City of Salem
National Pollutant Discharge Elimination System (NPDES)
Municipal Separate Storm Sewer System (MS4)

Surface Water and Stormwater Monitoring Plan

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Stormwater Services

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1.0 Introduction

On December 30, 2010, the Oregon Department of Environmental Quality (DEQ) issued the City of Salem a renewed National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit. As a condition of the renewed NPDES MS4 permit the City of Salem developed this "Surface Water and Stormwater Monitoring Plan". This plan implements multiple monitoring elements designed to meet the objectives identified in Schedule B of the NPDES MS4 permit.

Data collected through the implementation of this monitoring plan will undergo review and analysis before becoming an integral component of the NPDES MS4 Annual Reporting and Permit Renewal process. Statistical summaries of monitoring data will assist the City in an ongoing assessment of the effectiveness of the Best Management Practices (BMPs) that have been identified in the City's Stormwater Management Plan (SWMP). The City will ultimately utilize the collected data to evaluate and adaptively manage its Stormwater Management Program, thereby limiting the amount of pollutants entering receiving streams from the MS4 to the Maximum Extent Practicable (MEP). The long-term goal of this monitoring plan is to maintain permit compliance while providing high quality data to assist in decision making and the adaptive management process.

2.0 Permit Requirements

2.1 Monitoring Objectives

Requirements of the monitoring program are listed in Schedule B of the City's NPDES MS4 permit, and monitoring activities must address the following six objectives (Schedule B.1.a):

i. Evaluate the source(s) of the 2004/2006 303 (d) listed pollutants applicable to the co-permittees' permit area;
ii. Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities;
iii. Characterize stormwater based on land use type, seasonality, geography or other catchment characteristics;
iv. Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges;
v. Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters; and,
vi. Assess progress towards meeting TMDL pollutant load reduction benchmarks.

This monitoring plan describes eight different monitoring elements the City of Salem will utilize to meet these objectives, including the following: Instream Storm, Monthly Instream, Continuous Instream, Macroinvertebrate, Stormwater, Pesticide, Stormwater - Mercury , and Dry Weather Outfall monitoring. The City of Salem Stormwater Monitoring Matrix (Attachment 1) identifies how each monitoring element will be used to address the objectives listed in Schedule B.1.a. The City will implement these monitoring elements during the current NPDES MS4 permit term (December 2010 - December 2015).

2.2 Adaptive Management

By adaptively managing (e.g., implementing, evaluating, and adjusting) its stormwater management program, the City of Salem continues to reduce the discharge of pollutants from its stormwater sewer system to the maximum extent practicable.

Stormwater quality data are characteristically highly variable, limiting the ability to conduct statistical analyses with small datasets. As a result, there is limited ability for data analyses to support short-term (*within* the NPDES MS4 permit cycle) decision making and adaptive management processes. However, the City recognizes that monitoring activities described in this plan may provide some opportunity to do so. For example, pesticide monitoring data may identify the presence of particular compounds only applied by particular users. That data could potentially be used to target outreach efforts to those identified users. Additionally, short-term trends in continuous water quality monitoring data could indicate the presence of discharges that potentially require follow-up through illicit discharge detection or erosion control investigation.

Data collected through implementation of this monitoring plan will largely contribute to the preparation of the City's NPDES MS4 permit renewal application (due July 1, 2015), where the City of Salem will evaluate the overall effectiveness of its Stormwater Management Program. Specifically, collected data will contribute to the following analyses: 1) an evaluation of 303(d) listed parameters (Schedule D.2), 2) preparation of a Total Maximum Daily Load (TMDL) wasteload allocation attainment assessment (Schedule D.3.b), 3) conducting a TMDL pollutant load reduction evaluation, including water quality trend analyses (Schedule D.3.c), and 4) if necessary, the establishment of TMDL benchmarks (Schedule D.3.d). These analyses will support decision-making and proposed improvements to the SWMP, and its BMPs, for the upcoming NPDES MS4 permit cycle.

Also, consistent with Schedule D.4 of the current NPDES MS4 permit, by November 1, 2011, the City of Salem will provide the DEQ with a description of the adaptive management approach/process that will be followed through expiration of the permit on December 29, 2015.

3.0 Instream Storm

3.1 Project / Task Organization

Instream Storm refers to the monitoring of MS4 receiving streams, where sampling is to occur during defined storm events ('storm event' criteria are discussed in Section 3.4.5). The City's Stormwater Monitoring Analyst will serve as the Project Manager and the Responsible Sampling Coordinator. The City's Stormwater Services workgroup will perform sampling and collect field data. The City's Willow Lake Laboratory will perform all analytical laboratory analyses.

3.2 Monitoring Objectives

Instream Storm monitoring will contribute, at least in part, to monitoring objectives i, ii, iii, iv, v, and vi, as identified in Schedule B.1 of the City of Salem's NPDES MS4 Permit. Refer to the City of Salem Surface Water and Stormwater Monitoring Matrix (Attachment 1) for a more detailed explanation of how this monitoring element addresses each objective.

3.3 Background

Instream Storm monitoring is a new monitoring strategy. It was developed to help the City expand its understanding of receiving waters within the Pringle Creek Watershed during storm events. Three separate sites were selected for sampling, as described in 3.4.3.

3.4 Study Design / Sampling Process

3.4.1 Study Design

The study design is a spatial layout of the three different sites that are to be monitored during storm events only. The name of each site, the receiving stream, and location are included in Table 1, and are identified in Figure 1. Relevant characteristics for each site are as follows:

- **PRI12-** This site is located at the City's jurisdictional boundary, where Pringle Creek enters city limits, and represents an upstream catchment area with little influence from the City's MS4 system.

- **CLK1-** This site on Clark Creek represents an older portion of town, with the majority of the catchment being built-out and having limited stormwater structural controls. As identified in the City's 2008 NPDES MS4 Permit Renewal Application, 0.7% of the CLK1 catchment had structural controls in 2008.

- **PRI3-** This site on Pringle Creek represents a portion of the city with a larger percentage of catchment being treated by stormwater structural controls. As identified in the City's 2008 NPDES MS4 Permit Renewal Application, 3.9% of the catchment area had structural controls in 2008, and the coverage was estimated to rise to 8.1% by 2013.

Data collected by way of this monitoring element will help guide Salem's stormwater management strategies in the Pringle Creek Watershed and watersheds throughout the city.

3.4.2 Frequency and Duration

Instream Storm monitoring will be conducted during twenty-five storm events at each of the three sites throughout the duration of the permit term.

3.4.3 Sites

The receiving streams to be monitored are East Fork Pringle Creek, Pringle Creek and Clark Creek. PRI12 is where the East Fork Pringle Creek enters the City's jurisdiction and PRI3 is located on Pringle Creek just before the confluence of Shelton Ditch with Pringle Creek. CLK1 is located on Clark Creek just upstream of the confluence with Pringle Creek. These sites are identified in Figure 1 and described in Table 1.

Table 1: Instream Storm Monitoring Sites

Site ID	Creek Name	Site Location
PRI3	Pringle Creek	Pringle Park
PRI12	East Fork Pringle Creek	Trelstad Ave SE
CLK1	Clark Creek	Bush Park

3.4.4 Sample Collection Method

Sample collection methods will include grab samples, field measurements, and flow-weighted composites[1] (Table 2). All grab samples will be collected and field measurements will be taken during the first three hours of the sampled storm event. Portable sampling units will be programmed to collect a flow-weighted composite sample based on the predicted rainfall depth. The predicted rainfall depth will be calculated prior to the sampling event using a local forecast, with cessation of the event being identified by the first predicted 6 hour dry period or at the end of 24 hours, whichever comes first. The portable sampling units will remain in the field until the program is completed or 24 hours from the start of the event, whichever comes first.

Table 2: Instream Storm Parameter List and Collection Method

Instream (Storm Only) Parameters	Collection Method
TSS	Composite
BOD ('stream')	Composite
Total Phosphorus	Composite
Nitrate+Nitrite as Nitrogen	Composite
Ammonia Nitrogen	Composite
Copper (Total Recoverable & Dissolved)	Composite
Lead (Total Recoverable & Dissolved)	Composite
Zinc (Total Recoverable & Dissolved)	Composite
Hardness	Composite
Specific Conductivity	Field and Composite
Dissolved Oxygen	Field
Temperature	Field
pH	Field
E. coli	Grab

Note: BOD 'stream' analytical method is not identified in 40 CFR 136; however, this method has been identified as an acceptable method under Table B-1 Special Condition #5 in the City's NPDES MS4 permit.

3.4.5 Storm Event Criteria

The following criteria will be used to select storm events to conduct sampling (Schedule B.3):

- Storm event must be greater than 0.1 inch of rainfall
- A minimum of 50% of the water quality sample events must be collected during the wet season (October 1 to April 30)
- Each unique sample event must occur at a minimum of 14 days apart

3.5 Data Quality Criteria

3.5.1 Data Quality Objectives

The data quality objectives for field measurements are detailed in Table 3. Analytical methods for composite and grab samples analyzed at Willow Lake Laboratory will follow methods identified in 40 CFR 136 or otherwise identified in Table B-1 Special Conditions of the NPDES MS4 permit.

[1] If stream gauging equipment fails and it is infeasible to repair equipment before a targeted storm event starts, a time-composite sample will be collected in place of flow paced sample.

Table 3: Instream Storm Field Quality Objectives

Parameters	Accuracy	Precision	Analytical Methods
Temperature	± 0.5 °C	± 0.5 °C	NIST Temperature checks
pH	± 0.2 SU	± 0.3 SU	EPA-NERL 150.1
Dissolved Oxygen	± 0.2 mg/L	± 0.3 mg/L	ASTM D888-09
Specific Conductivity	± 7% of standard value	± 10%	EPA-NERL 120.1

3.5.2 Representativeness

All samples will be collected during storm events described in Section 3.4.5. Samples will be collected where the water is well mixed and representative of the ambient conditions. Grab samples will be collected and field measurements will be taken within the first three hours of the storm.

3.5.3 Comparability

Field, grab, and composite samples will utilize the same handling requirements and laboratory procedures that are used for the Stormwater, Monthly Instream, and Continuous Instream monitoring elements. This uniformity increases the validity of the data for analyses and comparisons with other data collected within the scope of this plan.

3.5.4 Completeness

It is anticipated that twenty-five samples from each of the three sites will be collected over the five year permit term. However, unanticipated circumstances including, but not limited to, personnel illness and turnover, vehicular malfunction, equipment malfunction, and various safety issues could prevent the collection of all of the samples. If such a situation exists, Oregon DEQ will be informed following notification procedures in Schedule B. 2.e of the NPDES MS4 permit.

3.6 Quality Assurance / Quality Control / Record Keeping

3.6.1 Duplicate and Blank Samples

Duplicates will be taken for a minimum of ten percent of the total number of grab samples and field measurements. For composite sampling, an equipment blank (involving suction line tubing, pump tubing, strainer, and sample container vessel) will be done prior to the first sampling event of each sampling season.

3.6.2 Instrument Calibration

Instrument calibration will be completed prior to each sampled storm event. Instrument calibration procedures are documented in the City's "Stormwater and Instream (Storm Only) Monitoring Standard Operating Procedures" (2011).

3.6.3 Instrument Inspection and Maintenance

Instrument inspection and maintenance procedures are documented and will be followed according to the City's "Stormwater and Instream (Storm Only) Monitoring Standard Operating Procedures" (2011).

3.6.4 Mobilization / Handling / Custody Procedures

The City contracts with a weather service that provides a detailed precipitation forecast that is updated daily. The Responsible Sampling Coordinator will monitor this weather forecast and make the final decision to sample. Once it has been decided to sample a storm, Willow Lake

Laboratory will be notified, a two person team will deploy portable samplers filled with ice, and all other relevant equipment and forms will be prepared. The contracted weather service will provide notification prior to the start of the storm event, ensuring the collection of grab samples and field measurements during the first 3 hours of the storm event.

The City has four staff that are trained on proper handling procedures to collect samples during a storm event. Field measurements will be taken using a sterilized beaker for sample collection. These measurements will be completed immediately after collection of the water sample. Grab samples will be collected using a sterilized beaker, transferred to appropriate bottles, put on ice, and transported immediately to Willow Lake Laboratory. As soon as the portable samplers have completed their programs, the flow-weighted composite sample(s) will be put on ice and taken to Willow Lake Laboratory. All grab and composite samples will have a chain of custody form associated with them.

3.6.5 Documentation and Records

A field data sheet will be filled out for each sampling event. All field measurements and pertinent information will be put on this sheet, including the details identified in Table 4.

Table 4: Instream Storm Field Data Sheet

Sampler's name	Number of samples collected by portable sampler
Project name	Total volume during sampling event
Site name	Baseline cfs at start of storm
Date/time of each field measurement	cfs when last sample was taken
Number of samples programmed	Total rainfall during event
Field measurement readings	Rainfall intensity during event
Current rating curve (equation)	Antecedent dry period (as defined in permit)
Portable sampler start and end date/time	Total rainfall in previous 7, 14, and 30 day periods

3.6.6 Data Management

All laboratory analytical results will be kept in Willow Lake Laboratory's Laboratory Information Management System (LIMS) database and Stormwater Services' Aquarius database. In addition, applicable data from the field sheet will be entered into the Aquarius database.

3.6.7 Data Validation and Verification

The Project Manager will review all field and laboratory data. It will be the responsibility of the Project Manager to perform the final review and verification of information on the field data sheets and chain of custody forms. In addition, the Project Manager will follow up with Willow Lake Laboratory on any laboratory-generated data that has fallen outside an expected range. Decisions to accept, qualify, or reject any data collected under this monitoring element will be made by the Project Manager.

3.7 Long-term Strategy

This monitoring element supports the long-term monitoring program strategy by providing data that will contribute to the understanding of the relationship between post-construction stormwater controls (stormwater design standards) and receiving stream water quality. The sites selected for sampling in this monitoring element have catchments with various levels of stormwater controls. Evaluating data by these catchment characteristics is intended to provide

the City a basis to assess the aggregate effectiveness of stormwater controls. Understanding this effectiveness will help the City prioritize its stormwater retrofit efforts and evaluate progress towards pollutant reduction in MS4 receiving streams. This is a new monitoring element, and it is expected that this element will continue beyond the current permit cycle; ultimately providing a dataset for long-term and spatial analyses.

4.0 Monthly Instream

4.1 Project / Task Organization

Monthly Instream refers to the monitoring of MS4-receiving streams, where sampling is to occur once a month on a schedule that is determined at the beginning of each calendar year. The City's Stormwater Administrative Analyst will serve as the Project Manager and Responsible Sampling Coordinator. The City's Stormwater Administrative Analyst and Flow Monitoring Technician will take the lead on sampling and collection of field and in-situ data. The City's Willow Lake Laboratory will perform all analytical laboratory analyses.

4.2 Monitoring Objectives

Monthly Instream monitoring will contribute, at least in part, to monitoring objectives i, ii, iii, iv, v, and vi, as identified in Schedule B.1 of the City of Salem's NPDES MS4 Permit. Refer to the City of Salem Surface Water and Stormwater Monitoring Matrix (Attachment 1) for a more detailed explanation of how this monitoring element addresses each objective.

4.3 Background

The Monthly Instream monitoring element was initiated in 2001 and has been implemented since then. Since 2001 there have been twenty-one sampling sites on local streams and all but one has remained at the same location. The exception is the upstream Battle Creek site which was moved in 2003 due to lack of access.

Beginning July 1st, 2013, the City added three sampling sites on the Willamette River to this monitoring element, thus bringing the total number of sites to twenty-four. The three new Willamette River sampling sites are described in Table 5, and are generally located at:

- upstream of the Salem city limits (new site)
- mid-way through Salem (since 1990)
- downstream of Salem city limits (since 1990)

Monthly sampling has been completed as part of a combined effort to assess the impacts of the city's wastewater effluent and MS4 discharges on receiving water bodies.

4.4 Study Design / Sampling Process

4.4.1 Study Design

The study design for this monitoring element is a paired design, where samples are collected monthly at upstream and downstream sites (except for on the Willamette River where there is a third, mid-way sampling point) on ten of Salem's local streams that receive MS4 discharges and the Willamette River. There is also a downstream monitoring site on the West Fork Little Pudding River. The Little Pudding River starts within Salem city limits, but runs dry during the summer months, so an upstream site was not selected. Dates for sampling are determined at the beginning of each calendar year and are therefore independent of weather conditions.

Due to the number of sites and limited personnel resources, a narrowed set of parameters were chosen for this monitoring element. When initiated in 2001, this monitoring element was intended to produce a dataset that could provide an index of stream quality, as well as spatial and trend analysis. For this permit cycle, 303(d) and TMDL listed parameters were added to the study design. Refer to Table 6 for a list of parameters for all sites.

4.4.2 Frequency and Duration

The sampling frequency will be once a month at twenty-four sites. Two of the sites (LPW1 and CGT5) typically run dry during the summer months resulting in fewer samples at these sites. Per Table B-1, the original twenty-one Monthly Instream sites must be monitored for a total of forty eight events per site; the three Willamette River sites will be in addition to this monitoring requirement and not be counted towards the monitoring frequency requirement.

4.4.3 Monitoring Sites

The receiving water bodies to be monitored include Glenn Creek, Gibson Creek, Croisan Creek, Pringle Creek, Clark Creek, Battle Creek, Mill Creek, Mill Race, Shelton Ditch, Claggett Creek, West Fork Little Pudding River, and the Willamette River. These sites are identified in Figure 1 and described in Table 5.

Table 5: Monthly Instream Monitoring Sites

Site ID	Creek Name	Site Location
PRI1	Pringle Creek	Riverfront Park
PRI5	Pringle Creek	Bush Park
SHE1	Shelton Ditch	Church St SE
SHE10	Shelton Ditch	State Printing Office
MRA1	Mill Race	High St SE
MRA10	Mill Race	Mill Race Park
MIC1	Mill Creek	Front St Bridge
MIC10	Mill Creek	Turner Rd SE
BAT1	Battle Creek	Commercial St SE
BAT12	Battle Creek	Rees Hill Rd SE
CRO1	Croisan Creek	Courthouse Athletic Club
CRO10	Croisan Creek	Ballantyne Rd S
CLA1	Clark Creek	Bush Park
CLA10	Clark Creek	Ewald St SE
CGT1	Claggett Creek	Mainline Dr NE
CGT5	Claggett Creek	Hawthorne St NE @ Hyacinth St NE
GLE1	Glenn Creek	River Bend Rd NW
GLE10	Glenn Creek	Hidden Valley Dr NW
GIB1	Gibson Creek	Wallace Rd NW
GIB15	Gibson Creek	Brush College Rd NW
LPW1	West Fork Little Pudding River	Cordon Rd NE
WR1 (WR8104)	Willamette River	Sunset Park (Keizer)-River Mile 81
WR5 (WR8303)	Willamette River	Railroad Bridge-River Mile 83
WR10 (WR8602)	Willamette River	Halls Ferry-River Mile 91

4.4.4 Sample Collection Method

The sample collection method will vary by parameter, as described in Table 6.

Table 6: Monthly Instream Parameter List and Collection Method

Monthly Instream Constituents	Collection Method	Site
BOD ('stream')	Grab	All
Nitrate+Nitrite as Nitrogen	Grab	All
E. coli	Grab	All
Total Phosphorus	Grab	WR1, WR5, WR10
Alkalinity	Grab	WR1, WR5, WR10
Ammonia	Grab	WR1, WR5, WR10
Copper (Total & Dissolved)	Grab	PRI1[1], PRI5[1], CLA1[1], CLA10[1]
Lead (Total & Dissolved)	Grab	PRI1[1], PRI5[1], CLA1[1], CLA10[1]
Zinc (Total & Dissolved)	Grab	PRI1[1], PRI5[1], CLA1[1], CLA10[1]
Hardness	Grab	PRI1[1], PRI5[1], CLA1[1], CLA10[1]
TSS	Grab	LPW 1[1], WR1, WR5, WR10
TS	Grab	WR1, WR5, WR10
TDS, calc.	Grab	WR1, WR5, WR10
Dissolved Oxygen	In-Situ	All
Temperature	In-Situ	All
Specific Conductivity	In-Situ	All
pH	Field	All
Turbidity	Field	All

Note: BOD 'stream' analytical method is not identified in 40 CFR 136; however; this method has been identified as an acceptable method under Table B-1 Special Condition #5 in the City's NPDES MS4 permit.
[1]New parameter for this location, added this permit term

4.5 Data Quality Criteria

4.5.1 Data Quality Objectives

The data quality objectives for field measurements are detailed in Table 7. Analytical methods for grab samples analyzed at Willow Lake Laboratory will follow 40 CFR 136.

Table 7: Monthly Instream Field and In-Situ Quality Objectives

Parameters	Accuracy	Precision	Analytical Methods
Temperature	± 0.5 °C	± 0.5°C	Standard Method 2500 B
pH	± 0.2 SU	± 0.3 SU	Standard Method 4500 H^+ B
Dissolved Oxygen	± 0.2 mg/L	± 0.3 mg/L	Standard Method 4500 O G
Turbidity	± 5%	± 5%	Standard Method 2130 B
Specific Conductivity	± 7% of standard value	± 10%	Standard Method 2510 B

4.5.2 Representativeness

For monitoring sites on local streams, sampling will be performed at or near the center of the stream channel where the water is well mixed and representative of the ambient conditions. For the three Willamette River sites, samples will be collected from within fifty feet of the bank of the Willamette River (west bank for new upstream site, east bank for the midway and downstream sites).

4.5.3 Comparability

Field and grab samples for this monitoring element will utilize the same handling requirements and laboratory procedures that are used for the Instream Storm, Stormwater, and Continuous

Instream monitoring. This uniformity increases the validity of the data for analyses and comparisons with other data collected within the scope of this plan.

4.5.4 Completeness

Per Table B-1 in the City's NPDES MS4 permit, a minimum of forty-eight samples, from each of the twenty-one stream sites, will be collected. However, Table B-1 Special Condition #3 states that the minimum number of samples may be reduced to thirty-six if insufficient flow does not allow for sample collection. In addition, personnel illness and turnover, vehicular malfunction, equipment malfunction, and various safety issues, including flooding and/or high flows and debris (in particular on the Willamette River) could prevent the collection of all of the samples. If such a situation exists, Oregon DEQ will be informed following notification procedures in Schedule B. 2.e of the NPDES MS4 permit.

4.6 Quality Assurance / Quality Control / Record Keeping

4.6.1 Duplicate Samples

Duplicate field measurements and duplicate grab samples will be taken at ten percent of the sites each month. These sites will be randomly selected prior to the sampling event.

4.6.2 Instrument Calibration

All field meters will be calibrated prior to collecting samples. Each meter will be calibrated according to procedures outlined in its user manual. Willow Lake Laboratory performs all required laboratory equipment calibrations following their QA/QC protocols to maintain lab certifications.

4.6.3 Instrument Inspection and Maintenance

Field equipment will be checked prior to each sampling event. Routine maintenance will be performed before going into the field. Basic replacement parts will be kept on hand or made available. Willow Lake Laboratory maintains and operates all laboratory test equipment in accordance with requirements to maintain laboratory certifications.

4.6.4 Handling / Custody Procedures

Field measurements will be collected using a sterilized beaker for sample collection. These measurements will be completed immediately after collection of the water sample. Grab samples will be collected using a sterilized beaker, transferred to appropriate bottles, and taken to Willow Lake Laboratory after each day's sampling event.

4.6.5 Documentation and Records

Field data sheets will be completed for each monthly sampling event. Information to be recorded on these field data sheets includes project name, time of sample collection, site ID, sampler's name, and sample date. Results obtained in the field will be recorded on the field data sheets.

4.6.6 Data Management

The sampling person is responsible for completion of the field data sheets. The Laboratory Manager at the Willow Lake Laboratory will provide laboratory results. Field and laboratory data will be entered into the Aquarius database managed by Stormwater Services.

4.6.7 Data Validation and Verification

The Project Manager will do a review of all information on field data sheets. Once the data have been entered into the database, the Project Manager will print a paper copy of the data and proofread it against the original field data sheets, and then have the secondary lead do the same. Errors in data entry will be corrected at that time. Outliers and inconsistencies will be flagged for further review. It is the responsibility of the Project Manager to investigate further and determine validity of the data. Data quality problems will be addressed as they occur, and will be identified in the final report to data users.

4.7 Long-term Strategy

By providing the oldest continuous dataset of instream water quality, the Monthly Instream monitoring element is central to the long-term monitoring program strategy. Data collected through this monitoring element has been used (and will continue to be used) for long-term trending, spatial analysis, and observations of seasonal differences. It is expected that by the end of this permit term, there will be sufficient data to create a sub-dataset that represents stream conditions during storm events; thus, allowing for spatial analysis and long-term trending analyses based on storm conditions only.

5.0 Continuous Instream

5.1 Project / Task Organization

Continuous Instream monitoring refers to the continuous monitoring of MS4 receiving streams at fixed sites. The City's Stormwater Monitoring Analyst will serve as the Project Manager. The City's Stormwater Services workgroup will perform all operation/maintenance and quality assurance/quality control procedures.

5.2 Monitoring Objectives

Continuous Instream monitoring will contribute, at least in part, to monitoring objectives i, ii, iii, iv, v, and vi, as identified in Schedule B.1 of the City of Salem's NPDES MS4 Permit. Refer to the City of Salem Surface Water and Stormwater Monitoring Matrix (Attachment 1) for a more detailed explanation of how this monitoring element addresses each objective.

5.3 Background

Continuous Instream monitoring began in 2006 with a total of six sites, including: two on Mill Creek, two on Pringle Creek, and two on Clark Creek. In 2007, three sites were added, two on Glenn Creek, and one on Mill Creek. In 2008, two sites were added on Battle Creek. Due to concerns with data quality and maintenance, a site on Mill Creek, MIC1, is scheduled for removal in 2012 and therefore was not included as part this monitoring element.

5.4 Study Design / Sampling Process

5.4.1 Study Design

The study design is a paired design with two stations positioned in an upstream/downstream configuration on each monitored stream. The upstream sites are adjacent to where the stream enters the City, and the downstream sites are either above the confluence with another stream or where the stream exits the City's jurisdictional boundary. All monitoring equipment was installed to collect a representative dataset that describes the stream conditions during both

storm and non-storm conditions. This study design allows for both spatial analysis as well as long-term trend analysis.

An addition to the study design of this monitoring element was to aid in the Illicit Discharge Detection and Elimination (IDDE) program by utilizing the near real time monitoring capabilities. This was accomplished in 2008 through the development of a water quality alarm system designed to detect readings that may be a result from an illicit discharge.

5.4.2 Frequency and Duration

The City's network of ten continuous monitoring sites are designed to run 24 hours a day, 365 days a year. The data collection interval is every 15 minutes. Infrequent disruptions to data collection can result from power outages or equipment failures, creating 'gaps' in the continuous data time series record.

5.4.3 Sites

A total of ten continuous monitoring sites are currently installed on Pringle, Clark, Mill, Battle, and Glenn Creeks. The positioning of these sites are identified in Figure 1 and described in Table 8.

Table 8: Continuous Instream Monitoring Sites

Site ID	Creek Name	Site Location
PRI3	Pringle Creek	Pringle Park
PRI12	Pringle Creek	Trelstad Ave SE
MIC3	Mill Creek	North Salem High School
MIC12	Mill Creek	Turner Rd SE
BAT3	Battle Creek	Commercial St SE
BAT12	Battle Creek	Lone Oak Rd SE
CLK1	Clark Creek	Bush Park
CLK12	Clark Creek	Ewald St SE
GLE3	Glenn Creek	Wallace Rd NW
GLE12	Glenn Creek	Hidden Valley Dr NW

5.4.4 Collection Method

Data are collected in-situ using automated datasondes for the following water quality parameters: temperature, pH, dissolved oxygen, specific conductivity, and turbidity. Stage readings are measured in-situ. Provisional flow measurements will be computed using a polynomial equation in real time. Finalized flow measurements will be computed using proprietary rating curve software. Table 9 details each of the parameters and the sample collection method.

Table 9: Continuous Instream Parameter List and Collection Method

Continuous Instream Parameters	Collection Method
Temperature	In-situ
pH	In-situ
Dissolved Oxygen	In-situ
Specific Conductivity	In-situ
Turbidity	In-situ
Stage	In-situ

5.5 Data Quality Criteria

5.5.1 Data Quality Objectives

The data quality objectives for continuous in-situ measurements are detailed in Table 10.

Table 10: Continuous Instream In-Situ Quality Objectives

Parameters	Accuracy	Precision	Analytical Methods	
			In-Situ	YSI
Temperature	± 0.5 °C	± 0.5 °C	NIST Temperature checks	
pH	± 0.2 SU	± 0.3 SU	EPA-NERL 150.1	Standard Method 4500-H
Dissolved Oxygen	± 0.3 mg/L	± 0.5 mg/L	Method 1002-8-2009	ASTM D888-09
Turbidity	± 5% or 2 NTU (whichever is greater)	± 5% or 3 NTU (whichever is greater)	EPA-NERL 180.1	Standard Method 2130B
Specific Conductivity	± 7% of standard value	± 10%	EPA-NERL 120.1	Standard Method 2510

5.5.2 Representativeness

The datasondes are positioned to capture representative readings of ambient conditions for each site.

5.5.3 Comparability

In-situ measurements utilize the same type of instrumentation for all stations except for the two Glenn Creek sites (GLE3 and GLE12). Despite this difference in instrumentation, internal tests have shown that temperature, pH, dissolved oxygen, and specific conductivity readings are comparable. The one exception to this is turbidity. Turbidimeter comparison tests have shown a significant variation of the data at the upper range of sensor readings. In order to develop a comparable understanding of the data the City is working to develop a regression that explains the relationship between the two different types of turbidimeters. Once this regression has been established, data from all stations will be comparable.

5.5.4 Completeness

The continuous monitoring stations are maintained following the “Continuous Water Quality Monitoring Program Quality Assurance Project Plan (QAPP)”, revised in 2011. Power outages or unanticipated equipment malfunctions can occur and may contribute to data gaps within the continuous data sets.

5.6 Quality Assurance / Quality Control / Record Keeping

5.6.1 Instrument Calibration

All datasonde sensors will be calibrated according to documented procedures in the “Continuous Water Quality Monitoring Program QAPP”.

5.6.2 Instrument Inspection and Maintenance

Station instrumentation will be inspected and maintained according to the “Continuous Water Quality Monitoring Program QAPP”.

5.6.3 Documentation and Records

Separate field sheets will be completed for each station visit. Information to be recorded on these field sheets is described in the "Continuous Water Quality Monitoring Program QAPP".

5.6.4 Data Management

Field technicians are responsible for completion of the field sheets. Data will be stored in the Stormwater Services Aquarius database.

5.6.5 Data Validation and Verification

The Stormwater Monitoring Analyst will do a review of all information provided on the field sheets following procedures documented in the "Continuous Water Quality Monitoring Program QAPP". All collected data will be audited and assigned a grade value to describe the quality of each datum recorded. A verification process of all data collected between audit periods is completed on a quarterly basis. Once the verification process is complete, the data can be distributed to data users.

5.7 Long-Term Strategy

All monitoring sites for this element are at fixed locations that are either on City-owned property or locations where the City has obtained easements. This ensures that sites will continue to be operated and maintained for stream discharge and water quality monitoring into the future.

This monitoring element provides data that will support multiple long-term monitoring program strategies. Examples for intended use of the data include: aiding and showing progress in the IDDE program (by use of station alarms); studying the impacts relating to hydromodification and strategies to address hydromodification (stream flow/stage data); continued evaluation of receiving stream status (water quality data); examining the cumulative effects (chemical, physical, and biological) of the City's MS4 stormwater runoff on receiving streams; and assessing progress towards meeting TMDL load reduction benchmarks.

6.0 Macroinvertebrate

6.1 Project / Task Organization

Macroinvertebrate monitoring will consist of sampling benthic macroinvertebrates at fixed sites in the Pringle Creek and/or Clark Creek subwatersheds. The City's Stormwater Monitoring Analyst will serve as the Project Manager. The City's Stormwater Services workgroup will be responsible for the completion of this monitoring effort.

6.2 Monitoring Objectives

Macroinvertebrate monitoring will contribute, at least in part, to monitoring objectives iv and v as identified in Schedule B of the City of Salem's NPDES MS4 Permit. Refer to City of Salem Stormwater Monitoring Matrix (Attachment 1) for a more detailed explanation of how this monitoring element addresses each objective.

6.3 Background

Macroinvertebrate monitoring is a new environmental monitoring element of the City's NPDES MS4 permit designed to help the City assess the biological effects of MS4 discharges on receiving waters. The City collected macroinvertebrate data within the Pringle Watershed in

2000 and 2001. To expand on these data, three targeted sites will be selected within the Pringle Creek and/or Clark Creek subwatersheds for monitoring during this permit cycle.

6.4 Study Design / Sampling Process

6.4.1 Study Design

The study design for this monitoring element is a targeted approach, where macroinvertebrates will be collected at three fixed sites within the Pringle Creek Watershed. Selected sites will be on Clark Creek, East Fork Pringle Creek, and the main stem of Pringle Creek. Sites selected for sampling will be in proximity to previous macroinvertebrate sampling sites (conducted in summer of 2000 and 2001) and, where possible, near other instream monitoring sites identified in this plan. The intent of this study design is to collect macroinvertebrate community data that can be compared with sites sampled in previous studies. Additionally, physical habitat data of the sampled stream site will be collected during macroinvertebrate sampling events. Data from other monitoring elements and the physical data collected will aid in the interpretation of the results and comparison analysis.

6.4.2 Frequency and Duration

Macroinvertebrate sample collection will be completed during two of the five permit years for a total of two samples per site. Sampling will occur at a similar time of year for each collection event.

6.4.3 Sites

Three targeted macroinvertebrate sampling sites will be selected in the Pringle and/or Clark Creek subwatersheds. Whenever possible, sites will be chosen that are in the vicinity of a continuous instream monitoring site.

6.4.4 Sample Collection Method

The Oregon DEQ Benthic Macroinvertebrate Protocol for Wadeable Rivers and Streams will be followed for each monitoring event. A qualified taxonomist will process all macroinvertebrate samples.

6.5 Quality Criteria

6.5.1 Representativeness

Targeted macroinvertebrate sites will be selected to represent MS4 receiving waters within the Pringle and/or Clark Creek subwatersheds.

6.5.2 Comparability

Targeted sampling at the same time of year at the same three sites using recognized sampling procedures will reduce the potential for spatial and temporal sample variation while increasing the comparability of data in the long term. Data collection methods used during this permit cycle will be comparable to those used in 2000 and 2001.

6.5.3 Completeness

Physical habitat data, including both quantitative and qualitative variables, will be collected at the same targeted sites. As applicable, water quality data collected from nearby continuous instream and/or monthly instream monitoring sites will supplement the data record. This

combined data set will provide information of stream conditions that will be used to assist in the identification of limitations and/or stressors to existing macroinvertebrate assemblages.

6.6 Quality Assurance / Quality Control / Record Keeping

6.6.1 Duplicate Samples

Field and laboratory duplicates will be collected for 10% of all samples.

6.6.2 Handling / Custody Procedures

All samples will be preserved in the field using a 70-95% ethanol concentration and labeled with sample collection information. This information will also be documented in pencil on waterproof paper and placed inside the preserved sample jar. If the sample is not immediately sent off to the lab for identification, the preservative will be replaced with fresh solution within one week of sample collection. Chain of custody forms will be completed for each monitoring event.

6.6.3 Documentation and Records

Field sheets documenting the site, date, and sampling personnel will be completed for each macroinvertebrate sampling event. This information will be combined with a set of additional field sheets designed to document the associated physical habitat data. It is the responsibility of the Project Manager to ensure that these documents are correctly completed during each monitoring event.

6.6.4 Data Management

All field documents and data received from the laboratory will be entered into the Stormwater Services Aquarius database by the Project Manager.

6.6.5 Data Validation and Verification

Macroinvertebrate samples will be preserved in the field, with sorting and identification conducted by a qualified taxonomist. Identification of organisms will be performed following the Oregon DEQ Benthic Macroinvertebrate Protocol for Wadeable Rivers and Streams.

6.7 Long-term Strategy

The macroinvertebrate monitoring that will be completed this permit term will provide a measure of the biological conditions at targeted sites within the Pringle Creek Watershed. This data will be compared with data collected during the summers of 2000 and 2001, providing a long-term assessment of changes in macroinvertebrate communities, and helping to evaluate the overall effectiveness of the City's Stormwater Management Program. Performing macroinvertebrate monitoring at or near the same sites during subsequent permit cycles will continue to be a key element of the long-term monitoring program strategy.

7.0 Instream Assessment

To fulfill the permit monitoring objectives and to help the City understand the effectiveness of its Stormwater Management Plan (SWMP); Instream Storm, Monthly Instream, Continuous Instream, and Macroinvertebrate data will be used to address the following assessment questions.

Question: **(Trend Analysis, Spatial)** What are the influences of City MS4 discharges on receiving stream water quality and flow during storm events?

Assumptions: City MS4 discharges are assumed to have some level of affect on water quality and flow of a receiving stream during storm events. The rationale is that the amount of impervious surface, differences in land use, and traffic volume will contribute to spatial changes in water quality parameters.

Question: **(Trend Analysis, Time)** Does data for the monitored water quality parameters change over time?

Assumption: The assumption is that water quality results will change over time. Through implementation of the City's SWMP, in-stream water quality results may change at different rates and at different points of SWMP implementation.

Question: **(Seasonal Observation)** Are there seasonal differences in the frequency that specific parameters exceed water quality criteria?

Assumption: The assumption is that certain water quality results will have more frequent exceedances of water quality standards during the dry season (summer), while others will have more frequent exceedances during the wet season (fall-winter-spring). The rationale is that some water quality parameters are more impacted by stormwater runoff while others are more subject to climatic conditions, flow volume, and land use activity outside of the City's jurisdictional area (e.g., agricultural land use adjacent to Mill Creek).

7.1 Analysis Methodology

Data mining will be used to organize the data to account for variables such as rainfall, stream levels, and seasonality. Once data have been organized into data sub sets, a normality test will be done to select a proper statistical hypothesis test to address trend analysis for both time and spatial questions. Seasonal observations will be addressed using descriptive statistics and graphical illustration.

8.0 Stormwater

8.1 Project / Task Organization

Stormwater monitoring refers to the monitoring of MS4 stormwater runoff during defined storm events. The City's Stormwater Monitoring Analyst(s) will serve as the Project Manager and the Responsible Sampling Coordinator. The Stormwater Services workgroup will perform sampling and collect field measurements. The City's Willow Lake Laboratory will perform all analytical laboratory analyses.

8.2 Monitoring Objectives

Stormwater monitoring will contribute, at least in part, to monitoring objectives i, ii, iii, iv, v, and vi, as identified in Schedule B.1 of the City of Salem's NPDES MS4 Permit. Refer to the City of Salem Surface Water and Stormwater Monitoring Matrix (Attachment 1) for a more detailed explanation of how this monitoring element addresses each objective.

8.3 Background

The City of Salem began collecting stormwater samples from four land use based monitoring sites (Redleaf, Edgewater, Cottage, Commercial) in January 1995. The City's first NPDES MS4 permit was subsequently issued in 1997. Annual stormwater sampling continued at these four sites through the winter of 2005. In 2006, the City discontinued these sites and began to

sample four new stormwater sites. These new sites were selected to represent stormwater discharges to 303(d) listed streams and have been identified by the associated stream name (Clark Storm, Mill Storm, Pringle Storm, Glenn Storm).

During this NPDES MS4 permit term (December 2010 - December 2015) the City will resume land use based stormwater sampling from three sites which represent residential, commercial, and industrial land use in Salem. Two of the sites, commercial and industrial, are new sites. These sites are discussed in Section 8.5.3 of this document.

8.4 Stormwater Assessment

Question: **(Pollutant Concentrations)** How does weather and/or other environmental conditions serve as a predictor of pollutant concentration levels in stormwater discharges from the MS4 system?

Assumptions: The assumption is that multiple factors contribute to the variability typically observed in stormwater pollutant data. Over time, it may be possible to identify key factors and further refine the SWMP to address those factors.

Question: **(Comparison)** Is there a statistical difference between the City's land use event mean concentrations (EMCs) and the Oregon Association of Clean Water Agencies (ACWA) EMCs that were used for the 2008 permit renewal process (ACWA data; modified 2008)?

Assumptions: The assumption is that there is a statistical difference between the City's land use EMCs and the ACWA land use EMCs. The rationale is that the ACWA EMCs are based on pre-SWMP data from all Oregon Phase 1 municipalities. While the City did contribute to the ACWA data set, the City has since collected a significant number of data points post implementation of the City's SWMP and therefore would expect to see a decreasing trend in the data.

8.4.1 Analysis Methodologies

To answer the assessment questions historic and data collected this permit term will be used for analyses. Regression analysis may be used to address the pollutant concentration question. To address the comparison question, analysis may include a non-parametric statistical test.

8.5 Study Design / Sampling Process

8.5.1 Study Design

The study design for this monitoring element provides for the characterization of MS4 stormwater runoff as a result of implementation of the City's SWMP. This will be done for commercial, industrial, and residential land uses. To acquire a more representative dataset for both commercial and industrial land use, the monitoring sites will differ from those sampled during the first two MS4 permit cycles. The residential land use monitoring will be at the same site sampled during the last MS4 permit cycle (2004 – 2010). Through this monitoring element, stormwater sampling data collected from similar land uses will be aggregated, with the intent to produce representative pollutant load concentration values.

8.5.2 Frequency and Duration

Stormwater monitoring will be conducted during fifteen storm events at each of the three sites throughout the duration of the permit term.

8.5.3 Sites

Three sites will be monitored over the course of the permit cycle. These sites are storm sewer manholes and represent residential, industrial, and commercial land use activity within the City. The residential and commercial catchments are within the Pringle Creek Watershed. The industrial catchment resides within the Upper Claggett Watershed. These sites are identified in Figure 1 and described in Table 11.

Table 11: Stormwater Monitoring Sites

Dominant Land Use	Residential	Industrial	Commercial
Site Identifier	Electric	Salem Industrial	Hilfiker
Manhole Number	D42466227	D51488226	D42456231
Number of Monitoring Events	3/year or 15/permit cycle	3/year or 15/permit cycle	3/year or 15/permit cycle
Watershed	Pringle Creek	Upper Claggett	Pringle Creek
Receiving Stream	Clark Creek	Claggett Creek	West Fork Pringle Creek

8.5.4 Sample Collection Method

Sample collection methods will include grabs samples, field measurements, and flow-weighted composites[2] (Table 12). All grab samples will be collected and all field measurements will be taken during the first three hours of the sampled storm event. Portable sampling units and flow modules will be programmed to perform a flow-weighted composite sample based on the predicted rainfall depth. The predicted rainfall depth will be calculated prior to the sampling event using a local forecast, with cessation of the event being identified by the first predicted 6 hour dry period or at the end of 24 hours, whichever comes first. The portable sampling units will remain in the field until the program is completed or 24 hours from the start of the event, whichever comes first

Table 12: Stormwater Parameter List

Pollutant Parameter	Collection Method
TSS	Composite
$BOD_{5\text{-day}}$	Composite
Total Phosphorus	Composite
Nitrate+Nitrite as Nitrogen	Composite
Ammonia Nitrogen	Composite
Copper (Total Recoverable & Dissolved)	Composite
Lead (Total Recoverable & Dissolved)	Composite
Zinc (Total Recoverable & Dissolved)	Composite
Hardness	Composite
Sp. Conductivity	Field and Composite
Temperature	Field
pH	Field
Dissolved Oxygen	Field
E. coli	Grab

[2] If flow equipment fails and it is infeasible to repair equipment before a targeted storm event starts, samplers will be programmed to take a time-composite sample in place of a flow paced sample.

8.5.5 Storm Selection Criteria

The following criteria will be used to select storm events for sampling:

- Storm event must be greater than 0.1 inch of rainfall
- When possible, samples must be collected after an antecedent dry period of a minimum of 24 hours

8.6 Data Quality Criteria

8.6.1 Data Quality Objectives

The quality objectives for field measurements are detailed in Table 13. Analytical methods for composite and grab samples analyzed at Willow Lake Laboratory will follow 40 CFR 136.

Table 13: Stormwater Field Measurement Quality Objectives

Parameters	Accuracy	Precision	Analytical Methods
Temperature	± 0.5 °C	± 0.5 °C	NIST Temperature checks
pH	± 0.2 SU	± 0.3 SU	EPA-NERL 150.1
Dissolved Oxygen	± 0.2 mg/L	±0.3 mg/L	ASTM D888-09
Specific Conductivity	± 7% of standard value	± 10%	EPA-NERL 120.1

8.6.2 Representativeness

All samples will be collected under a specific 'storm event' condition detailed in 8.5.5. Grab samples will be collected and field measurements will be taken within the first three hours of the storm.

8.6.3 Comparability

Field measurements and grab samples for this monitoring element will utilize the same handling requirements and laboratory procedures that are used for the Instream (Storm Only), Monthly Instream, and Continuous Instream monitoring elements. This uniformity increases the validity of the data for analyses and comparisons with other data collected within the scope of this plan.

8.6.4 Completeness

It is anticipated that fifteen samples from each of the three sites will be collected over the five year permit term. However, unanticipated circumstances including but not limited to; personnel illness and turnover, vehicular malfunction, equipment malfunction, and various safety issues could prevent collection of a hundred percent of the samples. If such a situation exists, Oregon DEQ will be informed following notification procedures in Schedule B.2.e of the NPDES MS4 permit.

8.7 Quality Assurance / Quality Control / Record Keeping

8.7.1 Duplicates and Blank Samples

Duplicate samples for grab samples and field measurements will be taken for a minimum of ten percent of the total number of samples. For composite sampling, an equipment blank (involving suction line tubing, pump tubing, strainer, and sample container vessel) will be done prior to the first sampling event of each sampling season.

8.7.2 Instrument Calibration

Calibration procedures are detailed in the City's "Stormwater and Instream (Storm Only) Monitoring Standard Operating Procedures" (2011).

8.7.3 Instrument Inspection and Maintenance

Instrument calibration will be completed prior to each sampled storm event. Instrument inspection and maintenance procedures will be followed according to the City's "Stormwater and Instream (Storm Only) Monitoring Standard Operating Procedures" (2011).

8.7.4 Mobilization / Handling / Custody Procedures

The City contracts with a weather service that provides a detailed precipitation forecast that is updated daily. The Responsible Sampling Coordinator will monitor this weather forecast and make the final decision to sample. Once it has been decided to sample a storm, Willow Lake Laboratory will be notified, a two person team will deploy portable samplers filled with ice, and all other relevant equipment and forms will be prepared. The contracted weather service will provide notification prior to the start of the storm event, ensuring the collection of grab samples and field measurements during the first 3 hours of the storm event.

The City has four staff that are trained on proper handling procedures to collect samples during a storm event. Field measurements will be taken using a sterilized beaker for sample collection. These measurements will be completed immediately after collection of the water sample. Grab samples will be collected using a sterilized beaker, transferred to appropriate bottles, put on ice, and transported immediately to Willow Lake Laboratory. As soon as the portable samplers have completed their programs, the flow-weighted composite sample(s) will be put on ice and taken to Willow Lake Laboratory. All grab and composite samples will have a chain of custody form associated with them.

8.7.5 Documentation and Records

A field data sheet will be filled out for each sampling event. All field measurements will be put on this sheet. Additional information recorded on the sheet is described in Table 14.

Table 14: Stormwater Field Data Sheet

Sampler's name	Predicted rainfall for sampling event
Project name	Predicted runoff volume for sampling event
Site name	Flow quantity interval
Date/time of each field measurement	Number of samples programmed
Portable sampler start and end date/time	Actual number of sample collected
Total volume during sampling event	Presence/absence of base flow before sampling
Presence of base flow after sampling	Total rainfall during event
Total rainfall prior to grab and field measurements	Average rainfall intensity during event
Rainfall intensity prior to grab collection and field measurements	Time of concentration
Antecedent dry period (as defined in permit)	Total rainfall in previous 7, 14, and 30 day periods
Field measurement reading(s)	Baseline CFS, start of storm

8.7.6 Data Management

All composite and grab sample data from each wet-weather sampling event will be entered into Willow Lake Laboratory's LIMS database. Stormwater personnel receive hard and electronic copies of these data. All data will be imported into Stormwater Services Aquarius database.

8.7.7 Data Validation and Verification

The Project Manager will review all field and laboratory data. It will be the responsibility of the Project Manager to perform the final review and verification of the data reported on the field data sheet. In addition, the Project Manager will follow up with Willow Lake Laboratory on any laboratory-generated data that has fallen outside an expected range. Decisions to accept, qualify or reject any data collected under this monitoring element will be made by the Project Manager.

8.8 Long-term Strategy

This element contributes to the long-term monitoring program strategy by providing data that characterizes the quality of MS4 discharges, and supports long-term evaluation of the effectiveness of the City's Stormwater Management Program. Datasets can be utilized for comparison between ACWA concentration values used for estimating total annual pollutant loads and benchmark analysis completed as part of the 2008 permit renewal package; thus, providing a gauge of the effectiveness of both structural and non-structural stormwater controls. Additionally, seasonal and geographic characterization will also be evaluated to help identify future stormwater control facility implementation priorities.

9.0 Pesticide

9.1 Project / Task Organization

Pesticide monitoring refers to the monitoring of pesticides in MS4 stormwater discharges during defined storm events. The City's Stormwater Monitoring Analyst(s) will serve as the Project Manager and the Responsible Sampling Coordinator. The Stormwater Services workgroup will perform sampling. The City will have a contracted laboratory perform all analytical laboratory analyses.

9.2 Monitoring Objectives

Pesticide monitoring will contribute, at least in part, to monitoring objectives ii, iii, iv, and v, as identified in Schedule B.1 of the City of Salem's NPDES MS4 Permit. Refer to the City of Salem Surface Water and Stormwater Monitoring Matrix (Attachment 1) for a more detailed explanation of how this monitoring element addresses each objective.

9.3 Background

This will be the first time the City has monitored for pesticides within MS4 discharges. This sampling will provide the City with information to determine if pesticides are present in the City's storm sewer system and discharging to receiving streams.

9.4 Pesticide Assessment

Question: **(Presence)** Are there pesticides present in residential, commercial, or industrial MS4 stormwater runoff in concentrations that are measureable using the identified pesticide screening method(s) in this plan? If so, does presence or type of pesticide vary by land use?

***Assumptions*:** The assumption is that pesticide compounds will be found within MS4 stormwater runoff from the monitored sites in concentrations that are measureable using the identified pesticide screening methods in this plan. An additional assumption is that samples from the residential land use site will have more frequent detection of pesticide compounds at

higher concentrations—resulting from relatively uncontrolled pesticide application by household applicators and larger areas of green space.

9.4.1 Analysis Methodology

Analysis methodology will include graphical representation of pesticide compounds detected. If pesticides are detected a source review of the specific pesticide compound will be done to determine whether the pesticide was most likely applied by a commercial applicator or a household applicator.

9.5 Study Design / Sampling Process

9.5.1 Study Design

The study design for this monitoring element is a land use-based design that will identify the presence of specifically-identified pesticides (or lack of) in MS4 stormwater discharges. The land use types to be monitored include residential, commercial, and industrial. Following the collection of data through this monitoring element, the City anticipates being able to evaluate and potentially modify its outreach efforts based on various pesticide user groups.

9.5.2 Frequency and Duration

Pesticide sampling will be completed during two of the five permit years for a total of four storm events at each of the three sites.

9.5.3 Sites

The storm sewer sites to be monitored for this element are the same land use based sites as the Stormwater monitoring sites. The residential and commercial sites are within the Pringle Creek Watershed. The industrial catchment resides within the Upper Claggett Watershed. These sites are identified in Figure 1 and described in Table 15.

Table 15: Pesticide Monitoring Sites

Dominant Land Use	Residential	Industrial	Commercial
Site Identifier	Electric	Salem Industrial	Hilfiker
Manhole Number	D42466227	D51488226	D42456231
Number of Monitoring Events	4/permit cycle	4/permit cycle	4/permit cycle
Watershed	Pringle Creek	Upper Claggett	Pringle Creek
Receiving Stream	Clark Creek	Claggett Creek	West Fork Pringle Creek

9.5.4 Sample Collection Method

The sample collection method will be grab samples. The City will collect pesticide samples when application rates are assumed heaviest.

9.5.5 Pesticide Parameters

Two separate screens will be done for pesticide sampling events, including a halogenated pesticide screen and a chlorinated herbicide screen. There are sixty-two different compounds in the halogenated pesticide screen and sixteen different compounds in the chlorinated herbicide screen (Attachment 2).

9.5.6 Pesticide Storm Selection Criteria

The following criteria will be used to select storm events to conduct sampling:

- Storm event must be greater than 0.1 inch of rainfall
- When possible, samples must be collected after an antecedent dry period of a minimum of 24 hours

9.6 Quality Criteria

9.6.1 Measurement Quality Objectives

It is anticipated that analytical method EPA SW-846, 8081B (GC-ECD) will be used for the halogenated pesticide screen and analytical method EPA SW-846, 8321B (HPLC-MS) will be used for the chlorinated herbicide screen. The expected reporting limits for each compound within these screens are included in Attachment 2.

9.6.2 Representativeness

All pesticide monitoring will be done under defined storm events with a target of capturing a sample from the most intense period of the defined storm event. All grab samples will be collected from the middle of the water column of the inflow pipe.

9.6.3 Comparability

To ensure comparability between the different land use sites, attempts will be made to collect samples at all three sites during each pesticide monitored storm event. If possible, the same laboratory and analytical methods will be used for all sampling.

9.6.4 Completeness

It is anticipated that pesticide samples will be collected from one hundred percent of selected sites during a minimum four sampling events per site.

9.7 Quality Assurance / Quality Control / Record Keeping

9.7.1 Duplicate, Blank, and Replicate Samples

Duplicate, blank, and replicate samples will be done according to the contracted laboratory's specifications. Duplicate samples will be collected and analyzed for a minimum of ten percent of total samples. All results from these samples will be included within the data records.

9.7.2 Mobilization / Handling / Custody Procedures

The City contracts with a weather service that provides a detailed precipitation forecast that is updated daily. The Responsible Sampling Coordinator will monitor this weather forecast and make the final decision to sample. Once it has been decided to sample a storm, the contracted laboratory for pesticide analysis will be notified and all other relevant equipment and forms will be prepared. The contracted weather service will provide notification prior to the start of the storm event, ensuring the collection of grab samples and field measurements during the first 3 hours of the storm event.

The City has four staff that are trained on proper handling procedures to collect pesticide samples during a storm event. Grab samples will be collected using sterilized beakers and then transferred to bottles provided by the laboratory. A separate beaker will be used for each site.

Beakers will be triple rinsed before each sample is collected. All samples will have a chain of custody form.

9.7.3 Documentation and Records

A field data sheet will be filled out for each sampling event. Information to be recorded on the field sheet is described in the Table 16 below.

Table 16: Pesticide Field Data Sheet

Sampler's name	Rainfall intensity prior to grab sample
Project name	Time of concentration
Site name	Antecedent dry period (as defined in permit)
Date/time of each field measurement	Total rainfall in previous 7, 14, and 30 day periods
Total rainfall prior to grab sample	Field measurement readings

9.7.4 Data Management

All analytical results and applicable field measurements including field data sheet information will be stored in the Stormwater Services Aquarius database.

9.7.5 Data Validation and Verification

It will be the responsibility of the Project Manager to perform the final review and verification of the data reported on the field data sheet. In addition, the Project Manager will follow up with the contracted laboratory on any laboratory-generated data that has fallen outside an expected range. Decisions to accept, qualify, or reject any data collected under this monitoring element will be made by the Project Manager.

9.8 Long-term Strategy

This pesticide monitoring element will guide future pesticide monitoring and outreach efforts by first identifying the scope of pesticide use. With these data, trends of particular pesticides/compounds may be identified that can guide future pesticide monitoring efforts. Furthermore, data collected will help guide outreach efforts to target specific pesticide users. It is anticipated that pesticide monitoring will not continue in this same study design in upcoming MS4 permit cycles as trends are identified.

10.0 Stormwater – Mercury

10.1 Project / Task Organization

Stormwater – Mercury monitoring refers to the monitoring of low level mercury and methyl mercury (total recoverable and dissolved) in MS4 discharges during defined storm events. The City's Stormwater Monitoring Analyst will serve as the Project Manager and Responsible Sampling Coordinator. The City will have a contracted laboratory to perform all analytical laboratory analyses.

10.2 Monitoring Objectives

Stormwater – Mercury monitoring will contribute, at least in part, to monitoring objectives ii, iii, iv, and v, as identified in Schedule B.1 of the City of Salem's NPDES MS4 Permit.

10.3 Background

This will be the first time the City has monitored MS4 stormwater runoff for low level mercury and methyl mercury (total recoverable and dissolved).

10.4 Study Design / Sampling Process

10.4.1 Study Design

The study design for this monitoring element is to provide modeling efforts by the DEQ with low level total and dissolved mercury and methyl mercury data from MS4 discharges that is representative residential and commercial land use catchments. Storms to be sampled include one summer storm and one winter storm from each site for a minimum of two years.

10.4.2 Frequency and Duration

Stormwater– Mercury monitoring will be conducted at two sites two times per year, one summer and one winter storm event. Following NPDES MS4 permit Table B-1 Special Condition #6, after two years of monitoring the City may request from the DEQ that this monitoring element be eliminated.

10.4.3 Sites

The sampling sites are the same commercial and residential land use based sites identified in the Stormwater monitoring element. These sites are within the Pringle Creek Watershed and are identified in Figure 1 and described in Table 17.

Table 17: Stormwater – Mercury Monitoring Sites

Dominant Land Use	**Residential**	**Commercial**
Site Identifier	Electric	Hilfiker
Manhole Number	D42466227	D42456231
Number of Monitoring Events	2/year; one summer and one winter storm event	2/year; one summer and one winter storm event
Watershed	Pringle Creek	Pringle Creek
Receiving Stream	Clark Creek	West Fork Pringle Creek

Note: Per Table B-1 Special Condition #6 of the City's NPDES MS4 permit after two years of monitoring the City may request from the DEQ that this monitoring element be eliminated.

10.4.4 Sample Collection Method

The sample collection method will be grab samples. EPA method 1669 ultra clean sampling protocol will be used to collect samples under this monitoring element.

10.4.5 Stormwater- Mercury Storm Selection Criteria

The following criteria will be used to select storm events to conduct sampling:

- Storm event must be greater than 0.1 inch of rainfall
- When possible, samples must be collected after an antecedent dry period of a minimum of 24 hours

10.5 Quality Criteria

10.5.1 Measurement Quality Objectives

The analytical method for total recoverable and dissolved mercury is US EPA method 1631E with a quantitation limit of 0.5 ng/L. The analytical method for total recoverable and dissolved methyl mercury is US EPA method 1630 with a quantitation limit of 0.05 ng/L.

10.5.2 Representativeness

All samples will be collected under a specific storm criteria identified in Section 10.4.5 of this document. Sample collection will follow EPA Method 1669 ultra clean sampling protocol.

10.5.3 Comparability

If possible, the same laboratory will be used for all mercury sample analyses. Attempts will be made to collect samples from both sites during the same storm events. Rainfall data from the nearest applicable rain gauge station will accompany the data set for each monitoring event.

10.5.4 Completeness

Stormwater - Mercury monitoring will be conducted two times per year, one summer and one winter storm event, at two sites. However, unanticipated circumstances including but not limited to; personnel illness and turnover, vehicular malfunction, equipment malfunction, and various safety issues could prevent the collection of all of the samples. If such a situation exists, Oregon DEQ will be informed following notification procedures in Schedule B.2.e of the NPDES MS4 permit. Following NPDES MS4 permit Table B-1 Special Condition #6, after two years of monitoring the City may request from the DEQ that this monitoring element be eliminated.

10.6 Quality Assurance / Quality Control / Record Keeping

10.6.1 Duplicate and Blank Samples

Duplicate and blank samples will be collected according to EPA Method 1669 ultra clean sampling protocol and sent to the laboratory for analysis following methods identified in 10.5.1. All results from these samples will be included within the data records.

10.6.2 Mobilization / Handling / Custody Procedures

The City contracts with a weather service that provides a detailed precipitation forecast that is updated daily. The Responsible Sampling Coordinator will monitor this weather forecast and make the final decision to sample. Once it has been decided to sample a storm, the contracted laboratory for mercury analysis will be notified and all other relevant equipment and forms will be prepared. The contracted weather service will provide notification prior to the start of the storm event, ensuring the collection of grab samples and field measurements during the first 3 hours of the storm event.

The City has four staff that are trained on the collection procedures outlined in EPA Method 1669 ultra clean sampling protocol prior to sampling. All samples will be collected and handled according to EPA Method 1669 ultra clean sampling protocol. Samples will be put on ice immediately and shipped overnight to the laboratory. All samples will have a chain of custody form.

10.6.3 Documentation and Records

After each sample is collected, field documentation will be recorded in a sampling log and any unusual observations concerning the sample and sampling will be documented.

10.6.4 Data Management

All analytical results including field documentation recorded during sampling will be stored in the Stormwater Services Aquarius database.

10.6.5 Data Validation and Verification

It will be the responsibility of the Project Manager to perform the final review and verification of the data reported on the field data sheet. Decisions to accept, qualify, or reject any data collected under this monitoring element will be made by the Project Manager.

10.7 Long-term Strategy

The study design for monitoring of mercury in MS4 discharges is unlikely to be similar to this approach in future efforts. The current study design is largely driven by data needs for modeling by DEQ. Future mercury monitoring will likely be guided by Willamette River TMDL requirements that at this time are uncertain.

11.0 Dry Weather Outfall

In support of the IDDE program and to satisfy requirements of the City's NPDES MS4 permit (Schedule A.4.a), the City will continue to conduct annual dry-weather outfall inspections. These inspections will be based on a prioritization process following a standard operating procedure. Stormwater Services field staff will work cooperatively with Environmental Services Compliance Specialists for this monitoring element.

12.0 Coordinated Environmental Monitoring

The City's NPDES MS4 permit allows for the opportunity to coordinate environmental monitoring with other MS4-permitted municipalities (Schedule B.4). City staff recognizes that there are potential benefits to such a coordinated effort (e.g., cost savings, data set size, efficiency). If a coordinated environmental monitoring strategy is developed, the City would modify this monitoring plan and notify the DEQ in accordance with NPDES MS4 permit Schedule B.2.e.

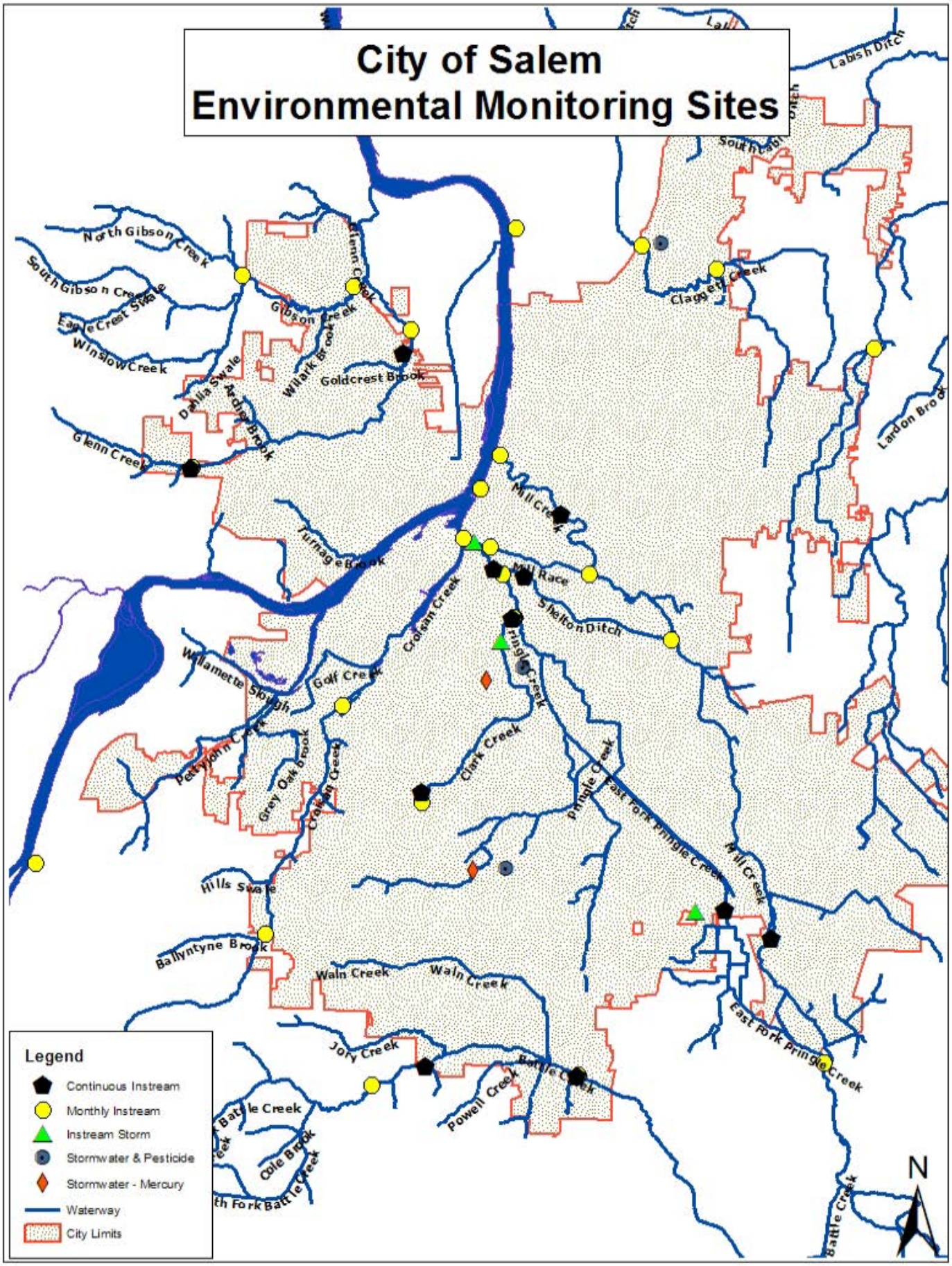

Figure 1: Surface Water and Stormwater Monitoring Sites

City of Salem Surface Water and Stormwater Monitoring Matrix

DEQ NPDES MS4 Permit Monitoring Objective	Environmental Monitoring Elements							Program Monitoring Elements				
	Instream Monitoring			Stormwater Monitoring			Biological Monitoring	Dry Weather Outfall	Pollutant Load Modeling	Literature Review	SWMP Program Monitoring *(measurable goals and BMP tracking)*	Data Evaluation
	Instream Storm	Monthly Instream	Continuous Instream	Stormwater	Pesticide	Mercury	Macro-Invertebrate					
1. Evaluate the source of the 2004/2006 303(d) listed pollutants applicable to the co-permittees permit	**Applicable 303(d) parameters will be monitored at in-stream storm event monitoring sites.**	**Upstream / Downstream configuration assists with source ID.**	**303(d) pollutants measured directly and indirectly through indicator parameters.**	**Land use based monitoring may contribute to the source evaluation of 303(d) pollutants.**	**Data will contribute to the source evaluation of applicable pesticide pollutants**	this monitoring element is not designed to meet this objective	this monitoring element is not designed to meet this objective	**Potential source ID of 303(d) pollutants.**	this monitoring element is not designed to meet this objective	**Literature review during permit term may contribute to the understanding of the source of 303(d) pollutants and most applicable BMPs.**	this monitoring element is not designed to meet this objective	**Contribute to 303(d) source evaluations**
2. Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities	**Data will be analyzed with consideration of current structural and non structural BMPs within each catchment.**	**Data will contribute to the ID of specific watersheds for focused structural and non-structural BMP efforts.**	**Data will be analyzed with consideration of current structural and non structural BMPs within each catchment.**	**Data will be analyzed with consideration of current structural and non structural BMPs within each catchment.**	**Data will be analyzed with consideration of current structural and non structural BMPs within the catchment area.**	**Data will be analyzed with consideration of current structural and non structural BMPs within the catchment area.**	this monitoring element is not designed to meet this objective	**Information gathered will contribute to the evaluation of SWMP BMPs. e.g., Illicit Discharge Elimination Program.**	**BMP effectiveness contributes to pollutant load modeling analysis.**	**Literature review during permit term that focuses on BMP performance, removal efficiency, and life cycle cost may contribute to the evaluation and prioritization of BMPs.**	**Program monitoring may help evaluate the effectiveness of SWMP BMPs.**	**Contribute to annual report and end of permit term evaluations.**
3. Characterize Stormwater based on land use type, seasonality, geography or other catchment	**Contribute to the characterization of MS4 runoff discharges.**	**Data will support seasonal, land use, and geographical characterization.**	**Data will support seasonal, land use, and geographical characterization.**	**Contribute to land use, geographical, and seasonality characterization.**	**Contribute to land use and seasonality characterization.**	**Contribute to land use and seasonality characterization.**	this monitoring element is not designed to meet this objective	this monitoring element is not designed to meet this objective	**Land use MS4 characterization contributes to pollutant load modeling analysis.**	No literature review will be done to address this objective	this monitoring element is not designed to meet this objective	**Contribute to annual report and end of permit term evaluations.**
4. Evaluate status and long-trends in receiving waters associated with MS4 stormwater discharges	**By end of permit term we expect to have enough data to evaluate the status of the three sites. Data will contribute to evaluation of long term trends in receiving**	**Contribute to the evaluation of status and trends in receiving waters. Established monitoring element, initiated in 2001.**	**Contribute to the evaluation of status and trends in receiving waters. Monitoring element established in 2006.**	**Will assist in the interpretation of status and trends in receiving waters.**	**Will contribute to the evaluation of the status in receiving waters.**	**Will contribute to the evaluation of the status in receiving waters.**	**Contribute to status and trends in biological diversity and abundance.**	this monitoring element is not designed to meet this objective	this monitoring element is not designed to meet this objective	No literature review will be done to address this objective	this monitoring element is not designed to meet this objective	**Contribute to annual report and end of permit term evaluations.**
5. Assess the chemical, biological, and physical effects of MS4 stormwater on receiving waters	**Will contribute to the assessment of chemical effects of MS4 runoff on receiving waters.**	**Will contribute to the assessment of chemical effects of MS4 runoff on receiving waters.**	**Will contribute to the assessment of chemical and physical effects of MS4 runoff on receiving waters.**	**Will contribute to the understanding of MS4 discharges that enter receiving waters.**	**Will contribute to the understanding of MS4 discharges that enter receiving waters.**	**Will contribute to the understanding of MS4 discharges that enter receiving waters.**	**Will contribute in assessing the biological effect of MS4 runoff on receiving waters.**	this monitoring element is not designed to meet this objective	**Pollutant load modeling will contribute to the understanding of the effects of MS4 runoff on receiving waters.**	**Literature review during permit term may contribute to the understanding of the effects of MS4 runoff on receiving waters.**	this monitoring element is not designed to meet this objective	**Contribute to annual report and end of permit term evaluations.**
6. Assess progress towards meeting TMDL pollutant load reduction benchmarks	**E.Coli at all sites, data will assist in assessing progress toward TMDL load reduction benchmarks.**	**E. Coli at all sites and TSS at West Fork Little Pudding location. Data will contribute in assessing progress toward TMDL load reduction benchmarks.**	**Will contribute in assessing progress towards meeting TMDL pollutant load reduction benchmarks.**	**E.Coli, Mercury and TSS** *(mercury benchmark not established at this time)* **will contribute in assessing progress towards TMDL load reduction benchmarks.**	this monitoring element is not designed to meet this objective	this monitoring element is not designed to meet this objective	this monitoring element is not designed to meet this objective	this monitoring element is not designed to meet this objective	**Data will contribute to modeling and TMDL reduction evaluations and benchmark analysis.**	No literature review will be done to address this objective	**Program monitoring may help evaluate progress towards meeting TMDL pollutant load benchmarks.**	**Contribute to end of permit term TMDL pollutant load reduction evaluations and benchmark analysis.**

Parameters, Number of Sites and Frequency	**Instream (storm event only)**	**Monthly Instream**	**Continuous Instream**	**Stormwater -** *(With DEQ approval stormwater monitoring design may be substituted with a collaborative approach with other phase I municipalities.)*	**Pesticide**	**Mercury -** *(With DEQ approval mercury monitoring design may be substituted with a collaborative approach with* ***other phase I municipalities.)***	**Macro Invertebrate Monitoring**
Parameters	BOD, TSS, Hardness, Temperature, Dissolved Oxygen, Conductivity, pH, Nitrate+Nitrite, Ammonia Nitrogen, Total Phosphorus, Total and disssolved (Cu, Pb, Zn), E. Coli.	BOD, Temperature, DO, Specific Conductivity, Turbidity, pH, Nirate+Nitrite, E. Coli [Additional parameters that are basin specific. Pringle Basin only (total and dissolved (Cu, Zn, Pb) and hardness) Little Pudding only (TSS)]	Temp, DO, pH, Specific Conductivity, Turbidity, Stage, Flow	$BOD_{5\text{-}day}$, Dissolved Oyxgen, total and disssolved (Cu, Pb, Zn), Nitrate+Nitrite N, Ammonia N, Total-P, Specfic Conductivity, Hardness, Temperature, pH, TSS, E. Coli.	Halogenated Pesticides Screen, Chlorinated Herbicides Screen	Mercury (Total Recoverable and Dissolved), Methyl Mercury (Total Recoverable and Dissolved)	Macro invertebrate screen
Number of Monitoring Location(s)	3 sites	21 sites	10 sites	3 sites	3 sites	2 sites	3 sites
Frequency or total number of storm event in permit term	25 storm events per site in permit cycle	1 per month per site, unless water levels are too low to sample, i.e. during summer months for some sites	every 15 minutes for all sites	15 storm events per site in permit cycle	4 storm events per site in permit cycle	2 storm events per year, one winter and one summer storm per site. After 2 years may request in writing to the Department that mercury and methyl mercury monitoring be eliminated	2 events per site in permit cycle

Pesticide Screen Compound List

Attachment 2

Provided by: Pacific Agricultural Laboratory

5/13/2010

Halogenated Pesticides

Analyte	Reporting limit	Analyte	Reporting limit
Acetachlor	0.20 ug/liter (ppb)	Ethalfluralin (Sonalan)	0.080 ug/liter (ppb)
Alachlor	0.080 ug/liter (ppb)	Fenarimol (Rubigan)	0.080 ug/liter (ppb)
Aldrin	0.080 ug/liter (ppb)	Fenvalerate	0.080 ug/liter (ppb)
Benfluralin (Balan)	0.080 ug/liter (ppb)	Flutolanil	0.80 ug/liter (ppb)
Bifenthrin	0.080 ug/liter (ppb)	Folpet	0.20 ug/liter (ppb)
α-BHC	0.080 ug/liter (ppb)	Heptachlor	0.080 ug/liter (ppb)
β-BHC	0.080 ug/liter (ppb)	Heptachlor epoxide	0.080 ug/liter (ppb)
δ-BHC	0.080 ug/liter (ppb)	Hexachlorobenzene	0.080 ug/liter (ppb)
γ-BHC (Lindane)	0.080 ug/liter (ppb)	Iprodione (Rovral)	0.080 ug/liter (ppb)
Captafol	0.080 ug/liter (ppb)	Kelthane (Dicofol)	0.20 ug/liter (ppb)
Captan	0.20 ug/liter (ppb)	Metolachlor (Dual)	0.20 ug/liter (ppb)
Chlordane	0.80 ug/liter (ppb)	Methoxychlor	0.080 ug/liter (ppb)
Chloroneb (Terraneb)	0.20 ug/liter (ppb)	Mirex	0.080 ug/liter (ppb)
Chlorobenzilate	0.20 ug/liter (ppb)	Norflurazon (Solicam)	0.080 ug/liter (ppb)
Chlorothalonil (Bravo)	0.080 ug/liter (ppb)	Ovex	0.080 ug/liter (ppb)
Cyfluthrin	0.80 ug/liter (ppb)	Oxyfluorfen (Goal)	0.080 ug/liter (ppb)
Cyhalothrin	0.80 ug/liter (ppb)	PCA	0.080 ug/liter (ppb)
Cypermethrin	0.80 ug/liter (ppb)	PCNB	0.080 ug/liter (ppb)
Dacthal	0.080 ug/liter (ppb)	Permethrin	0.80 ug/liter (ppb)
p,p'-DDD	0.080 ug/liter (ppb)	Prodiamine (Barricade)	0.080 ug/liter (ppb)
p,p'-DDE	0.080 ug/liter (ppb)	Pronamide (Kerb)	0.080 ug/liter (ppb)
p,p'-DDT	0.080 ug/liter (ppb)	Propachlor	0.20 ug/liter (ppb)
Deltamethrin	0.80 ug/liter (ppb)	Propanil	0.080 ug/liter (ppb)
Dicloran (Botran)	0.080 ug/liter (ppb)	Propiconazole	0.20 ug/liter (ppb)
Dieldrin	0.080 ug/liter (ppb)	Pyrethrins	0.80 ug/liter (ppb)
Endosulfan I(Thiodan)	0.080 ug/liter (ppb)	Terbacil	0.080 ug/liter (ppb)
Endosulfan II	0.080 ug/liter (ppb)	Toxaphene	4.0 ug/liter (ppb)
Endosulfan sulfate	0.080 ug/liter (ppb)	Trifloxystrobin	0.080 ug/liter (ppb)
Endrin	0.080 ug/liter (ppb)	Triflumazole	0.080 ug/liter (ppb)
Endrin aldehyde	0.080 ug/liter (ppb)	Trifluralin	0.080 ug/liter (ppb)
Esfenvalerate (Asana)	0.080 ug/liter (ppb)	Vinclozalin	0.080 ug/liter (ppb)

Chlorinated Herbicides in Water

EPA Method 8321B (HPLC-MS)

The chlorinated acids are converted to their free acid forms. These residues are then identified and quantitated as free acids.

Analyte	Reporting Limit
2,4-D	0.080 ug/liter (ppb)
2,4-DB	0.080 ug/liter (ppb)
2,4,5-T	0.080 ug/liter (ppb)
2,4,5-TP	0.080 ug/liter (ppb)
Acifluorfen	0.080 ug/liter (ppb)
Bentazon	0.080 ug/liter (ppb)
Clopyralid	0.080 ug/liter (ppb)
Dicamba	0.080 ug/liter (ppb)
Dichlorprop	0.080 ug/liter (ppb)
Dinoseb	0.080 ug/liter (ppb)
MCPA	0.080 ug/liter (ppb)
MCPP	0.080 ug/liter (ppb)
Pentachlorophenol	0.080 ug/liter (ppb)
Picloram	0.080 ug/liter (ppb)
Quinclorac	0.080 ug/liter (ppb)
Triclopyr	0.080 ug/liter (ppb)