# QUALITY ASSURANCE PROJECT PLAN

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# Pierce County
# Phase I Municipal Stormwater NPDES Permit

## Section S8.D – Stormwater Characterization

Prepared for

Pierce County
Surface Water Management

November 2009

**Note:**
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# QUALITY ASSURANCE PROJECT PLAN

# Pierce County
# Phase I Municipal Stormwater NPDES Permit
## Section S8.D. – Stormwater Characterization

Prepared for

Pierce County
Surface Water Management
2702 South 42nd Street, Suite 201
Tacoma, Washington 98409-7322

Prepared by

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November 5, 2009

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# Introduction

This Quality Assurance Project Plan (QAPP) has been prepared by Herrera Environmental Consultants (Herrera) and Pierce County to describe the management of the stormwater characterization monitoring study required under Section S8.D of the Phase I Municipal Stormwater Permit (WAR04-4503). This permit was issued by the Washington State Department of Ecology (Ecology) on January 17, 2007, with an effective date of February 16, 2007, under the National Pollutant Discharge Elimination System (NPDES) program. The permit required three types of monitoring under Section S8:

- Stormwater characterization (S8.D)
- Program effectiveness (S8.E)
- BMP effectiveness (S8.F)

This QAPP describes stormwater characterization monitoring and is submitted to meet the permit requirements of Section S8.D. This QAPP provides a description of the monitoring approach and detailed descriptions of the experimental design at each of three monitoring sites. This QAPP was prepared in accordance with Ecology's *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology 2004) and specifically documents the procedures that will be used during sample collection, processing, and analysis to ensure that the resultant data are scientifically and legally defensible. This information is organized within this document under the following subheadings:

- Background
- Project Description
- Organization and Schedule
- Quality Objectives
- Experimental Design
- Sampling Procedures
- Measurement Procedures
- Quality Control
- Data Management Procedures
- Audits and Reports
- Data Verification and Validation
- Data Quality (Usability) Assessment

# Background

Stormwater discharges are regulated through the National Pollutant Discharge Elimination System (NPDES) program that was established by the federal government through Section 402 of the Clean Water Act. The NPDES permit requires development and implementation of stormwater management programs to reduce the discharge of pollutants to the maximum extent practicable. In the state of Washington, Ecology is responsible for implementing all provisions of the Clean Water Act, including the NPDES program. Phase I of the NPDES program, which went into effect in 1990, applies to all municipalities with populations greater than 100,000.

In 1995, Ecology issued a separate Phase I permit for each of the following water quality management areas in Washington: Cedar/Green, Island/Snohomish, and South Puget Sound. In these permits, Pierce County was identified as a co-permittee with other Phase I jurisdictions (i.e., King, Clark, and Snohomish counties and the cities of Seattle and Tacoma). These permits were originally set to expire on July 5, 2000; Ecology administratively extended permit coverage until they issued the revised permit in January 2007. Ecology combined the three current general permits into a single statewide general permit. The general permit applies to all entities required to have permit coverage under current (Phase I) U.S. Environmental Protection Agency (EPA) stormwater regulations. Ecology's intent is to combing monitoring results from all Phase I permittees to provide them with a sufficient data set from which to draw conclusions about the effectiveness of these programs on a region-wide basis.

# Project Description

The goal of this stormwater characterization monitoring project is to meet the requirements of Section S8.D of the Phase I Municipal Stormwater Permit. The purpose of the permit is to provide Ecology with information on the pollutant loading and average event mean concentrations from representative basins serviced by municipal storm sewer systems. Each basin is to represent a different land use type, so that pollutant export can be correlated with land use within the basins.

Section S8.D requires stormwater monitoring for three basins with three sampling components:

- **Stormwater sampling:** Both composite and grab samples will be collected during 11 to 14 storm events and analyzed for conventionals, nutrients, metals, some organic pollutants and bacteria. A full list of constituents can be found in the *Sampling Process Design* section. Sampling will be conducted throughout the year, reflecting the distribution of rainfall between wet and dry seasons; 60 to 80 percent of the samples will be collected in the wet season.

- **Baseflow sampling:** Grab samples will be collected during baseflow conditions, twice during the dry season and twice during the wet season, during the first full year of monitoring. These samples will be analyzed for a subset of constituents as listed in the *Sampling Process Design* section.

- **Toxicity sampling:** Starting in 2011, toxicity sampling will be conducted once per year during a seasonal first-flush storm event near the end of summer. Samples will be collected with an automated sampler as flow-weighted composites.

- **Sediment sampling:** Sediment sampling will be carried out over the annual discharge period with one composite sample analyzed per year. Sediment will be collected by installing a passive sediment sampler at the base of the outfall pipe to collect sediment on annual basis for high flows. The sediment will be analyzed for conventionals, organics, PCBs, and metals. A full list of constituents can be found in the *Sampling Process Design* section.

Three basins representing different land use types; commercial, low-density residential, and high-density residential, were selected for this monitoring. To facilitate monitoring, continuous flow monitoring equipment, automated water samplers, rain gauges, and sediment samplers will be deployed at the terminus of each basin.

Monitoring for this project will begin in August 2009 and continue through February of 2012. The results of the monitoring will be summarized in an annual report that will present the data collected during each water year (October 1 – September 30). These reports will be submitted to Ecology in accordance with the requirements of the Phase I permit.

# Project Organization and Schedule

This section initially describes the project organization and identifies key personnel and their roles. The project schedule is then summarized at the end of this section.

## Project Organization and Key Personnel

Herrera is responsible for developing this QAPP with oversight from Pierce County and Ecology. Herrera Environmental Consultants staff will assist with site equipment installations and provide some training to Pierce County staff. Pierce County staff will do the field monitoring and Herrera staff will carry out data management and reporting functions. Laboratory service providers have been proposed for this project as listed below, however the final selection of the laboratories has not been confirmed. Key personnel that will be involved in this effort are identified below with their respective roles:

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| | |
|---|---|
| Mary Ann Rempel-Hester | Laboratory Manager |

Test America [a]
Tacoma Laboratory
5755 8th Street East
Tacoma, WA 98424
Kathy Kreps Laboratory Manager

[a] Pierce County is required to use a competitive bid process for laboratory services and lab selection may change as a result of that process. Appropriate laboratory certification will be identified as a requirement in that bid process.

## Roles and Responsibilities

A detailed description of the responsibility associated with key roles is outlined in Table 1.

**Table 1. Roles and responsibilities for the Pierce County Phase 1 NPDES Stormwater Characterization QAPP implementation.**

| Roles and Responsibilities |
|---|
| **Pierce County Project Manager/Storm Event Coordinator:** Responsible for the development, approval, implementation, and maintenance of the QAPP. Acts as a liaison between the analytical laboratory, the Field Supervision Technical Lead, the Data Quality Assurance Officer and the organization. Responsible for: maintaining records of QAPP distribution, including appendices and amendments; maintaining written records of sub-tier commitment to requirements specified in this QAPP; identifying, receiving, and maintaining study quality assurance records; coordinating with the Data Quality Assurance Officer to resolve QA- related issues. Ensure that the staff has the necessary education, experience, and/or training to perform their stated duties. Enforces corrective action. Responsible for ensuring tasks and other requirements in the contract for field implementation are executed on time and are of acceptable quality. Monitors and assesses the quality of work. Coordinates attendance at conference calls, training, meetings, and related study activities. Responsible for verifying the QAPP is followed and the study is producing data of known and acceptable quality. Ensures adequate training and supervision of all monitoring and data collection activities. Complies with corrective action requirements.<br><br>Supervises the assigned study personnel (scientists, technicians, and support staff) in providing for their efficient utilization by directing their efforts either directly or indirectly on studies. In general, other specific responsibilities include: coordinate study assignments in establishing priorities and scheduling, ensure the completion of high-quality studies within established budgets and time schedules, provide guidance and technical advice to those assigned to studies by evaluating performance, implement corrective actions and provide professional development to staff, and prepare and/or review preparation of study deliverables, interact with technical reviewers to assure technical quality requirements are met in accordance with QAPP specifications. |
| **Field Supervision Technical Lead:** Responsible for: supervising all aspects of the sampling and measurement in the field; the acquisition of samples and field data measurements in a timely manner that meet the quality objectives; field scheduling, staffing, and ensuring that staff are appropriately trained. |
| **Data Quality Assurance Officer:** Responsible for the acquisition, verification, and transfer of data to the database. Oversees data management for the study. Ensures data are submitted according to work plan specifications. Responsible for validation and verification of data collected. Provides the point of contact to resolve issues related to the data. |
| **Laboratory Manager:** Responsible for supervision of laboratory personnel involved in generating analytical data for this study. Responsible for ensuring that laboratory personnel involved in generating analytical data have adequate training and a thorough knowledge of the QAPP and all SOPs specific to the analyses or task performed and/or supervised. Responsible for oversight of all operations, ensuring that all QA/QC requirements are met, and documentation related to the analysis is completely and accurately reported. Enforces corrective action, as required. Develops and facilitates monitoring systems audits. |

# Project Schedule

Monitoring associated with this study will begin in August 2009 and continue through February 2012. Reporting for this project will be organized to evaluate and present the results of the data collected during this period. In keeping with this schedule, the following project milestones have been identified:

- August 2009 – monitoring begins
- August 16, 2009 – September 30, 2009 – Partial Monitoring Year 1
- March 31, 2010 – Year 1 Monitoring Report Due
- October 1, 2009 – September 30, 2010 – Monitoring Year 2
- March 31, 2011 – Year 2 Monitoring Report Due
- October 1. 2010 – September 30, 2011 – Monitoring Year 3
- March 31, 2012 – Year 3 Monitoring Report Due
- October 1, 2011 – February 15, 2012 – Partial Monitoring Year 4

# Quality Objectives

A primary goal of this QAPP is to ensure that the data collected for this study are scientifically accurate, useful for the intended analysis, and legally defensible. To achieve this goal, the collected data will be evaluated relative to the following indicators of quality assurance:

- **Precision:** A measure of the variability in the results of replicate measurements due to random error
- **Bias:** The systematic or persistent distortion of a measurement process that causes errors in one direction (i.e., the measured mean is different from the true value)
- **Representativeness:** The degree to which the data accurately describe the conditions being evaluated based on the selected sampling locations, sampling frequency and duration, and sampling methods
- **Completeness:** The amount of data obtained from the measurement system
- **Comparability:** The ability to compare data from the current study to data from other similar studies, regulatory requirements, and historical data

Measurement quality objectives (MQOs) are performance or acceptance criteria that are established for each of these quality assurance indicators. The specific MQOs to be used for this study are described below in separate subsections for hydrologic and laboratory data, respectively.

## Measurement Quality Objectives for Hydrologic Data

Hydrologic monitoring will involve measurements of precipitation depth, water level, and velocity, depending on the specific method used at each site. MQOs for these measurements are defined for the following data quality indicators: bias, representativeness, completeness, and comparability. (Precision generally cannot be readily assessed due to the difficulty associated with obtaining repeat measurements from hydrologic monitoring equipment during continuously changing site conditions.) The associated MQOs for hydrologic monitoring are defined in the subsections below.

### Bias

Bias will be assessed based on a comparison of monitoring equipment readings to an independently measured "true" value. Bias in discharge data collected through this study will be assessed based on a comparison of the monitoring equipment's actual readings to an independently measured "true" value. This independently measured value will be determined by measuring the cross-sectional area of flow at a particular station and the average flow velocity using a portable meter (e.g., Marsh-McBirney Flo-Mate). These data will then be processed in accordance with standard procedures (PSEP 1997) to estimate discharge. Alternatively, the independently measured value will be determined by routing the flow from a particular station to a container with a known volume (e.g., graduated cylinder or bucket) and measuring the time required to fill this container.

The MQO for discharge measurements will be a difference of no more than 20 percent between the monitoring equipment's reading and the independently measured value when flows are between 10 and 90 percent of the equipment's operational range. When flows are less than 10 percent or greater than 90 of percent of the monitoring equipment's operational range, the MQO for discharge measurements will be a difference of no more than 35 percent between the equipment's reading and the independently measured value.

If the monitoring station is utilizing a velocity meter, the velocity bias will be captured in the bias estimated for both level and discharge. At monitoring stations without velocity meters, velocity bias is not applicable.

Bias in water level data will be assessed based on a comparison of the monitoring equipment's actual readings to an independently measured value. In this case, the independently measured values will be derived by measuring the water depth in the primary measuring device at a particular station using a staff gauge or ruler, and manually measuring discharge using a flow meter, using standard operating procedures. The MQO for water level and discharge measurements will be a difference of no more than 10 percent between the monitoring equipment's readings and the independently measured value.

Bias in precipitation depth data collected through this study will be assessed based on a comparison of 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 initiate one tip of its bucket by adding incremental drops of water with a pipette. The resultant value will then be compared to the manufacturer's specifications for this volume. The MQO for precipitation depth will be a difference of no more than 5 percent between the rain gauge's actual reading and the volume specified by the manufacturer.

### Representativeness

The representativeness of the hydrologic data for the flow monitoring will be ensured by the proper installation of all associated monitoring equipment. Rainfall patterns, stormwater conveyance features, and surrounding land uses were also considered in the identification of monitoring locations and sampling frequencies to ensure that representative data will be obtained for this study. Additionally, monitoring will be conducted for at least 2 years, which will help to ensure that data are collected during representative climatic conditions for the region.

### 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 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.

### Comparability

There is no numeric MQO for this data quality indicator; however, standard monitoring procedures, units of measurement, and reporting conventions will be applied in this study to meet the goal of data comparability. The strategy for measuring bias in flow monitoring equipment described above will also help to ensure comparable data since it will be performed at all three outfall locations.

## Measurement Quality Objectives for Water Quality Data

Quality assurance objectives for laboratory data are defined for the following data quality indicators: precision, bias, representativeness, completeness, and comparability. The specific MQOs that have been identified for this project are described below and summarized in Table 2. Note that the term "reporting limit" in this document refers to the practical quantification limit established by the laboratory, not the method detection limit.

### Precision

In this study, overall data quality will be based on analytical precision. Analytical precision will be assessed by laboratory splits of samples, matrix spikes, and laboratory control samples (described below, under Bias). These will be assessed using relative percent difference (*RPD*) as calculated by the following equation:

$$RPD = \left( \frac{|C_1 - C_2|}{C_1 + C_2} \right) \times 200\%$$

Where: $RPD$ = Relative percent difference

$C_1$ and $C_2$ = Concentration values

If split sample concentrations are both within 5 times the reporting limit, the RPD goal for all parameters is < 2 times the reporting limit. If either of the split samples is at or below the reporting limit, the MQO cannot be calculated. *RPD* values exceeding those described here and in Table 1 will trigger an assessment as to whether there are any problems with the laboratory methodology which might warrant corrective actions.

**Table 2. Measurement quality objectives for water quality data.**

| Analyte Group | Analyte | Laboratory Method Blank [a] | Equipment Rinsate Blank [a] | Control Standard Recovery | Surrogate Recovery | Matrix Spike Recovery [b] | Laboratory and Field Duplicate *RPD* [c] |
|---|---|---|---|---|---|---|---|
| Conventional Parameters | Total suspended solids | ≤RL | NA | 90–110% | NA | NA | ≤25% or ±2 × RL |
| | Turbidity | ≤RL | NA | 90–110% | NA | 80–120% | ≤25% or ±2 × RL |
| | Conductivity | ≤RL | NA | 90–110% | NA | 80–120% | ≤25% or ±2 × RL |
| | Chloride | ≤RL | NA | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | $BOD_5$ | ≤RL | NA | 90–110% | NA | 80–120% | ≤25% or ±2 × RL |
| | Hardness as $CaCO_3$ | ≤RL | NA | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Methylene Blue Activated Substances (MBAS) | ≤RL | ≤ 2 x RL | 80–120% | NA | 80–120% | ≤25% or ±2 × RL |
| Bacteria | Fecal Coliform | ≤RL | NA | NA | NA | NA | ≤35% or ±2 × RL |
| Nutrients | Total phosphorus | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Ortho-phosphate phosphorus | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Total Kjeldahl nitrogen | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Nitrate + nitrite nitrogen | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| Metals | Zinc, total | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Zinc, dissolved | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Lead, total | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Lead, dissolved | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Copper, total | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Copper, dissolved | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Cadmium, total | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Cadmium, dissolved | ≤RL | ≤ 2 x RL | 90–110% | NA | 75–125% | ≤20% or ±2 × RL |
| | Mercury, total | ≤RL | ≤ 2 x RL | 80–120% | NA | 75–125% | ≤20% or ±2 × RL |
| | Mercury, dissolved | ≤RL | ≤ 2 x RL | 80–120% | NA | 75–125% | ≤20% or ±2 × RL |
| Semivolatile Organic Compounds | Polycyclic aromatic hydrocarbons | ≤RL | ≤ 2 x RL | Laboratory established limits | Laboratory established limits | Laboratory established limits | Laboratory established limits for laboratory duplicate ; ≤20% for field duplicate |
| | Phthalates | | | | | | |
| | Pentachlorophenol | | | | | | |

**Table 2 (continued). Measurement quality objectives for water quality data.**

| Analyte Group | Analyte | Laboratory Method Blank [a] | Equipment Rinsate Blank [a] | Control Standard Recovery | Surrogate Recovery | Matrix Spike Recovery [b] | Laboratory and Field Duplicate *RPD* [c] |
|---|---|---|---|---|---|---|---|
| Chlorinated Herbicides | 2,4-D and MCPP<br>Triclopyr | ≤RL | ≤ 2 x RL | Laboratory established limits | Laboratory established limits | Laboratory established limits | Laboratory established limits for laboratory duplicate ; ≤20% for field duplicate |
| Halogenated Pesticide | Dichlobenil | ≤RL | ≤ 2 x RL | Laboratory established limits | Laboratory established limits | Laboratory established limits | Laboratory established limits for laboratory duplicate ; ≤20% for field duplicate |
| Organonitrogen Pesticides | Prometon | ≤RL | ≤ 2 x RL | Laboratory established limits | Laboratory established limits | Laboratory established limits | Laboratory established limits for laboratory duplicate ; ≤20% for field duplicate |
| Organophosphorus Pesticides | Chloropyrifos, Diazinon, and Malathion | ≤RL | ≤ 2 x RL | Laboratory established limits | Laboratory established limits | Laboratory established limits | Laboratory established limits for laboratory duplicate ; ≤20% for field duplicate |
| Petroleum Hydrocarbons | NWTPH-Dx | ≤RL | NA | 75–125% | 50–150 | 75–125% | ≤35% or ±2 × RL |
| | NWTPH-Gx | ≤RL | NA | 75–125% | 50–150 | 75–125% | ≤35% or ±2 × RL |
| Toxicity | Environmental Canada Trout Embryo Viability | Meet performance criteria in method relative to negative control. | NA | Meet performance criteria in method relative to reference toxicant. | NA | NA | Meet performance criteria in method relative to sample replication. |

[a] If criteria is not met associated blank concentration is defined as the new reporting limit and project sample data within 5 times this de facto reporting limit are flagged with a *J*.
[b] For inorganics, the CLP Functional Guidelines state that the spike recovery limits do not apply when the sample concentration exceeds the spike concentration by a factor of four or more (Ecology 2005).
[c] The relative percent difference must be less than or equal to the indicated percentage for values that are greater than 5 times the reporting limit. RPD must be and ±2 times the reporting limit for values that are less than or equal to 5 times the reporting limit.

Acronyms:
NA = not applicable.
RL = reporting limit.
RPD = relative percent difference.

## Bias

Bias will be assessed based on analyses of method blanks, equipment rinsate blanks, matrix spikes, and laboratory control samples (LCS).

### *Field Sample Bias*

Equipment rinsate blank results greater than two times the laboratory reporting limit (RL) will be flagged as a de facto detection limit (*U*), and associated project samples within 5 times the de facto reporting limit will be labeled with a *J*. For details regarding remedial steps if contamination from field equipment is detected, refer to the *Verification and Validation* section.

### *Laboratory Bias*

The values for method blanks will not exceed the reporting limit. The percent recovery of matrix spikes and the percent recovery of LCS are described in Table 2 for all applicable parameters. Percent recovery for matrix spikes will be calculated using the following equation:

$$\%R = \frac{(S - U)}{C_{sa}} \times 100\%$$

Where: %R = Percent recovery
S = Measured concentration in spike sample
U = Measured concentration in unspiked sample
$C_{sa}$ = Actual concentration of spike added

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

Percent recovery for LCS will be calculated using the following equation:

$$\%R = \frac{M}{T} \times 100\%$$

Where: %R = Percent recovery
M = Measured value
T = True value

## Representativeness

The sampling design will provide samples that represent a wide range of water quality conditions during storm flow conditions. Sample representativeness will be ensured by adequate sample size over a sufficient time span, and by employing consistent and standard sampling procedures.

One of the goals of this project is to collect flow-weighted composite samples with chemistries that are representative of event-mean concentrations (EMCs). In order for a composite sample to be representative of an EMC, certain sampling criteria are required. The sampling criteria for this project as defined by the Phase I Municipal Stormwater Permit for Stormwater Monitoring (S8.D) are as follows:

Sampling must occur for **67 percent** of the forecasted qualifying storms or up to a **maximum of 11 qualifying storm** events per year. (The number of qualifying storms is influenced by the constraints of the laboratory as well as laboratory and Pierce County staff holiday schedules. Storms that meet storm event criteria, but that occur on days that the laboratory cannot accept the samples [e.g., Fridays or Saturdays) or on major holidays (i.e., Christmas Day, Thanksgiving Day, New Year's Day, Memorial Day, Labor Day and the Fourth of July)]), will not be included as a qualifying storm and therefore will not be included in the calculation of total qualifying storms.)

- At least **10 flow-weighted sub-samples** (or aliquots) must be collected during each sampled event. Composite samples with seven to nine aliquots are acceptable if they meet the other sampling criteria and help provide a balance of wet and dry season events and storm sizes.

- Samples shall be collected for at least **75 percent of the storm event hydrograph** as measured by volume. For storms events exceeding 24 hours, samples shall be collected for at least 75 percent of the hydrograph for the first 24 hours of the storm.

Sampling events will be selected to reflect the distribution of rainfall between the wet and dry seasons throughout the year with a goal of 60 to 80 percent of the samples collected during the wet season. The following criteria will serve as guidelines for defining the acceptability of specific storm events for **wet season** (October 1 through April 30) sampling:

- Target storm depth: A **minimum of 0.20 inches** of precipitation, with no fixed maximum. (Up to 3 storm events that do not meet the criteria can be included but cannot be counted as one of the 11 qualifying storm events.)

- Antecedent conditions: A period of **at least 24-hours** preceding the event **with less than or equal to 0.02 inches** of precipitation

- Storm duration: There are no fixed minimum or maximum storm durations.

- Inter-event dry period: A continuous **6-hour period with zero** precipitation

The following criteria will serve as guidelines for defining the acceptability of specific storm events for **dry season** (May 1 through September 30) sampling:

- Target storm depth: A **minimum of 0.20 inches** of precipitation, with no fixed maximum

- Antecedent conditions: A period of **at least 72 hours** preceding the event **with less than or equal to 0.02 inches** of precipitation
- Storm duration: There are no fixed minimum or maximum storm durations.
- Inter-event dry period: A continuous **6-hour period with zero** precipitation

Although there is no fixed minimum duration for a sampled storm event, the sampling should continue past the longest estimated time of concentration for the tributary area.

The following will serve as the guideline for defining acceptability of dry and wet season baseflow monitoring:

- Antecedent conditions: At least 72 hours with no precipitation

### Completeness

Completeness will be calculated by dividing the number of valid values by the total number of values. Valid sample data consists of unflagged data and estimated data that has been assigned a *J* qualifier. A qualitative assessment will be made as to which *J* flagged data may need to be excluded from this calculation. If less than 95 percent of the samples submitted to the laboratory are judged to be valid, then additional samples will be collected until at least 95 percent are judged to be valid.

### Comparability

Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied in this study to meet the goal of data comparability. The results will be tabulated in standard spreadsheets to facilitate analysis and comparison with water quality threshold limits (i.e., WAC 173-201A), where appropriate.

## Measurement Quality Objectives for Sediment Quality Data

Quality assurance objectives for sediment quality data results received from the laboratory are expressed in terms of precision, bias, representativeness, completeness, and comparability. The specific MQOs that have been identified for this project are described below and summarized in Table 3. Note that the term “reporting limit” in this document refers to the practical quantification limit established by the laboratory, not the method detection limit.

### Precision

In this study, overall project data quality will be based on analytical precision. Analytical precision will be assessed by laboratory splits of samples, matrix spikes, and laboratory control

**Table 3. Measurement quality objectives for sediment quality data.**

| Parameter Group | Parameter | Laboratory Method Blank [a] | Control Standard Recovery | Surrogate Recovery | Matrix Spike Recovery [b] | Laboratory and Field Duplicate *RPD* [c] |
|---|---|---|---|---|---|---|
| Conventional Parameters | Total solids (% solids) | NA | NA | NA | NA | ≤35% or ± 2X RL |
| | Grain-size | NA | NA | NA | NA | ≤35% or ± 2X RL |
| | Total organic carbon | ≤RL | 75 – 125% | NA | 75 – 125% | ≤35% or ± 2X RL |
| Metals | Zinc | ≤RL | 80 – 120% | NA | 75 – 125% | ≤20% or ± 2X RL |
| | Lead | | | | | |
| | Copper | | | | | |
| | Cadmium | | | | | |
| | Mercury | | | | 80 – 120% | |
| Semivolatile Organic Compounds | PAHs | ≤RL | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits for laboratory duplicate; ≤35% for field duplicate |
| | Phthalates-BNA | | | | | |
| | Phenolics-BNA | | | | | |
| | Pentachlorophenol | | | | | |
| PCBs | PCBs as Aroclors | ≤RL | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits for laboratory duplicate; ≤35% for field duplicate |
| Chlorinated Herbicides | 2,4-D and MCPP | ≤RL | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits for laboratory duplicate; ≤35% for field duplicate |
| | Triclopyr | | | | | |
| Halogenated Pesticide | Dichlobenil | ≤RL | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits for laboratory duplicate; ≤35% for field duplicate |
| Organonitrogen Pesticides | Prometon | ≤RL | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits for laboratory duplicate; ≤35% for field duplicate |
| Organophosphorus Pesticides | Chloropyrifos, Diazinon, and Malathion | ≤RL | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits | Laboratory established control limits for laboratory duplicate; ≤35% for field duplicate |

[a] If criteria is not met associated blank concentration is defined as the new reporting limit and project sample data within 5 times this de facto reporting limit are flagged with a J.
[b] For inorganics, the CLP Functional Guidelines state that the spike recovery limits do not apply when the sample concentration exceeds the spike concentration by a factor of four or more (Ecology 2005).
[c] The relative percent difference must be less than or equal to the indicated percentage for values that are greater than 5 times the reporting limit. RPD must be and ±2 times the reporting limit for values that are less than or equal to 5 times the reporting limit.
RL = reporting limit.
RPD = relative percent difference.

samples (described below, under Bias). These will be assessed using relative percent difference (*RPD*) as calculated by the following equation.

$$RPD = \left( \frac{|C_1 - C_2|}{C_1 + C_2} \right) \times 200\%$$

Where: *RPD* = Relative percent difference
$C_1$ and $C_2$ = Concentration values

If split sample concentrations are both within 5 times the reporting limit the RPD goal for all parameters is < 2 times the reporting limit. If either of the split samples is at or below the reporting limit the MQO cannot be calculated. *RPD* values exceeding those described in Table 3 will trigger an assessment as to whether there are any problems with laboratory methodology, which might warrant corrective action.

**Bias**

Bias will be assessed based on analyses of method blanks, equipment rinsate blanks, matrix spikes, and laboratory control samples (LCS).

***Field Sample Bias***

Equipment rinsate blanks for sediment collection bottles will not be performed because the rinsate sample would have a water matrix while the project samples would have a sediment matrix. This discrepancy in matrices renders the results of the blank analysis useless for the assessment of potential contamination of the project sediment samples.

***Laboratory Bias***

The values for method blanks will not exceed the reporting limit. The percent recovery of matrix spikes and the percent recovery of LCS are described in Table 3 for all applicable parameters. Percent recovery for matrix spikes will be calculated using the following equation:

$$\%R = \frac{(S - U)}{C_{sa}} \times 100\%$$

Where: %R = Percent recovery
S = Measured concentration in spike sample
U = Measured concentration in unspiked sample
$C_{sa}$ = Actual concentration of spike added

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

Percent recovery for LCS will be calculated using the following equation:

$$\%R = \frac{M}{T} \times 100\%$$

Where: %R = Percent recovery
M = Measured value
T = True value

**Representativeness**

The sampling design will provide samples that represent a wide range of sediment quality conditions during varying storm flow conditions. Annual collection of sediment will allow for a sample representative of the full year of sediment conditions. Sample representativeness will be ensured by adequate sample size over a sufficient time span, and by employing consistent and standard sampling procedures.

**Completeness**

Because only one sediment sample will be collected for each site, the only test for completeness will be that a sample is collected and analyzed for each site. If data quality problems occur with the sample, the appropriate QA step identified in previous portions of this QAPP (e.g., re-analyzing the sample) will be performed.

**Comparability**

Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied in this study to meet the goal of data comparability. The results will be tabulated in standard spreadsheets to facilitate analysis and comparison with sediment quality threshold limits where appropriate.

# Measurement Quality Objectives for Toxicity Data

Quality assurance objectives for toxicity data are expressed in terms of precision, bias, representativeness, completeness, and comparability. The specific MQOs that have been identified for this project are described below and summarized in Table 2.

### Precision

Precision will be assessed based on method performance criteria relative to sample replication. At a minimum, the laboratory will conduct four replicates per test dilution.

### Bias

Bias will be assessed based on analyses of a reference toxicant sample.

### Representativeness

Beginning in 2011, toxicity samples will be collected in August or September yearly to represent seasonal **first-flush storm** event conditions. The following criteria will serve as guidance for defining the acceptability for the toxicity sample storm event:

- Target storm depth: A **minimum of 0.20 inches** of precipitation, with no fixed maximum
- Antecedent conditions: A period of **at least 1 week** preceding the event **with less than or equal to 0.02 inches** of precipitation
- Storm duration: There are no fixed minimum or maximum storm durations.
- Inter-event dry period: A continuous **6 hour period with zero** precipitation

If conditions are not met for the seasonal first-flush storm event in August or September, toxicity samples will be collected in October, irrespective of antecedent conditions.

### Completeness

Completeness will be calculated by dividing the number of valid values by the total number of values. Valid sample data consists of unflagged data and estimated data that has been assigned a *J* qualifier. A qualitative assessment will be made as to which *J* flagged data may need to be excluded from this calculation prior to the production of the TER. If less than 95 percent of the samples submitted to the laboratory are judged to be valid, then additional samples will be collected until at least 95 percent are judged to be valid.

### Comparability

Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied in this study to meet the goal of data comparability. An $EC_{50}$ and, if possible, an $EC_{25}$ will be reported for each test.

# Experimental Design

This section provides an overview of the experimental design that will be used for this study. It begins with a detailed description of the study site for the three outfall basins defined as: Low Density Residential (LORES), High Density Residential (HIRES) and Commercial (COMM). Then, the sampling process design for each site is described including the type of equipment that will be installed and the configuration and set up of that equipment.

## Study Site Description

Pierce County staff reviewed maps and land use data and performed initial reconnaissance to identify six potential sites for stormwater characterization monitoring in accordance with Section S.8.D of the Phase I Permit. Pierce County and Herrera staff jointly visited these sites to perform a more detailed visual assessment of basin conditions and to assess sampling constraints including: safety and ease of site access, equipment security, power source, and site configuration for monitoring equipment installation. A third site visit was subsequently performed with Ecology staff to further discuss the merits of each site based on these considerations.

As a result of these efforts, three sites were selected, one to represent each of the three land use types specified in the Phase I NPDES permit: low density residential, high density residential, and commercial. Using GIS based land use and drainage system information provided by Pierce County; Herrera delineated the basin boundaries and characterized land use for each site. This information is described in detail in the following subsections.

### Low-Density Residential (LORES)

A site near Lake Sylvia was chosen for the Low Density Residential site. This site is located near the town of Gig Harbor on the Kitsap Peninsula. The specific outfall monitoring location is near the corner of 81st Street Avenue Northwest and 68th Street Court Northwest. Figure 1 shows the boundaries and land use for the watershed associated with this site. The watershed size and land use characteristics also summarized in Table 4.

As indicated in Figure 1, the site has one new residential development but is primarily comprised of forest, open space and occasional single-family residents. (The new residential development is not visible in the most recent Pierce County land use layer but is indicated by the system of drainage pipes and catch basins shown in Figure 1, and is visible in more recent aerial photos). The catchment is 218.5 acres in size and is comprised of approximately 5 percent impervious surface. As shown in Table 1, 43 percent of the catchment is classified as single-family residential and the majority of the remaining land is open space.

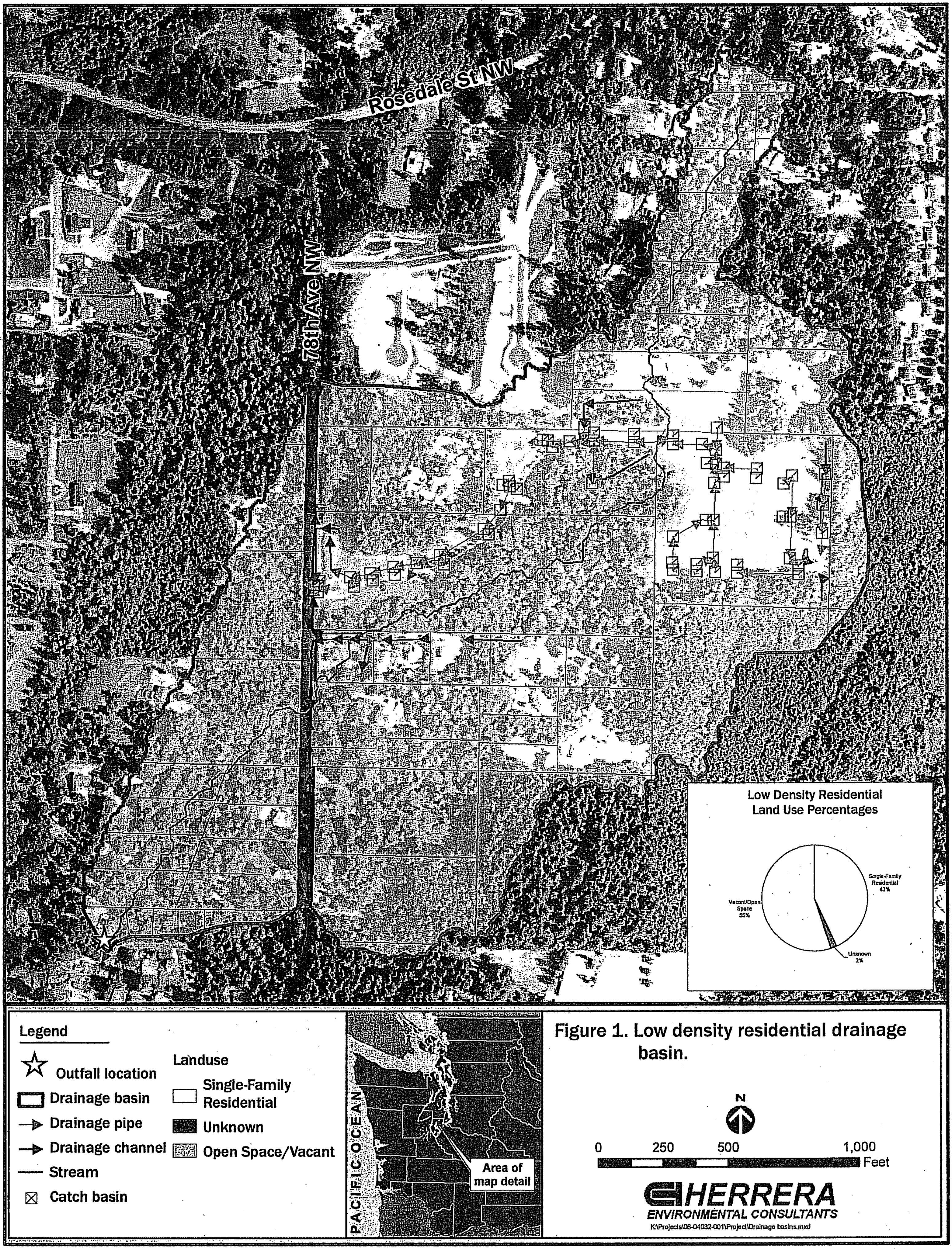



Figure 1. Low density residential drainage basin.

**Table 4. Summary of catchment land use types.**

| Land Use Category | Drainage Basin | Site Name | Catchment Size (acres) | Land Use Residential | Commercial | Industrial | Open Space | Other |
|---|---|---|---|---|---|---|---|---|
| Low Density Residential | Carr Inlet | Lake Sylvia | 218.5 | 43% [a] | 0% | 0% | 55% | 2% |
| High Density Residential | Puyallup River | Afden Pond | 125 | 62% [b] | 16% | 0% | 8% | 14% [c] |
| Commercial | Puyallup River | Canyon Road | 11.2 | 0% | 96% | 0% | 4% | 0% |

[a] This is all identified as single-family residential.
[b] Most of this (60%) is single family residential.
[c] This appears to be primarily roadway area.

Stormwater runoff from the new development in the catchment is served by a system of drainage pipes, but runoff from the majority of the catchment is through overland flow and drainage swales. The time of concentration for the catchment has been calculated as 27 minutes. The worksheet for time of concentration calculations is included in Appendix B.

### High Density Residential (HIRES)

A site adjacent to Afden Pond was chosen to characterize a high density residential land use watershed. The site is located in the City of Puyallup, Washington within the Puyallup River basin. The specific outfall monitoring location is near the intersection of 128th Street East and 82nd Avenue Court east, at the end of the cul-de-sac on 82nd Avenue Court East. Figure 2 shows the boundaries and land use for the associated catchment. The catchment size and land use characteristics are also summarized in Table 4.

As shown in Table 4, the catchment is approximately 125 acres in size, with approximately 35 acres (28 percent) of impervious surface. Land use in the catchment is predominantly single-family residential (60 percent), but primarily at urban density levels. The 14 percent of the catchment that is identified as 'unknown' in Table 4 largely represents the roadways that serve the residential area. Finally, multi-family housing represents an additional 2 percent of catchment. Collectively, these land uses represent 76 percent of the catchment; therefore, this catchment comes close to meeting the land use distribution required in the NPDES permit (80 percent). There is also a fairly high percentage (16 percent) of commercial land use in the catchment which also reflects the nature of high density residential land use in Pierce County.

The developed portions of the catchment (commercial and high density residential) are largely served by piped stormwater conveyance. However, open drainage channels also serve some of the low density and open space areas. The time of concentration has been calculated at 41 minutes. The worksheet for time of concentration calculations is included in Appendix B.

### Commercial (COMM)

The proposed Commercial site is located near the City of Tacoma, Washington and is also located within the Puyallup basin. The specific outfall monitoring location is located adjacent to

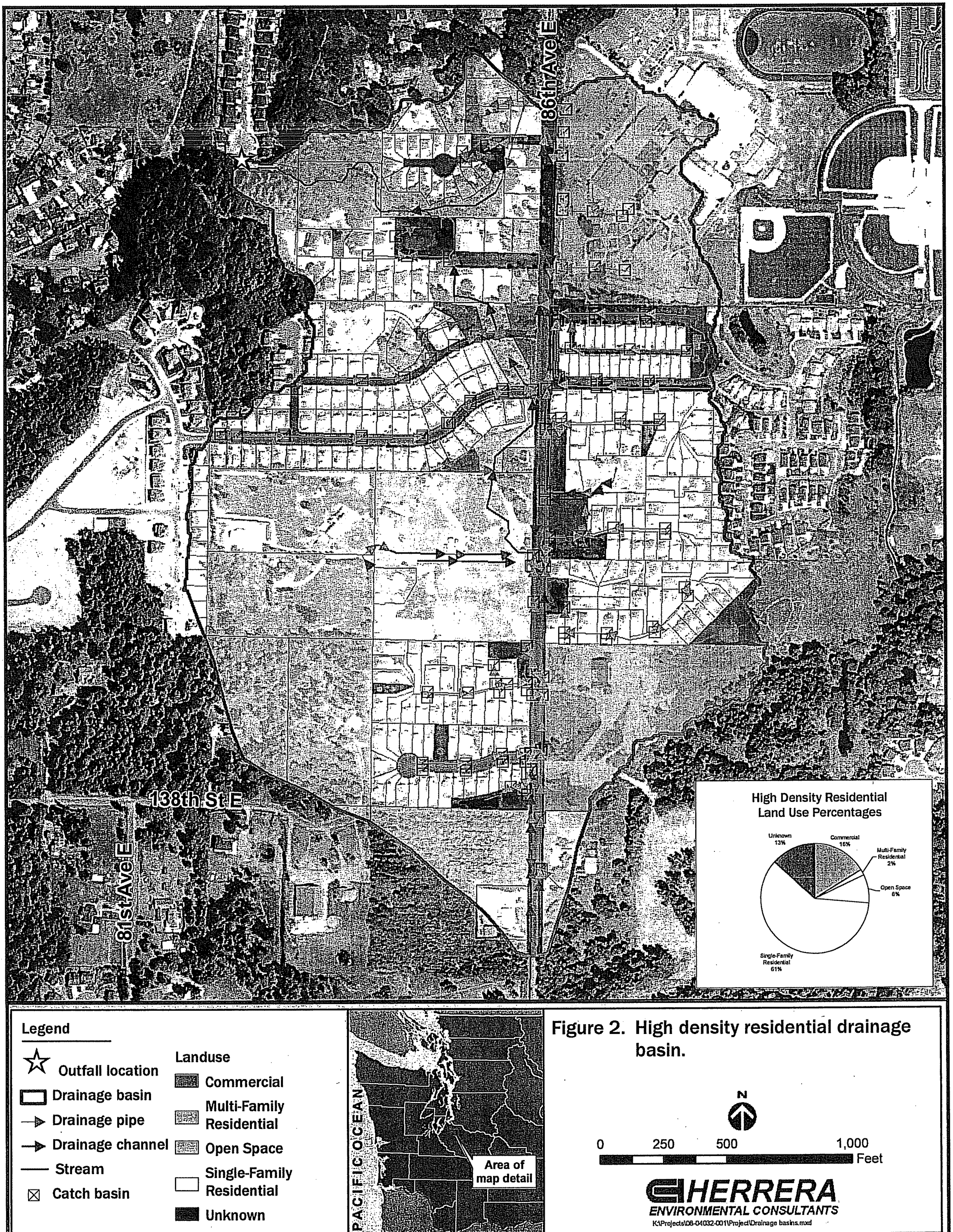



Figure 2. High density residential drainage basin.

a culverted stream near the intersection of112th Street East and Canyon Road East. Figure 3 shows the catchment boundaries and land use for the site. The catchment size and land use breakdown for the site is also summarized in Table 4.

As shown in Table 4, the total catchment size is approximately 11.2 acres; with 96 percent (10.8 acres) of this total estimated to be impervious surface. Land use in the catchment is predominantly commercial (96 percent); and exceeds the NPDES permit criteria of 80 percent. As is common in a commercial area, the majority of the area is served by piped stormwater conveyance. The time of concentration to the outlet was calculated to be approximately 40 minutes. The worksheet for time of concentration calculations is included in Appendix B. This monitoring site is located at the inlet catch basin to a Contech StormFilter stormwater treatment system. The monitoring at this site will be conducted in conjunction with monitoring at the outlet of the StormFilter system in order to quantify the performance of the system. (This system performance monitoring will be conducted to satisfy Section S.8.F of the NPDES Phase I Permit (Ecology 2007). The specific details regarding Section S.8.F monitoring will be discussed in a separate QAPP.)

## Sampling Process Design

Monitoring will consist of three primary components: hydrologic, water quality (including toxicity), and sediment quality monitoring. Each basin provides different constraints for the implementation of these different monitoring objectives, thus the following sections first generally describe the means by which these objectives will be met, and then provide specific details for each of the three monitoring sites. Table 5 summarizes the sample collection processes that are described in this section.

**Table 5. Sampling process design summary.**

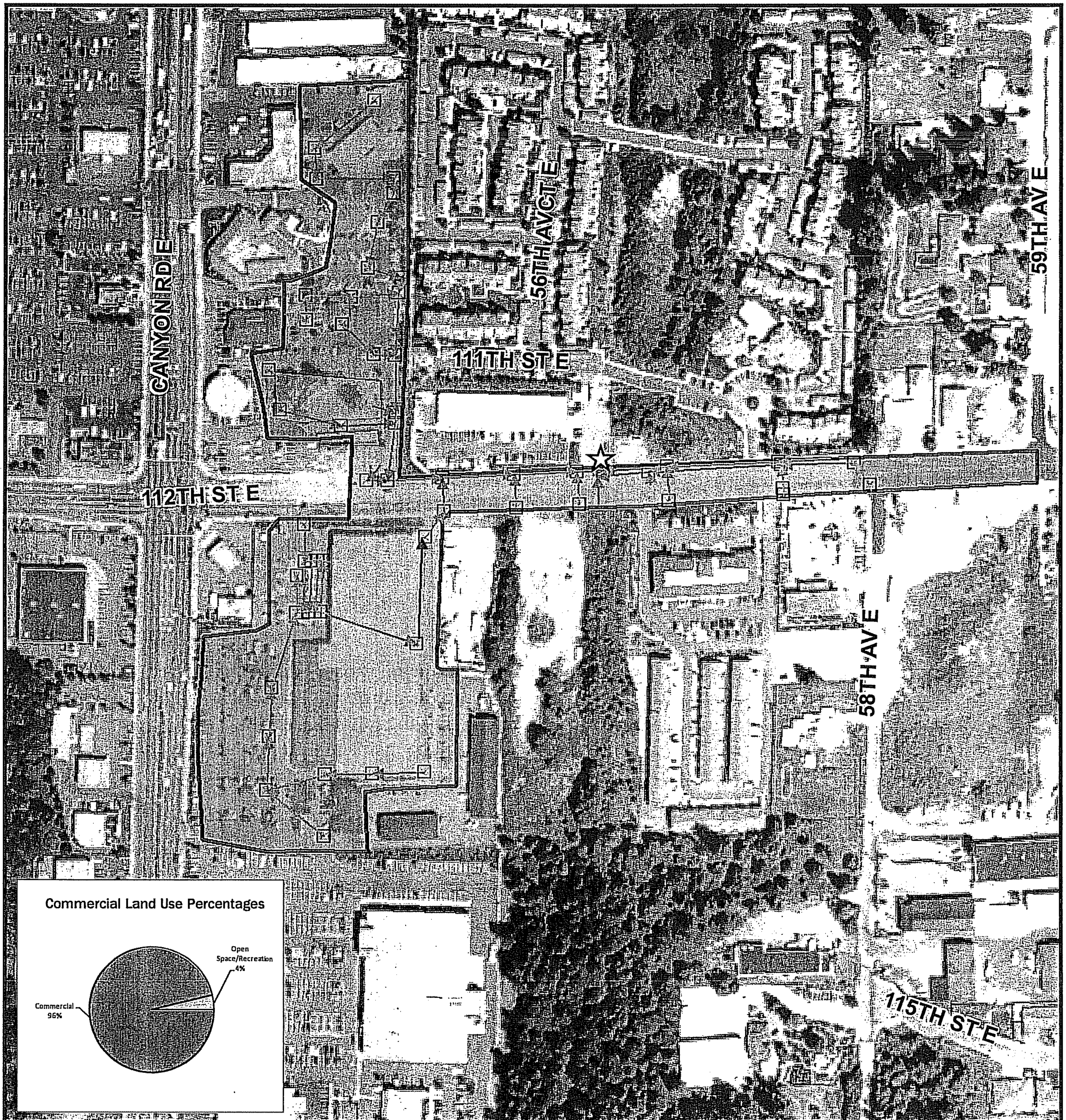
| Matrix | Temporal Boundaries | Sample/Technique | Parameters | Number of Events per Year [a] |
|---|---|---|---|---|
| Stormwater | Qualifying storm | Composite Sample | Water chemistry | 11 |
| | | Grab sample | Water chemistry (bacteria and TPH) | 11 |
| | First-flush Qualifying Storm | Composite Sample | Water chemistry [b] | 1 |
| | | | Toxicity | 1 |
| | | Grab sample | Water chemistry (bacteria and TPH) | 1 |
| Baseflow | Dry and wet season | Grab sample | Water chemistry [c] | 4[d] |
| Sediment | Annualized | Manual sediment trap | Sediment chemistry | 1 |

[a] Sampling occurs over a 2-year monitoring period.

[b] The first-flush qualifying storm parameter list includes a subset of those parameters identified for qualifying storms, as shown in Table.7.

[c] The baseflow monitoring parameter list includes a subset of those parameters identified for qualifying storms, as shown in Table.7.

[d] Applies only to first full year of monitoring.



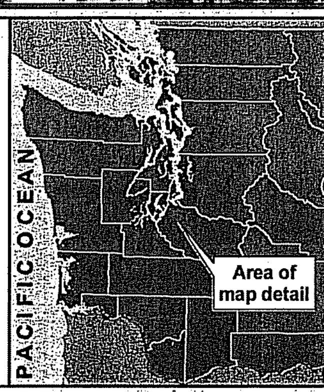




Figure 3. Commercial drainage basin.

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### Hydrologic Monitoring

At each of the three outfall stations, flow will be monitored over a 2 1/2-year period from August 16, 2009, through February 15, 2012. Flow will be monitored to develop a baseline rainfall/runoff relationship as well as to characterize storm flow volumes. In order to develop a baseline rainfall/runoff relationship, a continuous flow record of all storm events for at least one year is required (not just sampled storm events). Storm flow volumes, specific to monitoring storm events, will also be calculated in order to develop pollutant loadings and define storm events.

Monitoring at the three outfall stations will be conducted with an approach and equipment that are customized to each site's unique configuration. Flow monitoring equipment will be interfaced with a data logger which will record data on a 15-minute time-interval. The data loggers in this study will have their own station designations (e.g., COMM-DL, HIRES-DL, and LORES-DL) and the station designations will aid in data management. The data loggers will be equipped with a wireless modem link to allow remote communication. Continuous AC power will be used to power the instruments.

Precipitation will also be continuously monitored at each site. To facilitate this monitoring, a rain gauge will be installed on an 8- to 12-foot pole and interfaced with the same data logger that records flow. If tree cover prohibits the installation of a precipitation gauge at a station, precipitation from a nearby station may be used as a surrogate.

Data from all hydrologic monitoring devices will be remotely downloaded on a weekly basis via the wireless modem link. The data will then be processed and validated in accordance with procedures described in subsequent sections of this QAPP. A detailed explanation of the specific hydrologic monitoring design at each site is presented below, and is illustrated in schematic diagrams in Figures 4 through 7.

#### Low Density Residential Site (LORES)

A flow monitoring station designated LORES will be established at the Low Density Residential site. At this monitoring location, the stream, which has been confined to a 30-inch steel pipe, discharges to a Type 2 catch basin (Figures 4 and 5). The stream exits the catch basin from a 30-inch steel outlet pipe which conveys runoff to a downstream outfall.

A Sigma Model 900 MAX refrigerated sampler with an integrated flow meter and data logger will be used to monitor flow, and to collect water quality samples (the sample process design for water quality sampling will be discussed in a separate section below). A list of specific equipment to be installed at each site is provided in Table 6. Product specifications are included in Appendix C.

A Sigma 77065 A/V sensor will be installed 3feet up the inlet pipe to the catch basin located near the corner 81st Street Northwest and 68th Street Court Northwest in Gig Harbor. This flow monitoring station will be designated LORES-FM (Figures 4 and 5). The flow meter will be

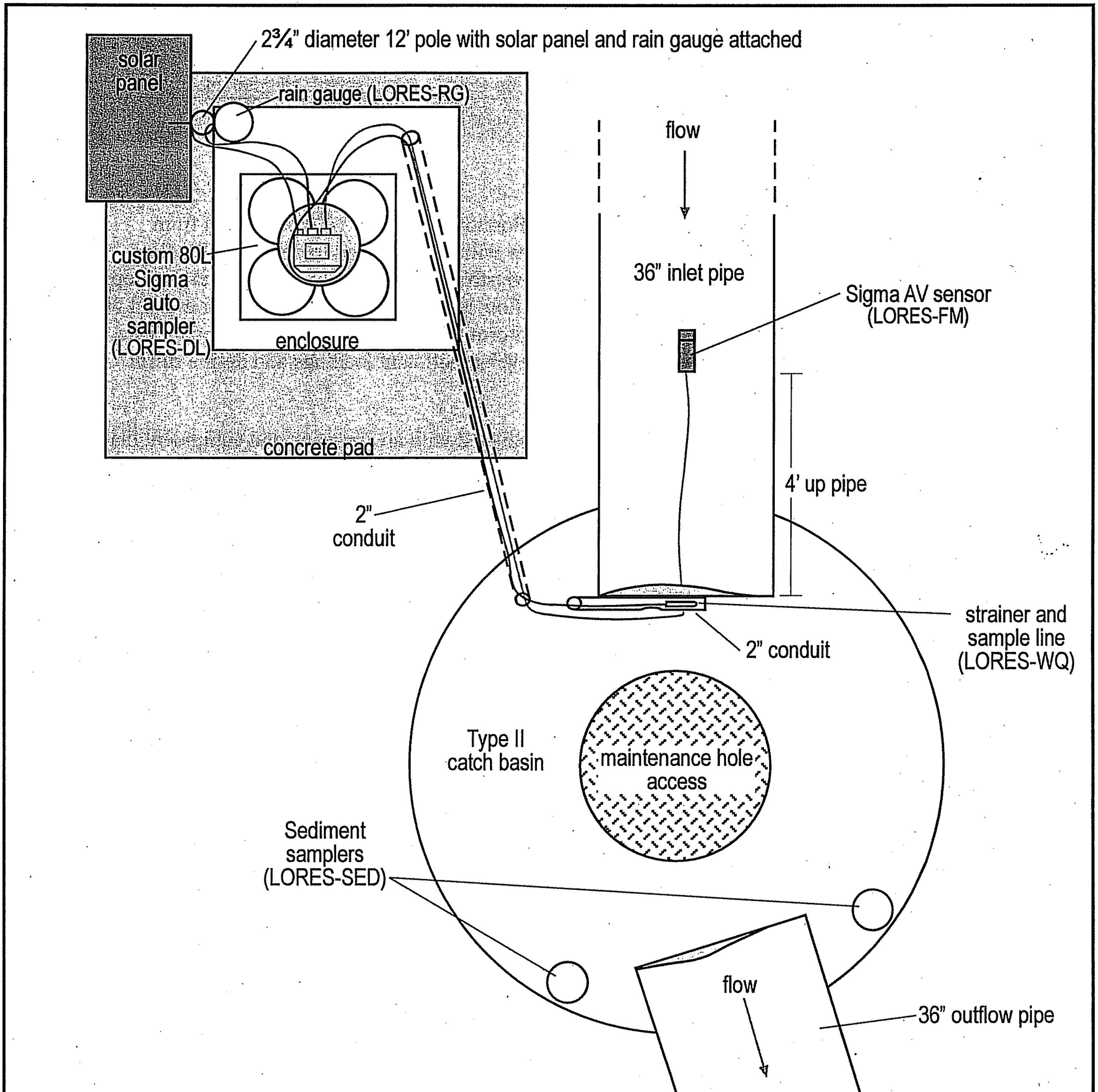


**Figure 4.**
**Plan view of site design for hydrological and water quality monitoring of the Low Density Residential site.**

Not to scale

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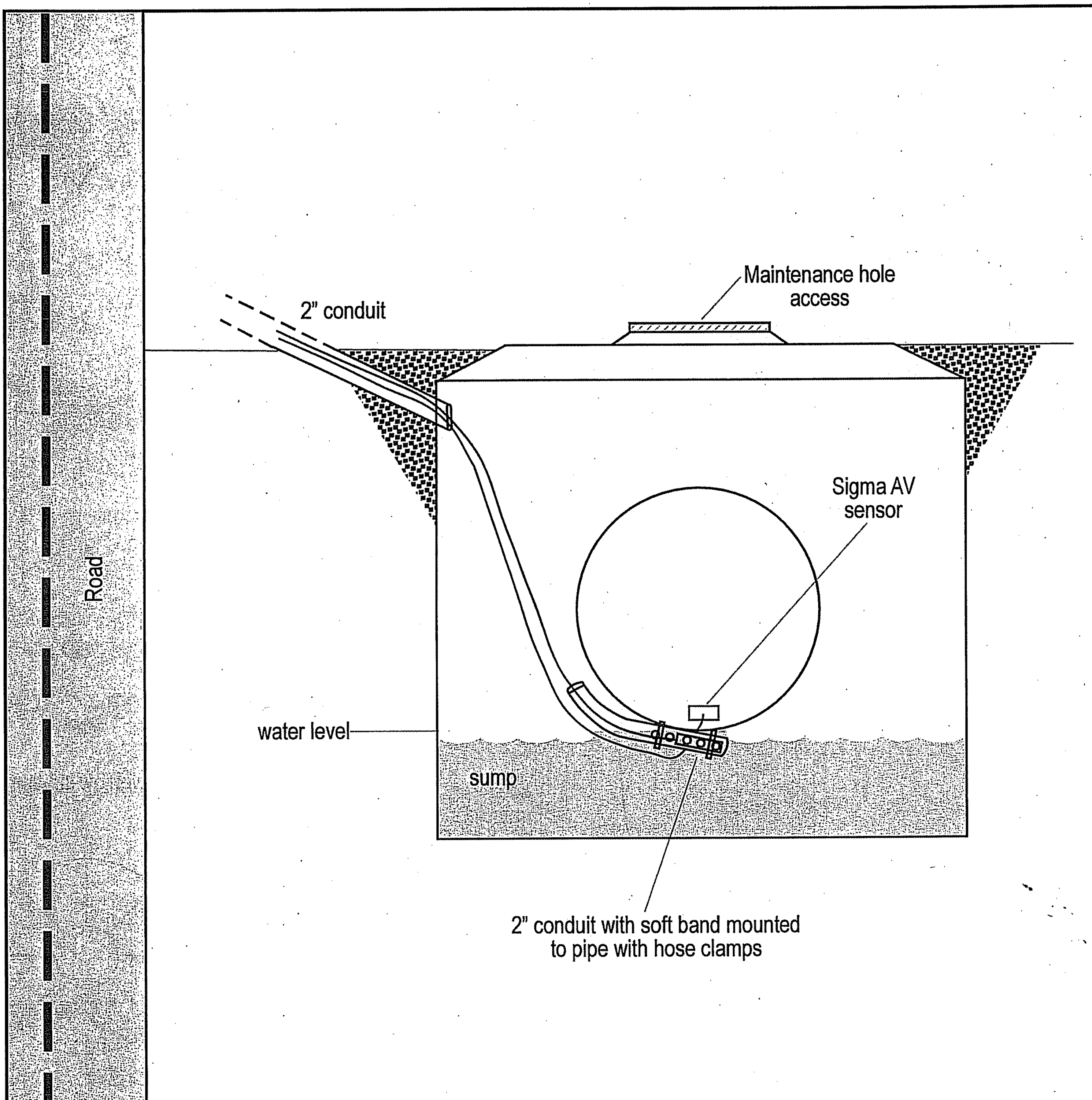


**Figure 5.**
**Cross section detail of monitoring equipment installation at the Low Density Residential site.**

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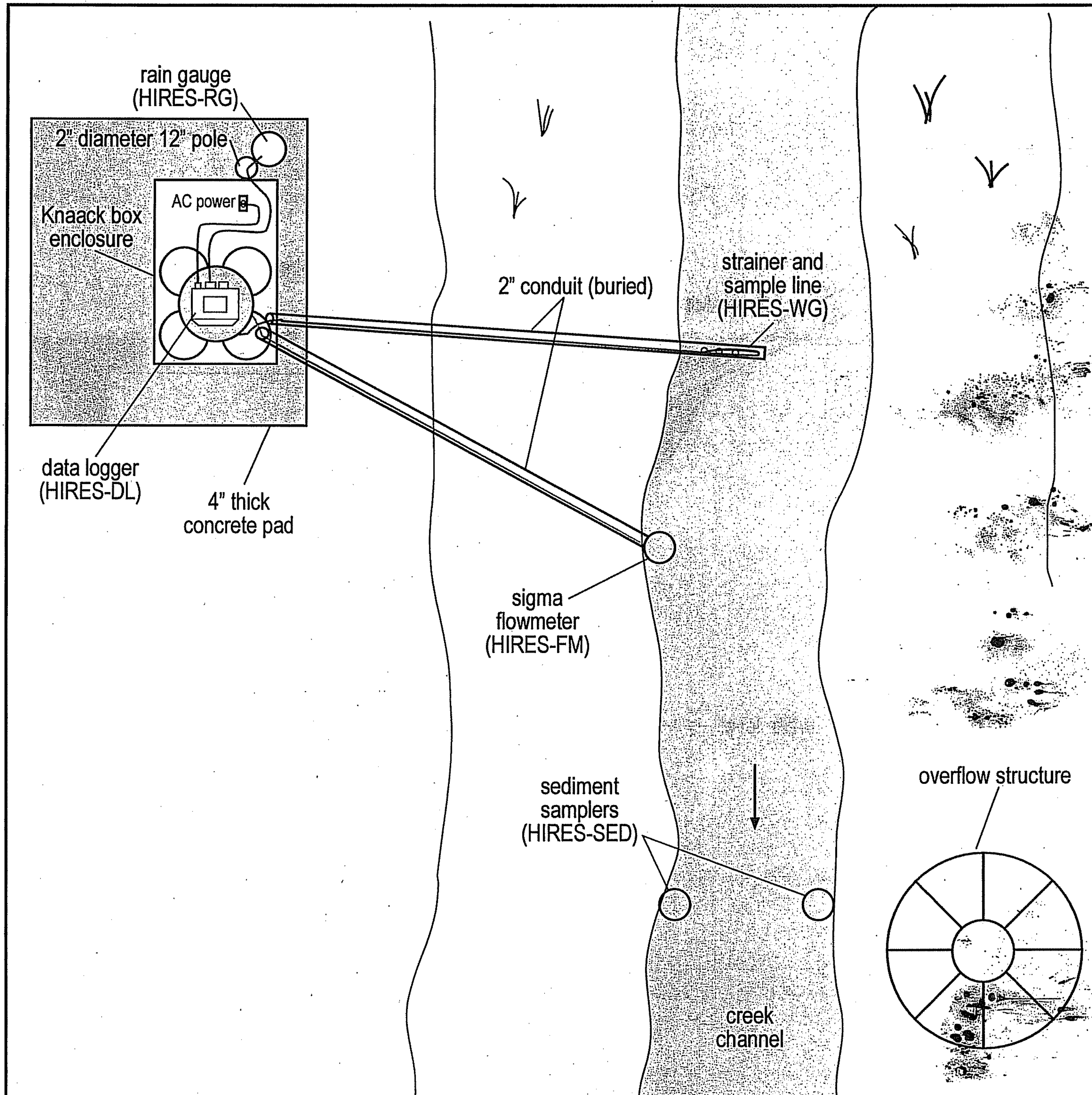


**Figure 6.**
**Plan view of site design for hydrological and water quality monitoring of the High Density Residential site.**

Not to scale

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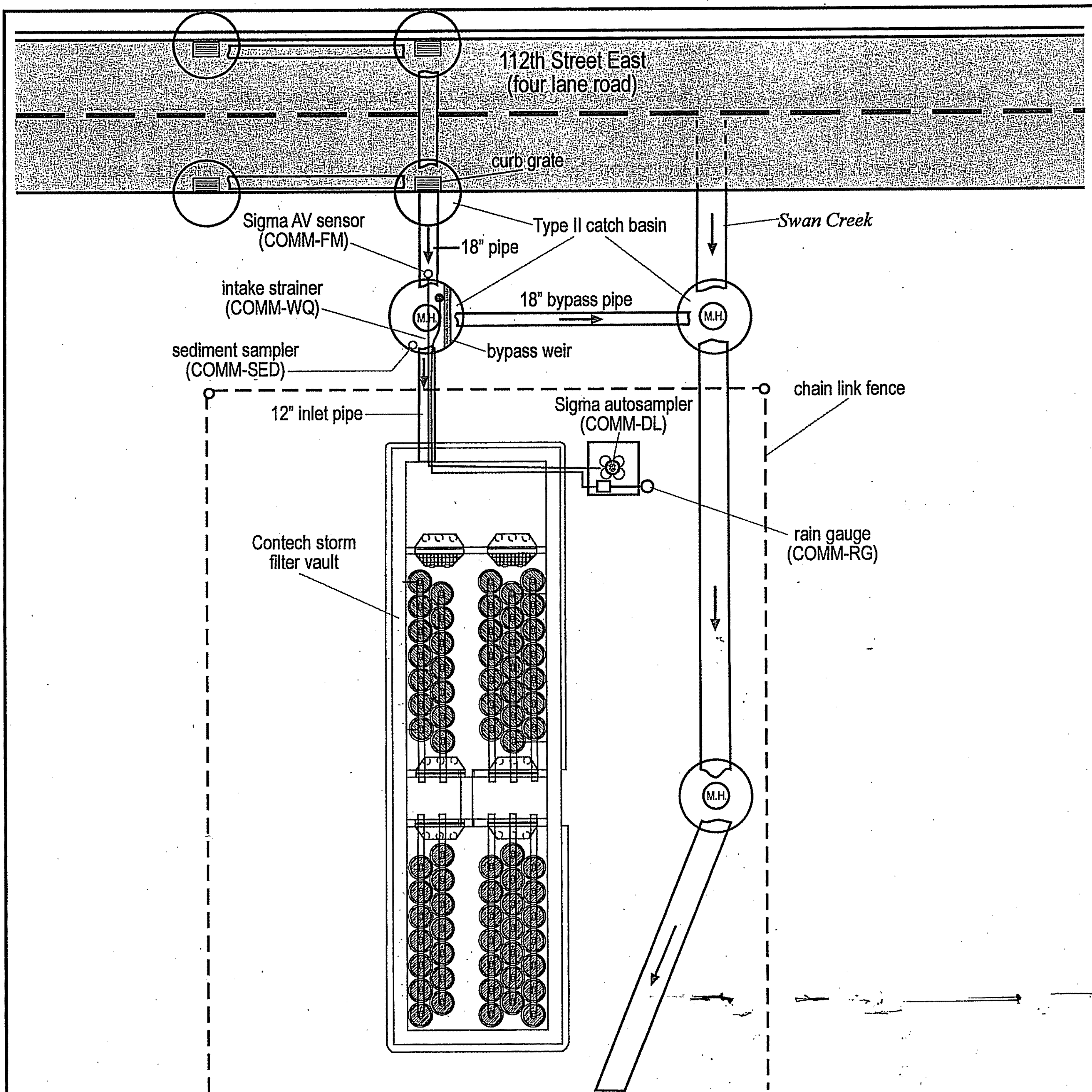


**Figure 7.**
**Plan view of site design for hydrological and water quality monitoring of the Commercial site.**

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interfaced with the integral data logger on the refrigerated sampler, will be programmed to scan every 10 seconds and record average water levels and velocities in the pipe on a 15-minute time interval.

**Table 6. Hydrologic monitoring and water quality sampling equipment identified for Pierce County's Phase I NPDES stormwater characterization sites.**

| |
|---|
| **Low Density Residential** |
| Sigma 900 MAX all weather refrigerated sampler (or similar) with integrated pump, data logger, and 14.4 modem |
| Sigma 920 A/V sensor (77065-030) (or similar) |
| Sigma 2149 rain gauge (or similar) |
| Cellular antennae |
| **High Density Residential** |
| Sigma 900 MAX all weather refrigerated sampler (or similar) with integrated pump, data logger, and 14.4 modem |
| Sigma 920 A/V sensor (77065-030) (or similar) |
| Sigma 2149 rain gauge (or similar) |
| Cellular antennae |
| **Commercial Site** |
| Sigma 900 MAX all weather refrigerated sampler (or similar) with integrated pump, data logger, and 14.4 modem |
| Sigma 920 A/V sensor (77065-030) (or similar) |
| Sigma 2149 rain gauge (or similar) |
| Cellular antennae |

The integral data logger in the Sigma 900 MAX portable sampler will be designated as station LORES-DL. The data logger will convert the water level and velocity readings to estimates of discharge based on standard equations and measurements of pipe geometry entered into the data logger at the start of the study.

The refrigerated sampler will also be equipped with a Sigma 14.4 wireless modem to allow communication with the system via remote access. Power to the refrigerated sampler will be supplied using standard AC power provided at the site. This sampler will be mounted on a concrete pad and secured with expansion bolts through the floor of the housing. (All equipment specifications are included in Appendix C.)

Station LORES-RG will be established in the immediate vicinity of the sampler to facilitate continuous monitoring of precipitation depths. A Sigma 2149 rain gauge will be installed on a 12-foot steel pole and interfaced with the integrated data logger on the sampler. The data logger will be programmed to record precipitation depth at the monitoring site on a 15-minute time interval.

## High Density Residential Site (HIRES)

At the High Density Residential site at the end of the cul-de-sac on 82nd Avenue Court East in Puyallup, the stream flows through a poorly defined channel. This location will be designated as monitoring station HIRES-FM. An area velocity flow meter from a Sigma 900 MAX will be installed in edge of the stream channel to allow automated flow monitoring. A rating curve will be developed for this site by taking manual depth and velocity measurements and using them to calculate flow in the channel. These manual measurements will be taken at least 12 times during the first monitoring year, representing a range of small and large flows, and used to calibrate the AV sensor. If site conditions prevent the development of an accurate rating curve for this monitoring station, the stream will be constrained into a 36-inch H-flume with a shallow depression at the bottom to allow installation of the area velocity sensor.

The water level and velocity will be measured by the area velocity flow sensor every 10 seconds, and the portable sampler's integral data logger will be programmed to record the average water levels and velocities on a 15-minute time interval. The data logger station, designated HIRES-DL in Figure 6, will record the flow data from the area velocity sensor, control the pump, and record rainfall data from the associated rain gauge. (The sampling process design for collecting water samples at the site will be discussed in the section on water quality sampling.)

Station HIRES-RG will be established in the immediate vicinity of the sampler to facilitate continuous monitoring of precipitation depths. An existing Sigma 2149 rain gauge will be interfaced with the same data logger on the portable sampler described above. The data logger will be programmed to scan every 10 seconds and record precipitation depth at the monitoring site on a 15-minute time interval.

The refrigerated sampler will also be equipped with a Sigma 14.4 wireless modem to allow remote communication with the system. Power to the refrigerated sampler will be supplied using standard AC power provided at the site. The refrigerated sampler will be mounted on a concrete pad and secured with expansion bolts through the floor of the housing.

### Commercial Site (COMM)

Flow at the Commercial site has a more complex configuration than at the two residential sites. At this site, water flows from the upstream drainage system through an 18-inch stormwater conveyance pipe that discharges into a type 2 catch basin. This catch basin acts as a flow control structure for a downstream Contech StormFilter stormwater treatment system. During high flows, water bypasses the StormFilter by overtopping a bypass weir within the catch basin and flowing to an 18 inch pipe that discharges to an adjacent stream. During normal flows, water leaves the catch basin through the 12-inch diameter pipe that leads to the inlet bay of the StormFilter. Within the StormFilter, the water passes through 70 filter cartridges, which drain through a series of manifolds to a single, 12-inch diameter outlet pipe.

The flow monitoring station (COMM-FM) will be located in the 18 inch pipe upstream of the catch basin at the head of the StormFilter (Figure 7). Water level and velocity will be measured with an area- velocity sensor every 10 seconds, and the refrigerated sampler's integral data logger will be programmed to record the average water levels and velocities on a 15-minute time interval. The data logger station, designated COMM-DL in Figure 7, will record the flow data from the area-velocity sensor, control the pump, and record rainfall data from the associated rain gauge.

The refrigerated sampler will also be equipped with a Sigma 14.4 wireless modem to allow remote communication with the system. Power to the refrigerated sampler will be supplied using standard AC power provided at the site. The refrigerated sampler will be mounted on a concrete pad and secured with expansion bolts through the floor of the housing. (All equipment specifications are included in Appendix C.)

A precipitation monitoring station, designated COMM-RG, will be established in the immediate vicinity of the equipment enclosure (Figure 7) to facilitate continuous monitoring of precipitation depths. A Sigma 2149 rain gauge will be installed on an 8-foot steel pole and interfaced with COMM-DL. The data logger will be programmed to scan every 10 seconds and record precipitation depth at the monitoring site on a 15-minute time interval.

## Water Quality Monitoring

### *Storm Event Monitoring*

As described previously, 11 to 14 storm events will be sampled annually at each of the three stormwater characterization basins. The data collected from these samples will be used to characterize the pollutant concentrations in the runoff from each basin. Flow -weighted composite samples and grab samples will be collected during each storm event and analyzed for conventionals, metals, bacteria, PAHs and pesticides (Table 7). During the course of the study, grab samples may be collected for events for which no flow-weighted composite samples were collected, and vice-versa.

To facilitate the collection of the flow-weighted composite samples, Sigma 900 MAX all weather refrigerated automated samplers will be installed at each of the three outfall monitoring stations (LORES, HIRES, and COMM), as was described above in the discussion of flow monitoring. Each sampler will hold one, 45-liter glass bottle and be powered by continuous AC power available at the site.

Poly (tetrafluoroethylene) (PTFE) lined sample tubing will be routed from the portable samplers in the enclosure to the stations. Care will be taken to ensure the tubing is installed with a constant linear grade so that water completely drains through the sample tube during rinse, purge, and sampling cycles. The sampler intakes will be carefully positioned at each station to ensure that an adequate depth will be available for sampling and to avoid the capture of litter, debris, and other gross solids that may be present.

The large 45-liter glass bottle will store sample volume for both organic and metal constituents. The bottle will be rinsed with hydrochloric acid and a solvent so that metals and organics can be analyzed from the same bottle. The refrigerated samplers will be triggered to collect a 1 L sample after a pre determined volume of water has passed.

**limits for water quality analyses.**

| e Container [b] | Pre-Filtration Holding Time [c] | Total Holding Time [c] | Field Preservation | Laboratory Preservation | Reporting Limit/ Resolution | Units |
|---|---|---|---|---|---|---|
| **amples** | | | | | | |
| lass/plastic ved bottle | NA | 6 hours (accept) 24 hours (estimate) | Maintain ≤ 6°C | Maintain ≤ 6°C | 2 min, 2E6 max | CFU |
| ber glass bottle | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.25-0.50 | mg/L |
| r glass vial | NA | 14 days | Maintain ≤ 6°C | Maintain ≤ 6°C, HCL to pH < 2 | 0.25 | mg/L |
| **e samples** | | | | | | |
| HDPE | 7 days | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 1.0 | mg/L |
| , HDPE[1] | NA | 48 hours | Maintain ≤ 6°C | Maintain ≤ 6°C | ±0.2 | NTU |
| , HDPE[1] | NA | 28 days | Maintain ≤ 6°C | Maintain ≤ 6°C | ±1 | umho/cm |
| , HDPE[1] | NA | 28 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.2 | mg/L |
| HDPE | NA | 48 hours | Maintain ≤ 6°C | Maintain ≤ 6°C | 2.0 | mg/L |
| , HDPE[2] | NA | 6 months | Maintain ≤ 6°C | Maintain 4°C, $HNO_3$ to pH < 2 | 1.0 | mg/L |
| ber glass | NA | 48 hours | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.025 | mg/L |
| | | | | Maintain ≤ 6°C | 0.01 | mg/L |

| | | | | | | |
|---|---|---|---|---|---|---|
| , HDPE[3] | NA | 28 days | Maintain ≤ 6°C | Maintain ≤ 6°C, $H_2SO_4$ to pH < 2 | 0.01 | mg/L |
| mber glass | 24 hours | 48 hours | Filter (0.45-micron syringe), Maintain ≤ 6°C | Maintain ≤ 6°C, $H_2SO_4$ to pH < 2 | 0.005 | mg/L |
| , HDPE[3] | NA | 28 days | Maintain ≤ 6°C | Maintain ≤ 6°C, $H_2SO_4$ to pH < 2 | 0.1 | mg/L |
| , HDPE[3] | 48 hours | 28 days | Maintain ≤ 6°C | Maintain ≤ 6°C, $H_2SO_4$ to pH < 2 | 0.01 | mg/L |
| , HDPE[2] | 24 hours | 6 months | Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 | 5.0 | µg /L |
| , HDPE[4] | NA | | Filter (0.45-micron syringe), Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 after filtration | 1.0 | |
| , HDPE[2] | 24 hours | 6 months | Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 | 0.1 | µg /L |
| , HDPE[4] | NA | | Filter (0.45-micron syringe), Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 after filtration | 0.02 | |
| , HDPE[2] | 24 hours | 6 months | Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 | 0.1 | µg /L |
| , HDPE[4] | NA | | Filter (0.45-micron syringe), Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 after filtration | 0.1 | |
| , HDPE[2] | 24 hours | 6 months | Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 | 0.2 | µg /L |
| , HDPE[4] | NA | | Filter (0.45-micron syringe), Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 after filtration | 0.02 | |
| Teflon-lined lid | 24 hours | 28 days | Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 | 0.1 | µg /L |
| Teflon-lined lid | NA | | Filter (0.45-micron syringe), Maintain ≤ 6°C | Maintain ≤ 6°C, $HNO_3$ to pH < 2 after filtration | | |

**Table 7. Methods and reporting**

| Parameter Group | Parameter | Analytical Method | Method Number [a] | Field Sampl |
|---|---|---|---|---|
| | | | | **Grab S** |
| **Bacteria** | Fecal Coliform | Multiple tube fermentation | SM 9221E | 250 mL g auto-cla |
| **Petroleum Hydrocarbons** | Diesel Range Organics | GC/FID | Ecology's NWTPH-Dx method | 2 x 500 mL am |
| | Gasoline Range Organics | GC/FID | Ecology's NWTPH-Gx method | 2 x 40 mL ambe |
| | | | | **Composit** |
| **Conventionals** | Total suspended solids[d] | Gravimetric | SM 2540D | 1 L l |
| | Turbidity | Nephelometric | EPA 180.1 | 500 mL |
| | Conductivity | Resistivity | SM 2510B or EPA 120.1 | 500 mL |
| | Chloride[d] | IC | EPA 300.0 or 325.2 | 500 mL |
| | $BOD_5$ | Membrane electrode or titration | SM5210B | 1 L l |
| | Hardness as $CaCO_3$[d] | ICP-AES | EPA 200.7 | 250 mL |
| | Methylene Blue Activated Substances (MBAS)[d] | Colorimetric | SM 5540C | 1 L am |
| **Nutrients** | Total phosphorus | Digestion/Colorimetric | EPA 365.3 or 365.4 | |

| | | | | |
|---|---|---|---|---|
| Nutrients | Total phosphorus | Digestion/Colorimetric | EPA 365.3 or 365.4 | 500 ml |
| | Ortho-phosphate phosphorus | Colorimetric | EPA 365.1 | 500 mL a |
| | Total Kjeldahl nitrogen | Digestion/Colorimetric | EPA 351.2 | 500 ml |
| | Nitrate + nitrite nitrogen | Digestion/Colorimetric | EPA 353.2 | 500 ml |
| **Metals** | Zinc, total recoverable[d] | ICP-MS | EPA 200.8 | 500 ml |
| | Zinc, dissolved[d] | | | 500 ml |
| | Lead, total recoverable[d] | ICP-MS | EPA 200.8 | 500 ml |
| | Lead, dissolved[d] | | | 500 ml |
| | Copper, total recoverable[d] | ICP-MS | EPA 200.8 | 500 ml |
| | Copper, dissolved[d] | | | 500 ml |
| | Cadmium, total recoverable | ICP-MS | EPA 200.8 | 500 ml |
| | Cadmium, dissolved[d] | | | 500 ml |
| | Mercury, total[d] | CVAA | EPA 7470 | 500 mL FEP, ' |
| | Mercury, dissolved[d] | | | 500 mL FEP, ' |

**ırting limits for water quality analyses.**

| e Container b | Pre-Filtration Holding Time c | Total Holding Time c | Field Preservation | Laboratory Preservation | Reporting Limit/ Resolution | Units |
|---|---|---|---|---|---|---|
| ber glass bottle[5] | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.1 | µg /L |
| ber glass bottle[5] | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 1.0 | µg /L |
| ber glass bottle[5] | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 1.0 | µg /L |
| ıber glass bottle | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.3 | µg /L |
| ıber glass bottle | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.3 | µg /L |
| ber glass bottle[6] | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.3 | µg /L |
| ber glass bottle[6] | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.3 | µg /L |
| ıber glass bottle | NA | 7 days | Maintain ≤ 6°C | Maintain ≤ 6°C | 0.3 | µg /L |
| ılastic head-space[e] | NA | 36 hours to first use | 0 to 12°C (if received with 4 hours of sample collection) 0 to 6°C (if received after 4 hours of sample collection) | Maintain ≤ 6°C, sample cannot be frozen | NA | NA |

ute holding times for dissolved metals, ortho-phosphate and pH cannot realistically be met with flow-weighted automated sampling techniques. Consequently, a erefore samples held between 6 and 24 hours will be included in the database as estimated values.

**Table 7 (continued). Methods and rep(**

| Parameter Group | Parameter | Analytical Method | Method Number a | Field Sampl |
|---|---|---|---|---|
| **Semivolatile Organic Hydrocarbons** | Polycyclic aromatic hydrocarbons[d] | GC/MS | EPA 8270D SIM | 2 x 500 mL am |
| | Phthalates[d] | GC/MS | EPA 8270D | 2 x 500 mL am |
| | Pentachlorophenol[d] | GC/MS | EPA 8151 | 2 x 500 mL am |
| **Chlorinated Herbicides** | 2,4-D and MCPP[d] | GC/ECD | EPA 8151 | 2 x 500 mL an |
| | Triclopyr[d] | LC/MS | EPA 8321 | 2 x 500 mL an |
| **Halogenated Pesticide** | Dichlobenil[d] | GC/MS | EPA 8270D SIM | 2 x 500 mL am |
| **Organonitrogen Pesticides** | Prometon[d] | GC/MS | EPA 8270D SIM | 2 x 500 mL am |
| **Organophosphorus Pesticides** | Chloropyrifos, Diazinon, and Malathion[d] | GC | EPA 8141A | 2 x 500 mL an |
| **Toxicity** | Environmental Canada Trout Embryo Viability[d] | WET | E-Test in Env. Canada EPS 1/RM/28. | 44 L, glass or p containers, low |

a SM method numbers are from APHA et al. (1998); EPA method numbers are from U.S. EPA (1983, 1984); Ecology method is from Ecology (1997).

b Sample bottles that share the same numeric notation will be used for multiple parameters.

c Holding time specified in U.S. EPA guidance (U.S. EPA 1983; U.S. EPA 2007) or referenced in APHWA et al. (1992) for equivalent method. Fifteen min surrogate holding time of 24 hours will be used for the purposes of this study. Six hour holding times for fecal coliform bacteria are not always realistic; th

[d] First-flush qualifying storm parameter

[e] The total volume required for toxicity testing ranges from 24 to 44 liters.

[1,2,3,4,5,6] These numeric notations refer to where analyses can be shared between bottles. See footnote b.

Units and Acronyms

°C = degrees Celsius.
FEP = fluorinated ethylene propylene
GC = gas chromatography.
GC/ECD = gas chromatography/electron capture detection.
GC/FID = gas chromatography/flame ionization detector.
GC/MS = gas chromatography/mass spectroscopy.
HDPE = high-density polyethylene.
IC = ion chromatography.
ICP = inductively coupled plasma – atomic emission spectroscopy.
ICP-MS = inductively coupled plasma/mass spectrometry.
LC/MS = liquid chromatography/mass spectroscopy.
mg/L = milligrams per liter.
NA = not applicable.
µg /L = micrograms per liter.

Sample volumes required for each parameter are provided in Table 7. Composite sampling includes the following list of parameters:

- TSS
- Turbidity
- Conductivity
- Chloride
- $BOD_5$
- Hardness as $CaCO_3$
- Total phosphorus
- Orthophosphate
- Nitrate/nitrite
- Total Kjeldahl nitrogen
- Phthalates
- Polycyclic aromatic hydrocarbons (PAHs)
- Methlyene blue activated substances (MBAS)
- Metals (total and dissolved zinc, copper, cadmium and lead. Mercury will be analyzed at the Commercial site only)
- Pesticides (2,4-D, MCPP, Triclopyr, Diazinon, Malathion, Chlorpyrifos)
- Dichlobenil, Prometon and Pentachlorophenol

To insure there is adequate volume to perform stormwater monitoring analysis of the composite sample, approximately 12 L should be collected at the Commercial site where mercury analysis is required and approximately 11 L at the Low Density Residential and High Density Residential sites, where mercury is not required. However this volume may change depending upon specific laboratory requirements and should be verified once the final laboratory is selected. A priority list is included in the permit that details a list of priority parameters to be analyzed should the stormwater sample volume be insufficient to analyze all parameters listed above.

- For residential sites (both LORES and HIRES), the priority list is:
  - TSS
  - Conductivity
  - MBAS

  - Metals and hardness
  - Nutrients
  - Pesticides
  - PAHs and phthalates
  - BOD5
  - Chlorides

- For the Commercial site (COMM), the priority list is:

  - TSS
  - Conductivity
  - MBAS
  - Metals and hardness
  - PAHs and phthalates
  - Pesticides
  - Nutrients
  - BOD5
  - Chlorides

Grab samples must also be collected to characterize stormwater and should be collected early in the storm event. Grab samples will be collected with three separate bottles based on the sample test constituents. Each bottle will be attached to a sampling pole and lowered into the flowpath at each of the three monitoring stations. Parameters measured from grab samples include:

- Fecal coliform bacteria
- Total petroleum hydrocarbons (NWTPH-Dx and NWTPH-Gx)

A 250-mL sterile bottle, 1-liter amber glass bottle, and 80-mL amber glass vial, will be used to collect samples for fecal coliform bacteria, NwTPH-Dx, and NwTPH-Gx, respectively.

Aspects of the sampling process design which are unique to each monitoring location are discussed below.

*Low Density Residential*

Figures 4 and 5 show the planned monitoring location layout for the Low Density Residential land use site. The refrigerated Sigma sampler will be installed and the sample lines and pressure transducer cables will be run into the catch basin through the provided conduits. The sample line and strainer will be mounted in the catch basin and will collect water quality samples from the sump just below the invert of the outlet pipe at a station designated LORES-WQ.

*High Density Residential*

Figure 6 shows the planned monitoring location layout for the High Density Residential land use site. The refrigerated Sigma sampler will be installed and the sample lines will be run to a stilling well that will be mounted in the stream immediately upstream of the Sigma A/V flow meter at a station that will be designated HIRES-WQ.

*Commercial*

Figures 7 shows the planned monitoring location layout for the Commercial land use site. The refrigerated Sigma sampler will be installed and the sample lines and pressure transducer cables will be run into the upstream catch basin through the open grate above the stormwater treatment system. The sample line will then be run up the 12-inch pipe to the flow control catch basin. The sample line and strainer will be mounted in the vault on the bypass weir wall and will collect water quality samples from the sump just below the invert elevation of the outlet pipe. This station will be designated COMM-WQ.

***Baseflow Monitoring***

Baseflow samples will be collected from all 3 sites as grab samples. Grab samples will be collected with three separate bottles based on the sample test constituents. Each bottle will be attached to a sampling pole and lowered into the flow path at each of the three water quality monitoring stations (LORES-WQ, HIRES-WQ, and COMM-WQ). Parameters measured from baseflow grab samples include:

- TSS
- Total phosphorus
- Total copper
- Pesticides

**Sediment Monitoring**

In addition to water quality sampling, sediment samples will also be collected and analyzed on an annual basis. To facilitate the collection of sediment, two passive sediment samplers will be installed to capture sediment during high flows in each outfall station's pipe or conveyance system. Sediment will be collected with sediment traps that are designed to passively collect suspended particulates in stormwater. The sediment traps were originally designed by Ecology (Wilson and Norton 1996; Norton 1997) and have since been modified. These traps are not standard sampling equipment, and will be fabricated by an outside vendor.

Each trap consists of a wide-mouth Teflon bottle that is mounted inside the monitoring station pipe or on the bed of an open ditch using stainless steel brackets and anchors. Two traps will be installed at each monitoring station to guarantee a sufficient sample volume for analysis. The bottles will be positioned to collect sediment during storm flows only. At stations with baseflow, the sample bottle will be mounted just above the baseflow level. At stations without baseflow, bottles will be installed at the lowest point in the catch basin or channel. Due to the small diameters of the pipes (18 to 36 inches), sediment trap monitoring stations will be installed in the downstream catch basins.

After the initial installation, the traps will be monitored to ensure proper installation and adequate collection of sediment. If after 3 months the traps require modification, changes will be allowed including: moving the trap to a different location, installing a weir to enhance deposition, or installing additional traps to collect sediment. The sediment sample will be removed once a year and the bottles will be replaced. The sediment composite sample will be analyzed for the following list of parameters (with sample volume information presented in Table 8):

- Total solids (percent solids)
- Grain size
- Total organic carbon
- PAHs
- Phthalates
- Phenolics
- PCBs
- Pesticides (diazinon, chloropyrifos, malathion, pentachlorophenol)
- Metals (total copper, zinc, cadmium, lead, and mercury)

Adequate volume to perform the sediment monitoring analysis of the sediment sample is approximately 1 liter for each site. Mercury and PCBs analyses are not required for residential sites; however, this does not reduce the total sediment volume needed for analysis. A priority list is included in the permit that details a list of priority parameters to be analyzed should the sediment sample volume be insufficient to analyze all parameters listed above.

- For the Commercial site (COMM), the priority list is:
  - Grain size (use grain size method, characterize grain size qualitatively if not enough sample is available)
  - Total organic carbon
  - Metals (total copper, zinc, cadmium, lead, and mercury)
  - PAHs and Phthalates
  - Phenolics
  - PCBs
  - Pesticides (diazinon, chloropyrifos, malathion, pentachlorophenol)
- For residential sites (both LORES and HIRES), the priority list is:
  - Grain size (use grain size method, characterize grain size qualitatively if not enough sample is available)

**mits for sediment quality analyses.**

| ainer[b] | Total Holding Time[c] | Field Preservation | Laboratory Preservation | Reporting Limit/ Resolution | Units |
|---|---|---|---|---|---|
| 1 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 0.1 | % |
| .2 | 6 months | Refrigerate, 4°C | NA | 0.1 | % |
| 1 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 0.1 | % |
| 3 | 14 days[d],<br>12 months if frozen | Refrigerate, 4°C | NA | 20 | µg/kg |
| 3 | 14 days[d],<br>12 months if frozen | Refrigerate, 4°C | NA | 20 | µg/kg |
| 3 | 14 days[d],<br>12 months if frozen | Refrigerate, 4°C | NA | 20 | µg/kg |
| 3 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 1 | µg/kg |
| 3 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 80 | µg/kg |
| 3 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 20 | µg /kg |
| 4 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 20 | µg/kg |
| 4 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 20 | µg/kg |

| | | | | | |
|---|---|---|---|---|---|
| 4 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 20 | µg/kg |
| 4 | 14 days,<br>6 months if frozen | Refrigerate, 4°C | NA | 25-50 | µg/kg |
| 1 | 6 months<br>2 years if frozen | Refrigerate, 4°C | NA | 0.1 | mg/kg |
| 1 | 6 months<br>2 years if frozen | Refrigerate, 4°C | NA | 5.0 | mg/kg |
| 1 | 6 months<br>2 years if frozen | Refrigerate, 4°C | NA | 0.1 | mg/kg |
| 1 | 6 months<br>2 years if frozen | Refrigerate, 4°C | NA | 0.1 | mg/kg |
| 1 | 28 days | Refrigerate, 4°C | NA | 0.1 | mg/kg |

anic compounds. The elutriate must be analyzed within 40 days of extraction.

**Table 8. Methods and reporting li**

| Parameter Group | Parameter | Analytical Method | Method Number [a] | Field Sample Cont |
|---|---|---|---|---|
| Conventional Parameters | Total solids (% solids) | Gravimetric | SM2540B | 2 oz glass jar |
| | Grain-size | Sieve | Puget Sound Estuary Protocols: (PSEP 1997) | 8 oz plastic ja |
| | Total organic carbon | Carbon Determinator | PSEP 1997 | 2 oz glass jar |
| Semivolatil Organic Compounds | PAHs | GC/MS | EPA 8270D | 8 oz glass jar |
| | Phthalates-BNA | GC/MS | EPA 8270D | 8 oz glass jar |
| | Phenolics-BNA | GC/MS | EPA 8270D | 8 oz glass jar |
| | Pentachlorophenol | GC/MS | EPA 8151 | 8 oz glass jar |
| PCBs | PCBs as Aroclors [e] | GC/ECD | EPA 8082B | 8 oz glass jar |
| Chlorinated Herbicides | 2,4-D and MCPP | GC/ECD | EPA 8151A | 8 oz glass jar |
| | Triclopyr | GC/MS | EPA 8151A | 8 oz glass jar |
| Halogenated Pesticides | Dichlobenil | GC/MS | EPA 8270D SIM | 8 oz glass jar |

| | | | | |
|---|---|---|---|---|
| Organonitrogen Pesticides | Prometon | GC/MS | EPA 8270D SIM | 8 oz glass jar |
| Organophosphorus Pesticides | Chloropyrifos, Diazinon, and Malathion | GC | EPA 8141A | 8 oz glass jar |
| Metals | Total recoverable copper | ICP-MS | EPA 200.8 | 4 oz. glass jar |
| | Total recoverable zinc | ICP-MS | EPA 200.8 | 4 oz. glass jar |
| | Total recoverable cadmium | ICP-MS | EPA 200.8 | 4 oz. glass jar |
| | Total recoverable lead | ICP-MS | EPA 200.8 | 4 oz. glass jar |
| | Mercury [e] | CVAA | EPA 7471 | 8 oz. glass jar |

[a] SM method numbers are from APHA et al. (1998); EPA method numbers are from U.S. EPA (1983, 1984)
[b] Sample bottles that share the same numeric notation will be used for multiple parameters.
[c] Holding time specified in U.S. EPA guidance (U.S. EPA 1983, 1984) or referenced in APHA et al. (1998) for equivalent method.
[d] Semi-volatile organic compounds analyzed with method EPA8270 require separate holding times for extraction and analysis of the elutriate for org
[e] PCBs and mercury analyses are not required for residential sites.
[1,2,3,4,] These numeric notations denote where bottles can be shared. See footnote b.

Units and Acronyms
°C = degrees Celsius.
ICP-MS = inductively coupled plasma/mass spectrometry.
GC = gas chromatography.
GC/ECD = gas chromatography/electron capture detection.
GC/MS = gas chromatography/mass spectroscopy.
µg /kg = micrograms per kilogram.
mg/kg = milligrams per kilogram.
NA = not applicable.
PCBs = polychlorinated biphenyls.

- Total organic carbon
- Metals (total copper, zinc, cadmium, and lead)
- Pesticides (diazinon, chloropyrifos, malathion, pentachlorophenol)
- PAH's and Phthalates
- Phenolics

Aspects of the sediment sampling process design which are unique to each monitoring location are discussed below.

*Low Density Residential*
The passive sediment samplers for the Low Density Residential site will be installed in the catch basin downstream from the water quality monitoring station, as shown in Figure 4. This station will be designated LORES-SED.

*High Density Residential*
The passive sediment samplers for the High Density Residential site will be installed in the channel downstream from the water quality monitoring station, as shown in Figure 6. This station will be designated HIRES-SED.

*Commercial*
The passive sediment samplers for the Commercial site will be installed in the catch basin downstream from the water quality monitoring station, as shown in Figure 7. This station will be designated COMM-SED.

**Toxicity Monitoring**

As described previously, each monitoring station will be sampled annually during a first-flush storm event in August or September, or in October if antecedent conditions are not met. The data collected from these samples will be used to determine if implementation of a Toxicity Identification/Reduction Evaluation (TI/RE) plan is required as part of the annual report.

Samples for toxicity analysis will be collected using customized automated samplers at the water quality stations, as described above (stations LORES-WQ, HIRES-WQ, and COMM-WQ). A total volume of 54 L is required for toxicity testing. If a 54-L volume is not obtained, toxicity testing may follow the sample volume modifications described in *A simplified procedure for conducting small scale short-term embryo toxicity tests with salmonids* (Canaria et al. 1999). Using the modifications described, the laboratory can perform toxicity analysis with total volumes ranging from 26.5 to 45.5 L, which are described in the Measurement Procedures for Toxicity Testing section below.

A subset of the parameters identified above for water quality monitoring will be analyzed in samples collected for toxicity testing. Chemical analyses to be performed on samples collected for toxicity testing includes the following list of parameters:

- TSS
- Chloride
- Hardness as $CaCO_3$
- Phthalates
- Polycyclic aromatic hydrocarbons (PAHs)
- Methylene blue activated substances (MBAS)
- Metals (total and dissolved zinc, copper, cadmium and lead. Mercury will be analyzed at the Commercial site only)
- Pesticides (2,4-D, MCPP, Triclopyr, Diazinon, Malathion, Chlorpyrifos)
- Dichlobenil, Prometon, and Pentachlorophenol

# Sampling Procedures

The specific field safety and sample collection procedures that will be used in connection with this project are described in the following subsections.

## Field Safety Procedures

Field personnel will possess the following equipment while performing field work related to this project:

- Protective footwear
- Safety vest
- Roof-mounted flasher for vehicles

At a minimum, field personnel will follow the general requirements for personal protective equipment (PPE) by dressing appropriately for close proximity to vehicular traffic (WAC 296-155-200).

All installation and monitoring work will be conducted in accordance with standard safety protocols. At least two field personnel will always be present when confined space entry occurs at the site. All personnel entering maintenance holes for equipment installations, maintenance, and repairs will have confined-space entry training in accordance with Occupational Safety and Health Administration requirements (WAC 296-809).

## Field Sampling Procedures

As described above, this project involves tracking storms and then collecting flow-weighted composite, grab, and toxicity samples at three outfall monitoring sites. The following procedures describe each set of sampling procedures.

### Storm Tracking

The Storm Event Coordinator will review the daily National Weather Service forecasts (www.nws.noaa.gov) and track all potential rainfall events. If an event being tracked has a 75% or greater probability of generating 0.2" of rainfall within 24 hour period, the Storm Event Coordinator will inform the Monitoring Team 48 to 72 hours before it is predicted to arrive and a Team will be placed in a "Prepare Mode".

Monitoring Team "Prepare/Stand-By Mode":

- Alert lab of possible monitoring activities
- Check filed boxes for supplies
- Test, maintain, and clean, if necessary, all field equipment
- Identify, confirm, and arrange team members schedules for field activities
- Arrange vehicle for monitoring activities

If the storm is still predicted 24 hours before the event, the Storm Event Coordinator will issue a monitoring "Alert".

Monitoring Team "Alert Mode"

- Prep and label bottles
- Assemble field equipment and paperwork
- Load vehicles with monitoring equipment
- Update lab on monitoring activities

At 4 to 8 hours before a targeted event is scheduled to arrive, a Go/No-Go decision on monitoring will be made by the Storm Event Coordinator. Storms will not be sampled on major holidays such as: Christmas Day, Thanksgiving Day, New Year's Eve, etc. Additionally, storms will not be sampled on days when the laboratories are closed or unable to accept samples.

**Composite Sample Collection**

Once a storm event has been targeted, field personnel will conduct site visits to set up the automated samplers at each of the three monitoring stations. During these pre-storm site visits, field staff will also remove any blockages in the rain gage and flow monitoring device, calibrate the flow monitoring devices, backflush the sample lines with deionized water (as discussed in the *Quality Control* section), check the state of the desiccant associated with the equipment, and place a 45 L sample bottle in each of the samplers. The refrigeration function of the sampler will also be turned 'on' at this time.

Sample pacing for the automated samplers will be determined based on rainfall versus runoff relationships that are developed using linear regressions of data that were collected during previous storm events. These regressions will be continually updated throughout the year to reflect changing hydrologic conditions. The rainfall versus runoff regressions are used to convert forecast rainfall totals into runoff volumes. Sample pacing will be adjusted before each storm event based on the predicted storm size runoff volumes.

Flow-weighted composite sampling criteria will be assessed prior to post-storm sample retrieval by accessing sampling data with a remote cellular link. If sampling criteria are not met, the samples will be retrieved prior to the next storm event. If sampling criteria are met, field personnel will return to the site and make visual and operational checks of the system and collect detailed field notes using field forms (see *Field Quality Control Procedures*). Field personnel will then remove the 45-liter glass bottle from the automated sampler mix the sample with a

Teflon stirring paddle, and split the sample into one or more large (6 to 12 liters), glass composite bottle using a pump and Teflon tubing. Field personnel will transport the bottle on ice to the laboratory within the allowable limits for sample holding times (Table 7). In general, the laboratory will be given prior notice of a pending sampling event to ensure that adequate laboratory staff will be available to process the incoming samples. The samples will be analyzed for those parameters listed in Table 7.

### Grab Sample Collection

During a targeted storm event, weather conditions will be monitored via the internet to determine when stormwater has begun to flow past each monitoring station. Field personnel will then mobilize to collect grab samples for fecal coliform bacteria, NWTPH-Dx, and NWTPH-Gx in pre-labeled 250-mL sterile bottles, 1-liter amber glass bottles, and 80-mL amber glass vials, respectively. Field personnel will collect the grab sample with the sample bottle using aseptic techniques (gloves). The TPH grab samples must be collected early in the storm event and skimmed from the surface. The bacteria sample bottle should be submerged at least 6 inches beneath the water surface and oriented upstream while filling. During the grab sample field visit, field personnel will also check the field equipment and perform any maintenance that is necessary without interfering with the functioning of the automated sampler programs. Sample bottles will be immediately placed on ice and kept below 6 degrees Celsius until delivery to the laboratory.

The same sample collection techniques, field checks, and sample handling will occur during baseflow events.

### Sediment Sample Collection

Sediment samples will be collected with sediment traps that are designed to passively collect suspended particulates in stormwater (as discussed above). Sediment sampler bottles will be installed at the beginning of each monitoring year in order to collect sediment throughout each year. Field personnel will wear gloves when collecting sediment samples. Field personnel will then cap the sample bottles with a clean Teflon lined lid, remove the bottles from the brackets, and transport them on ice to the laboratory within the allowable limits for sample holding times (Table 8). With the removal of each sediment sample bottle, the bottles will be replaced with clean sample bottles for the upcoming year. Each sediment sample will be analyzed for the parameters listed in Table 8.

### Toxicity Sample Collection

One composite sample from each monitoring site per year will be submitted to the laboratory for toxicity testing. A total volume of 54-L is required for each composite sample. If a 54-L sample volume is not obtained, sample volume modifications described in *A simplified procedure for conducting small scale short-term embryo toxicity tests with salmonids* (Canaria et al. 1999) will be used by the laboratory. Using this modification, the laboratory requires total volumes ranging from 26.5 to 45.5-L. Composite samples will be collected as described in the section above; however, as described above, a subset of chemical parameters may be analyzed if sufficient volume is not collected. In order to collect sufficient volume, the 45-liter glass bottle will be replaced with a second bottle partway through sample collection.

Communication between field staff and the analytical laboratory regarding potential sample collection and storm tracking is critical to successful toxicity testing. Notifying the laboratory when a storm is being tracked will allow time for the laboratory to coordinate with the organism supplier and meet the holding time requirements. If the laboratory is unable to acquire gametes (test organism) of sufficient quantity and quality for toxicity testing, samples will not be collected for toxicity testing for that storm event. If gametes are available, it is necessary to notify the laboratory to cancel the testing at least 24 hours in advance, if the storm event does not meet the storm criteria.

Sample holding time is 36 hours; therefore, samples need to be received by the laboratory as soon as possible after collection. Sample containers will be stored on ice to meet temperature criteria.

# Measurement Procedures

As noted above, samples collected for this project will be analyzed for water chemistry, sediment chemistry, and toxicity. Laboratory analytical procedures for these parameters will follow methods that are required for the permit (Ecology 2007, Appendix 9). These methods provide reporting limits that are low enough to assess water quality at low pollutant concentrations and below the state and federal regulatory criteria or guidelines, which will allow comparison of the analytical results with these levels. The preservation methods, analytical methods, reporting limits, and sample holding times are presented in Table 7.

A laboratory (or laboratories) will be identified for this project that is certified by Ecology and participates in audits and interlaboratory studies by Ecology and U.S. Environmental Protection Agency (EPA). These performance and system audits have verified the adequacy of the laboratory's standard operating procedures, which include preventive maintenance, data reduction, and QA/QC procedures.

The laboratory will report the analytical results within 30 days of receipt of the samples. The laboratory will provide all sample and quality control data in standardized reports that are suitable for evaluating the project data. Submittals will include all raw data, including but not limited to:

- All raw values including those below the reporting limit and between the method detection limit and the laboratory reporting limit
- The laboratory method detection limits and reporting limits for all parameters for each batch
- All field duplicate and laboratory split results
- Data are to be submitted in hardcopy and in compiled electronic format in one of the following: a MS Excel (version 97 or later) spreadsheet, Access database table (version 97 or later), or a dBase IV database table.
- The reports will also include a case narrative summarizing any problems encountered in the analyses.

## Measurement Procedures for Toxicity Samples

This section describes specific procedures for the toxicity analysis. Samples will be submitted to an accredited laboratory for toxicity (bioassay) testing in accordance with the most recent version of Ecology's *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria* (Publication No. WQ-R-95-80) (Ecology 2008). Samples will be analyzed using the

Environment Canada Trout Embryo Viability Toxicity Test, a 7-day embryo viability test using rainbow trout (*Oncorhynchus mykiss*).

A receiving water sample may be submitted to the laboratory with the toxicity samples for analysis for hardness prior to beginning the toxicity test. The hardness of the stormwater sample can then be increased to match the hardness of the receiving water sample. If a receiving water sample is not collected at the same time as the stormwater samples, the toxicity tests must be performed on an unmodified sample of stormwater.

The required sample volume for toxicity tests ranges from 26.5 to 54-L. Ideally, 54-L will be collected for each first-flush event. If a full 54-L is collected, the test configuration will include a series of five test concentrations and a control with four replicates at each concentration. The test concentration series shall be determined using a 0.5 dilution factor. An additional seven replicates of 100 percent sample will be run in order to provide tissue for yolk/embryo analysis, if needed.

If the total sample volume for toxicity testing is less than 54-L but greater than 26.5-L, the volume collected will determine changes in the toxicity testing configuration described above as follows:

- 45.5 liters – base concentration series on a 0.3 dilution factor
- 40.5 liters – base concentration series on a 0.3 dilution factor and reduce the number of replicates to three
- 32.5 liters – reduce the number of extra replicates of 100 percent sample for yolk/embryo analysis from seven to three and the number of replicates in the test to three
- 31.5 liters – reduce the number of extra replicates of 100 percent sample for yolk/embryo analysis from seven to three and base the concentration series on a 0.3 dilution factor
- 26.5 liters – reduce the number of extra replicates of 100 percent sample for yolk/embryo analysis from seven to three, base the concentration series on a 0.3 dilution factor, and reduce the number of replicates in the test to three

# Quality Control

To ensure that the data quality objectives for this study are met, quality control procedures are identified in separate subsections below for field and laboratory activities. The overall objective of these procedures is to ensure that data collected for this project are of a known and acceptable quality.

## Field Quality Control Procedures

Quality control procedures that will be implemented for field activities are described in the following subsections. The frequency and type of quality control samples to be collected in the field are also summarized in Table 9.

### Instrument Maintenance and Calibration

Before and after each targeted event, routine maintenance and operational inspections will be performed to ensure that the field equipment is functioning properly. Maintenance activities and operational inspections will include:

- Inspection of battery and battery connections
- Replacement of desiccant for the data loggers and automated samplers
- Inspection of the rain gauge, including level check and debris removal
- Inspection of flow monitoring device, including level check and debris removal

The calibration of flow measurement devices will also be checked during the pre-storm site visits by measuring the depth of water (if present) at the monitoring station and adjusting the recorded level to match. If no water is present at the monitoring station and the flow measurement device is a bubbler or other level sensing device, then that device may be calibrated using a known depth in a container of water. Instrument maintenance and calibration activities will be documented on standardized field forms (Appendix A).

The rain gauge is a robust instrument that will only require annual calibration. On an annual basis, water will be metered into the rain gauge with a syringe until the tipping bucket mechanism triggers. This will be repeatedly conducted and adjustments on the rain gauge will be made until an equivalent volume of water triggers the tipping mechanism in either direction. Each bucket tip is calculated as equivalent to 0.01 inches of rain, consequently the volume of water that should initiate a bucket tip equals 0.01 inches multiplied by the area (in square inches) of the top of the rain gauge. This is the target volume that will be used when rain gauges are calibrated.

**Table 9. Anticipated total number of samples and associated quality assurance requirements for each study parameter.**

| | Parameter | Samples per Station | Number of Stations | Total Number of Samples | Laboratory Method Blanks | Field Equipment Rinsate Blanks | Laboratory Control Standard | Matrix Spike | Field Duplicates | Lab Duplicates |
|---|---|---|---|---|---|---|---|---|---|---|
| Water Quality Control | | | | | | | | | | |
| **Conventional Parameters** | Total suspended solids | 26 [d] | 3 | 78 | 1batch [a] | NA | 1/batch [a] | NA | 8 [c] | 1/batch [a] |
| | Turbidity | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Conductivity | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Chloride | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | $BOD_5$ | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Hardness as $CaCO_3$ | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Methylene Blue Activated Substances (MBAS) | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| **Bacteria** | Fecal Coliform | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| **Nutrients** | Total phosphorus | 26 [d] | 3 | 78 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 8 [c] | 1/batch [a] |
| | Ortho-phosphate phosphorus | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Total Kjeldahl nitrogen | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Nitrate + nitrite nitrogen | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| **Metals** | Zinc, total | 26 [d] | 3 | 78 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 8 [c] | 1/batch [a] |
| | Zinc, dissolved | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Lead, total | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Lead, dissolved | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Copper, total | 26 [d] | 3 | 78 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 8 [c] | 1/batch [a] |
| | Copper, dissolved | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Cadmium, total | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Cadmium, dissolved | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Mercury, total | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |
| | Mercury, dissolved | 22 | 3 | 66 | 1batch [a] | 2/year [b] | 1/batch [a] | 1/batch [a] | 7 [c] | 1/batch [a] |

**Table 9 (continued). Anticipated total number of samples and associated quality assurance requirements for each study parameter.**

| | Parameter | Samples per Station | Number of Stations | Total Number of Samples | Laboratory Method Blanks | Field Equipment Rinsate Blanks | Laboratory Control Standard | Matrix Spike | Field Duplicates | Lab Duplicates |
|---|---|---|---|---|---|---|---|---|---|---|
| **Organics** | Polycyclic aromatic hydrocarbons | 22 | 3 | 66 | 1batch [a] | 2/year[b] | 1/batch [a] | 1/batch [a] | 22 [c] | 1/batch [a] |
| | Phthalates | 22 | 3 | 66 | 1batch [a] | 2/year[b] | 1/batch [a] | 1/batch [a] | 22 [c] | 1/batch [a] |
| | Herbicides | 26 [d] | 3 | 78 | 1batch [a] | 2/year[b] | 1/batch [a] | 1/batch [a] | 26 [c] | 1/batch [a] |
| | Pesticides, Nitrogen | 26 [d] | 3 | 78 | 1batch [a] | 2/year[b] | 1/batch [a] | 1/batch [a] | 26 [c] | 1/batch [a] |
| | Pesticides, Organophosphates | 26 [d] | 3 | 78 | 1batch [a] | 2/year[b] | 1/batch [a] | 1/batch [a] | 26 [c] | 1/batch [a] |
| **Petroleum Hydrocarbons** | NWTPH-Dx | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 22 [c] | 1/batch [a] |
| | NWTPH-Gx | 22 | 3 | 66 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 22 [c] | 1/batch [a] |
| Sediment Quality Control | | | | | | | | | | |
| **Conventional Parameters** | Total solids (% solids) | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Grain-size | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Total organic carbon | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| **Metals** | Zinc | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Lead | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Copper | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Cadmium | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Mercury | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| **Semivolatile Organic Compounds** | PAHs | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Phthalates-BNA | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Phenolics-BNA | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Pentachlorophenol | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| **PCBs** | PCBs as Aroclors | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| **Chlorinated Herbicides** | 2,4-D and MCPP | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| | Triclopyr | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |

**Table 9 (continued). Anticipated total number of samples and associated quality assurance requirements for each study parameter.**

| | Parameter | Samples per Station | Number of Stations | Total Number of Samples | Laboratory Method Blanks | Field Equipment Rinsate Blanks | Laboratory Control Standard | Matrix Spike | Field Duplicates | Lab Duplicates |
|---|---|---|---|---|---|---|---|---|---|---|
| **Halogenated Pesticide** | Dichlobenil | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| **Organonitrogen Pesticides** | Prometon | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| **Organophosphorus Pesticides** | Chloropyrifos, Diazinon, and Malathion | 3 | 3 | 9 | 1batch [a] | NA | 1/batch [a] | 1/batch [a] | 1 [c] | 1/batch [a] |
| Toxicity Control | | | | | | | | | | |
| **Toxicity** | Environmental Canada Trout Embryo Viability | 3 | 3 | 9 | NA | NA | NA | NA | NA | 1/batch [a] |

NA: not applicable.

Note: Numbers provided assume that a total of 11 storms will be monitored at each station each year during a two-year monitoring period.

[a] Laboratory QA samples will be analyzed with each batch of samples submitted to the laboratory for analysis. A laboratory batch will consist of no more than 20 samples.

[b] Equipment rinsate blanks will be collected before the first event of each monitoring year. In the first monitoring year a second rinsate blank will be collected after the first sample has been collected.

[c] Field duplicates will be collected and analyzed for at least ten percent of the total number of submitted sample.

[d] This number reflects 4 additional samples that will be collected during baseflow conditions.

The sediment sampler does not require calibration but needs to be inspected at least twice during each monitoring year to ensure sufficient collection of sediment and proper functioning of the device.

### Field Notes

During each pre- and post-storm site visit to each monitoring station, the following information will be recorded on a waterproof standardized field form (Appendix A):

- Site Name
- Date/time of visit and last sample collected
- Name(s) of field personnel present
- Weather and flow conditions
- Sampler battery voltage
- Rain gage condition
- Desiccant condition
- Number of aliquots (if samples were collected)
- Sampling problems (if applicable)
- Estimated sample volume (if sampled)
- Presence of obstructions in weir/ measuring area, or sample tubing and corrective actions taken
- Unusual conditions (e.g., oily sheen, odor, color, turbidity, discharges or spills, and land disturbances)
- Modifications of sampling procedures

### Equipment Rinsate Blanks

Equipment rinsate blanks will be collected to verify that the automated sampler tubing is not a source of contamination. In order to collect the sample, the sample line will be rinsed in the same manner that it is during pre-storm site visits. The sample line will then be detached at the point of sample collection and placed in a carboy of reagent grade water. The sampler will be programmed to collect 20 liters of reagent grade water using normal sample collection procedures. Rinsate blanks will be collected prior to the first targeted storm event of each monitoring year. During the first year, another rinsate blank will be collected after the third storm event to further test potential tubing contamination after multiple storms. The number of rinsate blanks to be collected during the sampling season is presented in Table 9. All rinsate blank samples will be submitted to the laboratory and labeled as separate (blind) samples.

Sample intake tubing will be replaced annually. Rinsate blanks will be collected after the sampler tubing has been replaced following the first year of monitoring.

### Field Duplicates

Field duplicates will be collected at a sufficient frequency to represent 10 percent of the total number of project samples analyzed. The number of field duplicates to be collected during the sampling season is listed in Table 9. All duplicate samples will be submitted to the laboratory and labeled as separate (blind) samples. The resultant data from these samples will then be used to assess variation in the analytical results that is attributable to environmental (natural), sub-sampling, and analytical variability.

### Sample Handling

Automated samplers will be filled with ice before each sampled storm event. Ice will not be allowed to sit within the automated samplers for more than 24-hours before the initiation of an event (with the goal of keeping sample temperatures below 6 degrees Celsius). After each targeted storm event, all samples will be minimally processed in the field to prevent potential contamination from trace pollutants in the atmosphere.

All sample bottles (grab sample bottles and 20-liter composite bottles) will be transported in coolers with ice and kept below 6 degrees Celsius until delivery to the laboratory. The temperature of the samples will be measured upon sample delivery and recorded on the chain-of-custody form. Once in the laboratory, the composite samples will be transferred from the sampler bottles to pre-cleaned sample bottles for the required analyses. In order to minimize exposure of the samples to human, atmospheric, and other potential sources of contamination, laboratory staff will process the samples using "clean" techniques pursuant to protocols developed by the U.S. EPA (1996) for the low-level detection of metals.

### Sample Identification and Labeling

All sample containers will be labeled with the following information using indelible ink and labeling tape:

- Station name (i.e., COMM, LORES, HIRES)
- Date of sample collection (year/month/day: yyyy/mm/dd)
- Time of sample collection (international format [24 hour])
- Field personnel initials (ds)

QA samples (field duplicates and blanks) will only be labeled as QA1, QA2, etc. for delivery to the laboratory, but field staff will maintain a cross-check list of which stations and sample types the QA samples represent. When results are returned from the laboratory, the Herrera field lead will associate full label information with the results, and populate database fields for the QA sample and type.

Waterproof labels will be placed on dry sample container lids by self-adhesion or with tape. Waterproof labeling tape may be employed. Any written marks will be made with waterproof ink.

### Sample Containers and Preservation

Clean, decontaminated water sample bottles will be obtained from the analytical laboratory in advance of each storm event. Spare sample bottles will be carried by the sampling team in case of breakage or possible contamination. Sample containers and preservation techniques will follow U.S. EPA (2007) guidelines.

As noted above, bottles used for the collection of the samples will be cleaned by laboratory personnel with a five step process: 1) phosphate-free detergent wash, 2) tap water rinse, 3) dilute acid rinse, 4) carbon-free water rinse, 5) ultra-pure solvent rinse, and 6) carbon-free water rinse and air dry. The laboratory selected will specify the acid and solvents used for this procedure.

Decontamination of tubing will occur in the field before each sampling event. New tubing will be used at the beginning of the project for each station and will be replaced annually. Prior to installation, all sampling equipment (Teflon tubing and strainer) will be decontaminated using the following process: 1) phosphate-free detergent wash, 2) tap water rinse, 3) acid rinse, 4) carbon-free water rinse, 5) ultra-pure solvent rinse, and 6) carbon-free water rinse and air dry. Before each storm event, the sample and pump tubing will be backflushed with deionized water three times the length of the tubing and sample line. As discussed above, a rinsate blank will be collected between the first and third storm to ensure that the equipment cleaning process is sufficiently decontaminating the sampling equipment. Modifications to this method will be made if results from the rinsate blank suggest that adequate decontamination is not occurring.

Clean, decontaminated Teflon lined sample bottles will be obtained from the analytical laboratory in advance of each annual sediment sampling deployment. The Teflon-lined sample bottles will be cleaned in a four-step process: 1) phosphate-free detergent wash, 2) tap water rinse, 3) acid rinse, 4) carbon-free water rinse, 5) ultra-pure solvent rinse, and 6) carbon-free water rinse and air dry.

### Chain-of-Custody Record

A chain-of custody record will be maintained for each sample batch listing the sampling date and time, sample identification numbers, analytical parameters and methods, persons relinquishing and receiving custody, dates and times of custody transfer, and temperature of samples upon delivery.

# Laboratory Quality Control Procedures

## Water and Sediment Quality Control

Quality control procedures that will be implemented in the laboratory are described in the following subsections. The frequency and type of quality control samples to be analyzed by the laboratory are also summarized in Table 9.

### *Method Blanks*

Method blanks consisting of de-ionized and micro-filtered pure water will be analyzed with every laboratory sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of method blanks anticipated for this study is shown in Table 9 by parameter. Blank values will be presented in each laboratory report.

### *Control Standards*

Control standards for each parameter will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of control standards anticipated for this study is shown in Table 9 by parameter. Raw values and percent recovery (see formula in the Quality Objectives section) for the control standards will be presented in each laboratory report.

### *Matrix Spikes*

For applicable parameters, matrix spikes will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of matrix spikes anticipated for this study is shown in Table 9 by parameter. Raw values and percent recovery (see formula in the Quality Objectives section) for the matrix spikes will be presented in each laboratory report.

### *Laboratory Duplicates*

Laboratory duplicates for each parameter will be analyzed for specifically labeled QA samples submitted with every sample batch. This will represent no less than 10 percent of the project submitted samples. The total number of laboratory duplicates anticipated for this study is shown in Table 9 by parameter. Raw values and relative percent difference (see formula in the Quality Objectives section) of the duplicate results will be presented in each laboratory report.

## Toxicity Quality Control

Quality control procedures that will be implemented in the laboratory are described in the following subsections. The frequency and type of quality control samples to be analyzed by the laboratory are summarized below.

### *Negative Controls*

The negative control consists of nontoxic laboratory water tested in parallel with the samples under identical test conditions. A test with at least 70 percent embryo development rate and 70 percent embryo survival rate in negative control test chambers is considered acceptable.

### *Reference Toxicant Tests*

A reference toxicant test must be analyzed on a monthly basis by the laboratory.

### *Toxicity Water Quality*

Water quality monitoring will be conducted by the laboratory as described below on each of the test containers:

- Temperature – measured at the beginning of the test and daily throughout the test. Acceptable temperature range is 13 to 15 degrees Celsius
- Dissolved oxygen – measured daily
- pH – measured at the beginning and end of the test, and daily during the test
- Conductivity – measured at the beginning of the test, prior to each test solution renewal, and at the end of the test
- Total hardness and total alkalinity – measured in all samples and all dilution water of all tests

# Data Management Procedures

Data from the field data loggers will be remotely transferred on a weekly basis and/or at the beginning and end of each storm event. The hydrologic data from each monitoring station will be imported directly into a database (ISCO Flowlink or Aquarius data management software) for subsequent analysis and archiving purposes. These data will be immediately checked for evidence of an equipment malfunction or other operational problem. Gaps in flow data may need to be interpolated; if this occurs, data will be stored and presented in a manner that makes it clear which data are from measurement, and which have been interpolated. The database will be used to produce event based hydrologic summary statistics (e.g., station runoff volume, storm precipitation total, storm duration) for each applicable station. These summary statistics will ultimately be stored in Microsoft Access database with other water quality data collected during the project as described below.

The laboratory will report the analytical results within 60 days of receipt of the samples. The laboratory will provide sample and quality control data in standardized reports that are suitable for evaluating the project data. These reports will include all raw data including raw quality assurance data, and all quality control results associated with the data. The reports will also include a case narrative summarizing any problems encountered in the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers. Laboratory analytical and QA results will be delivered by the laboratory in both electronic and hardcopy form.

Analytical data for the project will be stored in a database (Microsoft Access) or spreadsheet (Microsoft Excel) format with related event-based hydrologic data from each storm. A continuous hydrologic record will also be stored so that annual loading assessments can be included. The Herrera quality assurance officer will perform an independent review of the data to ensure that all sample values are entered without error. This review will consist of checking that all laboratory data are entered into the database correctly. Results from this review will be documented in a data entry review worksheet (Appendix A).

Both the laboratory and Pierce County will retain project related data for 5 years after completion of the project.

# Audits and Reports

Audits will be performed in order to detect potential deficiencies in the hydrologic and water quality data that will be collected for this project. Audits for hydrologic and sample collection data will occur following each storm event. In connection with these audits, the data collected from each monitoring station over the sampled storm events will be examined in relation to data from prior storms and data from the rain gauge station to identify potential data quality issues. This audit will specifically include an examination of the data record for gaps, anomalies, or inconsistencies between the discharge and water level data from previous monitoring events. Any data generated from calibration checks that were performed at a particular monitoring station will also be entered into control charts and reviewed to detect potential instrument drift or other operational problems. In addition, sample collection and hydrologic data will be reviewed to assess whether MQOs have been met.

In the event that QA issues are identified on the basis of these audits, measures will be taken to troubleshoot the problem(s) and to implement corrective actions if possible. Further, if bias in the hydrologic record is detected and can be corrected by calibration, the corrective actions will be documented in the database and in separate tracking forms (Appendix A).

Audits performed for water quality data will occur within seven business days of receiving results from the laboratory. This review will be performed to ensure that all data are consistent, correct, and complete, and that all required quality control information has been provided. Specific quality control elements for the data (Table 2 and Table 3) and raw data will also be examined to determine if the MQOs for the project have been met. Results from these audits will be documented in QA worksheets (Appendix A) that will be prepared for each batch of samples.

In the event that a potential QA issue is identified through these audits, Herrera's data quality assurance officer will review the data to determine if any response actions are required. Response actions in this case might include the collection of additional samples, reanalysis of existing samples if not yet past holding time, and/or advising the laboratory that methodologies and/or QA/QC procedures need to be improved.

# Data Verification and Validation

Data verification and validation will be performed on both the hydrologic, water quality, and sediment data that are collected through the duration of this project. The specific procedures that will be used to verify and validate each type of data are described in the following sections.

## Verification and Validation Methods for Hydrologic Data

The verification and validation process for hydrologic data will involve the following steps:

1. Precipitation data from the study will be reviewed to identify any significant gaps. If possible, these gaps will be filled using data obtained from a nearby rain gauge.
2. The available discharge from COMM, LORES, HIRES will be verified based on comparisons of the associated hydrographs to the hyetographs for individual storm events. Gross anomalies (e.g., data spikes), gaps, or inconsistencies that are identified through this review will be investigated to determine if there are quality assurance issues associated with the data that limit their usability.
3. If minor quality assurance issues are identified in any portion of the discharge record or in the water level data from a particular station and storm event, the data from that station and event will be considered as an estimate and assigned a (*j*) qualifier. If major quality assurance issues are identified in any portion of the data from a particular station and /or storm event, the data from that station and event will be rejected and assigned an (*r*) qualifier. Estimated values will be used for evaluation purposes while rejected values will not.

## Verification and Validation Methods for Chemistry Data

Data will be reviewed and audited within seven business days of receiving the results from the field or laboratory. This review will be performed to ensure that all data are consistent, correct and complete, and that all required quality control information has been provided. Specific quality control elements for the data (Table 2) will also be examined to determine if the MQOs for the project have been met. Results from these data validation reviews will be summarized in quality assurance worksheets that are prepared for each sample batch (Appendix A). Values associated with minor quality control problems will be considered estimates and assigned *J* qualifiers. Values associated with major quality control problems will be rejected and qualified *R*. Estimated values may be used for evaluation purposes, while rejected values will not be used. The following sections describe in detail the data validation procedures for these quality control elements:

- Completeness
- Methodology
- Holding times
- Blanks
- Reporting limits
- Duplicates
- Matrix spikes and matrix spike duplicates
- Calibration and control standards
- Sample representativeness

### Completeness

Completeness will be assessed by comparing valid sample data with this quality assurance project plan and the chain-of-custody records. Completeness will be calculated by dividing the number of valid values by the total number of values. If less than 95 percent of the samples submitted to the laboratory are judged to be valid, then more samples will be collected until at least 95 percent are judged to be valid. If less than 95 percent of the collected flow data is complete, additional monitoring will be implemented until 95 percent of the flow record has been collected. Because of the nature of this data set both the analytical and hydrologic data quality need to be assessed when calculating completeness. Consequently, for loading calculations (loading = concentration multiplied by discharge) a complete flow and chemistry record is required, whereas for infiltration calculations only a flow record is required. To address this, completeness will be calculated for hydrologic and analytical data both separately and in combination.

### Methodology

Methodologies for analytical procedures will follow U.S. EPA approved methods (APHA et al. 1992; U.S. EPA 1983, 1984) specified in Table 7. Field procedures will follow the methodologies described in this quality assurance project plan. Any deviations from these methodologies must be approved by Pierce County and Ecology and documented in an addendum to this QAPP. The database will include a field for identifying analytical method. Deviations that are deemed unacceptable will result in rejected values (*R*) and will be corrected for future analyses.

### Holding Times

Holding times for each analytical parameter in this study are summarized in Table 7. For most samples, holding time compliance will be assessed by comparing sample collection dates and times to the analytical date and time. For those samples requiring filtration, sample collection time, filtration time, and analytical dates and times will be used to assess compliance. Sample collection times will be based on the date and time that the last aliquot was collected, but date and time of start of sampling will be recorded as well.

The recommended holding time for fecal coliform bacteria is 6 hours, but due to the difficulty to meet this holding time, a proxy holding time of 24 hours will be used. For holding times that fall between 6 and 24 hours the sample will be denoted as an estimated (J) value.

### *Pre-Filtration Holding Times*

The laboratory will be required to split the composite sample and filter the dissolved metals and orthophosphate samples immediately upon receipt of the samples, with the goal of filtering the samples within 24 hours of collection of the last aliquot. However, meeting this holding time will be difficult given that the time of the last aliquot collection will be unknown. If samples are filtered between 24 and 48 hours they will be accepted but flagged as 'estimated' (j) values. Samples that are not filtered within 48 hours will be rejected.

If sample retrieval occurs during the laboratory's non-business hours or the laboratory is not able for some other reason to receive, filter or process the samples; sampling staff can split, filter, and preserve the samples as soon as possible after retrieval; assuming the equipment and facilities are available. The samples will then be stored in a secure refrigerator and maintained at the required holding temperature until they can be delivered to the laboratory the morning of the next business day.

### *Post-Filtration or Total Holding Times*

- For analytes with holding times in excess of 7 days:
  - Data from samples that exceed the specified maximum post-filtration holding times by less than 48 hours will be considered estimates (*J*). Data from samples that exceed the maximum post-filtration holding times by more than 48 hours will be rejected values (*R*).
- For analytes with holding equal to or less than 7 days:
  - Data from samples that exceed the specified maximum post-filtration holding times by less than 24 hours will be considered estimates (*J*) (dissolved metals and orthophosphate will receive an *R*). Data from samples that exceed the maximum post-filtration holding times by more than 24 hours will be rejected values (*R*).

## Method Blanks

Method blank values will be compared to the MQOs that have been identified for this project (Table 2). If an analyte is detected in a method blank at or below the reporting limit, no action will be taken. If blank concentrations are greater than the reporting limit, the associated data will be labeled with a *U* (in essence increasing the reporting limit for the affected samples), and associated project samples within 5 times the de facto reporting limit will be flagged with a *J* (Grepogrove 2007).

**Rinsate Blanks**

Rinsate blank values for all nutrients, metals and organics will be compared to the MQOs that have been identified for this project (Table 2). If nutrients, metals and/or organics are detected in the rinsate blanks at concentrations that exceed 2 times the reporting limit, then associated sample tubing will be cleaned or replaced and associated samples collected since the previous rinsate blank that are within 5 times the new reporting limit will be flagged with a *J*. At the monitoring stations where corrective actions (e.g., replacement or cleaning of sample tubing) were taken, a follow-up rinsate blank will be collected and analyzed for any parameters exceeding 2 times the reporting limit in the midpoint rinsate blank.

**Reporting Limits**

Both raw values (i.e., values between the method detection limit and the reporting limit) and reporting limits will be presented in each laboratory report. If the proposed reporting limits are not met by the laboratory, the laboratory will be requested to reanalyze the samples and/or revise the method, if time permits. Proposed reporting limits for this project are summarized in Table 7.

**Duplicates**

Duplicate results exceeding the MQOs for this project (Table 2) will be recorded in the raw data tables, and noted in the quality assurance worksheets; and associated values will be flagged as estimates (*J*). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (*R*).

**Matrix Spikes**

Matrix spike results exceeding the MQOs for this project (Table 2) will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (*J*). However, if the percent recovery exceeds the MQOs and a value is less than the reporting limit, the result will not be flagged as an estimate. Nondetected values will be rejected (*R*) if the percent recovery is less than 30 percent.

**Control Standards**

Control standard results exceeding the MQOs for this project (Table 2) will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (*J*). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (*R*).

**Sample Representativeness**

Each flow-weighted composite sample is interpreted to represent the mean concentration for the sampled storm event. However, flow gage or laboratory error can lead to compromised data. The data collected for this study will be labeled with unique quality assurance flags for both laboratory and field data quality issues. Table 10 presents the flagging scheme that will be used for this project.

**Table 10. Data qualifiers and definitions.**

| Data Qualifier | Definition | Criteria for Use |
|---|---|---|
| J | Value is an estimate based on analytical results. | MQOs for field duplicates, laboratory duplicates, matrix spikes, laboratory control samples, holding times, or blanks have not been met. |
| R | Value is rejected based on analytical results. | Major quality control problems with the analytical results. |
| j | Value is an estimate based on storm sampling criteria. | Hydrograph is compromised from gage error, but is still deemed an adequate estimate. |
| r | Value is rejected based on storm sampling criteria. | Hydrograph is compromised from gage error, and has rendered the EMC non-representative. |
| Jj | Value is an estimate based on analytical results and storm sampling criteria. | Analytical and storm sampling criteria have not been met, but data is still usable. |
| Jr | Value is an estimate based on analytical results and rejected based on storm sampling criteria. | Analytical criteria have not been met but data still usable; Hydrograph is compromised from gage error, and has rendered the EMC non-representative. |
| U | Value is below the reporting limit. | Based on laboratory method reporting limit. |
| UJ | Value is below the reporting limit and is an estimate based on analytical results. | Based on laboratory method reporting limit; MQOs for analytical results have not been met. |
| Ur | Value is below the reporting limit and is rejected based on storm sampling criteria. | Based on laboratory method reporting limit; Hydrograph is compromised from gage error, and has rendered the EMC non-representative. |
| Uj | Value is below the reporting limit and is an estimate based on storm sampling criteria. | Based on laboratory method reporting limit; Analytical and storm sampling criteria have not been met, but data is still usable. |

# Verification and Validation Methods for Toxicity Data

All toxicity data will be compared to criteria outlined in Ecology's *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria* (Publication No. WQ-R-95-80) (Ecology 2008) and in the method: Environment Canada EPS 1/RM/28 (Environment Canada 1992).

A minimum of five concentrations and a control will be used in the toxicity testing, regardless of sample volume collected. A discussion of replicate number and dilution factors adjustments is provided in the Measurement Procedures section, based on the volume of sample collected. The effective concentration for 50 percent of the population ($EC_{50}$) will be calculated using the trimmed Spearman-Karber procedure (U.S. EPA 2002). Abbott's correction may be applied to the data before deriving this point estimate.

If the $EC_{50}$ from any valid and non-anomalous test is 100 percent stormwater or less, follow-up actions will be implemented. This includes a comparison of chemical analysis results for the same storm event to a library of toxicity test results complied by Ecology and identified for this purpose. If the presence of an analyzed contaminant is within a range reported in the literature that may adversely affect fish embryos is identified, a report summarizing the toxicity and chemical analysis results, the library comparison, a review of relevant sources of literature from the Ecology's library, the possible chemical contaminants of concern, and an explanation of how stormwater management actions are expected to reduce stormwater toxicity. If a possible chemical contaminant of concern is not determined by library comparison and literature review, eggs from the highest test concentrations will be analyzed at a screening level by gas chromatography/mass spectrometer (GC/MS). Therefore, terminated organisms must be preserved for up to 6 months.

# Data Quality Assessment

Separate subsections below describe the procedures that will be used to assess the usability of the data, analyze the data, and report the associated results.

## Data Usability Assessment

The Herrera quality assurance officer will provide an independent review of the water quality QC data from each sampling event in accordance with the MQOs that have been identified in this QAPP. The results will be presented in a data quality assessment report that will be prepared for each monitoring year. The report will summarize quality control results, identify when data quality objectives were not met, and discuss the resulting limitations, if any, on the use or interpretation of the data. Specific quality assurance information that will be noted in the data quality assessment report includes the following:

- Changes in and deviations from the monitoring and quality assurance plan
- Results of performance and/or system audits
- Significant quality assurance problems and recommended solutions
- Data quality assessment results in terms of precision, bias, representativeness, completeness, comparability, and reporting limits
- Discussion of whether the quality assurance objectives were met, and the resulting impact on decision-making
- Limitations on use of the measurement data

To assess the quality of the flow data, Herrera will compile flow QA worksheets (see *Audits and Reports* section) for inclusion in the annual data report. The QA worksheets will be summarized and presented in a tabular format. A brief narrative accompanying the table will summarize quality control results, identify when data quality objectives were not met, and discuss the resulting limitations, if any, on the use or interpretation of the data. Seasonal pollutant loading for both wet and dry seasons will be calculated by summing the respective loads for the specific time periods.

## Data Analysis Procedures

Data analysis for sediment and toxicity data will consist of reporting results, summary statistics, and then conducting a comparison among the basins using a Kruskal Wallis nonparametric comparison test (Helsel and Hirsch 2002).

Water quality data will be summarized in a similar manner to the toxicity and sediment data. In addition, pursuant to the requirements of the permit, various methods will be used to calculate event mean concentrations, annual pollutant loads, and seasonal pollutant loads for both base and storm flow.

### *Total Annual Pollutant Loading Calculations*

Total annual pollutant loading is the sum of base flow and storm flow loading for each monitoring year. Base flow is the flow contributed from non-storm sources, from groundwater, and subsurface flows. Base flow loading consists of the loading of chemical constituents from these sources, and is calculated separately from the storm flow loading because storm flow and base flow have distinct chemical compositions. Storm flow pollutant loadings are the loadings of chemical constituents from storm event surface runoff. The procedure below identifies how storm flow loading and base flow loading will be calculated and summed to generate a total annual pollutant loading. Seasonal pollutant loading for both wet (October through April) and dry (May through September) seasons will also be calculated.

The overall equation for calculating the total annual pollutant loading, or mass loading [ML], for a particular chemical constituent is:

$$ML = (F_{bd} \times C_{bd}) + (F_{bw} \times C_{bw}) + (F_{sd} \times C_{sd}) + (F_{sw} \times C_{sw})$$

Where [$F_{bd}$] is the base flow volume in the dry season, [$F_{bw}$] is the base flow volume in the wet season, [$C_{bd}$] is the average dry season flow-weighted base flow concentration, [$C_{bw}$] is the average wet season flow-weighted base flow concentration, [$F_{sd}$] is the storm flow volume in the dry season, [$F_{sw}$] is the storm flow volume in the wet season, and [$C_{sd}$] is the average dry season flow-weighted storm flow concentration, and [$C_{sw}$] is the average wet season flow-weighted storm flow concentration.

### *Base Flow Calculations*

As discussed earlier, four base flow grab samples will be collected at each station during the first monitoring year. The intent will be to collect two base flow samples during the dry season and two during the wet season. However, if there is no water flowing during the dry season, four samples will still be collected but will only represent wet season base flows. Water quality analysis for base flow samples will be conducted for a limited number of parameters (TSS, total phosphorus, total copper, and pesticides).

*Base Flow - Flows and Volumes:*

Base flows will be determined from the record of continuous flow data at each station. Base flows will be separated from the hydrograph using HYSEP hydrograph separation with a moving minimum.

*Base Flow Concentrations*

Base flow concentrations will be tabulated and seasonal flow-weighted mean concentrations will be calculated and used for the seasonal mean base flow concentrations for the monitoring year ($C_{bd}$ and $C_{bw}$).

*Base Flow Loadings*

The base flow loading is a product of the base flow volume and concentration. This loading may be calculated both seasonally and annually.

$$\text{Dry Season Base Flow Loading} = (F_{bd} \times C_{bd})$$

$$\text{Wet Season Base Flow Loading} = (F_{bw} \times C_{bw})$$

$$\text{Annual Base Flow Loading} = (F_{bd} \times C_{bd}) + (F_{bw} \times C_{bw})$$

***Storm Flow Calculations***

As discussed previously, flow -weighted composite samples and grab samples will be collected during eleven storm events each monitoring year and analyzed for conventionals, metals, bacteria, PAHs and pesticides (Table 7).

*Storm Flow - Flows and Volumes:*

Total flow is the sum of both base flow and storm flow. The total flow will be subtracted by the base flow volumes resulting in storm flow for the monitoring period. Wet and dry season storm flows ($F_{sd}$ and $F_{sw}$) will be calculated by subtracting the seasonal total flows by the seasonal base flows. For stations without base flow contributions, the total flow will equal the storm flow.

*Storm Flow Event Mean Concentration (EMC)*

The event mean concentration is the flow-weighted concentration over a storm event. The EMC from a flow-weighted composite sampled event includes a combination of both storm flow and base flow. As a result, the base flow must be removed from the $EMC_{tot}$ using the principles of mass balance to calculate an EMC for the storm flow contribution alone [$EMC_{sf}$]. This calculation is performed using the volumetric fractions [$f_s$ and $f_b$] and the mean base flow concentration [$C_b$]:

$$EMC_{sf} = [EMC_{tot} - (C_b \times f_b)] / f_s$$

*Flow-Weighted Mean Storm Flow Concentration*

Total stormwater EMCs ($EMC_{tot}$) for sampled storm events during each season will be converted to storm flow EMCs ($EMC_{sf}$) as described above, and then averaged for a flow-weighted mean storm flow concentration for each season ($C_{sd}$ and $C_{sw}$).

*Storm Flow Loading*

A total storm flow load will then be calculated for each storm event by multiplying the seasonal storm flow EMC ($C_{sd}$ and $C_{sw}$) by the seasonal storm flow volumes defined above ($F_{sd}$ and $F_{sw}$). The storm flow loading is calculated with the following equations:

$$\text{Dry Season Storm Flow Loading} = (F_{sd} \times C_{sd})$$

$$\text{Wet Season Storm Flow Loading} = (F_{sw} \times C_{sw})$$

$$\text{Annual Storm Flow Loading} = (F_{sd} \times C_{sd}) + (F_{sw} \times C_{sw})$$

## Reporting Procedures

Pierce County will prepare an Annual Stormwater Monitoring Report as an attachment to the Annual Report of the Phase I Permit beginning in 2009 for independent monitoring, and 2010 for collaborative monitoring as required in Permit Section H.1.a. This annual stormwater report will include monitoring data collected during the preceding period from October 1 through September 30. Additionally, each report will include data from earlier years to integrate into the data analyses. The report will specifically include the following information:

- A summary including the location, land use, drainage area size, and hydrology for each site
- A comprehensive data and QA/QC report for each component of the monitoring program, with an explanation and discussion of the results of each monitoring project
- The annual pollutant load based on water year for each site expressed in total pounds, and pounds/acre
- The wet and dry season pollutant load based on water year, expressed in total pounds, and pounds/acre
- A summary table of sediment pollutant concentrations
- A summary of the toxicity testing results
- A statistical comparison of water quality, sediment, and toxicity data among the various basins

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# APPENDIX A

# Field Forms and Quality Assurance Worksheets

# FIELD LOG SHEET

Project Name:________________________ Project #:________________________

Site Location:________________________ Client:________________________

Site ID:________________________ Event ID________________________

## Pre-Storm Visit

| Date: | Time: | Field Staff: | Weather: |
|---|---|---|---|

| Station Name: | | Station Name: | | Station Name: | |
|---|---|---|---|---|---|
| Sampler Battery Volt. (V): | | Sampler Battery Volt. (V): | | | |
| Primary Device Level: | *Yes No* | Primary Device Level | *Yes No* | | |
| Actual Stage (ft): | | Actual Stage (ft) | | Actual Stage (ft) | |
| Stage Before Adj. (ft): | | Stage Before Adj. (ft) | | Stage Before Adj. (ft) | |
| Stage After Adj. (ft): | | Stage After Adj. (ft) | | Stage After Adj. (ft) | |
| Actual Pump Vol (ml): | | Actual Pump Vol (ml) | | | |
| Pump Vol Before Adj. (ml): | | Pump Vol Before Adj. (ml) | | Rain Gauge Level? | *Yes No* |
| Pump Vol After Adj. (ml): | | Pump Vol After Adj. (ml) | | Rain Gauge Unobstructed? | *Yes No* |
| Intake Checked? | *Yes No* | Intake Checked? | *Yes No* | | |
| Desiccant: | *OK Replaced* | Desiccant: | *OK Replaced* | | |
| Sample Line Rinsed? | *Yes No* | Sample Line Rinsed? | *Yes No* | | |
| Clean Bottle? | *Yes No* | Clean Bottle? | *Yes No* | | |
| Pacing (cf): | | Pacing (cf): | | | |
| Ice Added? | *Yes No* | Ice Added? | *Yes No* | | |
| Program Started? | *Yes No* | Program Started? | *Yes No* | | |
| Flow Conditions: | *Rise Peak Fall None* | Flow Conditions: | *Rise Peak Fall None* | | |

Notes/Visual Conditions: (if 'no' to any questions above, explain why and remedial actions taken)

## Post-Storm Visit

| Date: | Time: | Field Staff: | Weather: |
|---|---|---|---|

| Station Name: | | Station Name: | | Station Name: | |
|---|---|---|---|---|---|
| Date/Time End: | | Date/Time End: | | | |
| # of Samples: | | # of Samples: | | Rain Gauge Level? | *Yes No* |
| Sampled Without Error? | *Yes No* | Sampled Without Error? | *Yes No* | Rain Gauge Unobstructed? | *Yes No* |
| Actual Stage (ft): | | Actual Stage (ft): | | | |
| Stage Before Adj. (ft): | | Stage Before Adj. (ft): | | | |
| Stage After Adj. (ft): | | Stage After Adj. (ft): | | | |
| Est. Sample Vol (L): | | Est. Sample Vol (L): | | | |
| Bottles Replaced? | *Yes No* | Bottles Replaced? | *Yes No* | | |
| Sent to Lab? | *Yes No* | Sent to Lab? | *Yes No* | | |
| Duplicate Sample? | *Yes No* | Duplicate Sample? | *Yes No* | | |
| Flow Conditions: | *Rise Peak Fall None* | Flow Conditions: | *Rise Peak Fall None* | | |

Notes/Visual Conditions: (if 'no' to any questions above, explain why and remedial actions taken)

## Grab Sample Visit

| Date: | Time: | Field Staff: | Weather: |
|---|---|---|---|

| Station | Parameter | Preservation | Bottle Type | # of Bottles | Bottle Volume (ml) | Duplicated | Flow Conditions |
|---|---|---|---|---|---|---|---|
| | | | *HDPE Glass* | | | *yes no* | *Rise Peak Fall None* |
| | | | *HDPE Glass* | | | *yes no* | *Rise Peak Fall None* |
| | | | *HDPE Glass* | | | *yes no* | *Rise Peak Fall None* |
| | | | *HDPE Glass* | | | *yes no* | *Rise Peak Fall None* |
| | | | *HDPE Glass* | | | *yes no* | *Rise Peak Fall None* |
| | | | *HDPE Glass* | | | *yes no* | *Rise Peak Fall None* |

Notes/Visual Conditions: (note any calibrations or maintenance on back)

| Maintenance Visit | | | | | |
|---|---|---|---|---|---|
| Date: | Time: | Field Staff: | | Weather: | |
| Station Name: BIPF | | Station Name: BIPF | | Station Name: BIPF | |
| Sampler Battery Voltage: | | Sampler Battery Voltage: | | | |
| Primary Device Level: | *Yes No* | Primary Device Level: | *Yes No* | | |
| Actual Stage (ft): | | Actual Stage (ft): | | Actual Stage (ft) | |
| Stage Before Adj. (ft): | | Stage Before Adj. (ft): | | Stage Before Adj. (ft) | |
| Stage After Adj. (ft): | | Stage After Adj. (ft): | | Stage After Adj. (ft) | |
| Actual Pump Vol (ml): | | Actual Pump Vol (ml): | | | |
| Pump Vol Before Adj. (ml): | | Pump Vol Before Adj. (ml): | | Rain Gauge Level? | *Yes No* |
| Pump Vol After Adj. (ml): | | Pump Vol After Adj. (ml): | | Rain Gauge Unobstructed? | *Yes No* |
| Intake Checked? | *Yes No* | Intake Checked? | *Yes No* | | |
| Desiccant: | *OK Replaced* | Desiccant: | *OK Replaced* | | |
| Sample Line Rinsed? | *Yes No* | Sample Line Rinsed? | *Yes No* | | |
| Flow Conditions: | *Rise Peak Fall None* | Flow Conditions: | *Rise Peak Fall None* | | |

Notes/Visual: (if 'no' to any questions above, explain why and remedial actions taken)

# Data Entry Review Worksheet

Project Name/No./Client: ______________________ Page ________ of ________

Data entered by: ______________________ Data reviewed by: ______________________

Laboratories: ______________________ Date reviewed: ______________________

Event ID ____________ Sample Date ______________

Monitoring Stations: ____________________________________________

Parameters: ____________________________________________

____________________________________________

## Percentage of Data Reviewed:

| Data Source (i.e., Lab or Field) | Monitoring Station | Parameter | Incorrect Value | Correct Value | Corrective Action |
|---|---|---|---|---|---|
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**Notes:**

# Automated Data Collection Quality Assurance Worksheet

By ____________________

Date __________ Page _____ of _____

initials ____________________

date ____________________

Project Name/No./Client: ______________________________

Site Name/Location: ______________________________

| | | | | |
|---|---|---|---|---|
| **Sensor 1:** | **Name:** | **Install Date:** | | |
| | **Make/Model:** | **S/N:** | | |
| **Sensor 2:** | **Name:** | **Install Date:** | | |
| | **Make/Model:** | **S/N:** | | |
| **Sensor 3:** | **Name:** | **Install Date:** | | |
| | **Make/Model:** | **S/N:** | | |

| **Sensor** | **Data Upload Time Span** | **Data Gaps** | | **Data Anomalies** | |
|---|---|---|---|---|---|
| | | **Description/Time Span** | **Corrective Action** | **Description/Time Span** | **Corrective Action** |
| | Start: | | | | |
| | Stop: | | | | |
| | Start: | | | | |
| | Stop: | | | | |
| | Start: | | | | |
| | Stop: | | | | |

NOTES:

# Data Quality Assurance Worksheet

By ____________________

Date ____________ Page ____ of ____

Checked: initials ____________

date ____________

Project Name/No./Client: ____________________

Laboratory/Parameters: ____________________

Sample Date/Sample ID: ____________________

| Parameter | Completeness/ Methodology | Pre-preservation Holding Times (days) | | Total Holding Times (days) | | Method Blanks Reporting Limit | Matrix Spikes/ Surrogate Recovery (%) | | Lab Control Samples Recovery (%) | | Lab Duplicates RPD (%) | | Field Duplicates RPD (%) | | Instrument Calibration/ Performance | ACTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Reported | Goal | Reported | Goal | | Reported | Goal | Reported | Goal | Reported | Goal[1] | Reported | Goal[1] | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | |
| | | | | | | 2 | | | | | | | | | | |

[1] If the sample or duplicate value is less than five times the reporting limit, the difference is calculated rather than the relative percent difference (RPD). The QA goal is a difference <2 times the detection limit instead of the number indicated in the goal column.

NA – not applicable or not available; NC – not calculable due to one or more values below the detection limit; NS – field duplicate not sampled.

**APPENDIX B**

# Time of Concentration Calculations

# Time of Concentration

Section S.8.D of the Phase I Municipal Stormwater Permit requires that sampling of storm events continues beyond the longest estimated time of concentration (Tc) for the tributary area. Therefore, this basin characteristic was estimated for each of the three outfall sites proposed for characterization monitoring. The times of concentration were estimated using the method described in Pierce County's Stormwater Management and Site Development Manual (2008). The table below lists the input parameters used to perform the calculation. Flows within the three basins were defined as open channel flow and used the Velocity Equation below:

$$V = k\sqrt{s_o}$$

Where: V = velocity (ft/s)

k = time of concentration velocity factor (ft/s)

$s_o$ = slope of flow path (ft/ft).

| Drainage Basin | Segment | Length (ft) | Slope "$s_o$" (ft/ft) | Velocity Factor "k" (ft/s)[a] | Velocity (V) (ft/s) | Time (minutes) |
|---|---|---|---|---|---|---|
| Low Density Drainage Basin | Channel | 5,173 | 0.0357 | 17.0 | 3.21 | 27 |
| | | | | | **Total Time** | **27** |
| High Density Drainage Basin | channel | 1,345 | 0.0106 | 17.0 | 1.75 | 13 |
| | pipe | 1,343 | 0.0056 | 42.0 | 3.14 | 7 |
| | channel | 1,496 | 0.0150 | 17.0 | 2.08 | 12 |
| | channel | 1,329 | 0.0222 | 17.0 | 2.53 | 9 |
| | | | | | **Total Time** | **41** |
| Commercial Drainage Basin | pipe | 1158 | 0.0107 | 42.0 | 4.34 | 4 |
| | channel | 194 | 0.0046 | 17.0 | 1.15 | 3 |
| | pipe | 444 | 0.0445 | 42.0 | 8.86 | 1 |
| | | | | | **Total Time** | **8** |

[a] Velocity factor "k" includes a value of 17 for channel flow and 42 for concrete pipe drainage.

# References

Pierce County Surface Water Management. 2008. Pierce County Draft Stormwater Management and Site Development Manual: Volume III Hydrologic Analysis and Flow Control BMPs. Ordinance No. 2008–59S. September 2008. Effective Date: March 1, 2009.

**APPENDIX C**

# Equipment Specifications

# Hach Sigma 900MAX All Weather Refrigerated Sampler



## Features and Benefits

### Resists Corrosion

The Hach Sigma 900MAX All Weather Refigerated (AWR) sampler is designed to endure humid and highly corrosive environments. The compressor is at the top of the unit to minimize damage caused by corrosive gases, rodents, and standing water which may occur at floor level. The NEMA 4X, 6 housing isolates all electro-mechanical components while the keypad, switches, and display are covered by a waterproof, corrosion resistant polyester membrane. Sealed connectors and pump shaft further guarantee environmental integrity.

### Applications

Hach Sigma 900MAX All Weather Refrigerated (AWR) Samplers are ideal for NPDES stormwater compliance, pretreatment compliance, CSO studies and monitoring, industrial wastewater discharge, and WWTP process control.

### Monitor and Manage

Easy, menu-type programming is made via a large 8-line by 40-character backlit display. The Hach Sigma 900Max AWR sampler can be equipped with a variety of factory-installed options to monitor and log, for example, rainfall, level, temperature, pH or ORP, and dissolved oxygen. Depending on model, up to seven external analog signals can also be logged. As many as 116,000 readings may be recorded. RAM memory is automatically allocated as necessary during operation. Flash memory is used to install software enhancements (available on the Internet), without returning the sampler to the factory.

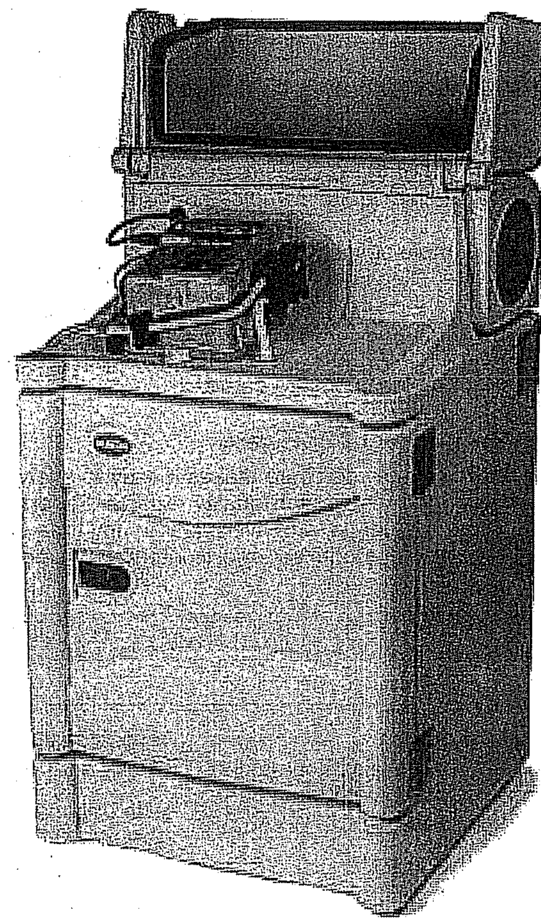
### Unique Constant Time/Variable Volume Sampling

The patented* Constant Time/Variable Volume sampling method varies sample size in proportion to flow rate—flow-weighted samples are captured on the first try. This method closely simulates manual grab samples. Limitations of conventional samplers, such as insufficient sample volumes during low flow periods or truncated sample time during high flow periods, make capturing short-lived, illicit discharges, or significant storm events difficult. The Constant Time/Variable Volume feature takes regularly timed, proportional samples depending on the flow rate—sample volume increases and decreases with the flow, ensuring that representative samples are taken at even intervals throughout the sampling period. (The factory-installed integral flow meter is required for CT/VV sampling.)

**Patent #5587926*

### Customizable Set Points

Use the Hach Sigma 900MAX AWR sampler to collect samples in response to changing levels of selected parameters—set high and low trip points to immediately collect when a parameter exceeds preset limits. Samples may also be taken only when the parameter exceeds these settings. Out-of-limit sample can then be segregated from normal samples to help quickly identify problem sources.



*The full-featured Hach Sigma 900MAX All Weather Refrigerated Sampler stands up to environmental extremes without a secondary enclosure.*

### Accurate Temperatures

The custom-designed air-sensing thermostat controls temperature in accordance with USEPA and international guidelines. A high efficiency compressor/condenser assembly, wraparound evaporator, and rigid foam insulation ensure optimum 4°C (39°F) sample temperature. A forced air blower and front ventilation provide the flexibility to position the sampler either against a wall or inside a sampler enclosure.

### Reliable Peristaltic Pump Technology

The Hach Sigma 900MAX AWR sampler uses a positive displacement peristaltic pump made of corrosion-resistant Delrin® material. Flow is induced by squeezing a flexible 3/8-in. tube (only the tubing is in contact with the liquid). The pump tubing is protected from the elements under the lockable, easy-lift lid.

Continued on next page.

*DW = drinking water . WW = wastewater municipal PW = pure water / power*
*IW = industrial water E = environmental C = collections FB = food and beverage*

## Features and Benefits *continued*

### Advanced Liquid Detection Techniques

The non-contact ultrasonic liquid sensing system guarantees volume accuracy and repeatability regardless of changes in head or composition of the waste stream or temperature variations in the sample liquid. Samples are compromised less often when the intake line is thoroughly purged before and after every sample collection. Reduce cross-contamination with a line rinse where the intake is preconditioned with the source liquid prior to collection. In the event that a plugged intake prevents collection, the unit detects the failed attempt and immediately repeats the cycle starting with a high-pressure purge.

### Easy Data Management Software

Powerful and user-friendly software makes it easy to analyze the data and produce presentation-quality reports—report maximums, minimums, totals, and averages for any time period. Also, generate customized reports integrating sample collections with flow, level, rainfall, other water quality parameters such as pH, ORP, temperature, conductivity, or dissolved oxygen.

### Three Ways to Download Data

**Sampler to DTU to PC**—the palm-sized and waterproof Data Transfer Unit (DTU) is faster, easier, and more economical than a laptop computer to get data from up to 20 samplers to the office.

**Sampler to Modem to PC**—a built-in modem transmits data via telephone right to the office. Automatically "call" the sampler at predetermined times to retrieve data, or retrieve data on demand. Also, alarm conditions may be sent to up to three pagers or a central monitoring computer.

**Sampler to PC**—link directly to a PC using the standard built-in RS-232 serial port.

## Specifications*

### General

*Sampler Housing*
*Controller:* High impact injection molded ABS, submersible, watertight, dust tight, corrosion and ice resistant; NEMA 4X,6

*Cabinet:* Linear, low-density polyethylene, UV inhibitor; rated IP 24

*Refrigeration components and copper plumbing:* corrosion protected with conformal coating; all exposed copper tubing is insulated to avoid sweating and condensation

*Sample Cooling*
Top mounted compressor and fan-forced air cooled condenser

1/10 HP, 75 Watt, 400 BTU/hr compressor

3-sided wraparound plate type evaporator

Rigid foam insulation: 3 in. sides, 5 in. top, 6 in. bottom

Microprocessor controlled thermostat maintains sample liquid at 4±1°C (39±1°F); frost free; non-CFC R134A refrigerant; compression gasket

Lockable lid to prevent tampering with programming

*Recovery Time:* Sampler temperature recovers to 4°C within 5 minutes after door has been held open for one minute in 24°C (75°F) ambient environment while in an active cooling cycle.

*Pull Down Time:* From 24°C (75°F) to 4°C (39°F), 20 minutes

*Sample Containers*
*Glass:* (2) 2-1/2 gal., (4) 2-1/2 gal., (8) 1.9 L, (24) 350 mL

*Polyethylene:* (1) 6 gal., (2) 3 gal., (4) 3 gal., (8) 2.3 L, (24) 1 L

*Temperature*
*Operating:* 0 to 50°C (32 to 122°F)

*With optional controller compartment heater:* -40 to 50°C (-40 to 122°F)

*With heater and AC battery back up:* -15 to 40°C (5 to 104°F)

*Storage:* -30 to 60°C (-22 to 140°F)

*Power Requirements*
*60 Hz Model:* 115 Vac, includes 1/5 Hp compressor, 4.2 A, 6.4 A with optional controller compartment heater

*50 Hz Model:* 230 Vac, includes 1/5 Hp compressor. 2.7 A, 4.1 A with optional controller compartment heater

*115 Vac Model:* 115°C thermal overload protector, 7.1 A locked rotor

230 Vac Model: 120°C thermal overload protector, 7.6 peak start current

*Overload Protection:* 115 Vac model: 7.5 A circuit breaker; 230 Vac model: 5.0 A circuit breaker

*ac Power Backup (Pump Controller Only)*
Rechargeable 6 amp-hour gel lead acid battery takes over automatically with ac line power failure

Integral trickle charger maintains battery as full charge

*Internal Battery*
5 year lithium battery maintains program settings and real time clock

*Graphics Display*
8 line x 40 character alphanumeric, back-lit liquid-crystal graphics display

Self prompting/menu driven program

*User Interface*
21 key membrane switch keypad with 4 multiple function soft keys

*Data Logging*
Records program start time and date, sample volume collected, sample volume remaining, stores up to 400 sample collection times/dates, all program entries, operational status including number of minutes or pulses to next sample, bottle number, number of samplers collected, number remaining, sample volume collected, volume remaining, sample identification, and all logged data (i.e. level, flow velocity, rainfall, stream temperature, pH or ORP, any logged external inputs)

*Set Point Sample Trigger*
When equipped with integral flow meter, pH/temperature/ORP meter, conductivity, and/or DO monitoring options, sampling can be triggered upon an upset condition when field selectable limits are exceeded

*Diagnostics*
Tests keypad, display, ROM, pump, distributor

*Program Languages*
Czech, Danish, Dutch, English, French, German, Italian, Spanish, Swedish

*Program Lock*
Access code protection prevents tampering

*Dimensions*
130 x 76 x 81 cm (51 x 30x 32 in.)

*Weight*
86 kg (190 lbs.)

*Continued on next page.*

## Communications

*EPROM Flash Memory*
Via RS232; permits embedded software upgrades in the field; requires ac power

*Serial Interface*
RS-232 compatible; 19,200 baud maximum, allows on-site collection of stored data

*Modem*
14,400 bps, V.32 bis, V.42, MNP2-4 error correction

V 0.42 bis MNP5 data compression

*Program Delay*
1 to 9,999 minutes or external flow pulses in one unit increments

Programmable start time/day and time/day/week

*Pager*
Alarm codes sent to up to three separate pager telephone numbers

## Sampling Features

*Multiple Programs*
Stores up to five sampling programs

*Cascade*
Allows using two samplers in combination where the first sampler at the completion of the program initiates the second sampler

*Sampling Modes*
Multiple bottle time, multiple bottle flow, composite time, composite flow, composite multiple bottle time, composite multiple bottle flow, flow with time override, variable interval, start/stop, and level actuation

*Mode 1:* Sampling can be triggered upon an upset condition when field selectable limits are exceeded

*Mode 2:* Concurrent with normal sampling routine, sample liquid is deposited in designated "Trouble" bottle(s)

*Status Display*
Alerts operator to low main battery, low memory battery, plugged intake, jammed distributor arm, sample collected, and purge failure

*Automatic Shutdown*
*Multiple Bottle Mode:* After complete revolution of distributor arm (unless Continuous Mode is selected)

*Composite Mode:* After preset number of samples have been delivered to composite container, from 1 to 999 samples, or upon full container

*Sample Volume*
Programmed in one mL increments from 10 to 9,999 mL

*Sample Volume Repeatability*
±5% typical

*Interval Between Samples*
Selectable in single increments from 1 to 9,999 flow pulses (momentary contact closure 25 ms or 5 to 12 Vdc pulse; 4-20 mA interface optional), or 1 to 9,999 minutes in one minute increments

## Sample Pump and Strainer

*Sample Pump*
High-speed peristaltic, dual roller, with 0.95 ID x 0.16 OD cm (3/8 ID x 5/8 in. OD) pump tube

*Pump Body*
Impact/corrosion resistant, glass reinforced Delrin®

*Vertical Lift*
8.23 m (27 ft.) maximum

*Note: Remote Pump Option recommended for lifts from 6.7 to 10.7 m (22 to 35 ft.)*

*Sample Transport Velocity*
0.61 cm/s (2 ft./s) minimum, at 4.6 m (15 ft.) vertical lift in a 0.95 cm (3/8-in.) ID intake tube

*Pump Flow Rate*
60 mL/s at 0.91 m (3 ft.) vertical lift in a 0.95 cm (3/8-in.) ID intake line

*Internal Clock*
Indicates real time and date; 0.007% time base accuracy

*Manual Sample*
Initiates a sample collection independent of program in progress

*Intake*
*Strainers:* Choice of Teflon® and 316 stainless steel construction, or all 316 stainless steel in standard size, high velocity, and low profile for shallow depth applications

*Purge:* Air purged automatically before and after each sample; duration automatically compensates for varying intake line lengths

*Rinse:* Intake line automatically rinsed with source liquid prior to each sample, from 1 to 3 rinses

*Retries or Fault:* Sample collection cycle automatically repeated from 1 to 3 times if sample not obtained on initial attempt

*Tubing:* 9.5 mm (3/8 in.) ID vinyl or 9.5 mm (3/8 in.) ID Teflon® lined polyethylene

*Continued on next page.*

## Factory Installed Options

*pH/Temperature/ORP Meter*
*Control/Logging:* Field selectable to log pH/temperature or ORP independent of sample operation or to control sample collection in response to exceeding low/high setpoints

*pH/Temperature Sensor:* Temperature compensated; impact resistant ABS plastic body; combination electrode with porous Teflon® junction

*pH Measurement Range:* 2 to 12

*Operating Temperature:*
0 to 80°C (32 to 176°F)

*Dimensions:* 1.9 x 15.2 cm (0.75 x 6 in.) with 1.9 cm (0.75 in.) MPT cable end

*Dissolved Oxygen Meter*
*Control/Logging:* Field selectable to log dissolved oxygen independent of sampler operation or to control sample collection in response to exceeding low/high setpoints

*Measurement Method:* Galvanic

*Sensor:* Temperature compensated; impact resistant polypropylene body

*Measurement Range:* 0 to 20 mg/L

*Resolution:* 0.01 mg/L

*Accuracy:* ±3% of reading or 0.1 mg/L

*Operating Temperature:*
0 to 50°C (32 to 122°F)

*Dimensions:* 1.7 x 15.7 cm (0.7 x 6.3 in.) with 1.9 cm (0.75 in.) MPT cable end

*Conductivity Meter*
*Control/Logging:* Field selectable to log conductivity independent of sampler connection or to control sample collection in response to volume exceeding low/high setpoints

*Sensor:* Temperature compensated; impact resistant polypropylene body

*Measurement Range:* 0 to 20 mS/cm

*Resolution:* 0.01 mS/cm or 1 mS/cm

*Accuracy:* ±2% of reading or 0.01 ms

*Operating Temperature:*
0 to 50°C (32 to 122°F)

*Dimensions:* 1.7 x 15.2 cm (0.67 x 6 in.) with 1.9 cm (0.75 in.) MPT cable end

*Integral Flow Meter*
*Control/Logging:* Field selectable to log flow/level independent of sampler operation or to pace sample collection in proportion to flow

*Operating Temperature:*
0 to 65.5°C (32 to 150°F)

*Monitoring Intervals:* 1, 2, 3, 5, 6, 10, 12, 15, 20, 30, and 60 minutes

*Accuracy:* 0.2% best straight line for combined nonlinearity, hysteresis, and repeatability

*Time Based Accuracy:*
±1 second per day

*Units of Measurement*
Level: cm, m, in., ft.
Flow: gps, gpm, gph, Lps, Lpm, Lph, mgd, afd, cfs, cfm, cfh, cfd, $m^3s$, $m^3m$, $m^3h$, $m^3d$
Totalized Flow: gal., ft,$^3$, acre-ft., $m^3$, L

*Totalizers:* Resettable and non-resettable

*Field Selectable Scaling Constant and Flow Units:* gal., ft.$^3$, acre-ft., $m^3$, and L

*Data Storage:* Capacity: 402 days of level, velocity, and rainfall readings at 15 minute intervals plus 300 events.

*Data Types:* level, velocity, rainfall and water quality.

*Storage Mode:* wrap or slate

*Output Conditions:* Set point on level, velocity, rainfall, flow, flow rate of change and water quality

*Communications:* Serial connection to IBM compatible computer with Hach Sigma data analysis software

*Integral Temperature Meter*
Measures and records ambient or sample stream temperature

*Control/Logging:* Field selectable to log temperature independent of sampler operation or to control sample collection in response to value exceeding low/high set points

*Recording Intervals:* 1, 2, 3, 5, 6, 10, 12, 15, 20, 30, and 60 minutes

*Sensor:* Platinum RTD with 316 stainless steel body

*Range:* 0 to 100°C (32 to 212°F)

*Accuracy:* ±1°C (±1.8°F)

*Operating Temperature:*
0 to 80°C (32 to 176°F)

*Dimensions:*
0.3 x 20.3 x 1.9 cm (0.125 x 8 x 0.75 in.)

*Cable Length:* 4.6 m (15 ft.)

*Submerged Pressure Transducer*
*Material:* Epoxy body with stainless steel diaphragm

*Cable:* Polyurethane sensor cable with air vent; 7.6 m (25 ft.) standard; 20 m (15.24 ft.) optional

*Sensor Dimensions*:
2 x 3.8 x 12.7 cm (0.8 x 1.5 x 5 in.)

*Maximum Range:* 2.5 psi, 0 to 5.76 ft.

*Maximum Allowable Level:*
3x over pressure

*Operating Temperature:*
0 to 71°C (32 to 160°F)

*Compensated Temperature Range:*
0 to 30°C (32 to 86°F)

*Air Intake:* Atmospheric pressure reference is desiccant protected

*Continued on next page.*

## Submerged Depth/Velocity Sensor Velocity Measurement

VELOCITY MEASUREMENT

*Range*
-1.52 to 6.10 m/s (-5 to 20 ft./s)

*Zero Stability*
0.015 m/s (<0.05 ft./s)

*Accuracy*
±2% of reading

*Operating Temperature*
0 to 60°C (32 to 140°F)

*Typical Minimum Depth for Velocity*
2 cm (0.8 in.)

*Method*
Doppler ultrasonic

*Transducer Type*
Twin 1 MHz piezoelectric crystals

LEVEL MEASUREMENT

*Range*
*Standard:* 0 to 3 m (0 to 10 ft.)

*Extended:* 0 to 9 m (0 to 30 ft.)

*Accuracy*
±0.16% full scale ±1.5% of reading at constant temp (±2.5°C)

±0.20% full scale ±1.75% of reading from 0 to 30°C (32 to 86°F)

±0.25% full scale ±2.1% of reading from 0 to 70°C (32 to 158°F)

*Maximum Allowable Level*
*Standard:* 10.5 m (34.5 ft.)

*Extended:* 31.5 m (103.5 ft.)

*Air Intake*
Atmospheric pressure reference is desiccant protected

*Method*
Pressure transducer with stainless steel diaphragm

GENERAL

*Material*
Noryl® plastic outer shell with epoxy potting

*Power Consumption*
~1.2 W at 12 Vdc

*Cable*
Urethane sensor cable with air vent

*Connector*
Hard anodized
(satisfies Military Spec 5015)

*Cable Length*
*Standard:* 9, 15, 23, and 30.5 m
(30, 50, 75 and 100 ft.)

*Custom:* greater than 30.5 m (100 ft.)

*Maximum:* 76 m (250 ft.)

*Cable Diameter*
0.91 cm (0.36 in.)

*Sensor Dimensions*
2.3 x 3.8 x 13.5 cm (0.9 x 1.5 x 5.3 in.)

## Velocity Sensor and In-Pipe Ultrasonic Level (optional)

*Nose Angle*
20 degrees from horizontal

*Cable Length*
*Standard:* 7.6 m (25 ft.)

*Custom:* to 76 m (250 ft.)

*Cable Diameter*
0.57 cm (0.225 in.)

*Materials*
*Sensor:* polymer

*Cable:* urethane

*Mounting hardware:* stainless steel

*Dimensions*
1.12 x 3.81 x 6.86 cm
(0.44 x 1.5 x 2.7 in.)

*Rain Gauge Input*
For use with Hach Sigma Tipping Bucket Rain Gauge

The Sampler Program can be initiated upon field selectable rate of rain

Sampler records rainfall data

Each tip = 0.25 mm (0.01in.) of rain

*Analog Input Channels*
Up to 3 additional data logging channels record data from external source(s)

Field assignable units

-4.0 to +4.0 Vdc and 0 to 20 mA

*4-20 mA Output*
Up to 2 output signals available

Optically isolated

600 ohm maximum load per output each

*Expanded Memory*
Increases memory from 18,432 data points to 116,736 points (512 K)

*Alarm Relays*
(4) 10 amp/120 Vac or 5 amp/220 Vac form C relays

User assignable with settable trip points

*Delrin® and Teflon® are registered trademarks of E.I. dù Pont de Nemours and Company*

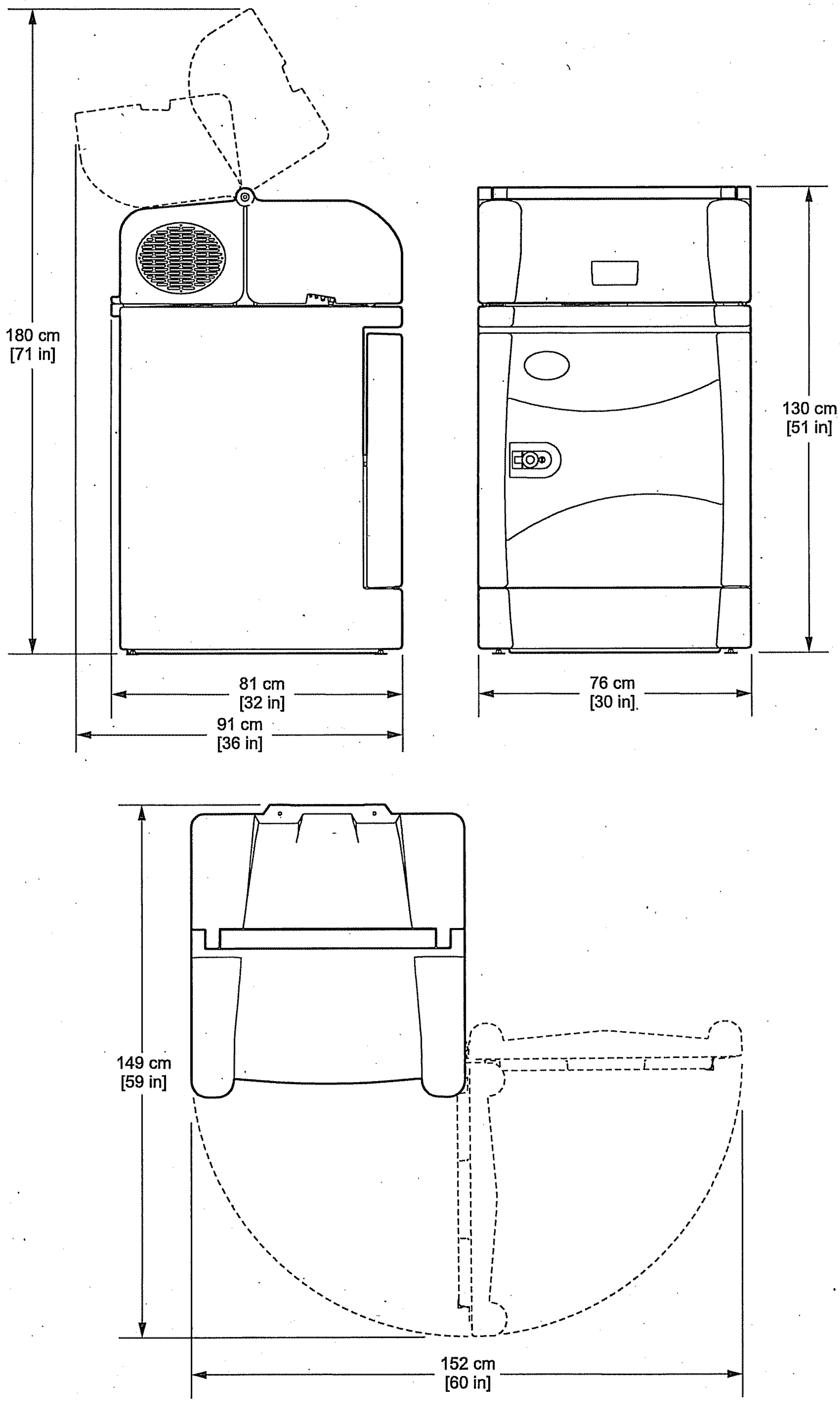
**Specifications subject to change without notice.*

## Engineering Specifications

1. The sampler shall be capable of representatively collecting and preserving, by refrigeration, of liquid samples.
2. The sampler which shall operate on AC power and incorporate a 12 Vdc back up battery.
3. The sampler shall be designed for operation outdoors without the use of a separate enclosure.
4. The refrigerated sampler cabinet shall be constructed of corrosion resistant, molded linear, low density polythylene. All cabinet exterior surfaces shall be UV resistant and sloped so as to shed water.
5. The sample compartment door shall have a compressible gasket seal and positive mechanical latch.
6. The temperature control system shall maintain 4°C in the refrigerated compartment in ambient temperatures to 120°F. The desired temperature shall be entered on the sampler keypad and indicated on the display.
7. The thermal control system shall be digital microprocessor-based and shall respond to a system of temperature sensors, which shall continually monitor the evaporator plate, ambient air, and sample liquid. Control systems relying on a knob to set "colder or warmer" shall not be considered equivalent.
8. An evaporator plate heater shall assure frost-free operation.
9. Refrigerated compartment temperature shall be indicated on the sampler controller display. Refrigerator temperature shall be data-logged for future review and compliance confirmation by accessing through the screen.
10. Logged data shall also be available through optional software and DTU for reporting and graphing.
11. For maximized cooling efficiency and to protect the compressor assembly from corrosion caused by heavier than air corrosive gases, the compressor assembly shall be mounted above the sample compartment. A compressor located at floor level shall not be acceptable.
12. The compressor compartment shall be side ventilated to allow locating the sampler against a wall.
13. The refrigerated sample compartment shall have 3 inches of rigid foamed in place insulation on the walls, 6 inches on the bottom, and 5 inches on top.
14. All refrigeration lines shall be protected with a phenolic resin coating.
15. The thermostat/thermal control system shall be housed within a NEMA 4X, 6 enclosure.
16. To prevent sample liquid from freezing in pump tubing and to enhance display readability in cold ambient temperatures, the sampler shall have a controller compartment heater option available.
17. The sampler shall be capable of receiving a 60 mL/sec flow.
18. The refrigerator compressor for the sampler shall be mounted at the top of the unit.
19. Refrigeration temperature shall be maintained at 4°C (39°F) in a 49°C (120°F) ambient, and controlled by a thermal mass equivalent to 150 mL of water in compliance with EPA methods.
20. The sample and controller compartments shall be lockable.
21. The cabinet shall be equipped with a pull out bottle tray.
22. The front controller compartment and rear compressor compartment shall have a compressible gasket seal to prevent insects and debris from collecting inside the compartments.
23. The sample volume shall be programmable in milliliters, one mL increments from 10 to 9,999 mL.
24. Sample modes shall include multiple bottle time, multiple bottle flow, composite time, composite flow, flow with time override, variable interval, start/stop, and level actuation.
25. Sampler operation shall terminate automatically with a completed sample program and shall be accomplished electronically with no switch or sensor coming in contact with the liquid.
26. It shall be possible to manually initiate a sample cycle without interrupting the program.
27. There shall be a provision to delay the sampling program from 1 to 9,999 minutes.
28. The sampler shall have the built-in and switch selectable capability for both timed cycle and flow proportional sampling.
29. The sampler shall use constant time/variable volume sampling method where regularly timed samples are adjusted for size depending on flow rate.
30. The sampler shall be equipped with Multiplex, which shall, in the 24-bottle mode, allow multiple sample bottles to be filled each interval. Multiplex modes shall be selectable in multiples of 1, 2, 4, 8, and 24.
31. The sampler shall be provided with a 24 bottle discrete assembly including (24) 475 mL polyethylene containers, bottle tray and distributor mechanism or one 6-gallon polyethylene composite container.
32. Factory installed options shall include selections of the following:
    a. Integral pH, temperature or ORP meter
    b. Integral dissolved oxygen meter
    c. Rain gauge input
    d. 4-20 mA outputs
    e. Expanded memory
    f. Integral flow meter
    g. Integral temperature meter
    h. Analog input data logging channels
    i. Modem
    j. Alarm relay
    k. Integral conductivity meter
    l. Integral submerged depth/velocity sensor(s)
33. The sampler shall operate from 115 Vac power.
34. Operating instructions shall be integral to the control panel.
35. The refrigerated sampler shall be the Sigma Model 900MAX All Weather Refrigerated Sampler (or AWRS) manufactured by Hach Company.

## Dimensions

The refrigeration compartment door of the Hach Sigma 900MAX All Weather Refrigerated Sampler is lockable (two keys are provided). The lock for the lid is optional.



## Ordering Information

### Hach Sigma 900MAX All Weather Refrigerated (AWR) Samplers

**3543R** 900MAX Controller with 115 Vac AWR cabinet
**3543RH** 900MAX Controller with 115 Vac AWR cabinet and controller compartment heater
**3545R** 900MAX Controller with 230 Vac AWR cabinet
**3545RH** 900MAX Controller with 230 Vac AWR cabinet and controller compartment heater

### Hach Sigma 900MAX All Weather Refrigerated Sampler (AWRS) Bundles

*Bundles include AWRS base (115 Vac), sample bottle(s), vinyl intake tubing (25 ft.), and Teflon/stainless steel strainer. To order components separately, please contact Hach Company.*

**900MAXAWRS1**
All Weather Refrigerated Sampler with 900MAX controller; included 21-L (5.5 gal) PE container and full bottle shut off

**900MAXAWRS13**
All Weather Refrigerated Sampler with 900MAX Controller; includes 10-L (2.5 gal) PE container and full bottle shut off

**900MAXAWRS24**
All Weather Refrigerated Sampler with 900MAX Controller; included 24 1-L PE containers with distributor

### Intake Tubing and Strainers

**922** Polyethylene Tubing, 25-ft., Teflon-lined, 3/8-in. ID (requires Connection Kit, Prod. No. 2186)
**2186** Connector Kit, for Teflon-lined polyethylene tubing
**920** Vinyl Intake Tubing, 25 ft., 3/8-in. ID
**2070** Strainer, 316 stainless steel
**2071** Strainer, for shallow depth applications, 316 stainless steel
**4652** Strainer, high velocity and shallow depth

### Pump Tubing

**4600-15** Pump Tubing, 15 ft.
**4600-50** Pump Tubing, 50 ft.

### Integral Water Quality Parameters

**8793** Integral pH-Temp/ORP option, factory installed
**3328** pH-Temperature Probe (grounded), with 25 ft. cable
**3227** DO and Conductivity receptacle, factory installed
**3216** D.O. Probe Kit, with 25 ft. cable
**3223** Conductivity Probe only, with 25 ft. cable

### 4-20mA Input

**8795** Analog Input Data Logging channels, qty. 3

### 4-20mA Output

**8797** First 4-20 mA Output
**8798** Second 4-20 mA Output

### Alarm Relays

**8984** Alarm Relays, qty. 4

### Modem

**1602** Modem, 14,400 baud

### Rain Gauge

**8800** Rain Gauge receptacle, factory installed
**2149** Rain Gauge, with 25 ft. cable and option

### Cables and Interfaces

**1727** PC Cable, for sampler or flow meter
**3358** RS232 Extension Cable

### Accessories

**2471** Flow-thru Module, with flanged ends
**6613100** Anchor Kit Set
**943** Liquid Level Actuator, 25 ft. cable

*At Hach, it's about learning from our customers and providing the right answers. It's more than ensuring the quality of water—it's about ensuring the quality of life. When it comes to the things that touch our lives...*

*Keep it pure.*

*Make it simple.*

*Be right.*

***For current price information, technical support, and ordering assistance, contact the Hach office or distributor serving your area.***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G8 Printed in U.S.A.



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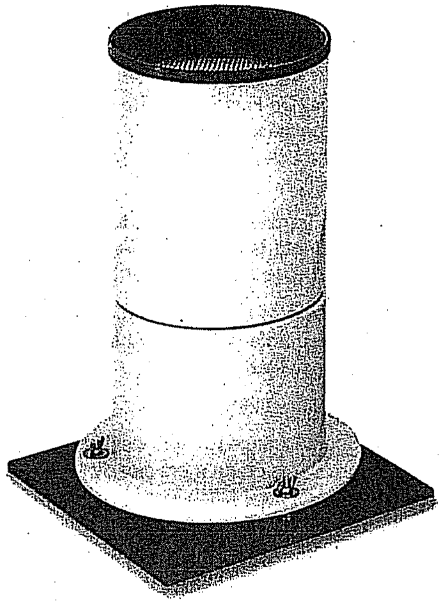
Be Right™

# Hach Sigma RAIN LOGGER™ Automatic Data Logging Rain Gauges





## Features and Benefits

### Diverse and Reliable Measuring

Built to National Weather Service standards, the Gauge accurately measures rainfall in 0.01" increments. The tipping bucket mechanism tips with every 0.01" of rainfall, producing a momentary contact closure with each movement.

A stainless steel funnel screen prevents plugging from leaves and other wind-blown debris. The removable funnel permits viewing of a built-in bubble level, with an innovative spring-loaded base plate providing an easy, convenient means to level the gauge. A hole in each corner of the base plate permits a secure, anchored installation.

### Principle of Operation

The 8" diameter funnel directs rainwater into a "tipping bucket", which is divided vertically into two halves. When 0.01" of rainfall fills one side of the bucket, the bucket tips, spilling the water through the bottom of the rain gauge. The other side of the bucket is then positioned under the funnel. The bucket alternates tips with each 0.01" of rainfall. With each tip, a magnet, mounted to the bucket, activates a sealed, magnetic reed (proximity) switch, producing a momentary contact closure. In a stand-alone state, the number of bucket tips, representing 0.01" of rainfall, is recorded in user selectable time intervals of 1, 2, 3, 5, or 10 minutes. Data storage capacity is 10,080 readings.

### Key Features

- *Stainless steel funnel screen prevents plugging from leaves and other wind blown debris*
- *Removable funnel makes cleaning easy*
- *Built-in bubble level, with an innovative spring-loaded base plate provides an easy, convenient means to level the gauge*
- *Base plate permits secure anchored installation*
- *Compatible with Sigma Flo-Center and Insight Data Management and Analysis Software.*

WW

IW

C

*DW = drinking water WW = wastewater municipal PW = pure water / power*
*IW = industrial water E = environmental C = collections FB = food and beverage*

# Rain Logger Specifications

## Rain Gauge

***Type:*** Tipping bucket with 8" diameter collector/funnel

***Overall Dimensions:*** 18"H x 12"W x 12"D, (45.7 cm x 30.5 cm x 30.5 cm)

***Weight:*** 9.25 lbs., (4.2 kg)

***Resolution:*** 0.01" rainfall per bucket tip

***Accuracy:*** 0.5% at 0.5" per hour

***Base Mounting Plate:*** Spring loaded, three-point adjustable

***Materials of Construction:*** Epoxy coated aluminum and anodized aluminum (funnel screen is stainless steel). Three point adjustable base plate. Removable screen.

## Rain Logger

***Enclosure:*** Impact resistant plastic

***Type:*** Solid-state memory, battery backed

***Dimensions:*** 1" x 2.75" x 4.125", (2.54 cm x 7 cm x 10.5 cm)

***Weight:*** 8.5 oz., (.24 kg)

***Operating Temperature:*** 32° to 135°F, (0 to 57°C)

***Storage Temperature:*** -20° to 150°F, (-29° to 66°C)

***Power Requirements:*** Replaceable 9 VDC alkaline battery

***Battery Life:*** 6 months, typical

***Data Capacity:*** 10,080 readings (i.e. 7 days at 1 minute recording intervals, 70 days at 10 minute recording intervals)

***Time Base Accuracy:*** ±1 minute per month over operating temperature range

***Battery Life Indicator:*** LED flashing once every 2.5 seconds indicates a good battery

***Data Interface:*** LED optically coupled RS-232 interface

## Rain Reader

***Enclosure:*** Impact resistant plastic

***Dimensions:*** 1" x 2.75"x 4.125", (2.54 cm x 7 cm x 10.5 cm)

***Weight:*** 8.5 oz., (.24 kg)

***Power Requirements:*** 9 VDC, nominal; supplied via 115 VAC/9 VDC power adapter

***Data Interface:*** LED optically coupled RS-232 interface

***Data Transfer Rate:*** 4800 baud

***Computer Interface:*** RS-232 serial cable, IBM PC compatible

***Data Collection Modes***

- Record immediately – Data logging starts immediately after any command that clears memory.
- Record On First Bucket Tip – Data logging starts upon the first bucket tip. (Each bucket tip represents 0.01" rainfall).
- Data Transfer Gauge – Indicates data transfer time when transferring data from the RainLogger to PC.

***Graphing Data:*** Produces rainfall x-y graph. Two selectable graph formats:

- Intensity Plot
- Cumulative Plot
- "Zoom" feature lets you inspect any area of the graph more closely. "Data cursor" lets you see individual readings by moving a cursor to the desired point on the graph.

## Rain Log Software

***Hardware requirements:*** IBM PC or IBM compatible

***Serial communications port***

***Memory Modes:***
"Slate" or "Wrap" memory modes

- Slate Mode – Recording stops with full memory
- Wrap Mode – Upon full memory, recording continues; oldest data is dropped as new data is recorded.

**ORDERING INFORMATION**

**Rainlogger System**

*Each site requires a Rain Gauge and one (or two) Rainloggers. Only one Rain Reader and software is required for use with (IBM compatible) PC.*

**2459** Rain Gauge with tipping bucket, bubble level, level adjust and base mounting plate.

**2390** Rainlogger includes 9 VDC battery.

**2391** Rain Reader, 115 VAC includes 115 VAC power adapter and rain reader/logger cradle. Domestic.

**4339** Rain Reader, 230 VAC includes 230 VAC power adapter and rain reader/logger cradle. International.

**5254** Insight Software (free of charge)

**Remote Rainlogger System**

*Each site requires Rain Gauge, Rainlogger, and Remote Rainlogger One Rain Reader is required to download data from all sites.*

**2149** Rain Gauge with 25 ft. Cable - For use with 3638 remote rainlogger. Mounting Base Plate

**3638** Remote Rainlogger requires 2149 rain gauge.

**2221** Rain Gauge Extension with 100 ft. Cable. Extension cable for 2149 rain gauge.

**2390** Rainlogger includes 9VDC battery.

**2391** Rain Reader, 115 VAC includes 115 VAC power adapter and rain reader/logger cradle. Domestic.

**4339** Rain Reader, 230 VAC includes 230 VAC power adapter and rain reader/logger cradle. International.

**5254** Insight Software (free of charge)

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# Hach Sigma 920 Area Velocity Flow Meter




*The Hach Sigma 920 Area Velocity Flow meter can be used in portable or permanent applications. Measure level and velocity independently in two channels or velocity in one and level in the other. Housed in rugged yet ergonomic watertight enclosure (NEMA 6P) measuring only 7 x 18 inches. Available with submerged pressure transducer/velocity sensor or in-pipe ultrasonic depth sensor combined with a "wafer-thin" velocity sensor that provides greater accuracy in shallow flows.*

## Features and Benefits

### Made for Submergence and Prolonged Surcharge Conditions

The rugged housing of the Hach Sigma 920 Area Velocity Flow Meter is NEMA 6P sealed to withstand submergence and prolonged surcharge conditions. A low power draw creates an extended 90-day battery life. Its size makes it portable and provides for easy storage and fit in a variety of applications such as sewer and storm water monitoring.

### Advanced Technology for Accuracy

The technology used in the Sigma 920 flow meter automatically corrects the effect of temperature on level measurement for a higher level of accuracy. With built in sampler pacing capabilities, it is ideal for CSO and storm water studies.

Advanced, ultrasonic one-MHz Doppler sensor technology avoids signal dropouts and ensures—without the need for on-site calibration—high levels of accuracy in low-flow, full-pipe, or reversed-flow conditions. The patented* "Drawdown Correction" feature corrects the effects of velocity on accurate level measurement.

**Patent U55691914*

### Versatile Features and Options

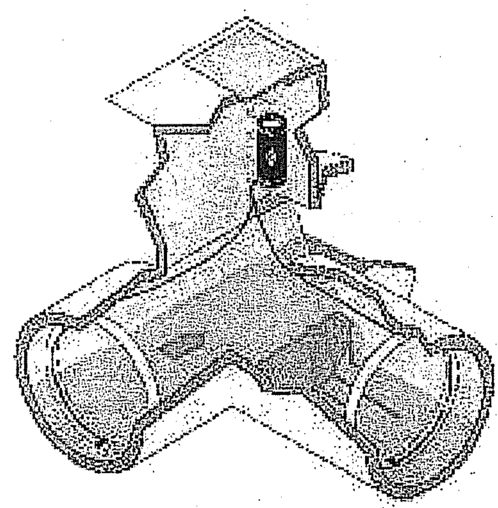
The optional rainfall logging feature of the Sigma 920 flow meter records and characterizes rain events—a true innovation in water monitoring. Use the optional internal modem to automate data retrieval, paging, and reporting. And with multiple sensor options, this meter can be used for redundancy, averaging, and multiple pipe monitoring.

### Simple and Reliable Velocity Sensor

The Submersible Area Velocity Sensor used with the Sigma 920 flow meter is accurate and reliable for maximum versatility for most open channel applications. It installs quickly and easily with no velocity calibration required. The hydrodynamic body and side-mounted cable also maintains accuracy by reducing turbulence along the sensor body. Noryl sensor housing dramatically improves sensor robustness and integrity. Single point calibration (atmospheric) makes calibration quick and accurate.

### Applications

The Hach Sigma 920 Area Velocity Flow Meter is ideal for short-term flow studies, sanitary sewer evaluation studies, CSO studies and monitoring, and NPDES stormwater compliance.



WW

IW

C

*DW = drinking water WW = wastewater municipal PW = pure water / power*
*IW = industrial water E = environmental C = collections FB = food and beverage*

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## Specifications*

### 920 Flow Meter

*Units of Measurement*
Level: m, cm, ft., in.

Flow: gps, gpm, gph, lps, lpm, lph, mgd, afd, cfs, cfm, cfh, cfd, $m^3s$, $m^3m$, $m^3h$, $m^3d$

Totalized Flow: L, $m^3$, $ft.^3$, gal., acre-ft.,

*Monitoring Intervals*
1, 2, 3, 5, 6, 10, 12, 15, 20, 30, and 60 minutes

*Operating Temperature*
-18 to 60°C (0 to 140°F)

*Storage Temperature*
-40 to 60°C (-40 to 140°F)

*Time-Based Accuracy*
±1 second per day

*User Interface*
IBM-compatible PC

*Program Memory*
Non-volatile programmable flash, can be updated via RS-232 port

*Data Storage (optional)*
Capacity: 240 days of 2 level, 2 velocity readings, and rainfall at 15-minute recording intervals

Data Types: Level, velocity, and rainfall

Storage Mode: Wrap or slate

*Sampler Output Conditions (optional)*
Set point on level, velocity, flow, or flow rate of change

*Sampler Output (optional)*
6 to 12 Vdc pulse, 100 mA maximum at 500 ms duration flow proportional

*Communications*
RS-232 serial connection to IBM-compatible computer with Hach Sigma Data Management Software

Optional modem: Bell 212

Baud: 14400

Transfer protocol: Binary or 14400, V.32 bis, V.42, MNP2-4 error correction V.42 bis, MNP5 data compression MNP10EC Cellular Protocol

Local terminal: RS-232 at 19.2 k-baud

*Enclosure Material*
PVC

*Enclosure Rating*
NEMA 6P (IP67)

*Power Source*
Two alkaline lantern 6 Vdc batteries or external AC power source

*Battery Life*
90 days typical (with 15-minute recording interval, 1 level and 1 velocity, data download once per week, at 10°C (50°F), also affected by site conditions)

*Dimensions*
16.8 cm diameter x 44.7 cm
(6.625 in. diameter x 17.625 in.)

*Weight*
7.5 kg (16.5 lbs.) with battery

### Submerged Depth/Velocity (AV) Sensor

VELOCITY MEASUREMENT

*Range*
-1.52 to 6.10 m/s (-5 to 20 ft./s)

*Zero Stability*
0.015 m/s (<0.05 ft./s)

*Accuracy*
±2% of reading

*Operating Temperature*
-18 to 60°C (0 to 140°F)

*Typical Minimum Depth for Velocity*
2 cm (0.8 in.)

*Method*
Doppler ultrasonic

*Transducer Type*
Twin 1 MHz piezoelectric crystals

DEPTH MEASUREMENT

*Range*
Standard: 0 to 3 m (0 to 10 ft.)

Extended: 0 to 9 m (0 to 30 ft.)

*Accuracy*
±0.16% full scale ±1.5% of reading at constant temp (±2.5°C)

±0.20% full scale ±1.75% of reading from 0 to 30°C (32 to 86°F)

±0.25% full scale ±2.1% of reading from 0 to 70 °C (32 to 160°F)

*Maximum Allowable Depth*
Standard: 10.5 m (34.5 ft.)

Extended: 31.5 m (103.5 ft.)

*Air Intake*
Atmospheric pressure reference is desiccant protected

*Method*
Pressure transducer with stainless steel diaphragm

GENERAL

*Material*
Noryl® plastic outer shell with epoxy potting

*Cable*
Standard: 9, 15, 23, and 30.5 m (30, 50, 75 and 100 ft.)

Custom: greater than 30.5 m (100 ft.)

Maximum: 76 m (250 ft.)

*Cable Diameter*
0.91 cm (0.36 in.)

*Sensor Dimensions*
2.3 x 3.8 x 13.5 cm (0.9 x 1.5 x 5.3 in.)

### Optional Velocity Sensor Accuracy and In-Pipe Ultrasonic Depth

VELOCITY MEASUREMENT

*Nose Angle*
20 degrees from horizontal

*Cable Length*
Standard: 7.6 m (25 ft.)

Custom: to 76 m (250 ft.)

*Cable Diameter*
0.57 cm (0.225 in.)

*Materials*
Sensor: polymer

Cable: urethane

Mounting hardware: stainless steel

*Dimensions*
1.12 x 3.81 x 6.86 cm (0.44 x 1.5 x 2.7 in.)

ULTRASONIC DEPTH MEASUREMENT (IN-PIPE)

*Range*
Distance from sensor to liquid:
0 to 3.35 m (0 to 11 ft.)

*Accuracy*
0.038 to 4.57 m ±0.003 m
(0.125 to 15 ft. ±0.01 ft.) at 22°C (72°F) still air, 40 to 70% relative humidity

*Span*
0.038 to 4.57 m (0.125 to 15 ft.)

*Operating Temperature*
-18 to 60°C (0 to 140°F)

*Temperature Error*
±0.00005 m/°C (±0.0001 ft./°F) maximum error within compensated temperature range per degree of change

Resolution: .0075", (.019 cm)

*Material*
Stainless steel housing with PVC acoustic window

*Cable*
4 conductors

*Cable Length*
Standard: 7.6 m (25 ft.) 305 m (1,000 ft.) using RS-485 two-wire remote sensor option

*Crystal Specification*
75 KHz, 7° beam angle

*Dimensions*
3.81 cm diameter x 30 cm (1.5 in. diameter x 12 in.)

*Specifications subject to change without notice.*

## Engineering Specifications

### 920 Flow Meter

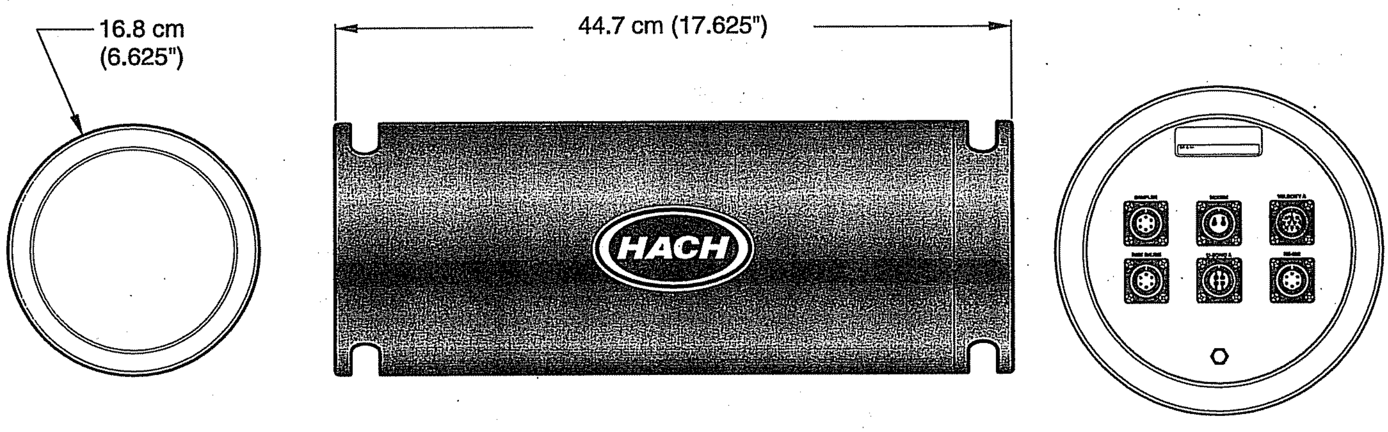
1. The flow meter system shall consist of a flow meter and a submerged depth/velocity sensor.
2. The flow meter shall be capable of storing at least 116,000 data points (240 days at 15-minute logging intervals of two level, two velocity, and rainfall).
3. Slate and wrap-around data storage shall be field selectable. Once programmed, the meter with software shall display the total time available for data logging. For fast data retrieval, the flow meter shall have an RS232 serial interface port with data transfer via modem at 19,200 baud to any IBM compatible PC operating Hach software.
4. Logging intervals shall be 1, 2, 3, 5, 6, 10, 12, 15, 20, 30 and 60-minute intervals. The meter shall log data at logical times automatically, i.e. 5 minute intervals at 0:00, 0:05, 0:10, etc. Battery voltage shall be logged as a separate parameter.
5. The meter shall operate 90 days at 15-minute logging intervals of level/flow and velocity including weekly data download utilizing two 6-volt alkaline lantern batteries.
6. The meter shall communicate with a computer using a serial connection and Modbus to allow integration to SCADA Systems or optional phone modem
7. The meter shall include a rain gauge input to accept contact closures from a tipping bucket rain gauge with 0.01-in. increments.
8. The meter shall include a sampler pacing output consisting of a 6-12V DC pulse, 10 mA maximum, 500 ms duration.
9. The method of velocity measurement shall be Doppler ultrasonic.
10. The sensor shall be equipped with level drawdown correction to compensate for the effects of velocity in depth measurement accuracy.
11. The flow meter housing shall be made of NEMA 6P (IP67) PVC sealed to withstand submergence and prolonged surcharge conditions.
12. The flow meter shall be capable of reporting in the following units:
    a. Level; m, cm, ft., in.
    b. Flow; gps, gpm, gph, lps, lpm, lph, mgd, afd, cfs, cfm, cfh, cfd, $m^3$s, $m^3$m, $m^3$h, $m^3$d.
    c. Totalized flow; L, $m^3$, ft. $^3$, gal., acre-ft.
13. Exterior dimensions shall not exceed 6-5/8 inches diameter and 17-5/8 inches length. The meter shall not exceed 16.5 lbs.
14. The flow meter shall be the Sigma Model 920 Area Velocity Flow Meter manufactured by Hach Company.

### Submerged Depth/Velocity (AV) Sensor

1. The sensor shall be capable of directly measuring average velocity.
2. The method of velocity measurement shall employ transducer type that is twin 1-MHz piezoelectric crystals.
3. The method of depth measurement shall be pressure transducer with stainless steel diaphragm.
4. Velocity range shall be -1.52 to 6.10 m/s (-5 to 20 ft./s)
5. The range of depth measurement shall be 0 to 3 m (0 to 10 ft.), standard, and 0 to 9 m (0 to 30 ft.), extended.
6. The body material of the sensor shall be Noryl® plastic outer shell with epoxy potting.
7. The connector of the sensor shall be hard anodized and satisfy Military Spec 5015.
8. Power consumption of the sensor shall be less than or equal to 1.2 W at 12 Vdc.
9. The sensor shall be the Sigma AV Sensor Flow Sensor manufactured by Hach Company.

## Dimensions

The Hach Sigma 920 Area Velocity Flow Meter should not be used in hazardous locations where combustible gases may be present. Mount the meter so that the connectors face down. When not in use, cover the connectors with their protective caps to prevent corrosion. Always use the appropriate manhole support bracket/spanner bar.



## Ordering Information

### Flow Meter

| | |
|---|---|
| 4850 | Sigma 920 Area Velocity Flow Meter with two 3667-lantern batteries. *(The meter can accommodate one additional AV sensor or one ultrasonic sensor. Each AV receptacle accommodates one sensor or one low profile velocity sensor.)* |

### Complete Flow Meter Systems

| | |
|---|---|
| 4850921 | Sigma 920 Area Velocity Flow Meter Bundle; includes Sigma 920 flow meter, two submerged AV sensors, and 30-ft cable for each sensor |
| 4850922 | Sigma 920 Area Velocity Flow Meter Bundle; includes Sigma 920 flow meter, one in-pipe ultrasonic sensor with 25-ft. cable, and one velocity only sensor with 25-ft. cable |

### Optional Flow Meter Sensor Configurations

| | |
|---|---|
| 4883 | Input; for additional submerged AV or low profile velocity sensor |
| 4869 | Input; for 75 kHz ultrasonic sensor |

### Sensors

*Non-oil Filled Standard Submerged Depth/Velocity (AV) Sensors (0 to 10 ft. range)*

| | |
|---|---|
| 77065-030 | With 30 ft. cable & connector |
| 77065-050 | With 50 ft. cable & connector |
| 77065-075 | With 75 ft. cable & connector |
| 77065-100 | With 100 ft. cable & connector |

*Oil Filled Standard Submerged Depth/Velocity (AV) Sensors (0 to 10 ft. range)*

| | |
|---|---|
| 77064-030 | With 30 ft. cable & connector |
| 77064-050 | With 50 ft. cable & connector |
| 77064-075 | With 75 ft. cable & connector |
| 77064-100 | With 100 ft. cable & connector |

### Down-looking 75 KHz Ultrasonic Level Sensor

| | |
|---|---|
| 1176-01 | With connector |
| 1176-03 | With bare leads |

### In-pipe 75 KHz Ultrasonic Level Sensor

| | |
|---|---|
| 3702-01 | With connector |
| 3702-02 | With bare leads |

### Sensor Mounting Hardware

*Spring Rings*

| | |
|---|---|
| 1361 | For 6-in. diameter pipe |
| 1362 | For 8-in. diameter pipe |
| 1363 | For 10-in. diameter pipe |
| 1364 | For 12-in. diameter pipe |

*Miscellaneous*

| | |
|---|---|
| 3263 | Sensor Mounting Clip; for 88000, wafer velocity, and bubbler level velocity sensors |
| 3305 | Velocity Sensor Mounting Plate |
| 9574 | Insertion Tool for Non-confined Space Entry |
| 2974 | Permanent Wall Mount Bracket; for down-looking ultrasonic sensor. |
| 2904 | Floor or Wall Adjustable Mounting Bracket; for down-looking ultrasonic sensor |
| 9538 | Tripod Mounting Bracket; for down-looking ultrasonic sensor. |
| 2883 | Cable Straightner; for down-looking ultrasonic sensor |
| 3183 | Cable Grip; for down-looking ultrasonic sensor |

### Cables and Interfaces

| | |
|---|---|
| 3513 | DTU-to-PC Cable; 115 Vac |
| 3580 | DTU-to-PC Cable; 230 Vac |
| 1727 | Sampler or Flow Meter to PC Cable |
| 3358 | RS232 Extension Cable |

### Accessories

| | |
|---|---|
| 8764300 | Flo-Center Software CD Only |
| 8764500 | Flo-Center Software CD with RS232 |
| 8764600 | Flo-Center Software CD with RS232 and USB |
| 5254 | Insight Software (free of charge) |
| 7724700 | Silicon Oil; dual 50-ml pack (refills 100 sensors) |
| 7724800 | Silicon Oil Refill Kit; includes dispensing tool and oil packs. |
| 7730000 | Retrofit Kit (converts non oil-filled to oil-filled); includes kit Silicon Oil Refill Kit |
| 8713200 | Solar Module; with 10-Watt panel and power regulator assembly |
| 8713300 | Solar Module; with 20-Watt panel and power regulator assembly |

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*In the interest of improving and updating its equipment, Hach Company reserves the right to alter specifications to equipment at any time.*

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