187
4/11/2007	8:50:00	14	0.428	0.187
4/11/2007	8:51:00	15	0.457	0.187
4/11/2007	8:52:00	16	0.483	0.187
4/11/2007	8:53:00	17	0.510	0.187
4/11/2007	8:54:00	18	0.537	0.187
4/11/2007	8:55:00	19	0.563	0.187
4/11/2007	8:56:00	20	0.587	0.187
4/11/2007	8:57:00	21	0.610	0.187
4/11/2007	8:58:00	22	0.631	0.187
4/11/2007	8:59:00	23	0.651	0.187
4/11/2007	9:00:00	24	0.670	0.187
4/11/2007	9:01:00	25	0.689	0.187
4/11/2007	9:02:00	26	0.707	0.187
4/11/2007	9:03:00	27	0.724	0.187
4/11/2007	9:04:00	28	0.740	0.187
4/11/2007	9:05:00	29	0.755	0.187
4/11/2007	9:06:00	30	0.770	0.140
4/11/2007	9:07:00	31	0.784	0.140
4/11/2007	9:08:00	32	0.798	0.140
4/11/2007	9:09:00	33	0.811	0.140
4/11/2007	9:10:00	34	0.816	0.140
4/11/2007	9:11:00	35	0.818	0.140
4/11/2007	9:12:00	36	0.821	0.140
4/11/2007	9:13:00	37	0.824	0.140
4/11/2007	9:14:00	38	0.827	0.140
4/11/2007	9:15:00	39	0.830	0.140
4/11/2007	9:16:00	40	0.833	0.140
4/11/2007	9:17:00	41	0.837	0.140
4/11/2007	9:18:00	42	0.839	0.140

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	9:19:00	43	0.843	0.140
4/11/2007	9:20:00	44	0.846	0.140
4/11/2007	9:21:00	45	0.849	0.140
4/11/2007	9:22:00	46	0.852	0.150
4/11/2007	9:23:00	47	0.855	0.150
4/11/2007	9:24:00	48	0.858	0.150
4/11/2007	9:25:00	49	0.861	0.150
4/11/2007	9:26:00	50	0.863	0.150
4/11/2007	9:27:00	51	0.866	0.150
4/11/2007	9:28:00	52	0.868	0.150
4/11/2007	9:29:00	53	0.870	0.150
4/11/2007	9:30:00	54	0.872	0.116
4/11/2007	9:31:00	55	0.875	0.116
4/11/2007	9:32:00	56	0.877	0.116
4/11/2007	9:33:00	57	0.880	0.116
4/11/2007	9:34:00	58	0.880	0.116
4/11/2007	9:35:00	59	0.879	0.116
4/11/2007	9:36:00	60	0.879	0.116
4/11/2007	9:37:00	61	0.879	0.116
4/11/2007	9:38:00	62	0.879	0.116
4/11/2007	9:39:00	63	0.879	0.116
4/11/2007	9:40:00	64	0.879	0.116
4/11/2007	9:41:00	65	0.879	0.116
4/11/2007	9:42:00	66	0.879	0.116
4/11/2007	9:43:00	67	0.879	0.116
4/11/2007	9:44:00	68	0.880	0.116
4/11/2007	9:45:00	69	0.880	0.116
4/11/2007	9:46:00	70	0.881	0.116
4/11/2007	9:47:00	71	0.881	0.116
4/11/2007	9:48:00	72	0.882	0.116
4/11/2007	9:49:00	73	0.882	0.116
4/11/2007	9:50:00	74	0.883	0.116
4/11/2007	9:51:00	75	0.884	0.116
4/11/2007	9:52:00	76	0.884	0.116
4/11/2007	9:53:00	77	0.885	0.116
4/11/2007	9:54:00	78	0.886	0.116
4/11/2007	9:55:00	79	0.887	0.116
4/11/2007	9:56:00	80	0.888	0.116
4/11/2007	9:57:00	81	0.889	0.116
4/11/2007	9:58:00	82	0.890	0.116
4/11/2007	9:59:00	83	0.890	0.098
4/11/2007	10:00:00	84	0.892	0.098
4/11/2007	10:01:00	85	0.893	0.098
4/11/2007	10:02:00	86	0.894	0.098

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	10:03:00	87	0.893	0.098
4/11/2007	10:04:00	88	0.891	0.098
4/11/2007	10:05:00	89	0.890	0.098
4/11/2007	10:06:00	90	0.889	0.098
4/11/2007	10:07:00	91	0.887	0.098
4/11/2007	10:08:00	92	0.886	0.098
4/11/2007	10:09:00	93	0.885	0.098
4/11/2007	10:10:00	94	0.884	0.098
4/11/2007	10:11:00	95	0.883	0.098
4/11/2007	10:12:00	96	0.882	0.098
4/11/2007	10:13:00	97	0.881	0.098
4/11/2007	10:14:00	98	0.880	0.098
4/11/2007	10:15:00	99	0.880	0.075
4/11/2007	10:16:00	100	0.879	0.075
4/11/2007	10:17:00	101	0.878	0.075
4/11/2007	10:18:00	102	0.878	0.075
4/11/2007	10:19:00	103	0.875	0.075
4/11/2007	10:20:00	104	0.872	0.075
4/11/2007	10:21:00	105	0.868	0.075
4/11/2007	10:22:00	106	0.865	0.075
4/11/2007	10:23:00	107	0.862	0.075
4/11/2007	10:24:00	108	0.858	0.075
4/11/2007	10:25:00	109	0.855	0.075
4/11/2007	10:26:00	110	0.852	0.075
4/11/2007	10:27:00	111	0.849	0.075
4/11/2007	10:28:00	112	0.846	0.075
4/11/2007	10:29:00	113	0.843	0.075
4/11/2007	10:30:00	114	0.840	0.075
4/11/2007	10:31:00	115	0.838	0.075
4/11/2007	10:32:00	116	0.835	0.075
4/11/2007	10:33:00	117	0.832	0.075
4/11/2007	10:34:00	118	0.830	0.075
4/11/2007	10:35:00	119	0.827	0.075
4/11/2007	10:36:00	120	0.825	0.075
4/11/2007	10:37:00	121	0.822	0.075
4/11/2007	10:38:00	122	0.820	0.075
4/11/2007	10:39:00	123	0.818	0.075
4/11/2007	10:40:00	124	0.816	0.075
4/11/2007	10:41:00	125	0.814	0.075
4/11/2007	10:42:00	126	0.811	0.075
4/11/2007	10:43:00	127	0.809	0.075
4/11/2007	10:44:00	128	0.807	0.075
4/11/2007	10:45:00	129	0.805	0.075
4/11/2007	10:46:00	130	0.803	0.075

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	10:47:00	131	0.801	0.075
4/11/2007	10:48:00	132	0.800	0.075
4/11/2007	10:49:00	133	0.798	0.075
4/11/2007	10:50:00	134	0.797	0.075
4/11/2007	10:51:00	135	0.795	0.075
4/11/2007	10:52:00	136	0.793	0.075
4/11/2007	10:53:00	137	0.792	0.075
4/11/2007	10:54:00	138	0.790	0.075
4/11/2007	10:55:00	139	0.788	0.075
4/11/2007	10:56:00	140	0.787	0.075
4/11/2007	10:57:00	141	0.786	0.075
4/11/2007	10:58:00	142	0.784	0.075
4/11/2007	10:59:00	143	0.783	0.075
4/11/2007	11:00:00	144	0.782	0.075
4/11/2007	11:01:00	145	0.781	0.075
4/11/2007	11:02:00	146	0.780	0.075
4/11/2007	11:03:00	147	0.779	0.075
4/11/2007	11:04:00	148	0.778	0.075
4/11/2007	11:05:00	149	0.777	0.075
4/11/2007	11:06:00	150	0.776	0.075
4/11/2007	11:07:00	151	0.775	0.075
4/11/2007	11:08:00	152	0.774	0.075
4/11/2007	11:09:00	153	0.774	0.077
4/11/2007	11:10:00	154	0.773	0.077
4/11/2007	11:11:00	155	0.772	0.077
4/11/2007	11:12:00	156	0.771	0.077
4/11/2007	11:13:00	157	0.770	0.077
4/11/2007	11:14:00	158	0.770	0.077
4/11/2007	11:15:00	159	0.769	0.077
4/11/2007	11:16:00	160	0.769	0.077
4/11/2007	11:17:00	161	0.768	0.077
4/11/2007	11:18:00	162	0.768	0.077
4/11/2007	11:19:00	163	0.767	0.077
4/11/2007	11:20:00	164	0.767	0.077
4/11/2007	11:21:00	165	0.766	0.077
4/11/2007	11:22:00	166	0.766	0.077
4/11/2007	11:23:00	167	0.765	0.077
4/11/2007	11:24:00	168	0.766	0.077
4/11/2007	11:25:00	169	0.767	0.077
4/11/2007	11:26:00	170	0.769	0.077
4/11/2007	11:27:00	171	0.771	0.077
4/11/2007	11:28:00	172	0.772	0.077
4/11/2007	11:29:00	173	0.773	0.077
4/11/2007	11:30:00	174	0.775	0.077

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	11:31:00	175	0.777	0.077
4/11/2007	11:32:00	176	0.778	0.077
4/11/2007	11:33:00	177	0.779	0.077
4/11/2007	11:34:00	178	0.781	0.077
4/11/2007	11:35:00	179	0.783	0.077
4/11/2007	11:36:00	180	0.784	0.077
4/11/2007	11:37:00	181	0.785	0.077
4/11/2007	11:38:00	182	0.787	0.077
4/11/2007	11:39:00	183	0.788	0.077
4/11/2007	11:40:00	184	0.790	0.077
4/11/2007	11:41:00	185	0.791	0.077
4/11/2007	11:42:00	186	0.793	0.077
4/11/2007	11:43:00	187	0.794	0.077
4/11/2007	11:44:00	188	0.796	0.077
4/11/2007	11:45:00	189	0.797	0.077
4/11/2007	11:46:00	190	0.799	0.077
4/11/2007	11:47:00	191	0.800	0.077
4/11/2007	11:48:00	192	0.802	0.102
4/11/2007	11:49:00	193	0.803	0.102
4/11/2007	11:50:00	194	0.805	0.102
4/11/2007	11:51:00	195	0.806	0.102
4/11/2007	11:52:00	196	0.808	0.102
4/11/2007	11:53:00	197	0.810	0.102
4/11/2007	11:54:00	198	0.811	0.102
4/11/2007	11:55:00	199	0.813	0.102
4/11/2007	11:56:00	200	0.814	0.102
4/11/2007	11:57:00	201	0.816	0.102
4/11/2007	11:58:00	202	0.817	0.102
4/11/2007	11:59:00	203	0.819	0.102
4/11/2007	12:00:00	204	0.820	0.062
4/11/2007	12:01:00	205	0.822	0.062
4/11/2007	12:02:00	206	0.823	0.062
4/11/2007	12:03:00	207	0.823	0.062
4/11/2007	12:04:00	208	0.822	0.062
4/11/2007	12:05:00	209	0.821	0.062
4/11/2007	12:06:00	210	0.820	0.062
4/11/2007	12:07:00	211	0.819	0.062
4/11/2007	12:08:00	212	0.818	0.062
4/11/2007	12:09:00	213	0.817	0.062
4/11/2007	12:10:00	214	0.816	0.062
4/11/2007	12:11:00	215	0.815	0.022
4/11/2007	12:12:00	216	0.815	0.022
4/11/2007	12:13:00	217	0.811	0.022
4/11/2007	12:14:00	218	0.803	0.022

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	12:15:00	219	0.794	0.022
4/11/2007	12:16:00	220	0.786	0.022
4/11/2007	12:17:00	221	0.778	0.022
4/11/2007	12:18:00	222	0.770	0.022
4/11/2007	12:19:00	223	0.762	0.022
4/11/2007	12:20:00	224	0.754	0.022
4/11/2007	12:21:00	225	0.746	0.030
4/11/2007	12:22:00	226	0.738	0.030
4/11/2007	12:23:00	227	0.730	0.030
4/11/2007	12:24:00	228	0.724	0.030
4/11/2007	12:25:00	229	0.717	0.030
4/11/2007	12:26:00	230	0.710	0.037
4/11/2007	12:27:00	231	0.703	0.037
4/11/2007	12:28:00	232	0.696	0.037
4/11/2007	12:29:00	233	0.691	0.037
4/11/2007	12:30:00	234	0.687	0.037
4/11/2007	12:31:00	235	0.683	0.059
4/11/2007	12:32:00	236	0.679	0.059
4/11/2007	12:33:00	237	0.678	0.059
4/11/2007	12:34:00	238	0.684	0.059
4/11/2007	12:35:00	239	0.690	0.059
4/11/2007	12:36:00	240	0.697	0.059
4/11/2007	12:37:00	241	0.703	0.059
4/11/2007	12:38:00	242	0.709	0.059
4/11/2007	12:39:00	243	0.715	0.059
4/11/2007	12:40:00	244	0.721	0.059
4/11/2007	12:41:00	245	0.727	0.059
4/11/2007	12:42:00	246	0.733	0.059
4/11/2007	12:43:00	247	0.739	0.059
4/11/2007	12:44:00	248	0.744	0.059
4/11/2007	12:45:00	249	0.750	0.059
4/11/2007	12:46:00	250	0.755	0.059
4/11/2007	12:47:00	251	0.761	0.059
4/11/2007	12:48:00	252	0.766	0.059
4/11/2007	12:49:00	253	0.771	0.059
4/11/2007	12:50:00	254	0.776	0.059
4/11/2007	12:51:00	255	0.781	0.262
4/11/2007	12:52:00	256	0.786	0.262
4/11/2007	12:53:00	257	0.791	0.262
4/11/2007	12:54:00	258	0.795	0.262
4/11/2007	12:55:00	259	0.799	0.262
4/11/2007	12:56:00	260	0.803	0.065
4/11/2007	12:57:00	261	0.807	0.065
4/11/2007	12:58:00	262	0.810	0.065

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	12:59:00	263	0.810	0.065
4/11/2007	13:00:00	264	0.810	0.065
4/11/2007	13:01:00	265	0.809	0.065
4/11/2007	13:02:00	266	0.808	0.065
4/11/2007	13:03:00	267	0.808	0.065
4/11/2007	13:04:00	268	0.807	0.065
4/11/2007	13:05:00	269	0.807	0.065
4/11/2007	13:06:00	270	0.806	0.065
4/11/2007	13:07:00	271	0.806	0.065
4/11/2007	13:08:00	272	0.806	0.065
4/11/2007	13:09:00	273	0.805	0.065
4/11/2007	13:10:00	274	0.804	0.065
4/11/2007	13:11:00	275	0.804	0.065
4/11/2007	13:12:00	276	0.804	0.065
4/11/2007	13:13:00	277	0.803	0.065
4/11/2007	13:14:00	278	0.803	0.065
4/11/2007	13:15:00	279	0.803	0.065
4/11/2007	13:16:00	280	0.802	0.065
4/11/2007	13:17:00	281	0.802	0.065
4/11/2007	13:18:00	282	0.802	0.065
4/11/2007	13:19:00	283	0.801	0.065
4/11/2007	13:20:00	284	0.801	0.065
4/11/2007	13:21:00	285	0.801	0.065
4/11/2007	13:22:00	286	0.801	0.065
4/11/2007	13:23:00	287	0.801	0.065
4/11/2007	13:24:00	288	0.800	0.065
4/11/2007	13:25:00	289	0.800	0.065
4/11/2007	13:26:00	290	0.800	0.065
4/11/2007	13:27:00	291	0.800	0.065
4/11/2007	13:28:00	292	0.800	0.065
4/11/2007	13:29:00	293	0.799	0.065
4/11/2007	13:30:00	294	0.800	0.065
4/11/2007	13:31:00	295	0.799	0.065
4/11/2007	13:32:00	296	0.799	0.065
4/11/2007	13:33:00	297	0.799	0.065
4/11/2007	13:34:00	298	0.799	0.065
4/11/2007	13:35:00	299	0.799	0.065
4/11/2007	13:36:00	300	0.799	0.065
4/11/2007	13:37:00	301	0.798	0.065
4/11/2007	13:38:00	302	0.798	0.065
4/11/2007	13:39:00	303	0.799	0.065
4/11/2007	13:40:00	304	0.798	0.065
4/11/2007	13:41:00	305	0.798	0.065
4/11/2007	13:42:00	306	0.798	0.065

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	13:43:00	307	0.798	0.065
4/11/2007	13:44:00	308	0.798	0.065
4/11/2007	13:45:00	309	0.798	0.065
4/11/2007	13:46:00	310	0.798	0.065
4/11/2007	13:47:00	311	0.798	0.065
4/11/2007	13:48:00	312	0.798	0.065
4/11/2007	13:49:00	313	0.798	0.065
4/11/2007	13:50:00	314	0.798	0.065
4/11/2007	13:51:00	315	0.798	0.065
4/11/2007	13:52:00	316	0.798	0.065
4/11/2007	13:53:00	317	0.798	0.065
4/11/2007	13:54:00	318	0.798	0.065
4/11/2007	13:55:00	319	0.799	0.065
4/11/2007	13:56:00	320	0.799	0.065
4/11/2007	13:57:00	321	0.799	0.065
4/11/2007	13:58:00	322	0.799	0.065
4/11/2007	13:59:00	323	0.799	0.065
4/11/2007	14:00:00	324	0.799	0.065
4/11/2007	14:01:00	325	0.800	0.065
4/11/2007	14:02:00	326	0.800	0.065
4/11/2007	14:03:00	327	0.800	0.065
4/11/2007	14:04:00	328	0.800	0.065
4/11/2007	14:05:00	329	0.800	0.065
4/11/2007	14:06:00	330	0.800	0.065
4/11/2007	14:07:00	331	0.801	0.065
4/11/2007	14:08:00	332	0.801	0.065
4/11/2007	14:09:00	333	0.801	0.065
4/11/2007	14:10:00	334	0.802	0.065
4/11/2007	14:11:00	335	0.802	0.065
4/11/2007	14:12:00	336	0.802	0.065
4/11/2007	14:13:00	337	0.803	0.065
4/11/2007	14:14:00	338	0.803	0.065
4/11/2007	14:15:00	339	0.803	0.065
4/11/2007	14:16:00	340	0.803	0.000
4/11/2007	14:17:00	341	0.803	0.000
4/11/2007	14:18:00	342	0.798	0.000
4/11/2007	14:19:00	343	0.788	0.000
4/11/2007	14:20:00	344	0.778	0.000
4/11/2007	14:21:00	345	0.768	0.000
4/11/2007	14:22:00	346	0.758	0.000
4/11/2007	14:23:00	347	0.748	0.000
4/11/2007	14:24:00	348	0.739	0.000
4/11/2007	14:25:00	349	0.727	0.000
4/11/2007	14:26:00	350	0.717	0.000

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	14:27:00	351	0.707	0.000
4/11/2007	14:28:00	352	0.697	0.000
4/11/2007	14:29:00	353	0.688	0.000
4/11/2007	14:30:00	354	0.678	0.000
4/11/2007	14:31:00	355	0.668	0.000
4/11/2007	14:32:00	356	0.658	0.000
4/11/2007	14:33:00	357	0.649	0.000
4/11/2007	14:34:00	358	0.639	0.000
4/11/2007	14:35:00	359	0.630	0.000
4/11/2007	14:36:00	360	0.620	0.000
4/11/2007	14:37:00	361	0.611	0.000
4/11/2007	14:38:00	362	0.601	0.000
4/11/2007	14:39:00	363	0.591	0.000
4/11/2007	14:40:00	364	0.582	0.000
4/11/2007	14:41:00	365	0.573	0.000
4/11/2007	14:42:00	366	0.563	0.000
4/11/2007	14:43:00	367	0.554	0.000
4/11/2007	14:44:00	368	0.545	0.000
4/11/2007	14:45:00	369	0.536	0.000
4/11/2007	14:46:00	370	0.527	0.000
4/11/2007	14:47:00	371	0.518	0.000
4/11/2007	14:48:00	372	0.508	0.000
4/11/2007	14:49:00	373	0.499	0.000
4/11/2007	14:50:00	374	0.490	0.000
4/11/2007	14:51:00	375	0.481	0.000
4/11/2007	14:52:00	376	0.472	0.000
4/11/2007	14:53:00	377	0.463	0.000
4/11/2007	14:54:00	378	0.454	0.000
4/11/2007	14:55:00	379	0.445	0.000
4/11/2007	14:56:00	380	0.436	0.000
4/11/2007	14:57:00	381	0.428	0.000
4/11/2007	14:58:00	382	0.419	0.000
4/11/2007	14:59:00	383	0.410	0.000
4/11/2007	15:00:00	384	0.401	0.000
4/11/2007	15:01:00	385	0.392	0.000
4/11/2007	15:02:00	386	0.384	0.000
4/11/2007	15:03:00	387	0.375	0.000
4/11/2007	15:04:00	388	0.367	0.000
4/11/2007	15:05:00	389	0.358	0.000
4/11/2007	15:06:00	390	0.349	0.000
4/11/2007	15:07:00	391	0.341	0.000
4/11/2007	15:08:00	392	0.332	0.000
4/11/2007	15:09:00	393	0.324	0.000
4/11/2007	15:10:00	394	0.315	0.000

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	15:11:00	395	0.307	0.000
4/11/2007	15:12:00	396	0.298	0.000
4/11/2007	15:13:00	397	0.290	0.000
4/11/2007	15:14:00	398	0.281	0.000
4/11/2007	15:15:00	399	0.273	0.000
4/11/2007	15:16:00	400	0.265	0.000
4/11/2007	15:17:00	401	0.256	0.000
4/11/2007	15:18:00	402	0.248	0.000
4/11/2007	15:19:00	403	0.240	0.000
4/11/2007	15:20:00	404	0.232	0.000
4/11/2007	15:21:00	405	0.224	0.000
4/11/2007	15:22:00	406	0.216	0.000
4/11/2007	15:23:00	407	0.209	0.000
4/11/2007	15:24:00	408	0.201	0.000
4/11/2007	15:25:00	409	0.193	0.000
4/11/2007	15:26:00	410	0.185	0.000
4/11/2007	15:27:00	411	0.177	0.000
4/11/2007	15:28:00	412	0.170	0.000
4/11/2007	15:29:00	413	0.162	0.000
4/11/2007	15:30:00	414	0.154	0.000
4/11/2007	15:31:00	415	0.146	0.000
4/11/2007	15:32:00	416	0.139	0.000
4/11/2007	15:33:00	417	0.131	0.000
4/11/2007	15:34:00	418	0.123	0.000
4/11/2007	15:35:00	419	0.114	0.000
4/11/2007	15:36:00	420	0.106	0.000
4/11/2007	15:37:00	421	0.098	0.000
4/11/2007	15:38:00	422	0.089	0.000
4/11/2007	15:39:00	423	0.081	0.000
4/11/2007	15:40:00	424	0.071	0.000
4/11/2007	15:41:00	425	0.060	0.000
4/11/2007	15:42:00	426	0.046	0.000
4/11/2007	15:43:00	427	0.027	0.000
4/11/2007	15:44:00	428	0.026	0.000
4/11/2007	15:45:00	429	0.026	0.000
4/11/2007	15:46:00	430	0.026	0.000
4/11/2007	15:47:00	431	0.026	0.000
4/11/2007	15:48:00	432	0.026	0.000
4/11/2007	15:49:00	433	0.026	0.000
4/11/2007	15:50:00	434	0.026	0.000
4/11/2007	15:51:00	435	0.026	0.000
4/11/2007	15:52:00	436	0.026	0.000
4/11/2007	15:53:00	437	0.026	0.000
4/11/2007	15:54:00	438	0.026	0.000

Table B1 (continued). Field measurements from controlled infiltration test on April 11, 2007

Date	Time	Elapsed Time (minutes)	Water Level (feet)	Inflow Discharge Rate (cubic feet per second)
4/11/2007	15:55:00	439	0.026	0.000
4/11/2007	15:56:00	440	0.026	0.000
4/11/2007	15:57:00	441	0.026	0.000
4/11/2007	15:58:00	442	0.026	0.000
4/11/2007	15:59:00	443	0.026	0.000

APPENDIX H

Laboratory Reports, Chain-of-Custody Records, and Data Quality Assurance Audit Forms

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER073-87 **PAGE 1**

REPORT DATE: 07/10/07

DATE SAMPLED: 06/09/07 **DATE RECEIVED:** 06/11/07

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

Two water samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. Samples for total metals were digested according to EPA procedures. Samples for total zinc were reanalyzed per the client's request. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TSS (mg/l)	SRP (mg/l)	TOTAL-P (mg/l)	SSL-COARSE (mg/l)	SSL-FINE (mg/l)
WQ-1	25	0.120 J	0.220	1.6	19
WQ-1-DUPE	23	0.120 J	0.232	1.4	19

	DISSOLVED METALS		TOTAL METALS	
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
WQ-1	0.0075 J	0.017 J	0.0101	0.035
WQ-1-DUPE	0.0077 J	0.016 J	0.0088	0.034

8/2/14/07

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER073-87 **PAGE 2**
REPORT DATE: 07/10/07
DATE SAMPLED: 06/09/07 **DATE RECEIVED:** 06/11/07
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA WATER

QC PARAMETER	TSS (mg/l)	SRP (mg/l)	TOTAL-P (mg/l)	SSL-COARSE (mg/l)	SSL-FINE (mg/l)
METHOD	EPA 160.2	SM18 4500PF	EPA 365.1	ASTM 3977-97C	ASTM 3977-97C
DATE ANALYZED	06/15/07	06/12/07	06/21/07	06/18/07	06/18/07
DETECTION LIMIT	0.50	0.001	0.002	0.50	0.50
DUPLICATE					
SAMPLE ID	BATCH	BATCH	BATCH		
ORIGINAL	14	0.026	0.013		
DUPLICATE	13	0.026	0.014		
RPD	7.41%	0.03%	1.34%	NA	NA
SPIKE SAMPLE					
SAMPLE ID		BATCH	BATCH		
ORIGINAL		0.026	0.013		
SPIKED SAMPLE		0.046	0.062		
SPIKE ADDED		0.020	0.050		
% RECOVERY	NA	101.98%	96.85%	NA	NA
QC CHECK					
FOUND	9.6	0.033	0.090		9.6
TRUE	10	0.033	0.090		10
% RECOVERY	96.00%	99.52%	100.53%	NA	96.00%
BLANK	<0.50	<0.001	<0.002	NA	<0.50

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER073-87 **PAGE 3**
REPORT DATE: 07/10/07
DATE SAMPLED: 06/09/07 **DATE RECEIVED:** 06/11/07
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA WATER

	DISSOLVED METALS		TOTAL METALS	
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)
METHOD	EPA 220.2	EPA 200.7	EPA 220.2	EPA 200.7
DATE ANALYZED	07/06/07	06/20/07	07/06/07	06/20/07
DETECTION LIMIT	0.0010	0.005	0.0010	0.005
DUPLICATE				
SAMPLE ID	WQ-1-DUPE	BATCH	BATCH	BATCH
ORIGINAL	0.0077	<0.005	<0.0010	<0.005
DUPLICATE	0.0080	<0.005	<0.0010	<0.005
RPD	4.72%	NC	NC	NC
SPIKE SAMPLE				
SAMPLE ID	WQ-1-DUPE	BATCH	BATCH	BATCH
ORIGINAL	0.0077	<0.005	<0.0010	<0.005
SPIKED SAMPLE	0.0193	0.995	0.0121	1.02
SPIKE ADDED	0.0125	1.00	0.0125	1.00
% RECOVERY	93.20%	99.48%	97.04%	101.97%
QC CHECK				
FOUND	0.0249	0.986	0.0249	0.988
TRUE	0.0250	1.00	0.0250	1.00
% RECOVERY	99.40%	98.55%	99.40%	98.79%
BLANK	<0.0010	<0.005	<0.0010	<0.005

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

MERUTS· 8.+

HERRERA ENVIRONMENTAL CONSULTANTS

2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
(206) 441-9080
FAX (206) 441-9108

CHAIN OF CUSTODY RECORD

Page ___ of ___

PROJECT NAME:	High Point
PROJECT NUMBER:	06-3304-050
CLIENT:	SPU
REPORT TO:	Niklas Christensen
COPY TO:	
SAMPLED BY:	NSC
DELIVERY METHOD:	
LABORATORY:	ARI
REQUESTED COMPLETION DATE:	6-30-07
TOTAL # OF CONTAINERS:	8
LAB USE:	

ANALYSES REQUESTED: TSS, SSC, TP, SRP, CU, dissolved, CU, total, Zn, dissolved, Zn, total

SAMPLE ID:	DATE:	TIME:	SAMPLE DESCRIPTION	# OF CONTAINERS:
WQ-1	6-9-07	12:00	@ overflow drain	4
			storm #1	
WQ-1-Dup	6-9-07	12:20	Duplicate of above	4

REMARKS:

RELINQUISHED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:	RECEIVED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:
Niklas Christensen	[signature]	6-11-07, 9am	SHAWN HENSON KAI	[signature]	6/11/07 0900

Data Quality Assurance Worksheet

HERRERA ENVIRONMENTAL CONSULTANTS

By John Lenth

Project Name/No./Client: Highpoint/06-03304-050/SPU

Date ______ Page 1 of 1

Laboratory/Parameters: Aquatic Research Incorporated/Sediment, Nutrients, Metals

Checked: initials gsc

Sample Date/Sample ID: June 9, 2007/WQ-1

date 12/4/07

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limit	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
TSS	O.K.	O.K.	<0.05 mg/L 0.05 mg/L	NA	7.41%	~~108.7%~~ 8.3%	96.0%	O.K.	
SRP	O.K.	Filtered @ 45 hours 48 Hour HT exceeded by 1-day*	<0.001 mg/L 0.001 mg/L	100.0%	0.03%	~~100.0%~~ 0	99.5%	O.K.	Flag "J"
Total –P	O.K.	O.K.	<0.002 mg/L 0.002 mg/L	98.0%	1.34%	~~94.8%~~ 5.3%	100.5%	O.K.	
SSC-Coarse	O.K.	7 Day HT exceeded by 2-days	NA/ 0.50 mg/L	NA	NA	~~114.3%~~ 13.3%	NA	O.K.	Filtered w/in 7-days - ok no flag
SSC-Fine	O.K.	7 Day HT exceeded by 2-days	<0.50 mg/L 0..50 mg/L	NA	NA	~~100.0%~~ 0	96.0%	O.K.	↓ gsc
Copper, Dissolved	O.K.	~~O.K.~~ Filtered @ 45 hours	<0.0010 mg/L 0.0010 mg/L	92.8%	4.72%	~~97.4%~~ 1.3%	99.4%	O.K.	Flag "J"
Zinc, Dissolved	O.K.	↓ O.K.	<0.005 mg/L 0.005 mg/L	100.0%	NC	~~106.3%~~ 6.1%	98.6%	O.K.	↓
Copper, Total	O.K.	O.K.	<0.0010 mg/L 0.05 mg/L	88.8%	NC	~~114.8%~~ 13.8%	99.4%	O.K.	
Zinc, Total	O.K.	O.K.	<0.005 mg/L 0.005 mg/L	101.5%	NC	~~102.9%~~ 2.9%	98.8%	O.K.	

* Sample collected on Saturday, June 9 when lab was closed. Samples delivered to lab on following Monday, June 11 when lab openned.

NA: Not applicable   NC: Not calculable due to one or more vaules being below the dectection limit

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER074-05 **PAGE 1**
REPORT DATE: 11/01/07
DATE SAMPLED: 09/27/07 **DATE RECEIVED:** 09/28/07
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

One water sample was delivered to the laboratory in good condition. The sample was analyzed according to the chain of custody. Samples for total metals were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TSS (mg/l)	SRP (mg/l)	TOTAL-P (mg/l)	SSL-COARSE (mg/l)	SSL-FINE (mg/l)	HARDNESS (mgCaCO3/l)
WQ1-092707	17	0.069	0.143	1.7	15	35.0

	DISSOLVED METALS		TOTAL METALS			
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)	FECAL COLIFORM (#/100ml)	E COLI (#/100ml)
WQ1-092707	0.0086	0.021	0.0088	0.035	160	160

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**HER074-05**		**PAGE 2**
REPORT DATE:	**11/01/07**		
DATE SAMPLED:	**09/27/07**	**DATE RECEIVED:**	**09/28/07**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA WATER

QC PARAMETER	TSS (mg/l)	SRP (mg/l)	TOTAL-P (mg/l)	SSL-COARSE (mg/l)	SSL-FINE (mg/l)	HARDNESS (mgCaCO3/l)
METHOD	EPA 160.2	EPA 365.1	EPA 365.1	ASTM 3977-97C	ASTM 3977-97C	SM 2340C
DATE ANALYZED	10/03/07	09/28/07	10/04/07	10/04/07	10/04/07	10/10/07
DETECTION LIMIT	0.50	0.001	0.002	0.50	0.50	2.00
DUPLICATE						
SAMPLE ID	BATCH	BATCH	BATCH			WQ1-092707
ORIGINAL	5.0	0.027	0.036			35.0
DUPLICATE	4.5	0.027	0.039			35.4
RPD	10.53%	0.53%	7.14%	NA	NA	1.11%
SPIKE SAMPLE						
SAMPLE ID		BATCH	BATCH			WQ1-092707
ORIGINAL		0.027	0.036			35.0
SPIKED SAMPLE		0.047	0.089			55.7
SPIKE ADDED		0.020	0.050			20.0
% RECOVERY	NA	102.18%	105.25%	NA	NA	103.58%
QC CHECK						
FOUND	9.5	0.033	0.090			39.5
TRUE	10	0.033	0.090			40.0
% RECOVERY	95.00%	100.45%	100.11%	NA	NA	98.70%
BLANK	<0.50	<0.001	<0.002	NA	<0.50	<2.00

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

AQUATIC RESEARCH INCORPORATED
LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER074-05
REPORT DATE: 11/01/07
DATE SAMPLED: 09/27/07 **DATE RECEIVED:** 09/28/07
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA WATER

	DISSOLVED METALS		TOTAL METALS			
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)	FECAL COLIFORM (#/100ml)	E COLI (#/100mls)
METHOD	SM 3113B	EPA 200.7	SM 3113B	EPA 200.7	SM18 9222D	EPA10029
DATE ANALYZED	10/30/07	10/12/07	10/31/07	10/09/07	09/28/07	09/28/07
DETECTION LIMIT	0.0010	0.005	0.0010	0.005	2	2
DUPLICATE						
SAMPLE ID	BATCH	BATCH	BATCH	BATCH		WQ1-092707
ORIGINAL	<0.0010	0.011	<0.0010	<0.005		160
DUPLICATE	<0.0010	0.010	<0.0010	<0.005		140
RPD	NC	2.87%	NC	NC	NA	13.33%
SPIKE SAMPLE						
SAMPLE ID	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	<0.0010	0.011	<0.0010	<0.005		
SPIKED SAMPLE	0.0131	0.997	0.0117	0.972		
SPIKE ADDED	0.0125	1.00	0.0125	1.00		
% RECOVERY	104.96%	98.59%	93.44%	97.21%	NA	NA
QC CHECK						
FOUND	0.0258	1.03	0.0243	0.997		
TRUE	0.0250	1.00	0.0250	1.00		
% RECOVERY	103.28%	102.98%	97.20%	99.69%	NA	NA
BLANK	<0.0010	<0.005	<0.0010	<0.005	< 2	< 2

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

HERRERA ENVIRONMENTAL CONSULTANTS
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
(206) 441-9080
FAX (206) 441-9108

CHAIN OF CUSTODY RECORD

PROJECT NAME: High Point	PROJECT NUMBER: 06-03304-050	CLIENT: SPU
REPORT TO: John Leath		COPY TO: Niklas Christensen
SAMPLED BY: Niklas Christensen		DELIVERY METHOD: in person by NSC
LABORATORY: ARI	REQUESTED COMPLETION DATE:	TOTAL # OF CONTAINERS: 5
LAB USE:		

ANALYSES REQUESTED

SAMPLE ID:	DATE:	TIME:	SAMPLE DESCRIPTION	# OF CONTAINERS:	TSS	SSC	TP	SRP	Hardness	Cu, dis.	Cu, ttl	Zn, dis	Zn, ttl	Fecal Coliform bac.	E. Coli					
WQ1 - 9/27/07	22:00 - NSC		High Point @ WQ1	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					

REMARKS:

RELINQUISHED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:	RECEIVED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:
Niklas Christensen	[signature]	9/28 9:30am	S NIELSON ARI	[signature]	9/28/07 0930
RELINQUISHED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:	RECEIVED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:

HERRERA ENVIRONMENTAL CONSULTANTS

Data Quality Assurance Worksheet

By: Elizabeth Woodcock

Project Name/No./Client: Highpoint/06-03304-050/SPU

Date: 11/16/07 Page 1 of 2

Laboratory/Parameters: Aquatic Research Incorporated/Sediment, Nutrients, Metals, Bacteria

Checked: initials SRC

Sample Date/Sample ID: September 27, 2007/WQ-1

date 12/4/07

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limit	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
TSS	O.K.	O.K.	<0.05 mg/L 0.05 mg/L	NA	7.41%	NA	95.0%	O.K.	
SRP	O.K.	O.K.	<0.001 mg/L 0.001 mg/L	100.0%	0.03%	NA	100.0%	O.K.	
TOTAL –P	O.K.	O.K.	<0.002 mg/L 0.002 mg/L	106.00%	1.34%	NA	100.0%	O.K.	
SSC-COARSE	O.K.	O.K.	NA/ 0..50 mg/L	NA	NA	NA	NA	O.K.	
SSC-FINE	O.K.	O.K.	<0.50 mg/L 0..50 mg/L	NA	NA	NA	NA	O.K.	
COPPER, DISSOLVED	O.K.	O.K.	<0.0010 mg/L 0.0010 mg/L	96.80%	<2 TIMES D.L.	NA	103.20%	O.K.	
ZINC, DISSOLVED	O.K.	O.K.	<0.005 mg/L 0.005 mg/L	98.60%	NC	NA	103.0%	O.K.	
COPPER, TOTAL	O.K.	O.K.	<0.0010 mg/L 0.05 mg/L	85.60%	NC	NA	97.20%	O.K.	
ZINC, TOTAL	O.K.	O.K.	<0.005 mg/L 0.005 mg/L	96.70%	NC	NA	99.7%	O.K.	

NA: NOT APPLICABLE NC: NOT CALCULABLE DUE TO ONE OR MORE VAULES BEING BELOW THE DECTECTION LIMIT

EW o:\proj\y2006\06-03304-050\data\water quality data qa\wq data qaqc form - 092707 event 1.doc

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER074-07

REPORT DATE: 10/24/07

DATE SAMPLED: 09/30/07 **DATE RECEIVED:** 10/01/07

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

CASE NARRATIVE

One water sample was delivered to the laboratory in good condition. The sample was analyzed according to the chain of custody. Samples for total metals were digested according to EPA procedures. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	TSS (mg/l)	SRP (mg/l)	TOTAL-P (mg/l)	SSL-COARSE (mg/l)	SSL-FINE (mg/l)	HARDNESS (mgCaCO3/l)
WQ1-9-30-07	31	0.032 J	0.140	22	10	9.58

	DISSOLVED METALS		TOTAL METALS			
SAMPLE ID	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)	FECAL COLIFORM (#/100ml)	E COLI (#/100ml)
WQ1-9-30-07	0.0011 J	0.012 J	0.0030	0.034	2200 J	2200 J

SR
12/4/07

AQUATIC RESEARCH INCORPORATED
LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: HER074-07
REPORT DATE: 10/24/07
DATE SAMPLED: 09/30/07 **DATE RECEIVED:** 10/01/07
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM HERRERA ENVIRONMENTAL

QA/QC DATA WATER

	DISSOLVED METALS		TOTAL METALS			
QC PARAMETER	COPPER (mg/l)	ZINC (mg/l)	COPPER (mg/l)	ZINC (mg/l)	FECAL COLIFORM (#/100ml)	E COLI (#/100mls)
METHOD	SM 3113B	EPA 200.7	SM 3113B	EPA 200.7	SM18 9222D	EPA10029
DATE ANALYZED	10/30/07	10/12/07	10/31/07	10/09/07	10/01/07	10/01/07
DETECTION LIMIT	0.0010	0.005	0.0010	0.005	2	2
DUPLICATE						
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	WQ1-9-30-07	WQ1-9-30-07
ORIGINAL	<0.0010	0.011	<0.0010	<0.005	2200	2200
DUPLICATE	<0.0010	0.010	<0.0010	<0.005	2300	2200
RPD	NC	2.87%	NC	NC	4.44%	0.00%
SPIKE SAMPLE						
SAMPLE ID	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	<0.0010	0.011	<0.0010	<0.005		
SPIKED SAMPLE	0.0131	0.997	0.0117	0.972		
SPIKE ADDED	0.0125	1.00	0.0125	1.00		
% RECOVERY	104.96%	98.59%	93.44%	97.21%	NA	NA
QC CHECK						
FOUND	0.0258	1.03	0.0243	0.997		
TRUE	0.0250	1.00	0.0250	1.00		
% RECOVERY	103.28%	102.98%	97.20%	99.69%	NA	NA
BLANK	<0.0010	<0.005	<0.0010	<0.005	< 2	< 2

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

HERRERA ENVIRONMENTAL CONSULTANTS

2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
(206) 441-9080
FAX (206) 441-9108

CHAIN OF CUSTODY RECORD

PROJECT NAME: High Point	PROJECT NUMBER: 06-3304-050	CLIENT: SPU	
REPORT TO: John Leith		COPY TO: Niklas Christensen	
SAMPLED BY: Niklas Christensen		DELIVERY METHOD: in person	
LABORATORY: ARI		REQUESTED COMPLETION DATE:	TOTAL # OF CONTAINERS: 5
LAB USE:			

ANALYSES REQUESTED

SAMPLE ID:	DATE:	TIME:	SAMPLE DESCRIPTION	# OF CONTAINERS:	TSS	SSC	Tot. phosphorus	Sol. Reac. Phosphorus	Hardness	Cu, dissolved	Cu, total	Zn, dissolved	Zn, total	Fecal Coliform bac.	E. Coli					
W01-9/30/07	15:00 -NSC		High Point W01	5	—	—	—	—	—	—	—	—	—	—	—					
	9/30/07	15:00																		

REMARKS:

RELINQUISHED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:	RECEIVED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:
Niklas Christensen	[signature]	10/1/07 11 am	S. Nelson ARI	[signature]	10/1/07 1100
RELINQUISHED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:	RECEIVED BY (NAME/CO.):	SIGNATURE:	DATE/TIME:

HERRERA ENVIRONMENTAL CONSULTANTS

Data Quality Assurance Worksheet

Project Name/No./Client: Highpoint/06-03304-050/SPU

Laboratory/Parameters: Aquatic Research Incorporated/Sediment, Nutrients, Metals, Bacteria

Sample Date/Sample ID: September 30, 2007/WQ-1

By: Elizabeth Woodcock

Date: 11/16/07 Page 1 of 2

Checked: initials SPC

date 12/4/07

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limit	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
TSS	O.K.	7 DAY HT EXCEEDED BY 1-DAY	<0.05 mg/L 0.05 mg/L	NA	1.36%	NA	93.0%	O.K.	Filtered w/in 7 day holding time. OK SPC
SRP	O.K.	O.K. not filtered w/in 12 hours	<0.001 mg/L 0.001 mg/L	105.0%	0.0%	NA	100.0%	O.K.	Flag "J" SPC
TOTAL –P	O.K.	O.K.	<0.002 mg/L 0.002 mg/L	106.0%	8.0%	NA	100.0%	O.K.	
SSC-COARSE	O.K.	O.K.	NA/ 0..50 mg/L	NA	NA	NA	NA	O.K.	
SSC-FINE	O.K.	O.K.	<0.50 mg/L 0..50 mg/L	NA	NA	NA	NA	O.K.	
COPPER, DISSOLVED	O.K.	O.K.	<0.0010 mg/L 0.0010 mg/L	96.80%	<2 TIMES D.L.	NA	103.20%	O.K.	not filtered w/in 12 hours –
ZINC, DISSOLVED	O.K.	O.K.	<0.005 mg/L 0.005 mg/L	98.60%	NC	NA	103.0%	O.K.	Flag "J" Cu, Zn diss.
COPPER, TOTAL	O.K.	O.K.	<0.0010 mg/L 0.05 mg/L	85.60%	NC	NA	97.20%	O.K.	
ZINC, TOTAL	O.K.	O.K.	<0.005 mg/L 0.005 mg/L	96.70%	NC	NA	99.7%	O.K.	

NA: NOT APPLICABLE NC: NOT CALCULABLE DUE TO ONE OR MORE VAULES BEING BELOW THE DECTECTION LIMIT

Data Quality Assurance Worksheet

By: Elizabeth Woodcock

Date: 11/16/07

Project Name/No./Client: Highpoint/06-03304-050/SPU

Laboratory/Parameters: Aquatic Research Incorporated/Sediment, Nutrients, Metals, Bacteria

Sample Date/Sample ID: September 30, 2007/WQ-1

Checked: initials ______

date ______

Parameter	Completeness/ Methodology	Holding Times	Blanks/ Detection Limit	Matrix Spikes/ Surrogate Recoveries	Lab Duplicates	Field Duplicates	Lab Control Samples	Instrument Calibration/ Performance	ACTION
HARDNESS	O.K.	O.K.	<2.0 mgCaCO3/l <2.0 mgCaCO3/l	103.50%	1.14%	NA	98.75%	O.K.	
FECAL COLIFORM	O.K.	12 HR HT EXCEEDED BY 10HR	<2.0 /100mls 2.0 /100mls	NA	NA	NA	NA	O.K.	Flag "J"
E.COLI	O.K.	12 HR HT EXCEEDED BY 10HR.	<2.0 /100mls 2.0 /100mls	NA	13.33%	NA	NA	O.K.	↓

NA: NOT APPLICABLE

NC: NOT CALCULABLE DUE TO ONE OR MORE VAULES BEING BELOW THE DECTECTION LIMIT