Thea Foss and Wheeler-Osgood Waterways
Stormwater Monitoring
Quality Assurance Project Plan

September 2014

Prepared for
Washington State Department of Ecology and
U.S. Environmental Protection Agency

Prepared by
City of Tacoma

1.0 TITLE PAGE WITH APPROVALS

Quality Assurance Project Plan

Thea Foss and Wheeler-Osgood Waterways Stormwater Monitoring for the Thea Foss Consent Decree and Phase I Municipal Stormwater NPDES Permit

Internal Review and Approval

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe
CD	Consent Decree
CFS	Cubic Feet per Second
City	City of Tacoma
COC	Chain of Custody
COCs	Contaminants of Concern
CRM	Certified Reference Material
CTP	Central Treatment Plant
CUW	Center for Urban Waters
DEHP	Di-2-ethylhexyl phthalate (Bis(2-ethylhexyl) phthalate)
DLG	Detection Limit Goals
DQI	Data Quality Indicator
DQA	Data Quality Assessment
DQO	Data Quality Objective
Ecology	Washington State Department of Ecology
EMC	Event Mean Concentrations
EPA	Environmental Protection Agency
ESSE	Environmental Services Department, Science and Engineering Division
FWDA	Foss Waterway Development Authority
IQR	Interquartile Range
LCS	Laboratory Control Sample
LD	Laboratory Duplicate
LIMS	Laboratory Information Management System
MDL	Method Detection Limit
MLLW	Mean Lower Low Water
MQO	Measurement Quality Objective
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OF	Outfall
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated biphenyls
Permit	NPDES Phase I Municipal Stormwater Permit
QA/QC	Quality Assurance/Quality Control
QAC	Quality Assurance Coordinator
QAPP	Quality Assurance Project Plan

RL	Reporting Limit
RPD	Relative Percent Difference
RSMP	Regional Stormwater Monitoring Program
SIDIR	Source Identification Information Repository
SOP	Standard Operating Procedure
SR	State Route
SSPM	Stormwater Suspended Particulate Matter
SWMP	Stormwater Management Program
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
USGS	United States Geological Survey
UWT	University of Washington Tacoma
WY	Water Year

ABSTRACT

This Quality Assurance Project Plan (QAPP), prepared by the City of Tacoma (City) with assistance from Anchor Environmental, Inc., is intended to cover stormwater monitoring required under the Thea Foss Waterway Consent Decree and Section S8.C of the 2013-2018 Phase I Municipal Stormwater Permit (Permit), permit number WAR04-04003. This QAPP is intended to replace the previously prepared sampling and analysis stormwater monitoring plans for the Thea Foss Waterway, which include:

- Thea Foss and Wheeler-Osgood Waterways Stormwater Monitoring, Sampling and Analysis Plan, City of Tacoma, September 2001[1].
- Section S8 Monitoring Program, Quality Assurance Project Plan, Phase I Stormwater NPDES Permit, Permit No.: WAR04-04003, City of Tacoma, March 31, 2011.[2]
- Section S8D Stormwater Characterization, Quality Assurance Project Plan, Phase I Stormwater NPDES Permit, Permit No.: WAR04-04003, City of Tacoma, March 31, 2011 (Tacoma 2011).[2]

The Thea Foss Consent Decree requires stormwater outfall monitoring of seven outfalls in the Thea Foss Waterway. The Phase I permit requires the City to either pay into a regional stormwater monitoring program for effectiveness monitoring or conduct stormwater discharge monitoring at five locations in accordance with Appendix 9 of the Permit.

The primary goal of this QAPP is to define procedures that assure the quality and integrity of the collected samples, the representativeness of the results, the precision and accuracy of the analyses, the completeness of the data, and ultimately deliver defensible products and decisions for stormwater monitoring described in the Thea Foss Consent Decree and Section S8.C of the Permit.

This document was developed with guidance from the Department of Ecology, Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies (Ecology 2004) and the Department of Ecology, Quality Assurance Project Plan Guidance: Special Condition S8.D Phase I Municipal Stormwater Permit (Ecology 2010).

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[1] Note that approved modifications to the sampling program have been identified in Appendix B of the Stormwater Monitoring Reports submitted annually to the agencies under this program.
[2] Including minor changes that were included in the S8.D annual reports.

3.0 BACKGROUND

Stormwater monitoring is required to be conducted under the Thea Foss Waterway Consent Decree (CD) with the Environmental Protection Agency (EPA) and by Section S8.C of the National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge General Permit for Discharges from Large and Medium Municipal Separate Storm Sewer Systems (Permit)[3]. To address these monitoring requirements, stormwater monitoring will be conducted at seven outfalls in the Thea Foss Waterway and will include collection of event-based composite and grab samples for chemical analysis as well as annual sediment samples for chemical analysis.

This Section describes the study area, the Thea Foss CD and Permit monitoring requirements, and provides an overview of stormwater monitoring (including historical rainfall patterns and contaminants of concern).

3.1 STUDY AREA

The Thea Foss and Wheeler-Osgood Waterways are estuarine waterways on the southeastern margin of Commencement Bay. In Commencement Bay and the waterways, average tidal fluctuations vary from 0 feet Mean Lower Low Water (MLLW) to 11 feet MLLW. Extreme tides, which generally occur in June and December, range from approximately –4.0 feet MLLW to 14.5 feet MLLW. The Thea Foss Waterway lies north-south along the City's downtown corridor. The Wheeler-Osgood Waterway lies west-east and connects to the east side of the Thea Foss Waterway just south of the 11th Street Bridge. The Thea Foss and Wheeler-Osgood Waterways are commonly referred to as the Thea Foss or Foss Waterway and are referred to herein as the Foss Waterway. The drainage area tributary to the Foss Waterway is referred to herein as the Foss Waterway Watershed.

The Foss Waterway Watershed is one of nine watersheds in the City (Figure 3-1). This watershed covers approximately 5,864 acres and is comprised of drainage basins located in the south-central portion of Tacoma. The area borders the North Tacoma Watershed on the north, Lawrence Street on the west, and East F to East K Streets on the east. The area extends as far south as 86th Street and also includes portions of the tideflats on the east side of the Foss Waterway (Figure 3-1).

The primary municipal outfalls to the Foss Waterway are OF237A and OF237B (the twin 96ers), OF230, OF235, OF243, OF245, and OF254. These seven outfalls cover 5,744 acres (98%) of the watershed. There are also several other smaller outfalls that discharge to the waterway.

Outfall	Area (Ac)	Land Use
230	557	Commercial and Residential
235	156	Commercial
237A	2,823	Residential, Commercial and Industrial
237B	1,991	Residential and Commercial
243	59	Industrial and Commercial

[3] The Permit requires that the City either pay-in to a regional stormwater monitoring fund for effectiveness monitoring or opt-out and conduct stormwater discharge monitoring at five locations. The City has elected to opt-out and conduct discharge monitoring to fulfill the Permit requirements.

245	39	Industrial and Commercial
254	119	Industrial and Commercial

3.2 Thea Foss Consent Decree Overview and Monitoring Requirements

Under a Consent Decree with the EPA dated May 9, 2003, the City completed remediation of marine sediments in the majority of the Thea Foss and Wheeler-Osgood Waterways in Tacoma, Washington in March 2006. Remediation of the southernmost 1,000 feet of the Thea Foss Waterway was completed in 2004 by a group of private utilities under a separate Consent Decree with EPA. The waterways are narrow estuarine water bodies on the southeastern margin of Commencement Bay, with 13 municipal outfalls that discharge stormwater to the waterways as well as numerous private outfalls.

With the completion of the cleanup action in the Thea Foss and Wheeler-Osgood Waterways, it is necessary to continue monitoring and source control activities to ensure sediment quality is protected in dredged and capped areas and to ensure that natural recovery is attained in areas where active remediation was not required. Included as part of the Consent Decree Statement of Work, a letter addendum dated November 1, 2001 (identified as Attachment 1 to the Consent Decree), provides a detailed schedule and work plan for the City's stormwater source control efforts for the Thea Foss and Wheeler-Osgood Waterways. This addendum, herein referred to as the Stormwater Work Plan Addendum, includes a description of stormwater monitoring efforts, studies, source control efforts and Best Management Practices (BMP) assessments for municipal stormwater sources.

The monitoring requirements have been modified periodically throughout the program to reflect agreed upon changes including changes in sampling methods/equipment, laboratory methods, and sampling frequency. These documented changes are incorporated in this QAPP.

3.3 Phase I Permit Overview and Monitoring Requirements

The Washington State Department of Ecology (Ecology) issued the most recent NPDES and Phase I Permit on August 1, 2012 with an effective date of August 1, 2013. The Phase I Permit applies to all entities in Washington State that are required to have stormwater permit coverage under current (Phase I) EPA stormwater regulations.

Section S8 – Monitoring and Assessment of the Phase I Permit includes three separate components with multiple compliance options for municipalities. The sections and compliance options in Section S8 are:

- **S8.B Status and Trends Monitoring** – For marine nearshore status and trends monitoring in Puget Sound
  - Option #1 – Pay in to the Regional Stormwater Monitoring Program (RSMP) collective fund.
  - Option #2 – Conduct wadeable stream monitoring of the first twelve qualified locations that are within the jurisdiction's boundaries.
- **S8.C Effectiveness Monitoring** – For effectiveness studies in Puget Sound
  - Option #1 – Pay in to the RSMP collective fund.
  - Option #2 – Conduct stormwater discharge monitoring at five locations.

- Option #3 – Partial payment into the RSMP collective fund AND conduct an independent effectiveness study.

- **S8.D Source Identification and Diagnostic Monitoring** – Pay into a collective fund to implement RSMP Source Identification Information Repository (SIDIR).

The City has elected to pay into the collective RSMP fund for Sections S8.B and S8.D and to conduct stormwater discharge monitoring at five locations (Option #2) for Section S8.C. This QAPP provides details on the stormwater discharge monitoring component under Section S8.C.

Section S8.C.2 encourages the City to continue monitoring the same locations that were monitored under Section S8.D of the Phase I Municipal Stormwater Permit February 16, 2007–February 15, 2012.

3.4 STORMWATER MONITORING PROGRAM OVERVIEW

In accordance with the Thea Foss CD and Section S8.C of the Permit, the City is monitoring seven outfalls as part of the Thea Foss monitoring program. All seven outfalls have been monitored for more than twelve years under the Thea Foss monitoring program, with three of the outfalls (OF235, OF237B, and OF245) being monitored under Section S8.D of the 2007 Phase I municipal stormwater permit. The results are used to track changes in stormwater quality and to document the improvements that have been realized over time due to source control and other efforts.

Based on a statistical analysis of the 11 year record[4] (August 2001-September 2012), the City determined that 41 statistically significant time trends (41 out of 49 tests, or approximately 84% of the tests) were shown in Year 11, with all trends in the direction of decreasing concentrations. The time trends were modeled with best-fit regression equations to estimate percent reductions over the 11 year monitoring period for these constituents and outfalls:

- **Total Suspended Solids (TSS)**: Approximately 52-63% reduction in OF230, OF235, OF237B and OF245;
- **Lead**: Approximately 51-56% reduction in OF230, OF235, OF237B and OF245;
- **Zinc**: Approximately 32-50% reduction in OF235, OF237A, OF237B, OF245 and OF254;
- **Polycyclic Aromatic Hydrocarbons (PAH)**: Approximately 87-97% reduction in phenanthrene, pyrene, and indeno(1,2,3-cd)pyrene in all seven outfalls; and
- **Bis(2-ethylhexyl)phthalate (DEHP)**: Approximately 58-91% reduction in all seven outfalls.

As shown by these significant reductions in various constituents of concern, the improvement in stormwater quality since the mid-1990s indicates that source control efforts by the City and others in the Foss Waterway Watershed have been effective in reducing chemical concentrations in stormwater. These efforts have resulted in fewer sites in the watershed with comparatively higher contaminant concentrations relative to other locations. Because the program has been so effective, the concentrations of contaminants of concern in stormwater in

[4] Year 12 data is currently being reviewed and will be reported in the annual report due March 31, 2014. Therefore, the conclusions at the end of Year 11 (reported on March 31, 2013) are presented in this Plan.

the Foss Waterway Watershed are reaching a level where the opportunities for large reductions are more limited. This may lead to few, if any, additional decreasing trends in contaminant concentrations, lower percentages of reduction per year, and potentially even a few minor increasing trends, particularly if looking only at results from more recent years.

The most recent summary of the previous results is summarized in the Thea Foss and Wheeler-Osgood Waterways: 2012 Source Control and Water Year 2012 Stormwater Monitoring Report, March 2013 (Tacoma 2013).

Monitoring under this QAPP will generally be conducted as follows:

- Continuous flow monitoring for the first year[5], and during all sampled storm events thereafter.
- Flow-weighted composite and grab samples of qualifying stormwater runoff for chemical analysis.
- Annual sediment sampling for chemical analysis.

3.4.1 Contaminants/Parameters of Concern

Contaminants of concern (COCs) are those contaminants which have been identified through sediment monitoring and model predictions to have the greatest potential to compromise sediment quality in the waterways following remediation. They are, therefore, the primary target for source control activities for the municipal storm drains as well as other potential sources which are largely not in the City's control. DEHP and various PAHs are the primary COCs for the Foss Waterway and have, therefore, been the primary focus of source control activities to date. In addition, residual concentrations of other legacy COCs for which sources have largely been controlled through regulatory bans or restrictions are continuing to be monitored. These legacy COCs include mercury, PCBs, and pesticides. Source control activities have also been conducted for these COCs.

The Permit identifies stormwater quality analytes as parameters of concern based on the analytes that have a history of association with stormwater discharges and are expected to be found in urban environments. These analytes include conventional parameters, nutrients, metals, selected organics (including PAHs, DEHP), fecal coliforms, and total petroleum hydrocarbons.

Table 3-1, Table 3-2, and Table 3-3 contain lists of all parameters to be analyzed under either the Thea Foss Consent Decree or the Permit. In the event that either the Permit or the Foss Consent Decree requirements are discontinued for any of the monitoring activities at some point in the future, these tables will be used to determine which analyses are required under the remaining regulations.

3.4.2 Historical Rainfall Summary

Long-term rainfall data has been collected at the NOAA Tacoma No. 1 rain gauge CTP01, which is located at the City's Central Wastewater Treatment Plant (CTP) (Building E) at 2201

[5] Except for outfalls (i.e., OF235, OF237B, and OF245) that already have a rainfall to runoff relationship established as a requirement of the 2007 NPDES permit.

Portland Avenue. The total monthly, annual and seasonal precipitation for October 2001 to September 2012 Thea Foss monitoring program and historical statistics are shown in Table 3-4.

In addition to the NOAA Tacoma No. 1 rain gauge, an ISCO Model 675 rain gauge (tipping bucket) is also located at the CTP on the STP-1 Digester building. This rain gauge is referred to as the STP01 gauge.

Starting in mid-WY2014, a new rain gauge on the roof of the Center for Urban Waters (CUW) building located at 326 East D Street, Tacoma, WA 98421 will be used to supplement this data. In the event that the CUW[6] gauge gives similar readings as the historical CTP gauges, the historical CTP tipping bucket gauge may be phased out. Tipping bucket rain gauge data will be collected at a minimum frequency of every 15 minutes.

The CTP rain gauges are located roughly 0.8 to 1.2 miles east of the outfall monitoring stations and the new CUW gauge is located 0.6 to 1.2 miles north of the outfall monitoring stations. Figure 3-2 shows the location of the rain gages.

For this project, water year will be reported as outlined in the Permit as October-September, with wet season as October-April and dry season as May-September.

[6] Sampling staff moved from CTP to CUW in 2010. By moving the gauge to CUW, staff will be able to more frequently maintain the gauge and troubleshoot issues.

4.0 PROJECT DESCRIPTION

This Section presents the goals and objectives of the project; describes the boundaries, target characteristics to be monitored and practical constraints of the study; and specifies the information and data required to meet the study objectives.

4.1 GOAL AND OBJECTIVES

The goal of the stormwater characterization monitoring study is to meet the requirements of the Foss CD and Section S8.C of the Permit. The goals of both of these programs generally involve:

- Measuring the effectiveness of stormwater source control actions, confirming that reductions in concentrations of target analytes have been realized, and confirming that recontamination from stormwater sources is not occurring. This will be achieved by gathering data to identify trends in the quality of the water;
- Providing an early indication of any new water or sediment quality problems associated with the storm drains;
- Informing decision-making regarding additional source controls; and
- Tracing sources of contamination to outfalls using sediment traps.

The objectives will be accomplished through performance of the following:

- Provide Ecology and EPA with data characterizing the quality of the water and sediments discharging into the Thea Foss and Wheeler-Osgood Waterways;
- Collect and submit for analysis representative composite and grab stormwater samples during stormflow events from all seven outfalls;
- Collect and submit for analysis representative annual sediment samples at specified manholes; and
- Produce an annual report documenting activities associated with the sampling and analysis effort, a quality assurance review of field and laboratory data, and an evaluation of the data relative to continuing source control efforts, and deliver the report to Ecology and EPA.

4.2 INFORMATION REQUIREMENTS

Information needed to meet the study goals and objectives includes:

- Land use and drainage area of each drainage basin;
- Concentrations of constituents of concern in stormwater samples from each outfall;
- Concentrations of constituents of concern in sediment samples from each outfall (except OF254)[7];
- Concentration of constituents of concern in upstream sediment samples for source tracing purposes;

[7] Due to tidal conditions, Outfall 254 does not have a sediment trap.

- Continuous record of rainfall data, especially prior to and during sampled storm events, including antecedent dry period and total rainfall during each event; and
- Continuous record of outfall flow data (storm and baseflow, where appropriate), especially flow data during sampled storm events for a minimum of one year. If this data already exists, the calculated rainfall-runoff relationship will be used.

4.3 Data Collection

The sampling design for stormwater monitoring under the Foss Consent Decree and Permit primarily includes both stormwater and sediment sampling at each outfall monitoring site for the duration of the Permit and/or Foss CD. Sediment sampling will also occur upstream from the outfalls for source tracing purposes.

The general requirements for both types of sampling are discussed in more detail below.

4.3.1 Stormwater Sampling

Automatic flow-weighted composite and manual grab sampling methods will be used to collect stormwater samples from qualifying storm events (defined in Section 7.2.1) throughout each water year. Manual grab samples required under the Permit will be collected at each stormwater monitoring site during qualifying storm events (defined in Section 7.2.1) as early in the storm event as possible.

Continuous flow data will be collected at each selected site during all storm events and for one year[8] to establish rainfall and runoff relationships at each basin. Rainfall data will be collected continuously to characterize the antecedent dry period, total rainfall distribution during the sampled events, inter-event dry period, and rainfall intensity during the sampled storm events.

Event Mean Concentrations (EMC), total annual pollutant loads and seasonal pollutant loads will be calculated for each required parameter at each monitoring site.

4.3.2 Sediment Sampling

In-line sediment traps will be utilized to collect annual sediment samples at each outfall where feasible. Due to tidal conditions, no sediment trap can be placed in OF254. In OF245, an existing manhole with a sump will be used instead of a sediment trap. Sediment traps will also be placed upstream from the outfalls for source tracing purposes.

Section 7.1 describes the sediment sampling sites in more detail.

4.4 Target Population

Sampling is designed to describe target populations, in this case, stormwater characteristics for each outfall. These include:

- Rate and volume of stormwater, and

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[8] Outfalls 235, 237B, and 245 were part of the 2007-2012 S8.D monitoring and a rainfall-runoff relationship was already developed for these outfalls based on one year continuous flow data. The existing rainfall-runoff relationship will be used for these outfalls.

- Concentrations and loads of specific constituents in stormwater and sediments carried by stormwater (Tables 3-1 and 3-2).

4.5 STUDY BOUNDARIES

Seven basins were selected for this project. They are the major outfalls that discharge into the Foss Waterway and thus represent the bulk of the inputs. The sampling locations for each outfall were selected to be as close to the end of the pipe as practical.

Three of the outfalls (OF235, OF237B, and OF245) were sampled under the 2007-2012 Permit and were selected to represent a discernible type of land use, but not a single industrial or commercial complex. As recommended by the Permit, ideally to represent a particular land use, the area shall have no less than 80 percent of the area served by the conveyance that is classified as having that land use. Specific details regarding the basins studied under this project are presented in Section 7.1.

4.6 PRACTICAL CONSTRAINTS

The unpredictable nature of storm events poses the greatest logistical challenge for this study. Only storms of particular depths and intensities will result in qualifying storm events and successful sample collection. However, the location, timing, duration, magnitude, and intensity of storm events cannot be forecast with certainty. It is inevitable that during this long duration and intense monitoring study, sampler programming based on the forecast will result in some amount of unsuccessful sample collection of qualifying storm events when storm intensities and depths are very different from the forecast for which the sampler was programmed.

Since long-term forecasts have greater uncertainty, mobilization of field staff and equipment setup for a potential storm-sampling event cannot happen more than two days ahead of a forecasted storm. During an event, staff must be mobilized to collect grab samples on very short notice and must visit a set of sites in a relatively short period (2 to 3 hours) in order to collect samples as early in the event as possible.

Although Standard Operating Procedures (SOPs) will be followed, it is inevitable that during these intense monitoring studies equipment malfunction and human error will result in some amount of unsuccessful sample collection of qualifying storm events. Although sites are selected to minimize safety concerns, traffic control may be necessary to access the monitoring stations safely. Access may be necessary during high traffic periods, at night, and/or during severe weather. These access conditions pose additional logistical challenges for sample collection. Specific logistical considerations for each selected site are described in Section 7.1.

4.7 DECISION MAKING

The results of this monitoring program will not be utilized to make specific decisions under the Permit, but will be used for decision making as part of the Foss program. For ongoing evaluation of the municipal stormwater discharges and their relation to future sediment conditions in the waterway, the City has established a source control strategy. This strategy is set forth in Figure 4-1. The results of the stormwater monitoring will be used in conjunction with modeling predictions and in-water sediment monitoring results to continue to focus additional source control efforts and to assess the source control program's effectiveness.

5.0 ORGANIZATION AND SCHEDULE

This Section describes the roles and responsibilities of the study team, the study timeline and schedule.

5.1 ROLES AND RESPONSIBILITIES

The team consists of representatives from key groups with a role in data collection or use, and often those with a critical interest or stake in the problem. This section includes the names, duties, and responsibilities of all key team participants. This includes internal and external team members. The organizational structure is designed to provide project control and proper quality assurance/quality control (QA/QC) for the field investigation.

The roles of key individuals and their roles in the project are provided below.

Title	Role	Name	Organization	Telephone No.
NPDES Permit Manager	Overall management of the City's NPDES Phase I compliance activities. Monitor and assess the quality of work. Comply with corrective action requirements.	Lorna Mauren	City of Tacoma – Surface Water	253-502-2192
Program Manager	Develop, implement, ensure approval of, and maintain the QAPP. Verify the QAPP is followed and the program is producing data of known and acceptable quality. Ensure adequate training and supervision of all monitoring and data collection activities. Validate and verify data collected, and initiate corrective action as appropriate. Prepare reports.	Mary Henley	City of Tacoma – Surface Water	253-502-2113
QA Coordinator	Manage and oversee monitoring activities, including sampling decisions for targeted storm events, and data management. Review laboratory data against project specific QA/QC requirements.	Chris Burke	City of Tacoma – Metering and Sampling	253-502-2247
Laboratory Manager	Supervise laboratory personnel involved in generating analytical data for program. Ensure all QA/QC procedures are completed as required and analytical documentation is accurate and complete. Enforce	Stuart Magoon	City of Tacoma - Laboratory	253-502-2130

	corrective action as required.			
Laboratory Quality Assurance Manager	Supervise and verify all aspects of QA/QC in the laboratory. Validate and verify data before released from the laboratory.	Lori Zboralski	City of Tacoma - Laboratory	253-502-2133

5.2 SPECIAL TRAINING NEEDS/CERTIFICATION

This section identifies and describes any specialized training or certifications needed by personnel in order to complete the monitoring program or task successfully.

Field staff that collect data shall undergo a training program to ensure that he or she has the knowledge and skills required to collect data in accordance with SOPs. Field personnel will receive training in proper sampling and field analysis for each SOP they will be using. They will demonstrate to the Program Manager or Quality Assurance Coordinator (in the field), their ability to properly operate the automatic samplers and retrieve the samples. Trainings are recorded in the Metering and Sampling Training Spreadsheet.

In addition to technical training, field personnel will receive training that addresses stormwater monitoring activities that have the potential to adversely affect their health and safety. Stormwater monitoring field crews often work in wet, cold, and poor visibility conditions. Sampling sites may be located in high traffic areas or remote, poorly lit areas that need to be accessed on a 24-hour basis. Monitoring personnel and workers installing or maintaining equipment may be exposed to traffic hazards, confined spaces, biological hazards (e.g., medical waste and fecal matter), vectors (e.g., snakes and rats), fall hazards, hazardous materials, fast moving stormwater, and slippery conditions. Health and Safety training is updated on an as needed (or required) basis and recorded in the Metering and Sampling Training Spreadsheet. All field personnel maintain 1stAid/CPR, 40-hr HAZWOPER, Traffic Flagger and Confined Space Entry certifications.

5.3 STUDY SCHEDULE

The estimated implementation schedule for the stormwater monitoring program is identified below. Please note that annual monitoring under the Foss program is currently underway and this schedule assumes that QAPP changes will be implemented at the start of the next water year (WY2014).

Activity	Anticipated Date of Initiation	Anticipated Date of Completion
City Prepare QAPP	December 1, 2013	February 1, 2014
Ecology Review of QAPP	February 2, 2014	April 30, 2014
Finalization of QAPP by City	May 1, 2014	June 30, 2014
Ecology Approval of Final QAPP	July 1, 2014	July 31, 2014
Start of Sampling under Revised QAPP	October 1, 2014	Until end of Permit term or end of Foss CD requirements

5.4 STUDY DELIVERABLES

Each annual report will include all monitoring data collected during the preceding water year (October 1–September 30). Each report shall also integrate data from earlier years into the analysis of results, as appropriate. Reports shall be submitted on March 31st of each year[9] in both paper and electronic form. Section 12.3 discusses reporting in more detail.

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[9] The first annual monitoring report submitted under this QAPP on March 31, 2016 will include data from, October 1, 2014 through September 30, 2015. Subsequent reports will be submitted on March 31st of each year and will contain data for the preceding water year.

6.0 QUALITY OBJECTIVES

This Section describes the study data quality and measurement quality objectives that will be utilized to evaluate the quality and usability of flow, stormwater and sediment data. These data quality objectives will be achieved through attention to the prescribed sampling, measurement, and QA/QC procedures presented in this QAPP.

6.1 DATA QUALITY OBJECTIVES (DQOS)

Data quality objectives (DQOs) may be either qualitative or quantitative, and describe the type, quality, and quantity of data that are required to fulfill the program objectives. DQOs are defined for this program as follows:

- Precision and accuracy will be known.
- Data will be generated from controlled procedures for field sampling, sample handling and processing, laboratory analysis, and record keeping.
- Reporting limits will be low enough to support stormwater management targets.
- Data collected will be of sufficient quality and quantity to enable calculation of event mean concentrations, and seasonal and total annual constituent loads.
- Data and samples collected will meet the program-specific requirements for representativeness.

6.2 DATA QUALITY INDICATORS (DQIS)

Data Quality Indicators (DQIs) are commonly used measures of acceptability for environmental data. Data collected will be evaluated relative to the following indicators:

- **Sensitivity** – Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest (EPA 2011). Sensitivity is measured through reporting limit performance. Generally, if the reporting limits obtained during the year meet detection limit goals (DLG), then the investigation was sufficiently sensitive to meet the needs of the client (EPA and Ecology).
- **Bias –** Bias is the systematic or persistent distortion of a measurement process which deprives the result of representativeness (i.e., the expected sample measurement is different than the sample's true value) (EPA 2011). Potential sources of bias include sampling and analytical procedures that introduce contamination, instability of samples during transportation and storage, interference from other constituents in the sample matrix, inability of the analytical method to measure all forms of the constituent of interest, and faulty calibration of the measurement process. Errors of bias are minimized through use of standardized procedures by properly trained staff.
- **Comparability and Precision** – Comparability is a very important quality control measure that answers the question, “If a different field and laboratory team conducted the same study at the same time, would the results be repeatable?” Precision is a measure of the repeatability of a set of replicated results, and is considered to represent random error in the measurement process. Poor precision is due to difficulties in obtaining samples under identical conditions (e.g., contamination, sub-sampling issues,

or variability of field conditions during the time the replicate samples are collected) or poor sensitivity of laboratory/field procedures.

- **Technical Consistency** – Technical consistency is a check to make sure that the results make sense. For example, is the total analysis greater than the results from the dissolved fraction analysis?
- **Completeness** – Completeness is defined as the proportion of samples collected relative to the total number planned to be collected. It also depends upon the completion of analytical work by the laboratory. Combined, it represents an assessment of how field and laboratory problems affected the success of the data collection effort. Completeness depends upon the proportion of target storms that are sampled, as well as adequate packing of samples for transport and timely processing at the laboratory.
- **Representativeness** – The degree to which the data accurately reflect the population from which it was taken.

6.3 MEASUREMENT QUALITY OBJECTIVES

Measurement quality objectives (MQOs) describe measures of performance and criteria for acceptance that provide the basis for evaluating data quality and usability. They are defined separately for hydrologic data and chemical data, although they all indicate the minimum threshold levels for measures of bias, repeatability, precision, accuracy, and sensitivity that must be associated with the data.

The specific MQOs to be used in this study are described below for whole-water and sediment quality data (Section 6.3.1) and for hydrologic data (Section 6.3.2).

6.3.1 Water and Sediment Quality Data

For chemical data, MQOs are based upon specific types of quality control (QC) samples that are collected in the field and/or analyzed in the laboratory (Figures 6-1 and 6-2). Additional criteria for completeness and representativeness of the samples collected are also required.

6.3.1.a Sensitivity

The method detection limit is the minimum concentration that can be statistically determined with 99 percent confidence to be greater than zero. The method reporting limit is the concentration that the laboratory can report with documented precision and accuracy under routine operating conditions, and is higher than the method detection limit. Concentrations greater than the method detection limit but less than the method reporting limit will be qualified by the laboratory with "J" for estimated. Section 14.0 contains further discussion of reporting limits.

6.3.1.b Bias

Bias associated with sample matrix will be evaluated using blanks and using the percent recovery (%R) on laboratory control samples (LCS), matrix spike/matrix spike duplicate (MS/MSD), surrogates, and Certified Reference Materials (CRM)[10].

[10] CRMs are only run on sediment samples.

Blanks. Bias associated with contamination will be assessed by analysis of blanks. Blanks (field and laboratory) may provide an indication of contamination due to bottle cleanliness (bottle blank), transport conditions (trip blank), exposure to surroundings during sampling (ambient air blank), and equipment which remains onsite between sampling events (equipment rinse blank). The MQO for any blank is to be less than the reporting limit target goal. If a blank detection is greater than the reporting limit and greater than 10% of the associated sample result, then the reporting limit will be raised to ten times the blank detection level and labeled 'UJ' as a non-detection.

Percent Recoveries. Matrix spikes may provide an indication of bias due to interference from the sample matrix. Surrogate recoveries will provide an estimate of bias for the entire analytical procedure. CRMs will be analyzed to monitor performance of the analytical systems in sediment samples. CRM Certificates of Analysis for each study year will be included in the annual data report.

Percent Recovery is calculated by:

$$\%R = \frac{C_1}{T_1} \times 100 \qquad \text{(Eqn. 6-1)}$$

where: C_1 = the sample measured concentration
T_1 = the true concentration

Matrix Spike Recovery is calculated by:

$$\%R = \frac{S_1 - C_1}{P_1} \times 100 \qquad \text{(Eqn. 6-2)}$$

where: S_1 = the spiked sample concentration
C_1 = the sample measured concentration
P_1 = known spike added concentration

Surrogate Recovery is calculated by:

$$\%R = \frac{R_1}{K_1} \times 100 \qquad \text{(Eqn. 6-3)}$$

where: R_1 = the measured concentration
K_1 = amount added

The acceptable recoveries for surrogates, LCS, MS/MSD, and CRMs are included in Figure 6-1 and Figure 6-2 for whole water and sediment samples.

6.3.1.c Comparability and Precision

Laboratory and field variability measure comparability, calculated as relative percent difference (RPD):

$$RPD = \frac{C_1 - C_2}{[C_1 + C_2]/2} \times 100. \qquad \text{(Eqn. 6-4)}$$

where: C_1 = the sample concentration
C_2 = the duplicate concentration

Comparability incorporates the use of laboratory duplicate (LD) analyses, MS/MSD samples and field duplicate samples. Precision is specifically a measure of laboratory variability. The analyses or measurements of the variable of interest are performed identically on two subsamples of the same sample. The results from duplicate analyses are used to evaluate analytical or measurement precision, but not the precision of sampling and preservation or storage internal to the laboratory.

Comparability is a measure of cumulative field and laboratory variability. Field duplicate samples are two samples taken from, and representative of, the same population and carried through all steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variance of sampling and analysis. Field duplicates are expected to have the greatest level of variation. Grab sample duplicates include two samples collected in the same manner, at the same location, and in the same time span. Time and flow composite (stormwater) samples are obtained using collocated samplers that are simultaneously triggered to collect a series of duplicate or replicate samples for estimating comparability of the total measurement system/process (comparability of sampling, preservation or storage internal to the laboratory and laboratory measurement).

Acceptable limits of field duplicates, LD and MSD are listed in Figures 6-1 and 6-2 for whole-water and sediment samples, respectively.

6.3.1.d Technical Consistency

Total metals[11] is the sum of the particulate and dissolved fractions of an analyte. The metals, cadmium, copper, lead, mercury and zinc are analyzed in both their dissolved and total form. Additionally, orthophosphate is a subcomponent of total phosphorus.

As shown in Figure 6-1, the MQO is met if the total concentration is greater than the dissolved concentration. The performance method detection limit is substituted for non-detect values. The analysis pair is rejected if dissolved is greater than 120% times total and at least one value is five times greater than the detection limit goal. Rejected values are included in the MQO exceedance calculation.

6.3.1.e Completeness

Data that are qualified, but still usable, will be counted as valid data for assessing completeness, although data that are rejected for use will not be considered. During the data validation process, an assessment will be made whether enough valid data exist to meet the requirements of the Permit or the Foss CD. The measurement quality objective is 95% completeness of laboratory data. Difficult compounds to analyze, and associated corrective actions, will be described in annual reports.

6.3.1.f Representativeness

Representativeness is a measure of the extent to which the sample data accurately and precisely represent site conditions. The representativeness of the data is dependent on:

[11] Total metals and total recoverable metals are synonymous.

(1) the sampling locations, (2) the flow regime during sample collection, (3) the number of years sampling is performed, and (4) the sampling procedures. Site selection and sampling of pertinent media (i.e., water) and use of only approved analytical methods will assure that the measurement data represents the population being studied at the site.

Stormwater Quality. Stormwater representativeness is achieved by selecting sample locations, methods and times so that the data describes the characteristics of stormwater runoff over the range of land use conditions in the drainage basins, the varying hydrologic conditions within an individual storm event (i.e., rising and falling portions of the hydrograph), and a representative cross-section of storm types. Additional details regarding representativeness of sample location, collection of storm flows, and the criteria used for sampling are presented in Sections 7.1 and 7.2.3.

Representativeness of land use – The 2007-2012 Permit called for each permittee to select three sites representing different land uses. To "represent" a particular land use, no less than 80 percent of the area served by the conveyance should be classified as having that land use. As recommended by the 2013-2018 Permit, the three outfalls monitored under the 2007-2013 Permit will continue to be monitored. The additional four outfalls[12] monitored under the 2013-2018 Permit, represent a range of land use conditions consistent with urban drainage basins.

Representativeness of individual storm events – Stormwater samples will be flow-weighted composite samples representing the range of discharge conditions during the sampling event, including where possible the rising and falling portions of the runoff hydrograph. This is discussed in more detail in Section 7.2.3.

Representativeness of storm types – Storm events are variable in nature by runoff volume, flow rate, antecedent rainfall, and season. Storm event criteria have been selected to consider the variation in storm event runoff volume, flow rate, antecedent rainfall conditions, and season. In addition, monitoring will be conducted over a sufficient length of time to ensure that data are collected during representative climatic conditions for the region. Each year, this variability will be evaluated by comparing the magnitude and intensity of the runoff hydrographs, where samples were collected on the hydrographs, time between storm events, and time of year the samples were collected to determine whether a representative range of storm types was included in the monitoring program.

Sediment Quality.

Sediment traps – Sediment traps are useful monitoring tools to help identify chemical concentrations in suspended sediments in stormwater. There are several issues relevant to the representativeness of sediment trap samples. It is difficult to predict potential sampling biases that may occur during sediment trapping, but considering the perturbations in the flow field that the bottle creates, certain grain size fractions in the suspended load could be preferentially trapped.

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[12] As discussed in more detail in Section 7.2, the City is proposing to meet the Permit requirements by using sampling data from all seven of the outfalls monitored under the Foss CD. The Permit requires that only five outfalls be monitored.

In addition, the physical characteristics of each sediment trap sampling location vary such that a different range and/or type of flow, and therefore, storm conditions may be sampled. Because there is a minimum height at which the sediment trap is over topped and starts to collect the sample, some sediment traps may not be collecting samples during smaller storms, and the frequency of such occurrence will vary from location to location.

Manhole sump sediment – Material captured by the manhole sump above OF245 is representative of settleable solids which are transported during both storm and baseflow conditions. However, it should be noted that a portion of this sediment may represent a source other than stormwater from this basin due to this sample station being tidally influenced.

6.3.2 Hydrology Data

Hydrologic data collected under this QAPP generally includes precipitation depth, water level, velocity and time or rate information. The MQOs for this data are described below and in Table 6-1.

6.3.2.a Sensitivity

The sensitivity for hydrologic measurements reflects the operational range of the equipment. These ranges are included in Table 6-1. Operational ranges for equipment are a combination of equipment specifications and past performance of the equipment model.

6.3.2.b Bias

The bias for hydrologic measurements will be assessed by comparing the monitoring equipment readings to an independently measured ‘true’ value. The independently measured value will be determined using a portable velocity meter (e.g., Marsh-McBirney Flo-Mate) multiplied by the cross-sectional area of flow at a particular location. The MQO for discharge measurements is provided in Table 6-1.

The bias in water level data will be assessed by comparing the monitoring equipment’s readings to an independently measured value. A ruler, staff gauge or portable discharge meter will be used as the independent value for confirmation of the regularly used meter, usually an area*velocity or non-contact laser Doppler sensor. A physical measurement is preferred over the pressure transducer of the portable discharge meter, but the portable meter will be used when flow conditions are not favorable for an accurate or safe physical measurement. The MQO for water level is provided in Table 6-1.

The bias in precipitation depth data will be assessed by comparing the rain gauge’s actual readings to its theoretical accuracy as specified by the manufacturer. The rain gauge’s actual readings will be determined by measuring the volume of water required to get one tip of the rain gauge bucket. This will be accomplished by adding incremental drops of water with a pipette. This volume of water will then be compared to the manufacturer’s specifications for the rain gauge. The MQO for precipitation depth is provided in Table 6-1.

6.3.2.c Comparability and Precision

Not applicable due to difficulty associated with obtaining repeat measurements in the field of hydrologic data (e.g., rain and flow).

6.3.2.d Technical Consistency

Rainfall totals for the event will be compared to the total runoff for the event. The total runoff should not exceed estimated baseflow volume plus the theoretical maximum runoff (rainfall depth times the basin area). The MQO is met if the total runoff for the event is less than or equal to the maximum predicted runoff.

6.3.2.e Completeness

Completeness will be assessed on the basis of the occurrence of gaps in the data record for all monitoring equipment. The associated MQO is that less than 10 percent of the total data record is missing due to equipment malfunctions or other operational problems. Completeness will be ensured through routine maintenance of all monitoring equipment and the immediate implementation of corrective actions if problems arise.

6.3.2.f Representativeness

Representativeness of hydrologic data will be ensured by the proper installation of all associated monitoring equipment. Since this is part of a long term study that has been ongoing for more than 12 years, this will help to ensure that data are collected during representative climatic conditions for the region.

7.0 SAMPLING PROCESS DESIGN

The sampling design strategy was developed to understand the pollutant loads and average event mean concentrations from stormwater draining to the Foss Waterway and to characterize land use types. This information will be used to measure the effectiveness of stormwater source control actions and to provide an early indication of any new water or sediment quality problems.

This section describes the overall sampling design for the study to support the program objectives identified in Section 4.1.

Three steps are generally specified prior to the initiation of any stormwater field collection activities. These steps, which are discussed in more detail below, include:

- Description/selection of the monitoring locations,
- Development of the stormwater sampling strategy, and
- Selection of the equipment to meet the study objectives and the site specific needs of the selected locations.

7.1 MONITORING LOCATIONS

In accordance with Section S8.C of the Permit and the Foss CD, Tacoma is monitoring seven outfalls in the Foss monitoring program. All seven outfalls have been monitored for more than 12 years under the Foss monitoring program, with three of the outfalls (OF235, OF237B, and OF245) also being monitored under Section S8.D of the 2007-2012 Phase I Permit. The selection of these outfalls is discussed in detail in the Foss SAP (Tacoma 2001) and the S8.D QAPP (Tacoma 2011). Since the locations have already been selected, this section will not go into detail on the selection methodology.

The outfalls selected for this project are the major outfalls discharging into the Foss Waterway and thus represent the bulk of the inputs. The sampling locations for each outfall were selected to be as close to the end of pipe as practical. In general, samples are collected at the first manhole upstream from the end of the outfall pipe which may be tidally influenced as discussed in more detail below. Details for each site are presented in Table 7-1.

All Foss outfalls are influenced to a certain degree by tidal inundation and portions of the pipe are inundated with marine water twice a day depending on the pipe elevations and the tide height. Table 7-2 lists each outfall, the invert elevation, whether the pipe is tidally influenced, and baseflow conditions whether continuous or tidal (including flow rates, if available). Baseflow sources are presented in Figure 7-1 and are described in the outfall specific sections below.

7.1.1 Outfall 230

The OF230 drainage basin is located on the mid-portion of the west side of the Foss Waterway. The basin boundaries are shown on Figure 3-2. The area is approximately 557 acres and discharges to the waterway through a 60-inch outfall pipe (Table 7-2) located at South 15th Street and Dock Street in the right of way just south of Johnny's Seafood (retail). The general basin boundaries are South 8th Street to the north, South 17th Street to the south, South Ainsworth Avenue to the west, and Dock Street to the east. Most of the storm drainage is channeled to South 15th Street via a main trunk line along Market Street. Because of the steep downhill grade, overflow pipes exist in manholes along Market Street directing excess water to downstream trunk lines. Trunk lines along Dock Street are susceptible to saltwater intrusion from high tides.

The OF230 drainage basin is heavily developed throughout with primarily commercial land use and some residential use on the west side of the basin. The northern portion of the University of Washington–Tacoma (UWT) discharges to OF230. The drainage area for UWT is bounded by Pacific Avenue, South 21st Street, Tacoma Avenue and South 17th Street. Also included in the basin is Tacoma Link light rail, Greater Tacoma Convention and Trade Center, downtown revitalization (condos and retail), Dock Street redevelopment, and the Foss Waterway Public Esplanade from South 17th Street to South 11th Street.

OF230 baseflow (continuous at approximately 0.12 cubic feet per second at ½-inch depth; Tacoma 2008) consists of groundwater from footing drains being pumped into several catch basins. Confirmed sources are:

- Since 2004, groundwater from footings for the Greater Tacoma Convention and Trade Center has been pumped to the storm drain.
- During WY2010, investigations led to a discovery of an eight inch lateral connection on South 11th Street between Commerce and Pacific. This discharge appears to be a continuous flow of clear water at ¼-inch in depth. City staff was unable to locate the source of the discharge due to a collapse in the pipe.
- In WY2011, City staff located water discharging into a catch basin (CB# 6502144) at 944 Pacific Avenue. At the time, it was noted that 90% of the baseflow in the 11th Street storm line was from this location. It is uncertain whether this discharge is non-contact cooling water or from footing drains.

This sampling site is located at South 15th and Dock Street in a landscaped area next the City-owned parking lot (Figure 7-2). This manhole has not been assigned an accounting number yet. Confined space entry is needed to maintain the sample line and flow sensor. Figure 7-3 shows the outfall sediment trap sampling site.

7.1.2 Outfall 235

The OF235 drainage basin is the fourth largest basin in the Foss Waterway Watershed. The drainage basin encompasses a section of downtown between the OF230 and OF237A drainage basins (Figure 3-2). The OF235 drainage basin is heavily developed and covers an area of approximately 156 acres which drains through a 42-inch outfall pipe located on the west bank of the Foss Waterway at South 21st and Dock Streets under the SR509 bridge. The general basin boundaries are South 18th Street to the north, South 23rd Street to the south, South “L” Street to the west and Dock Street to the east.

Commercial land use accounts for the majority of the area in this basin, with a small residential area on the western side (Figure 3-2). A small portion of freeway right-of-way is in the lower part of this basin including I-705 and the entire I-705 and State Route (SR)-509 interchange. Most of the stormwater runoff from the freeways discharges to an infiltration pond and not to the City-owned storm drains.

The southern portion of the University of Washington–Tacoma (UWT) and a portion of the St. Joseph Medical Complex discharges to OF235. The drainage area for UWT is bounded by Pacific Avenue, South 21st Street, Tacoma Avenue and South 17th Street. Also included in the basin is Tacoma Link Light Rail, downtown revitalization, Dock Street redevelopment and the Foss Waterway Public Esplanade from South 21st Street to South 17th Street.

OF235 baseflow originates from somewhere on the 19th Street branch above Tacoma Avenue South. There is no baseflow in the 21st Street branch of OF235. The actual source of the flow on the 19th Street branch has not been located, which leads the City to believe that the baseflow is an accumulation of groundwater springs possibly combined with non-contact cooling water.

A rainfall to runoff relationship based on one-year of continuous flow data was developed as a part of the 2007-2012 NPDES S8.D monitoring. This relationship is presented in Figure 7-4.

The stormwater sampling site is located at South 21st and Dock Street in a private parking lot along the Thea Foss Waterway. The equipment is sited in MH465 (MH# 6767530) Figure 7-5). The manhole is located in the middle of the parking lot under the SR-509 bridge. Confined space entry is needed to maintain the sample line and flow sensor. The sediment-trap sampling device is located in the next upstream manhole, MH463 (MH# 6767511). Traffic control will be used during work in this area.

The property, owned by the Foss Waterway Development Authority (FWDA), is a parking area and a park. MH465 manhole is located in the paved area. The City will continue to coordinate with the FWDA for access to the manhole.

7.1.3 Outfall 237A

The OF237A drainage basin is approximately 2,823 acres and drains to the Thea Foss Waterway through the west 96-inch outfall located in the 2300 block of East Dock Street at the head of the waterway. As shown in Figure 3-2, the drainage basin generally extends in the south and west directions from the outfall. The general boundaries are South 19th Street on the north, South 40th Street on the south, Lawrence Street on the west, and Tacoma Avenue on the east.

The OF237A drainage basin contains residential, commercial and industrial land uses. In addition, freeway rights-of-way for I-5, SR-16, the entire I-5/SR-16 interchange, and a portion of the I-5/I-705 interchange are located within this drainage basin.

Baseflow in OF237A is continuous at approximately 4.4 cubic feet per second (Table 7-2) and originates from the following major areas:

- An artesian well and seeps in Nalley Valley and near the railroad tracks along South Tacoma Way in Gallagher's Gulch.
- A ditch on Hood Street from South 25th Street to South 23rd Street which collects water from seeps and groundwater from the old Union Pacific railroad tunnel (75 gallons per minute discharging to the 23rd Street Lateral of OF237A).

During periods of increased precipitation, the Leach Creek Holding Basin located to the west of the drainage basin is pumped to the OF237A storm drainage system. The Leach Creek Holding Basin is located within the city limits of Fircrest (west of Tacoma) and has functioned as a stormwater facility since 1961, when a dike was constructed along the southern edge of the current site. Several storm pipelines feed the holding basin draining approximately 2,450 acres of residential, commercial, highways, and other high use developed properties in Tacoma and Fircrest. The primary outflow from the holding basin is a gated 42-inch outlet pipe which conveys stormwater to Leach Creek.

The pump station was constructed in 1991 and consists of four pumps, each with a capacity of 24 cubic feet per second (cfs) and maximum combined capacity of 96 cfs. During more intense rain events, stormwater from the Leach Creek Holding Basin is pumped through a 42-inch pipe to the Nalley Valley trunk line and discharged into the Thea Foss Waterway through OF237A. The number of pumps operating depends on the intensity of a given storm event; with any number of the four pumps potentially operating at a given time. At low levels of precipitation, no pumps operate and the water discharges to Leach Creek. At increased levels of precipitation[13], pumps sequentially engage up to a maximum of four pumps. The range of flow to the Nalley Valley system from the Leach Creek Holding Basin is from 0 to 96 cfs. Emergency overflow from the holding basin is provided by a 40-foot wide emergency spillway which discharges to Leach Creek.

In 2005, 60 feet of the OF237A outfall pipe was replaced by Burlington Northern Railroad as part of their rail track realignment project. Construction included extending the outfall, constructing a new manhole structure and replacing pipe from the City's sanitary pump station yard (known as Dock Street) to the outfall. The new manhole was constructed downstream of the current stormwater sampling location and FD2 and FD2a. The 23rd Street lateral (FD2a) was rerouted to the new manhole structure in the 237A main trunk line. The new manhole is used as the new end-of-pipe sampling location for OF237A New, baseflow and stormwater. The new manhole represents discharge from the entire drainage basin.

The stormwater and sediment trap sampling sites (Figure 7-6) are located in the City's Dock Street Pump Station Yard, in the 2300 block of East "C" Street. The yard is fenced and locked. The equipment is cited within MH# 6777413, which is located in the northwest section of the asphalt-paved yard. A confined space entry is needed to maintain the sample line and flow sensor. Traffic control is used during work in this active yard where City maintenance vehicles are constantly coming and going during work hours.

7.1.4 Outfall 237B

The OF237B drainage basin encompasses 1,991 acres of south and east Tacoma. This area drains to the Foss Waterway through a 96-inch outfall pipe located on East Dock Street at the head of the waterway. The general basin boundaries are East 23rd Street and East Dock Street to the north, East 84th Street to the south, South Fawcett Avenue to the west, and McKinley Avenue to the east. Most of the storm drainage is channeled to the main trunk line, which flows south to north along East "D" Street.

Primary land use in this drainage basin is residential with some commercial and a very small amount of industrial (Figure 3-2). Commercial areas are mostly linear and spread out in strips along Pacific Avenue and McKinley Avenue with some areas around I-5 to the Foss Waterway. Freeway right-of-way makes up a small percentage of this basin, and includes a portion of the I-5, I-705, Highway 7 interchange and Highway 7. This right-of-way area may increase slightly with the expansion and HOV lanes on I-5. Streets, parks, and open or undeveloped property account for the remaining land use in the basin.

Baseflow from OF237B is continuous at approximately 8.3 cubic feet per second (Table 7-2) and originates from the following major areas:

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[13] According to the City's best estimation, this occurs when greater than ¾-inch of precipitation falls within a 24-hour period.

- Seeps from the blueberry fields on East 72ndStreet.
- A swamp and seeps from along the railroad tracks by Highway 7.

As part of the Burlington Northern Santa Fe (BNSF) railroad realignment project, OF237B was reconstructed between July and September 2005. This work included installation of a new manhole structure downstream of the whole-water and stormwater suspended particulate matter (SSPM) (FD1) sampling location and included extension of the outfall pipe through installation of 60 feet of new concrete pipe. The SSPM and the whole-water monitoring station (Figure 7-6) remained at the same location since that location captures contributions from the entire basin.

A rainfall to runoff relationship based on one-year of continuous flow data was developed as a part of the 2007-2012 NPDES S8.D monitoring. This relationship is presented in Figure 7-7.

The sampling site is located in the City's Dock Street Pump Station Yard, in the 2300 block of East "C" Street. The yard is fenced and locked. The equipment is cited within MH122 (MH# 6762057). MH122 is located in the southeast section of the asphalt-paved yard. A confined space entry is needed at MH122 to maintain the sample line and flow sensor. Traffic control is used during work in this active yard where City maintenance vehicles are constantly coming and going during work hours.

7.1.5 Outfall 243

The OF243 drainage basin is 59 acres and discharges to the east side of the waterway at East 21st Street through a 48-inch outfall (Figure 3-2). The storm drainage is carried in two main laterals, one south to north on East "D" Street from East 26th Street to East 21st Street and the second east to west on East 21st Street. The majority of runoff in this basin is from Burlington Northern-Santa Fe Railway property and the portion of SR-509 between Portland Avenue and the Foss Waterway. Land uses in the basin are primarily industrial, with some commercial at the west side of the basin and some highway with SR-509.

The outfall has a tide valve which was originally installed in 1999 then reinstalled in 2001 when the outfall pipe was extended. In 2008, "D" Street was raised over the BNSF main line increasing the drainage area by ½ acre. The stormwater runoff from the new ½ acre is treated through a VortFilter unit which then discharges to OF243 through a new 15-inch pipe.

OF243 does not have any creeks or other sources that provide constant baseflow, but does have tidal backflushing year round and during the wet season there is evidence of groundwater infiltration due to the high water tables in the tideflat area. The groundwater table is comprised of a bottom layer, which is influenced by tides and an upper fresher water lens. In the wet season, the upper lens is freshened by rain recharge and salinity effects (e.g., conductivity) are less.

The stormwater sampling site (Figure 7-8) is located at East 21st and D Street in a private parking lot along the Foss Waterway. The equipment is sited in MH# 6761877. The manhole is located in the middle of the parking lot under the SR-509 bridge. Confined space entry is needed to maintain the sample line and flow sensor. Two sediment-trap sampling devices (Figure 7-8) are located within the sump just downstream of the sample location. Traffic control will be used during work in this area.

The property is an open lot parking area. The manhole is located within the right-of-way and is continually blocked off with cones to allow for access.

7.1.6 Outfall 245

The OF245 drainage basin is located in the tideflats of Tacoma on the southern portion of the east side of the waterway. Basin boundaries are shown on Figure 3-2. The outfall is located at East 19th Street, just south of Johnny's Dock Restaurant. The drainage area is approximately 39 acres in size and the main trunkline of the storm drainage system extends east from the Foss Waterway, down East 19th Street to East "I" Street. Because of the low basin elevation, the entire storm system is influenced by saltwater at high tide.

Land use in this basin is primarily industrial with the restaurant providing a small commercial area at the west side of the basin. Most facilities in the drainage basin are engaged in storage, transloading and warehousing of materials and products, and manufacturing.

Directly upstream of the outfall is a deep bottom sump manhole known as MH390 (Figure 7-7). MH390 is 60 inches inside diameter and approximately 18 feet in depth with the inlet pipe and outlet pipe at 55.5 inches above the bottom. A plastic tide gate (swing valve) is located on the inlet pipe. The tide gate does not securely seal and some tidal water does get into the upper reaches of the system. In fall 2004, the last 24 feet of pipe from MH390 to the waterway was replaced with HPDE. Drainage from MH390 was improved with the new slope of the outfall pipe, which replaced the old line that had a sag in it.

In August 2004, Tacoma replaced a 300-foot segment of the stormwater line and associated laterals in East 19th Street. This action sealed this segment from groundwater, sediment and product migration from the surrounding contaminated soil that remained in-place after an interim action remediation project was completed in this area.

Similar to OF243, OF245 does not have any creeks or other sources that provide constant baseflow, but does have tidal backflushing year round and during the wet season there is evidence of groundwater infiltration due to the high water tables in the tideflat area. The groundwater table is comprised of a bottom layer, which is influenced by tides and an upper fresher water lens. In the wet season, the upper lens is freshened by rain recharge and salinity effects (e.g., conductivity) are less.

A rainfall to runoff relationship based on one-year of continuous flow data was developed as a part of the 2007-2012 NPDES S8.D monitoring. This relationship is presented in Figure 7-10.

The sampling site is located in the Johnny's Dock Restaurant private parking lot, East 19th and "D" Street. The equipment is sited in MH390. A parking stall is designated for City of Tacoma use only where MH390 is located. Tacoma coordinates with the owner of the private parking lot on access to this location. Confined space entry is needed to maintain the sample line and flow sensor. While working, two parking stalls may be closed off.

7.1.7 Outfall 254

The OF254 drainage basin is located on the tideflats and is the fifth largest basin in the Foss Waterway Watershed (Figure 3-2). It is approximately 119 acres and drains through a 36-inch outfall pipe located at the head of Wheeler-Osgood Waterway on East "F" Street just north of East 15th Street. The drainage area includes East 15th Street from East "D" Street to St. Paul Avenue, East "J" Street from East 15th Street to the 1600 block, and St. Paul Avenue from East 11th Street to Portland Avenue.

The majority of the OF254 drainage basin is zoned for industrial use, but small commercial areas are present near the shoreline.

Similar to OF243 and OF245, OF254 does not have any creeks or other sources that provide constant baseflow, but does have tidal backflushing year round and during the wet season there is evidence of groundwater infiltration due to the high water tables in the tideflat area. The groundwater table is comprised of a bottom layer, which is influenced by tides and an upper fresher water lens. In the wet season, the upper lens is freshened by rain recharge and salinity effects (e.g., conductivity) are less.

The stormwater sampling site (Figure 7-11) is located near the southwest corner of the property at 625 East 15th Street next to the railroad tracks. The equipment is sited in MH# 6761601. Confined space entry is needed to maintain the sample line and flow sensor.

7.1.8 Upstream Sediment Trap Monitoring

For source control tracing purposes, the City has installed sediment traps upstream of the outfalls in several of the drainage basins. These traps will be used to identify potential problem areas in sub-drainages. The location of the sediment traps is provided in Figure 7-12. The analytes that these sediment trap samples will be analyzed for are listed in Table 3-3.

7.2 STORMWATER MONITORING STRATEGY

The number of samples (composite, grab, outfall sediment trap, and upstream sediment trap) required under the Foss CD and the Permit are outlined in Table 7-3. In addition to the total number of samples listed in Table 7-3, the City will try to sample the first flush event (first significant event that occurs after the summer dry period) even if the sample numbers for the year have already been achieved.

As identified in Table 7-3, the number of samples required under the Foss CD shall be increased or decreased based on the previous year's sampling results. This is discussed in more detail in Section 7.2.4.

A discussion of the stormwater monitoring strategy is presented below and includes:

- Qualifying storm events,
- Selection of parameters,
- Selection of sampling techniques and types, and
- Selection of sampling frequency and criteria to ensure representative samples.

7.2.1 Qualifying Storm Event

Table 7-4 lists the qualifying storm event criteria for dry and wet seasons. Collection of flow-weighted composite water samples will be attempted whenever favorable weather conditions present themselves in order to obtain total number of samples required per year.

Sampling will be distributed throughout the year, approximately reflecting the distribution of rainfall between the wet and dry seasons (60-80 percent of the samples collected during the wet season; 20-40 percent of the samples collected during the dry season). Attempts will be made to evenly distribute the samples throughout the year, but samples may be collected in subsequent storms, if needed to obtain the total number of required samples per year.

7.2.2 Sampling Techniques and Types

The following sampling techniques and types will be used.

7.2.2.a Automatic Composite Sampling

Automatic flow-weighted composite samples will be collected for analysis of water chemistry (Section 3.4.1 and Table 3-1). This automatic composite sampling will be used for all parameters, except fecal coliform bacteria and total petroleum hydrocarbons (NWTPH-Gx, NWTPH-Dx, and BTEX), which will instead use grab sampling.

The sampling of tidally influenced drains will be necessarily limited to those periods when the drain is not affected by tides, and therefore may include only a portion of the runoff hydrograph. The sampling of tidally influenced drains is difficult given the limit of those periods when the drain is not affected by tides.

Tidal effects have been excluded from the automatic samplers for the duration of the over 12 year Foss stormwater monitoring program using sequential sampling and using *in-situ* velocity monitoring (i.e., near zero during tidal inundation), height, and/or conductivity. Tidal exclusion is confirmed in the laboratory using conductivity (salinity) measurements prior to compositing the sample bottles from different portions of the storm. The goal for conductivity measurements of the all the aliquots composited from OF230, OF235, OF237A, OF237B, and OF245 is to be less than 2,000 umhos/cm. The goal for conductivity measurements for all the aliquots composited from OF243 and OF254 is to be less than 5,000 umhos/cm.

For comparison purposes, conductivity measurements of 95 percent stormwater/5 percent saltwater is approximately 2,400 umhos/cm and measurements of 50 percent stormwater/50 percent saltwater is approximately 20,000 umhos/cm (Tacoma 2008).

Appendix 9 of the Permit requires that automatic flow-weighted composite samplers be programmed to begin sampling as early in the runoff event as practical and to continue sampling past the longest estimated time of concentration, T_c, for the tributary area. The T_c provides a measure to ensure the pacing is set to obtain a representative sample and to ascertain if sampling of contributions from the entire basin are represented, (i.e., sampling at or near the T_c may not be representative of the entire basin). Estimated T_c's for each basin are included in Table 7-1.

For this project, the minimum time the automatic sampler will be programmed for sample collection in order to meet this permit requirement is two times the time of concentration.

7.2.2.b Manual Grab

Manual grab samples will be collected for total petroleum hydrocarbons and fecal coliform bacteria. Composite samples are not appropriate for these parameters due to their tendency to adhere to sampling equipment (total petroleum hydrocarbon) or change in concentration after a short period (fecal coliform bacteria).

Grab samples will be collected at each stormwater monitoring site during qualifying storm events as early in the storm event as possible. When possible, grab samples will be collected during the same storm events as the composite samples. If it is not possible to collect a manual grab sample due to logistical or safety reasons, a grab sample will be collected during a separate qualifying event.

Because we expect some storm events to occur in the middle of the night, on weekends, or during holidays (and automatic samplers may begin sampling if enabled), having staff immediately available for grab sampling may be difficult. During these times, it is possible that grab samples may be taken during different storm events when no composite samples are targeted. If the grab sample is collected during storm runoff that meets all qualifying storm event criteria, except for the minimum amount of rainfall, the grab sample will be analyzed and considered a valid sample.

Attempts should be made to have fecal coliform bacteria and TPH analyzed in the same grab sample. However, if the 8-hour maximum holding time for fecal coliform bacteria cannot be met (for example, due to the laboratory being closed on a weekend or holiday), a grab sample will be taken either later in the storm event, or during a future storm event.

7.2.2.c Manual Sediment Trap

Sediment samples will be collected with sediment traps. Sediment traps will be deployed for approximately 12-month intervals.

7.2.3 Representative Sample Criteria

Storm event criteria are established to ensure samples collected are "representative" of stormwater conditions. These criteria: (1) ensure that adequate flow will be discharged; (2) allow some build-up of pollutants during the dry weather intervals; and (3) ensure that the storm will be "representative" (i.e., typical for the area in terms of intensity, depth, and duration).

Collection of samples during a storm event meeting these criteria ensures that the resulting data will accurately portray the most common conditions for each site. Ensuring a representative sample requires two considerations: (1) the storm event must be representative, and (2) the sample collected must represent resulting runoff from the storm event.

7.2.3.a Representativeness of Individual Storm Events

The criteria to ensure the composite sample collected is representative of the storm event sampled are provided in Table 7-5. The sampling of tidally influenced drains, however, is necessarily limited to those periods when the drains are not affected by tides, and may therefore include only a portion of the runoff hydrograph. Tidal effects will be excluded from the automatic samplers as described in Section 7.2.2.a.

Over the course of the year and multi-year monitoring program, the tidal sampling windows will randomly overlap with different portions of the runoff hydrograph, and a representative range of rising, peak, and falling runoff conditions will be captured during multiple sampling events, if not during a single event.

This methodology has been used successfully as part of the existing Foss Stormwater Monitoring program over the last 11 years[14]. As shown in Table 7-6, an evenly distributed range of rising, peak, and falling runoff conditions was captured during

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[14] Year 12 data is currently under review and is not being presented in this Plan.

multiple sampling events. A majority of these events did capture most of the storm hydrograph during Years 1 to 11.

7.2.3.b Representativeness of Storm Types

Storm event criteria have been selected to consider the variation in storm event runoff volume, flow rate, antecedent rainfall conditions, and seasons. In addition, over the course of the year and the multi-year monitoring program, monitoring will represent a range of storm conditions which will be representative of climatic conditions for the region.

Over the course of Tacoma's eleven-year monitoring record for the Foss Waterway Program, a representative range of storm types have been sampled. Each storm is characterized by the following hydrologic variables:

- Total rainfall
- Runoff hydrograph
- Intensity
- Antecedent period; and
- Season

The ranges of average flow rates, magnitude and intensity of the runoff hydrographs were variable over the course of Years 1-11 (Table 7-7). In addition, a wide variety of storms were sampled during Years 1-11 including rainfall amounts, duration, intensities and antecedent conditions.

Rainfall amounts sampled ranged from 0.15 inches up to 2.71 inches and seasonal distributions were representative of the historical distribution of rainfall in Tacoma. The largest numbers of the storms sampled were less than 0.29 inches. Fifty-six percent of the total storms sampled were less than 0.4 inches in Years 1-11, followed by 21 percent of the total storms sampled that were between 0.4-0.59 inches and 23 percent of the total storms sampled were greater than 0.6 inches. The historic distribution is 52 percent for storms less than 0.4 inches, 24 percent for storms between 0.4-0.59 inches, and 24 percent for storms greater than 0.6 inches (Figure 7-13).

Durations ranged from two to greater than 24 hour storms with little difference from year to year (Table 7-8). Antecedent periods for all eleven years broke out as follows:

Antecedent Periods	No. of Storms for Years 1-11
Less than 24 hours	11
24 to 49.9 hours	86
50 to 99.9 hours	45
100 hours and greater	46

Average rainfall intensities were 0.01 to 0.13 inches per hour with a majority of the storm events sampled having intensities less than or equal to 0.03 inches per hour (Figure 7-14).

Seasons are appropriately represented by the number of events sampled (i.e., more samples during the wet season when there are more rain events and fewer samples during the dry season when there are fewer storm events). For the 11 year monitoring record, 75.6% of storms were sampled in the wet season compared to a historical average (1982 to 2009) of 83.9% of storms in the wet season (Figure 7-15).

7.2.4 Increasing or Decreasing the Number of Composite Samples

As outlined in the April 23, 2013 letter from EPA that reduced the number of samples under the Foss CD from 10 per year per outfall to 8 per year (OF230, OF235, OF237A, and OF237B) and 3 per year (OF243, OF245, and OF254), the number of samples per year shall be modified over the course of the program based on the statistics from the previous years of monitoring.

The number of samples required per year under the CD requirements shall be increased if there are two or more exceedances of the 98.5 percentile[15] in OF230, OF235, OF237A, and OF237B or two or more exceedances of the 96 percentile[14] in OF243, OF245, and OF254. The previous three years of monitoring data shall be used to develop the percentiles for each analyte. The number of samples, however, shall not be increased if the exceedances can be tied to a specific activity (e.g., spill or release in the waterway) that has been subsequently controlled.

The number of samples required per year under the CD may be decreased if no samples exceed the 88th percentile[14] in OF230, OF235, OF237A, and OF237B or exceed the 72nd percentile[14] in OF243, OF245, and OF254. The previous three years of monitoring data shall be used to develop the percentiles for each analyte.

The maximum number of samples required under the CD under this adaptive approach is 10 per year for any outfall with a minimum of 5 per year for OF230, OF235, OF237A, and OF237B and a minimum of 2 per year for OF243, OF245, and OF254.

As long as the 2013 Permit is still in effect[16], the City will meet the 55 samples per year requirement as outlined in Appendix 9 of the Permit. The distribution of the 55 samples per year is discussed in more detail in Table 7-3.

7.3 EQUIPMENT MONITORING STRATEGY

The general equipment strategy is to employ one ISCO Model 6712 composite sampler, area/velocity flow module (either an ISCO 750 flow module or an ISCO 2150 flow meter) and other sensors (conductivity probes), if necessary, for all selected sites.

At some sites, a second ISCO sampler may be installed in series so that a volume of up to 24 liters can be collected. This process will be used with the additional equipment is available, when it's logically feasible to install a second sampler, and when additional sample volume is needed to improve sample collection efficiency. Where possible, duplicate (as a split sample),

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[15] Percentiles are based the chance of these events occurring randomly of less than 5% using binomial statistics. See Table 7-9.

[16] This QAPP submittal pursuant to S8.C of the City's MS4 NPDES Permit is also a revision to the Thea Foss and Wheeler-Osgood Waterways Stormwater Sampling and Analysis Plan and cannot be modified or discontinued without prior written approval from both Ecology and EPA. Meeting the sampling requirement, and other applicable requirements of the Permit and Appendix 9, will continue on after the expiration of the 2013 Permit.

matrix spike, and matrix spike duplicates will be obtained from this arrangement. A field blank may be run at the start, middle or end of the sample series.

A true field duplicate will also be attempted during the year. The programming will be altered to obtain a 12 liter composite from each sampler (parallel). This may not provide sufficient volume for all parameters, given sampler performance, but will be able to cover the majority of the analyte list (in priority order). This design applies to field duplicates as well as matrix spike/spike duplicates.

Equipment specifications for each site will include: (1) rational for selected equipment strategy, (2) monitoring and communication equipment specifications, and (3) site configuration.

7.3.1 Thea Foss Waterway Stormwater Monitoring Sampling Strategy

Since all outfalls except OF237B are tidally influenced, it is challenging to coordinate the appropriate tide with the appropriate storm or dry period to collect representative samples. Sampling equipment was selected that is able to determine whether the tide is in or out, and to activate automatically when rainwater is running off into the storm line outside of the period of tidal influence. An additional safety check is through the use of discrete sampler containers known as sequential sampling. This prevents one aliquot from contaminating an entire composite sample with saltwater. It allows for compositing of just those samples that are most representative, determined through review of the storm hydrograph, and compositing of only those samples that best represent the storm criteria.

The City uses ISCO 6712 samplers with flow monitoring modules, sampler bases, and conductivity probes along with support equipment (battery chargers, data modules, sampler tubs, strainers, glass jars, etc.). Teflon suction tubing, silicon pump tubing and glass bottles are used in all locations. Sampler probes are attached to a stainless steel plate. The plate is bolted using concrete bolts to the bottom of the pipe. Hoses and electrical cords are attached to the side of the pipe and manhole using concrete bolts and plastic ties. The sampler is hung from the manhole rungs using stainless steel cable and iron hangers or is placed in a job box directly adjacent to the site.

In order to reduce staff time associated with sampler programming and to improve sampling efficiency, the City is planning to pilot a telemetry setup using Campbell Scientific telemetry equipment. This Campbell Scientific equipment will control the ISCO 6712 sampler and will send data back to the office through a cell phone modem. If the pilot is successful, Campbell Scientific telemetry will be implemented at some or all of the Foss outfall sites (depending on budget availability).

The ISCO samplers are composite samplers with sequential sampling capabilities. Each sampler base contains twelve one-liter discrete sample containers. Consistent with the previous Foss CD stormwater monitoring and the 2007 Permit[17] monitoring, the samplers are programmed to collect flow proportional discrete samples on the west side outfalls (OF230, OF235, OF237A, OF237B) and time composite discrete samples on the east side tidally influenced outfalls (OF243, OF245, OF254).

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[17] Only applies to OF235, OF237B, and OF245.

8.0 SAMPLING (FIELD) PROCEDURES

This Section describes field procedures that will be utilized to ensure that samples are collected in a consistent manner, are representative of the matrix being sampled, and that the data will be comparable to data collected by other existing and future monitoring programs.

The quality of data collected in an environmental study is critically dependent upon the quality and thoroughness of field sampling activities. General field operations, practices, and specific sample collection will be well planned and carefully implemented and follow specific SOPs that support the following field activities:

- Automatic flow-weighted composite sampling
- Grab Sampling
- Sediment Sampling

These SOPs include requirements for training and documentation of activities, collection of field quality control samples, and description of appropriate sample handling and processing techniques, where appropriate.

A general description of field activities is provided below.

8.1 EQUIPMENT DECONTAMINATION PROCEDURES

A general discussion of sample decontamination procedures is described below. Specific details are described below as well as in the SOPs, which are available for review upon request.

8.1.1 Sample Bottles

The City laboratory will provide glass containers for collecting stormwater samples. Glass containers and jars (ISCO 1000 mL glass containers) will be pre-cleaned to meet Level B requirements according to the City laboratory SOP titled, 'Standard Operating Procedure – Glass Cleaning'. Certification information will be kept in the laboratory information management system (LIMS) as outlined in the SOP.

Field and laboratory blanks, conducted at a rate of 5% of the sample load, will be used to assess glassware cleaning performance.

Teflon sample bottles will be cleaned by the City's laboratory and re-used. The one-liter Teflon bottles with Teflon lids are cleaned to EPA QA/QC specifications Glassware Cleaning Following EPA Protocols (EPA 1990). After cleaning, the bottles will be capped for storage and transport.

Stainless steel materials used for sediment sampling will be cleaned with phosphate and rinse free detergent (hot soapy water).

8.1.2 Automated Sampling Equipment

Prior to installation, all automatic sampling equipment (ISCO sampler head, Teflon suction tubing, strainers, silicone tubing and all other sampling equipment except glass sampling jars), will be cleaned by running the pump on continuous suction for two minutes with each of the following solutions:

- Hot soapy water (Liqui-Nox or equivalent).

- Hot water
- 5% nitric acid
- Reagent grade water

After decontamination, the Teflon suction tubing, strainers and silicone tubing will be wrapped with aluminum foil until placed in the field. The ends of the tubing will also be capped with aluminum foil.

After the equipment has been installed, the sampler head and Teflon tubing will be left in place at the sample station and rinsed with 1 gallon of laboratory pure water between each sample event or during routine maintenance. The ISCO sampling program will also rinse and purge the entire sample line with stormwater prior to sampling (obtaining aliquot). Teflon tubing is inspected following each sample event, and will be replaced with pre-cleaned tubing annually or whenever the integrity is compromised.

Equipment rinsate blanks will be performed by running enough reagent grade water through a decontaminated Teflon sampler hose, strainer and silicone pump tube installed in the sampler, into a pre-cleaned container until sufficient volume is collected to run the analytes of interest. Rinse blank performance will determine if the current decontamination procedure is sufficient for the study.

8.2 Sample Handling and Custody

Sample handling and custody procedures ensure that uniquely identifiable samples are transported to the analytical laboratory with appropriate preservation within prescribed holding times and with proper documentation. Written documentation of sample custody from the time of sample collection through the generation of data by analysis of that sample is recognized as a vital aspect of an environmental study. The chain-of-custody of the physical sample and its corresponding documentation will be maintained throughout the handling of the sample by following the procedures outlined below.

8.2.1 Sample Identification

All samples will be clearly labeled in the field with indelible ink. Each sample will be uniquely identified by its sample location identifier combined with the sample method (type and technique, i.e., manual grab, automatic flow-weighted composite), the event date and time stamp, and the sample matrix. For composite samples, the date and time stamp will reflect the last aliquot collected.

8.2.2 Sample Transportation

The sample teams will collect the stormwater from the automated samplers or collect grab samples, place the samples on ice, and transport them as soon as possible to the selected analytical laboratory.

8.2.3 Sample Preservation

Other than ice, sample preservation will not be required in the field. Sequential and Composite samples will be chilled with ice as they are collected. Grab samples must be chilled immediately following collection.

Chemical preservatives are added to the samples for certain analyses to prolong the stability of the parameters during transport and storage. Tables 9-1 and 9-2 list the required sample preservatives for the analytical parameters. If sequential or composite sampling procedures are used, no preservatives are added to the composite container because no single chemical preservative is suitable for all of the parameters to be analyzed. The laboratory must first divide the composite sample into the appropriate bottle for each analysis, and then add chemical preservatives as appropriate for each analysis. If manual grab sampling procedures are used (i.e., monitoring personnel directly fill the containers required for each analysis), the monitoring personnel will add the appropriate preservative to each sample container immediately.

8.2.4 Sample Processing

In general, all samples will be minimally processed in the field to prevent potential contamination from trace pollutants in the atmosphere. Samples will be transported to the analytical laboratory as soon as possible after sample collection.

8.2.5 Holding Times

Holding times (Tables 9-1 and 9-2) are short for some parameters, particularly fecal coliform bacteria, nutrients, and BOD (24-to-48 hours). For composite samples, the "sample collection time" used to evaluate holding time limits, is the time that the final sample aliquot is collected. To minimize the risk of exceeding holding times, the Sampling Lead will coordinate with the analytical laboratory prior to each event to ensure that the laboratory is prepared to begin processing samples as soon as samples are received. In addition, samples will be delivered to the laboratory immediately after retrieval from field samplers.

8.2.6 Chain of Custody Forms

A chain-of custody form will accompany each sample batch that is delivered to the laboratory. The purpose of chain-of-custody (COC) forms is to keep a record of the sample submittal information and to document the transfer of sample custody. The COC forms used in this study will include sample location identifier, analyses to be performed, and any special considerations, such as analyses priority order and sample filtration needs. At the time of sample collection, the field team will record the sample date and time, sample location, matrix, and analyses requested. Any special instructions for the laboratory will also be noted on the COC form such as specifications of quality control requirements (e.g., duplicate samples). The COC form must be signed by both the person relinquishing the samples and the person receiving the samples every time the samples change hands, thus documenting the chain of custody. During non-work hours the sample will be stored the City’s locked refrigerator, room 136 in the Center for Urban Waters building, until Custody officially changes hands.

8.2.7 Non-direct Measurements

Precipitation data will be collected following SOPs for data collection, validation, and management to ensure it is of known and documented quality.

8.3 Whole-Water Sample Collection Procedures

A general discussion of sample collection procedures is included below. Specific details are provided in the SOPs, which are available for review upon request.

8.3.1 Automatic Composite Samples

Automatic flow or time-weighted composite samples using the ISCO 6712 sampler will be collected for chemical analysis. Appropriate handling protocols shall be followed during sampler setup, sample collection and handling to avoid sample contamination. Samples should remain on ice during the collection period. For all sampling conditions, the samplers shall be programmed to perform one pre-flush prior to taking a sample. The sampler purges, rinses with sample water, purges and then samples.

The goal of composite sampling is to sample representative storm runoff as described in Section 7.2.3. The samplers will be programmed to sample any time storm drain conditions indicate that runoff is occurring and there is not tidal influence. This enable is determined based on the velocity of the water in the pipe, height of the water in the pipe, and/or the conductivity of the water in the pipe. Thus, the enable level will be set to discontinue sampling once baseflow returns at the end of a storm event or even during intra-event baseflow (that is, when flow rate falls to the baseflow level during short gaps within one storm event hydrograph). Some intra-event baseflow may be sampled if sufficient volume passes to accumulate the pacing volume.

The activation protocols (enables) will be dictated by type of sample to be collected (flow or time-weighted composite) and the site conditions, and are therefore site specific for each location. Site-specific sampler activation and programming protocols are listed in Table 8-1. These protocols will be updated periodically to reflect current flow conditions in the pipes.

Antecedent conditions and storm predictions will be monitored via the Internet and review of rain gauge data, and a determination will be made as to whether to target an approaching storm for sampling. Once a decision has been made to target a storm event for sampling, field personnel will conduct site visits to deploy clean sample bottles in the automated samplers at each monitoring station, calibrate equipment as necessary, clear any obstructions from the sampler intakes, and check the operational status of the flow monitoring equipment. Field personnel will then fill the automatic samplers with ice and initiate the sampler program. Ice is estimated to keep the interior of the samplers cool for 48 hours; consequently, ice will not be added to the samplers more than 24 hours before a targeted storm event. The speed and intensity of incoming storm events will then be tracked using Internet-accessible images from publicly available Doppler radar. Actual rainfall totals during sampled storm events will be monitored from the CTP and CUW rain gauges.

Sequential Sampling Program – Once the sampler detects the appropriate flow velocity, water height, and/or conductivity to indicate stormwater runoff, a flow based sampling sequence is activated. Once the sampler is activated, the sampler is programmed to collect discrete sequential flow proportional composite samples. Samples taken are based on the flow proportional sampling criteria set in Table 8-1 (every 50,000 gallons, 200,000 gallons, or whatever is set by the user based on the predicted storm).

Each time the sampler samples, approximately 250 mLs of sample is taken. Four samples are composited into each discrete sample container. If one ISCO 6712 sampler is located at a site, a complete sampling sequence will result in 48 samples in the 12, one-liter containers (Figure 8-1). If two ISCO 6712 samplers are located at a site (operating in series), a complete sequence will result in 96 samples in 24, one-liter containers.

The frequency of the flow proportional sampling is of course dependent on the magnitude of the storm and the flow in the pipe. Flow proportional sampling criteria are at times adjusted based on the magnitude of the storm that is predicted. At times, a small storm may not achieve the necessary volumes to trigger enough sampling to meet the minimum volume criteria to perform the necessary analysis. At other times, if the flow proportioning was set too low, and a large storm was encountered, the sampling containers may all have filled in a very short period of time sampling only a small portion (the beginning) of the storm.

Stormwater Compositing. Once back at the City's laboratory, the storm data is downloaded electronically from the samplers and transferred to a desktop computer for data analysis using ISCO FlowLink[18], the manufacturer-supplied software. The data is reviewed to determine the flow hydrograph and where on that hydrograph samples are taken. The storm data is compared to the storm criteria to determine if the samples are representative of the storm. This review includes:

1. Sufficient Sample for Analysis. The samples are checked to determine if there were adequate sample aliquots and volume for analysis (see Section 9.2).
2. Review Rainfall Data and Criteria. The total rainfall and antecedent dry weather period are determined to see if the minimum precipitation criteria are met using data from the City rainfall gage located at the CUW and the CTP (see Section 7.2.1).
3. Review Flow Hydrograph, Sample Collection (time and number), Corresponding Tide Chart, and Storm Criteria. The Sampling Lead or his/her designee determines which of the discrete samples will be composited by reviewing the flow hydrograph, the discrete sampling times relative to tidal stage and storm flow, and the conductivity (salinity) of the samples (see Section 7.2.3).

Stormwater Processing. Sample filtration is required when collecting samples for dissolved metals determinations. Filtration for metals will be conducted in the analytical laboratory to reduce the potential for contamination in the field, especially during storm conditions.

If sequential sampling procedures are used, field staff will mark on the chain-of-custody which subsample containers will be added to the storm composite sample. Laboratory and/or field staff will composite the subsamples. During this process, the subsample bottle will be vigorously agitated to ensure that all liquid and solid will be transferred.

Once the composite samples have been delivered to or composited by the laboratory, staff will transfer the composite sample to the appropriate bottles for the required analytical procedures (see Tables 3-1 and 3-2). During this process, the composite sample bottle will be vigorously agitated to ensure that a representative sample will be transferred to each bottle. In order to minimize exposure of the samples to human, atmospheric, and other potential sources of contamination, staff will process the samples using "clean" techniques pursuant to protocols developed by the EPA (1996) for the low-level detection of metals. If samples are delivered to the laboratory outside of normal operating hours (6:30 am to 4:30 pm), they will immediately be split, filtered into the appropriate containers and preserved by field or laboratory personnel.

8.3.2 Manual Grab Samples

Manual grab sampling will be attempted using a pole sampler as the intermediate grab sampling device as described in Ecology's grab sampling SOP (available for review at http://www.ecy.wa.gov/). The sample will be taken from mid-depth and center of the watercourse as described in the SOP.

Runoff conditions are very turbulent and forceful during intense storms at some sample locations. If the pole sampler does not work or use is dangerous, then a stainless steel bucket and line will be used to obtain sample from the water surface. In very turbulent conditions, the

[18] If telemetry is implemented at a site, the data will be automatically sent back to the City's network using cell phone modems. The data will be transferred from the telemetry software to FlowLink for review.

water column is well mixed and surface TPH samples are believed to be representative of the entire water column.

8.4 Sediment Sample Collection and Processing Procedures

8.4.1 Sediment Traps (OF230, OF235, OF237A, OF237B, OF243) & Upstream Sediment Traps

In all outfalls except OF245[19] and OF254[20], sediment samples will be collected using sediment traps, which consist of a stainless steel bracket mounted to the inside of the storm sewer pipe that holds a wide-mouth Teflon bottle (Figure 8-2). Sediment traps located upstream in the sub-drainage basins (see Figure 7-12) will also be installed and processed in a similar fashion.

Traps are designed to passively collect suspended particulates present in stormwater that passes by the sampling site. Sediment traps were initially designed by Ecology (Wilson and Norton 1996) and have since been modified by Tacoma (Norton 1997). Tacoma's modifications enable the sample bottle to be installed in a vertical position in most field conditions (i.e., manholes, vaults, and pipes). Brackets are mounted onto the wall of the pipe, maintenance hole, or other structure using stainless steel screws.

Traps[21] will be installed at each monitoring location to ensure that an adequate volume of sample is collected for chemical analysis. Wherever possible, traps will be mounted near the bottom of the junction boxes to maximize sample collection. The trap will be mounted so that the mouth of the sample bottle is just above the baseflow level to sample only storm flows. In pipes and other locations, the traps will be installed at the lowest point in the pipe. Sampling locations will be selected to avoid small diameter pipes (e.g., less than 24-inch diameter) because a large storm event is generally needed in these systems to inundate the approximately 8-inch tall sample bottle. A typical installation is shown in Figure 8-2.

Traps will be deployed for approximately 12 months. Following initial deployment, traps will be checked after about 3 months and after significant events to evaluate their condition (e.g., damage and sediment volume). Installations will be repaired if any damage does occur.

Trap samples will be retrieved following PSEP (1997) sample handling guidelines. Gloves will be worn at all times when collecting sediment samples. The sample bottles will be capped in place with a clean Teflon lid, removed from the bracket, stored in a cooler on ice, and transported directly to the analytical laboratory. Clean Teflon bottles will be immediately redeployed for the next 12-month sampling period. Descriptions of field observations (e.g., potential construction activities that could interfere with sample collection) and sample characteristics (e.g., sheen, odor, color, amount and type of particles being removed, size description) will be included in the field notes recorded during sample collection.

If traps need to be removed during the year (e.g., construction activities occurring in the pipe), the sample bottles will be kept refrigerated until they can be reinstalled in the pipe section. If the samples will not be reinstalled prior to collection of the remaining sediment traps, the samples

[19] This outfall uses a sump to collect an annual sediment sample. This is discussed in Section 8.4.2.
[20] Due to tidal influences, a sediment trap cannot be located in this basin.
[21] When feasible, two traps will be located at each site to provide additional sample volume. The outfall traps are the highest priority for receiving two traps.

will be analyzed immediately after the traps are removed or frozen (per PSEP (1997) guidelines) and analyzed with the other sediment traps.

8.4.2 Manhole 390 Sump (OF245)

Manhole 390, manhole sump, is located immediately upstream of OF245. This sump functions similarly to a catch basin and sediment traps (Figure 8-3).

Each year, a measurement of accumulated sediment will be obtained and recorded prior to cleaning of the sump. The sump will be inspected periodically throughout the sampling period and to determine the depth of accumulated sediment. In the event that the sump needs to be cleaned out prior to the end of the sampling period, the City will clean the sump and collect a sediment sample as described above and freeze this sample. When the sediment traps are collected, the sump will be cleaned and a second sediment sample will be collected. The first sample will then be composited with the second sample. The two samples will represent a composite sump sample that is collected over the same time period as the sediment trap samples.

Thirty random samples[22] are taken directly from the sump using a Ponar sampling device. These subsamples are then well mixed in a bowl prior to placing in the sample containers. If too much sediment is present in the sump to allow for a representative sample to be collected using the Ponar sampling method, the sediment will be well mixed using a high pressure truck water hose. After mixing with the high-pressure water, several aliquots will be collected at random locations, well-mixed in a stainless steel bowl, and the composite placed in two sample containers.

In addition, the protocol has been modified such that the MH390 sample is analyzed immediately after collection and not frozen and held to analyze with the sediment trap samples.[23]

After sampling is completed, the sump will be cleaned out to ensure that the stormwater sediment represents each discrete annual sampling period.

8.4.3 Stormwater Sediment Trap/Sump Sample Processing

Processing of stormwater sediment trap/sump samples will be performed following the specific procedures developed for the 2001 Foss SAP. Processing of the samples is accomplished using stainless steel utensils. These utensils are decontaminated prior to use in accordance with the City's laboratory SOP.

Analysis of the sediment trap samples is performed on the solids fraction of the collected sample. In order to separate the liquid fraction, the sediment samples are processed in accordance with the revised July 27, 2011 laboratory SOP, Foss Waterway Sediment Trap Sample Handling.[24] The process used is:

1. A portion of the overlying water is decanted and retained.

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[22] If insufficient volume exists for 30 samples, a lesser number of subsamples will be collected.
[23] If workload conditions do not allow for immediate analysis, the sample may be frozen followed PSEP (1997) guidelines.
[24] This revised SOP is an update to the March 25, 2005 Foss Waterway Sediment Trap Sample Handling laboratory SOP. The 2005 SOP was referenced in the 2001 Foss SAP.

2. Remaining water and sediment are slurried and then dispensed into Teflon cups. The retained water from step 1 is used to wash out the remaining solids in the sample container.
3. The sample is centrifuged for fifteen minutes at 2000 RPM or until the decanted overlying water is visually clear. The overlying water is then decanted and discarded.
4. The remaining solid portion is transferred to the appropriate containers and then submitted for analyses.

No part of the sample, in particular the liquid fraction, is discarded without being centrifuged. All particles that can be removed are removed and retained with the solid fraction for analyses.

9.0 MEASUREMENT PROCEDURES

This section describes the analytical methods to be used for each parameter, the reporting limits for each parameter, the frequency of analysis, number of samples to be analyzed, needed sample volume, container type, holding time, and preservation.

The selected laboratory will be accredited under by the Washington Department of Ecology Laboratory Accreditation Program for the parameters to be analyzed.

9.1 ANALYTICAL METHODS, REPORTING LIMITS, AND CONTAINERS

Table 9-1 and Table 9-2 present sample container type, holding time, preservative and reference for each required parameter for stormwater and sediment samples, respectively. NPDES-only parameters[25] that are below reporting limits for two years may be dropped from the analysis list.

Sediment trap samples are prone to matrix interferences. Multiple cleanup procedures are documented in the SW-846 to mitigate the interferences. The laboratory employs cleanup procedures and sample dilution to meet project reporting limit goals and provide data to meet the project QC requirements. Cleanup procedures are documented in the laboratory SOPs.

9.2 SAMPLE VOLUME REQUIREMENTS

9.2.1 Whole-Water

A significant sampling design concern is the ability to obtain adequate sample volume to complete the selected analyses. This section discusses the selected parameters, the volumes required to analyze those parameters, and the priority order in which analyses will be done. Table 9-3 summarizes the estimated volumes needed for stormwater analytical chemistry samples.

If the volume of stormwater sample collected from a qualifying storm is insufficient to allow analysis for all parameters listed in Table 3-1, the sample shall be analyzed for as many parameters as possible in the priority order identified in Table 9-4. If insufficient sample exists to run the next highest priority pollutant, that analysis should be bypassed and analyses run on lower priority parameters in accordance with the remaining priority order to the extent possible.

9.2.2 Sediment

Adequate volume to perform sediment analysis is outlined in Table 9-3. If the volume of sample for outfall sediment traps collected is insufficient to allow analysis for all parameters listed in Table 3-2, the sample shall be analyzed for as many parameters as possible in the priority order in Table 9-5. If the volume of sample for upstream sediment traps collected is insufficient to allow analysis of all the parameters listed for that trap in Table 3-3, the analyses shall be prioritized based on source tracing priorities in consultation with the Program Manager or his/her designee.

[25] Parameters that are only required as a part of the Permit and not as part of the Foss CD.

10.0 QUALITY CONTROL

This Section discusses the quality control samples needed (i.e., field splits, trip blanks, field blanks, temperature checks, etc.) to be collected in the field and the laboratory. Detailed laboratory QC requirements are contained within the laboratory Quality Assurance Manual, which will be reviewed by the Program Manager. The MQOs or criterion specified for each QC sample result is summarized in Figures 6-1 and 6-2. Sections 10.1 and 10.2 specify the frequency of quality control samples.

10.1 ANALYTICAL QUALITY CONTROL

Laboratory analytical quality control (QC) procedures involve the use of four basic types of QC samples. QC samples are analyzed within a batch of client samples to provide an indication of the performance of the entire analytical system. Therefore, QC samples go through all sample preparation, clean up, measurement, and data reduction steps in the procedure. In some cases, the laboratory may perform additional tests that check only one part of the analytical system. Table 10-1 contains the types of laboratory quality control samples and their frequency.

As noted in Table 10-1, the City laboratory will analyze a CRM sample once per year. The CRMs will be selected to represent a similar matrix as the sediment trap samples and will undergo the same laboratory extraction and analytical procedures as used in the sediment trap analyses. CRM are not commonly available for all analytes tested, though at least one CRM will represent each analyte 'group', such as PAHs.

10.2 FIELD QUALITY CONTROL

Field quality control procedures involve the use of duplicates (or field replicates) and blanks. The collection frequency for these types of samples is listed below.

- A duplicate will be taken from the composite (as a split) at a rate of 5% for each sample container and analysis (surface water and sediment). Due to difficulties of sampling within pipes, a minimum of one complete field duplicate (replicate automated sampler) will be executed per year. Additional field duplicates will be collected as circumstances allow.
- A trip blank will accompany sample events for Total Petroleum Hydrocarbons (TPH) and will be submitted from successfully sampled storms. TPH is collected as a grab sample.
- Equipment will not be cleaned in the field. Each piece of equipment, which is not certified pre-cleaned by the manufacturer, will be subjected to at least one equipment rinsate blank per year immediately before annual tubing replacement.
- Two field blanks will be conducted by field crews to estimate atmospheric/operations contributions of contaminants, including dissolved metals, bacteria and nutrients.
- Each bottle and container will be subjected to two blanks per year.

11.0 DATA MANAGEMENT PROCEDURES

This Section discusses data management, which addresses the path of data from recording in the field or laboratory to final use and archiving. The data management and documentation strategy combines the use of Standard Operating Procedures (SOPs) that specify documentation needs and provide for consistency when collecting, assessing, and documenting environmental data and electronic storage of all documents and records on servers that are regularly backed up.

Documents will be archived in portable document format (pdf) on City's network server. Data will also be managed and archived on City's network server. These documents and all data will be maintained in accordance with CD requirements.

11.1 DOCUMENTS AND RECORDS

Four types of documentation will be managed: (1) field operation records; (2) laboratory records; (3) data handling records; and (4) QAPP revision documentation.

11.1.1 Field Operation Records

Field operation records may include:

- Go/No-go event report
- Discharge measurement notes (when collected)
- Level notes (when collected)
- Data sheets and field notes
- Photographs taken of the described activities (when taken)
- Calibration & maintenance notes

Water quality sampling – During each pre- and post-storm site visit to each monitoring station for water quality sampling, the following information will be recorded on a waterproof standardized field form:

- Site name
- Date/time of visit and last sample collected
- Name(s) of field personnel present
- Weather and flow conditions
- Logger battery voltage
- Rain gauge condition, if applicable
- Desiccant condition
- Number of aliquots (if sampled)
- Sampling errors? (if sampled)
- Sample duplicated? (if sampled)
- Estimated sample volume (if sampled)

- Log of photographs taken (if abnormal conditions are observed)
- Presence of obstructions in primary measurement device or sample tubing and remedial actions taken
- Unusual conditions (e.g., oily sheen, odor, color, turbidity, discharges or spills, and land disturbances)
- Deviations from approved sampling procedures

Sediment Trap or Sediment Monitoring – During site visits made for sediment sampling related to this study, field personnel will record the following information on a waterproof standardized field form:

- Date and time of sample collection or visit
- Name(s) of sampling personnel
- Weather conditions
- Number and type of samples collected
- Location of each sample
- Sediment depth at each sample location
- Color, odor, and grain size characteristics of each sample
- Log of photographs taken
- Unusual conditions (e.g., water color or turbidity, presence of oil sheen, odors, and land disturbances).
- Deviations from approved sampling procedures

11.1.2 Laboratory Records

Internal and contract laboratories will be required to provide a Tier II Data Package as defined by the EPA, Contract Laboratory Program. The data package will be provided to the QA Coordinator and will be available to EPA and Ecology.

A hardcopy and electronic (PDF) report for each analysis suite to include:

- What analyses were performed and what results were obtained,
- That the data had acceptable properties (such as accuracy, precision, method reporting limits),
- That the analyses were done under acceptable conditions (such as calibration, control, custody, using approved procedures, and following generally approved good practices), and
- That the SOW was otherwise followed.

The data package will report the test results clearly and accurately. The test report will include the information necessary for interpretation and validation of data and will include the following:

- Report title
- Name and address of laboratory

- Name and address of client and study name
- Subcontractor results clearly identified
- Description and unambiguous name of tested sample
- Date and time of sample collection, date of sample receipt, and date and time of analysis
- Identification of test method
- QC results for method blank, MS/MSD, LCS, calibration and other as appropriate
- An explanation of failed QC and any non-standard conditions that may have affected quality, including corrective actions and plan to prevent loss of quality
- A signature and title of laboratory director or designee
- Chain of Custody and sample receipt forms

Internal laboratories will allow direct access of the Quality Assurance Coordinator (QAC) to the LIMS, including all QA/QC results. The QAC will not have author rights to alter data in the LIMS system but may further censure data beyond laboratory recommendation, in compliance with standard operating procedures and following consultation with the Laboratory Manager and Program Manager.

Contract laboratories will provide the Tier II data package in hardcopy and as an Excel or database uploadable file. If a contract laboratory is unable to provide an electronic file, the data will be manually entered into the City laboratory's database.

11.1.3 Data Handling Records

This section describes the approach for record control and storage of each sampling event. All documents associated with a sampling event will be stored electronically and as paper copies in accordance with the Foss CD document retention requirements. Each sampling event will be documented with the following records:

- Field Datasheet
- Chain of Custody (COC)
- Field QA Report
- Data Package
- Data Validation Memo
- Electronic Data Deliverable with Quality & Usability Flags

All documents will be provided in PDF with the exception of the flow data and the Electronic Data Deliverable, which will be in Excel format. Continuous flow data will be retained electronically on Tacoma's network server in accordance with the Foss CD document retention requirements.

11.2 REVISIONS TO THE QAPP

In the event that significant changes to this QAPP are required prior to the completion of the study, a revised version of the document shall be prepared and submitted to Agencies for review. The approved version of the QAPP shall remain in effect until the revised version has been approved.

Justifications, summaries, and details of changes to the QAPP will be documented and distributed to all persons on the QAPP distribution list by the Program Manager.

Minor changes to the QAPP shall be discussed in the annual reports and included in the next revision to the QAPP.

12.0 AUDITS AND REPORTS

This section discusses assessment, response actions, and corrective actions to ensure all data is being collected as described in this QAPP. This section also describes the reports that are prepared under this plan.

12.1 AUDITS

In order to detect potential deficiencies in the hydrologic and water quality data that will be collected under this QAPP, audits will be performed. For hydrologic data and sample collection data, these audits will occur following each storm event. Any issues are documented in the event field report. These audits will involve comparing the data from the storm event to previous data to determine if there are any data quality issues. Data will be reviewed for gaps, anomalies, or inconsistencies between the flow data and previous events and against calibration field visits to the sites.

Water quality data will be audited quarterly to ensure that data are consistent, correct, and complete, and that all required quality control information has been provided. Quality control elements for the data (Figures 6-1 and 6-2) and raw data will also be examined to determine if the MQOs for the project have been met.

12.2 DEFICIENCIES, NONCONFORMANCES AND CORRECTIVE ACTION

The Program Manager is responsible for implementing and tracking corrective action procedures because of audit findings. Records of audit findings and corrective actions are maintained by the laboratory QA manager (chemistry), quality assurance coordinator (QAC) for field actions and Program Manager.

Deficiencies are defined as unauthorized deviation from procedures documented in the QAPP. Nonconformances are deficiencies that affect quality and render the data unacceptable or indeterminate.

Field deficiencies and nonconformances are documented in sample logbooks and summarized in the yearly validation report. Additional deficiencies and nonconformance may be found during regular audits. Any deficiencies or nonconformances are reported to the sample lead, QAC and project manager; and corrective actions are applied (when possible) in a timely manner. Deficiencies and nonconformance examples include,

- Deficiencies
  - Chain of custody deviation such as incorrect sample time, resulting in holding time exceedances.
  - Conducting field Quality Control sampling at a rate less than described in the QAPP.
  - Non-reporting of conductivity or pump breakdown, resulting in loss of sample opportunities.
- Nonconformance
  - Drifting water level measurements that go uncorrected to the point that data is significantly biased.

- o Loss of flow data to accompany chemistry in calculation of an event mean concentration.
- o Preservation of nitrogen samples with incorrect (nitric acid) preservative.

The City laboratory has corrective actions forms that are prepared when corrective actions are required. These corrective actions are generally associated with analytical problems. The forms require a statement of the problem that initiated the corrective action and the corrective action that was taken. The form is then reviewed and signed by the supervisor over that section, the QC officer, and the Laboratory Manager. These corrective procedures are outlined in the laboratory's QA manual. Corrective action forms are filed with data packages and are available for review at any time. Corrective action forms or the action taken associated with them would be discussed in the narrative where appropriate. Corrective action forms will not be included in the standard data packages.

12.3 REPORTING

Reports that will be generated for this program include storm field reports, quality assurance/quality control summary, and the annual report.

12.3.1 Storm Field Report

For each sampling event, a written field report will be prepared by the City documenting the sample processing including collection and handling of samples. At a minimum, the following will be included in the storm field reports for whole water samples:

- Description of each sampling event including date, time, antecedent and rainfall data, tidal windows, storm duration (water samples only)
- Comparison to rainfall event goals (see Section 7.2.1)
- Description of sample collection and composting at each location
  - o Plot of flow hydrograph and aliquot number subsample collection time
  - o Tidal window
  - o Identify total number and which subsamples were composited
  - o Specific conductance of that subsample (water samples only)
  - o Settings/sampler results reports.
- Description of each sampling event including dates of installation and retrieval and total rainfall during that period
- Field observations
- Deviation of field procedures

The Field Reports will be submitted with the annual report.

12.3.2 Quality Assurance/Quality Control Summary

The QA/QC summary will include at a minimum:

- A case narrative for each sampling event that includes: (a) a narrative analysis of appropriate field quality control procedures, data quality indicator results and of any associated issues and corrections made, and (b) a narrative analysis of appropriate laboratory quality control procedures with measurement quality objectives discussed, any associated issues and corrections made.

- A summary Quality Assurance Report, which includes:
  - Chain-of-custody procedures used, and explanation of any deviations from the sampling plan procedures.
  - Summary of the data quality assurance results from all sampling events completed during the year (i.e., were data quality objectives met and, if not, why not).
  - An overall assessment of the usability and representativeness of the data.
  - A summary description of any planned changes or deviations from the approved QAPP to address problems encountered during QA/QC.
  - Corrective actions reported/taken.

The Quality Assurance/Quality Control Summary will be submitted with the annual report.

12.3.3 Annual Report

An annual report is required to be submitted on March 31st of each year as a part of the Permit (Appendix 9) and the Foss CD. Each report will contain all the monitoring data collected during the previous water year (October 1 through September 30). As appropriate, the reports will integrate data from earlier years into the analysis of results.

Annual Reports will be submitted in both paper and electronic form and will include:

- A brief summary of each monitored drainage basin, including any changes within the contributing drainage area or changes to the monitoring station that could affect hydrology and/or pollutant loading.
- Protocols used during sampling and testing, and an explanation of any deviations from the sampling plan protocols.
- A description of each flow-weighted composite and grab sample event, including:
  - Whole-water and sediment trap field report (see Section 12.3.1).
  - Precipitation data (in inches) including antecedent dry period and rainfall distribution throughout the event.
  - Flow and hydrograph data including sampled and total runoff time periods and volumes.
  - Total number of qualifying storm events captured and analyzed at each monitoring location.
  - Distribution of storms collected between wet and dry seasons (permit goals include 60-80% of storms during the wet season and 20-40% of storms during the dry season).
  - A rainfall/runoff relationship table used to estimate the un-sampled storm events.
  - Whether or not any chemicals were removed from the list of analysis due to two years of non-detect data.
  - A brief summary with storm event dates where insufficient volumes were collected. Include the parameters analyzed.

- A description of the sediment sampling event, including:
    - o Whether or not any chemicals were removed from the list of analysis due to two years of non-detect data.
    - o A summary of sediment sampling (including dates) where insufficient volumes were collected. Include the parameters analyzed.
- Event Mean Concentrations (EMCs)
- The wet and dry season pollutant loads and annual pollutant load based on water year for each discharge monitoring location expressed in total pounds, and pounds per acre. Include the following:
    - o For storm events where water quality samples were collected, the load in pounds per day for each parameter for each sampled storm event, include date of storm events.
    - o An estimated seasonal pollutant load for each parameter at each discharge monitoring location. This is calculated using all storm events (when water quality samples were collected and when samples were not collected).
    - o A total annual pollutant load (wet season load + dry season load) for each parameter (include estimated events).
    - o The rainfall/runoff relationship including the pollutant load estimates for un-sampled events.
    - o Note that if any data is unavailable to effectively estimate the rainfall to runoff relationship due to an incomplete water year, this information will be submitted in the next year's stormwater monitoring report.
- An explanation and discussion of results from each successfully sampled qualifying storm event at each discharge monitoring location and sediments collected at each discharge monitoring location, including:
    - o A statistical analysis of the event mean concentrations for each parameter and a narrative description of significant findings from this analysis.
    - o Any conclusions based on data from this study including analyses of previously collected data from these discharge monitoring locations.
- A description of stormwater management program/source control activities which occurred, are currently taking place, or are planned within the monitoring station's drainage area that may have affected or may potentially affect future monitoring results.
- A description of any minor changes made to the sampling program. Significant changes must be documented in a revised QAPP.

Once three years of data has been collected for each analyte or indicator compound (see Section 14.3), the Annual Monitoring Report shall include:

- Trend analyses (see Section 14.3),
- An evaluation of the data as it applies to the Stormwater Management Program (SWMP) (Tacoma 2010), and
- Any stormwater management activities the Permittee has identified that can be adjusted to respond to this data.

13.0 DATA VERIFICATION AND VALIDATION

This element describes the procedures used to determine if the MQOs established in Section 6.3 for the six data quality indicators have been met. The intent is to ensure data of known and documented quality and quantity to meet the use for which they are intended.

The quality of the data is indicated by data qualifier codes, notations used by laboratories and data reviewers to briefly describe, or qualify, data and the systems producing data. Laboratory data qualification generally follow EPA's Superfund Methods of Organic and Inorganic Data Review (http://www.epa.gov/oerrpage/superfund/programs/clp/guidance.htm).

During data review, verification, and validation, results are either accepted or reported with data qualifiers or flags. Data that meet all QC acceptance limits are potentially usable and are not qualified. Data that fail one or more QC criteria are qualified as estimated (with the J flag) or rejected (with the R flag). The distinction between estimated and rejected data resides in the degree of the QC failure and is highly dependent upon the reviewer's understanding of the objectives of the study.

This section discusses data review, verification, and validation. Data will be reviewed, verified, and validated using a Tier II data review level[26] or higher (Table 13-1).

13.1 DATA REVIEW, VERIFICATION, AND VALIDATION

This section discusses how data are reviewed and decisions made regarding accepting, rejecting, or qualifying data.

For the purposes of this document, data verification is a systematic process for evaluating performance and compliance of a set of data to ascertain its completeness, correctness, and consistency using the methods and criteria defined in the QAPP. Validation means those processes taken independently of the data-generation processes to evaluate the technical usability of the verified data with respect to the planned objectives or intention of the study. Additionally, validation can provide a level of overall confidence in the reporting of the data based on the methods used.

All data obtained from field and laboratory measurements will be reviewed and verified for conformance to study requirements, and then validated against the measurement quality objectives, which are listed in Section 6. Only those data that are supported by appropriate quality control data and meet the measurement performance specification defined for this study will be considered acceptable and used in the study.

The procedures for verification and validation of data are described in Section 13.2 below.

13.2 VERIFICATION AND VALIDATION METHODS

All data will be verified to ensure they are representative of the samples analyzed and locations where measurements were made, and that the data and associated quality control data conform to study specifications. The data verification procedures will generally include:

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[26] Tier II is equivalent to EPA Stage 2b data validation.

- Storm event verification (i.e., did the sampling event meet the established storm criteria);
- Sampler verification (i.e., did the sampler collect a valid flow-paced or time-paced sample and capture the appropriate storm volume);
- Flow data verification (i.e., does the flow volume look appropriate based on the rainfall total);
- Field QC (i.e., did we collect samples at appropriate frequency and did they meet the established control limits); and
- Laboratory QA/QC (i.e., did the lab meet method quality objectives).

14.0 DATA QUALITY (USABILITY) ASSESSEMENT

This element describes the procedures used to determine if the MQOs established in Section 6.3 have been met. The intent is to obtain data of known and documented quality of sufficient quality and quantity to meet the use for which they are intended. During the data usability assessment, data that are believed to be completely unusable with a high degree of confidence (e.g., because of the gross failure of QC criteria) are qualified as rejected and would not normally be used to support decisions for an environmental study.

This section describes the process for determining the data usability, the method for data reduction, and the process for assessing the data quality. The methods and procedures that will be used to determine if the DQO's established in Section 6.1 have been met and to prepare presentation of the study results are discussed. The purpose of this process is to determine if the decision (or estimate) can be made with the desired confidence, given the quality of the data set.

Usability is defined as a qualitative decision process whereby the decision-makers evaluate the achievement of measurement quality objectives and determine whether the data may be used for the intended purpose.

Data reduction is the process of converting raw data to results. Study-specific data reduction methods are designed to ensure that data are accurately and systematically reduced into a usable form.

Data Quality Assessment (DQA) is the scientific and statistical evaluation of data to determine if data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use.

14.1 DATA USABILITY ASSESSMENT

Usability is defined as a qualitative decision process whereby the decision-makers evaluate the achievement of measurement quality objectives and determine whether the data may be used for the intended purpose. Three levels or classes of data quality are used:

- **Accepted** – Data conform to all requirements, all quality control criteria are met, methods were followed, and documentation is complete.
- **Qualified** – Data conform to most, but not all, requirements, critical QC criteria are met, methods were followed or had only minor deviations, and critical documentation is complete.
- **Rejected** – Data do not conform to some or all requirements, critical QC criteria are not met, methods were not followed or had significant deviations, or critical documentation is missing or incomplete. The results are unusable.

Data usability assessment is a more complex and comprehensive activity than data review or validation and is usually performed by the end user (rather than by the data reviewer) because the data user typically possesses a greater understanding of the study's DQOs (e.g., because of a more extensive knowledge of the study's history). Therefore, the end user must ultimately determine the acceptability of the data. However, this does not imply that the end user may apply qualified data in an indiscriminate fashion.

Tentatively rejected data must not be used to support study decisions unless the data user presents (i.e., documents) some technical rationale for doing so. In other words, tentatively rejected data must ultimately be rejected (e.g., using the R flag) in the absence of a scientifically defensible rationale to do otherwise. Furthermore, when data qualified as tentatively rejected are used to support decisions for a study, the data reviewer should be consulted for a consensus unless it is clear that the reviewer did not possess a complete understanding of the objectives of the investigation (e.g., new DQOs were established after the data review was performed).

Ideally, estimated (i.e., J-qualified) data, though presumed to be usable by the data reviewer, should be accepted by the end user only after the reasons for the data qualifications and their impact on the achievement of study DQOs have been examined.

The usability assessment includes assessment of potential outliers, confirmation that the data is comparable and representative, and calculation of the completeness:

- Identification of outliers from the previous quarter's data collection efforts,
- Confirmation of outliers from previous data collection efforts when sufficient data is available to complete the outlier test,
- Confirmation of the comparability of the data,
- Confirmation of the representativeness of the data,
- Calculation of the completeness for each dry and wet season for the water year to date, and
- Definitions for each DQI can be found in the Glossary as well as the equation for calculating completeness.

14.2 Data Quality Assessment Metrics

The data quality assessment process determines whether the sampling and analytical program has fulfilled the project objectives, including the DQOs established in Section 6.1, and whether the data can be used to support project management decisions with the desired level of confidence.

Data quality assessment is a professional judgment based on several lines of evidence:

- **Laboratory Data Validation Results**. This metric evaluates laboratory data quality, i.e., the extent to which MQOs for accuracy, precision, sensitivity, and bias have been met during laboratory analysis, as determined by the data validation process (see Section 13).
- **Field and Laboratory Completeness**. This metric evaluates data quantity, i.e., the extent to which the QAPP-specified number of valid field and laboratory measurements has been obtained and whether field and laboratory completeness goals have been achieved.
- **Sample Representativeness**. The degree to which the monitoring program provides a representative sample of the physical-chemical characteristics of stormwater and sediment in space and time will be evaluated. An assessment as to whether the data are suitably representative of the spatial characteristics of the drainage area (i.e., land use, gradient, ground cover, etc.) will be performed, as well as the time-varying

characteristics of stormwater within an individual storm event (i.e., adequate sampling of the runoff hydrograph and time of concentration) and between storm events (i.e., seasonal changes throughout the monitoring year, baseflow versus storm flow), and the representativeness of the weather and hydrology during the monitored year(s) compared to an average or "normal" year.

14.3 DATA ANALYSIS METHODS

This section describes the statistical analysis procedures to be used to monitor the temporal trends in contaminant concentrations from stormwater discharge to the Foss Waterway. The discussion begins with an evaluation of long-term trends in the changes of pollutant concentrations being discharged from specific outfalls to the waterway.

14.3.1 Assumptions

The 2001 Foss SAP (Tacoma 2001) made a series of assumptions with regard to the ability to discern trends in concentrations. These assumptions were the basis of the number of samples per year (originally 10, then reduced to 8 for west side and 3 east side for the start of WY2012). Key statistical assumptions are:

- The desired statistical significance α of trends determination of 0.10
- The desired statistical power of trends determination is 0.80
- Null hypothesis for trend detection is that there is no change in chemical concentration at an outfall over time

In the event that number of samples per year under the Foss requirements (not NPDES) is proposed to be changed (outside the methodology described in Section 7.2.4), the original assumptions in Section 9.3.1 of the 2001 Foss SAP (Tacoma 2001) will be revisited.

14.3.2 Summary Statistics

For each detected chemical at each outfall, the following summary statistics will be calculated for stormwater and sediment trap data sets:

- Number of samples analyzed
- Number and percentage of samples with detected concentrations
- Arithmetic mean concentration
- Standard deviation of the arithmetic mean
- Percent coefficient of variation
- Minimum and maximum concentrations
- Median concentration (50^{th} percentile)
- 10^{th} and 90^{th} percentile concentrations
- 95^{th} percentile upper and lower confidence limits of the arithmetic mean and the median (N>20; see Gilbert [1987], p.141)

Summary statistics will be calculated each year for the current monitoring year as well as for the entire duration of the monitoring program. In addition, the following hydrologic parameters will be tabulated for each sampled storm event:

- Rain depth (inches)
- Average storm intensity (inches/hour)
- Antecedent dry period (hours)
- Event-average and peak flow (cfs)
- Total runoff volume (acre-feet)

14.3.3 Key Constituents

Graphical presentations and trending statistics will be performed for key constituents of interest[27]. For whole-water, key constituents include the following analytes:

- Total suspended solids (TSS)
- Metals: Total copper, total lead, and total zinc
- Bis(2-ethylhexyl)phthalate (DEHP)
- Phenanthrene (a low-molecular weight PAH)
- Pyrene and Indeno(123-cd)pyrene (high-molecular weight PAHs)

For sediment, key constituents include the following analytes:

- Metals: Total lead, total mercury, and total zinc
- TPH-Oil
- DDT
- Butylbenzylphthalate and bis(2-ethylhexyl)phthalate (DEHP), and total phthalates
- Phenanthrene (a low-molecular weight PAH)
- Pyrene and Indeno(123-cd)pyrene (high-molecular weight PAHs)
- Total PCBs

14.3.4 Graphical Data Presentation

Graphical data presentations will be prepared for key constituents of interest (Section 14.3.3) in the Thea Foss Waterway. Box-and-whisker plots will provide a graphical representation of spatial and temporal trends in stormwater quality. Box-and-whisker plots will be generated using SYSTAT® Version 13, IDL by Exelis, or a suitable substitute. These plots will display the following characteristics of the data distributions:

- Interquartile range, or IQR (data between the 25^{th} and 75^{th} percentile)
- Median and arithmetic mean
- Moderate outliers (more than 1.5 x IQR above the 75^{th} percentile, or below the 25^{th} percentile)

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[27] The compounds were selected as indictors due to their high presence of detection and due to the challenges in performing statistical analyses on all analyzed compounds. Graphical presentation and trending analyses will only be prepared for these analytes.

- Extreme outliers (more than 3 x IQR above the 75th percentile, or below the 25th percentile)

The following box-and-whisker plots will be prepared:

- Outfall-to-outfall comparison – stormwater (land use differences)
- Wet season versus dry season comparison (seasonal differences)
- Year-by-year comparisons within a given outfall (long-term trends)

In addition, time-series scatter plots of the key constituents (identified above) in stormwater will be prepared with annotation to delineate the different monitoring years, and the wet and dry seasons within each monitoring year. Time-series plots, as well as box plots, will include comparable data collected back to August 2001.

Evaluation of box plots and time-series graphs will initially be qualitative in nature. Possible trends will be preliminarily identified by visual inspection, to be confirmed with more quantitative statistical tests, as described below in Sections 14.3.6 and 14.3.7.

14.3.5 Treatment of Non-Detected Values

The analytical laboratory will be required to report estimated values for any detections between the Method Detection Limit (MDL) and the reporting limit (RL), with appropriate data qualifiers (e.g., J-flags). For general summary statistics, undetected values will be substituted at one-half the MDL.

14.3.6 Identification of Outliers

Outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. It should be noted, however, that lognormal data distributions can tolerate relatively extreme high values, and nonparametric tests are relatively insensitive to the magnitude of the outlier concentration. Thus, it may be possible to select statistical tests that minimize the impacts from outliers.

Moderate outliers (deviations greater than 1.5 times the IQR) and extreme outliers (deviations greater than 3 times the IQR) will initially be identified in the box plots described in Section 14.3.4. Other types of outlier tests may be selected based on the recommended methods in Section 4.4 of the EPA document "Guidance for Data Quality Assessment" (EPA/600/R-96/084).

Outliers will not be removed from any data set unless there is supporting information to indicate the outlier was caused by an unusual and non-representative event. Such events could include acts of nature (e.g., fire, landslide) or man-made events, such as extensive land disturbance from an unexpected construction activity. The impact the outlier has on the statistical processing of the data will be evaluated. The information will be discussed with Ecology before any decisions are made whether to include or exclude any outlier data points.

14.3.7 Statistical Distribution Testing

To verify the appropriateness of using parametric statistical tests, including analysis of variance (ANOVA) and various regression techniques, conformance of stormwater and storm sediment data with standard statistical distributions (e.g., normal or lognormal distributions) should be demonstrated. Statistical distribution testing will generally follow *Statistical Guidance for Ecology Site Managers* (Ecology 1992, 1993) using the *MTCAStat* program.

Coefficients of determination and lognormal test results for Tacoma's stormwater monitoring data from 2001 through 2012 are shown in Table 14-1. Forty-eight of the 52 data sets showed excellent conformance to lognormal distributions, with coefficients of determination greater than 0.90, and in no case did the coefficient drop below 0.86. These results indicate there is a high likelihood that Tacoma's stormwater monitoring data is lognormal in character. Therefore, parametric statistics will be used on stormwater data.

Coefficients of determination and lognormal test results for Tacoma's sediment monitoring data from 2001 through 2012 are shown in Table 14-2. Based on this analysis and the fact that at least one sediment trap location for each analyte was not well described by a lognormal distribution, nonparametric statistical tests will be used. Statistical distribution testing will be repeated periodically to evaluate the use of parametric vs. nonparametric statistical tests.

14.3.8 Testing for Spatial Trends

ANOVA will be performed on key constituents of interest (Section 14.3.3) to determine whether or not there are statistically significant differences in stormwater and sediment quality between the outfalls and the land uses they represent. The ANOVA test will help to determine whether stormwater and sediment quality is relatively uniform across drainages, or whether there is reason to believe that certain drainages are unique, i.e., characterized by unusually high or low concentrations.

For data that is well defined by lognormal distributions (e.g., stormwater), ANOVA tests will be conducted using log-transformed data, as described in Zar (1999). The test statistic is the F statistic with n-1 degrees of freedom. If the ANOVA test shows statistically significant differences in stormwater quality between drainages, follow-on tests will be performed to determine which specific drains are higher or lower than normal. These follow-on tests are called pair-comparison tests, or post-hoc tests. The Tukey Test will be used for post-hoc testing.

For data that is well not defined by lognormal distributions (e.g., sediment), a nonparametric ANOVA (Kruskal-Wallis Test) will be performed. The Kruskal-Wallis Test statistic is approximated by the Chi-squared distribution with n-1 degrees of freedom (n = number of stormwater outfalls or drainages). Because it is a nonparametric test, it requires no assumptions about the underlying statistical distribution of the data. The equivalent nonparametric post-hoc test is the Dunn Test (Zar 1999; Tacoma 2007).

If the test for statistical difference is between two populations, for example, a test of wet season versus dry season concentrations, it reduces to a simple T-test (Gilbert 1987).

The ANOVA, Kruskal-Wallis, Tukey, and t-tests analyses will be performed using SYSTAT® Version 13 or equivalent. The nonparametric post-hoc test (Dunn Test) will be performed in Microsoft Excel using the equations in Zar (1999).

14.3.9 Testing for Time Trends - Stormwater

The objective of time trend analysis is to identify particular constituents in particular drains that show evidence of improvement or degradation of stormwater quality over time. Improvements (i.e., decreasing concentrations) can be the result of source control actions in the drainage basins, whereas degrading conditions (i.e., increasing concentrations) may be the result of development or disturbance in the watershed, including the effects of population pressure such as increased urban density and traffic congestion.

14.3.9.a Seasonal Kendall Test

Stormwater time trends will be evaluated using the nonparametric Seasonal Kendall test on key constituents of interest (Section 14.3.3). The use of the Seasonal Kendall test requires that the data be stratified by season. The monitoring year will be divided into two seasons (i.e., wet season from October 1 through April 30 and dry season from May 1 through September 30), as specified in the Permit. The p-value should be less than 0.05 to provide evidence of a significant time trend with 95% confidence.

Time trend analysis (Seasonal Kendall test) will be performed using the freeware Kendall.exe (a DOS executable program that runs under current versions of the Windows operating system) available from the United States Geological Survey (USGS) (http://pubs.usgs.gov/sir/2005/5275/downloads/).

14.3.9.b Regression Analysis

The primary parametric method for time trend analysis is linear regression performed on either the original data or log-transformed data. The magnitude and statistical significance of the slope of the regression line will be calculated for key constituents of interest (Section 14.3.2) and outfalls for which time trends in stormwater quality are indicated based on visual inspection of the data. Nonparametric methods may be preferable for censored data sets or data sets that do not conform to standard statistical distributions. An equivalent nonparametric method for time trend analysis is the Mann-Kendall Test (Helsel and Hirsch 2002). If strong seasonality is evident, seasonality may be controlled using the Seasonal Kendall Test (Gilbert 1987).

The regressions will be performed on key constituents of interest (Section 14.3.3) using Microsoft Excel.

14.3.10 Estimation of Annual Mass Loads

This Section provides methods to calculate seasonal and annual contaminant mass loads for storm flow and baseflow. Annual mass loads will be expressed as pounds per year, and pounds per acre per year.

The mass loading calculations will be performed as described in the Pollutant Loading SOP (Thornburg and Lowe 2009), as modified per the procedures described below to incorporate the basin-specific rainfall-runoff relationship.

- The rain record was separated into discrete storm events based on previously established criteria for threshold rain amounts and antecedent dry periods.
- The hourly rainfall amounts were summed to provide a total rain depth for each storm. The corresponding runoff depth was then estimated from the rainfall-runoff correlations.
- The runoff depths (in inches) were converted to discharge volumes (in acre-feet) by multiplying by the basin area (in acres), with appropriate unit conversions. These were then converted to event mean flow rates by dividing the event discharge volume by the duration of the storm. The storm fraction was calculated as the ratio of the storm flow to the combined storm plus baseflow for each event.
- The total wet season, dry season, and annual discharge volumes were calculated by summing over the appropriate storm events. Mean seasonal storm flow rates were

calculated by dividing the total discharge volume (wet season or dry season volume) by the time period of interest.

- Stormwater concentrations were "unmixed" from the combined flow concentrations (i.e., "as measured" concentrations) using the mass balance equations described in the Pollutant Load SOP. In a few instances, negative concentrations resulted from the "unmixing" calculation. Typically, these instances occurred when there were higher concentrations in baseflow, such that baseflow accounted for all (and more) of the combined storm flow concentration, and in some instances they were an artifact of undetected concentrations with variable detection limits. In any instance where negative "unmixed" stormwater concentrations were calculated, these values were replaced with half the detection limit values (essentially they are equivalent to undetected stormwater concentrations).
- Mean annual stormwater concentrations were calculated as volume-weighted average concentrations. The estimated storm volumes were paired with their corresponding analytical results, and provided the weighting functions for calculating a volume-weighted concentration. A volume-weighted mean rather than a flow weight mean will be used because it is believed to provide a better statistic since it captures the significance of a storm event in terms of both flow *and* duration.
- The mean seasonal and annual baseflow and storm flow rates, the storm fraction in the combined discharges, and the mean annual baseflow and stormwater concentrations were input to the pollutant load worksheet provided in the Pollutant Load SOP. The worksheet calculated the seasonal and annual baseflow and stormwater pollutant loads as per the Pollutant Load SOP.
- Since baseflow is no longer monitored for the Foss, baseflow data from the last water year (WY2011) of baseflow analysis will be used in the calculator.

15.0 REFERENCES

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TABLES

FIGURES

Table 3-1
Surface Water Methods and Detection Limit Goals

Analyte	Analysis Method	Detection Limit Goal	Foss and/or NPDES Parameter
Conventionals			
Anionic Surfactants (MBAS)	SM 5540 C	0.025 mg/L	NPDES
BOD	SM 5210B	2 mg/L	NPDES
Chloride	SM 4500-Cl-E	0.2 mg/L	NPDES
Conductivity	SM 2510B	±1 µS/cm	Foss/NPDES
Hardness	SM 2340B	0.05 mg/L	Foss/NPDES
pH	SM 4500-H	0.1 std units	Foss/NPDES
TSS	SM 2540-D	1 mg/L	Foss/NPDES
Turbidity	EPA 180.1	±0.2 NTU	NPDES
Metals			
Cadmium	EPA 200.8	0.2 µg/L	NPDES
Copper	EPA 200.8	0.1 µg/L	NPDES
Lead	EPA 200.8	0.1 µg/L	Foss/NPDES
Mercury	EPA 245.7	0.1 µg/L	Foss/NPDES
Zinc	EPA 200.8	5 µg/L	Foss/NPDES
Dissolved Cadmium	EPA 200.8	0.1 µg/L	NPDES
Dissolved Copper	EPA 200.8	0.1 µg/L	NPDES
Dissolved Lead	EPA 200.8	0.1 µg/L	Foss/NPDES
Dissolved Mercury	EPA 245.7	0.1 µg/L	Foss/NPDES
Dissolved Zinc	EPA 200.8	1 µg/L	Foss/NPDES
PAHs			
2-Methylnaphthalene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Acenaphthene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Acenaphthylene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Anthracene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Benzo(a)anthracene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Benzo(a)pyrene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Benzo(g,h,i)perylene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Benzo(b,k)fluoranthenes[1]	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Chrysene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Dibenz(a,h)anthracene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Fluoranthene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Fluorene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Indeno(1,2,3-cd)pyrene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Naphthalene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Phenanthrene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Pyrene	EPA 8270D SIM	0.01 µg/L	Foss/NPDES
Phthalates			
Di(2-ethylhexyl)phthalate	EPA 8270D	1 µg/L	Foss/NPDES
Butylbenzylphthalate	EPA 8270D	1 µg/L	Foss
Diethylphthalate	EPA 8270D	1 µg/L	Foss
Dimethylphthalate	EPA 8270D	1 µg/L	Foss
Di-n-butylphthalate	EPA 8270D	1 µg/L	Foss
Di-n-octyl phthalate	EPA 8270D	1 µg/L	Foss
Insecticides			
Carbaryl	EPA 632	0.5 µg/L	NPDES
Chlorpyrifos	EPA 8270D	0.5 µg/L	NPDES
Herbicides			
2,4-D	EPA 8270D SIM	1 µg/L	NPDES
Dichlobenil	EPA 8270D SIM	0.1 µg/L	NPDES
Nutrients			
Total Nitrogen [3]	ATP [3]	0.1 mg/L	NPDES [3]
Nitrate/Nitrite	EPA 353.2	0.01 mg/L	NPDES
Total Phosphorus	EPA 365.4	0.01 mg/L	NPDES
Orthophosphate	EPA 365.1 [2]	0.01 mg/L	NPDES
Total Petroleum Hydrocarbons			
NWTPH-Gx	Ecology97-602	0.25 mg/L	NPDES
NWTPH-Dx	Ecology97-602	0.5 mg/L	NPDES
BTEX	EPA 8620	1 µg/L or 5 µg/L	NPDES
Bacteria			
Fecal Coliform	SM 9221E	2 to 2E6 max	NPDES

[1] *Since the toxicity equivalence factor is the same for both benzo(b)fluoranthene and benzo(k)fluoranthene compounds (WAC 173-340-708(e)),the compounds will be reported as benzo(b,k)fluoranthene in order to be consistent with the over 12 years of Foss monitoring data.*

[2] *Method is not included in Appendix 9, but this is an acceptable method per 40 CFR 136. This is the method that was used for S8.D monitoring under the 2007 Permit. To remain consistent with previous S8.D, the City proposes to keep the same method. The City has received accreditation for this method.*

[3] *Total Kjeldahl Nitrogen (TKN) can be calculated as the difference between Total Nitrogen and Nitrate/Nitrite. Total Nitrogen will be calculated using an Alternative Test Procedure which was approved for use in determining nitrogen in stormwater (Ecology 2013).*

Table 3-2
Sediment Methods and Detection Limit Goals

Analyte	Analysis Method	Detection Limit Goal	Foss and/or NPDES Parameter
Conventionals			
Total Organic Carbon	9060 Mod	0.1%	Foss/NPDES
Grain Size	ASTM D422[4]	NA	Foss/NPDES
Total Solids	SM 2540G	1%	Foss/NPDES
Total Volatile Solids	SM 2540G	0.1%	NPDES
Metals			
Total Recoverable Cadmium	EPA 6020A or 6010	0.1 mg/kg dry	NPDES
Total Recoverable Copper	EPA 6020A or 6010	0.1 mg/kg dry	NPDES
Total Recoverable Lead	EPA 6020A or 6010	0.1 mg/kg dry	Foss/NPDES
Total Recoverable Mercury	EPA 7471B	0.005 mg/kg dry	Foss/NPDES
Total Recoverable Zinc	EPA 6020A or 6010	0.5 mg/kg dry	Foss/NPDES
PAHs[1]			
2-Methylnaphthalene	EPA 8270D	70 µg/kg dry	Foss/NPDES
Acenaphthene	EPA 8270D	70 µg/kg dry	Foss[1]
Acenaphthylene	EPA 8270D	70 µg/kg dry	Foss[1]
Anthracene	EPA 8270D	70 µg/kg dry	Foss[1]
Benzo(a)anthracene	EPA 8270D	70 µg/kg dry	Foss[1]
Benzo(a)pyrene	EPA 8270D	70 µg/kg dry	Foss/NPDES
Benzo(g,h,i)perylene[2]	EPA 8270D	70 µg/kg dry	Foss/NPDES
Benzo(b,k)fluoranthenes[3]	EPA 8270D	70 µg/kg dry	Foss/NPDES
Chrysene	EPA 8270D	70 µg/kg dry	Foss/NPDES
Dibenz(a,h)anthracene	EPA 8270D	70 µg/kg dry	Foss[1]
Fluoranthene	EPA 8270D	70 µg/kg dry	Foss/NPDES
Fluorene	EPA 8270D	70 µg/kg dry	Foss[1]
Indeno(1,2,3-cd)pyrene	EPA 8270D	70 µg/kg dry	Foss[1]
Naphthalene	EPA 8270D	70 µg/kg dry	Foss/NPDES
Phenanthrene	EPA 8270D	70 µg/kg dry	Foss/NPDES
Pyrene	EPA 8270D	70 µg/kg dry	Foss/NPDES
Phthalates			
Di(2-ethylhexyl)phthalate	EPA 8270D	70 µg/kg dry	Foss
Butylbenzylphthalate	EPA 8270D	70 µg/kg dry	Foss
Diethylphthalate	EPA 8270D	70 µg/kg dry	Foss
Dimethylphthalate	EPA 8270D	70 µg/kg dry	Foss
Di-n-butylphthalate	EPA 8270D	70 µg/kg dry	Foss
Di-n-octyl phthalate	EPA 8270D	70 µg/kg dry	Foss
Insecticides			
Bifenthrin	EPA 8270D	1 µg/kg dry	NPDES
PCBs			
Aroclor-1016	EPA 8082	80 µg/kg dry	Foss/NPDES
Aroclor-1221	EPA 8082	80 µg/kg dry	Foss/NPDES
Aroclor-1232	EPA 8082	80 µg/kg dry	Foss/NPDES
Aroclor-1242	EPA 8082	80 µg/kg dry	Foss/NPDES
Aroclor-1248	EPA 8082	80 µg/kg dry	Foss/NPDES
Aroclor-1254	EPA 8082	80 µg/kg dry	Foss/NPDES
Aroclor-1260	EPA 8082	80 µg/kg dry	Foss/NPDES
Nutrients			
Total Phosphorus	EPA 365.4	0.01 mg/kg	NPDES
Total Petroleum Hydrocarbons			
NWTPH-Diesel	NWTPH-Dx	25 mg/kg dry	Foss/NPDES
NWTPH-Heavy Oil	NWTPH-Dx	50 mg/kg dry	Foss/NPDES

[1] Appendix 9 lists 2,6-Dimethylnapthalene, which is not part of the City laboratory's PAH method Instead of reporting 2,6-Dimethylnapthalene, the City will report the acenaphthene, acenaphthylene, anthracene, dibenz(a,h)anthracene, fluorene, and indeno(1,2,3-cd)pyrene to Ecology to fulfill the Permit requirement.

[2] Appendix 9 states perylene. To be consistent with the 2001 Foss SAP, benzo(g,h,i)perylene will be reported.

[3] Appendix 9 only requires benzo(b)fluoranthene. Since the 2001 Foss SAP required the "b" and "k" isomers, this will be reported as benzo(b,k)fluoranthene.

[4] A visual, qualitative determination of grain size shall be reported for all samples (in addition to the quantitative analysis for all samples with sufficient volume)

Table 3-3
Sediment Traps - List of Analytes Location

Outfall ID	Sediment Trap ID	Location	Grain Size	Total Solids	Total Volatile Solids	Total Organic Carbon	Total Phosphorus	NWTPH-Dx	Bifenthrin	Chlorinated Pesticides	Copper	Cadmium	Lead	Mercury	Zinc	PAHs	Total Phthlates	Total PCBs
OF230	FD3-New[a]	South 15th & "A" Street; MH 262 at crest of bridge (31 ft. deep)	Foss/ NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES		NPDES	NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss	Foss/ NPDES
	FD3a	South 15th & Court "A;" MH 21 ft. east of FD3 in brick plaza, under SR 705 off-ramp	Foss	Foss		Foss		Foss					Foss	Foss	Foss	Foss	Foss	Foss
	FD3	South 15th & Court "A;" MH in brick plaza , under SR 705 off-ramp																
	FD3b	Pacific Avenue & Hood Street; MH on sidewalk	Foss	Foss		Foss		Foss								Foss	Foss	
	FD16	South 15th and Market Streets (MH-226)	Foss	Foss		Foss		Foss								Foss	Foss	Foss
	FD16b	Near 609 So. 15th (MH-422) (above Bates Tech. College)																
	FD18	1100 block of Market Street (MH-144) (downtown, near YMCA)	Foss	Foss		Foss		Foss					Foss	Foss	Foss	Foss	Foss	Foss
	FD18b	Tacoma Ave. So. And So. 11th (MH-261) (near County City Bldg and WNG Armory)	Foss	Foss		Foss		Foss					Foss	Foss	Foss	Foss	Foss	
OF235	FD6[a]	East 21st & Dock Street; MH on Dock Street under SR 509	Foss/ NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES		NPDES	NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss	Foss/ NPDES
	FD6a	South 19th and Market; MH in the center of the intersection																
	FD6b	South 21st and Fawcett; MH at NW corner of the intersection																
OF237A	FD2[a]	Dock Street pump station; MH inside pump station yard	Foss/ NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES		NPDES	NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss	Foss/ NPDES
	FD2a	E. 23rd & Dock Street; MH inside Dock Street Pump Station next to power control station.	Foss	Foss		Foss		Foss					Foss	Foss	Foss	Foss	Foss	Foss
	FD13	Off Center Street, alley between Ash and Wilkenson Streets (MH-294)	Foss	Foss		Foss		Foss								Foss	Foss	
	FD13b	So. 23rd and Ferry St. (MH-104) (below major complexes, TNT, AT&T, DSHS)	Foss	Foss		Foss		Foss						Foss	Foss	Foss	Foss	
	FD13b New	In between So. 23rd and Ferry St. upstream from FD13-B (below major complexes, TNT, AT&T, DSHS	Foss	Foss		Foss		Foss						Foss	Foss	Foss	Foss	
	FD5	South 18th & Cedar Street; MH in intersection																
	FD10	BNSF right of way between Cedar and Lawrence Streets (MH-412) (near Nalley's Fine Foods warehouse yard, approximately 500 ft. NE of main office)	Foss	Foss		Foss		Foss					Foss	Foss	Foss	Foss	Foss	Foss
	FD10c	Lawrence Street near Nalley's main Bldg 7, loading dock door (MH-303) (Nalley's processing and shipping yard)	Foss	Foss		Foss		Foss					Foss	Foss	Foss	Foss	Foss	Foss
	FD10b	Near So. Tacoma way and Lawrence street (MH-022) (above Nalley's and picks up major car lots, dealerships, retail complexes, PSE yard) MH behind 3215 STW.	Foss	Foss		Foss		Foss					Foss	Foss		Foss	Foss	Foss
OF237B	FD1[a]	Dock Street pump station; MH inside pump station yard	Foss/ NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES		NPDES	NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss	Foss/ NPDES
	FD30	Tacoma Dome Parking Lot, SW section, (MH459)																
	FD31	East 50 feet at intersection of Pacific and So. 32nd (MH570)	Foss	Foss		Foss		Foss					Foss		Foss	Foss	Foss	
	FD32	Intersection of So. Wright and Pacific Ave (MH576) (main truck line check point)																
	FD33	In front of 5209 Pacific Ave (MH110)																
	FD34	In front of 402 E. 53rd (MH167)	Foss	Foss		Foss		Foss						Foss	Foss			Foss
	FD35	500 Block of E. 56th (MH244)	Foss	Foss		Foss		Foss										Foss
	FD36	E. 72nd and E. D Street (MH234)																
	FD37	7216 E. D street, backyard (MH262)																
	FD38	E. B Street and E. 72nd (MH229)																
OF243	FD23[a]	East 21st & "D" Street; MH in sidewalk on west side of "D" Street (under SR 509)	Foss/ NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES		NPDES	NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss	NPDES
OF245	FD21	457 East 18th Street; CB on East 18th Street near main office (former MPS, now Quality Transport)	Foss	Foss		Foss		Foss					Foss	Foss	Foss	Foss	Foss	
	MH390[a]	SAP #6761877	Foss/ NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES	Foss/ NPDES	NPDES		NPDES	NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss/ NPDES	Foss	NPDES
OF248	FD22[a,b]	East 18th Street; CB downstream of site adjacent to Super Value (West Coast Grocery) warehouse (approximately 510 ft. west of FD21)	Foss	Foss		Foss		Foss					Foss	Foss	Foss	Foss	Foss	

a - Outfall sediment trap
b - Outfall is not a NPDES outfall. Therefore, NPDES analytes do not apply to this outfall trap.
(shaded) Not analyzed for this trap. Historical analyses that are no longer required are shown to indicate changes from 2001 Foss SAP. Incorporates changes from EPA April 23, 2013 letter.

Table 3-4
Total Rain Depth (inches) during Past Monitoring Years

		WY2002	WY2003	WY2004	WY2005	WY2006	WY2007	WY2008	WY2009	WY2010	WY2011	WY2012	WY2002 -WY2012 Average	Historical Monthly Mean NCDC 1971-2000	Historical Monthly Average Mar 1982 - Aug 2009
WET	October	3.32	0.41	8.88	3.61	3.00	1.28	3.64	2.36	4.18	4.64	3.39	3.52	3.39	3.49
WET	November	10.13	2.96	6.15	2.81	6.25	15.81	2.64	7.61	7.74	5.37	5.98	6.68	6.10	6.73
WET	December	6.82	6.58	4.65	4.03	6.28	8.05	8.36	4.03	2.67	6.83	6.44	5.89	5.89	5.65
WET	January	6.68	8.5	6.79	4.71	11.93	6.92	4.63	7.15	7.40	5.17	7.02	6.99	5.38	6.01
WET	February	3.56	1.71	2.55	0.79	2.59	4.09	2.84	1.61	3.95	3.54	3.19	2.77	4.44	3.63
WET	March	4.16	5.08	2.18	3.14	1.91	6.09	4.16	4.68	4.91	6.57	7.11	4.54	4.18	4.09
WET	April	3.64	3.3	0.91	4.74	2.46	1.34	1.76	3.31	2.90	5.13	3.74	3.02	2.87	2.96
DRY	May	1.14	0.55	2.56	3.34	1.56	1.31	1.01	3.03	4.15	3.77	2.33	2.25	2.01	1.93
DRY	June	1.36	0.36	0.64	1.26	2.25	1.44	1.26	0.33	3.05	1.40	2.54	1.44	1.58	1.56
DRY	July	0.42	0.13	0.00	1.16	0.11	1.30	0.26	0.00	0.78	0.74	0.87	0.52	0.86	0.73
DRY	August	0.06	0.29	2.75	0.04	0.00	0.90	2.32	1.04	0.24	0.27	0.00	0.72	0.83	0.88
DRY	September	0.36	0.69	3.26	0.92	0.74	2.22	0.39	2.82	3.93	0.96	0.02	1.48	1.42	1.14
	Wet Season	38.31	28.54	32.11	23.83	34.42	43.58	28.03	30.75	33.75	37.25	36.87	33.40	32.25	32.56
	Dry Season	3.34	2.02	9.21	6.72	4.66	7.17	5.24	7.22	12.15	7.14	5.76	6.42	6.70	6.24
	Total	41.65	30.56	41.32	30.55	39.08	50.75	33.27	37.97	45.90	44.39	42.63	39.82	38.95	38.80

Key:

	Months	*Seasons/Years*
(dark green)	*> 2" above historical monthly average*	*> 8" above historical seasonal/yearly average*
(light green)	*> 1" above historical monthly average*	*> 4" above historical seasonal/yearly average*
(white)	*≤ 1" above/below historical monthly average*	*≤ 4" above/below historical seasonal/yearly average*
(yellow)	*> 1" below historical monthly average*	*> 4" below historical seasonal/yearly average*
(orange)	*> 2" below historical monthly average*	*> 8" below historical seasonal/yearly average*

Table 6-1
MQOs for Hydrological Accuracy and Bias

Measurement Type	Operational Range	Sensitivity	Accuracy measured as %Bias
Discharge	0.05 to 45 cfs	0.05 cfs	50% when 10% < Q < 90% of operational range 35% when 90% < Q < 10% of operational range
Water Level	0.01 to 8 ft	0.01 ft	10%
Precipitation Depth	0.02 to 12 inches	0.02 in	10% tipping bucket volume

Table 7-1
Monitoring Site Basin Characterization Summary

	OF230	OF235	OF237A	OF237B	OF243	OF245	OF254
Represented Land Use	N/A	Commercial	N/A	Residential	N/A	Industrial	N/A
Surface Area Distribution							
Total Area (acres)	557	156	2823	1991	59	39	119
Impervious Estimate (%)	69.7	64.5	54.0	42.1	85.6	90.6	81.6
Land Use Distribution Estimate [1, 2]							
Residential (%)	25.6	2.9	53.8	80.3	0.0	0.0	0.0
Industrial (%)	0.0	0.0	17.7	0.8	65.6	83.8	79.6
Commercial (%)	74.5	96.7	28.5	19.0	34.4	16.2	20.4
Open Space (%)	0.0	0.0	2.4	5.0	0.0	0.0	0.0
Hydrologic Information							
Time of Concentration (minutes)[3]	23	11	62	129	16	18	11
Rain Gauge	NOAA Station Tacoma No. 1						
	RG10						
	RG03						
Rain Gauge Location (latitude/longitude)	47.2472/ 122.4122						
	47.5000/ 122.2600						
	47.6481/122.3081						
Mean Annual Precipitation (in)[4]	38.09						
	34.3						
	35.6						

[1] City of Tacoma Zoning, Street, and Parcel Data using ESRI ArcGIS 9 for calculations – April 2007

[2] Land use is generally grouped into four categories: (1) residential which includes one family, two family, and low density multifamily and may include other/NA; (2) commercial which includes residential commercial, community commercial, downtown commercial, hospital medical, schools, government/public facility and may include other/NA; (3) industrial which includes light and heavy industrial and port maritime/industrial and may include vacant; and (4) open which includes parks/open space and may include vacant residential lots.

[3]The times of concentration were estimated using SBUH methodology (Tacoma 2000). This method is described in the City's Surface Water Management Manual (Tacoma 2003). The Time of Concentration, Tc, is defined as:

T c =L¸k×s 1/2

Where:

Tc = time of concentration (minutes)

L = flow length (ft)

k = velocity factor (ft/s) (value for sheet, shallow and channel flow)

s = slope of flow path (ft/ft)

[4] NOAA Station Tacoma No. 1 52-year record: 1948-1998 (2003).

Table 7-2
Mean Lower-Low Water (MLLW) Tidal Elevations

Outfall	Pipe Size	Baseflow	Flow Rate (cfs)	Outfall Pipe Elevation	Sed Trap Location Elevation	Tidal Influence	Whole Water Location Elevation (MLLW ft.)	Tidal Influence
OF230	60"	Cont.	0.12	3.5	20+	No	7.02	Yes
OF235	41"	Cont.	0.4	4.5	9.5	Yes	9.79	Yes
OF237A	72"	Cont.	2.8	6.8	15	No	15	No
OF237A New	96"	Cont.	4.4	6.8	--	--	11.73	Yes
OF237B	72"	Cont.	8.3	6.8	16.5	No	13.56	No
DA-1 Line	--	--	--	--	--	--	14.61	No
OF243	36"	Tidal	0.4	4.5	5	Yes	5.23	Yes
OF245	18"	Tidal	0.1	2.8	3.5 (sump)	Yes	3.15	Yes
OF254	37.5"	Tidal	0.4	3.5	--	--	4.37	Yes

Notes: All elevations are estimated based on review of plans and visual observations. Baseflow was measured in January and February 2001 for Outfalls 230, 235, 243, 245, and 254. Baseflow for 237A and 237B was measured in October to December 1995 and site is tidally influenced when tide elevation is above the whole water location elevation.
0 feet MLLW tidal Datum is equal to -6.32 feet City of Tacoma Datum

Table 7-3
Sampling Design Summary

	OF230	OF235	OF237A	OF237B	OF243	OF245	OF254	Total
	Composite Stormwater Samples per Year[e]							
# Samples/Year -Required by Foss CD	8[a]	8[a]	8[a]	8[a]	3[a]	3[a]	3[a]	N/A
# Samples/Year - Required by NPDES Permit	8 min 11 max[b]	8 min 11 max[b]	8 min 11 max[b]	8 min 11 max[b]	0 min 11 max[b]	8 min 11 max[b]	0 min 11 max[b]	55[b]
	Grab Samples per Year[e]							
# Samples/Year - Required by Foss CD	0	0	0	0	0	0	0	
# Samples/Year - Required by NPDES Permit	8 min 11 max[c]	8 min 11 max[c]	8 min 11 max[c]	8 min 11 max[c]	0 min 11 max[c]	8 min 11 max[c]	0 min 11 max[c]	55[c]
	Outfall Sediment Trap Samples per Year[e]							
# Samples/Year -Required by Foss CD	1	1	1	1	1	1	0[d]	
# Samples/Year - Required by NPDES Permit	1	1	1	1	0	1	0[d]	
	Upland Sediment Trap Samples per Year[e]							
# Samples/Year -Required by Foss CD	As described in Table 3-3							
# Samples/Year - Required by NPDES Permit	None							

a - Due to the statistical record associated with the Foss program, the number of samples required per outfall under the Foss program shall be increased or decreased based on the procedure outlined in Section 7.2.4. This increase or decrease in sampling frequency under the Foss CD shall not affect the number of samples required by the NPDES Permit (e.g., the NPDES requirements will not change even if fewer samples are required by the Foss CD).

b - The Permit requires a total of 55 composite samples (5 outfalls, 11 samples each). Since the City is monitoring 7 outfalls required to comply with the Foss CD requirements, the City will meet the NPDES requirements by collecting 55 total samples from all 7 outfalls with a minimum of 8 samples (maximum of 11) from 5 of the outfalls . All of the 55 samples collected will be sampled for the full Foss/NPDES analyte list (Table 3-1). Since the City has a strong statistical record for all of the Foss analytes (analytes that have been monitored under the Foss program for over 12 years), the City would likely be able to provide Ecology with a statistical analysis (in accordance with Appendix 9 of the Permit) for all the Foss analytes that demonstrates that the number of samples per year can be reduced for these Foss analytes while still meeting the monitoring goals. For the new NPDES analytes where the City does not have a statistical record, the City feels that providing Ecology with information potentially from more outfalls representing a broader area with slightly fewer samples per outfall is more useful than providing more samples from fewer outfalls. These new NPDES analytes have very limited data available from other stormwater monitoring programs (especially in Washington state). Information about the spatial distribution and the associations with various land uses for these new analytes is more useful than gathering more samples from fewer outfalls since the goal for these new analytes is not necessarily to develop long term trends.

c - The Permit requires a total of 55 grab samples (5 outfalls, 11 samples each). Consistent with the approach for the composite samples, the City will collect 55 total grab samples from all 7 outfalls with a minimum of 8 samples (maximum of 11) from 5 of the outfalls and the remainder coming potentially from the other two Foss outfalls. This will provide Ecology with better information about the spatial distribution (i.e., the variability of these analytes in stormwater outfalls) of these NPDES analytes.

d - Due to tidal conditions, a sediment trap cannot be installed in OF254.

e - These numbers do not include QC samples.

Table 7-4
Representative Storm Event Criteria and Sampling Frequency

Criteria	Wet season	Dry season
Period	October 1 through April 30	May 1 through September 30
Rainfall volume	0.20” minimum, no fixed maximum	0.20” minimum, no fixed maximum
Rainfall duration	No fixed minimum or maximum	No fixed minimum or maximum
Spacing between Sampling Events	Minimum 1 week spacing between events. No more than 2 samples per month.	Minimum 1 week spacing between events. No more than 2 samples per month.
Antecedent dry period	≤ 0.05” rain in the previous 24 hours	≤ 0.02” rain in the previous 48 hours
Inter-event dry period	6 hours	6 hours
% of samples per season	60% to 80%	20% to 40%

a - See Table 7-3 for total annual sample numbers

Table 7-5
Representative Sampler Collection Criteria

Storm event duration	<24 hours	>24 hours
Minimum storm volume to sample	75% of the storm event hydrograph[c]	75% of the hydrograph of the first 24 hours of the storm[c]
No. of Aliquots	≥10: 7-to-9 accepted[b]	≥10: 7-to-9 accepted[b]
Minimum duration to program ISCO for sampling (hours)[a]	2 X time of Concentration	2 X time of Concentration

a - "Time of Sampling" in Appendix 9 of the Permit requires the sampler to be programmed to continue sampling past the longest estimated time of concentration

b - Composite samples with 7-to-9 aliquots are acceptable if they meet the other sampling criteria and help achieve a representative balance of wet season/dry season events and storm sizes.

c - Applies to non-tidally influenced outfalls (OF237B) only. Tidally infuenced drains shall be sampled to include only the portion of runoff that is not affected by tides.

Table 7-6
Portion of Storm Event Sampled in Tidally Influenced Drains

Portion of storm sampled	Number of Events Sampled					Number of Events Sampled						Number of Events Sampled					
	230	235	243	245	254	230	235	243	245	254	237A New	230	235	243	245	254	237A New
	Year 1					Year 5						WY2010 (Year 9)					
Rising limb			2		1	1											
Rising and peak limb	1	1	1	1					2	1		2	2		3		1
Peak			1	1	1	3		2		2	1			2		1	
Peak and falling limb					2	1	1	1	1	3	1	1				4	1
Falling limb			3		1			1						2		2	
Most of the storm	10	9		9	3	2	5	1	4	2	1	8	14	3	9	5	11
Total Number	11	10	7	11	8	7	6	5	7	8	3	11	16	7	12	12	13
	Year 2					Year 6						WY2011 (Year 10)					
Rising limb			1	1		1			1			1	1	1	1	1	
Rising and peak limb	1			2						1		1	1	1			
Peak			1							2						2	
Peak and falling limb	3	1	1	1	1	1				1			1		1		2
Falling limb					2							1		3	1	3	
Most of the storm	4	8	5	5	5	4	7	2	6	2	2	6	11	2	6	3	5
Total Number	8	9	8	9	8	6	7	2	7	6	2	9	14	7	9	9	7
	Year 3					Year 7						WY2012 (Year 11)					
Rising limb			1		1		1			1							
Rising and peak limb	1	1	1		1	2		1	1	2		2	1		3		
Peak			1			2	2		1	2			1			1	
Peak and falling limb	2	1	1	3	1	1	1	4	2	3	1	3		1		1	1
Falling limb					2			1	1	1	1			3			
Most of the storm	8	9	4	6	3	7	8	2	7	3	10	4	10		9	2	8
Total Number	11	11	8	9	8	12	12	8	12	12	12	9	12	4	12	4	9
	Year 4					WY2009 (Year 8)						Years 1-11					
Rising limb												3	2	5	3	4	0
Rising and peak limb	2	1	1	2	1							12	7	5	14	6	1
Peak	1	2	1	1				2	1	1		6	5	10	4	12	1
Peak and falling limb			2	2	3			1		1	1	12	5	11	10	20	7
Falling limb			2		1					1		1	0	15	2	13	1
Most of the storm	6	9	1	5	4	8	10	5	9	5	9	67	100	25	75	37	46
Total Number	9	12	7	10	9	8	10	8	10	8	10	101	119	71	108	92	56

Table 7-7
Ranges of Magnitude and Intensity - Years 1 to 11 Stormwater Runoff Hydrographs

Year	237A New		237A		237B		230		235		243		245		254	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Storm Volume Sampled (cf)																
1	--	--	429,000	3,800,000	308,000	6,305,000	83,000	3,174,000	15,000	339,300	82,100	678,000	43,200	187,000	4,500	389,000
2	--	--	367,772	1,447,097	337,514	1,858,007	57,654	335,361	43,381	234,063	3,428	25,869	5,654	60,984	6,162	107,162
3	--	--	354,601	1,311,768	183,431	1,526,854	15,467	211,513	32,390	142,119	12,402	113,464	4,641	23,892	3,831	24,393
4	--	--	330,582	1,396,364	267,243	1,537,388	45,187	237,215	37,913	163,159	11,801	14,710	12,185	45,869	7,064	70,355
5	300,853	895,775	284,679	760,818	259,048	1,069,716	42,203	196,511	52,074	208,197	4,158	26,798	16,106	63,754	11,306	54,775
6	792,530	1,157,840	352,880	894,480	375,780	846,670	98,080	215,920	81,980	176,350	8,090	--	11,790	72,630	7,080	36,140
7	158,821	1,389,140	196,531	766,050	282,139	1,905,083	53,663	486,483	23,687	177,293	4,901	13,675	2,179	43,437	4,863	70,208
8	312,758	1,966,758	223,854	712,018	739,508	2,596,115	73,381	638,148	34,050	122,187	3,432	53,066	8,971	29,569	11,010	290,348
9	326,300	3,813,500	283,600	3,137,500	565,400	5,740,600	55,300	395,100	34,800	327,200	1,200	14,100	12,300	84,900	20,740	149,200
10	127,205	2,363,333	242,884	3,474,912	431,750	7,110,919	73,802	679,556	37,465	165,666	6,742	40,419	4,478	51,050	15,434	230,917
11	365,849	3,800,000	--	--	433,523	3,042,117	36,155	619,242	19,399	278,843	17,303	94,952	9,336	47,757	64,625	170,439
Event Average Flow Rate (cfs)																
1	--	--	9	53	23	87	7	115	3	12	7	50	1.3	1.3	2	24
2	--	--	9.4	41	16	27	1.5	8.7	1.4	4	0.2	1.4	0.6	2.8	0.5	2.2
3	--	--	8.4	22	8.2	48	1.7	7.9	1.6	3.3	0.7	15.1	1.1	4.4	0.8	3.6
4	--	--	11.2	28.5	16.2	51	3	13.5	1.9	5.2	0.8	1.2	0.5	2	0.5	3.9
5	16.7	34	10.3	21.8	15.1	36.9	3.2	10.7	2.0	4.1	0.9	1.7	1.1	2.7	1.5	3.4
6	28.6	29.3	9.1	18	14.5	59.6	3.9	9.7	2.4	6.5	0.5	0.5	0.9	3.1	0.9	2.6
7	9.3	38.3	5.9	20.9	14.5	47.7	2.9	13	1.5	7.7	0.4	1.8	0.7	3.2	0.5	4.5
8	18.3	42.9	7.3	15.6	21.9	47.2	2.7	16.9	1.4	3.7	0.2	3.3	0.8	2.1	0.9	23.5
9	9.5	63	9.4	36.5	20	86.6	3.3	17.5	1.1	4.1	0.2	0.7	0.7	2.6	1.6	5.0
10	9.5	39.1	9.4	45	24.4	98.3	2.8	16.9	1.2	7.1	0.2	0.6	0.6	2.7	0.9	5.2
11	9	42	--	--	25	55	2	13	2	5	1	2	1	2	2	5
Maximum Flow Rate (cfs)																
1	--		145		186		280		52		53		3.4		25	
2	--		83		154		35.5		26.9		3.1		8.1		7.5	
3	--		78		187		22.8		14.2		39.1		7		5.5	
4	--		105		172.2		37.5		21.7		2.7		6.3		8.6	
5	63		70.7		99.7		35.5		29.8		3.3		6.1		5.5	
6	71.5		37.1		80.9		29.9		25.2		0.9		6.9		6.3	
7	208.6		77.5		277		118.5		34.4		3		11		15.3	
8	178		113.4		145.1		43.7		11.9		8		4.8		25.3	
9	321.3		104.7		263.6		105.6		26.7		2.7		8.8		21.9	
10	152.2		110.2		219.3		85.8		19.1		2.4		11.1		20.0	
11	107		--		150		48		33		4		7		13	

Table 7-8
Precipitation Summary of Storm Events Sampled

	Antecedent (hours)	Precip (in)	Duration (hours)	Avg Intensity
WY2005				
10/5-6/2004	316.5	0.26	11.75	0.02
(1)	--	0.25	5.45	0.05
10/8/2004	47.25	1.04	15.5	0.07
11/1/2004	53.75	0.23	11.25	0.02
(1)	--	0.22	7.25	0.03
11/17-18/2004	30.25	0.34	4	0.09
12/9/2004	25	0.63	25.75	0.02
1/15-16/2005	259	0.41	14.25	0.03
2/6/2005	44.5	0.4	13	0.03
(1)	--	0.33	9.25	0.04
3/19/2005	66.25	0.21	9.5	0.02
(1)	--	0.2	6.75	0.03
4/10-11/2005	76.5	0.59	9.25	0.06
5/17-18/2005	37	0.57	24.5	0.02
6/16-17/2005	213	0.65	9.5	0.07
7/8/2005	52.75	0.33	10.5	0.03
9/29/2005	440.25	0.62	14.25	0.04
Annual Avg	**127.85**	**0.48**	**13.31**	**0.04**
WY2006				
10/14/2005	40.75	0.29	5.5	0.05
1/5/2006	33.75	**1.3**	22.25	0.06
(1)	--	1.06	12	0.09
1/16/2006	53.25	0.72	17	0.04
(1)	--	0.4	6.75	0.06
1/31/2006	26.75	0.27	4.75	0.06
2/26/2006	67.25	0.2	23.5	0.01
(1)	--	0.11	4.25	0.03
3/8/2006	25	0.41	13.25	0.03
(1)	--	0.28	2.45	0.11
4/8/2006	110	0.23	12.75	0.02
4/13/2006	114	0.97	27.25	0.04
(1)	--	0.65	9.5	0.07
5/21/2006	47	0.33	22.25	0.01
(1)	--	0.31	13.75	0.02
9/17/2006	2240.25	0.42	12	0.04
(1)	**--**	0.4	6.25	0.06
Annual Avg	**275.80**	**0.51**	**16.05**	**0.04**
WY2007				
10/14/2006	200	0.57	13.75	0.04
Partial	--	0.27	11.25	0.02
11/2/2006	335.75	0.93	19.75	0.05
Partial	--	0.31	11	0.03
Partial	--	0.54	15.75	0.03
Partial	--	0.66	16.5	0.04
11/15/2006	40.25	0.26	11.5	0.02
11/19/2006	58.5	0.49	6.75	0.07
Partial	--	0.28	2.75	0.10
2/17/2007	58	0.26	6	0.04
2/24/2007	48	0.32	7.75	0.04
3/19/2007	35.25	0.44	18	0.02
Partial	--	0.25	7.22	0.03
5/2/2007	83	0.35	21.5	0.02
6/9/2007	466.25	0.38	8	0.05
6/28/2007	85.5	0.24	15	0.02
9/3/2007	336.5	0.38	8.25	0.05
(1)	--	0.24	0.75	0.32
9/16-17/2007	288.25	0.28	22	0.01
9/27-28/2007	249.25	0.63	10.25	0.06
Annual Avg	**175.73**	**0.43**	**12.96**	**0.04**
WY2008				
10/10/2007	54.5	0.24	17.75	0.01
11/9-10/2007	385.5	0.20	6.75	0.03
11/26/2007	34.25	0.22	2.5	0.09
11/28-29/2007	43.75	0.23	14.25	0.02
12/14-15/07	29.75	0.27	18.25	0.01
12/27/2007	39.25	0.42	11.75	0.04
1/8/2008	37.5	0.28	8	0.04
1/14/2008	34.25	0.24	4.5	0.05
(1)	--	0.18	2.25	0.08
1/26/2008	147	0.28	11.25	0.02
(1)	--	0.24	4.5	0.05
2/29/2008	53.5	0.28	5.25	0.05
(1)	--	0.27	3.75	0.07
3/23/2008	53.25	0.53	14.25	0.04
Partial	--	0.23	5.5	0.04
5/20/2008	394	0.47	14	0.03
(1)	--	0.4	7.5	0.05
7/31/2008	45	0.22	12.75	0.02
8/19/2008	27.5	0.36	12	0.03
Annual Avg	**98.50**	**0.30**	**10.95**	**0.03**
WY2009				
10/3/2008	178.5	0.46	24.5	0.02
(1)	--	0.41	12.5	0.03
10/20/2008	54.75	0.25	8.5	0.03
10/31/2008	185.75	0.29	11.25	0.03
11/5/2008	38.75	2.71	36.25	0.07
Partial	--	0.36	10.25	0.04
11/10/2008	42.75	0.22	7.5	0.03
11/20/2008	183.25	0.2	8.75	0.02
12/12/2008	42	0.62	22.75	0.03
3/14/2009	111	0.34	14.5	0.02
3/28/2009	70	0.65	24	0.03
Partial	--	0.49	11.75	0.04
4/1/2009	24.25	0.32	18	0.02
4/17/2009	71.75	0.3	12.75	0.02
5/2/2009	75.75	0.25	10.75	0.02
5/18/2009	30.75	0.35	6.25	0.06
9/5/2009	44	0.29	8	0.04
(1)	--	0.28	4.75	0.06
9/19/2009	278.5	0.28	4	0.07
Annual Avg	**95.45**	**0.35**	**12.78**	**0.03**

	Antecedent (hours)	Precip (in)	Duration (hours)	Avg Intensity
WY2010				
10/16/2009	31.25	0.91	26.25	0.03
Partial	--	0.58	10	0.06
10/22/2009	31	0.52	17.25	0.03
(1)	--	0.51	12.5	0.04
10/28/2009	56.25	0.2	10	0.02
10/30/2009	38.25	0.22	13.75	0.02
11/5/2009	119.5	0.69	21.5	0.03
11/15/2009	42	0.37	11.25	0.03
11/25/2009	26.75	1.00	25.75	0.04
Partial	--	0.67	11	0.06
12/31/2009	24	0.29	5.75	0.05
1/4/2010	43.75	1.18	39.25	0.03
Partial	--	0.64	8.3	0.08
Partial	--	0.69	9	0.08
Partial	--	0.49	7	0.07
1/7/2010	53	0.98	28.25	0.03
Partial	--	0.49	15.5	0.03
1/10/2010	42.25	0.63	15.5	0.04
1/24/2010	159.25	0.41	9.5	0.04
2/10/2010	68.5	0.15	10.75	0.01
2/15/2010	28.25	0.25	11.5	0.02
3/11/2010	25.25	1.04	30.5	0.03
3/28/2010	36.25	0.22	4.75	0.05
4/2/2010	34	0.92	26	0.04
Partial	--	0.83	22.5	0.04
Partial	--	0.62	18.25	0.03
5/25/2010	44	0.58	31	0.02
Partial	--	0.29	20.75	0.01
5/27/2010	26.5	0.35	20	0.02
6/3/2010	32.25	0.25	9.25	0.03
6/8/2010	48.75	0.55	23.5	0.02
6/19/2010	67.25	0.2	14	0.01
9/26/2010	64.5	0.28	6	0.05
Annual Avg	**49.68**	**0.53**	**17.88**	**0.03**
WY2011				
10/8/2010	300.25	1.34	39.25	0.03
10/30/2010	42	0.38	16.25	0.02
11/9/2010	50	0.37	15.5	0.02
11/17/2010	32.5	0.51	30	0.02
11/29/2010	70	0.39	25.75	0.02
12/11/2010	31.25	1.84	42.25	0.04
1/20/2011	84.75	0.29	13	0.02
1/29/2011	106.5	0.22	8.5	0.03
2/12/2011	106.75	0.55	4.25	0.13
3/4/2011	21	0.21	5	0.04
3/12/2011	30.75	0.30	11.5	0.03
4/4/2011	21.25	0.37	24.5	0.02
4/13/2011	53	0.18	17	0.01
4/26/2011	26.25	0.23	2.25	0.10
5/2/2011	92.25	0.19	7.75	0.02
5/14/2011	70.5	1.36	20.5	0.07
5/25/2011	234.75	0.22	7.25	0.03
8/22/2011	861.5	0.22	10.5	0.02
Annual Avg	**124.18**	**0.51**	**16.72**	**0.04**
WY2012				
10/10/2011	10.75	0.75	28.75	0.03
Partial	--	0.54	10.25	0.05
Partial	--	0.56	11.75	0.05
Partial	--	0.66	16.75	0.04
10/28/2011	136.75	0.30	3.5	0.09
11/2/2011	75.75	0.47	5.75	0.08
11/11/2011	170.25	0.17	2.25	0.08
11/16/2011	86.25	0.31	15.25	0.02
Partial	--	0.19	5.5	0.03
11/21/2011	72.75	0.18	3.25	0.06
11/27/2011	58.75	0.30	5	0.06
1/4/2012	39	0.48	20.75	0.02
Partial	--	0.39	10.25	0.04
1/9/2012	101.5	0.21	7.5	0.03
1/24/2012	34.5	0.98	29	0.03
1/29/2012	73.25	1.32	21.5	0.06
1/31/2012	42	0.41	16.25	0.03
2/17/2012	27.25	0.86	24.25	0.04
Partial	--	0.83	24	0.03
2/24/2012	59.75	0.23	11.75	0.02
3/5/2012	62.5	0.31	4.75	0.07
3/14/2012	20.25	1.04	48.25	0.02
Partial	--	0.21	10.3	0.02
Partial	--	0.46	24	0.02
4/3/2012	41.25	0.15	3	0.05
4/19/2012	30.5	0.77	20	0.04
4/25/2012	11	0.65	34.5	0.02
4/29/2012	73.5	0.37	18.25	0.02
5/3/2012	28	0.62	18.25	0.03
5/20/2012	398.75	0.26	11.75	0.02
6/5/2012	21.25	0.30	6.25	0.05
6/7/2012	43.25	0.62	16	0.04
6/22/2012	329	0.23	17.75	0.01
Annual Avg	**81.91**	**0.49**	**15.74**	**0.04**

Avg Intensity is total rainfall (in) for the event divided by duration of event (hr)
Minimum value for the monitoring year
Maximum value for the monitoring year
(1) Most of the precipitation occurred in a shorter amount of time. The resulting Avg Intensity is believed to be a better representation of the event.
Partial - Event sampled represents only a part of the entire event. Rainfall characteristics reflect partial event sampled for that outfall.

Table 7-9
Thea Foss Trigger Criteria for Sampling Frequency

THEA FOSS TRIGGER CRITERIA FOR SAMPLING FREQUENCY

WEST SIDE DRAINS
(8 smpls/yr X 3 yr)
Count: 24

EAST SIDE DRAINS
(3 smpls/yr X 3 yr)
Count: 9

CRITERIA FOR DECREASED SAMPLING INTENSITY

Probability of No Exceeds in 24 samples

p	Exceedance Percentile
0.005	80%
0.006	81%
0.009	82%
0.011	83%
0.015	84%
0.020	85%
0.027	86%
0.035	87%
0.047	88%
0.061	89%
0.080	90%
0.104	91%
0.135	92%
0.175	93%
0.227	94%
0.292	95%

Probability of No Exceeds in 9 samples

p	Exceedance Percentile
0.040	70%
0.046	71%
0.052	72%
0.059	73%
0.067	74%
0.075	75%
0.085	76%
0.095	77%
0.107	78%
0.120	79%
0.134	80%
0.150	81%
0.168	82%
0.187	83%
0.208	84%
0.232	85%

CRITERIA FOR INCREASED SAMPLING INTENSITY

Bi Coeff: 276

Probability of >2 Exceeds in 24 samples

p	Exceedance Percentile
0.006	99.5%
0.022	99.0%
0.045	98.5%
0.072	98%
0.131	97%
0.188	96%
0.236	95%
0.272	94%
0.296	93%
0.309	92%
0.311	91%
0.305	90%

Bi Coeff: 36

Probability of 2 Exceeds in 9 samples

p	Exceedance Percentile
0.001	99.5%
0.003	99.0%
0.007	98.5%
0.013	98%
0.027	97%
0.045	96%
0.066	95%
0.089	94%
0.114	93%
0.140	92%
0.166	91%
0.191	90%

Table 8-1
ISCO Site-Specific Settings and Enables

Storm 1.0	
Location	**Pacing**
OF230	165,220
OF235	60,000
OF237A New	650,000
OF237B	1,000,000

Storm 0.2	
Location	**Pacing**
OF230	25,000
OF235	17,955
OF237A New	100,000
OF237B	135,000

Storm 0.3	
Location	**Pacing**
OF230	31,000
OF235	22,610
OF237A New	140,000
OF237B	203,000

Storm 0.4	
Location	**Pacing**
OF230	35,000
OF235	30,000
OF237A New	180,000
OF237B	255,000

Storm 0.5	
Location	**Pacing**
OF230	42,500
OF235	35,000
OF237A New	230,000
OF237B	425,000

Storm 0.6	
Location	**Pacing**
OF230	50,000
OF235	40,000
OF237A New	300,000
OF237B	600,000

Storm 0.7	
Location	**Pacing**
OF230	60,000
OF235	45,000
OF237A New	375,000
OF237B	550,000

Storm 0.8	
Location	**Pacing**
OF230	80,000
OF235	50,000
OF237A New	450,000
OF237B	700,000

Storm 0.9	
Location	**Pacing**
OF230	115,000
OF235	55,000
OF237A New	550,000
OF237B	900,000

All Storms	
Location	**Pacing**
OF243	8 to 10 Minutes
OF245	10 Minutes
OF254	10 Minutes

Storm Enables	
Location	**Enable**
OF230	LEV > 0.20, VEL > 1.00
OF235	LEV > 0.40, VEL > 0.60
OF237A New	LEV > 0.40, VEL > 6.75
OF237B (0.300 ft offset)	LEV > 1.05
OF243	CON < 5.50
OF245	VEL > 0.25
OF254	CON < 5.00

Note: Pacing and enables may be adjusted at any time based on current site conditions.
Pacing and enbales are identified in the ISCO reports for each sampling event.
ISCO Reports are included in the field report for each event.

Table 9-1
Stormwater Container, Preservation, and Holding Time

Parameter	Container[1]	Preservation[2]	Maximum holding time[3,4]	Reference[5]
Conventionals				
Biochemical oxygen demand	P, FP, G	Cool, ≤6 °C[6]	48 hours.	40 CFR 136
Conductivity, specific	P, FP, G	Cool, ≤6 °C[6]	28 days.	40 CFR 136
Chloride	P, FP, G	None required	28 days.	40 CFR 136
Hardness	P, FP, G	HNO3 or H2SO4 to pH<2	6 months.	40 CFR 136
Surfactants (MBAS)	P, FP, G	Cool, ≤6 °C[6]	48 hours.	40 CFR 136
Total suspended solids	P, FP, G	Cool, ≤6 °C[6]	7 days.	40 CFR 136
Turbidity	P, FP, G	Cool, ≤6 °C[6]	48 hours.	40 CFR 136
Bacteria				
Fecal Coliform	PA, G	Cool, <10 °C	8 hours.[7]	40 CFR 136
Nutrients				
Phosphorous, total	P, FP, G	Cool, ≤6 °C[6], H2SO4 to pH<2	28 days.	40 CFR 136
Orthophosphate	P, FP, G	Cool, ≤6 °C[6]	Filter within 15 minutes[8]; Analyze within 48 hours.	40 CFR 136
Total Nitrogen[12]	P, FP, G	Cool, ≤6 °C[6], H2SO4 to pH<2	28 days.	40 CFR 136
Nitrate-nitrite	P, FP, G	Cool, ≤6 °C[6], H2SO4 to pH<2	28 days.	40 CFR 136
Metals				
Mercury[8]	P, FP, G	HCl to pH<2[9]	28 days.	40 CFR 136
Metals (zinc, lead, copper and cadmium)[8]	P, FP, G	HNO3 to pH<2 within 15 minutes or preserve at least 24 hours prior to analysis[9]	6 months.	40 CFR 136
Organics				
PAHs[10]	G, FP-lined cap	Cool, ≤6 °C[6], store in dark	7 days until extraction, 40 days after extraction.	40 CFR 136
Phthalate esters[10]	G, FP-lined cap	Cool, ≤6 °C[6]	7 days until extraction, 40 days after extraction.	40 CFR 136
Pesticides[10]	G, FP-lined cap	Cool, ≤6 °C[6]	7 days until extraction, 40 days after extraction.	40 CFR 136
Carbaryl	G, FP-lined cap	Cool, ≤6 °C[6]		
TPH, NWTPH-Dx	G, FP-lined cap	HCl to pH < 2, Cool to ≤6°C	7 days	Ecology 97-602
TPH, NWTPH-Gx	G, septum	HCl to pH < 2, Cool to ≤6°C	14 days[11]	
Herbicides (2,4-D, dichlobenil)	G, FP-lined cap	Cool, ≤6 °C[6]	7 days	SW-846
BTEX	G, FP-lined septum	Cool, ≤6 °C[6], 0.008% $Na_2S_2O_3$, HCl to pH 2	14 days [11]	40 CFR 136

[1]"P" is polyethylene; "FP" is fluoropolymer (polytetrafluoroethylene (PTFE; Teflon&supreg;), or other fluoropolymer, unless stated otherwise in this Table II; "G" is glass; "PA" is any plastic that is made of a sterlizable material (polypropylene or other autoclavable plastic); "LDPE" is low density polyethylene.

[2]Except where noted in Table II (40 CFR Part 136) and the method for the parameter, preserve each grab sample within 15 minutes of collection. For a composite sample collected with an automated sampler (e.g., using a 24-hour composite sampler; see 40 CFR 122.21(g)(7)(i) or 40 CFR Part 403, Appendix E), refrigerate the sample at ≤6 °C during collection unless specified otherwise in this Table II or in the method(s). For a composite sample to be split into separate aliquots for preservation and/or analysis, maintain the sample at ≤6 °C, unless specified otherwise in this Table II or in the method(s), until collection, splitting, and preservation is completed. Add the preservative to the sample container prior to sample collection when the preservative will not compromise the integrity of a grab sample, a composite sample, or an aliquot split from a composite sample; otherwise, preserve the grab sample, composite sample, or aliquot split from a composite sample within 15 minutes of collection. If a composite measurement is required but a composite sample would compromise sample integrity, individual grab samples must be collected at prescribed time intervals (e.g., 4 samples over the course of a day, at 6-hour intervals). Grab samples must be analyzed separately and the concentrations averaged. Alternatively, grab samples may be collected in the field and composited in the laboratory if the compositing procedure produces results equivalent to results produced by arithmetic averaging of the results of analysis of individual grab samples. For examples of laboratory compositing procedures, see EPA Method 1664A (oil and grease) and the procedures at 40 CFR 141.34(f)(14)(iv) and (v) (volatile organics).

[3]Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before the start of analysis and still be considered valid (e.g., samples analyzed for fecal coliforms may be held up to 6 hours prior to commencing analysis). Samples may be held for longer periods only if the permittee or monitoring laboratory has data on file to show that, for the specific types of samples under study, the analytes are stable for the longer time, and has received a variance from the Regional Administrator under §136.3(e). For a grab sample, the holding time begins at the time of collection. For a composite sample collected with an automated sampler (e.g., using a 24-hour composite sampler; see 40 CFR 122.21(g)(7)(i) or 40 CFR Part 403, Appendix E), the holding time begins at the time of the end of collection of the composite sample. For a set of grab samples composited in the field or laboratory, the holding time begins at the time of collection of the last grab sample in the set. Some samples may not be stable for the maximum time period given in the table. A permittee or monitoring laboratory is obligated to hold the sample for a shorter time if it knows that a shorter time is necessary to maintain sample stability. See §136.3(e) for details. The date and time of collection of an individual grab sample is the date and time at which the sample is collected. For a set of grab samples to be composited, and that are all collected on the same calendar date, the date of collection is the date on which the samples are collected. For a set of grab samples to be composited, and that are collected across two calendar dates, the date of collection is the dates of the two days; e.g., November 14–15. For a composite sample collected automatically on a given date, the date of collection is the date on which the sample is collected. For a composite sample collected automatically, and that is collected across two calendar dates, the date of collection is the dates of the two days; e.g., November 14–15.

[4]Holding time is calculated from time of sample collection to elution for samples shipped to the laboratory in bulk and calculated from the time of sample filtration to elution for samples filtered in the field.

[5]References: 40 CFR Part 136 Table II - Accessed August 13, 2008; Ecology 97-602 – Analytical methods for petroleum hydrocarbons.

[6]Aqueous samples must be preserved at ≤6 °C, and should not be frozen unless data demonstrating that sample freezing does not adversely impact sample integrity is maintained on file and accepted as valid by the regulatory authority. Also, for purposes of NPDES monitoring, the specification of "≤ °C" is used in place of the "4 °C" and "< 4 °C" sample temperature requirements listed in some methods. It is not necessary to measure the sample temperature to three significant figures (1/100th of 1 degree); rather, three significant figures are specified so that rounding down to 6 °C may not be used to meet the ≤6 °C requirement. The preservation temperature does not apply to samples that are analyzed immediately (less than 15 minutes).

[7]Samples analysis should begin immediately, preferably within 2 hours of collection. The maximum transport time to the laboratory is 6 hours, and samples should be processed within 2 hours of receipt at the laboratory.

[8]Orthophosphate and dissolved metals have a 15-minute holding time prior to filtration. The City will filter samples as soon as practicable, but the timing of the storm may make the 15-minute holding time impractical and failure to meet this criteria will not require the data to be J flagged. The 15-minute holding time will be discussed in annual reports, and the non-flagging convention for this rule is consistent with prior City NPDES stormwater monitoring (WY2010-2012).

[9]An aqueous sample may be collected and shipped without acid preservation (for total metals). However, acid must be added at least 24 hours before analysis to dissolve any metals that adsorb to the container walls. If the sample must be analyzed within 24 hours of collection, add the acid immediately (see footnote 2). Soil and sediment samples do not need to be preserved with acid. The allowances in this footnote supersede the preservation and holding time requirements in the approved metals methods.

[10]When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity (i.e. , use all necessary preservatives and hold for the shortest time listed). When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to ≤6 °C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6–9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction.

[11] If the sample is not adjusted to pH 2, then the sample must be analyzed within seven days of sampling.

[12] Total Kjeldahl Nitrogen will be calculated from Total Nitrogen and Nitrate/Nitrite.

Table 9-2
Sediment Container, Preservation, and Holding Time

Parameter	Container[1]	Preservation	Maximum holding time	Reference[2]
Total solids	P, FP, G	Cool, ≤6 °C	7 days.	40 CFR 136
Grain size	P, FP, G	Cool to 4°C	6 months	ASTM D422
Total organic carbon	P, FP, G	Cool to 4°C	14 days, 12 mos if frozen to -18°C	PSEP 1997
Total recoverable metals (zinc, lead, copper, cadmium)	P, FP, G	Cool to 4°C	6 months	EPA 6020A
Total recoverable mercury	P, FP, G	Cool to 4°C	28 days	EPA 7471
PAH	G, FP-lined cap	Cool to 4°C	14 days, 12 mos if frozen to -18°C	PSEP 1997
Phthalates	G, FP-lined cap	Cool to 4°C	14 days, 12 mos if frozen to -18°C	EPA 8270D
Phenols	G, FP-lined cap	Cool to 4°C	14 days, 12 mos if frozen to -18°C	EPA 8270D
PCBs	G, FP-lined cap	Cool to 4°C	14 days, 12 mos if frozen to -18°C	EPA 8270D
Pesticides	FP, G	Cool to 4°C	14 days, 12 mos if frozen to -18°C	EPA 8270D
Pyrethroids (bifenthrin)	G, FP-lined cap	Cool to 4°C	14 days, 12 mos if frozen to -18°C	EPA 8270D

[1]"P" is polyethylene; "FP" is fluoropolymer (polytetrafluoroethylene (PTFE; Teflon&supreg;), or other fluoropolymer, unless stated otherwise in this Table
[2]40CFR136 Accessed August 13, 2008; Puget Sound Estuary Protocols 1997, EPA Method 8270D – revision 4 (2007).

Table 9-3
Volume Required for Stormwater and Sediment Analysis

Stormwater - Composite		
Parameter	**Recommend quantity (ml)**	**Minimum quantity (ml)**
Biochemical oxygen demand	2500	900
Conductivity, specific	50	25
pH		
Chloride	100	25
Surfactants (MBAS)	1000	400
Total suspended solids	1000	725
Turbidity	500	20
Phosphorous, total	125	20
Orthophosphate	100	30
Total Nitrogen*	125	20
Nitrate-nitrite	125	20
Total Mercury	250	50
Dissolved Mercury	125	50
Hardness	250	50
Total Metals (zinc, lead, copper and cadmium)		
Dissolved Metals (zinc, lead, copper and cadmium)	125	50
PAHs	4000	1000
Phthalate esters		
Dichlobenil		
Chlorpyrifos		
Carbaryl	40	20
Herbicides (2,4-D)	3000	1000
Minimum sample volume	**13,415**	**4,405**

*Total Nitrogen will be analyzed so that Total Kjeldahl Nitrogen can be calculated.

Stormwater - Grab		
Parameter	**Recommend quantity (ml)**	**Minimum quantity (ml)**
Fecal Coliform	250	100
TPH, NWTPH-Dx	1000	400
TPH, NWTPH-Gx, and/or BTEX	120	40
Minimum sample volume	**1,370**	**540**

Sediment		
Parameter	**Recommend Quantity (g)**	**Minimum Quantity (g)***
Total solids	30	10
Total volatile solids		
Grain size	300	100
Total organic carbon	25	10
Total phosphorus	25	5
Total recoverable metals (zinc, lead, copper, cadmium)	50	10
Total recoverable mercury	50	10
PAHs, Phthaltes, Phenolics, Pesticides, Pyrethroids, PCBs	200	25
Total Volume	**680**	**170**

* for samples with moisture content < 50%. Moisture content >50% requires proportionately higher amounts

25 g is the minimum needed for organics QC and sample analyses. 12 g is the minimum for sample analyses only.

Table 9-4
Required Whole-Water Composite Sample Analysis Priority Order[1]

Order[a]	All Outfalls
1	Conductivity
2	PAHs and Phthalates
3	Mercury
4	Other Metals
5	TSS
6	Hardness
7	pH
8	Remaining organics (herbicides, insecticides)
9	Nutrients
10	BOD5
11	Remaining conventional parameters

a - Order reflects a combination of the Foss CD (Section 8.1 of the 2001 SAP) and Appendix 9 of the Permit.

[1] Based on changes in the sampling procedures, i.e. the addition of a second sampler in all locations, the City expects to capture enough sample in most cases that this priority order is not necessary. In the event that sample volume becomes an issue, the City will propose additional measures in the applicable annual report.

Table 9-5
Required Sediment Sample Analysis Priority Order

Order[a,b]	All Outfalls
1	Total solids
2	PAHs and phthalates
3	NWTPH-Dx
4	PCBs
5	Pesticides
6	Grain size
7	Total organic carbon
8	Mercury
9	Other Metals
10	Insecticides
11	Nutrients
12	Total Volatile Solids
13	Remaining conventional parameters

a - Order reflects Foss CD requirements (Table 6 of the 2001 SAP) plus NPDES analytes in Appendix 9 of the Permit. If an analyte is not required to be analyzed (see Table 3-3), that analyte shall be skipped in the order listed above.

b - Order of analyses may be modified based on past sampling results. The goal of modifying the order is to ensure analyses are conducted for contaminants that have historically shown elevated concentrations.

Table 10-1
Laboratory Quality Control Samples by Matrix[1]

QC Sample	Matrix	Frequency of Analysis
Matrix Spike (MS)	Water	One of each per batch of 20 or fewer samples of similar matrix.
Laboratory (or Matrix) Duplicate (MSD)	Water Sediment	One of each per batch of 20 or fewer samples of similar matrix.
Method or Preparation Blank (MB)	Water Sediment	One of each per batch of 20 or fewer samples of similar matrix.
Laboratory Control Samples (LCS)	Sediment	One of each per batch of 20 or fewer samples of similar matrix.

[1] Refer to Figures 6-1 and 6-2 for MQO targets.

Table 13-1
Data Review Levels

Tier	Description
Tier I – Compliance Screening	Includes evaluation of package completeness; sample chain-of-custody; sample preservation and analytical holding times; blank contamination; precision (replicate analyses); accuracy (compound recovery); target analyte list, and detection limits.
Tier II – Summary Validation[1]	Includes evaluation of all QC elements from Compliance Screening plus instrument performance (initial calibration, continuing calibration, tuning, sensitivity and degradation.)
Tier III – Full Validation	Includes evaluation of all QC elements from Summary Validation plus evaluation of compound identification and quantitation (transcription and calculation checks).

[1] Tier II is equivalent to EPA Stage 2b data validation.

Table 14-1
Lognormal Goodness of Fit - Stormwater

Lognormal Goodness of Fit Test using *MTCA Stat* - 11 Year Data Set							
Analyte	**OF230**	**OF235**	**OF237A**	**OF237B**	**OF243**	**OF245**	**OF254**
TSS	LOGNORM 1.00	LOGNORM 1.00	LOGNORM 0.98	LOGNORM 0.97	LOGNORM 0.98	LOGNORM 0.96	LOGNORM 0.96
Copper[a]	Not monitored	LOGNORM 0.93	Not monitored	LOGNORM 0.98	Not monitored	LOGNORM 0.99	Not monitored
Lead	LOGNORM 0.98	LOGNORM 0.97	LOGNORM 0.98	LOGNORM 0.99	LOGNORM 0.97	LOGNORM 0.99	LOGNORM 0.99
Zinc	LOGNORM 0.96	LOGNORM 0.98	LOGNORM 0.99	LOGNORM 0.99	LOGNORM 0.94	LOGNORM 0.99	LOGNORM 0.99
Phenanthrene	LOGNORM 0.97	LOGNORM 0.97	LOGNORM 0.95	LOGNORM 0.97	LOGNORM 0.97	LOGNORM 0.98	LOGNORM 0.99
Pyrene	LOGNORM 0.94	LOGNORM 0.94	(LOGNORM) 0.90	LOGNORM 0.96	LOGNORM 0.97	LOGNORM 0.98	LOGNORM 0.97
Indenopyrene	(LOGNORM) 0.88	(LOGNORM) 0.90	LOGNORM 0.95	LOGNORM 0.98	LOGNORM 0.93	(LOGNORM) 0.86	LOGNORM 0.93
BEP	LOGNORM 0.97	LOGNORM 0.99	LOGNORM 0.94	LOGNORM 0.97	LOGNORM 0.96	LOGNORM 0.98	LOGNORM 0.97

Notes:

a - Monitored under the 2007 Permit only. Only 3 years of data for this analyte at 3 outfalls.

R^2 value provided below each distribution determination.

LOGNORM - R^2 value greater than 0.9

(LOGNORM) = R^2 value greater than 0.8, but less than 0.9

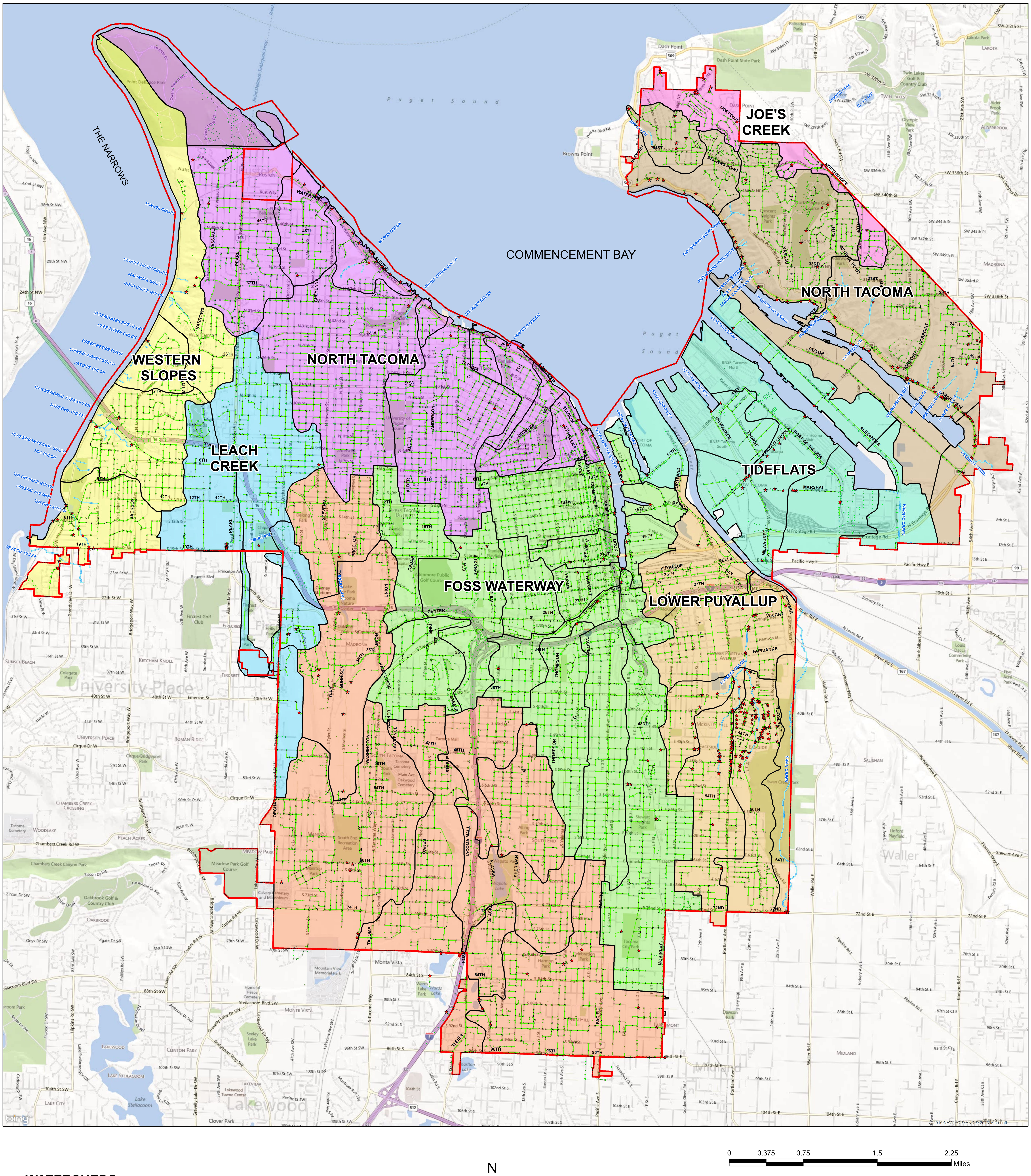
Table 14-2
Lognormal Goodness of Fit - Sediment

Lognormal Goodnes of Fit Test using *MTCA Stat* - 11 Year Data Set						
Analyte	**OF230 FD3New**	**OF235 FD6**	**OF237A FD2**	**OF237B FD1**	**OF243 FD23**	**OF245 MH390**
Lead	Not Normal	LOGNORM	LOGNORM	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.77	0.93	0.92	0.96	0.95	0.93
Normal R^2	0.45	0.91	0.96	0.85	0.94	0.98
Copper	N/A	N/A	N/A	N/A	N/A	N/A
Lognormal R^2	N/A - 1 pt	N/A - 2 pt	N/A - 1 pt	N/A - 2 pt	N/A - 1 pt	N/A - 3 pt
Normal R^2	N/A - 1 pt	N/A - 2 pt	N/A - 1 pt	N/A - 2 pt	N/A - 1 pt	N/A - 3 pt
Mercury	LOGNORM	Not Normal	LOGNORM	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.92	0.56	0.99	0.95	0.93	0.96
Normal R^2	0.73	--	0.95	0.81	0.86	0.85
Zinc	Not Normal	(LOGNORM)	LOGNORM	LOGNORM	(LOGNORM)	(LOGNORM)
Lognormal R^2	0.71	0.88	0.92	0.96	0.87	0.88
Normal R^2	0.45	0.93	0.95	0.96	0.93	0.95
TPH - Heavy Oil	Not Normal	LOGNORM	LOGNORM	LOGNORM	(LOGNORM)	(LOGNORM)
Lognormal R^2	0.54	0.97	0.97	0.97	0.81	0.81
Normal R^2	0.95	0.94	0.97	0.91	0.95	0.90
DDT	N/A	N/A	N/A	N/A	N/A	N/A
Lognormal R^2	--	--	--	--	--	No Detects
Normal R^2	0.97	--	--	--	--	No Detects
Phenanthrene	(LOGNORM)	LOGNORM	Not Normal	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.85	0.92	0.70	0.96	0.92	0.94
Normal R^2	0.78	0.87	0.90	0.92	0.89	0.75
Indeno(1,2,3-cd)pyrene	(LOGNORM)	LOGNORM	Not Normal	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.88	0.98	0.72	0.98	0.98	0.97
Normal R^2	0.95	0.92	0.92	0.90	0.96	--
Pyrene	LOGNORM	LOGNORM	Not Normal	LOGNORM	LOGNORM	(LOGNORM)
Lognormal R^2	0.96	0.93	0.72	0.91	0.97	0.84
Normal R^2	0.99	0.96	0.90	0.79	0.96	0.43
Total PCBs	N/A	N/A	N/A	N/A	N/A	N/A
Lognormal R^2	--	--	--	--	--	--
Normal R^2	0.83	0.69	0.79	0.57	0.73	0.46
DEHP	LOGNORM	Not Normal	LOGNORM	LOGNORM	(LOGNORM)	(LOGNORM)
Lognormal R^2	0.95	0.71	0.93	0.95	0.88	0.86
Normal R^2	0.96	0.97	0.96	0.75	0.97	0.86
Butylbenzylphthalate	(LOGNORM)	LOGNORM	LOGNORM	LOGNORM	(LOGNORM)	LOGNORM
Lognormal R^2	0.87	0.94	0.96	0.98	0.90	0.92
Normal R^2	0.60	0.80	0.87	0.81	0.78	0.73
Total Phthalates	LOGNORM	Not Normal	LOGNORM	LOGNORM	LOGNORM	LOGNORM
Lognormal R^2	0.94	0.79	0.93	0.96	0.92	0.95
Normal R^2	0.98	0.95	0.96	0.78	0.89	0.79

Notes:

R^2 value provided below each distribution determination.
LOGNORM - R^2 value greater than 0.9
(LOGNORM) = R^2 value greater than 0.8, but less than 0.9

Figure 3-1
City of Tacoma Watersheds



WATERSHEDS

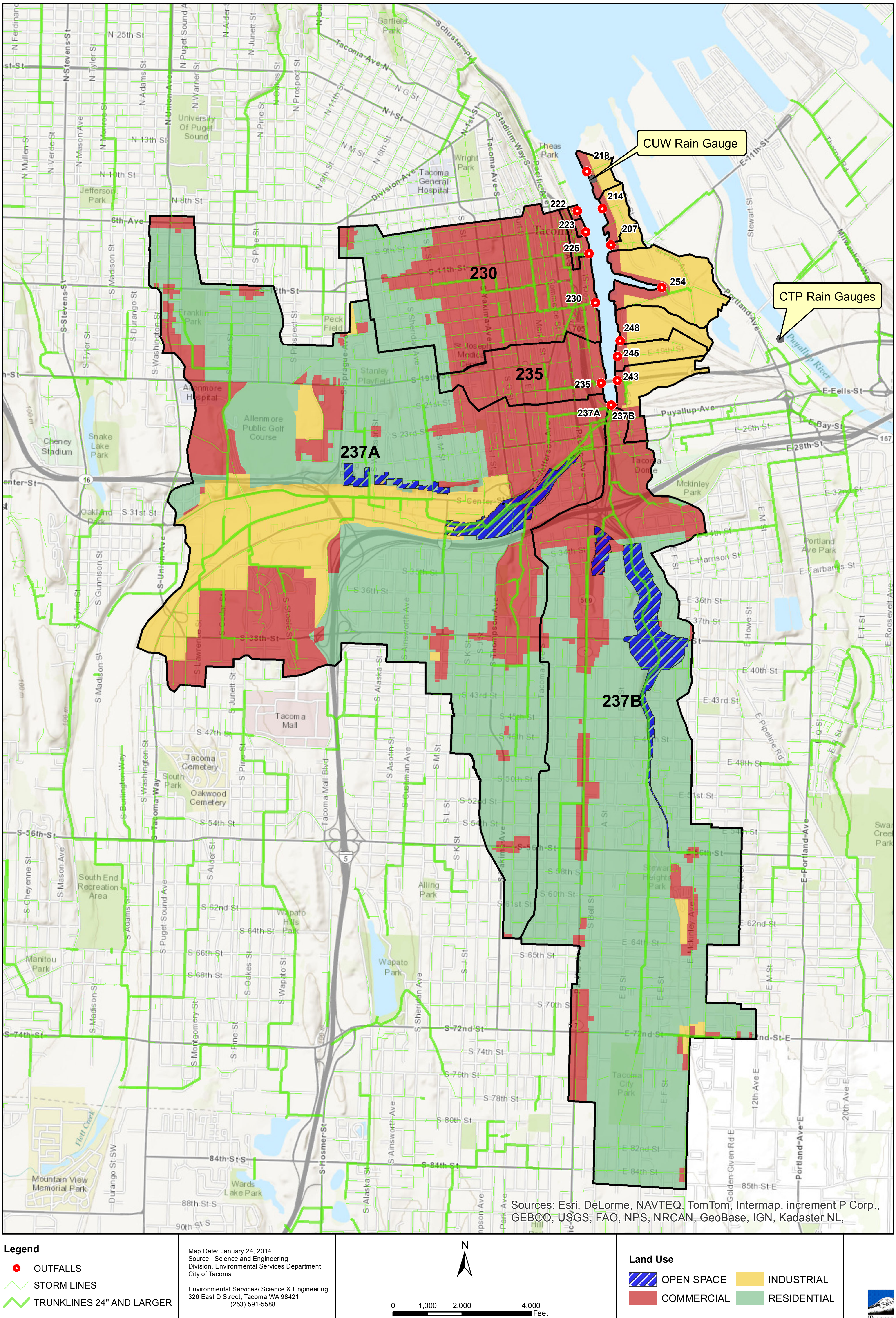
WESTERN SLOPES	LOWER PUYALLUP	FLETT CREEK
TIDEFLATS	LEACH CREEK	TACOMA CITY LIMITS
NORTH TACOMA	JOE'S CREEK	OUTFALLS
NE TACOMA	FOSS WATERWAY	SUB-BASINS

Created in ArcGIS 9 using ArcMap

Source: Environmental Services Division,
Public Works Department City of Tacoma
Date: June 2009

GPS DATAREQUEST\NEW\SUB-BASINS - VAN PELT

Figure 3-2
Thea Foss Basins Land Use



Datarequest/KBartlett/Figure 1-3

Figure 4-1
Thea Foss Post-Remediation Source Control Strategy

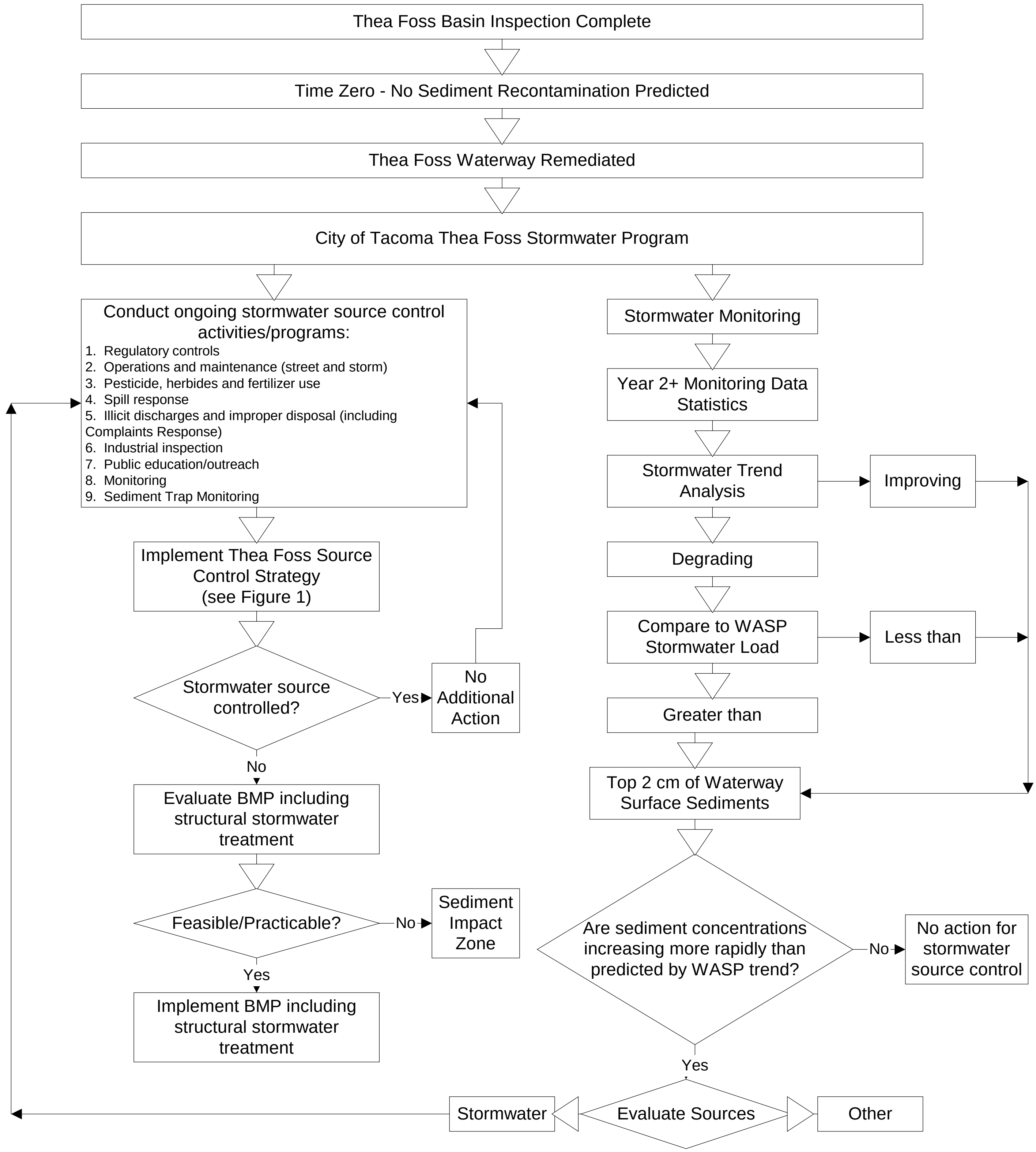


Figure 4-1 Source Control Strategy

Figure 6-1
Simplified Guidance for Evaluating Performance-Based Chemical Data – Whole-Water

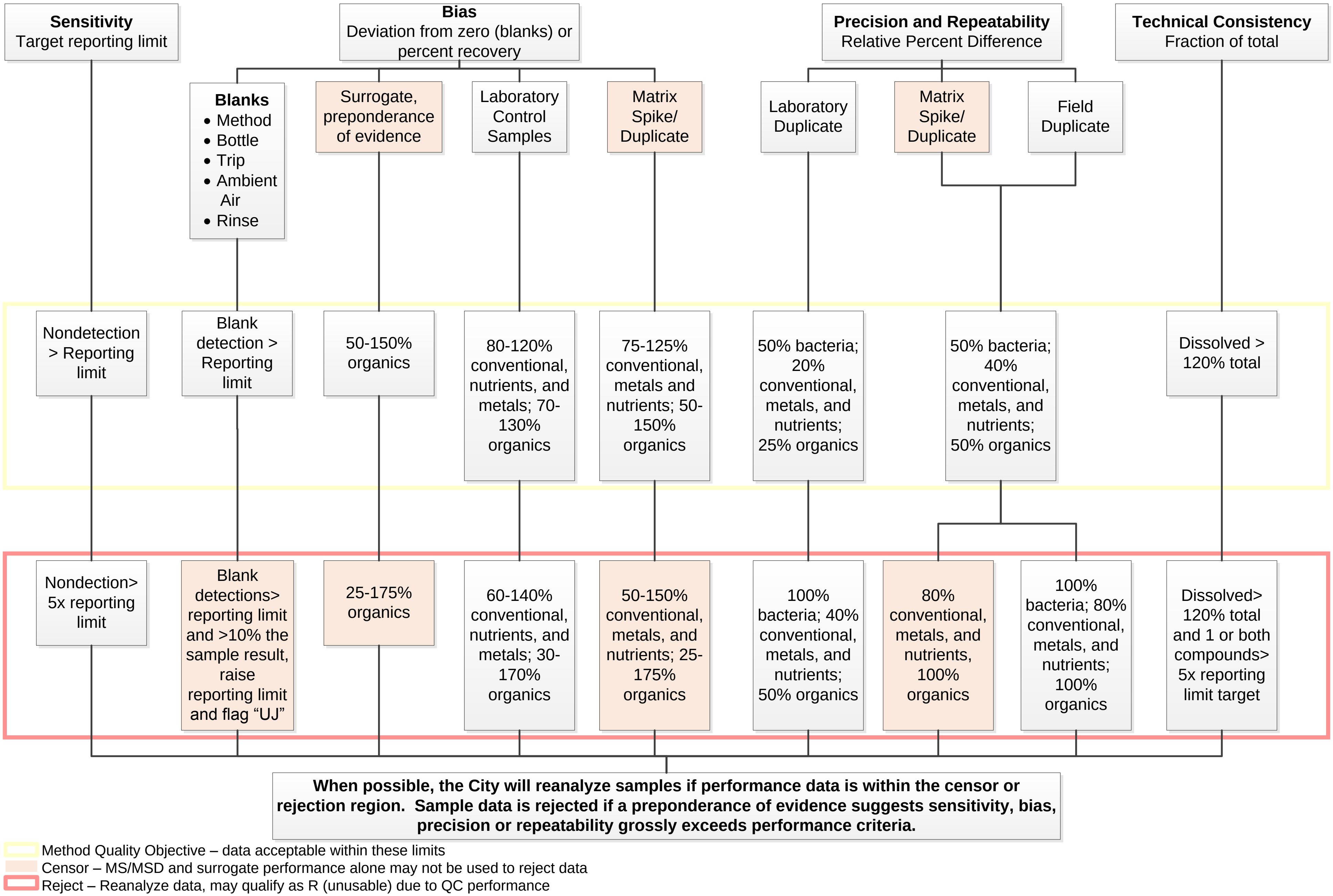


Figure 6-1.vsd

Figure 6-2

Simplified Guidance for Evaluating Performance-Based Chemical Data – Suspended Sediment Particulate Matter

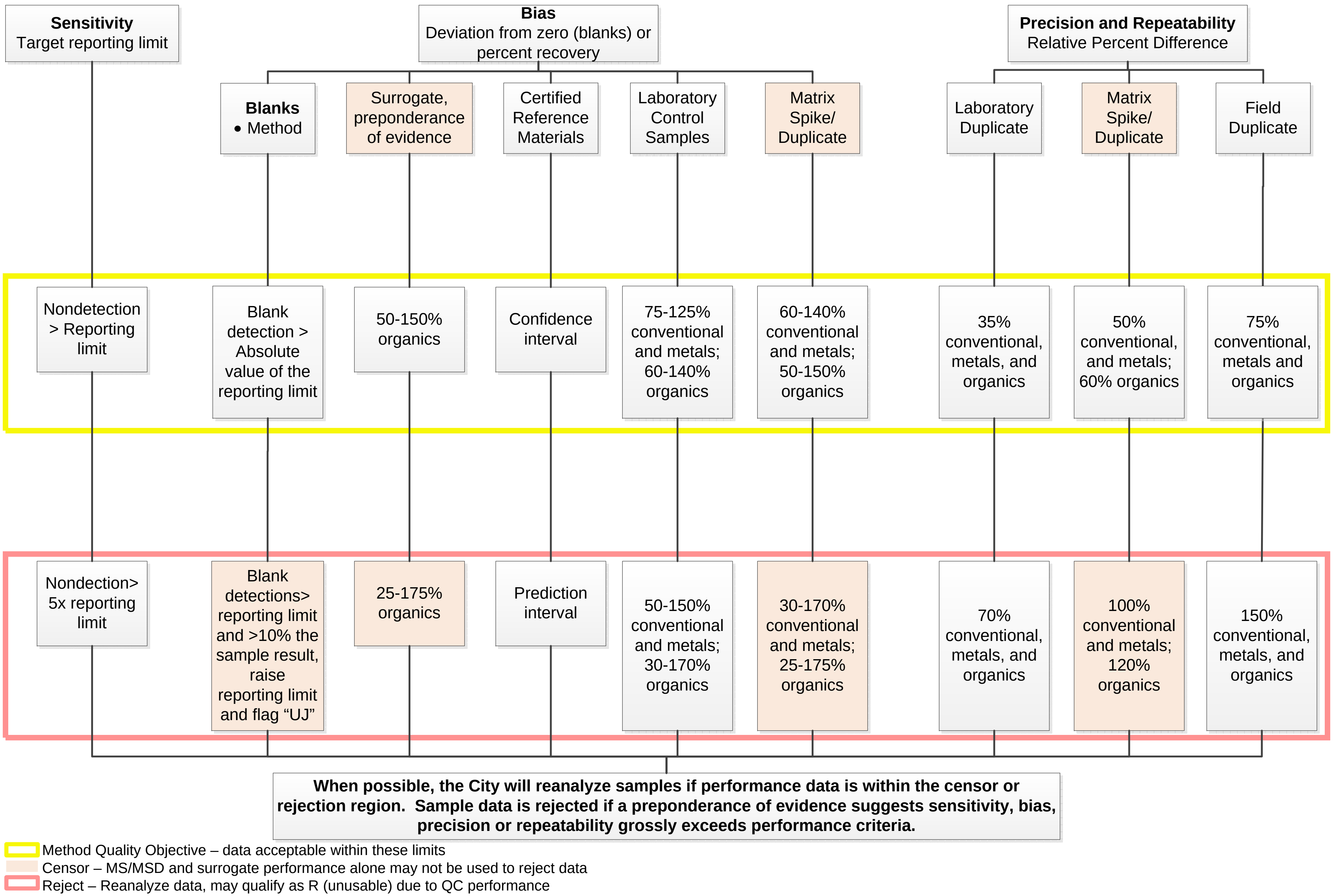
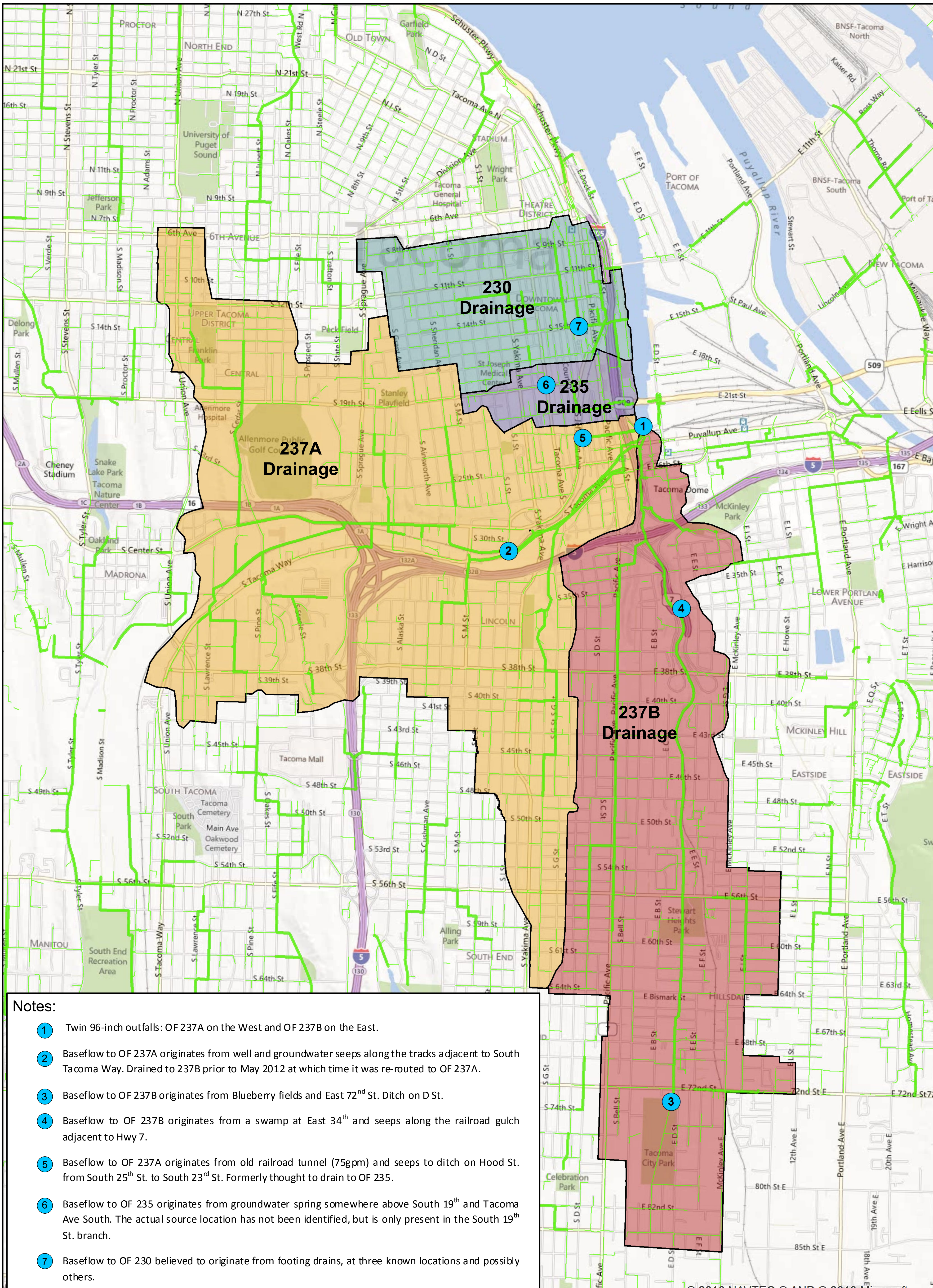


Figure 6-2.vsd

Figure 7-1
Baseflow Origins in Foss Drainage



Notes:

1. Twin 96-inch outfalls: OF 237A on the West and OF 237B on the East.
2. Baseflow to OF 237A originates from well and groundwater seeps along the tracks adjacent to South Tacoma Way. Drained to 237B prior to May 2012 at which time it was re-routed to OF 237A.
3. Baseflow to OF 237B originates from Blueberry fields and East 72nd St. Ditch on D St.
4. Baseflow to OF 237B originates from a swamp at East 34th and seeps along the railroad gulch adjacent to Hwy 7.
5. Baseflow to OF 237A originates from old railroad tunnel (75gpm) and seeps to ditch on Hood St. from South 25th St. to South 23rd St. Formerly thought to drain to OF 235.
6. Baseflow to OF 235 originates from groundwater spring somewhere above South 19th and Tacoma Ave South. The actual source location has not been identified, but is only present in the South 19th St. branch.
7. Baseflow to OF 230 believed to originate from footing drains, at three known locations and possibly others.

Legend

STORM LINES

TRUNKLINES 24" AND LARGER

Map Date: February 22, 2013
Source: Environmental Services Division, Public Works Department City of Tacoma

Center for Urban Waters
326 East D Street, Tacoma WA 98421
(253) 591-5588

N

0 1,000 2,000 4,000 Feet

Foss Basins

230 | 237A
235 | 237B

Tacoma

Datarequest/MHenley/Thea Foss Monitoring Program Figure B-2 - Van Pelt

Figure 7-2
Whole-Water Monitoring Location - OF230

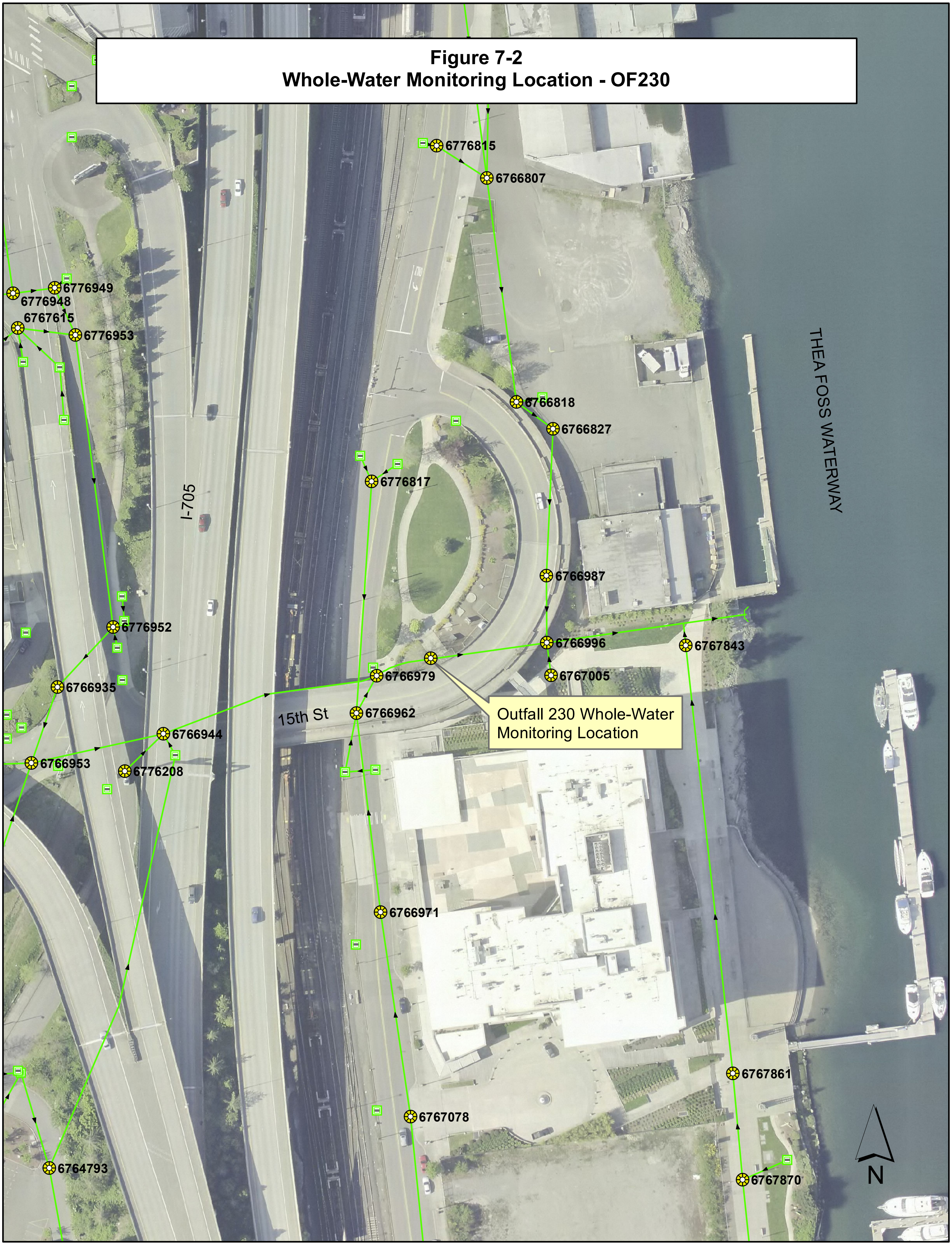


Figure 7-3
Sediment Trap Monitoring Location (New) - OF230

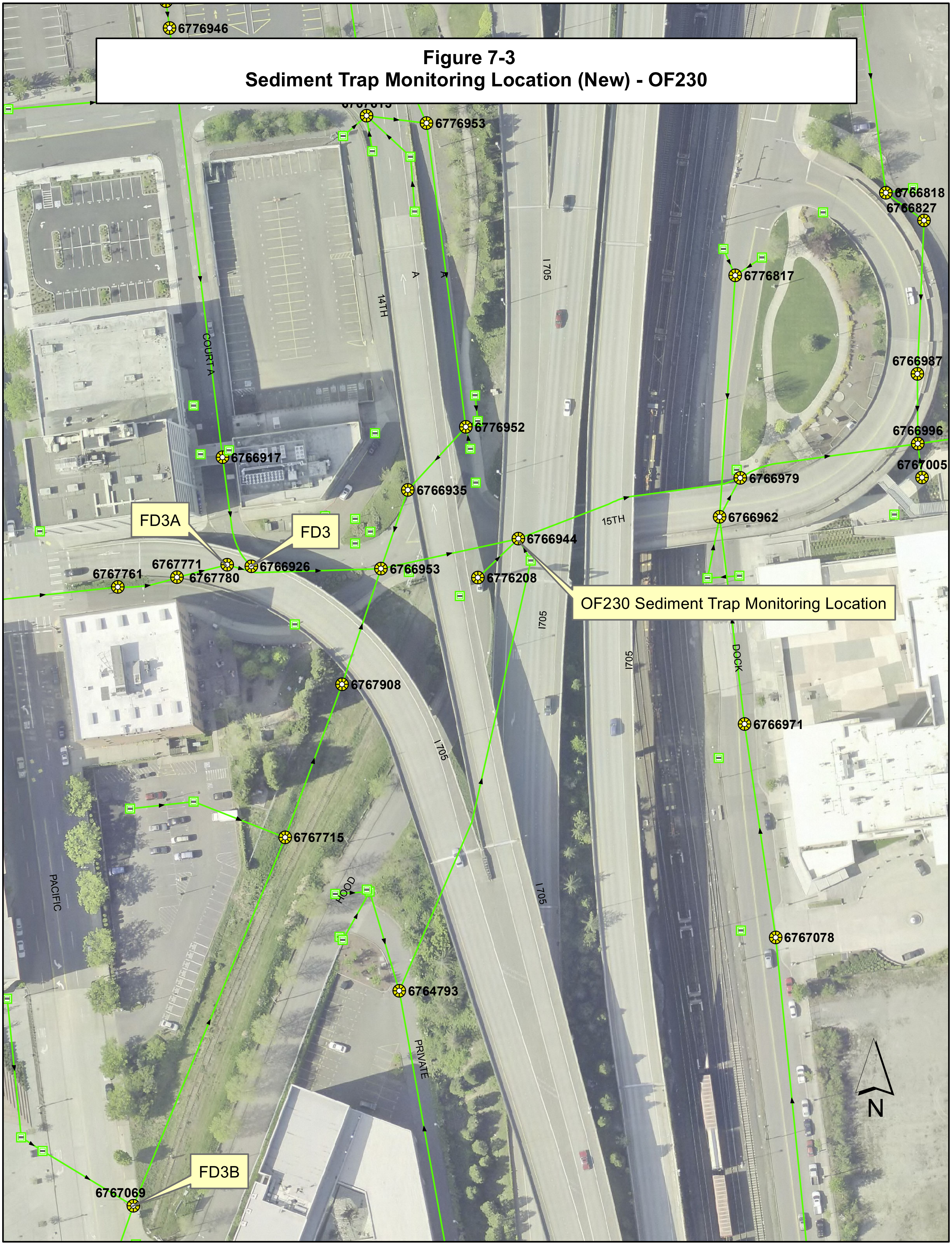


Figure 7-4
Rainfall-Runoff Correlations for OF235

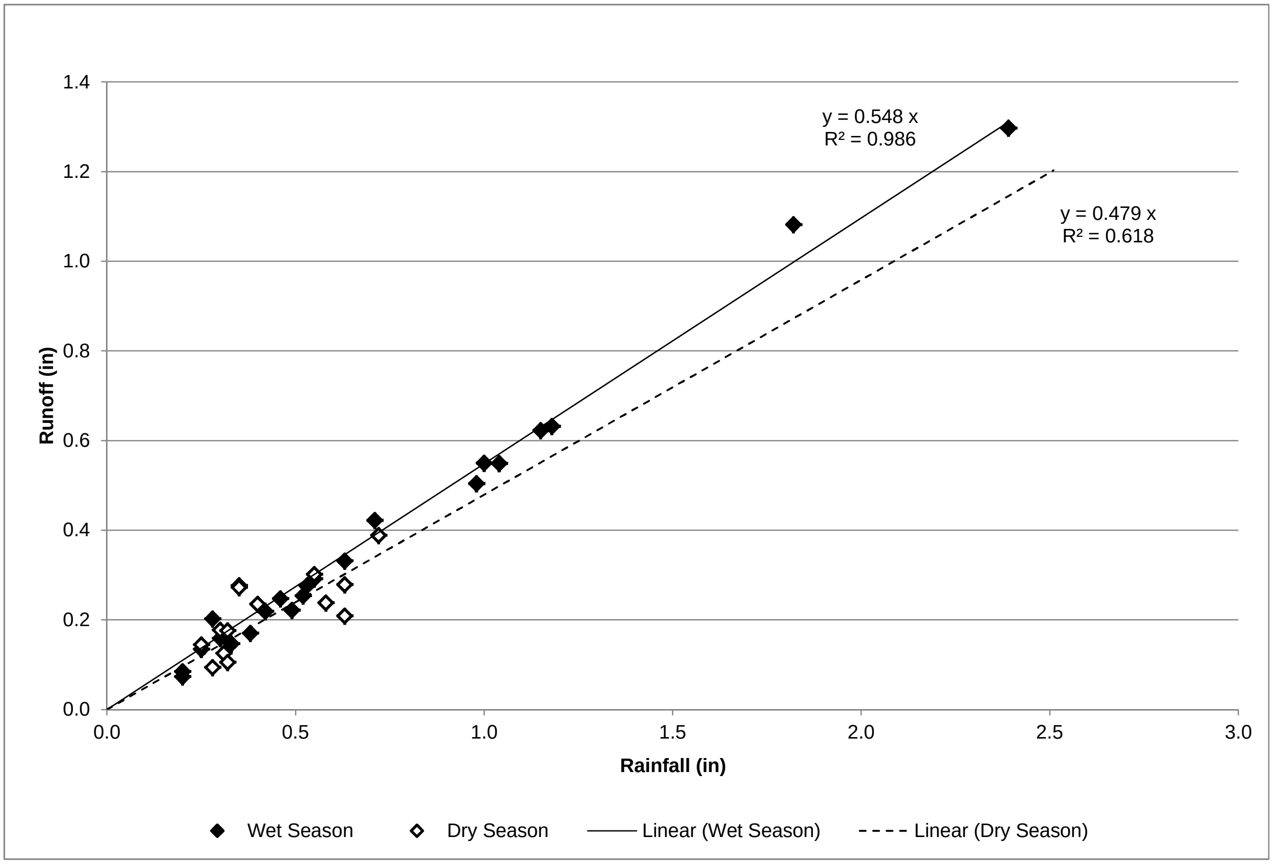


Figure 7-5
Whole-Water Monitoring and Sediment Trap Monitoring Locations - OF235

Figure 7-6
Whole-Water Monitoring and Sediment Trap Monitoring Locations - OF237A and OF273B

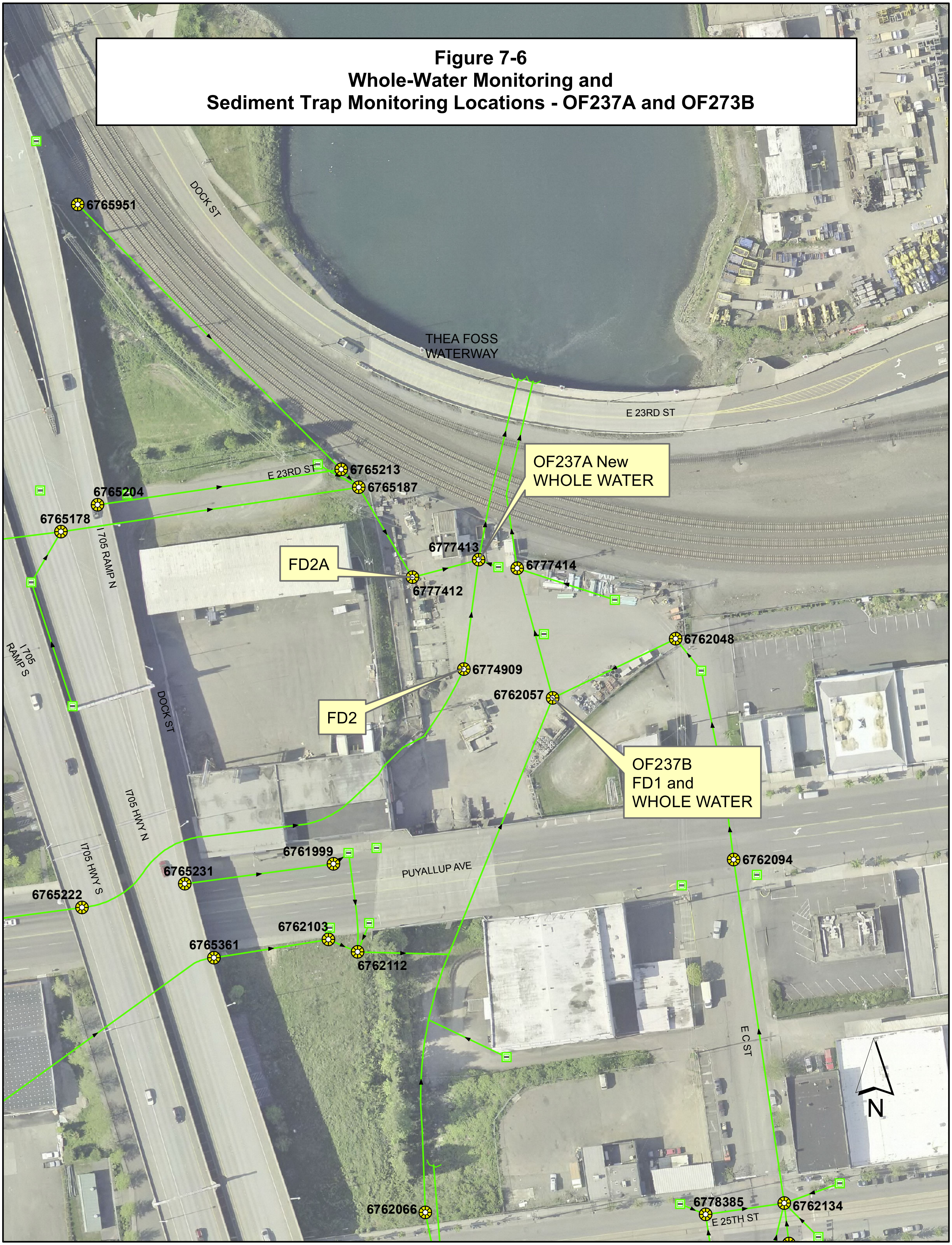


Figure 7-7
Rainfall-Runoff Correlations for OF237B

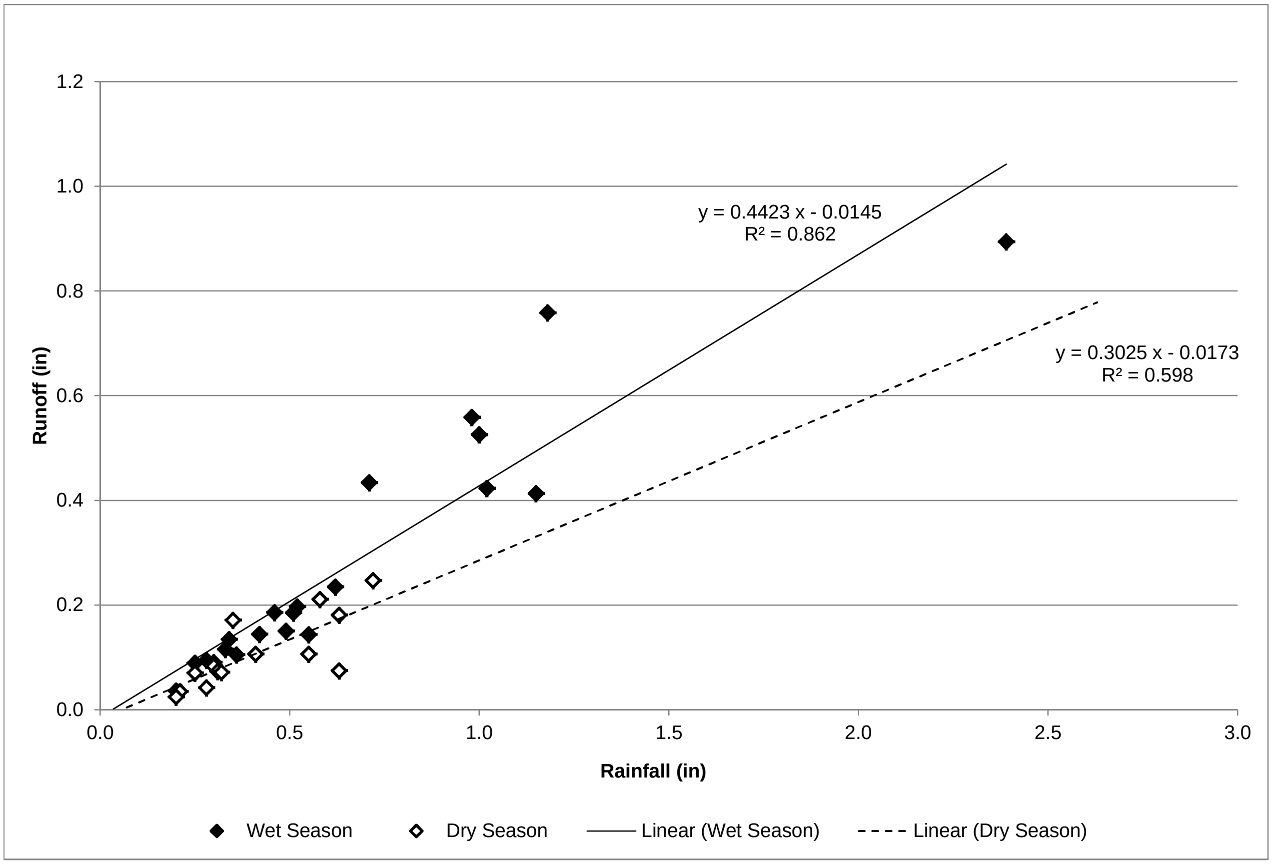


Figure 7-7 - Rainfall-Runoff Correlations for OF237B

Figure 7-8
Whole-Water Monitoring and Sediment Trap Monitoring Locations - OF243

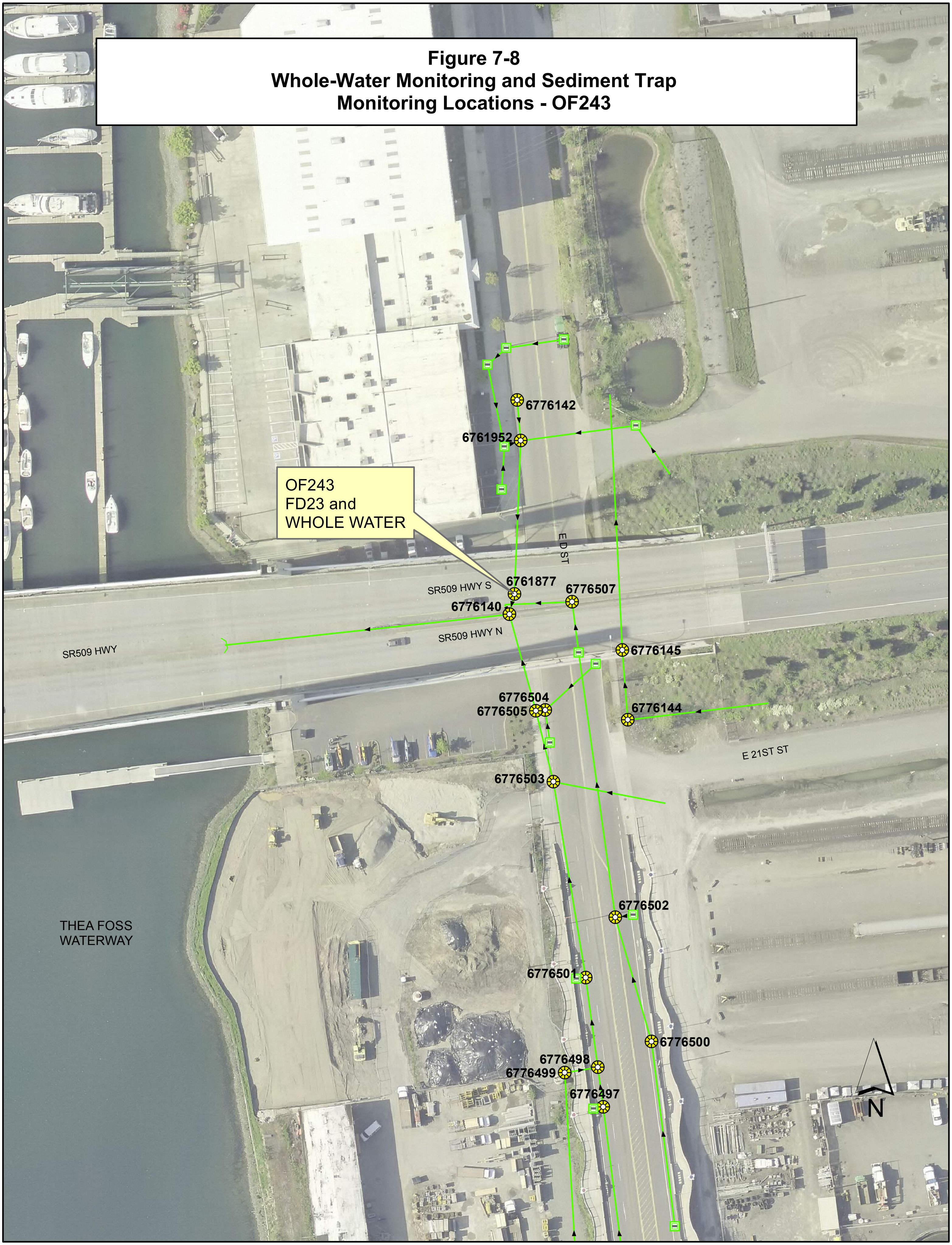


Figure 7-9
Whole-Water Monitoring and Manhole Sump Sample Location - OF245

Figure 7-10
Rainfall-Runoff Correlations for OF245

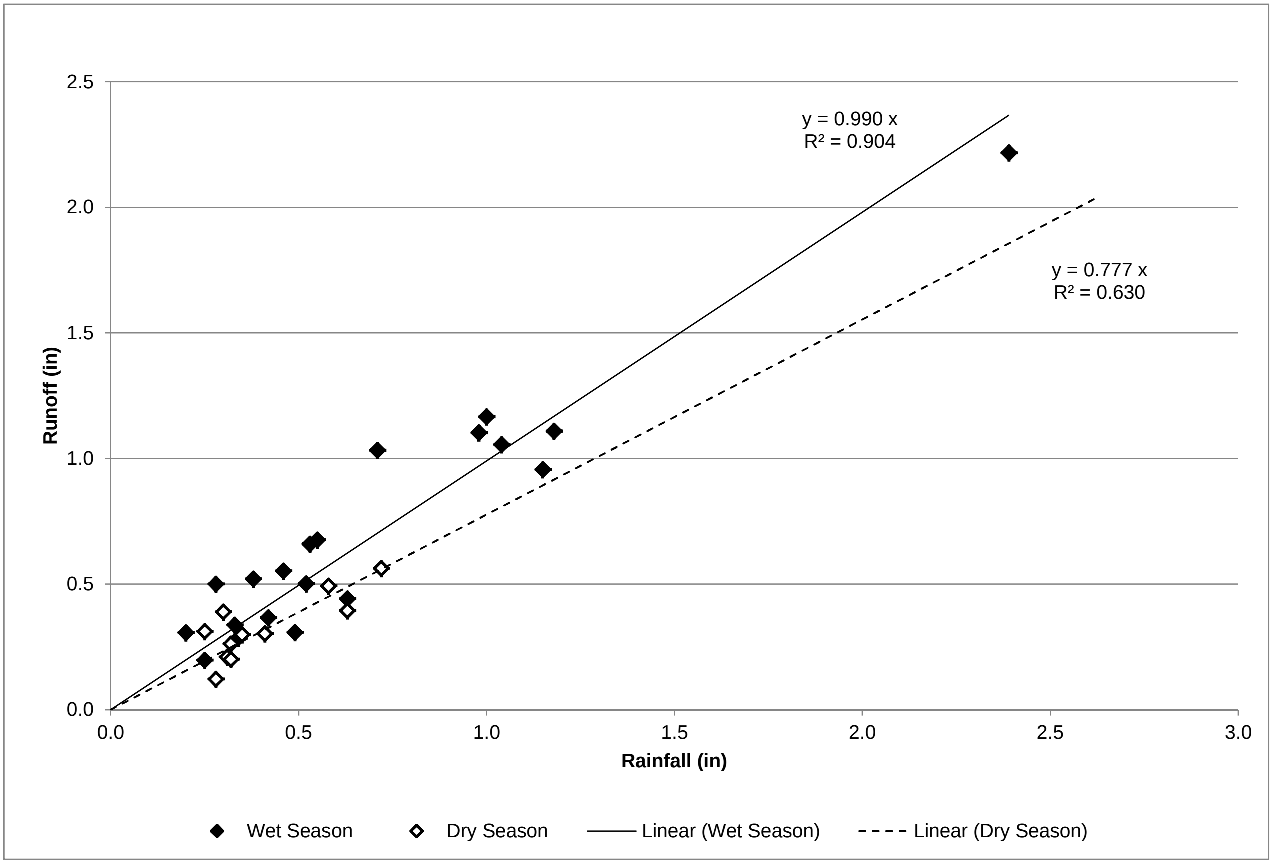
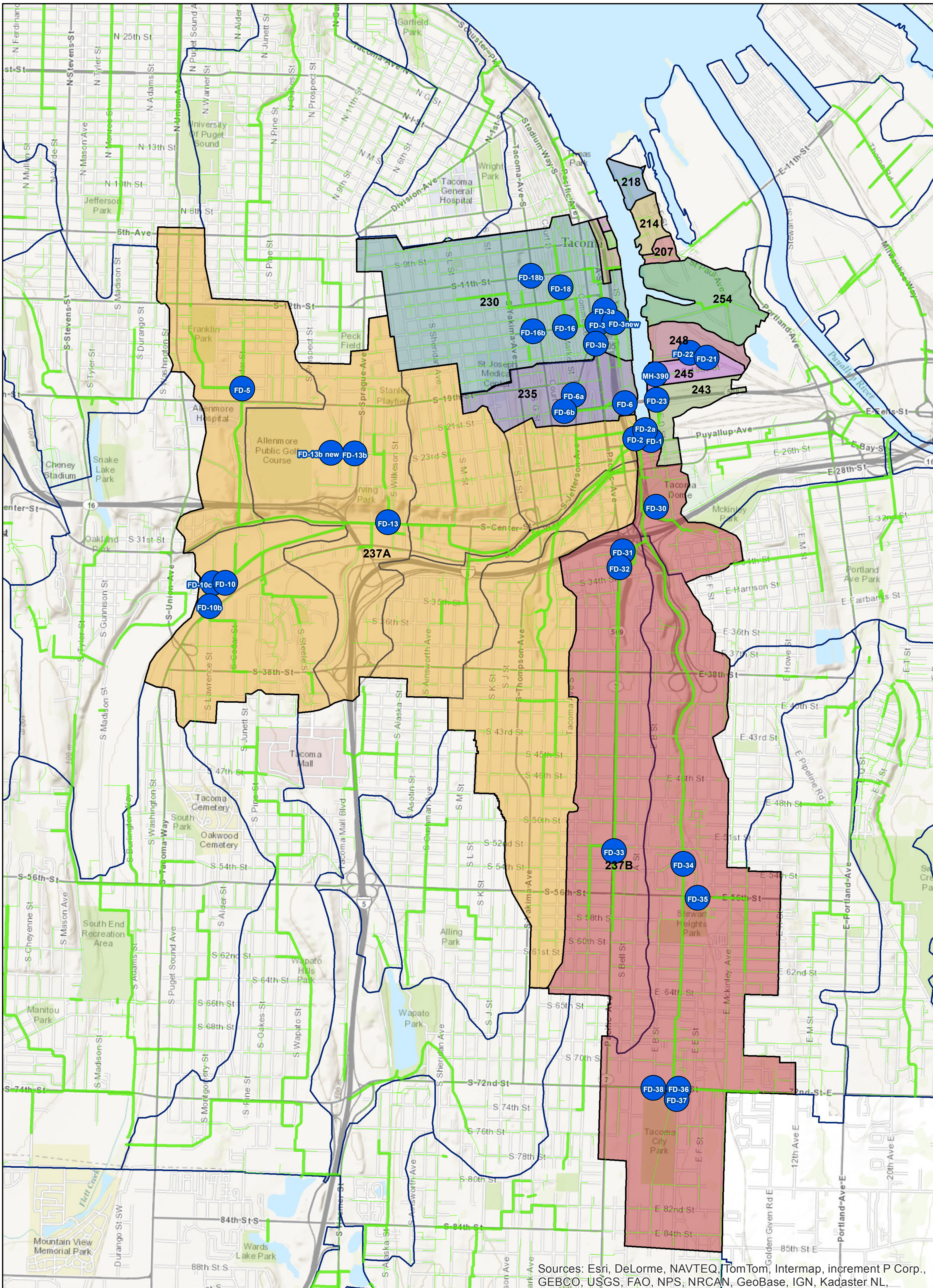


Figure 7-11
Whole-Water Monitoring Location - OF254

Figure 7-12
Upstream Sediment Trap Locations



Legend

- SEDIMENT TRAP LOCATIONS
- STORM LINES
- TRUNKLINES 24" AND LARGER
- STORMWATER SUB-BASINS

N

0 1,000 2,000 4,000 Feet

Map Date: September 16, 2014
Source: Science and Engineering Division, Environmental Services Department City of Tacoma

Environmental Services/ Science & Engineering
326 East D Street, Tacoma WA 98421
(253) 591-5588

Tacoma

Datarequest/KBartlett/NPDES_2014/Figure 7-12 - Van Pelt

Figure 7-13
Representativess of Sampled Storm Sizes

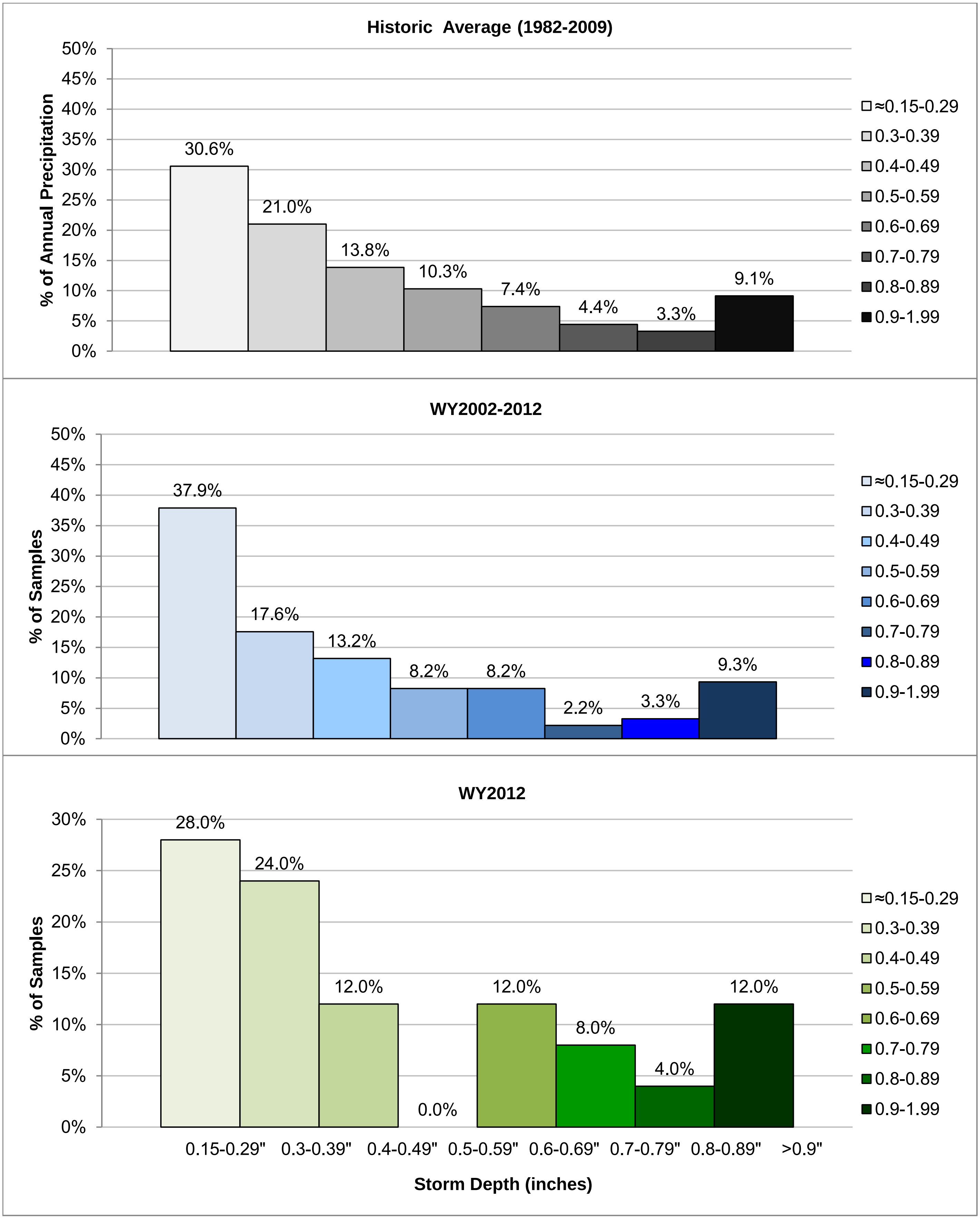


Figure 7-14
Storm Event Hydrologic Parameters, October 2001 - September 2012

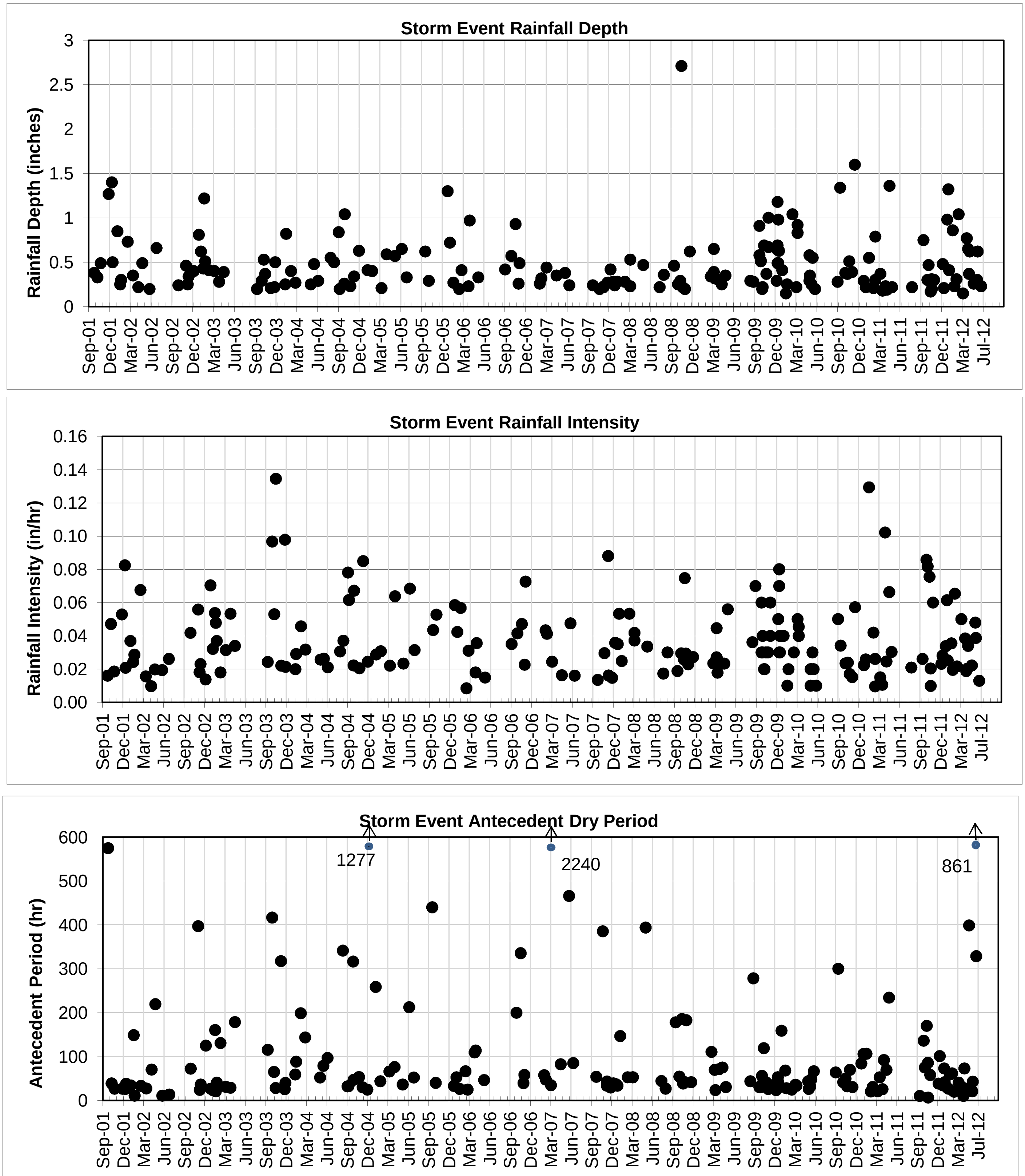
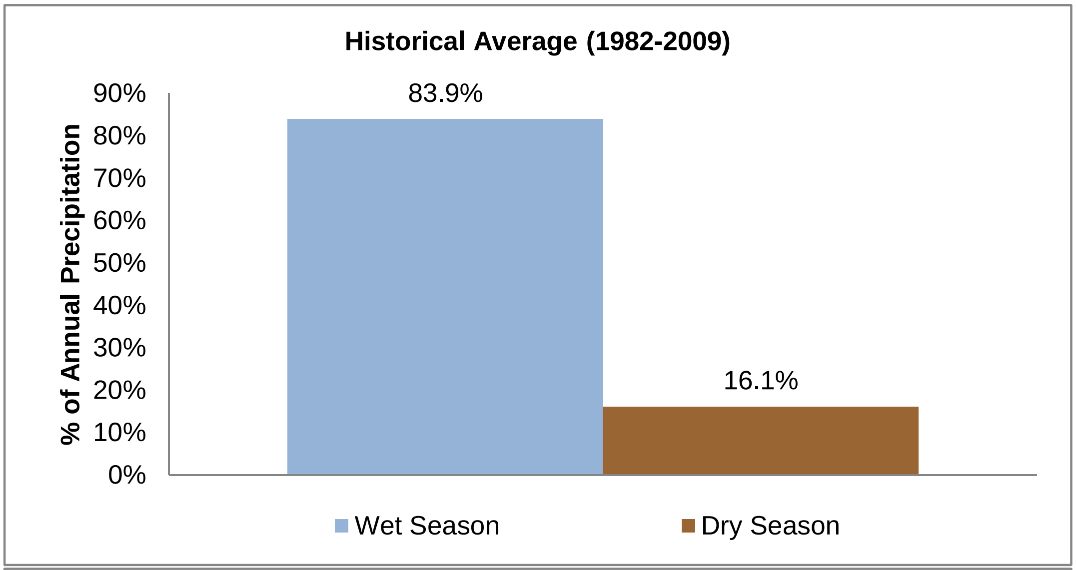
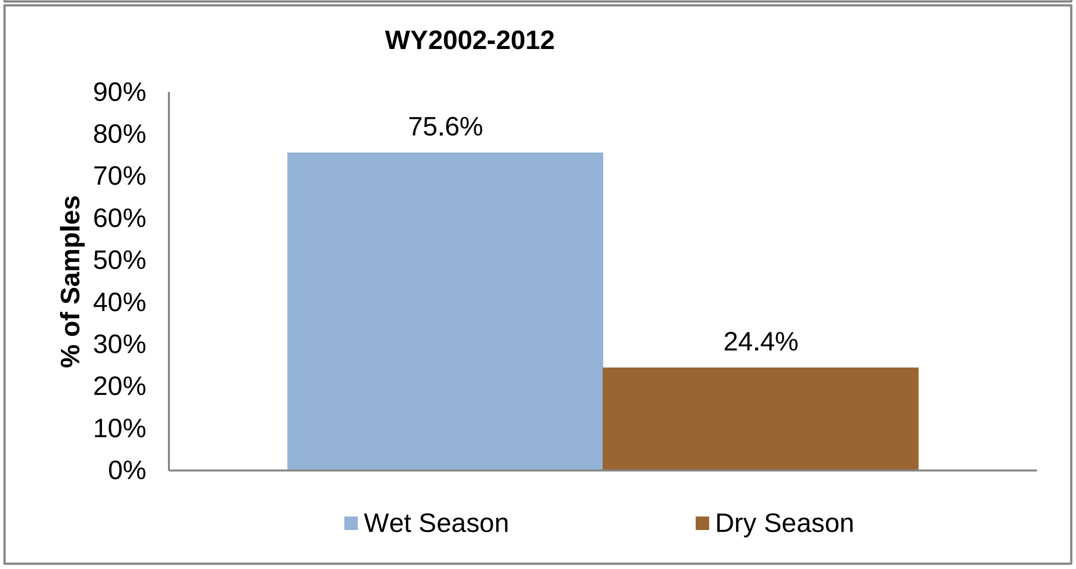


Figure 7-15
Representativeness of Seasonal Sampling Distribution





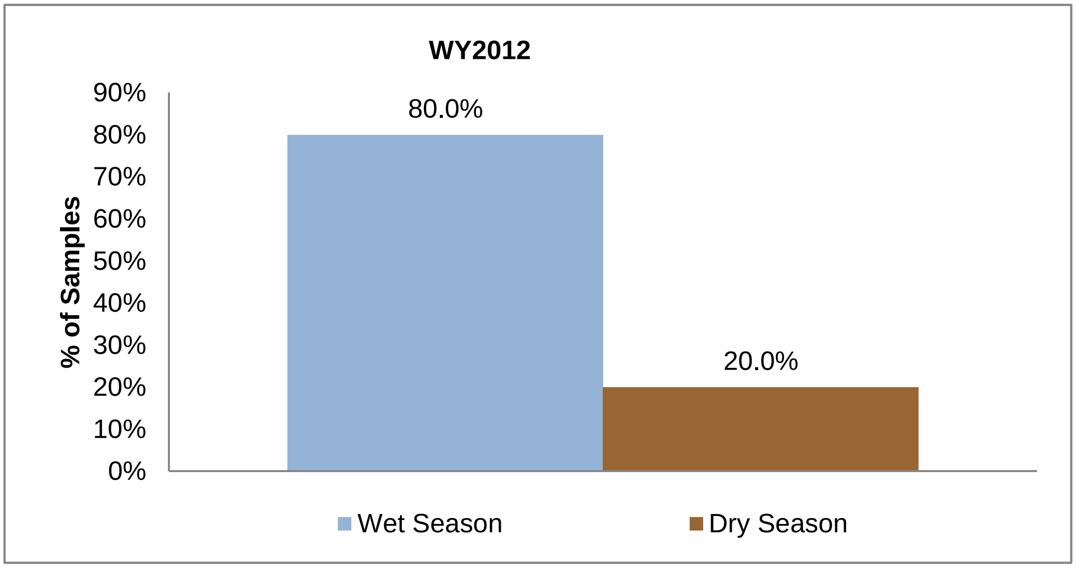


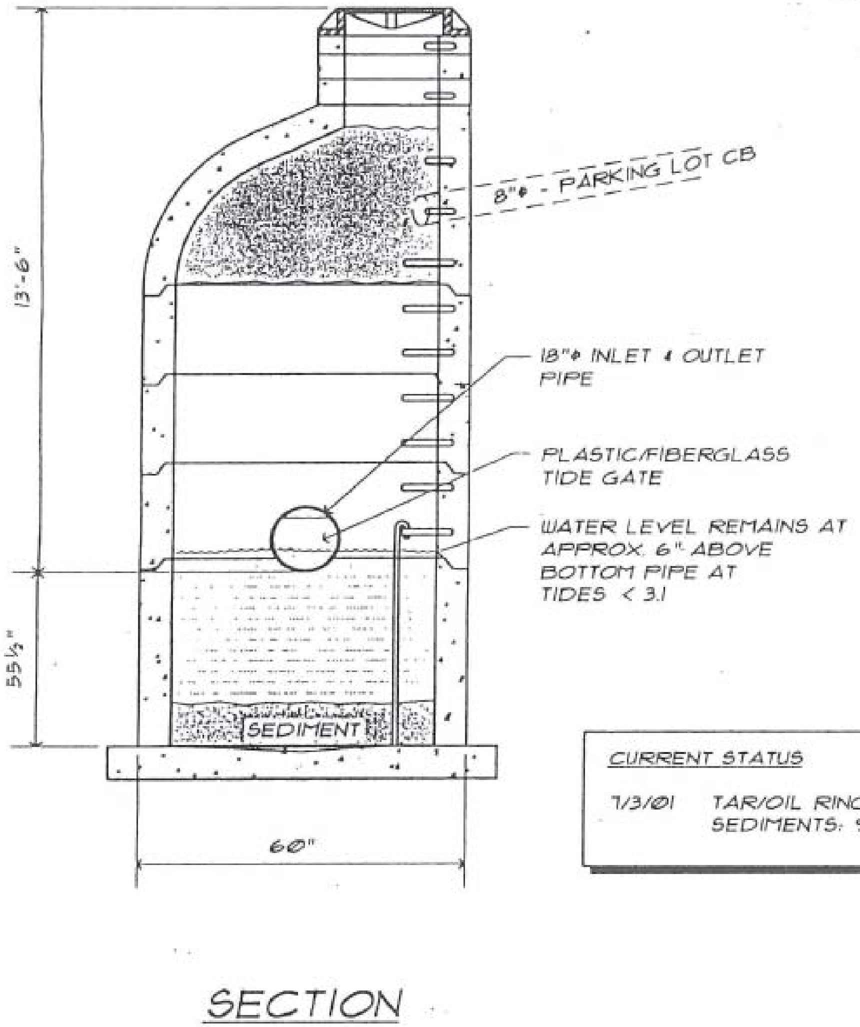
Figure 8-1
Sequential Sampler Base

Figure 8-2
Stormwater Sediment Traps

Sediment trap mounting bracket.

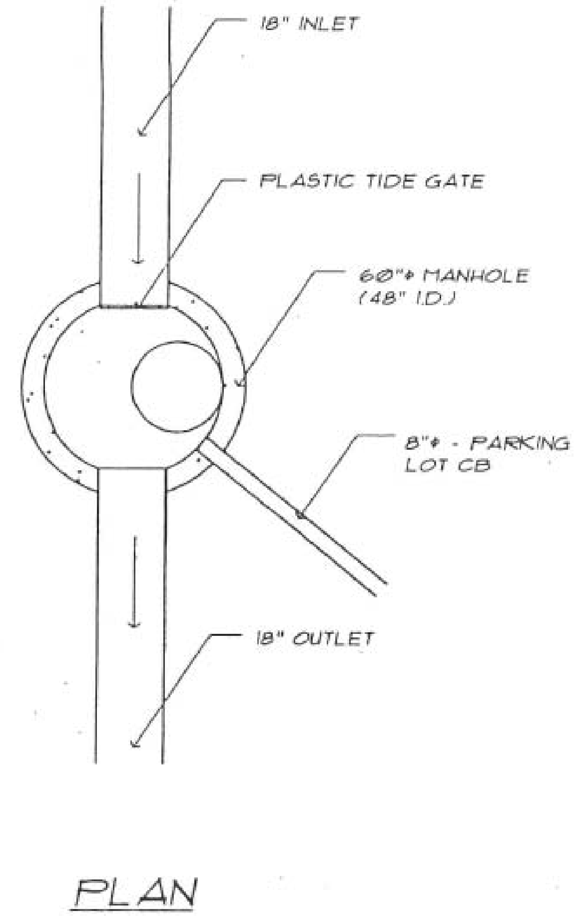
Typical sediment trap installation – large and medium pipe.

Figure 8-3
Sediment Trap Thea Foss Waterway



CURRENT STATUS

7/3/01 TAR/OIL RING, 3'-6', ±1½" THICK. SEDIMENTS: 9½"-16½" DEEP.



Manhole #390
OF 245
Johnny's Dock Restaurant
1900 East 'D' Street