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2012 Stormwater Outfall Monitoring Report

APDES Permit No. AKS-052558

MUNICIPALITY OF ANCHORAGE
WATERSHED MANAGEMENT PROGRAM

FINAL REPORT

December 2012

WATERSHED MANAGEMENT

HDR Alaska

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WATERSHED MANAGEMENT PROGRAM

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1.0 Introduction

1.1 Background

The U.S. Environmental Protection Agency (EPA) issued the Municipality of Anchorage (MOA) and the Alaska Department of Transportation and Public Facilities (ADOT&PF) a Municipal Separate Storm Sewer System (MS4) permit under the National Pollutant Discharge Elimination System (NPDES) in 1999. EPA re-issued the permit (Permit No. AKS-052558) in October 2009 (EPA 2009a), with an effective date of February 1, 2010, that included a requirement to conduct stormwater outfall monitoring at 10 priority stormwater outfalls beginning in the second year of the permit. The MOA has taken the lead role in implementing the monitoring requirements of the permit. Since permit issuance, EPA has delegated the NPDES stormwater program to the Alaska Department of Environmental Conservation (ADEC) who now oversees its implementation. The permit is now administered by the (ADEC) under the Alaska Pollutant Discharge Elimination System (APDES).

The APDES MS4 permit establishes minimum control measures requiring the co-permittees to develop programs and policies, and implement actions designed to prevent and control contaminants entering publicly-owned storm sewer systems. The permit also identifies a number of objectives for monitoring of which the stormwater outfall monitoring is one component. The objective most relevant to stormwater outfall monitoring is to broadly identify fecal coliform and petroleum product loading from stormwater. To accomplish this objective, a variety of land uses must be examined to ensure representative water quality conditions across the MS4 area are included in the monitoring program. This report and the data collected during the monitoring program fulfill the annual outfall monitoring objectives of the APDES Permit. The stormwater sampling that was conducted during 2012, was the second of four years of monitoring that will be performed for the program.

1.2 Stormwater Definition

The EPA has recognized urban stormwater as a major contributor to pollution of the nation's streams, rivers, and lakes. EPA and delegated states are using the NPDES MS4 permit to control pollutants from urban stormwater to the maximum extent practicable. Urban stormwater can contribute to the degradation of the quality of water bodies. Runoff from precipitation and snowmelt events can transport contaminants from impervious surfaces, such as driveways, sidewalks, and roads and semi-pervious surfaces, such as lawns, into the local water bodies. Most stormwater runoff flows into a storm sewer system or directly to a water body, often without receiving treatment to remove the pollutants.

In issuing the Anchorage MS4 permit, EPA recognized that a number of water bodies in the greater Anchorage watershed have been categorized as impaired under section 303(d) of the Clean Water Act. For thirteen of the water bodies impaired for elevated concentrations of fecal coliform and one water body impaired for petroleum hydrocarbons, ADEC has developed (and EPA has approved) Total Maximum Daily Loads (TMDL) plans to improve water quality to the extent that the waters will meet the current standards. The TMDLs identify stormwater runoff as a contributor of fecal coliform and petroleum hydrocarbon contamination to the water bodies; and the TMDLs establish reduction goals for concentrations of these pollutants in stormwater.

1.3 Goals and Objectives of Monitoring Program

The monitoring elements of the MS4 permit are designed to identify sources of stormwater pollution, such as fecal coliform and petroleum hydrocarbons, monitor the effectiveness of best management practices (BMPs), and monitor the status of stormwater outfalls and receiving waters. The goal of the stormwater outfall monitoring component of the permit is to obtain sufficient data to characterize the quality of the stormwater runoff for pollutants identified in the permit. By monitoring the same outfalls over the four-year period, the results should provide a qualitative characterization that meets the objectives identified in the APDES Permit and Fact Sheet (EPA, 2009a and 2009b).

The stormwater outfall monitoring program measured pollutants and pollutant indicators during precipitation events that generated runoff at 10 high priority stormwater outfall sites. This monitoring program will allow MOA to meet the EPA objectives specified in the permit. In preparing the permit, EPA anticipated that the stormwater outfall monitoring would address the following objectives:

- Broadly estimate the annual pollutant loading for fecal coliform and petroleum hydrocarbon to specific watersheds
- Assess the effectiveness of existing stormwater controls
- Prioritize portions of the MS4 that need additional controls
- Provide feedback on whether TMDL objectives are being met

2.0 Explanation of Report Organization

This report is divided into the following sections:

- Introduction, background information, and goals and objectives of the program
- Summary information about the field phase of the project including project design, site selection and descriptions, parameters to be measured, field and laboratory procedures, deviations from the QAPP, and summary of QA/QC results
- Tabular and graphical summaries of the data along with a discussion of results
- Summary and preliminary conclusions
- References
- Appendices that include: field photographs, laboratory data reports, field and laboratory data validation summary, and completed field log forms

3.0 Monitoring Program

3.1 Sampling Design

Beginning in the summer of 2011 and for the following three years, the 10 priority outfalls will be sampled four times each summer when there is sufficient precipitation to generate runoff (typically, 0.1 to 0.25 inches depending upon percent impervious land use within the watershed). For planning purposes, 0.1 inches of rain was used as the trigger for a potential sampling event. Samples were analyzed for parameters that serve as indicators of nonpoint sources of pollutant inputs. Monitoring of the outfalls included both *in situ* field measurements and discrete grab samples to be submitted for laboratory analyses. At each outfall, the following parameters were monitored as stipulated in the *Stormwater Outfall Monitoring Plan,* which is Appendix B of the Quality Assurance Project Plan (QAPP)(MOA 2011), to evaluate the quality of the stormwater: flow, dissolved oxygen (DO), pH, temperature, turbidity, 5-day biochemical oxygen demand (BOD_5), fecal coliform, and total suspended solids (TSS). For outfalls whose tributary land uses are predominantly commercial, industrial, or paved collector or arterial streets or parking lots, samples were also analyzed for total aromatic hydrocarbons (TAH) and total aqueous hydrocarbons (TAqH). In addition, the supplemental measurement of specific conductance was also obtained with the field parameters.

3.2 Monitoring Site Selection and Descriptions

The stormwater outfall monitoring prescribed in the permit requires the MOA to monitor specific water quality parameters and flow four times each year at 10 locations. To best meet the permit objectives, the outfalls selected were intended to represent a diversity of land uses. The MOA developed a selection process for identifying the 10 outfalls as the highest priority locations from a list of 30 medium to high priority outfalls. First, MOA identified the following criteria for targeted monitoring within the Anchorage Basin:

- Include a variety of land uses
- Include storm drains that discharge to water quality impaired (303(d)-listed) stream(s)
- Experience approximately the same annual precipitation
- Be geographically diverse while allowing relatively easy access to all outfalls during a single rainfall event

To meet these criteria, MOA selected a portion of the MS4 that extends from C Street on the west to Lake Otis Parkway on the east, and from the northern portion of the Chester Creek watershed to the southern edge of the Furrow Creek Watershed. The targeted area included substantially urbanized portions of the watershed tributary to Chester Creek, Furrow Creek, Little Campbell Creek, and Campbell Creek. These four streams are impaired for fecal coliform and have an approved TMDL and therefore, meet one of the permit objectives (ADEC 2004a, 2004b, 2005, and 2006).

Within the target area, the MOA identified as priorities outfalls that represent homogeneous land use subbasins, heterogeneous land use subbasins, and subbasins with and without oil/grit separator (OGS) devices. This diversity of land uses and structures was designed to meet the permit objectives of broadly quantifying pollutant loads and assessing effectiveness of existing best management practices (BMPs).

Monitoring data from subbasins meeting the four different conditions (homogeneous land use, heterogeneous land use, with OGS and without OGS) were intended to serve different functions. For the subbasins with a homogeneous land use:

- Data were intended to identify specific pollutants originating from a predominant land use that require additional controls. Specific controls could be tailored to a specific land use and targeted for use in those watersheds.
- Data from basins with homogeneous land uses are considered appropriate for developing loading estimates for fecal coliform and TAH, as described below.
- Fecal coliform, TAH, and TAqH data were also considered appropriate for comparison with receiving water quality criteria. Since water quality criteria do not apply directly to stormwater, the criteria were intended to serve as benchmarks.
- Fecal coliform data were considered appropriate for comparison with TMDL reduction goals for fecal coliform to determine improvement over time.

For subbasins with heterogeneous land uses:

- Data were intended to be used to develop loading estimates of fecal coliform and petroleum hydrocarbons.
- Data were also to be used to assess pollutants originating across land uses that may require additional controls, and additional BMP controls that could be applied across the basin.
- Fecal coliform and petroleum hydrocarbon data were considered appropriate for comparison with receiving water quality criteria.
- Fecal coliform data were considered appropriate for comparison with TMDL reduction goals for fecal coliform to determine improvement over time.

For subbasins with or without OGS systems:

- Data were intended to be used to assess the effectiveness of the OGS systems and determine whether additional OGS systems could be installed to improve stormwater quality.
- Petroleum hydrocarbon data were considered appropriate for comparison with receiving water quality criteria.

MOA used its hydrogeographic database (HGDB) and other municipal geographic data to select subbasins with the aforementioned characteristics. Application of this selection process resulted in the initial identification of 10 priority outfalls (Table 1). Following the pre-sampling field reconnaissance, it was determined that one of the selected outfalls (Node ID 299-20, highlighted in Table 1) exhibited severe corrosion within the outfall pipe and was not suitable for sampling. An alternative outfall location within the Little Campbell Creek Watershed, having the same land use and BMP characteristics (Node ID 847-1) was selected as having the next highest priority.

To facilitate sample labeling and simplify outfall identification in the field per the *Monitoring, Evaluation and Quality Assurance Plan* (MOA 2011), the outfall stations were sequentially numbered from south to north along the sampling corridor (SWM01 thru SWM10)(refer to Table 2). The physical characteristics of each outfall including: physical location, geographic location, outfall dimensions, acreage of subbasin, and percent impervious surface of subbasin are presented in Table 2. An overview map is presented in Figure 1 that shows the final 10 monitoring outfall locations along with the subbasins for each watershed. Detailed larger scale maps that clearly show land use types for each of the outfalls and subbasins are depicted in Figure 2 through Figure 8 (refer to Table 2 for outfall cross reference location).

Table 1. Top 10 Priority and Replacement Outfalls

Subbasin ID	Outfall/Node ID	Watershed	Contributing Land Use*	OGS Present?	Priority Rank
10 Identified Priority Outfalls					
805	207-1	Campbell Creek	CI	Yes	1
219	314-22	Chester Creek	R	Yes	2
1224a	1224-1	Campbell Creek	R	Yes	3
132	499-1	Chester Creek	CI	Yes	4
554	525-2	Chester Creek	M	No	5
549	86-1	Chester Creek	M	No	6
1224b	1224-2	Campbell Creek	R	Yes	6
133	299-20	Chester Creek	CI	No	8
507	484-1	Chester Creek	CI	No	8
1040b	1040-3	Little Campbell Cr.	R	No	10
Medium Priority Replacement Outfall					
1210	847-1	Little Campbell Cr.	CI	No	17

Yellow highlighted Subbasin 133 was replaced with yellow highlighted Subbasin 1210.
*R = Residential; CI = Commercial and Industrial; M = Mixed

Table 2. Outfall Identification, Physical Location, and Characteristics

Station ID	Detail Map	Outfall Node ID	Subbasin ID	Physical Location	Latitude	Longitude	Outfall Diam (in)	Acreage	Percent Impervious
Little Campbell Creek Watershed									
SWM01	Fig 2	1040-3	1040b	Ridgemont	61° 07.526'	-149° 50.196'	18	91.38	35.52
SWM02	Fig 3	847-1	1210	Home Depot	61° 08.665'	-149° 50.797'	18	37.17	81.53
Campbell Creek Watershed									
SWM03	Fig 4	1224-1	1224a	Sylvan (north)	61° 09.548'	-149° 52.443'	36	99.99	70.05
SWM04	Fig 4	1224-2	1224b	Sylvan (south)	61° 09.545'	-149° 52.451'	18	20.10	31.78
SWM05	Fig 5	207-1	805	East 56th	61° 10.202'	-149° 52.326'	24	58.34	75.41
Chester Creek Watershed									
SWM06	Fig 6	314-22	219	Maplewood	61° 11.996	-149° 50.750'	26	33.81	37.26
SWM07	Fig 7	484-1	507	New Seward	61° 12.100'	-149° 52.114'	24	50.17	87.68
SWM08	Fig 8	86-1	549	New Seward	61° 12.095'	-149° 52.114'	42	354.62	68.94
SWM09	Fig 7	499-1	132	Ben Boeke	61° 12.176'	-149° 52.554'	24	40.04	53.65
SWM10	Fig 7	525-2	554	Eagle Street	61° 12.161'	-149° 52.486'	24	47.51	74.62

*R = Residential; CI = Commercial and Industrial; M = Mixed

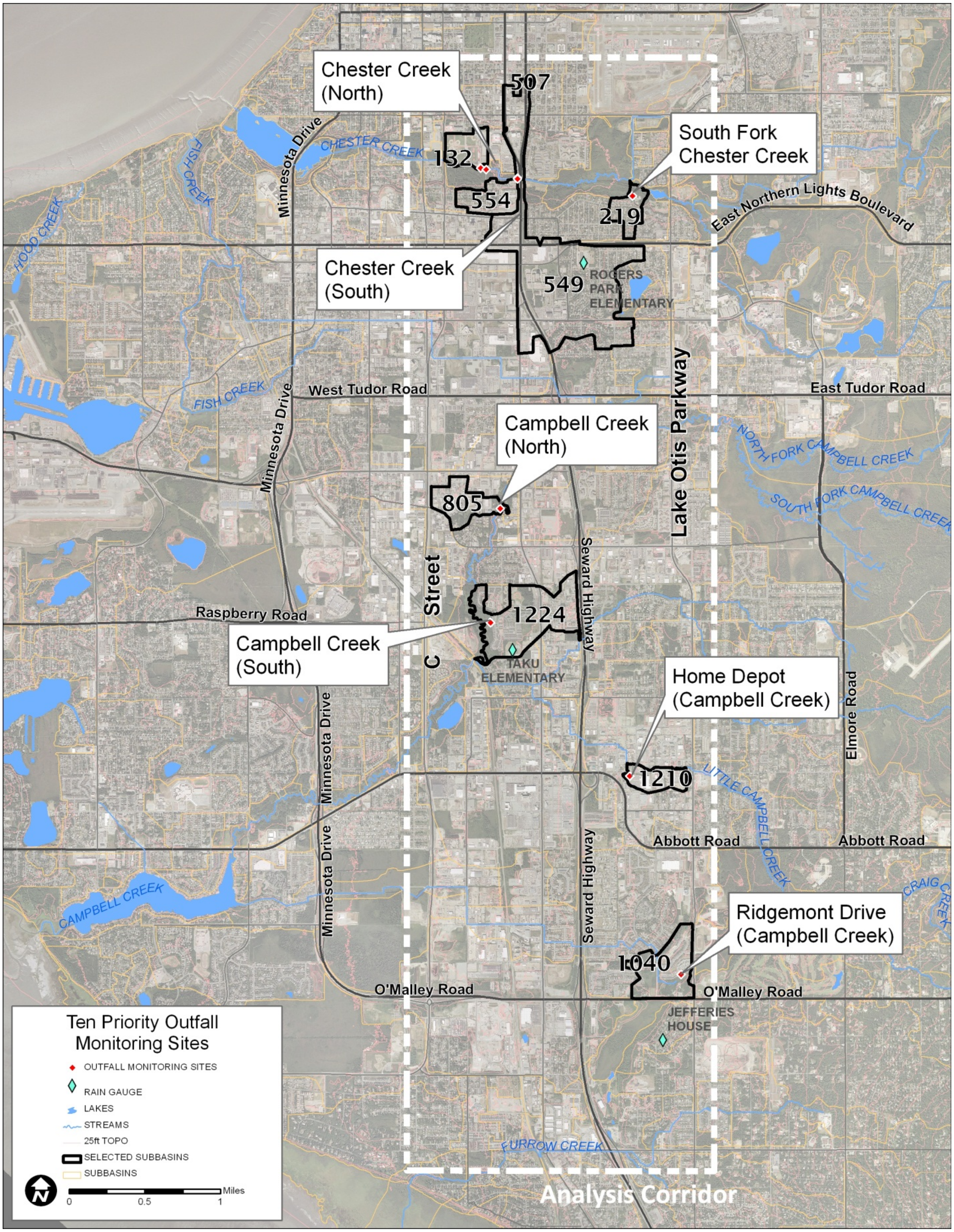


Figure 1. Overview Map of the Ten Final Outfall Monitoring Sites and Subbasins

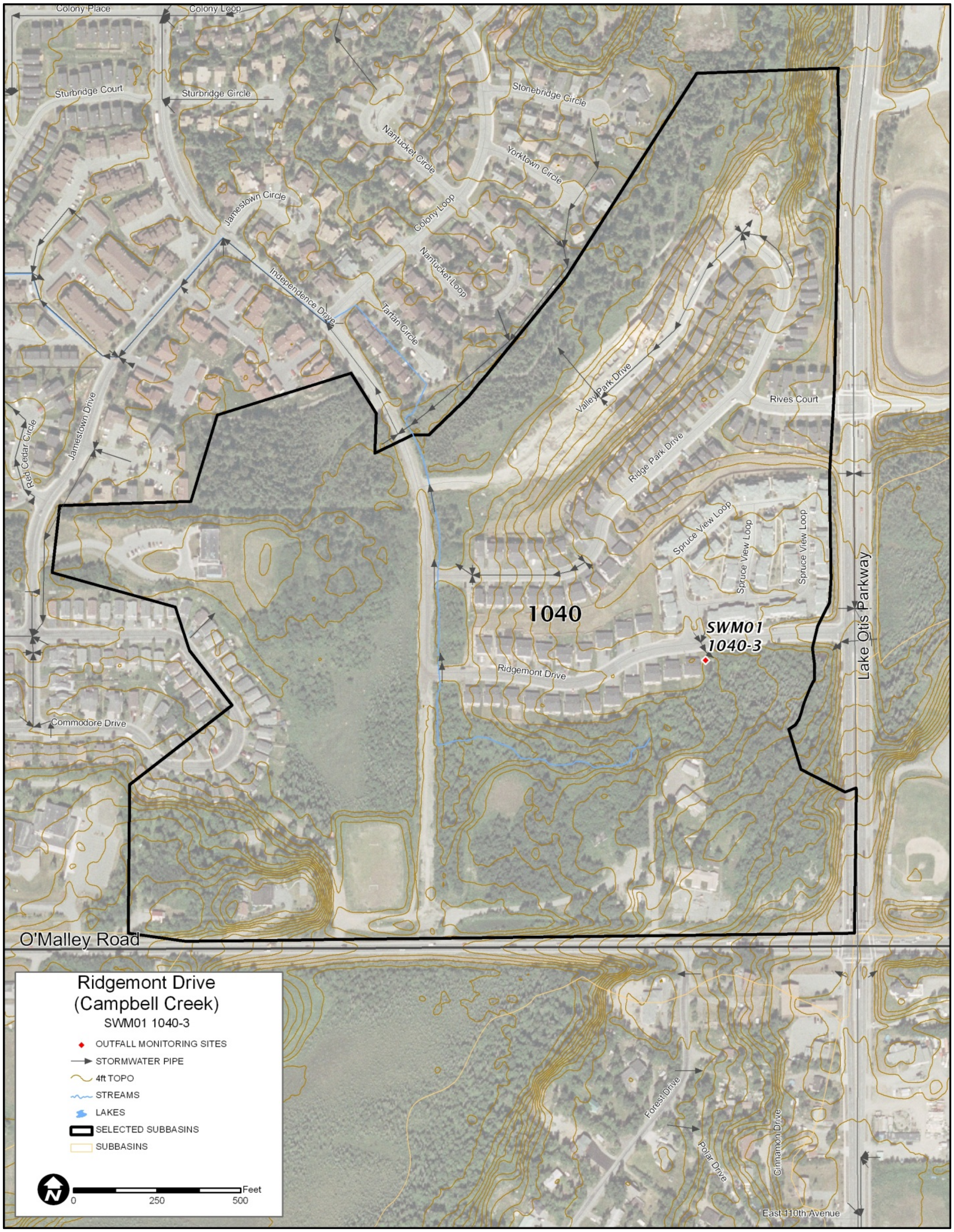


Figure 2. Outfall SWM01, Ridgemont Drive (Little Campbell Creek)

Figure 3. Outfall SWM02, Abbot Road at Home Depot (Little Campbell Creek)

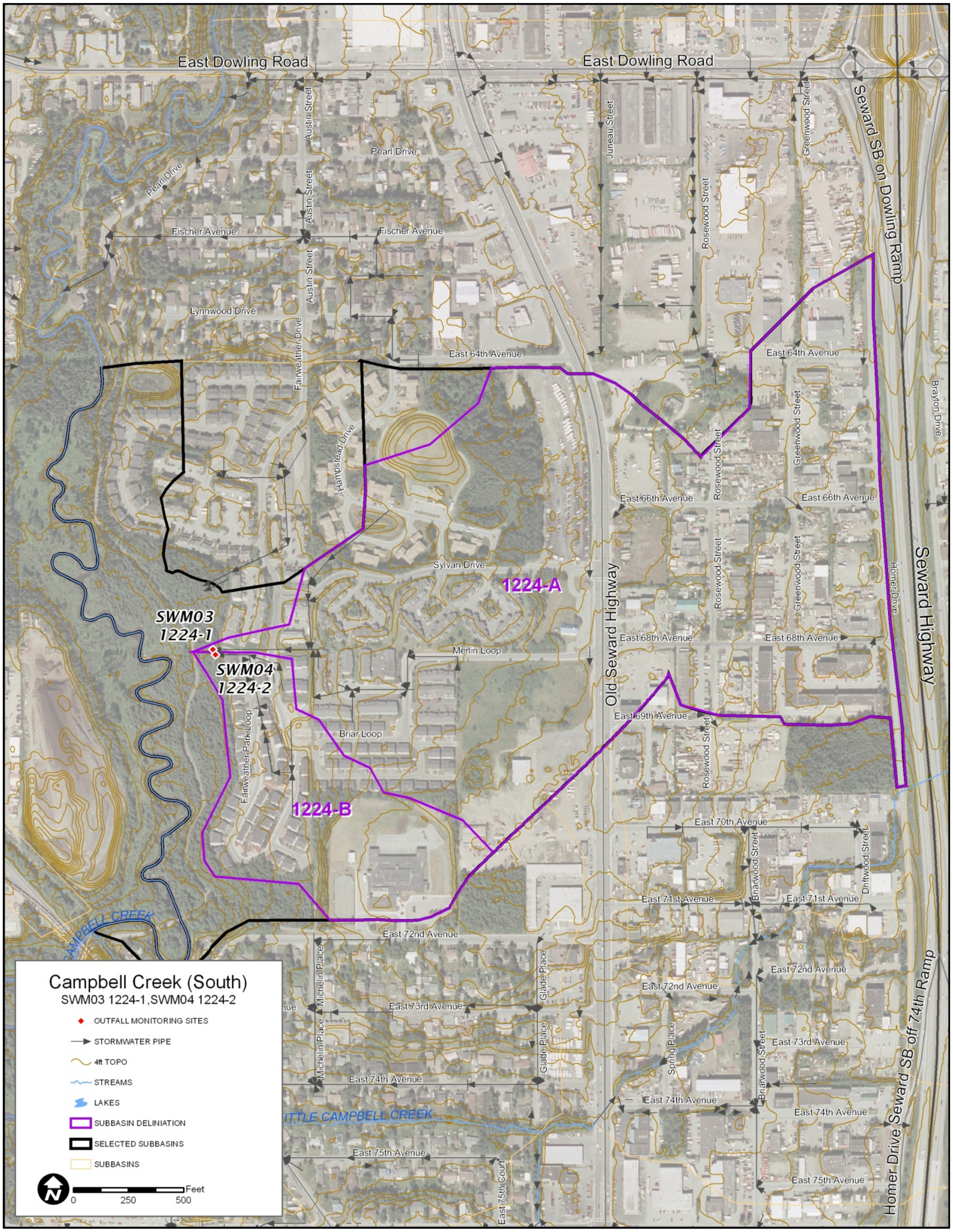


Figure 4. Outfalls SWM03 and SWM04, Fairweather Loop off Sylvan Drive (Campbell Creek)

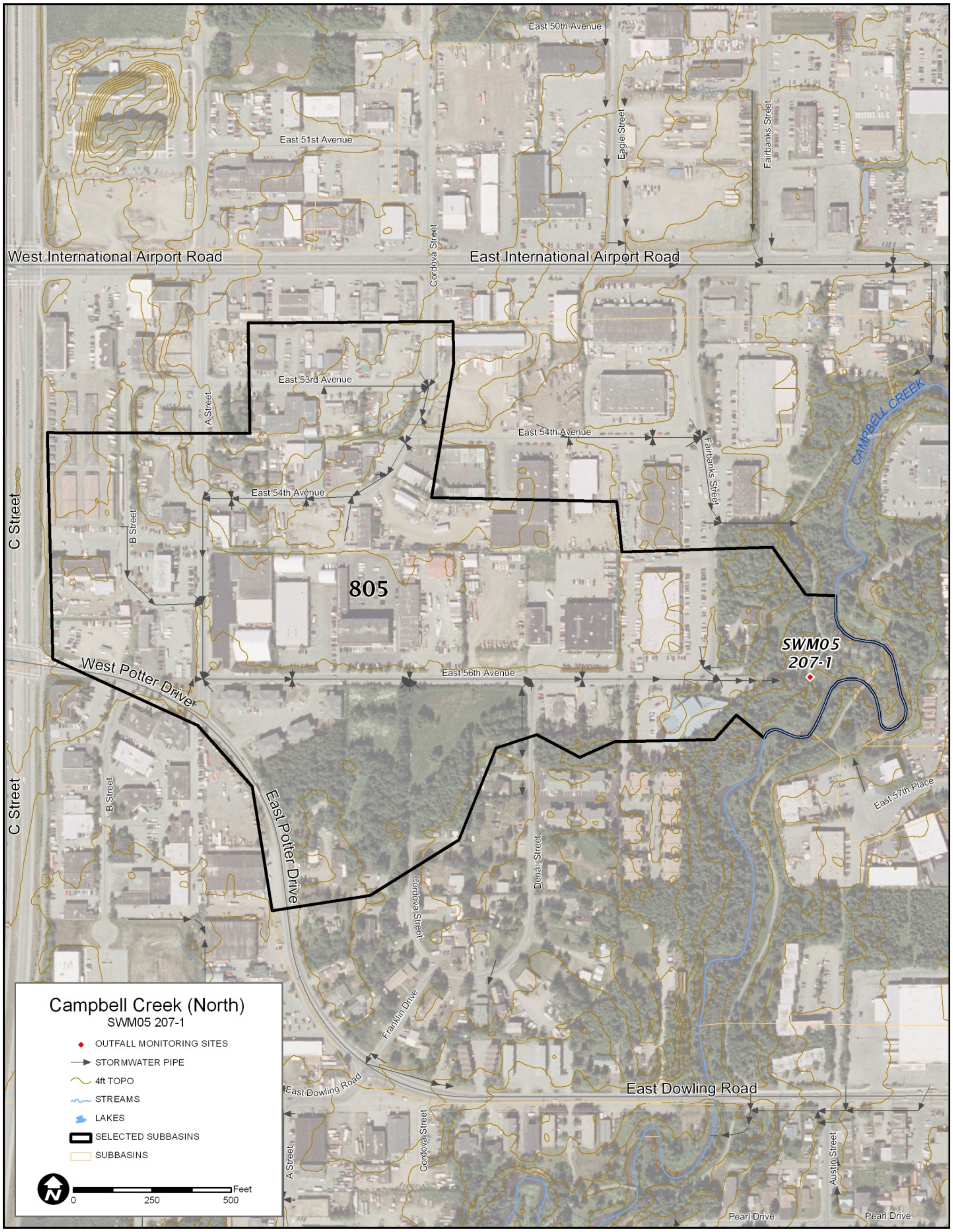


Figure 5. Outfall SWM05, East 56th Avenue (Campbell Creek)

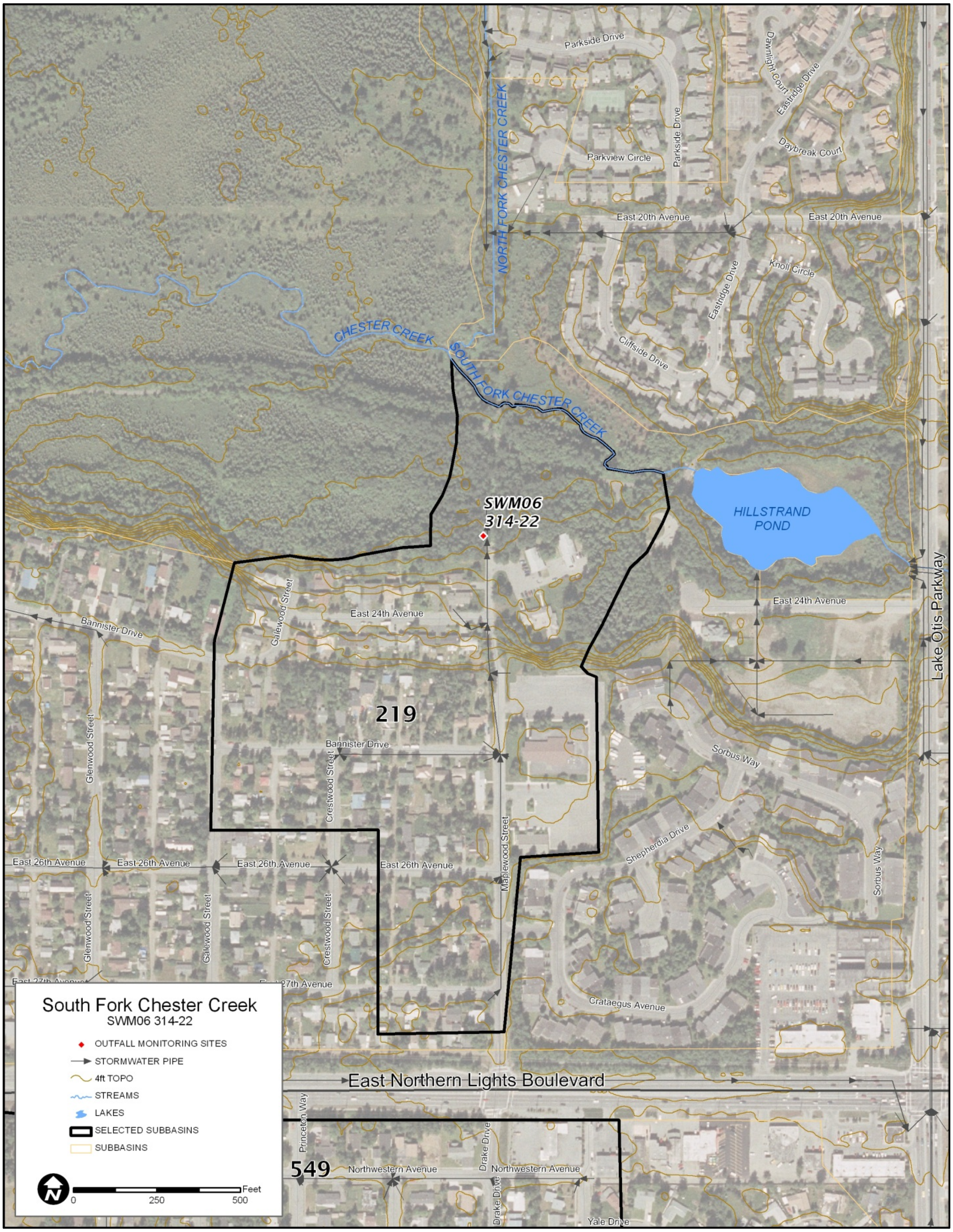


Figure 6. Outfall SWM06, Maplewood Street (South Fork Chester Creek)

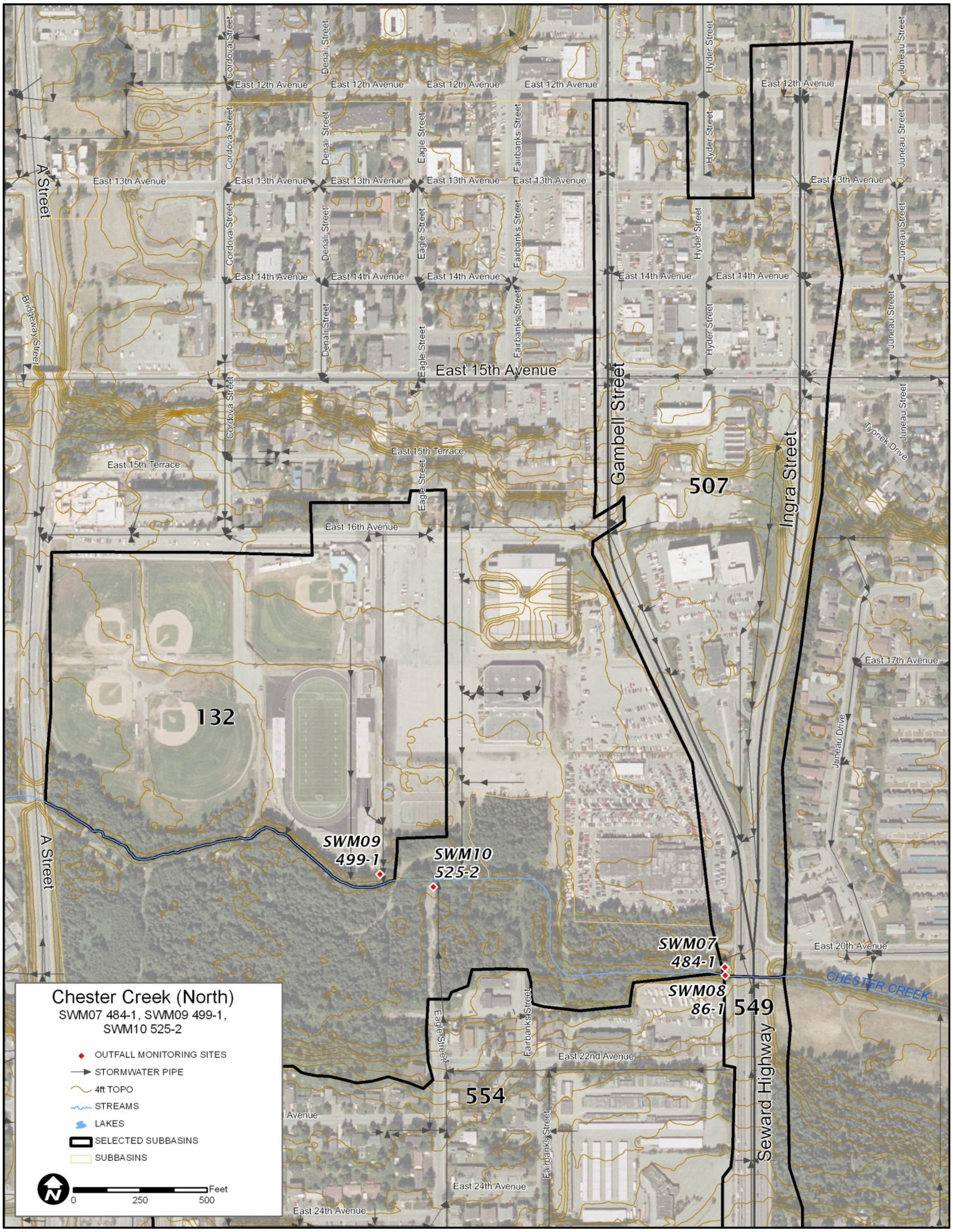


Figure 7. Outfalls SWM07, SWM09, & SWM10 (Chester Creek)

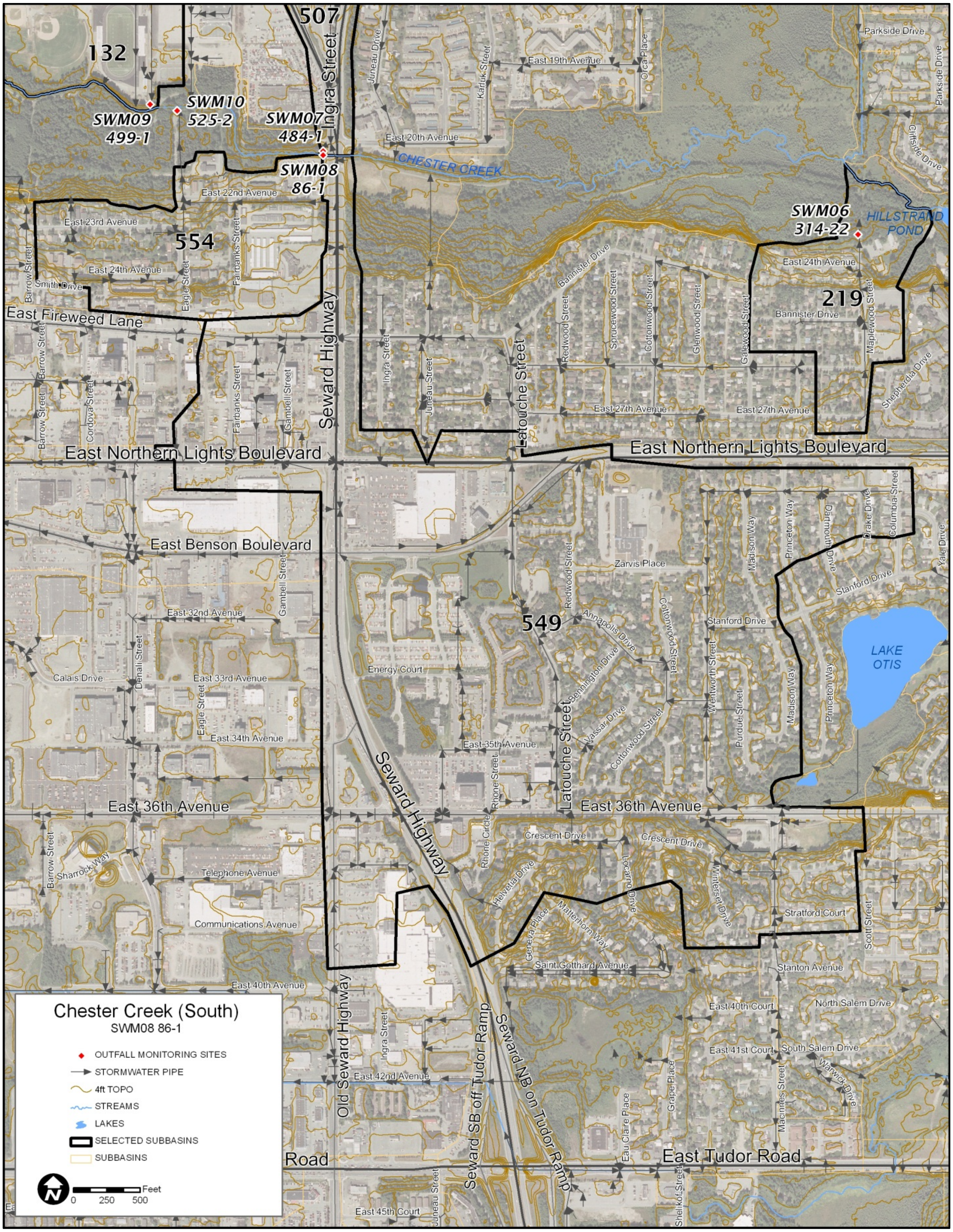


Figure 8. Outfall SWM08, New Seward Highway (Chester Creek)

3.3 Measured Parameters

Parameters that were measured during the stormwater outfall monitoring are shown in Table 3. The table includes measurement type, analysis method, frequency of sampling, purpose of monitoring, as well as whether the parameter was measured in the field or submitted for laboratory analysis. Measurement quality objectives for each parameter including precision, accuracy, sensitivity, and measurement range were presented in the final QAPP for the program (MOA 2011). In addition to the water quality parameters listed in Table 3, field observations were recorded at each outfall including: any evidence of oily sheen, scum, odor, detritus, floating material, water color and clarity, deposits or stains, vegetation, and any other pertinent observation.

Three tipping bucket rain gauges were installed within the monitoring area to record precipitation during each monitoring event. The rain gauges were located along the north-south sampling corridor in order to provide a good representation of rainfall within each of the sampled subbasins (refer to Figure 1 for rain gauge locations).

Table 3. Measured Parameter, Type, Purpose, and Method of Analysis

Parameter	Type of Sample	Measurement Type	Method	Purpose	Frequency
Flow	IR	Field	Flow meter, or bucket	Characterize flow	4/year
Conductance	IR	Field	EPA 120.1/ YSI 556	Stormwater quality	4/year
DO	IR	Field	EPA 360.1/ YSI 556	Stormwater quality	4/year
pH	IR	Field	EPA 150.2/ YSI 556	Stormwater quality	4/year
Temperature	IR	Field	SM2550B/ YSI 556	Stormwater quality	4/year
Turbidity	IR/G	Field	EPA 180.1M/ Hach 2100	Stormwater quality	4/year
BOD_5	G	Laboratory	SM 5210 B	Stormwater quality	4/year
Fecal Coliform	G	Laboratory	SM 9222D	Stormwater quality & estimate loading	4/year
TSS	G	Laboratory	SM 2540D	Stormwater quality	4/year
TAH	G	Laboratory	EPA 624	Stormwater quality & estimate loading	4/year
TAqH	G	Laboratory	EPA 625 + EPA 624	Stormwater quality & estimate loading	4/year

IR = instantaneous recording of field analysis; G = grab sample for laboratory analysis; M = modified for field use

Table 4 identifies the parameters that were monitored at each outfall location. The commercial industrial (CI) land use categories in the table represent predominantly commercial and industrial areas with paved collectors, arterial streets and parking lots. Outfalls with watersheds dominated by these land uses are those most likely to contribute petroleum hydrocarbon pollutants to stormwater and were monitored for TAH and the TAqH in addition to the other parameters. For this monitoring program, two CI subbasin categories were selected that had existing OGS systems and two others were selected that did not have OGS systems. Other than petroleum hydrocarbons, all other parameters were measured at each outfall location.

Table 4. Parameters Measured at each Subbasin Outfall

Station ID	Outfall ID	Watershed	Contributing Land Use*	OGS Present?	Field Parameters						Lab Samples				
					Flow	Cond	pH	Temp	DO	Turb	BOD	FC	TSS	TAH	TAqH
SWM01	1040-3	L. Campbell Cr	R	No	x	x	x	x	x	x	x	x	x		
SWM02	847-1	L. Campbell Cr	CI	No	x	x	x	x	x	x	x	x	x	x	x
SWM03	1224-1	Campbell Cr	R	Yes	x	x	x	x	x	x	x	x	x		
SWM04	1224-2	Campbell Cr	R	Yes	x	x	x	x	x	x	x	x	x		
SWM05	207-1	Campbell Cr	CI	Yes	x	x	x	x	x	x	x	x	x	x	x
SWM06	314-22	Chester Cr	R	Yes	x	x	x	x	x	x	x	x	x		
SWM07	484-1	Chester Cr	CI	No	x	x	x	x	x	x	x	x	x	x	x
SWM08	86-1	Chester Cr	M	No	x	x	x	x	x	x	x	x	x		
SWM09	499-1	Chester Cr	CI	Yes	x	x	x	x	x	x	x	x	x	x	x
SWM10	525-2	Chester Cr	M	No	x	x	x	x	x	x	x	x	x		

*R-Residential, CI-Commercial/Industrial, M-Mixed

3.4 Field Sampling Procedures

Precipitation was monitored throughout the summer rainfall season in order to capture four storms that were representative of typical Anchorage rainfall conditions. Water sampling was conducted during storm events that were both expected to create runoff in the MS4 area and that met antecedent dry weather conditions. Typically, rain events yielding 0.1 inches to 0.25 inches within a 24-hour period were considered sufficient to generate runoff at all sites. Therefore, a minimum of 0.1 inches of rain was required before targeting an event. In addition, all storm events were to be preceded by a relatively dry period. A dry period was defined as rainfall of ≤ 0.1 inches in the preceding 24 hour period.

Once a storm event was identified for sampling, the field crew prepared field sampling equipment and laboratory bottles for sampling. All portable water quality measurement instrumentation were pre-calibrated immediately prior to going in the field for each event per the manufacturer's recommendation as outlined in Appendix H of the QAPP. In addition, all bottles were pre-labeled with station location, date, number of bottles, and analysis type and method.

The field sampling team consisted of two people to address safety concerns and to allow one-person to be the designated recorder while the second person performed measurements and conducted the grab sampling. Upon arriving on site at the outfall, the field team took flow measurements and placed the YSI 556 multi-probe into the outfall stream in order to allow the probes to equilibrate for at least three minutes prior to taking any measurements.

The QAPP called for flow measurements to be made by either of two methods; installation of a portable weir or by timing the collection of flow in a bucket of known volume. However, after performing the pre-sampling reconnaissance in 2011 it was determined that only one of the ten outfalls was amenable to collection of the flow in a bucket. For most outfalls, a drop did not exist at the end of the outfall pipe where the discharge could easily be collected with a bucket. Likewise, it was determined that due to the varying outfall sizes, condition of the outfall pipe, and corrugated nature of most outfall pipes, that a portable weir sized properly for variable flow and that would seal completely with the outfall pipe would be nearly impossible to install in a timely manner during a storm sampling event. For these reasons, flow was measured with an acoustic Doppler flow meter and staff gauge. The flow meter was used to measure the average velocity of the outfall pipe. The average velocity was then used in conjunction with the water depth and pipe diameter to calculate the instantaneous flow of each outfall.

After measuring flow, the field crew measured dissolved oxygen (DO), conductivity, pH, and temperature with a YSI 556 multi-probe system. Turbidity was also measured in the field by collecting a discrete sample that was analyzed on-site with a portable Hach 2100P/Q turbidimeter. All water quality measurements were obtained from the water flowing out of the end-of-pipe prior to any mixing with the receiving water body. All field measurements were recorded on project specific field log forms that were bound in the project field log books along with field instrument calibration logs (refer to Appendix D).

The field crew obtained the water samples necessary to fill the laboratory bottles for BOD, TSS, fecal coliform, TAH, and TAqH. The water quality samples were collected to represent the water column by collecting samples from the water flowing out of the end-of-pipe. Sample crews took extra care not to disturb any accumulated sediment when collecting a water sample. To avoid having to perform decontamination procedures, all samples, with the exception of TAH, were collected directly into their respective sample containers. In the case of TAH, the samples were first collected into the pre-cleaned and certified TAqH (PAH) bottle which was then used to carefully fill the 40-ml vials for TAH analyses. The TAqH bottle was then topped off with additional water from the outfall discharge. Since the TAqH bottles were pre-cleaned and certified, it was unnecessary to perform equipment rinsate analyses. Once the water samples were collected, the field crew recorded visual observations at each outfall location.

The field crew conducted replicate field measurements and laboratory analyses at a rate of 15 percent per sampling event. This resulted in two additional measurements for all parameters except TAH and TAqH. TAH and TAqH required only one additional field measurement since fewer outfalls were sampled. Additional water for TAH and TAqH was taken at one station to allow the laboratory to perform matrix spike/ matrix spike duplicate (MS/MSD) analyses. TAH analyses also included a trip blank sample that was provided by the laboratory and that accompanied the sample bottles in the field.

Precipitation was recorded using tipping a bucket rain gauge and data logger recording in 0.01 inch increments. During precipitation events, the collection cup in the gage collects precipitation until it reaches the equivalent of 0.01 inches of precipitation where upon the bucket tips, triggering a reed switch and recording an event with a time stamp. These events are stored in the data logger and downloaded into a computer program where they can be summarized over different time intervals or graphed as a time series. Three rain gauges were installed for this program and were located at Rogers Park Elementary School, Taku Elementary School, and on Forest Drive (“Jefferies’ House”) and represented the northern, middle, and southern portions of the study area respectively (refer to Figure 1 for rain gauge locations).

3.5 Sampling Handling and Chain of Custody Procedures

BOD, TSS, fecal coliform, TAH, and TAqH samples were collected, preserved, and packed for shipment to the laboratory as described in the QAPP. Since the laboratory that was selected for the program, SGS North America, Inc., is located in Anchorage, no special sample shipping or packaging was required. Upon sample collection, all samples were immediately chilled to 6°C with gel ice and delivered to the laboratory by the field crew following the sample collection effort. All samples were transferred to the laboratory under strict chain of custody (COC) procedures as outlined in the QAPP. Copies of all completed COCs are included with the laboratory data reports in Appendix B. When necessary, fecal samples were taken to the laboratory in two batches during the storm event to ensure that the 6-hour holding time requirement was met.

3.6 Laboratory Analyses

The water quality constituents that were selected for this program were established based upon the requirements of MOA's APDES Stormwater Permit (AKS-052558). All analyses were conducted by SGS North America, Inc. a laboratory that is certified for conducting such analyses. All analytical methods (refer to Table 3) were based upon approved EPA methodology and included all necessary Quality Assurance/Quality Control (QA/QC) procedures and analyses as outlined in the methodology and detailed in the QAPP.

The laboratory QA/QC activities provide information needed to assess potential laboratory contamination, analytical precision and accuracy, and representativeness. Analytical quality assurance for this program included:

- Employing analytical chemists trained in the procedures and analytical methods to be conducted
- Adherence to documented procedures, EPA methods, and laboratory SOPs
- Calibration of analytical instruments
- Use of quality control samples, internal standards, surrogates, and standard reference material (SRMs)
- Complete documentation of sample tracking and analysis

Internal laboratory control checks included the use of internal standards, method blanks, MS/MSDs, duplicates, laboratory control spikes, and SRMs as required by the sample analysis methodology. For additional detail on laboratory QA/QC procedures, refer to the QAPP.

3.7 Deviation from the QAPP

Ten priority outfalls were selected for sampling based on a series of selection criteria and are identified in Appendix B of the QAPP. However, following pre-sampling field reconnaissance in 2011, it was determined that one of the selected outfalls (Node ID 299-20) could not be sampled due to severe corrosion within the outfall pipe. Therefore, this outfall was replaced with the next highest priority outfall (Node ID 847-1) that had the same land use and BMP characteristics.

The QAPP called for flow measurements to be made by either of two methods; installation of a portable weir or by timing the collection of flow in a bucket of known volume. However, after performing the pre-sampling reconnaissance in 2011 it was determined that only one of the ten outfalls was amenable to collection of the flow in a bucket since a drop did not exist at most outfalls where a bucket could be used to collect the flow. Likewise, it was determined that due to the varying outfall sizes, condition of the outfall pipe, and corrugated nature of most outfall pipes, that a portable weir would be nearly impossible to install in a timely manner during each storm that would be sized properly for variable flow and that would seal completely with the outfall pipe. For these reasons, flow was measured with with an acoustic Doppler flow meter, which provided the average flow velocity, and a staff gauge which provided the centerline depth of the flow. This information was then used to calculate the volumetric flow rate at each site.

3.8 QA/QC and Data Validation Results

Quality Control and Quality Assurance (QA/QC) procedures were followed according to the QAPP (MOA 2011). The procedures included analytical checks (field replicates, trip blanks, matrix spikes and matrix spike duplicates); instrument calibration; and procedures to assess data for precision, accuracy, representativeness, comparability, and completeness.

Verification analyses for laboratory parameters were conducted by SGS. The data review focused on criteria for the following QA and QC parameters and their overall effects on the data:

- Sample handling (chain of custody)
- Temperature blank
- Holding time compliance
- Matrix spikes and matrix spike duplicates
- Field replicate comparison
- Data validation.

The laboratory performing the analyses, SGS, is certified by the EPA and the Alaska Drinking Water Program and has an approved QA/QC program. Analytical methods and testing procedures were in adherence with EPA-approved protocols and guidelines.

Sample custody was adequately maintained for the samples. The coolers transporting the samples were held at temperatures of less than 6 °C. The holding times for all parameters tested were adhered to and were analyzed before the hold time expirations.

The analyses for the fecal coliform, biological oxygen demand (BOD), total suspended solids (TSS), total aqueous hydrocarbons (TAqH), and total aromatic hydrocarbons (TAH) were reported as required with appropriate method detection limits and report detection limit.

The QA/QC officer validated all data reported by the laboratory. Data that was determined to be a biased low estimate was flagged based on low recovery rates from laboratory control samples. Any data that was considered suspicious was also rejected and flagged as such. For a more detailed summary of field and laboratory data validation results, refer to Appendix C.

Other QA/QC procedures included a field audit in 2011 of the sampling team to ensure that all field protocols were being followed and to ensure that protocols being used were sufficient. The field audit conducted concluded that all protocols were being followed. The field team was also required to QC all field data at the end of each event to insure all data was collected and complete.

4.0 Results and Discussion

The 2012 stormwater monitoring at the 10 long-term monitoring sites was initiated in July and was the second year of monitoring for the program. Approximately seven inches of rain (including snow) had been measured in 2012 at the National Oceanic and Atmospheric Administration (NOAA), National Weather Service's PAFC weather station located at the Anchorage International Airport (AIA) before the first event was sampled on 15 July (Figure 9). Four stormwater outfall monitoring events were conducted in 2012 as required by the *Stormwater Outfall Monitoring Plan* (MOA 2011) and the APDES Permit. Sampling events took place on 15 July, 30 July, 20 August, and 23 August and included sampling of all ten outfalls during each of the four events. Based on the long-term historic record, rainfall for July was fairly typical with measured precipitation in 2012 slightly higher than normal whereas the August time period was lower than the long-term mean (Figure 9).

4.1 Precipitation

A total of four events were sampled in 2012 starting on 15 July and ending on 23 August. Total rainfall, as measured at the three stations in the monitoring area, during each monitored event ranged from 0.17 inches during the first event to 0.45 inches during the fourth event although the second and third events were similar in size to the last event (Table 5 and Figure 10). The highest outfall flow rates usually occurred during the third event for each of the outfalls. Flow rates at the outfall draining the largest of the watersheds, SWM08, were measured at 1,868 gallons per minute (gpm) which was more that ten times higher than all other sites (Table 6 and Figure 11). Refer to Table 2 for a cross reference of monitoring station locations, outfall identification numbers, subbasins, and physical locations within each watershed.

Daily rainfall records are illustrated in Figure 10 for each of the three rain guages located along the sampling corridor. Since the three rain gauges were not active throughout the entire year, rainfall records from the PAFC weather station at the AIA were used to supplement the three project rain gauges to provide a comparison to the long term historic record (Table 5).

The first storm event took place on July 15th with rainfall ranging from 0.17 inches recorded at Rogers Park to 0.23 inches recorded at AIA. Light rain $\leq$ 0.1 inches was recorded at all four locations during the preceding 24-hr period with the rain event beginning in the evening on July 14th. Sampling was initiated the following morning after 0.1 inches of rain had fallen.

The second storm event occurred on July 30th with recorded rain ranging from 0.25 inches at AIA to 0.36 inches at Taku with 0.0 inches inches recorded within the study area during the preceding 24-hr period. Sampling for the second event was initiated within 7 hours of the beginning of the storm after approximately 0.15-0.25 inches of rain had fallen.

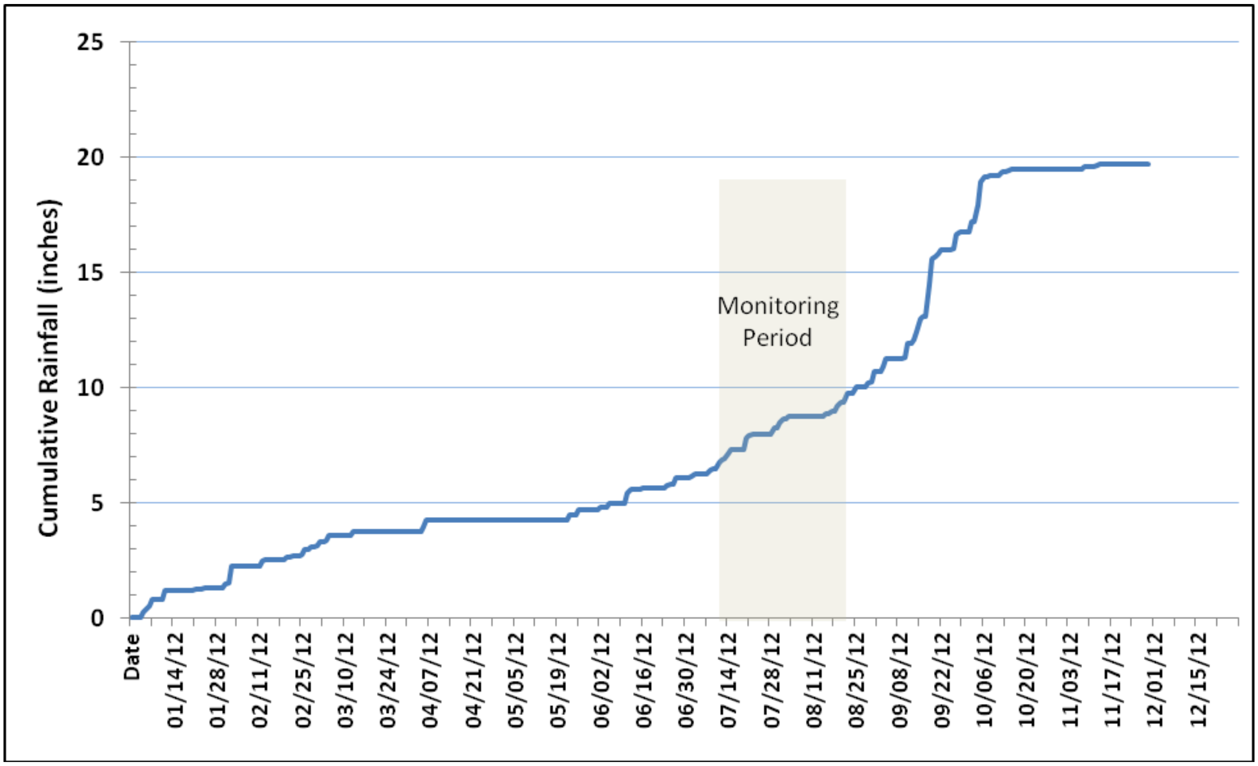
The third event took place on August 20th. Precipitation ranged from 0.25 inches at AIA to 0.33 inches recorded at both Taku and Jefferies'. Very light precipitation of 0.01 to 0.02 inches was recorded within the study area during the preceding 24-hr period. Outfall monitoring for the third storm event was intiated within 7-8 hours of the start of the storm event after approximately 0.15 inches of rain had fallen.

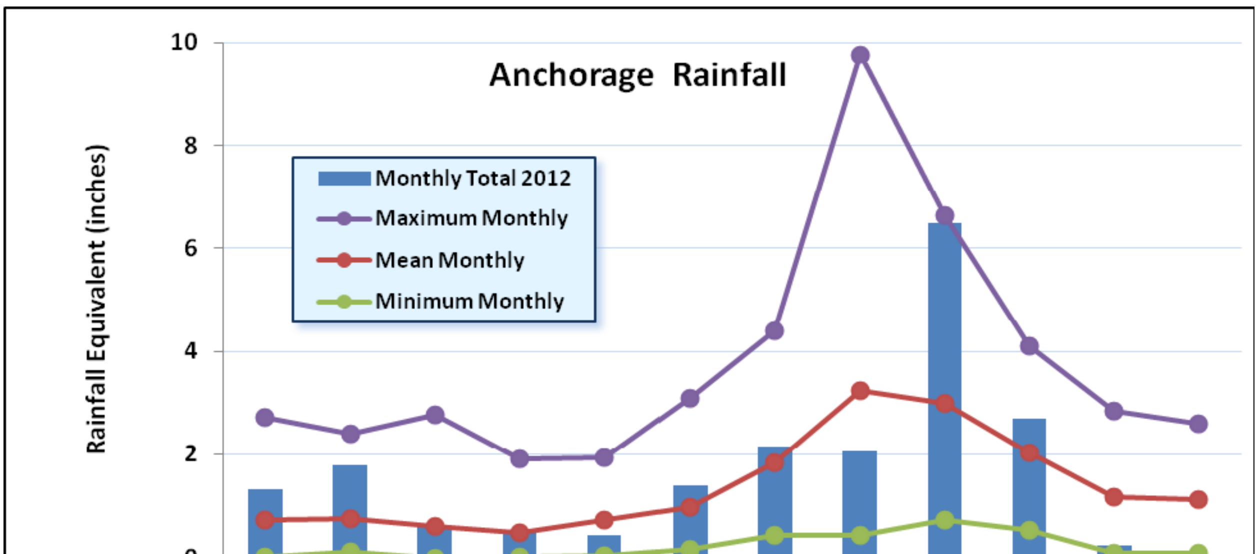
The fourth monitoring event took place on August 23rd. Precipitation for this event ranged from 0.31 inches at Jefferies' to 0.45 inches at Taku. No precipitation was recorded at any of the rain gauges during preceding 24-hr period. Outfall monitoring for the fourth storm event began within 5-6 hours of the start of the storm event with the majority of the storm occuring prior to the start of sampling. Although all of the outfalls were found to be flowing, the discharge rates were not as large as expected and seemed to respond quickly to the drop in rainfall rate.

Table 5. Anchorage Precipitation Data for 7 Days Prior to Each Sampling Event

Date	PANC NOAA Airport (in)	Rogers Park Elementary (in)	Taku Elementary (in)	Jeffries' Residence (in)
07/08/12	0	0	0	0.01
07/09/12	0.19	0.13	0	0.01
07/10/12	0.04	0.07	0.03	0.03
07/11/12	T	0	0	0
07/12/12	0.3	0.15	0.17	0.18
07/13/12	0.1	0.03	0.05	0.05
07/14/12	0.06	0.1	0.07	0.06
07/15/12 (Event 1)	0.23	0.17	0.19	0.22
07/23/12	0.03	0.01	0.01	0.08
07/24/12	0	0	0	0
07/25/12	0	0	0	0
07/26/12	0	0	0	0
07/27/12	0	0	0	0
07/28/12	0	0	0	0
07/29/12	T	0	0	0
07/30/12 (Event 2)	0.26	0.26	0.36	0.29
08/13/12	0	0	0	0
08/14/12	0	0	0	0
08/15/12	T	0	0	0
08/16/12	0.11	0.04	0.05	0.19
08/17/12	T	0	0	0.01
08/18/12	0.1	0.07	0.05	0.07
08/19/12	0.01	0.02	0.01	0.01
08/20/12 (Event 3)	0.25	0.28	0.33	0.33
08/21/12	0.14	0.01	0	0
08/22/12	0	0	0	0
08/23/12 (Event 4)	0.38	0.39	0.45	0.31

T = Trace level measurement

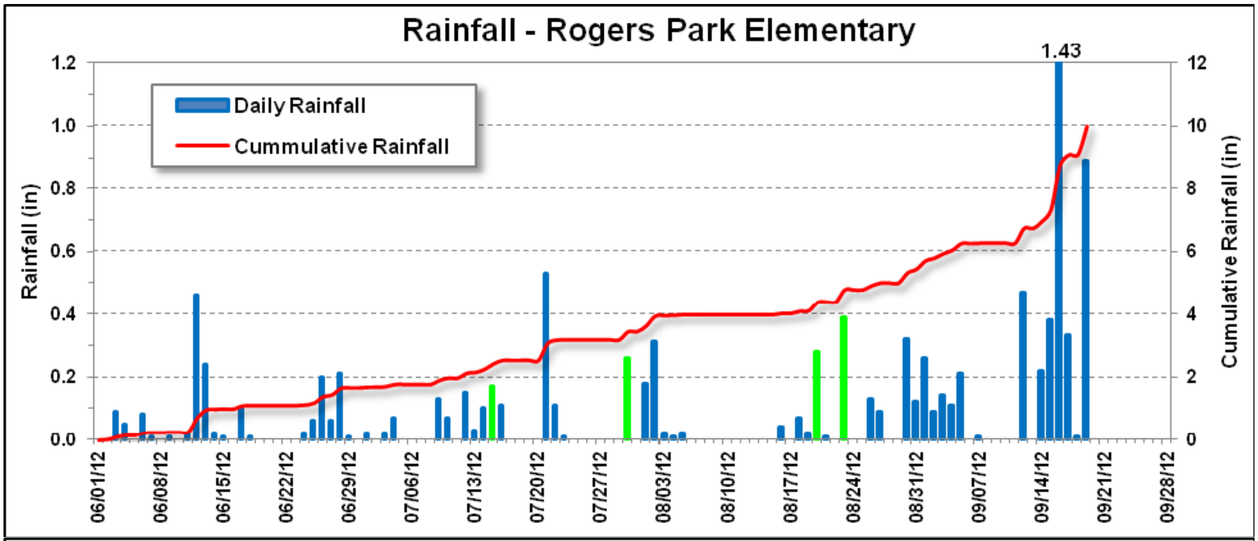




	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Monthly Total 2012	1.32	1.79	0.64	0.50	0.44	1.39	2.15	2.05	6.49	2.70	0.23	
Maximum Monthly	2.71	2.40	2.76	1.91	1.93	3.09	4.39	9.77	6.64	4.11	2.84	2.60
Mean Monthly	0.73	0.74	0.60	0.47	0.72	0.97	1.83	3.25	2.99	2.03	1.16	1.11
Minimum Monthly	0.02	0.11	0.00	0.02	0.03	0.17	0.42	0.43	0.72	0.54	0.08	0.09

Note: Data for 2012 is incomplete at this time and includes only the period of 1/1/12 through 11/25/12.

Figure 9. Cumulative, Monthly, and Historic Rainfall Measured at the PANC NOAA Weather Station. Snowfall Has Been Converted to Rain Equivalent.


Rainfall - Rogers Park Elementary
Daily Rainfall
Cummulative Rainfall
Rainfall (in)
Cumulative Rainfall (in)
1.43
06/01/12
06/08/12
06/15/12
06/22/12
06/29/12
07/06/12
07/13/12
07/20/12
07/27/12
08/03/12
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08/31/12
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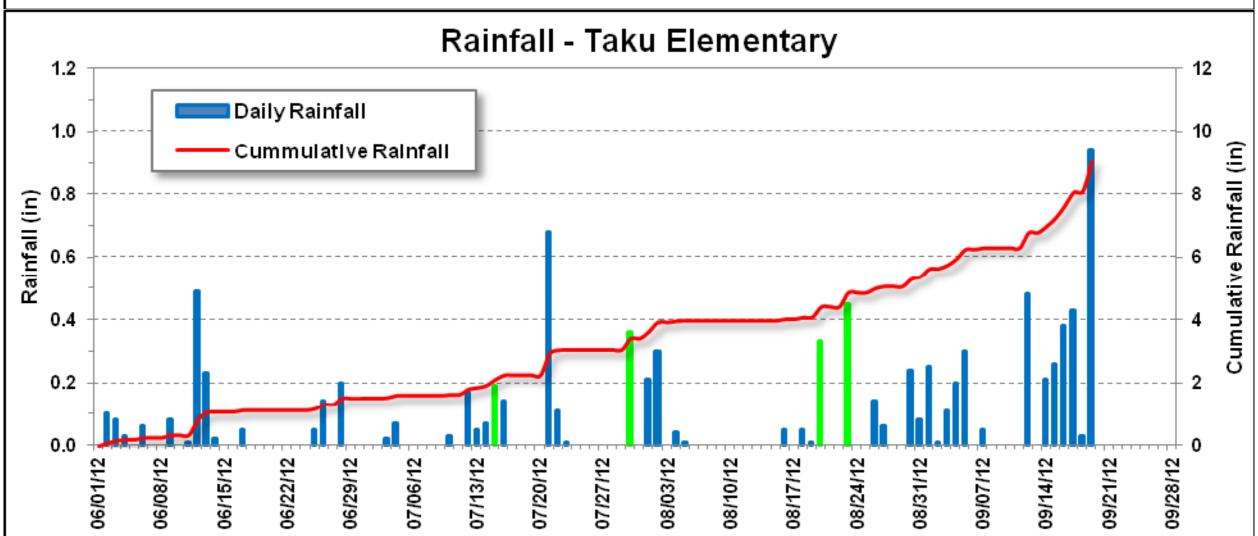
09/14/12
09/21/12
09/28/12


Rainfall - Taku Elementary
Daily Rainfall
Cummulative Rainfall
Rainfall (in)
Cumulative Rainfall (in)
06/01/12
06/08/12
06/15/12
06/22/12
06/29/12
07/06/12
07/13/12
07/20/12
07/27/12
08/03/12
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09/14/12
09/21/12
09/28/12

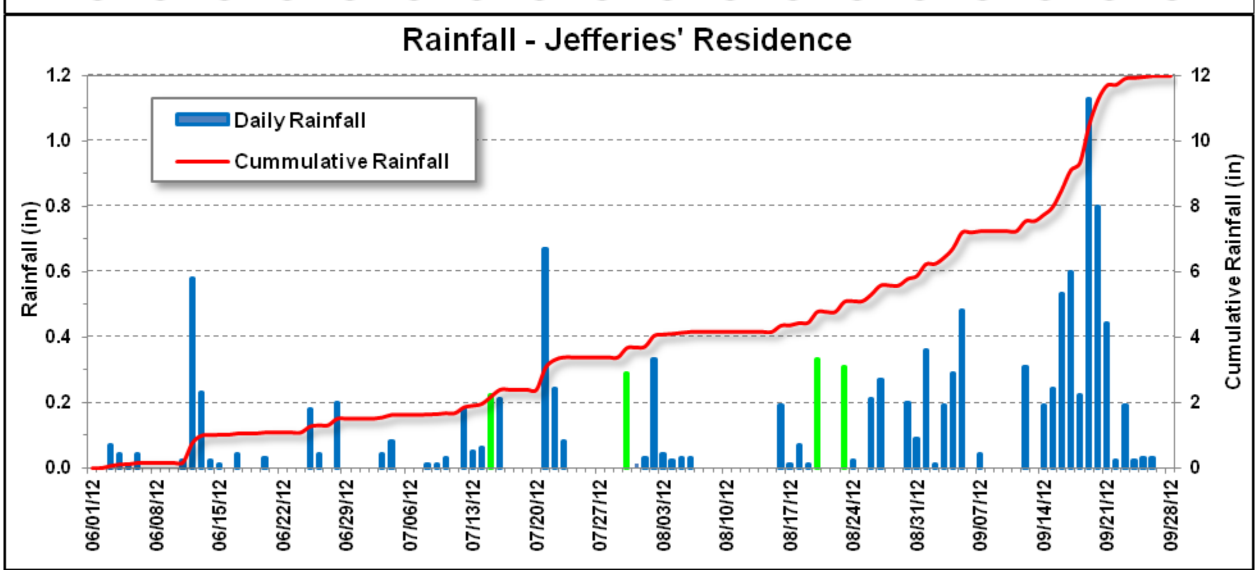

Rainfall - Jefferies' Residence
Daily Rainfall
Cummulative Rainfall
Rainfall (in)
Cumulative Rainfall (in)
06/01/12
06/08/12
06/15/12
06/22/12
06/29/12
07/06/12
07/13/12
07/20/12
07/27/12
08/03/12
08/10/12
08/17/12
08/24/12
08/31/12
09/07/12
09/14/12
09/21/12
09/28/12

Figure 10. Rainfall Measured at the Three Monitoring Rain Gauges. (note: sampling days highlighted in green)

4.2 Field Measurements

The results of field measurements for flow, turbidity, DO, conductivity, pH, and temperature are shown graphically in Figure 11 through Figure 16 and in Table 6 and Table 7. Where appropriate, field and laboratory measurements were compared against the most stringent Alaska Water Quality Standard (AWQS) numeric criteria for each parameter as a reference (refer to Table 10 for AWQS benchmarks used for comparisons). The AWQS do not directly apply to stormwater meaning that data found during this study that is over the AWQS does not mean a violation has occurred.

Flow rates were highly variable between sites and storm events with SWM08 having highest flow rates for three of the four storm events. Flow rates ranged from no discharge at two locations to 1,868 gal/min at SWM08 during the third storm event. The highest flows for six of the ten locations occurred during the third event on 20 August. Three locations (SWM02, SWM03, and SWM04) had the highest measured flow during the second storm event, and one location (SWM01) had highest flows during the first storm event.

Mean turbidity levels ranged from a low of 9.8 NTUs at SWM02 to 195 NTUs at SWM07. Station SWM07 was found to have the highest turbidity levels for three of the four storm events. Large differences between outfalls are expected for turbidity since it is highly dependent on the drainage area and is a function of the type of useage, percent impervious surfaces, amount of disturbed land from construction and other activities, drainage slope, flow rate, and other factors.

Although not required by the monitoring plan, conductivity was recorded at each site since it was available on the portable multi-parameter field instrumentation and was considered useful for interpretation of the data. Conductivity was then converted to total dissolved solid (TDS) concentrations so that comparisons could be made with AWQS criteria. The highest TDS concentrations generally occurred during the second and third storm events which also coincided with the highest outfall flows. Mean TDS concentrations ranged from 29.7 mg/L at SWM01 to 186.7 mg/L at SWM04. Although elevated conductivities and TDS can be indicative of contaminants, the highest concentrations measured were well within expected ranges for stormwater (EPA 1983). Also, the highest TDS concentrations that were measured at any site were less than half of the most restricive AWQS criteria of 500 mg/L.

Dissolved oxygen levels were generally found to be fairly high and near saturation. The highest concentrations at five locations were seen during the fourth storm event which is not unexpected since oxygen saturation levels increase as water temperatures decrease. Many of the outfalls had fairly turbulent flows which tend to raise DO levels. The lowest DO concentrations were seen at SWM03 with one concentration of 6.80 mg/L measured during the third storm event which was below the minimum AWQS criteria of 7.0 mg/L for the growth and propagation of fish, shellfish, and other aquatic life, and wildlife.

Measurements of pH in stormwater were all within AWQS criteria for all storm events and all locations. pH ranged from a low of 6.95 at SWM06 to a high of 7.69 at SWM03. Rainfall is often slightly acidic but exposure to minerals in soils typical mitigates any brief depressions.

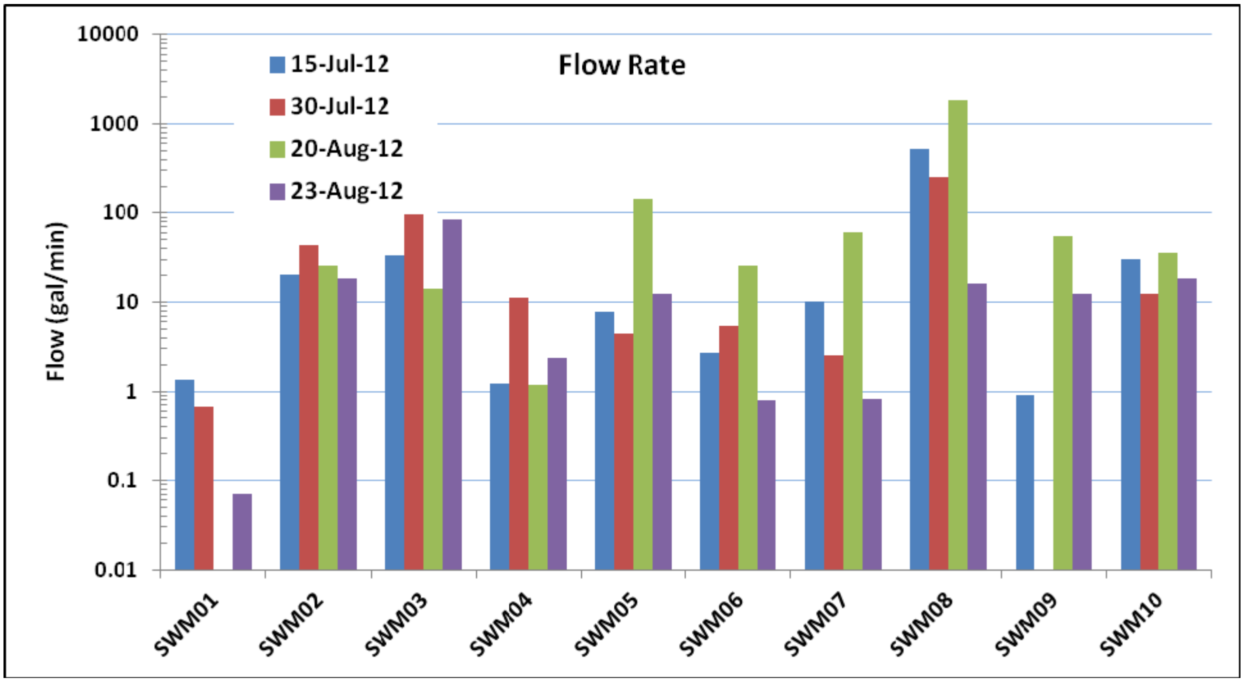


Figure 11. Flow Rates Measured at Monitoring Sites During all Four Events.

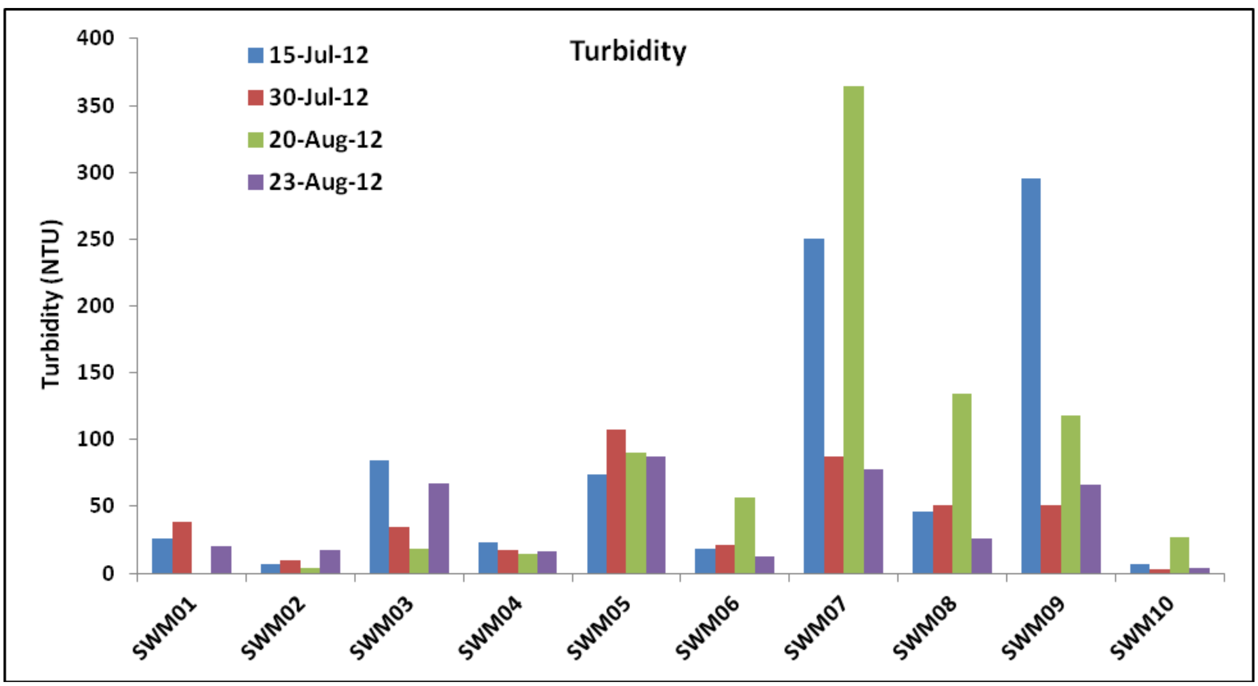


Figure 12. Turbidity Measured in Stormwater Sampled at Monitoring Sites During all Four Events.

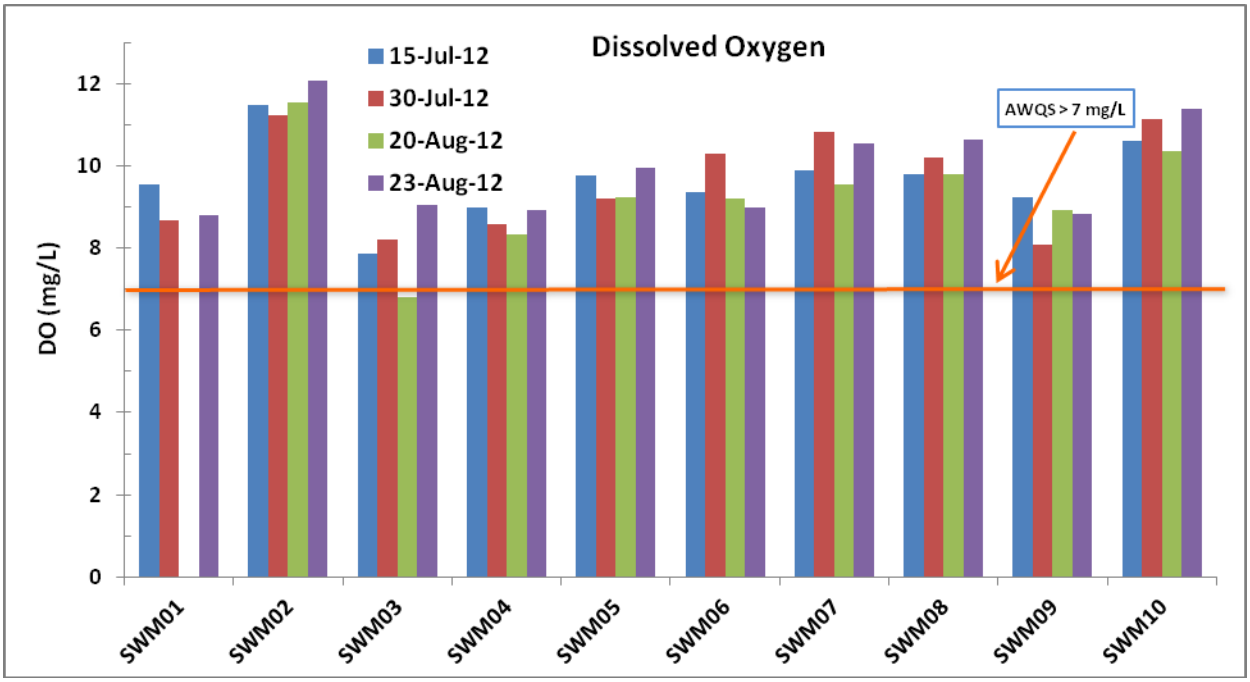


Figure 13. Dissolved Oxygen Measured in Stormwater Sampled at Monitoring Sites During all Four Events. (AWQS Criteria > 7 mg/L)

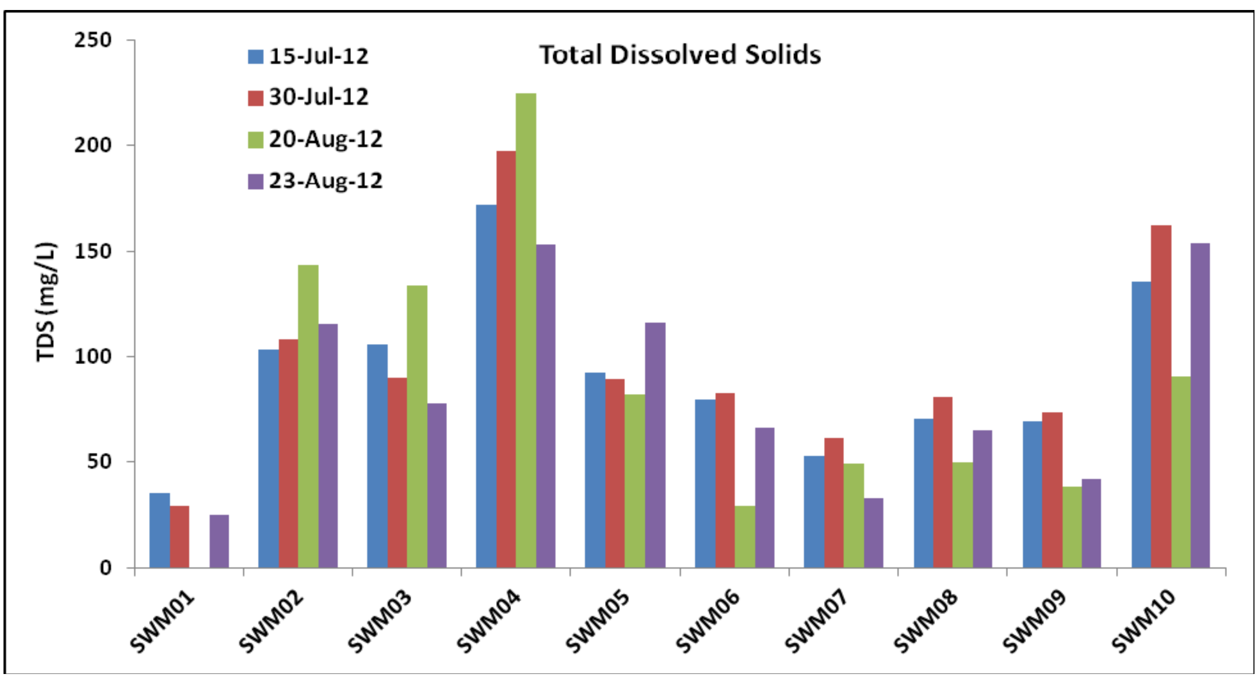
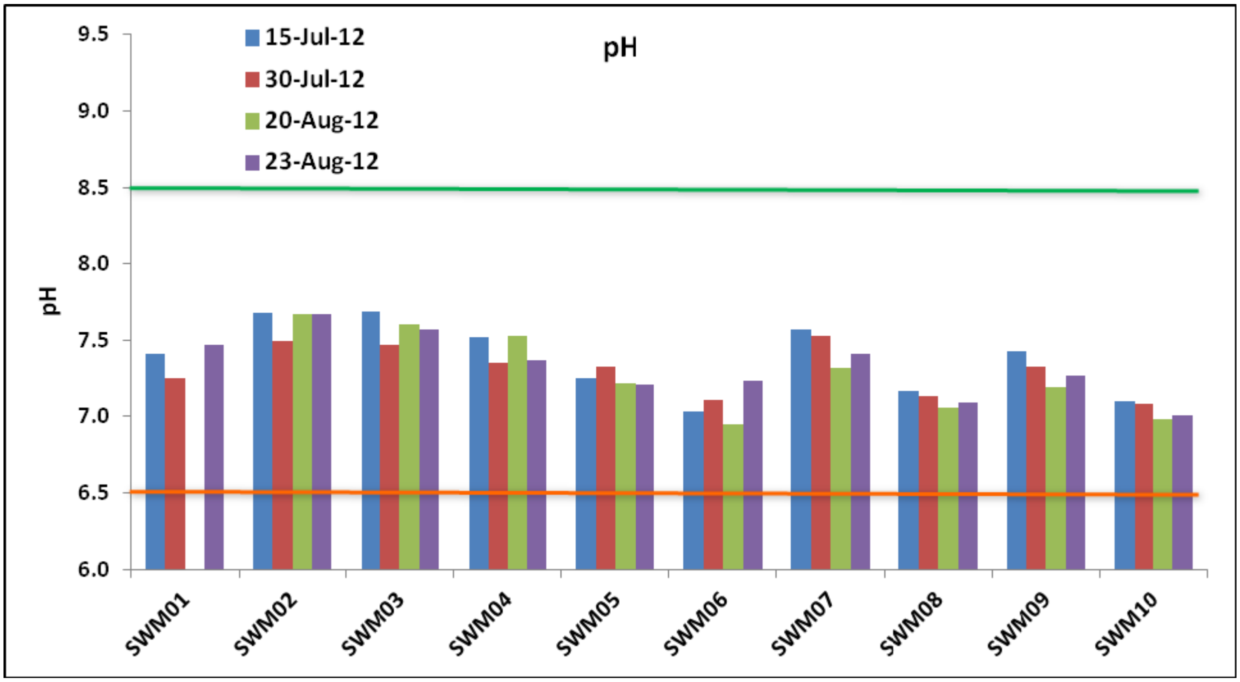
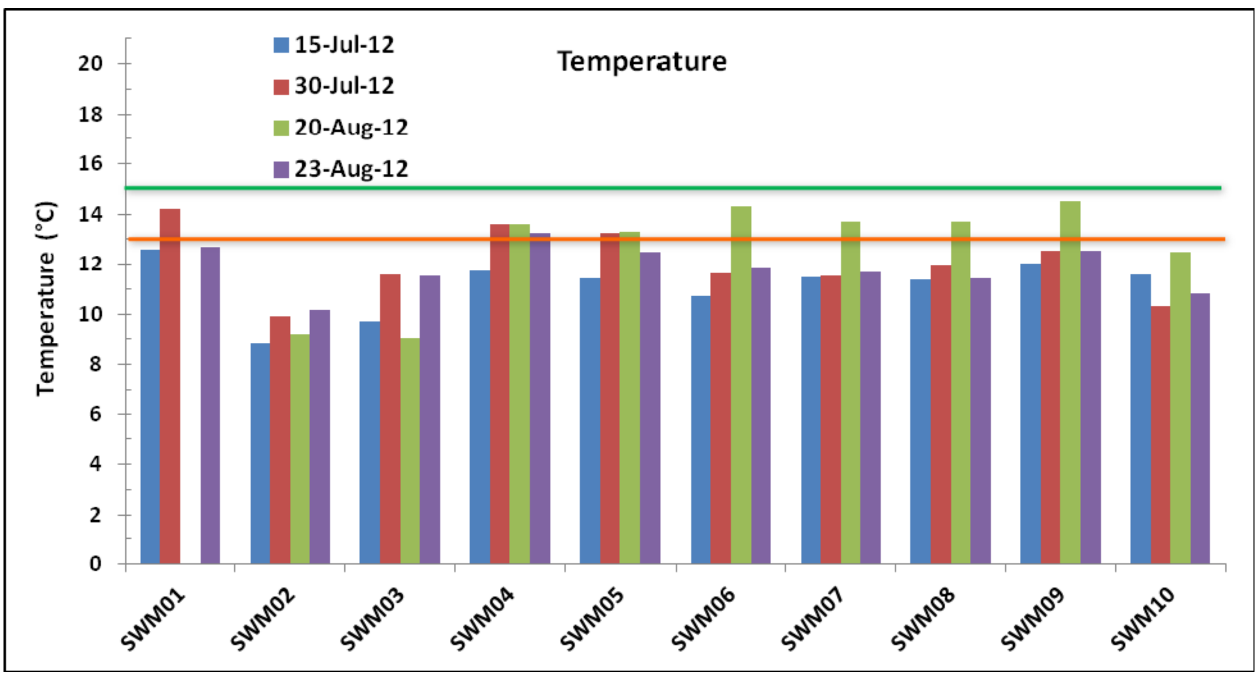


Figure 14. Total Dissolved Solids Measured in Stormwater Sampled at Monitoring Sites During all Four Events. (AWQS Criteria ≤ 500 mg/L).



Green line indicate the upper limit of 8.5 and the red line indicates the lower limit of 6.5.

Figure 15. pH (units) Measured in Stormwater Sampled at Monitoring Sites During all Four Events (AWQS Criteria ≥6.5 and ≤8.5).



Red line indicate the upper limit of 13°C for spawing and the green line indicates the upper limit of 15°C for migration.

Figure 16. Temperature (°C) Measured in Stormwater Sampled at Monitoring Sites During all Four Events. (AWQS Criteria ≤13°C for spawning and

egg/fry incubation and ≤15°C for migration routes and rearing areas).

Table 6. Flow Rate, Turbidity, and pH Measured at Monitoring Sites During All Four Sampling Events

Station	Event-01 15-Jul-2012	Event-02 30-Jul-2012	Event-03 20-Aug-2012	Event-04 23-Aug-2012	Mean
Flow Rate (gpm)					
SWM01	1.4	0.7	0.0	0.07	0.70
SWM02	20.5	44.0	25.6	18.6	27.2
SWM03	33.8	113.7	13.9	85.5	61.7
SWM04	1.2	11.1	1.2	2.4	4.0
SWM05	7.9	4.4	145.6	12.2	42.5
SWM06	2.7	5.4	25.6	0.8	8.6
SWM07	10.2	2.5	60.0	0.8	18.4
SWM08	528	256	1868	16.2	667
SWM09	0.9	0.0	54.8	12.2	17.0
SWM10	30.3	12.5	35.2	18.2	24.0
Turbidity (NTU)					
SWM01	26.2	38.7	(a)	20.4	28.4
SWM02	7.24	9.68	4.37	17.8	9.8
SWM03	84.8	34.8	18.0	67.0	51.2
SWM04	22.9	17.5	14.0	16.1	17.6
SWM05	73.8	107	90.2	87.7	89.7
SWM06	18.4	21.5	56.3	12.8	27.3
SWM07	250	87.7	364	78.2	195.0
SWM08	46.4	50.9	134	25.8	64.3
SWM09	295	51.3	118	66.7	132.8
SWM10	6.82	3.29	26.8	3.72	10.2
pH					
SWM01	7.41	7.25	(a)	7.47	7.25 – 7.47
SWM02	7.68	7.49	7.67	7.67	7.49 – 7.68
SWM03	7.69	7.47	7.60	7.57	7.47 – 7.69
SWM04	7.52	7.35	7.53	7.37	7.35 – 7.53
SWM05	7.25	7.33	7.22	7.21	7.21 – 7.33
SWM06	7.03	7.11	6.95	7.23	6.95 – 7.23
SWM07	7.57	7.53	7.32	7.41	7.32 – 7.57
SWM08	7.17	7.13	7.06	7.09	7.06 – 7.17
SWM09	7.43	7.33	7.19	7.27	7.19 – 7.43
SWM10	7.10	7.08	6.98	7.01	6.98 – 7.10

a. Samples not taken due to lack of flow at the site.

Table 7. Dissolved Oxygen, Total Dissolved Solids, and Temperature Measured at Monitoring Sites During All Four Sampling Events.

Station	Event-01 15-Jul-2012	Event-02 30-Jul-2012	Event-03 20-Aug-2012	Event-04 23-Aug-2012	Mean
Dissolved Oxygen (mg/L)					
SWM01	9.55	8.67	(a)	8.81	9.01
SWM02	11.48	11.24	11.53	12.06	11.58
SWM03	7.87	8.20	6.80	9.29	8.04
SWM04	8.98	8.58	8.34	8.91	8.70
SWM05	9.75	9.20	9.24	9.95	9.54
SWM06	9.36	10.30	9.21	8.97	9.46
SWM07	9.89	10.81	9.54	10.55	10.20
SWM08	9.78	10.20	9.80	10.63	10.10
SWM09	9.23	8.08	8.91	8.82	8.76
SWM10	10.62	11.15	10.37	11.37	10.88
Total Dissolved Solids (mg/L)					
SWM01	35.1	29.3	(a)	24.7	29.7
SWM02	103.4	107.9	143.7	115.1	117.5
SWM03	105.3	89.7	133.9	78.0	101.7
SWM04	171.6	197.6	224.9	152.8	186.7
SWM05	92.3	89.1	81.9	115.7	94.7
SWM06	80.0	82.6	29.3	66.3	64.5
SWM07	52.7	61.8	48.8	32.5	48.9
SWM08	70.9	80.6	49.4	65.0	66.5
SWM09	69.6	73.5	38.4	41.6	55.7
SWM10	135.9	161.9	90.4	153.4	135.4
Temperature (°C)					
SWM01	12.57	14.22	(a)	12.68	13.16
SWM02	8.83	9.93	9.19	10.15	9.53
SWM03	9.69	11.56	9.03	11.54	10.46
SWM04	11.75	13.60	13.60	13.24	13.05
SWM05	11.41	13.26	13.28	12.47	12.61
SWM06	10.74	11.65	14.33	11.84	12.14
SWM07	11.48	11.55	13.71	11.69	12.11
SWM08	11.39	12.00	13.73	11.44	12.14
SWM09	12.02	12.54	14.52	12.54	12.91
SWM10	11.60	10.31	12.51	10.82	11.31

a. Samples not taken due to lack of flow at the site.

The National Atmospheric Deposition Program (NADP) indicates that rainfall in Alaska is typically in the range of 5.2 to 5.5 pH.

Temperatures underwent a seasonal decline in the prior year's sampling with the last sampling event in October which is in contrast to 2012 when most locations exhibited the cooler temperatures during the first storm event. The last sampled storm event in 2012 occurred in late August and air temperatures had not begun to decrease. The coolest outfall discharge temperatures were seen at SWM02 for three of the four storm events with a mean temperature of 9.53°C and the warmest temperatures were seen at SWM01, which drains a small residental area, with a mean temperaure of 13.16°C. Temperature values were found to be less than the AWQS of 13°C for spawning and egg/fry incumbation areas during three of the four sampling events, and all were below the AWQS criteria of 15°C for migration routes and rearing areas (Figure 16).

In addition to the standard field measurements, the field crew also recorded visual observations of any odor, water color, clarity, floatables, deposits or stains, sheens, and debris. Observations for petroleum odor and sheen are noted below under hydrocarbons. Observations of water color and clarity were consistent and matched those outfalls where high turbidity and TSS were observed. Floatables consisted of some suds, vegetative material, and other small pieces of organic material that were noted at a few locations (refer to field logs in Appendix D). Other observations included: a small amount of scum at a couple of sites, some garbage type debris, sediment deposits, and algae. Other than hydrocarbons, no attempt has been made to correlate any of the visual observations with the conventional or pollutant measurements that were obtained.

4.3 Conventional Parameters (BOD_5 and TSS)

The 5-day biological oxygen demand (BOD_5) (Table 8 and Figure 17) was typically less than 5-7 mg/L at most sites. The highest BOD_5 concentrations were seen at SWM07 and SWM08 for all the four sampling events with the mean concentrations of 12.9 and 11.8 mg/L, respectively. These concentrations were approximately twice as high as those seen at other locations where the 2012 mean concentrations ranged from < 2 to 6.7 mg/L. A number of the sites exhibited fairly high variability between sampling events which may have been due to decomposing leaves or other organic material in the stormwater runoff samples.

As noted earlier, it is expected that TSS levels would be highly correlated with turbidity. In comparing these two measurements it was seen that the location (SWM07) with the highest TSS also exhibited the highest turbidity levels (Table 6, Table 8, and Figure 18). TSS concentrations ranged from a low of 1.95 mg/L at SWM02 to a high of 192 mg/L at SWM07 seen during storm event 3. The station mean concentrations ranged from 4.6 mg/L at SWM02 to 83.5 mg/L at SWM07. In general mean concentrations appeared to be somewhat lower at most locations than that seen in 2011 with most individual measurements less than 50-60 mg/L. As noted with turbidity, large differences can occur for TSS since it is highly dependent on the drainage area and is a function of the type of useage, percent impervious surfaces, slope, flow rate, and other factors.

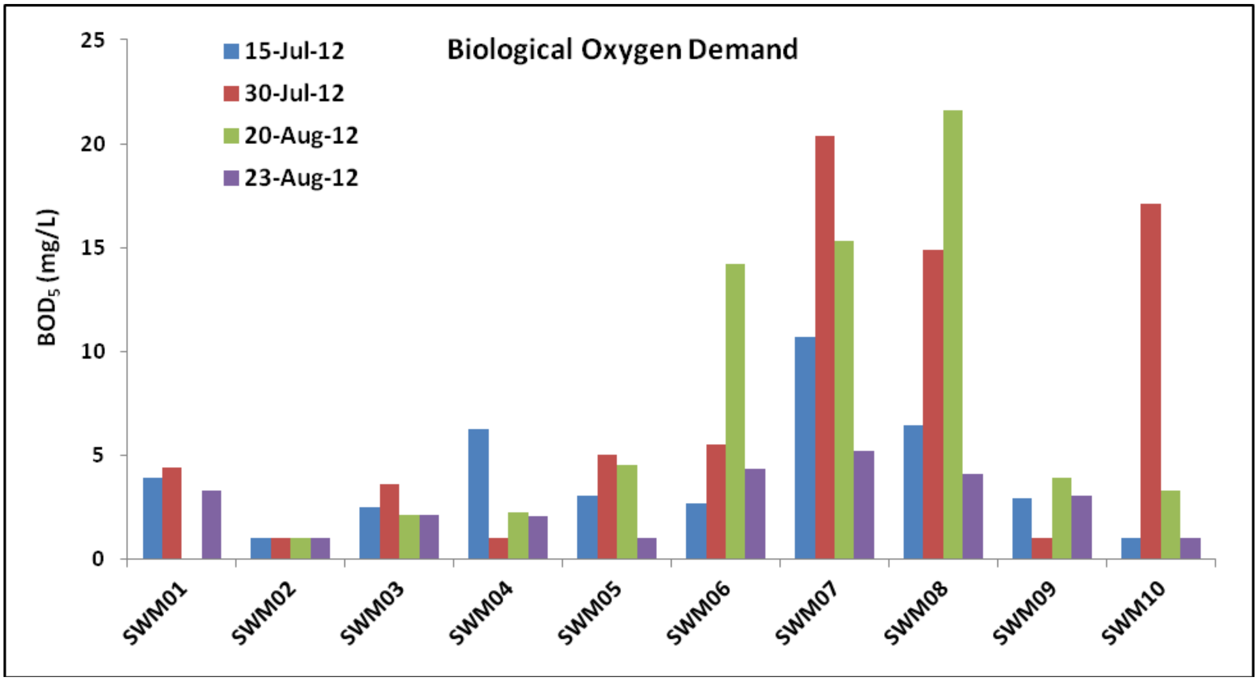


Figure 17. BOD5 (mg/L) Measured in Stormwater Sampled at Monitoring Sites During all Four Events.

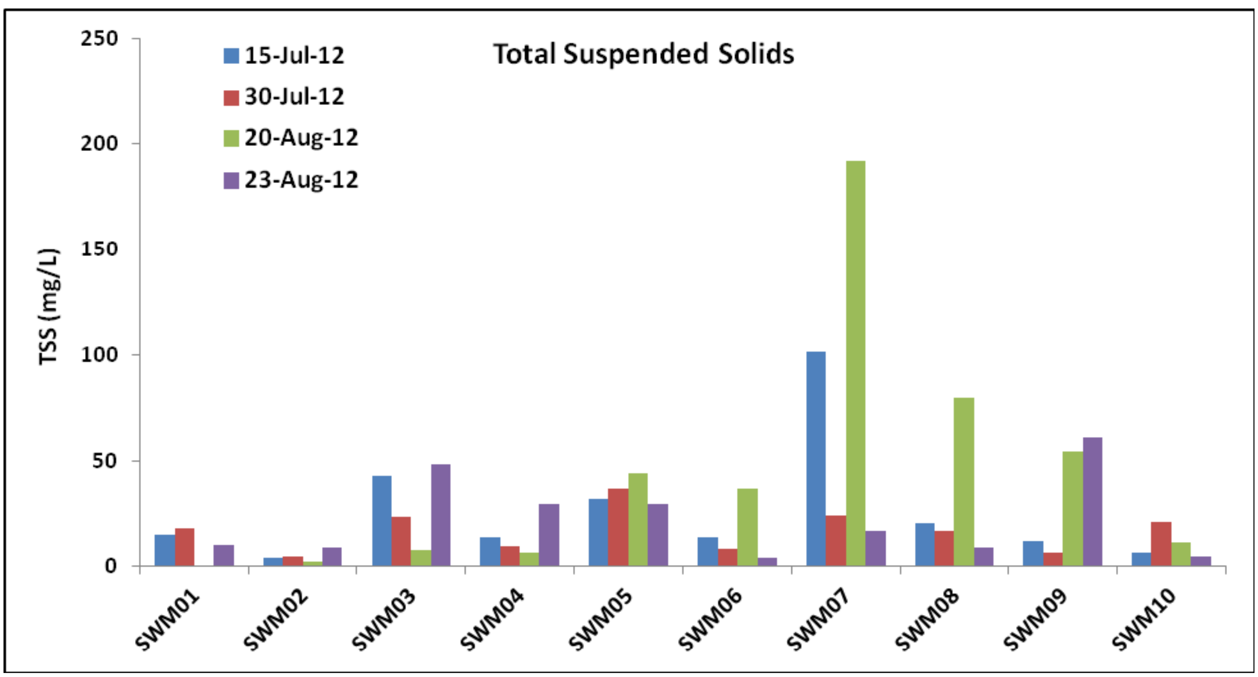


Figure 18. Total Suspended Solids Measured in Stormwater Sampled at Monitoring Sites During all Four Events

Table 8. Concentrations of Microbiological and Conventional Parameters.

Station	Event-01 15-Jul-2012	Event-02 30-Jul-2012	Event-03 20-Aug-2012	Event-04 23-Aug-2012	Mean
Fecal Coliform (CFU/100 ml)					
SWM01	2500	450	(a)	94	473
SWM02	14	13	230	96	45
SWM03	84	220	1464	3600	559
SWM04	1336	205	250	19900	1080
SWM05	1973	440	560	1455	917
SWM06	200	460	2000	1082	668
SWM07	4400	1409	2600	1300	2140
SWM08	1555	700	1545	520	967
SWM09	13600	16	973	228	469
SWM10	31	709	230	48	125
Biological Oxygen Demand (mg/L)					
SWM01	3.91	4.37	(a)	3.26	3.8
SWM02	2U	2U	2U	2U	2
SWM03	2.47	3.60	2.09	2.13	2.6
SWM04	6.26	2U	2.2	2.07	3.1
SWM05	3.01	5.02	4.53	2U	3.6
SWM06	2.64	5.49	14.2	4.35	6.7
SWM07	10.7	20.4	15.3	5.17	12.9
SWM08	6.45	14.9	21.6	4.06	11.8
SWM09	2.91	2U	3.91	3.01	3.0
SWM10	2U	17.1	3.26	2U	6.1
Total Suspended Solids (mg/L)					
SWM01	14.3	17.4	(a)	9.80	13.8
SWM02	3.92	4.30	1.95	8.24	4.6
SWM03	43.0	22.8	7.40	48.3	30.4
SWM04	13.1	9.0	5.80	29.7	14.4
SWM05	32.0	37.0	44.0	29.3	35.6
SWM06	13.4	7.86	37.0	3.40	15.4
SWM07	102	24.0	192	16.0	83.5
SWM08	20.0	16.0	79.5	8.20	30.9
SWM09	11.3	6.20	54.5	61.0	33.3
SWM10	6.10	20.4	11.0	4.44	10.5

Footnotes: U = not detected at the associated detection limit that is shown. Mean calculations used geometric mean for fecal coliform and utilized the reporting limit where analyte was not detected.

a. *Samples not taken due to lack of flow at this site.*

4.4 Fecal Coliform

Although fecal coliform measurements were found to often exceed the 200 fecal coliform (FC)/100 mL AWQS criteria, overall concentrations were relatively low (Table 8 and Figure 19). Although the AWQS do not directly apply to stormwater, the limit of 200 FC/100 ml was used as a benchmark comparison since most applicable beneficial use criteria are based on this numeric limit (refer to Table 10). One site, SWM02, had measured concentrations below the standard during three of the four surveys. The geometric mean of fecal coliform ranged from a low of 45 FC/100 ml at SWM02 to a high of 2,140 FC/100 ml measured at SWM07. Studies conducted by EPA in the early 1980s (EPA, 1983) indicated that fecal coliform levels in warm climates were typically in the range of 10s to 100s of thousand FC/100 ml with a median of 21,000 FC/100 mL. In colder climates, the median concentration of fecal coliform was in the range of 1,000 FC/100 mL which is slightly higher than that seen at most project locations during 2012.

Despite the fact that established fecal coliform standards are shown to be surpassed at least once at all 10 sites, overall concentrations were not alarming. The highest mean concentrations were seen at SWM04, SWM05, SWM07, and SWM08 with geometric means of 1080, 917, 2140, and 967 FC/100 mL, respectively, although elevated individual samples were also seen at a number of other locations (Table 8). An earlier analysis of fecal coliform in Anchorage streams indicated that highest loads would be most likely to occur in August/September in association with peak runoff and rainfall in urban areas (MOA 2003). This analysis appeared to agree with what was seen during 2011 when the highest levels of fecal coliform tended to occur in August with somewhat lower levels seen in October, no seasonal differences were readily apparent in the 2012 data set.

4.5 Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) and total volatile aromatic hydrocarbons (TAH) were measured at four of the monitoring sites; SWM02, SWM05, SWM07, and SWM09). In all cases, PAH concentrations were found to be very low with total PAHs ranging from non detect (ND) to 1.43 µg/L. With the exception of one sample, TAH concentrations were all found to be below detection limits for all sites and all storms. The one sample where TAH was detectable was from the third storm event at SWM07 with a concentration of 474 µg/L (Table 9 and Figure 20). Except for the one high sample, all samples were found to be well within the AWQS criteria for both total aqueous hydrocarbons (TAqH) and TAH measured as benzene, ethylbenzene, tolulene, and xylenes (BETX). TAqH is defined in the AWQS as the summation of total PAH and TAH with a criteria of 15 µg/L whereas TAH alone has an AWQS criteria of 10 µg/L. The highest concentration of TAqH seen during the sampling was 475 µg/L seen at SWM07 during the third stormwater sampling event as a result of the high BETX discussed above. This one high concentration was confirmed by the laboratory, however the field team did not note any sheen or obvious gasoline type odor at the site.

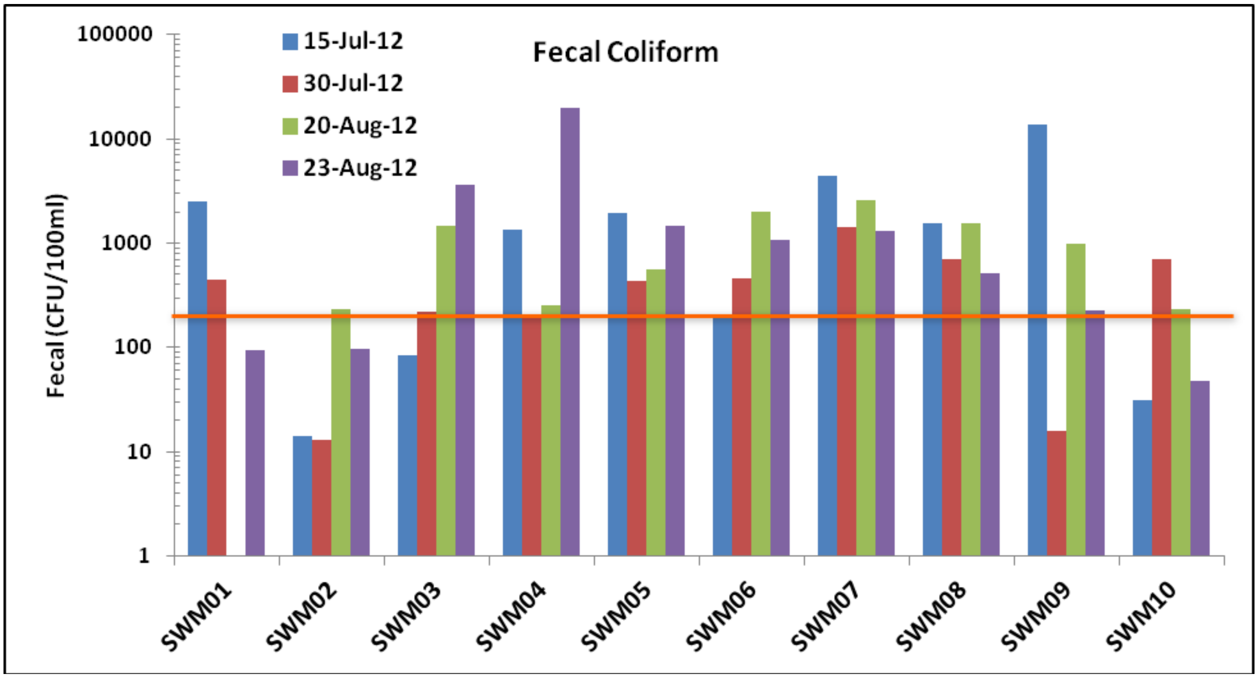


Figure 19. Fecal Coliform (FC/100 mL) Measured in Stormwater Sampled at Monitoring Sites during all Four Events. (AWQS less than 200 FC/100mL).

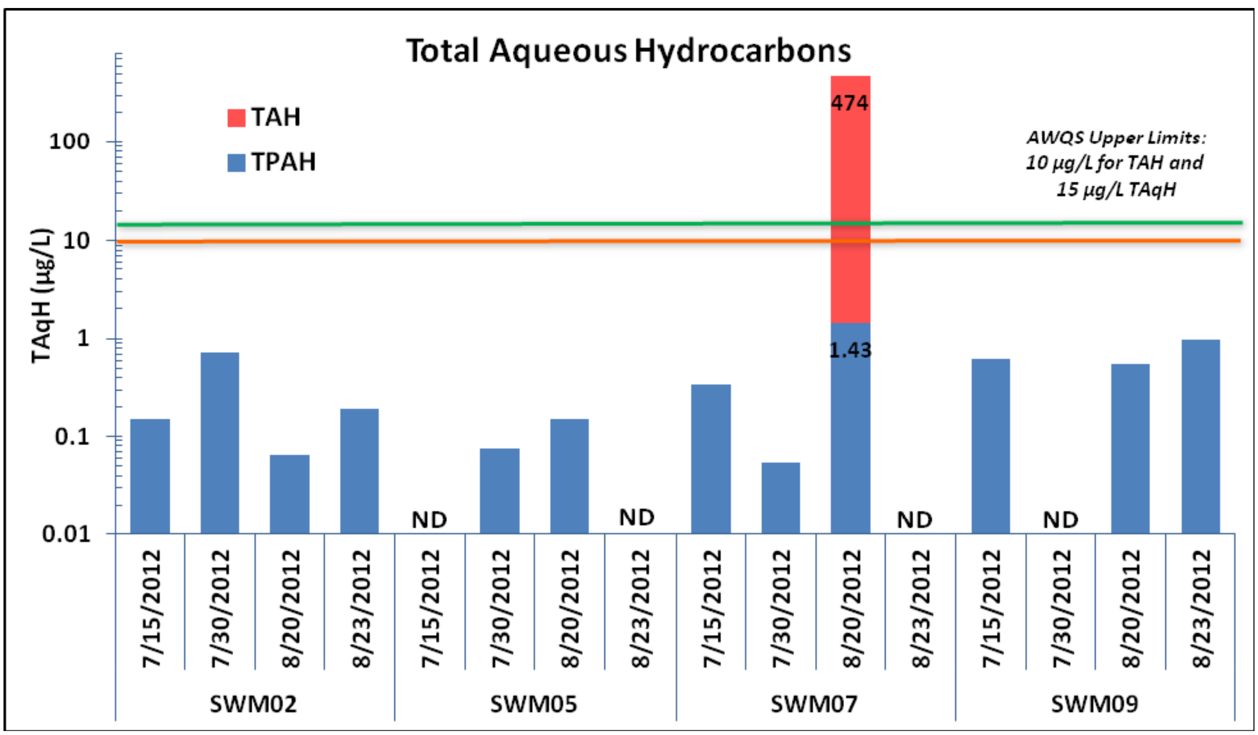


Figure 20. Total Aqueous Hydrocarbons (TAqH = TAH + TPAH) Measured in Stormwater Sampled at Monitoring Sites During all Four Events (AWQS ≤ 10 µg/L for TAH and ≤ 15 µg/L for TAqH).

Table 9. Hydrocarbon Concentrations Measured in Stormwater at Four Sites During All Four Storm Events

	SWM02 - OGS (No)				SWM05 - OGS (Yes)				SWM07 - OGS (No)				SMW09 - OGS (Yes)			
	07/15/12	07/30/12	08/20/12	08/23/12	07/15/12	07/30/12	08/20/12	08/23/12	07/15/12	07/30/12	08/20/12	08/23/12	07/15/12	07/30/12	08/20/12	08/23/12
Polycyclic Aromatic Hydrocarbons (µg/L)																
Acenaphthene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.05U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Acenaphthylene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.05U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Anthracene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.05U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Benzo(a)anthracene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.5U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Benzo(a)pyrene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.5U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Benzo(b)fluoranthene	0.0543U	0.152	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.5U	0.05U	0.0535	0.0526U	0.0771	0.157
Benzo(g,h,i)perylene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.053	0.05U	0.5U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Benzo(k)fluoranthene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.5U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Chrysene	0.0543U	0.162	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.0864	0.05U	0.5U	0.05U	0.0707	0.0526U	0.0752	0.129
Dibenzo(a,h)anthracene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.5U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Fluoranthene	0.097	0.275	0.0655	0.127	0.05U	0.0742	0.0949	0.0556U	0.05U	0.05U	0.5U	0.05U	0.256	0.0526U	0.21	0.348
Fluorene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.05U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Indeno(1,2,3-cd)pyrene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.05U	0.05U	0.5U	0.05U	0.0526U	0.0526U	0.0532U	0.0704U
Naphthalene	0.109U	0.111U	0.111U	0.119U	0.1U	0.1U	0.103U	0.111U	0.1U	0.1U	1.29	0.1U	0.105U	0.105U	0.106U	0.141U
Phenanthrene	0.0543U	0.0556U	0.0556U	0.0595U	0.05U	0.05U	0.0515U	0.0556U	0.0713	0.05U	0.141	0.05U	0.0927	0.0526U	0.0606	0.116
Pyrene	0.0543	0.131	0.0556U	0.0604	0.05U	0.05U	0.0539	0.0556U	0.128	0.0541	0.5U	0.05U	0.151	0.0526U	0.122	0.22
Volatile Aromatic Hydrocarbons (µg/L)																
1,2-Dichlorobenzene	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U
1,3-Dichlorobenzene	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U
1,4-Dichlorobenzene	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
Benzene	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
Chlorobenzene	0.4U	0.4U	0.4U	0.4U	0.4U	0.4U	0.4U	0.4U	0.4U	0.4U	5.2	0.4U	0.4U	0.4U	0.4U	0.4U
Ethylbenzene	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	36.7	1U	1U	1U	1U	1U
o-Xylene	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	76.6	1U	1U	1U	1U	1U
Toluene	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	189	1U	1U	1U	1U	1U
Xylene, Isomers m & p	2U	2U	2U	2U	2U	2U	2U	2U	2U	2U	166	2U	2U	2U	2U	2U
Hydrocarbon Summary Parameters (µg/L)																
TPAH	0.1513	0.72	0.0655	0.1874	ND	0.0742	0.1488	ND	0.3387	0.0541	1.431	ND	0.6239	ND	0.5449	0.97
TAH as BETX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	474	ND	ND	ND	ND	ND
TAqH (TPAH + TAH)	0.1513	0.72	0.0655	0.1874	ND	0.0742	0.1488	ND	0.3387	0.0541	475	ND	0.6239	ND	0.5449	0.97

Footnotes: U = not detected at the detection limit, ND = no concentration detected in any analyte tested.
All detected concentrations are shown in bold.

Table 10. Pertinent Numeric Alaska Water Quality Standard Criteria

Designated Use	Description of Standard
Fecal Coliform Bacteria	
(A) Water Supply (i) drinking, culinary and food processing	In a 30-day period, the geometric mean may not exceed 20/FC/100 ml, and not more than 10% of the samples may exceed 40 FC/100 ml.
(A) Water Supply (ii) agriculture, including irrigation and stock watering	The geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml. For products not normally cooked and for dairy sanitation of unpasteurized products, the criteria for drinking water supply, (1)(A)(i), apply.
(A) Water Supply (iii) aquaculture	For products normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml. For products not normally cooked, the criteria for drinking water supply, (1)(A)(i), apply.
(A) Water Supply (iii) Industrial	Where worker contact is present, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml.
(B) Water Recreation (iv) contact recreation	In a 30-day period, the geometric mean of samples may not exceed 100 FC/100 ml, and not more than one sample or more than 10% of the samples if there are more than 10 samples, may exceed 200 FC/100 ml.
(B) Water Recreation (ii) secondary contact	In a 30-day period, the geometric mean of samples may not exceed 200 FC/100 ml, and not more than 10% of the total samples may exceed 400 FC/100 ml.
(C) Growth and Propagation of Fish, Shellfish, other Aquatic Life and Wildlife	Not applicable.
Dissolved Oxygen (most restrictive shown)	
(A) Water Supply (iii) aquaculture (C) Growth and Propagation of Fish, Shellfish, other Aquatic Life and Wildlife	DO must be greater than 7mg/L in surface waters. The concentration of total dissolved gas my not exceed 110% of saturation at any point of sample collection.
pH	
(A) Water Supply (i) drinking, culinary and food processing	May not be less than 6.0 or greater than 8.5.
(A) Water Supply (ii) agriculture, including irrigation and stock watering, & (iv) Industrial	May not be less than 5.0 or greater than 9.0.
(A) Water Supply (iii) aquaculture	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.
(B) Water Recreation (iv) contact recreation	May not be less than 6.5 or greater than 8.5. If the natural condition pH is outside this range, substances may not be added that cause an increase in the buffering capacity of the water.
(B) Water Recreation (ii) secondary contact	Same as (6)(A)(iv)
(C) Growth and Propagation of Fish, Shellfish, other Aquatic Life and Wildlife	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.
Petroleum Hydrocarbons	
(A) Water Supply (iii) aquaculture & (C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife.	TAqH in the water column may not exceed 15 µg/L. TAH in the water column my not exceed 10 µg/L. Surface waters and adjoining shorelines must be virtually free from floating oil, film, or discoloration.
Dissolved Inorganic Substances (most restrictive show)	
(A) Water Supply (i) drinking, culinary, and food processing	Total dissolved solids (TDS) from all sources may not exceed 500 mg/L.
Temperature (most restrictive show)	
(A) Water Supply (iii) aquaculture & (C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife.	The following maximum temperatures may not be exceeded, where applicable: Migration routes and rearing areas: 15°C Spawning areas, egg & fry incubation: 13°C

PAHs were the most common compounds found at each site and were typically comprised of combustion related compounds like pyrene, chrysene, fluoranthene, and benzo(b)fluoranthene. Concentrations of individual PAHs were found to be low and with the exception of one sample were all less than 0.5 µg/L. The one sample that exhibited high BETX in the TAH analysis had concentrations of naphthalene and phenanthrene that may have come from a gasoline source since no combustion related PAHs were seen, and BETX concentrations in diesel fuel are typically a couple of orders of magnitude less than that seen in gasoline. PAHs were seen during all four storm events at SWM02 which captures runoff from a commercial area including a Home Depot parking lot, and in three of the four storms at both SWM09 which drains a parking area near Ben Boeke Ice and Sullivan Arenas and at SWM07 adjacent to the Seward Highway. The last site, SWM05, experienced measurable levels of PAHs on two storm events. This site receives runoff from predominantly commercial and light industry land use areas.

In addition to the laboratory measurements of PAH and TAH, field observations were taken for any sheens or odors. A sheen was observed at one site, SWM01, which drains a small residential area during the second and third storm events in the water downstream of the outfall. A sheen was also observed downstream of the outfall at SWM02 during the fourth storm event.

4.6 Site Comparisons

This report presents the second of four years of monitoring that will be conducted for this program. It is still too early to compare any trends between years, but some general patterns between sites were seen, that in some cases have persisted across sampling events and between years. General site differences were investigated graphically with boxplots that have been prepared for each field and laboratory parameter (Figure 21 and Figure 22). The boxplots constitute the results from 7–8 samples that were collected at each location during 2011 and 2012, which depict the minimum, maximum, median, 25-percentile, 75-percentile, and grand median measurements across all locations. In addition, AWQS criteria have been plotted where appropriate for each parameter.

A few locations seem to stand out for each parameter. For pH, SWM06 appears to be consistently lower than the other locations with a few measurements below the AWQS lower limit of 6.5. Temperature appeared to be somewhat lower at three locations which may be function of which outfall pipes are buried (cooler) versus those with open-channel flow that may be influenced more by warmer air temperatures. TDS was slightly higher at both SWM04 and SWM10. Dissolved oxygen was found to be fairly high at all locations, with SWM02 having the highest levels as a result of the turbulent flow in the outfall pipe prior to discharge. Both TSS and turbidity were found to be highly variable, although there did appear to be a general correlation between TSS and turbidity in the boxplot location patterns. For BOD_5, SWM07 and SWM08 appear to be somewhat higher. For fecal coliform, SWM02

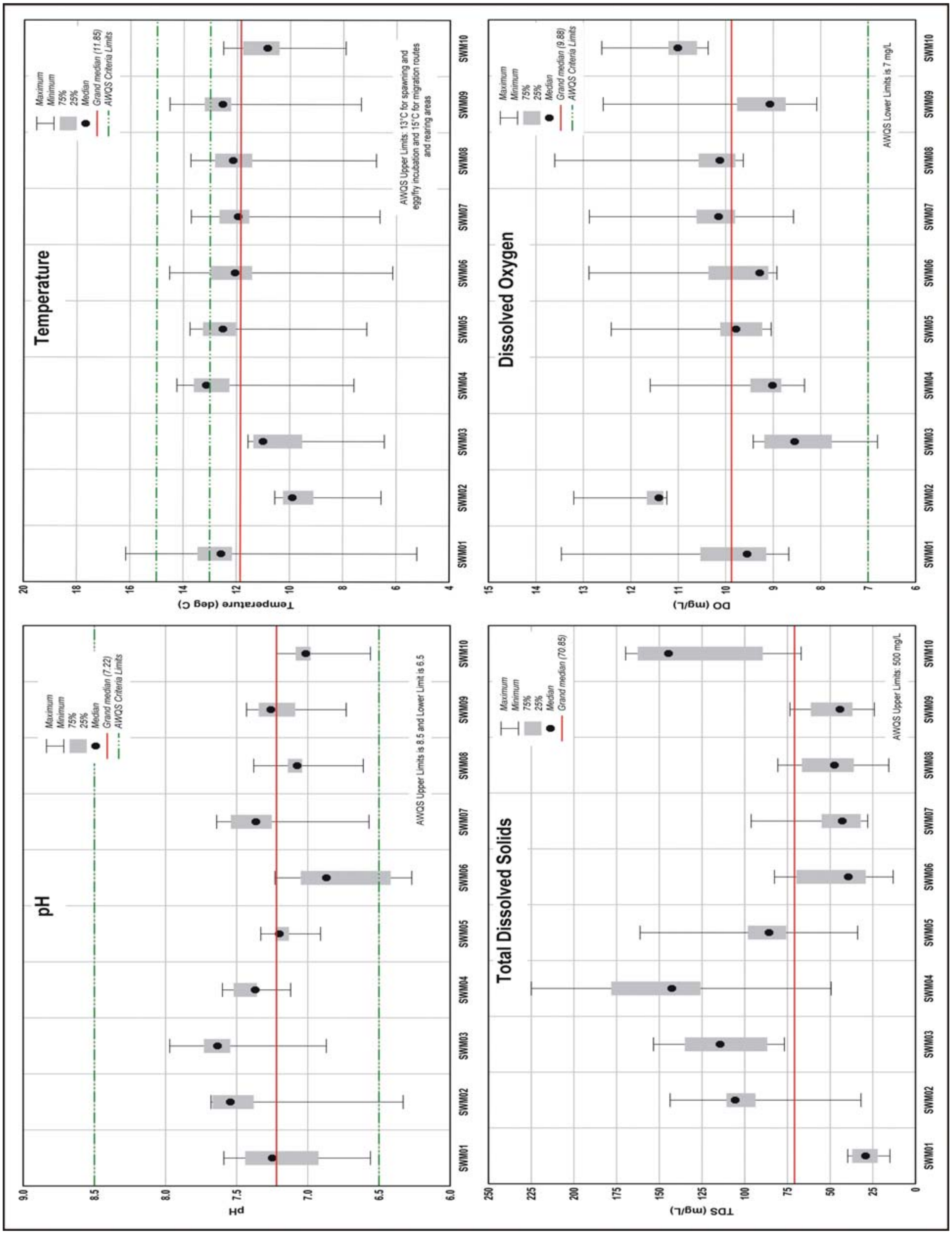


Figure 21. Station Boxplots of pH, Temperature, Total Dissolved Solids, and Dissolved Oxygen for 2011 and 2012.

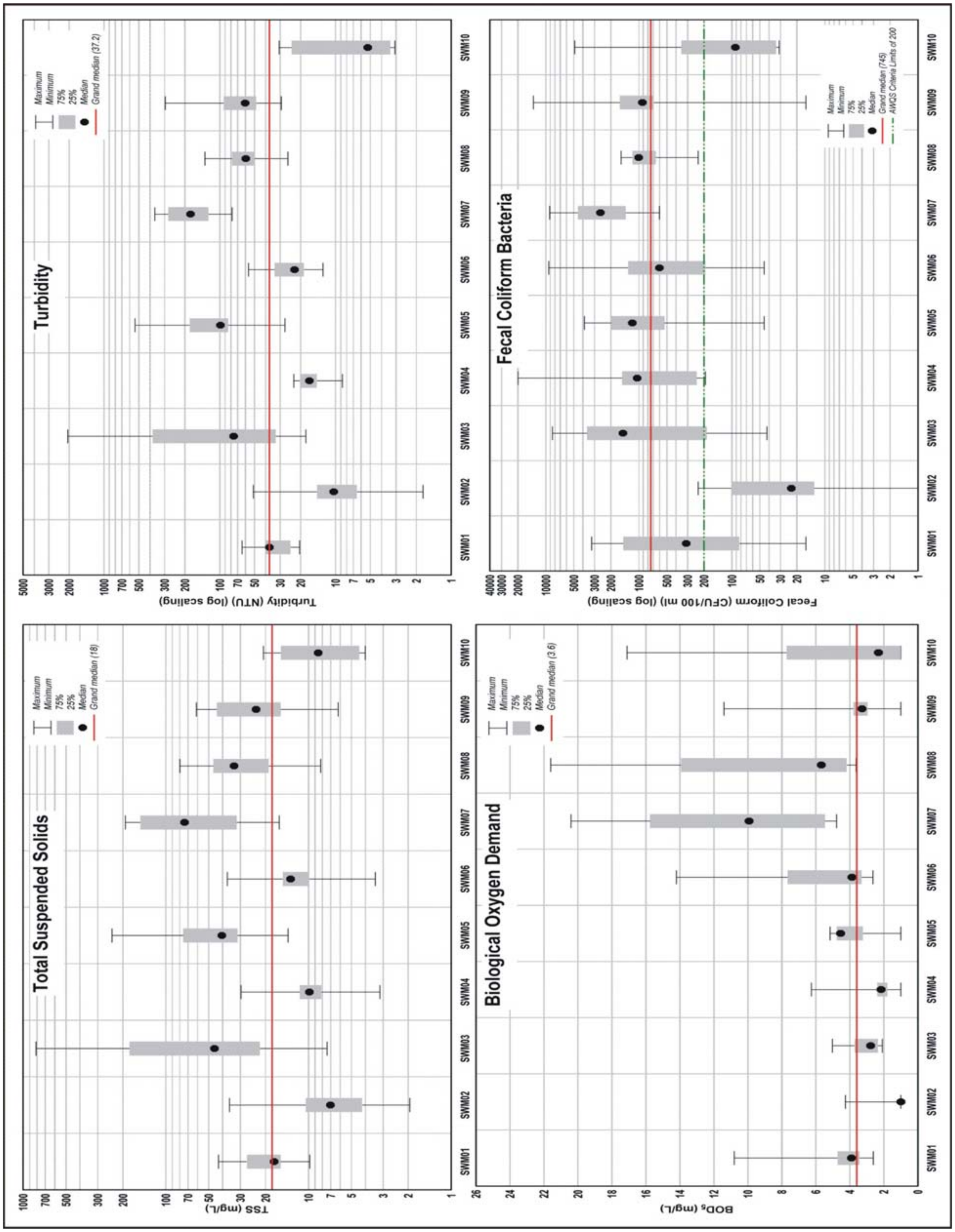

Total Suspended Solids
TSS (mg/L)
Biological Oxygen Demand
BOD_5 (mg/L)
Turbidity
Turbidity (NTU) (log scaling)
Fecal Coliform Bacteria
Fecal Coliform (CFU/100 ml) (log scaling)
Maximum
Minimum
75%
25%
Median
Grand median (18)
Grand median (3.6)
Grand median (37.2)
Grand median (745)
AWQS Criteria Limits of 200
SWM01
SWM02
SWM03
SWM04
SWM05
SWM06
SWM07
SWM08
SWM09
SWM10

Figure 22. Station Boxplots of Total Suspended Solids, Turbidity, Biological Oxgen Demand, and Fecal Coliform for 2011 and 2012.

and SWM10 were found to be consistently lower than other locations. A detailed examination of these site patterns is premature at this time, but with sampling over the next two years, there might be enough data to determine statistical trends.

5.0 Summary and Conclusions

This report describes the second of four years of sampling under the current APDES permit specified monitoring program. Results from the first two years were intended to allow an initial screening by comparison against all available water quality standards. If exceedances were identified, the intent was that MOA would identify likely causes and take actions such as education and outreach or installation of additional BMPs to reduce the pollutant loading.

Overall, there were no significant findings from either 2011 or 2012 that would suggest the need for any special investigations to be initiated at this time. Except for high TSS/turbidity seen at one location in 2011, and high hydrocarbons at one location during one storm event in 2012, concentrations of target constituents in the grab samples and in the field measurements were all well within the range of expected values. Although fecal sampled data was higher than AWQS criteria, the AWQS is being used as a comparison only until there is enough data to determine trends and does not directly apply to stormwater.

High TSS and turbidity concentrations were noted at one location during two storm events in 2011. Since that time, no high turbidity or TSS concentrations have been seen at that location. In 2012, the one high hydrocarbon sample, that was collected adjacent to the Seward Highway, is believed to have originated from a gasoline type source as there was no indication that it originated from a combustion source and BETX levels in diesel fuel are typically much less. A sample taken at the same location three days later during the subsequent storm event did not detect any volatile hydrocarbons. A protocol was established in the QAPP that field crews should immediately report any anomoulous field measurements that might warrant further investigation. This would allow MOA an opportunity to perform a site inspection and potentially identify the source of the problem. No anomolous field measurements were noted in 2012 that warranted further investigation.

A comprehensive summary report will be prepared after four years of sampling is completed. Based upon the full four years, data will be evaluated comprehensively to estimate loadings at each site and compare differences in water quality between basins with and without OGSs. Data will also be used to determine whether the TMDL objectives are being met and assess whether existing stormwater controls are effective and whether additional controls are necessary in portions of the MS4 area. It is premature to attempt to evaluate these differences at this time with the limited data from the first two years of monitoring.

Based on the results of this monitoring, the sampling plan will be re-examined prior to the 2013 field effort to determine whether there are any areas of the program that should be adjusted to better address the overall program objectives. With the exception of one site where there was no flow during one storm event, the second year of monitoring successfully sampled all parameters specified for each of the ten selected outfalls during all four monitoring events and met the permit requirements.

6.0 References

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