13c.

2012-2013 Pre-Construction Stormwater Monitoring Report

November 2013

REVISION/COR
SUBMITTAL

CITY OF BLACK DIAMOND
RECEIVED
JAN 10 2014
PLANNING DEPT

Submittal Requirements:

All revisions / correction submittals MUST contain the following:

1. A completed City of Black Diamond Revision/Correction submittal form
2. Two (2) sets of revised and/or corrected drawings/sheets (wet stamped by architect, if applicable.
3. Revised structural calculations, if applicable (must be stamped by engineer)
4. A written letter to the City that shows an itemized summary of your submittal (must include sheet and detail numbers)
5. All changes **MUST BE CLOUDED** or **HIGHLIGHTED** on each plan set

Date: 1/10/14 **Permit #:** PLN13-0027 (2C)

Property Address: See the Phase 2C project narrative/plat drawings
Project Name: The Villages MPD Phase 2 Preliminary Plat C
Contact Person: Colin Lund
Phone: (425) 898-2100
Email: clund@yarrowbayholdings.com

TYPE OF SUBMITTAL:

(X) SUPPLEMENTAL INFO.

( ) **REVISION**: A change the applicant has made to a plan that is either:
1. An approved plan already issued by the City or
2. A project under current plan review

( ) **CORRECTION**: An applicant response to a correction letter written by the City to the applicant

Permit Issued? ( )Yes (✓)No *A plan check fee for revision is $84 per hour with a minimum of $42 for ½ hour

Please describe revision/correction submittal:
The Villages and Lawson Hills MPDs 2012-2013 Pre-Construction Stormwater Monitoring Report dated November 2013, prepared by TetraTech.

Sheets Affected: _____ If more than two (2) sheets will be changed, please submit two (2) new full sets of plans. Revisions on issued permits only require submittal of the affected sheets.

For City Use Only:

REQ'D APPROVAL	CHECKED BY	ROUTE TO	DATE	INITIAL	COMMENTS	FEES
( )	1.BUILDING					
( )	2.PLANNING					
( )	3.FIRE					
( )	4.PW					
( )	5					

TOTAL $

PLN13-0027

Technical Memorandum

THE VILLAGES AND LAWSON HILLS MPDS

2012-2013 PRE-CONSTRUCTION STORMWATER MONITORING IN ROCK CREEK TO ESTABLISH THE BASELINE PHOSPHORUS LOAD

BLACK DIAMOND, WA

NOVEMBER 2013

Submitted To

YARROWBAY

CITY OF BLACK DIAMOND
RECEIVED
JAN 10 2014
PLANNING DEPT.

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INTRODUCTION

Water quality conditions in lakes and streams are a reflection of the surrounding landscape, including human activity that changes hydrology and destabilizes surrounding soils and vegetation patterns. These features of a drainage influence the quantity of nutrients transferred from terrestrial to aquatic environments, the length of time transfer occurs, and locations in a stream or lake where nutrient introduction is detectable. Historic disturbance in a drainage affects nutrient dynamics in the aquatic ecosystem and are reflected in current water quality conditions.

Some areas of the Villages and Lawson Hills MPDs are in the Rock Creek drainage that supplies water to Lake Sawyer and is part of a Lake Sawyer TMDL. The combined input of total phosphorus (TP) from several sources like the larger Ravensdale Creek drainage, Rock Creek drainage, non-point sources (e.g., on-site septic systems surrounding the lake), and air deposition should not produce in-lake steady state TP concentrations higher than 16 µg/L (Caroll and Peletier,1991). Rock Creek is characterized by three large wetlands over its length between Jones Lake and Lake Sawyer. The upper end of this Rock Creek reach receives water from the smaller Ginder Creek drainage. The downstream wetlands function differently from stream ecosystems in sequestering and releasing nutrients. Timing for sequestration and release as well as the mechanism for this process in wetlands differs from that in flowing water. The unique properties of these three wetlands are taken into account as reflected in objectives of this study and how data are interpreted. This more intensive water quality monitoring program provides greater detail on how Rock Creek can influence Lake Sawyer TP concentration under stormflow conditions and baseflow conditions, which is beyond earlier Washington Department of Ecology studies.

OBJECTIVES

The overall objective for the 2012-2013 water year was to conduct stormwater monitoring pursuant to the Baseline Monitoring section of the No Net Phosphorus Implementation Plan set forth as Exhibit O to the Villages and Lawson Hills MPD Development Agreements. This segment of the pre-construction monitoring program involved sampling eight different locations within the Lake Sawyer/Rock Creek drainage area and analyzing the samples for nutrients such as TP and other parameters in order to determine pre-construction MPD (Master Planned Development) conditions. Storm events (greater than 0.2 inches of precipitation) and non-storm/baseflow monitoring were completed in order to describe baseline concentrations and to add to historical records from previous years. This information will be combined with future monitoring activities including location and frequency of visits so that loading analysis can be completed during and following construction of the MPDs.

1.0 MONITORING COMPONENTS

The 2012-2013 Pre-Construction Stormwater Monitoring efforts generated monitoring results that describe current nutrient (phosphorus input) conditions in select segments of Rock Creek and the surrounding Lake Sawyer drainage in accordance with the Baseline Monitoring section of the No Net Phosphorus Implementation Plan set forth as Exhibit O to the Villages and Lawson Hills MPD Development Agreements. This stormwater monitoring program measured the nutrient concentrations at eight locations in the Lake Sawyer/Rock Creek drainage.

STORM EVENT MONITORING

For the purposes of defining a single storm event, the target minimum amount of rainfall was required to be 0.2 inches. A total of six storm events were monitored between December of 2012 and April of 2013. To account for the variability within each sampling event and storm conditions, three sets of samples were collected from each site during each storm event. Samples were collected at successive time intervals and determined based on the characteristics of the storm event (i.e., one sample every hour or when rises in the hydrograph were observed). Water level at six of the eight locations was continuously recorded with a data logger in order to develop a flow rating curve used for determining nutrient loading. Flow estimates and water levels were not collected from two of the sites (SW-3 and SW-8). Both locations were not natural channels and generated results with poor precision so could not be used to construct flow-rating curves. Water level, flow, and in-situ parameters were recorded during

five of the six storm events at seven of the eight sites. One of the sites (SW-8) did not consistently have water in the channel during the sampling times.

AMBIENT (BASELINE) MONITORING

Monitoring of non-storm event conditions occurred once during the middle of each month from November of 2012 through October of 2013. Samples as well as flow and in-situ parameters were taken at seven of the eight sites during a variety of weather conditions. One of the sites (SW-8) did not consistently have water in the channel during the sampling times.

A) LAKE SAWYER DRAINAGE AND ROCK CREEK MONITORING

Purpose: Pursuant to Section 7.4.5 and the Baseline Monitoring section of the No Net Phosphorus Implementation Plan (Exhibit "O" of The Villages and Lawson Hills MPD Development Agreements), three water quality samples were collected during six different storm events during the wet season at seven locations within the Lake Sawyer and Rock Creek drainages with one location (SW-8) frequently without flowing water. In addition, twelve water quality samples were collected in twelve separate months during non-storm conditions in the Lake Sawyer and Rock Creek drainage. These samples were taken in order to characterize pre-development conditions and establish baseline TP levels and loads that will be further refined by the Expanded Baseline Monitoring Program (2013-2014 water year monitoring plan) prior to construction of the first project within the Lake Sawyer and Rock Creek drainage basin.

Approach: Grab samples were collected within the Lake Sawyer and Rock Creek drainage at seven locations to characterize baseline nutrient levels during storm events and non-storm conditions during the 2012-2013 water year. Grab samples were collected at the following locations: (1) Ginder Creek, (2) Mud Creek, (3) Storm Basin at SR 169, (4) Ditch on Roberts Drive, (5) Abrams Avenue, (6) SE Auburn Black Diamond Road, and (7) 312th Street. These seven locations within the Lake Sawyer and Rock Creek drainages were mutually agreed to by the City and Master Developer. On one occasion an eighth site, Hammerhead Ditch was sampled. This site was directly below the proposed Lawson Hills development site and received drainage from both the proposed development and from a flowing ditch adjacent the road access to the old mine. The site was mostly absent of flowing water, however results from one sampling event showed inconclusive results since the sample appeared to contain sediment with surface water. Leveloggers (continuous water level recording devices) were deployed at SE Auburn-Black Diamond Road (SW-6), Abrams Avenue (SW-5), 312th Street (SW-7), the Ditch on Roberts Drive (SW-4), Ginder Creek, and Mud Creek. Currently, a flow rating curve based on water level records and channel morphology has been constructed for Ginder Creek, Mud Creek, the Ditch on Roberts Drive, Abrams Avenue, SE Auburn Black Diamond Road, and the 312th Street site. However, recent beaver activity has modified the rating curves at Abrams Ave., SE Auburn Black Diamond Rd., and 312th St. Samples were collected at the sites during storm events for laboratory analysis to characterize baseline nutrient levels during stormwater runoff events. Additional non-storm monitoring provided flow and TP concentration data to determine annual base-flow loading to Lake Sawyer from this source. All samples were analyzed for TP, soluble reactive phosphorus (SRP), ammonia, nitrate and nitrite (NO3 + NO2), total nitrogen (TN), total suspended solids (TSS), and turbidity. Flow and field parameters (e.g., temperature, pH, conductivity, and dissolved oxygen) were determined during each sampling event. Figures 1- 6 depict the seven locations that were sampled during each event in the Lake Sawyer, Rock Creek drainages.

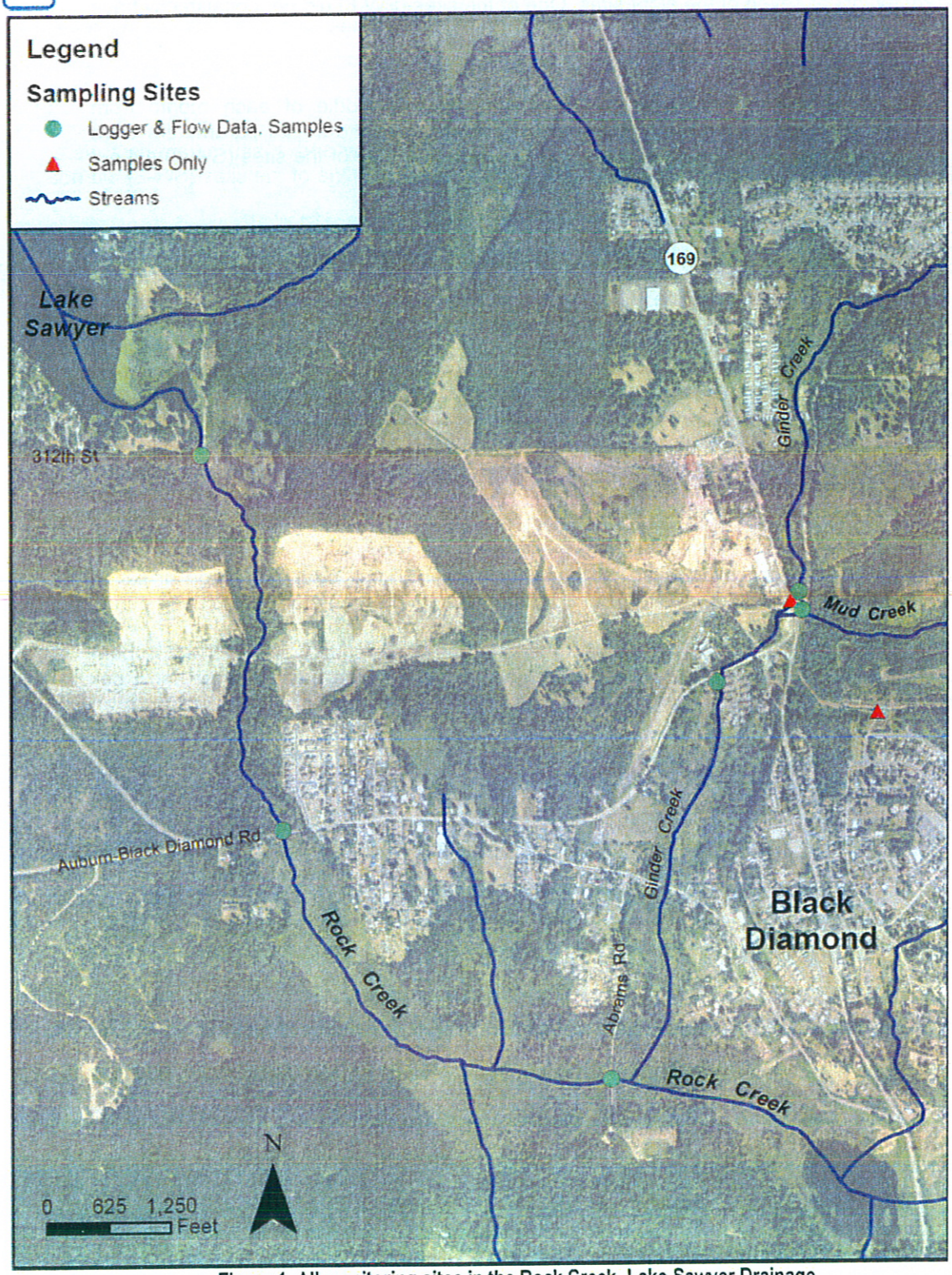

Figure 1. All monitoring sites in the Rock Creek- Lake Sawyer Drainage

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Figure 3. Monitoring site Hammerhead Ditch and the Ditch at Roberts Drive in the Lake Sawyer drainage area

Figure 4. Monitoring site at the Ditch at Roberts Drive in the Lake Sawyer Drainage

Figure 5. Site locations for monitoring on lower Rock Creek, SE Auburn Black Diamond Rd, and 312th Street.

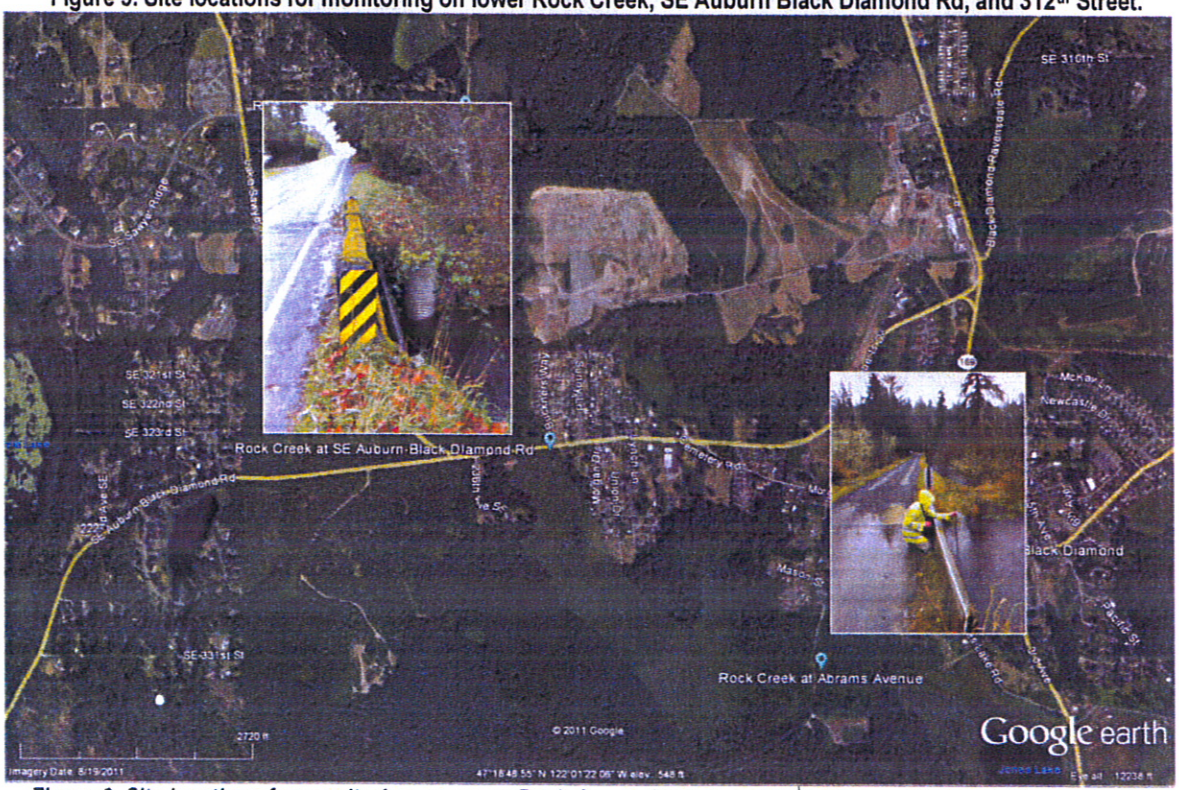

Figure 6. Site locations for monitoring on upper Rock Creek; SE Auburn Black Diamond Rd and Abrams Avenue

Site locations for stormwater sampling in the Lake Sawyer/ Rock Creek drainage are reported in Table 1. Pictures of each site can be found below in Figure 6 through Figure 13.

Table 1. Locations for Lake Sawyer drainage monitoring sites.

SITE NAME	LATITUDE	LONGITUDE
Rock Creek at SE 312th Street	47°19'44.76"N	122°01'21.31"W
Rock Creek at SE Auburn-Black Diamond Road	47°18'43.32"N	122°01'30.76"W
Rock Creek at Abrams Avenue	47°18'17.31"N	122°00'44.12"W
Rock Creek at the Ditch at Robert's Drive	47°18'58.12 N	122°00'27.38 W
Basin at SR 169	47°19'04.87 N	122°00'17.52 W
Mud Creek	47°19'03.82 N	122°00'15.97 W
Ginder Creek	47°19'05.59 N	122°00'16.76 W
Hammerhead Ditch*	47°18'53.70 N	122°00'04.84 W

*Additional monitoring site added (April 10, 2013).

Figure 7. Ginder Creek sampling location

Figure 8. Mud Creek sampling location

Figure 9. Ditch on Roberts Drive sampling location

Figure 10. Abrams Avenue sampling location

Figure 11. Rock Creek at 312th Street sampling location

B) STORMWATER AND AMBIENT MONITORING PARAMETERS

Several nutrient parameters and physical properties including turbidity and total solids were measured as part of each round of samples for each site. The list of parameters measured at each site is reported in Table 2. A total of 6 storm events and 12 ambient events were characterized during the 2012-2013 year.

Table 2. Water quality parameters described from monitoring sites

WATER QUALITY PARAMETER	Rock Creek at SE 312th St	Rock Creek at SE Auburn-Black Diamond Rd	Rock Creek at Abrams Rd	Rock Creek at the Ditch at Robert's Drive	The Basin at SR 169	Ginder Creek	Mud Creek	No. of Stormwater Sampling Events	No. of Samples per Visit at each Site	No. of Non-storm Monitoring Events	Total number of sites
Total Phosphorus	X	X	X	X	X	X	X	6	3	12	7+1*
Soluble Reactive Phosphorus	X	X	X	X	X	X	X	6	3	12	7+1*
Ammonia	X	X	X	X	X	X	X	6	3	12	7+1*
NO_3+ NO_2	X	X	X	X	X	X	X	6	3	12	7+1*
Total Nitrogen	X	X	X	X	X	X	X	6	3	12	7+1*
Total Suspended Solids	X	X	X	X	X	X	X	6	3	12	7+1*
Turbidity	X	X	X	X	X	X	X	6	3	12	7+1*
Temperature	X	X	X	X	X	X	X	6	3	12	7+1*
Conductivity	X	X	X	X	X	X	X	6	3	12	7+1*
Dissolved Oxygen	X	X	X	X	X	X	X	6	3	12	7+1*
pH	X	X	X	X	X	X	X	6	3	12	7+1*

*Additional monitoring site added (April 10, 2013).

2.0 RESULTS

Storm event sampling was conducted on the following six dates (1) December 4, 2012, (2) December 17, 2012, (3) January 23, 2013 (4) January 30, 2013, (5) February 28, 2013, and (6) April 4, 2013. Data were collected from seven sites and three sets of water samples were collected from each of those sites during each storm event. Samples were collected within a 12-hour period to determine concentration changes on the rising and falling limbs of each storm event. The data reflect the delivery of nutrients and other elements to receiving streams in the sub-drainage.

Concentrations were recorded for each parameter and compared among all sites from farthest downstream to furthest upstream in both Rock Creek and the sub-drainage Ginder Creek. These data compared concentrations for portions of the storm hydrograph as the event progressed. A comparison of water quality conditions between sub-drainage sites (Ginder Creek) and downstream of the confluence with Rock Creek described changes that occurred as stormwater moved toward the lower portion of Rock Creek.

Flow monitoring was conducted during five of the seven storm events sampled at the seven sites in these two drainages. Flow-rating curves were developed for six sites that related staff gage height (or levelogger stage heights) with flow observations collected from storm and non-storm (base flow) monitoring events. The stage height-flow relationships are being used to calculate flow values for each levelogger stage-height data point when sites were not visited for either storm event monitoring or for ambient (baseline) monitoring.

Regular, non-storm monitoring was conducted during the twelve consecutive months beginning November 2012 and ending October 2013. Water samples were collected that characterized nutrient concentrations, suspended solids, and in-situ parameters on a monthly timeline from the mid-portion of the channel at each site in order to characterize base flow conditions during the pre-construction period. Data were collected from seven sites routinely and an eighth site when water was present. In-situ parameters recorded were DO, conductivity, temperature, pH, and flow.

2.1 Stormwater Results: Storm Event Sampling (December 4, 2012)

The first stormwater samples were collected on December 4, 2012 beginning at 08:20 with the last storm event set of sample collection ending at 17:00. Figure 12 shows precipitation at the Black Diamond I&I rain gage (operated by King County) and water level recordings in Rock Creek at SE Auburn Black Diamond Road. Precipitation for December 4, 2012 (for the 24 hour period) totaled 0.47 inches.

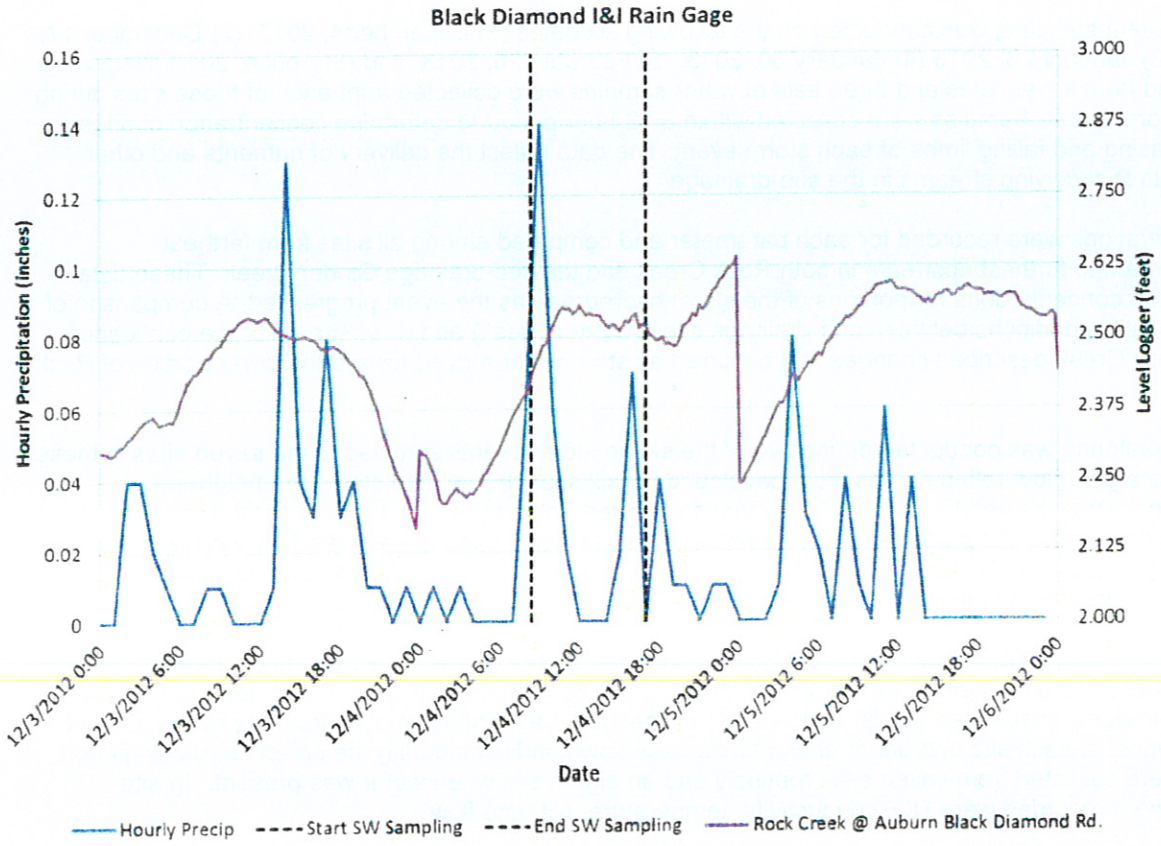

Figure 12. Precipitation at the Black Diamond I&I Rain Gage for the December 4, 2012 Sampling Event Compared to Rock Creek Water Level Recorded at SE Auburn Black Diamond Road

Water quality data from laboratory analysis from the December 4, 2012 storm event are presented in Appendix 1, Table A1. A comparison of TP, SRP, and TSS results among sites are shown in Figures 13-18.

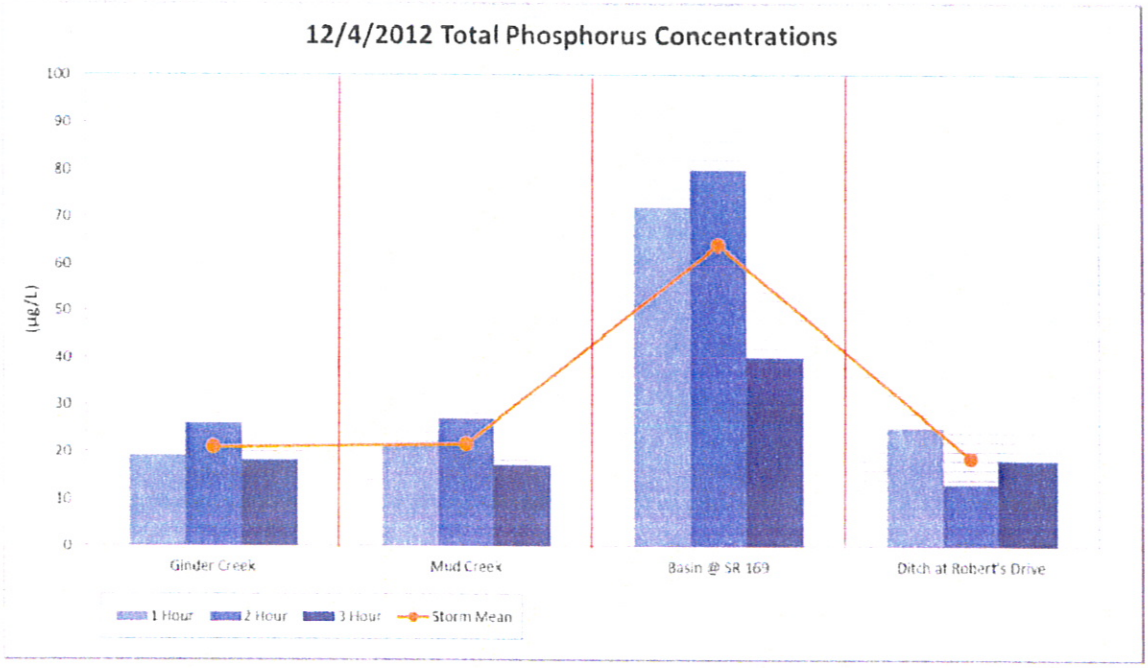

Figure 13. Total phosphorus concentrations in the Lake Sawyer drainage basin during the 12/4/2012 stormwater sampling event.

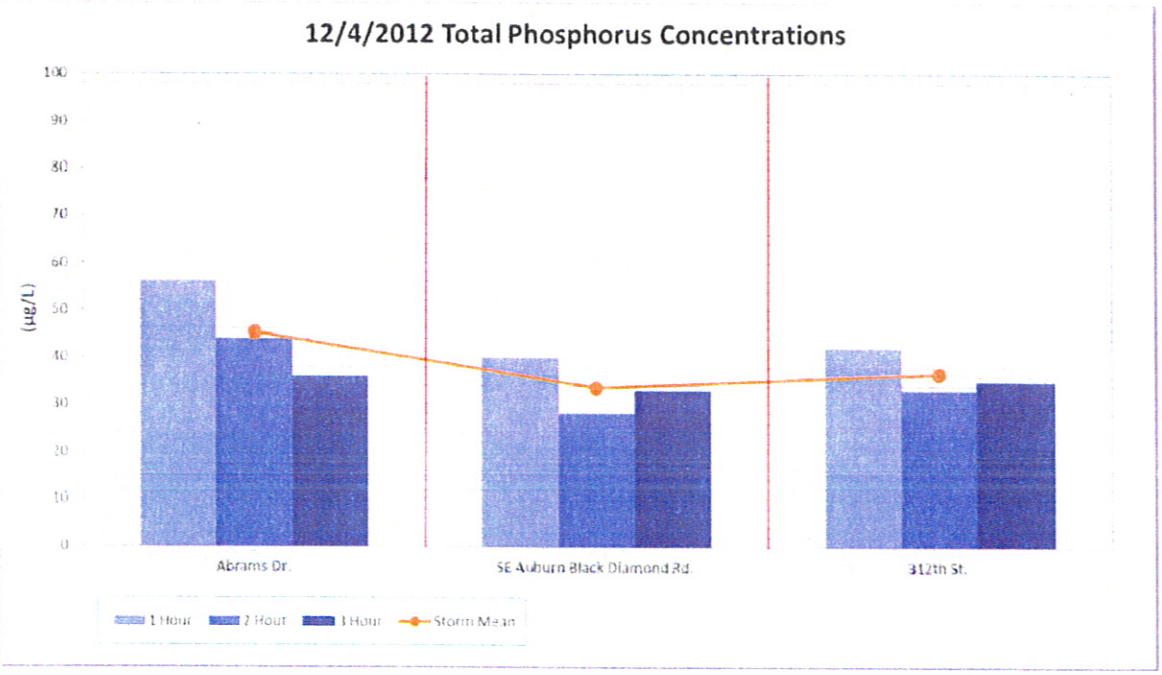

Figure 14. Total phosphorus concentrations in Rock Creek during the 12/4/2012 stormwater sampling event.

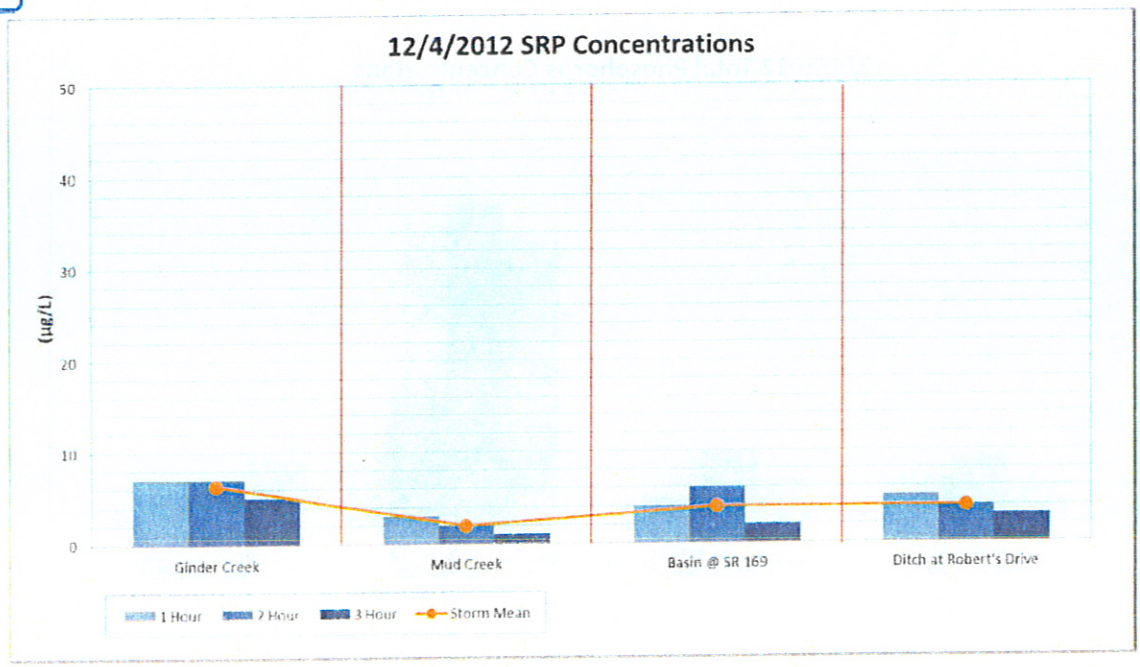

Figure 15. Soluble reactive phosphorus concentrations in the Lake Sawyer drainage during the 12/4/2012 stormwater sampling event.

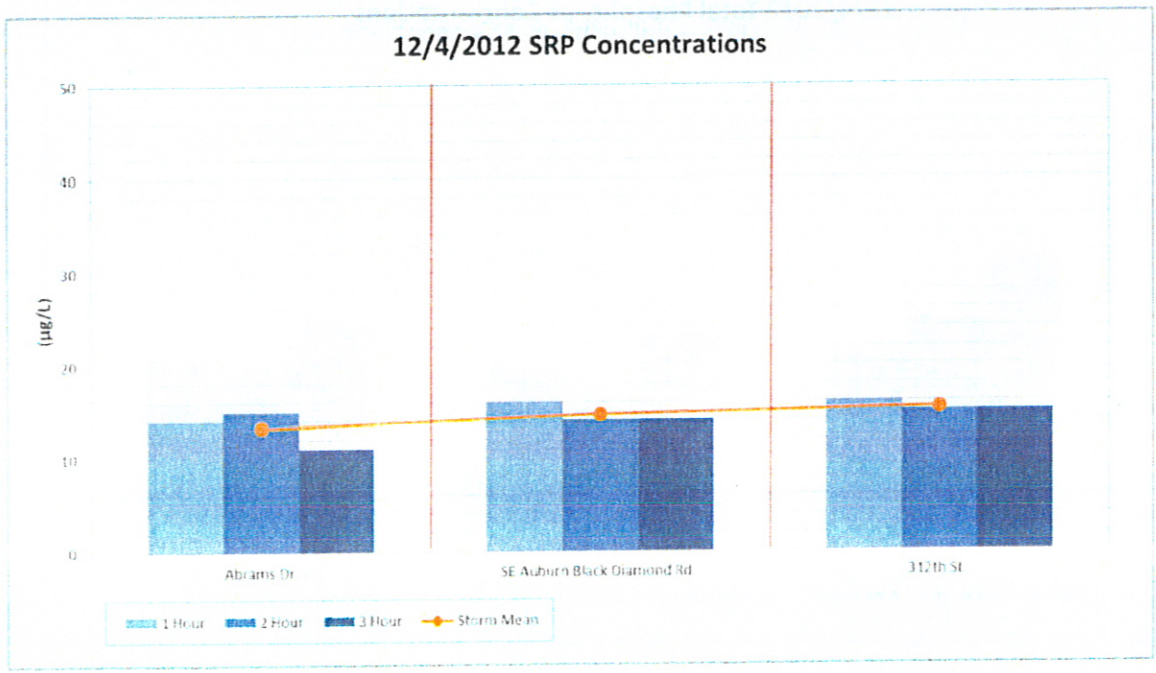

Figure 16. Soluble reactive phosphorus concentrations in Rock Creek during the 12/4/2012 stormwater sampling event.

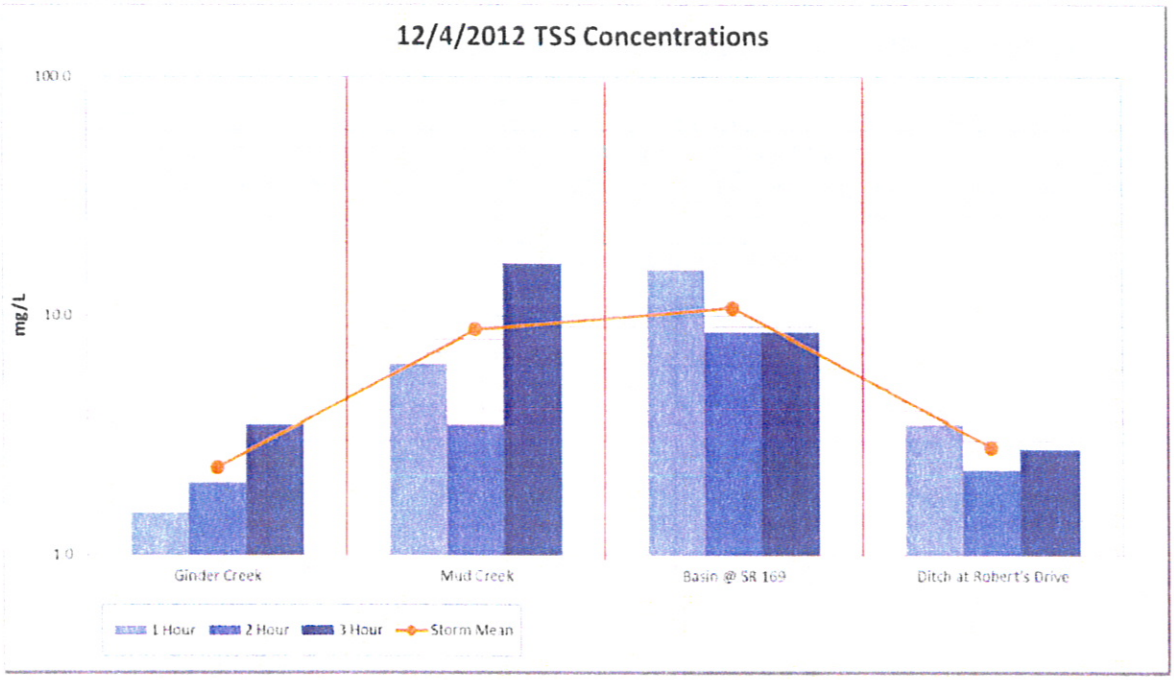

Figure 17. Total suspended solids concentrations in the Lake Sawyer drainage during the 12/4/2012 stormwater sampling event

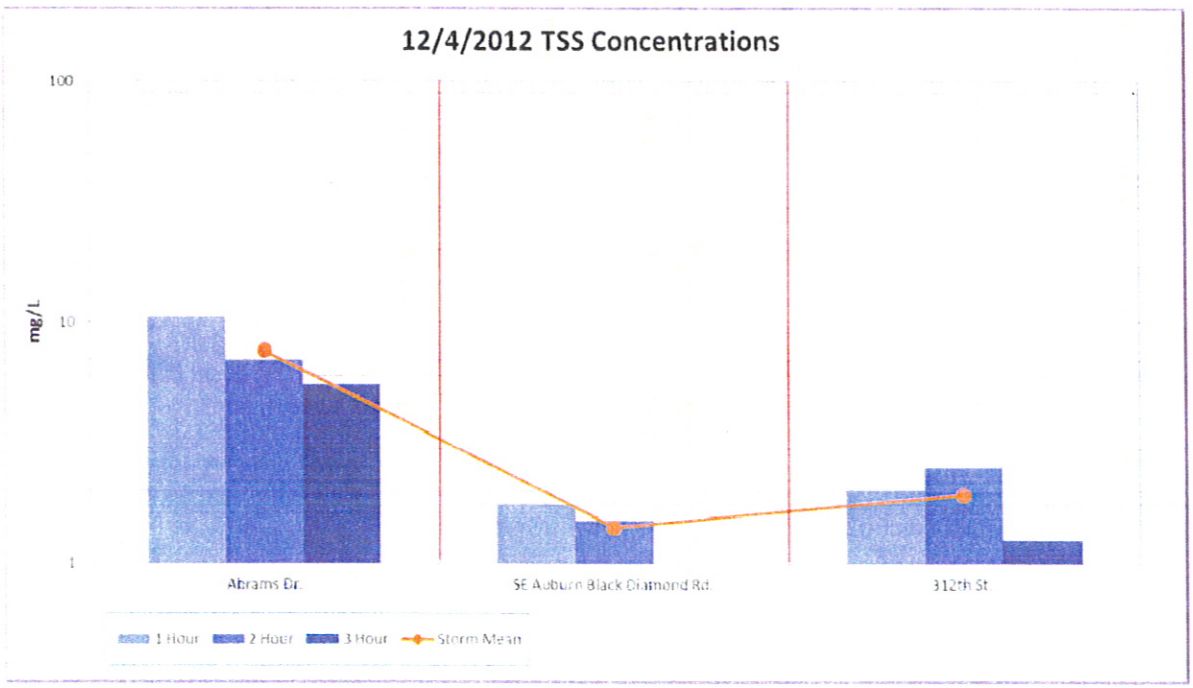

Figure 18. Total suspended solids concentrations in the Rock Creek drainage during the 12/4/2012 stormwater sampling event

2.2 Stormwater Results: Storm Event Sampling (December 17, 2012)

A second set of stormwater samples were collected on December 17, 2012 from 09:15 through 18:15. Figure 19 reports precipitation at the Black Diamond I&I rain gage (operated by King County) during the sampling event with corresponding water levels (level logger records) at the Rock Creek at SE Auburn Black Diamond Road. Precipitation for December 17, 2012 (for the 24 hour period) totaled 0.49 inches.

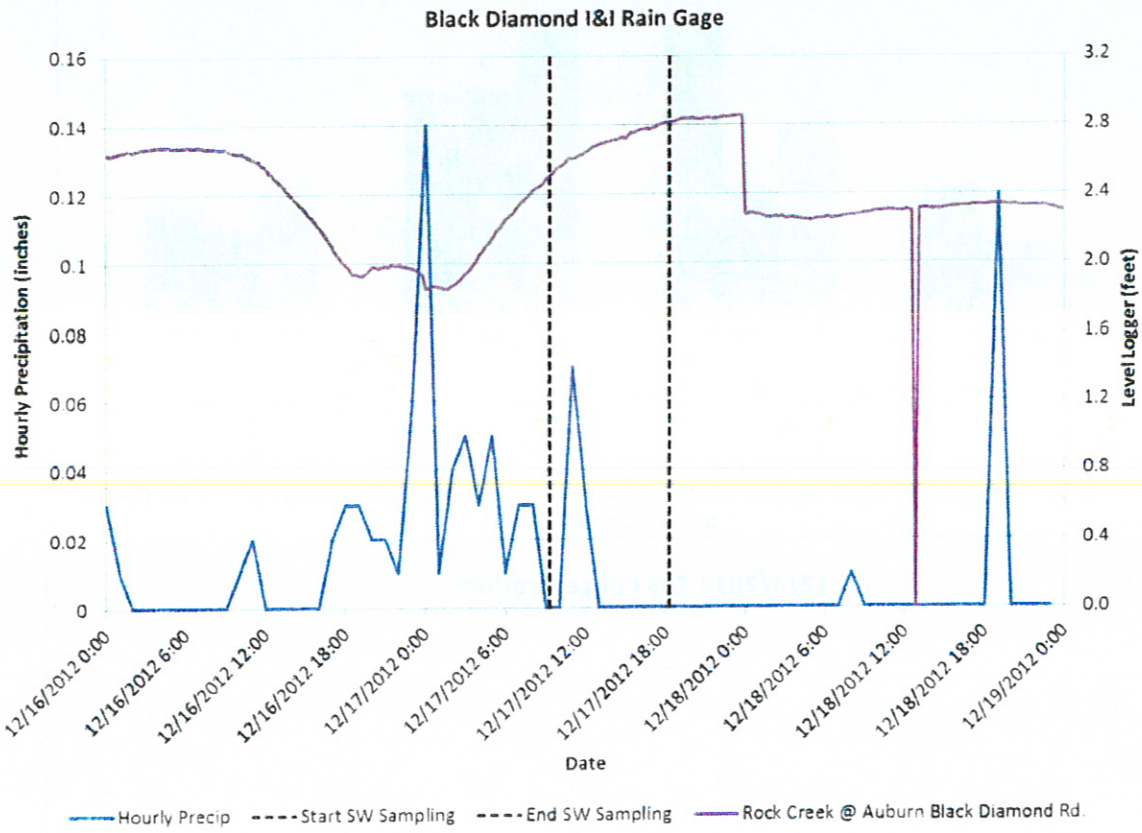

Figure 19. Precipitation at the Black Diamond I&I Rain Gage for the December 17, 2012 Sampling Event Compared to Rock Creek Water Level Recorded at SE Auburn Black Diamond Road

Water quality data from laboratory analysis for the December 17, 2013 storm event are presented in Appendix 1, Table A2 and field water quality measurements are reported in Table A3. A comparison of TP, SRP, and TSS results among sites are found below in Figures 20-25.

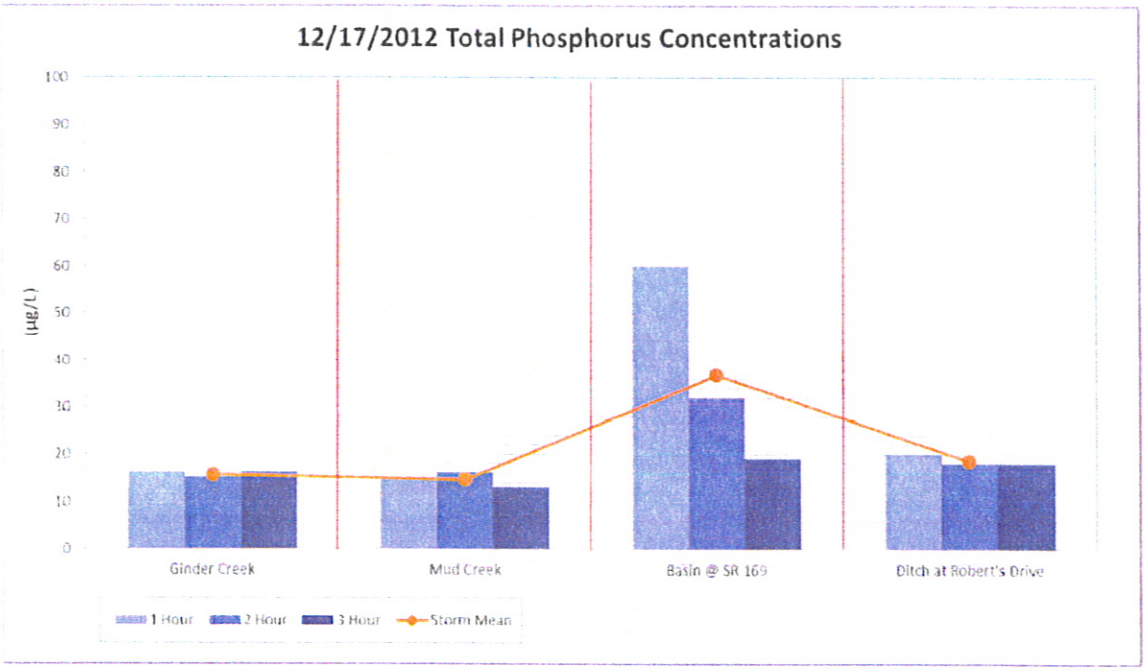

Figure 20. Total phosphorus concentrations in the Lake Sawyer Drainage Basin during the 12/17/2012 stormwater sampling event

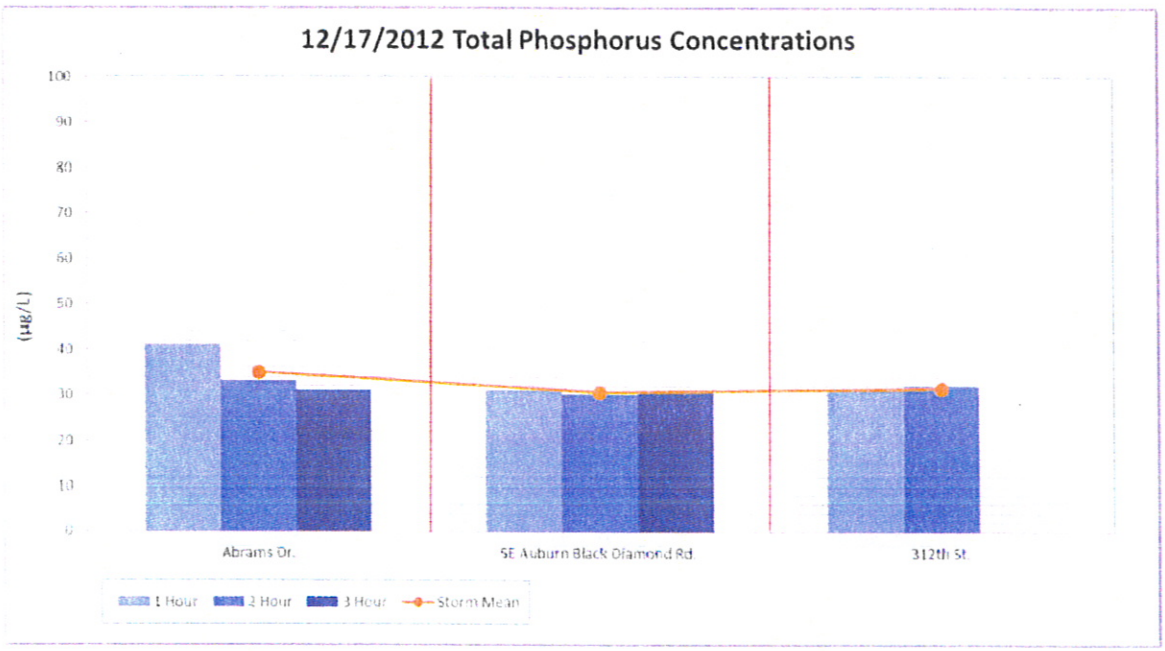

Figure 21. Total phosphorus concentrations in the Rock Creek drainage during the 12/17/2012 stormwater sampling event

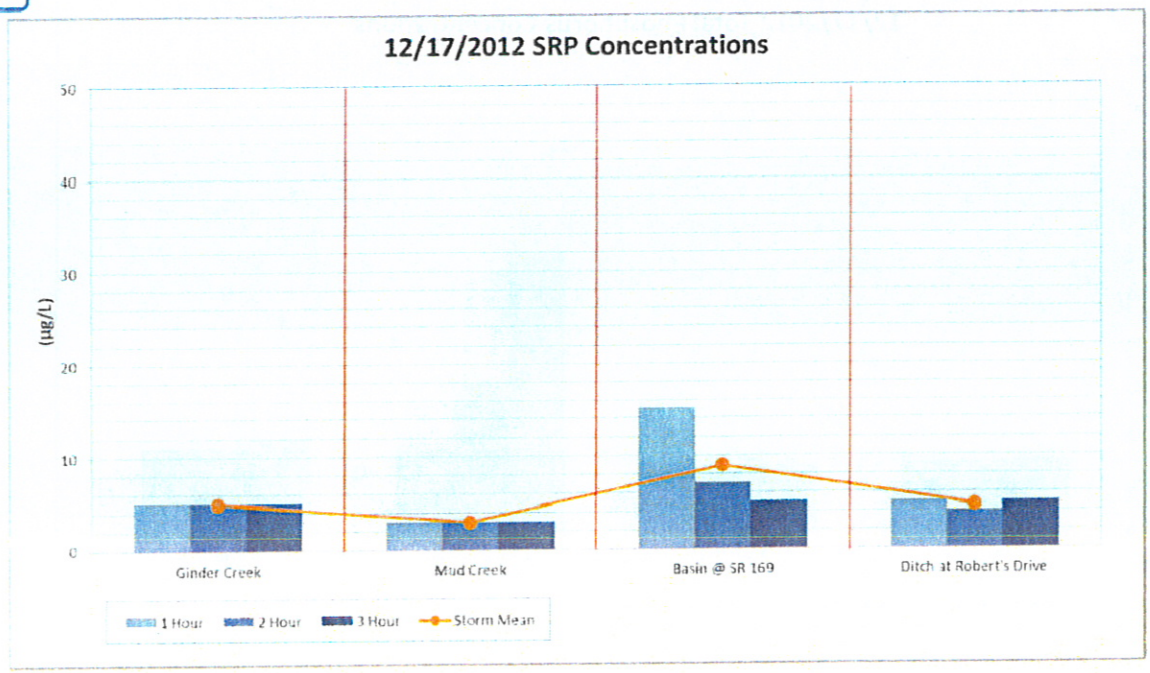

Figure 22. Soluble reactive phosphorus concentrations in the Lake Sawyer drainage during the 12/17/2012 stormwater sampling event

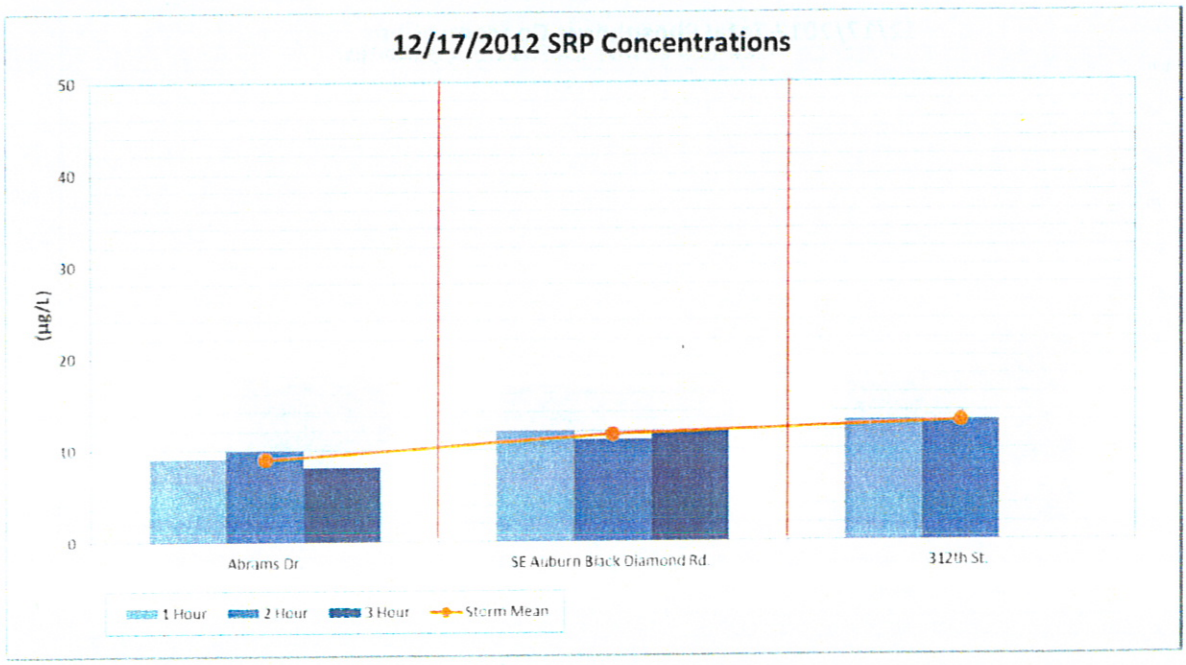

Figure 23. Soluble reactive phosphorus concentrations for the 12/17/2012 stormwater sampling event

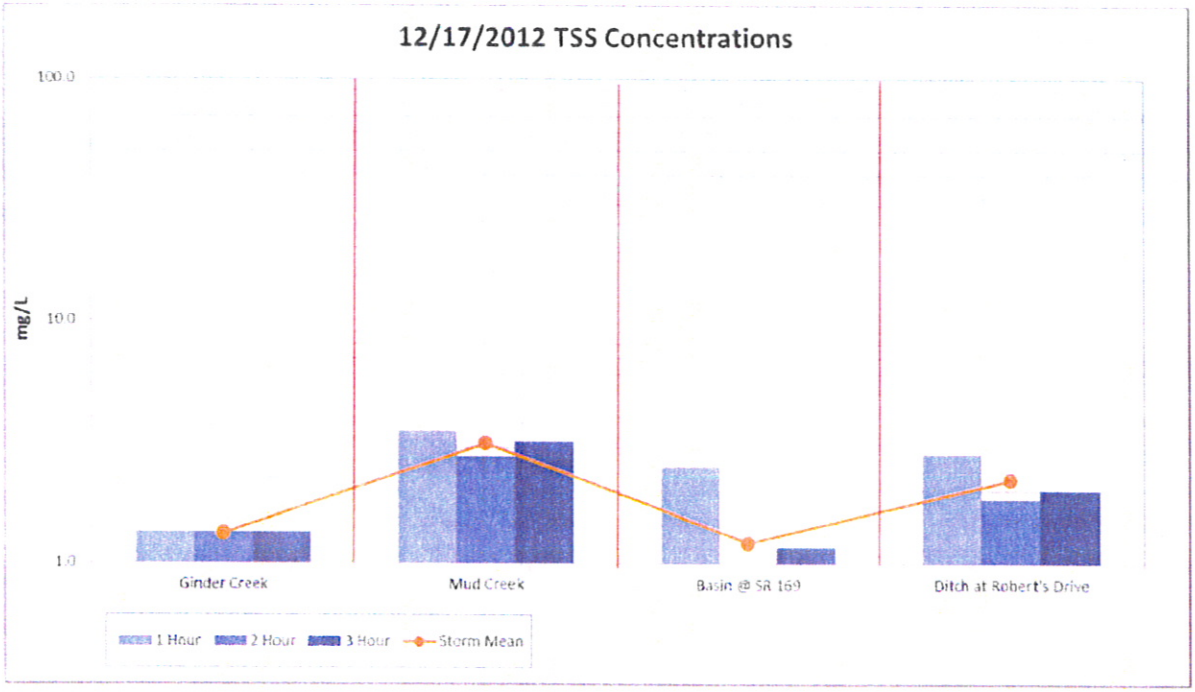

Figure 24. Total suspended solids concentrations for the Lake Sawyer drainage during the 12/17/2012 stormwater sampling event

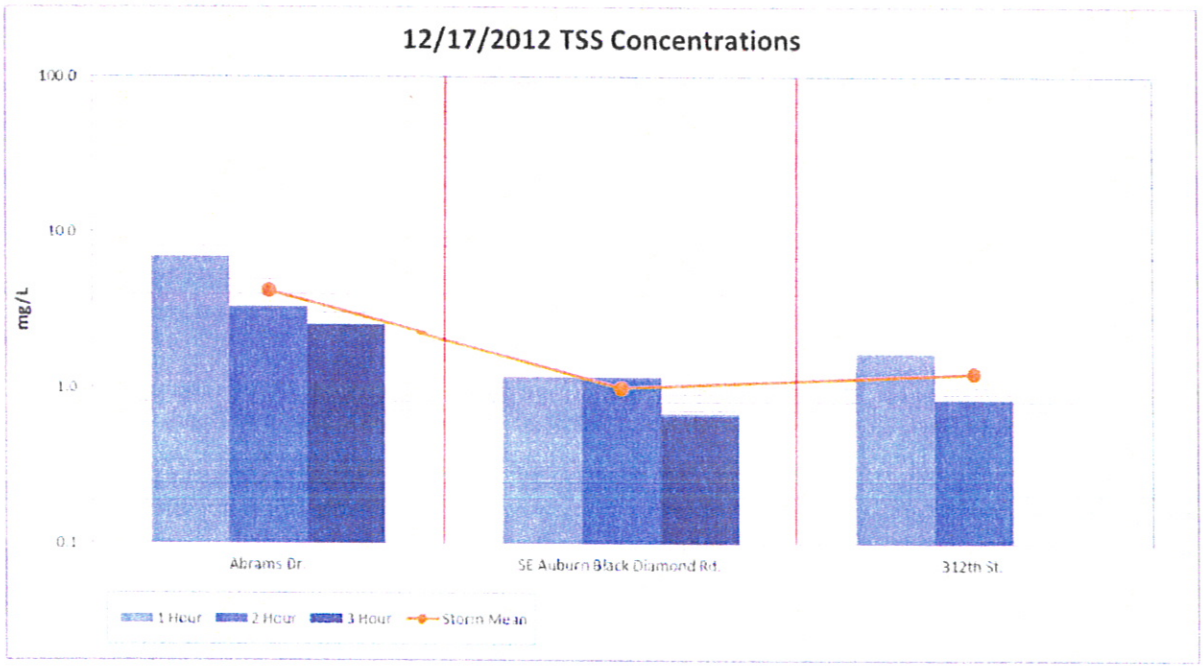

Figure 25. Total suspended solids concentrations for the Lake Sawyer drainage during the 12/17/2012 stormwater sampling event

2.3 Stormwater Results: Storm Event Sampling (January 23, 2013)

Stormwater samples were collected from 10:10 to 19:45 on January 23, 2013. Figure 26 shows precipitation at the Black Diamond I&I rain gage (operated by King County) during the sampling event compared to water level recorded in Rock Creek at SE Auburn Black Diamond Road. Precipitation for January 23, 2013 (for the 24 hour period) totaled 0.09 inches.

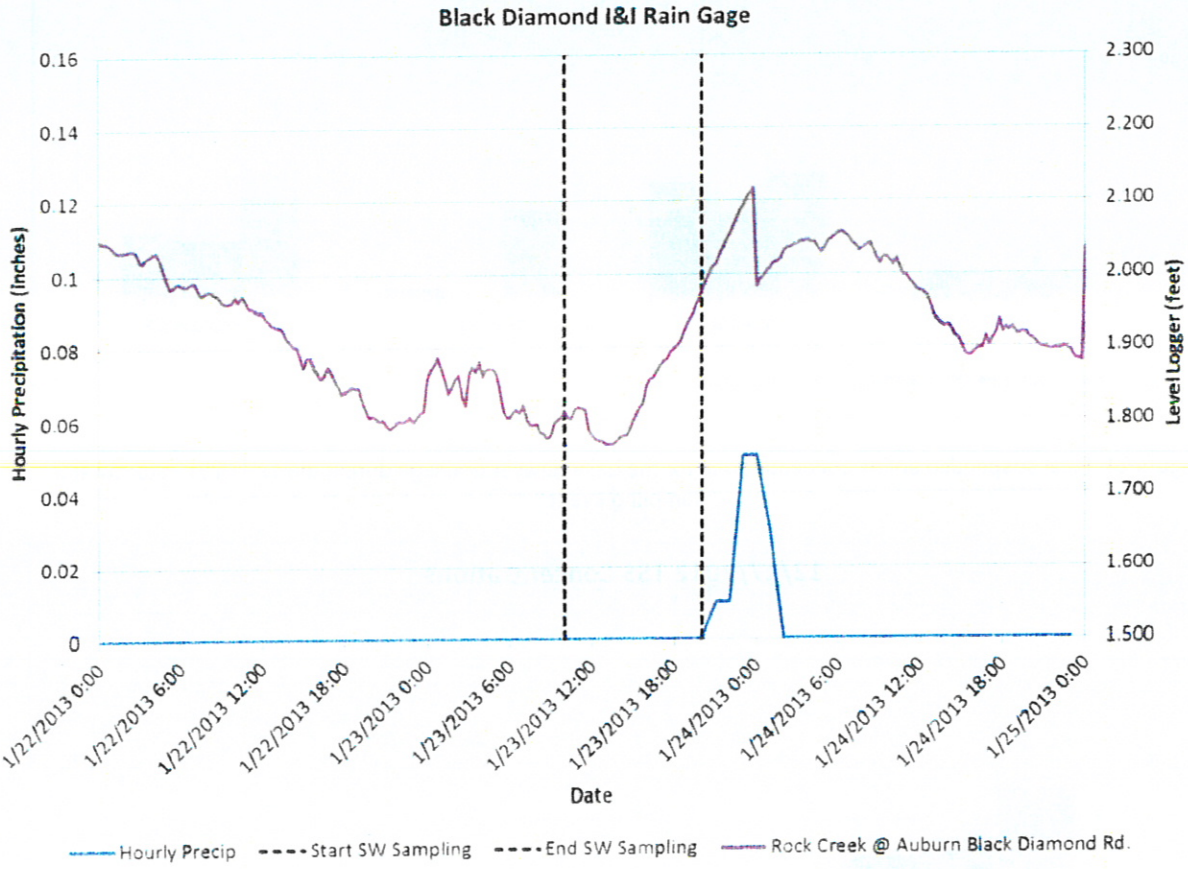

Figure 26. Precipitation at the Black Diamond I&I Rain Gage for the January 23, 2013 Sampling Event Compared to Rock Creek Water Level Recorded at SE Auburn Black Diamond Road.

Water quality data from laboratory analysis from the January 23, 2013 storm event are presented in Appendix 1, Table A4 and field water quality measurements are reported in Table A5. A comparison of TP, SRP, and TSS results among sites are found below in Figures 27-32.

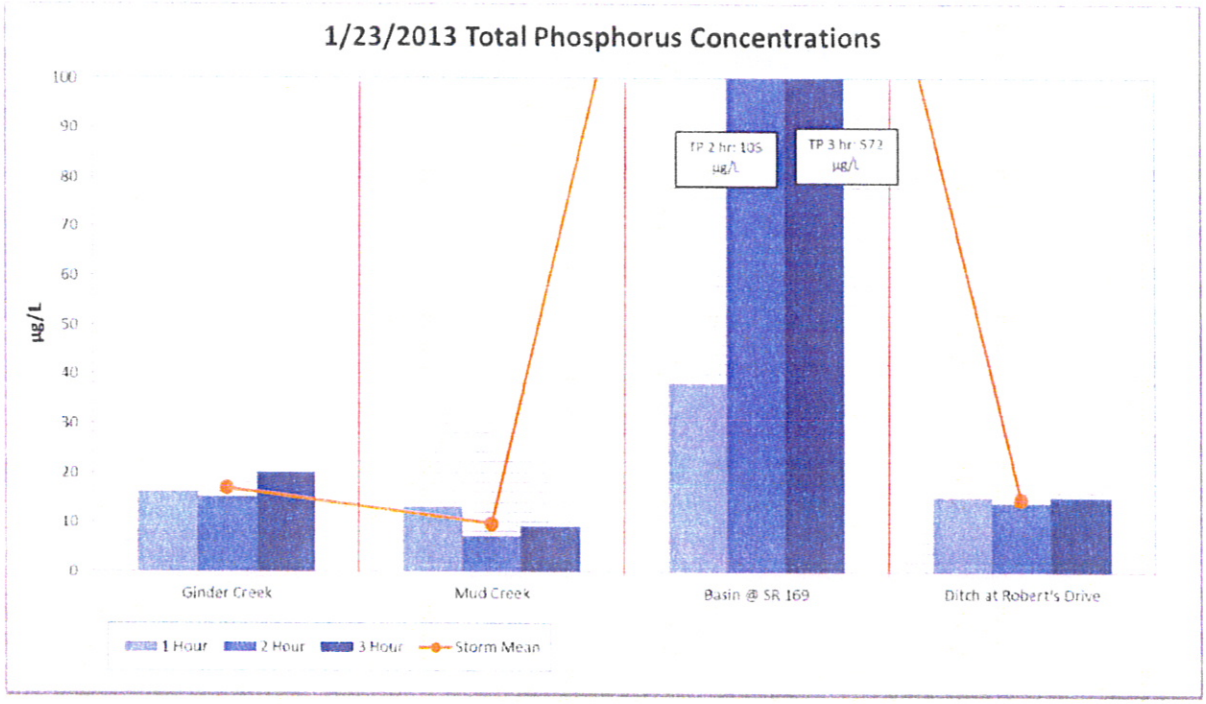

Figure 27. Total phosphorus concentrations for the Lake Sawyer drainage during the 1/23/2013 stormwater sampling event

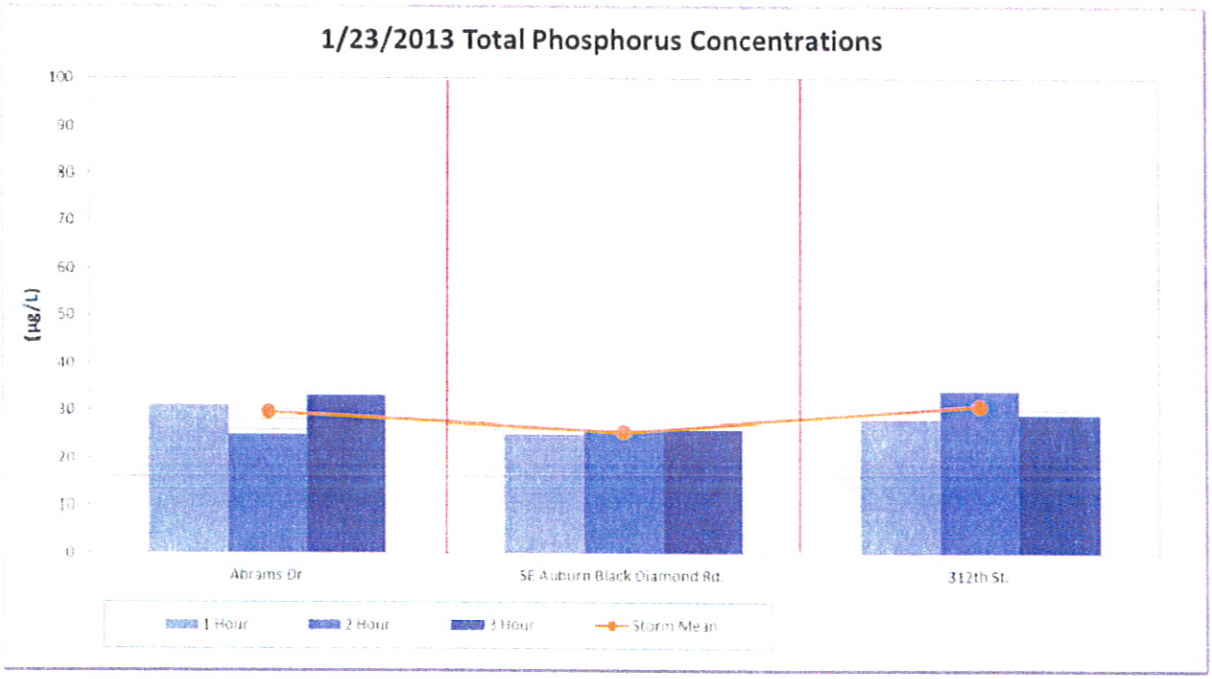

Figure 28. Total phosphorus concentrations for the Rock Creek drainage during the 1/23/2013 stormwater sampling event

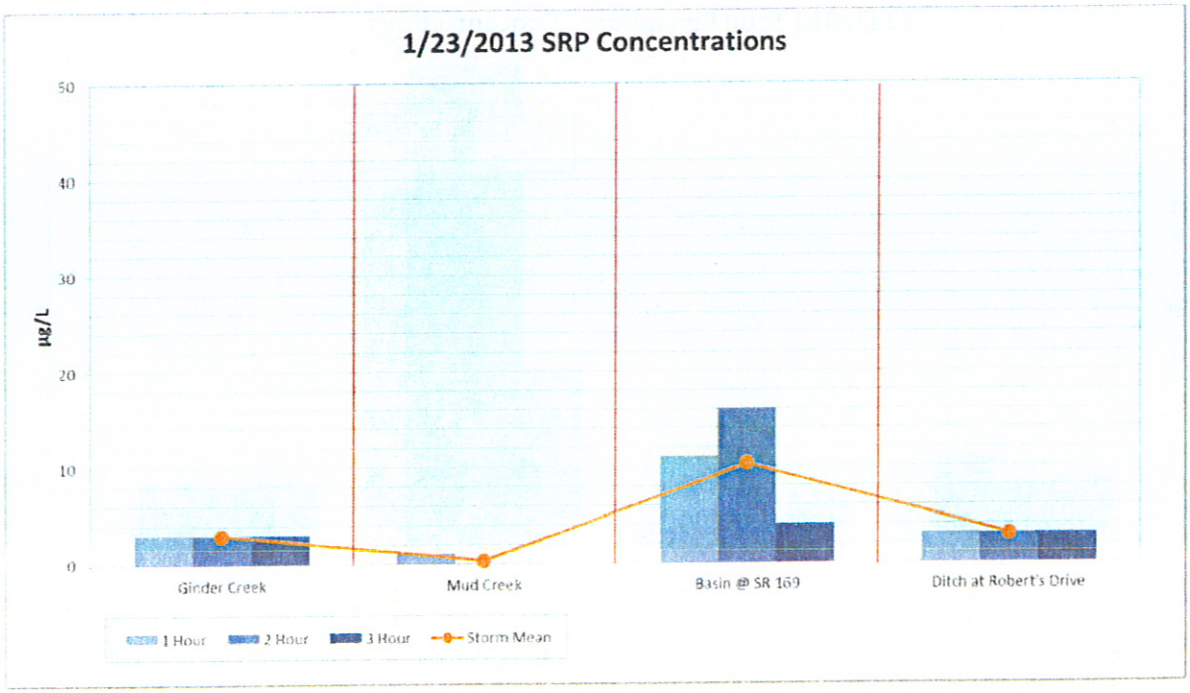

Figure 29. Soluble reactive phosphorus for the Lake Sawyer drainage during the 1/23/2013 stormwater sampling event

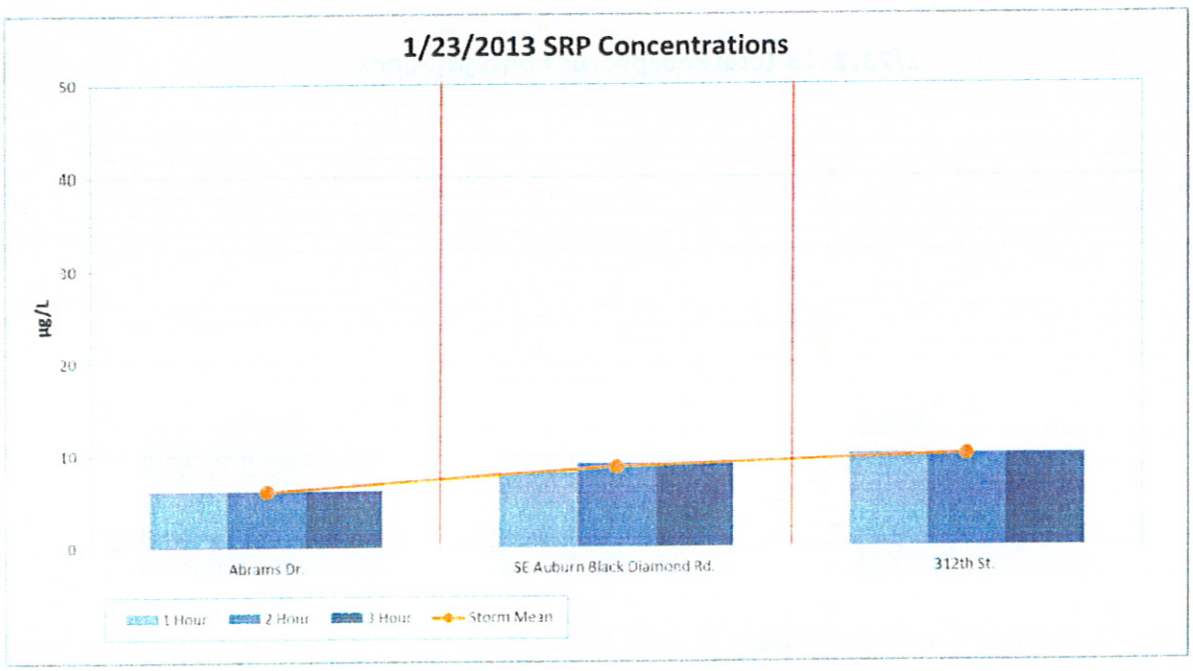

Figure 30. Soluble reactive phosphorus concentrations for the Rock Creek drainage during the 1/23/2013 stormwater sampling event

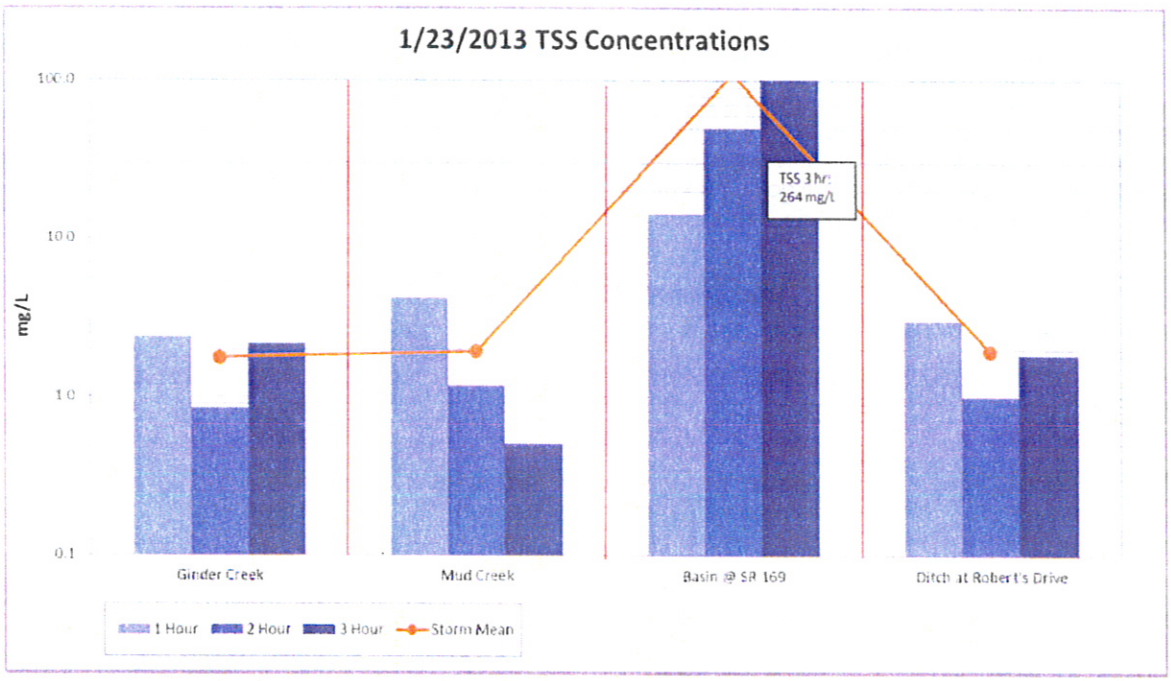

Figure 31. Total suspended solids concentrations for the Lake Sawyer drainage during the 1/23/2013 stormwater sampling event

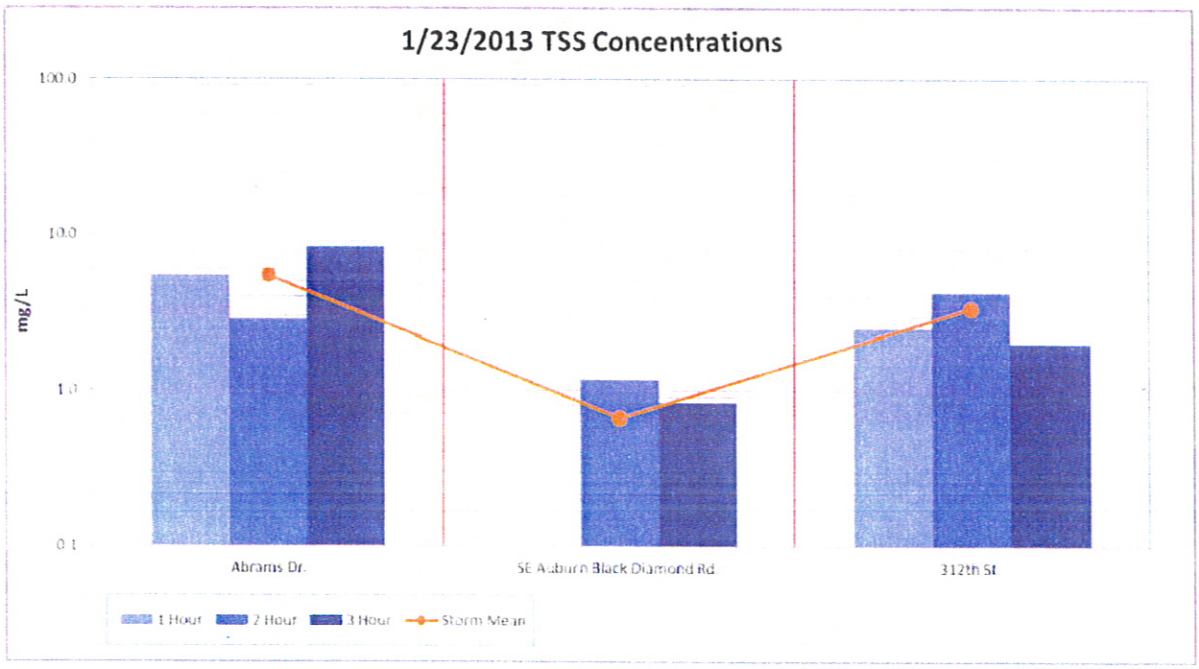

Figure 32. Total suspended solids concentrations for the Rock Creek drainage during the 1/23/2013 stormwater sampling event

2.4 Stormwater Results: Storm Event Sampling (January 30, 2013)

Stormwater samples were collected from 9:00 to 21:30 on January 30, 2013. Figure 33 shows precipitation at the Black Diamond I&I rain gage (operated by King County) during the sampling event compared to water level recorded in Rock Creek at SE Auburn Black Diamond Road. Precipitation for January 30, 2013 (for the 24 hour period) totaled 0.42 inches.

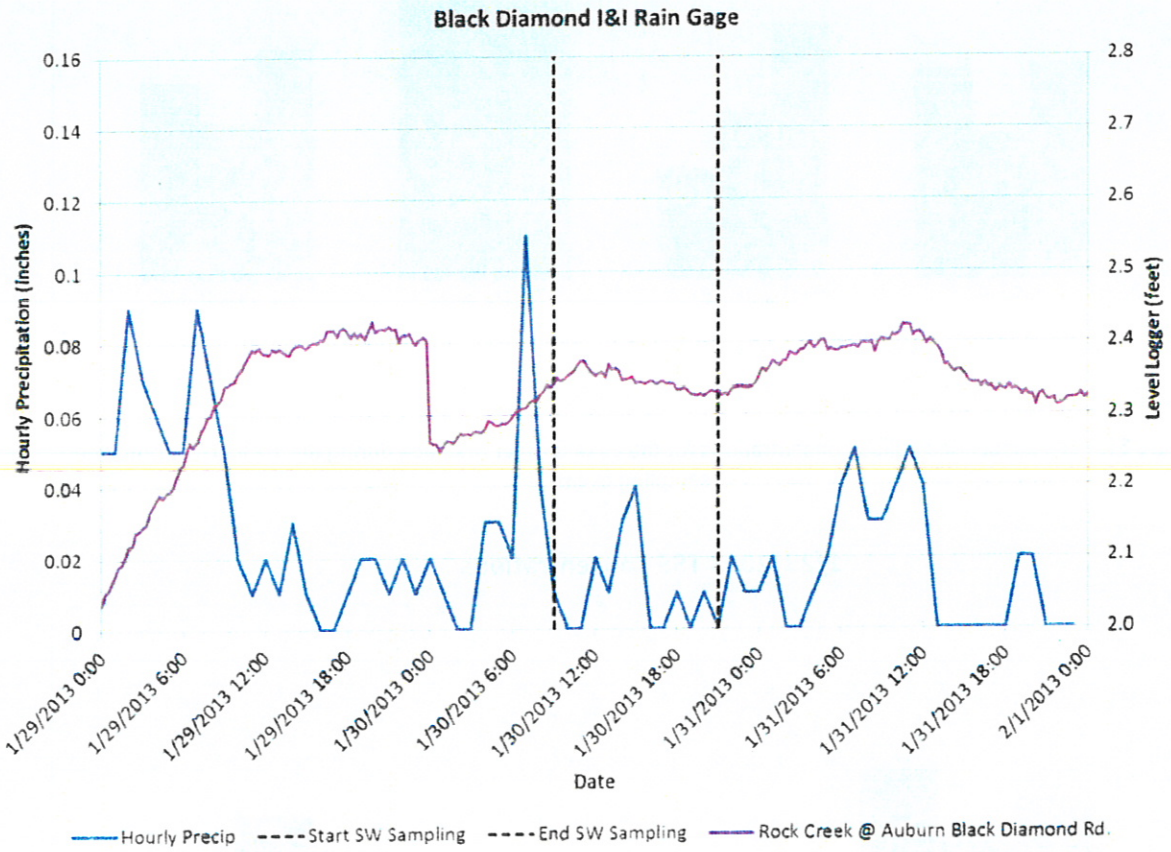

Figure 33. Precipitation at the Black Diamond I&I Rain Gage for the January 30, 2013 Sampling Event Compared to Rock Creek Water Level Recorded at SE Auburn Black Diamond Road.

Water quality data from laboratory analysis for the January 30, 2013 storm event are presented in Appendix 1, Table A6 and field water quality measurements are reported in Table A7. A comparison of TP, SRP, and TSS results among sites are found below in Figures 34-39.

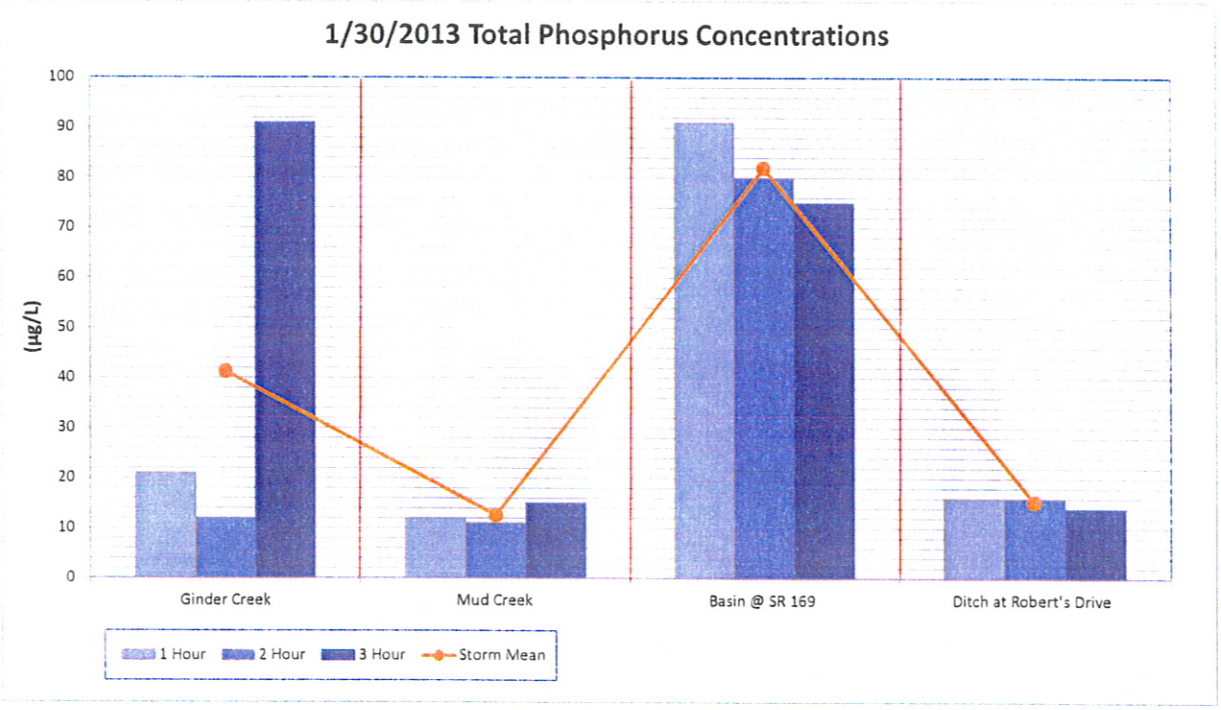

Figure 34. Total phosphorus concentrations in the Lake Sawyer drainage during the 1/30/2013 stormwater sampling event

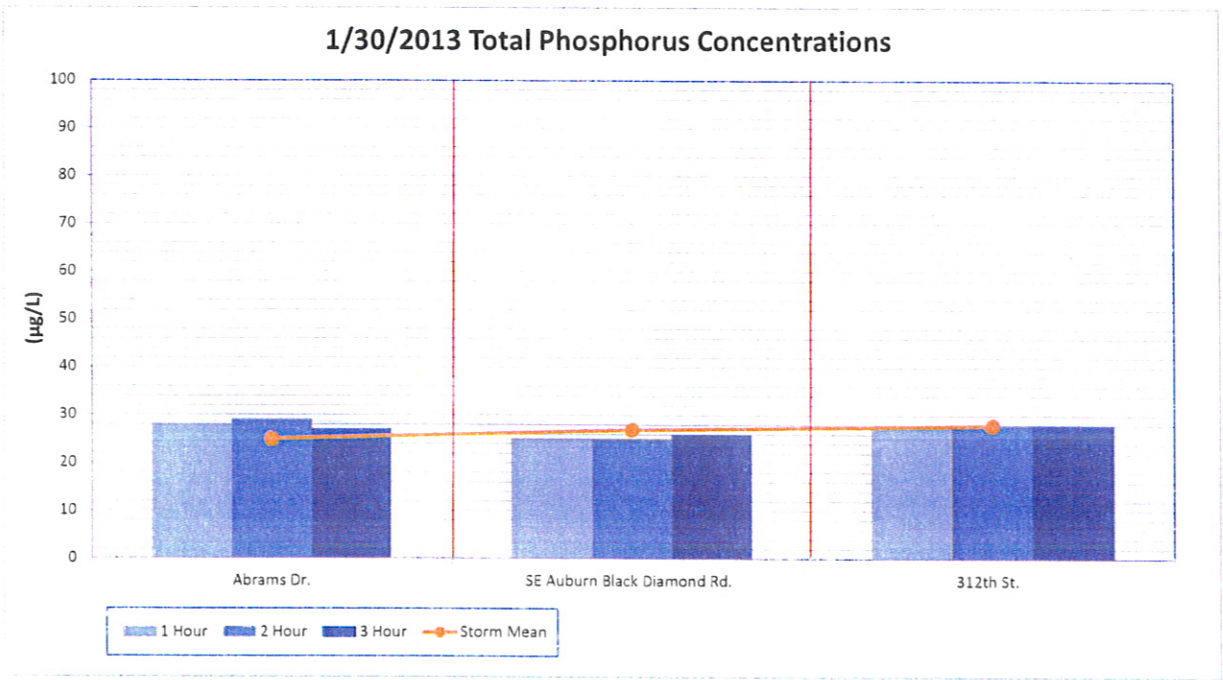

Figure 35. Total phosphorus concentrations in the Rock Creek drainage during the 1/30/2013 stormwater sampling event

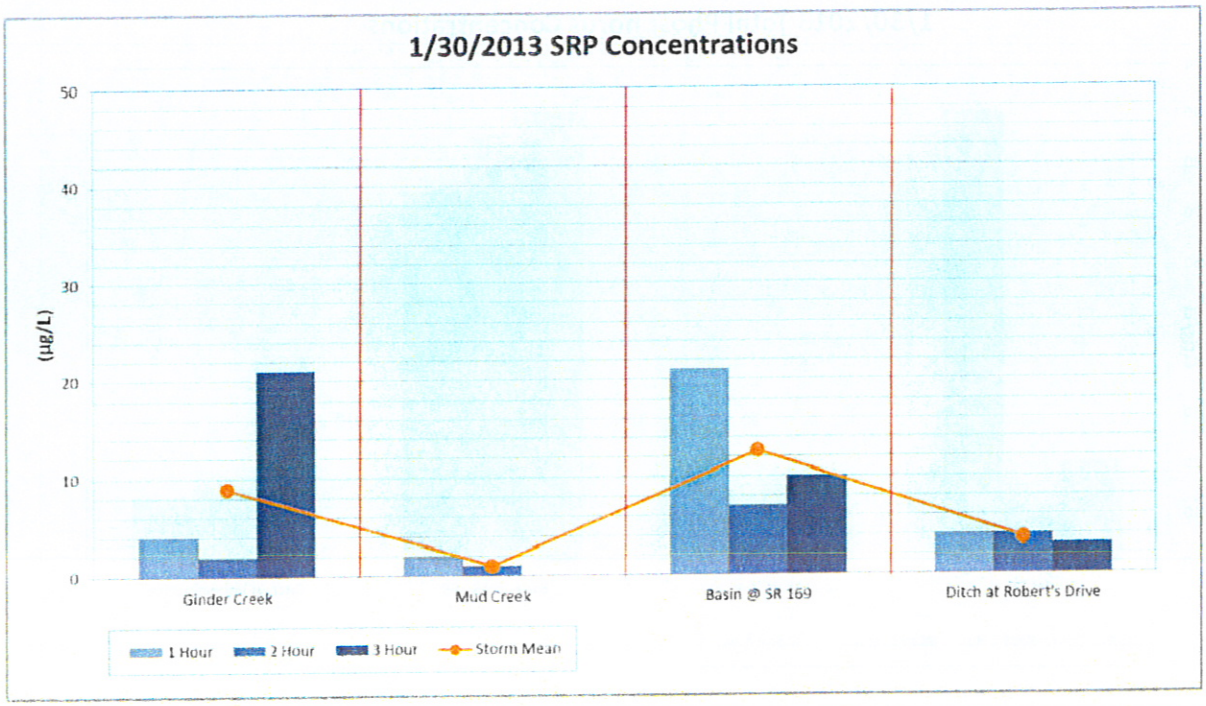

Figure 36. Soluble reactive phosphorus concentrations in the Lake Sawyer drainage during the 1/30/2013 stormwater sampling event

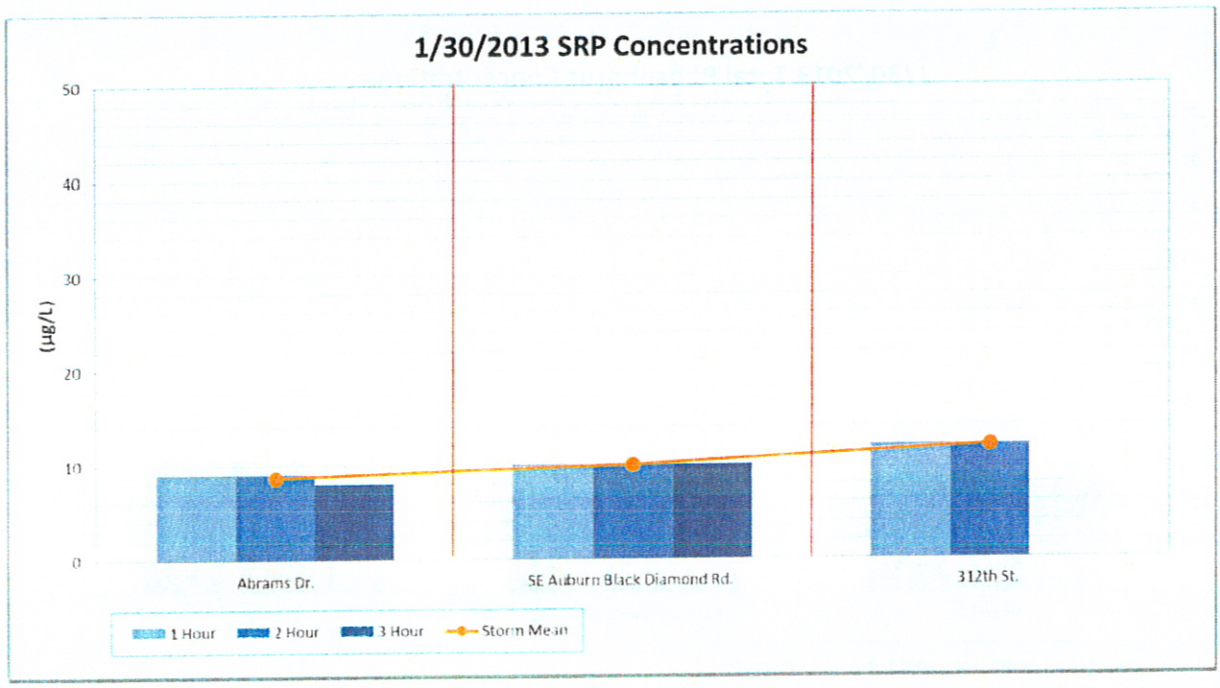

Figure 37. Soluble reactive phosphorus concentrations in the Rock Creek drainage during the 1/30/2013 stormwater sampling event

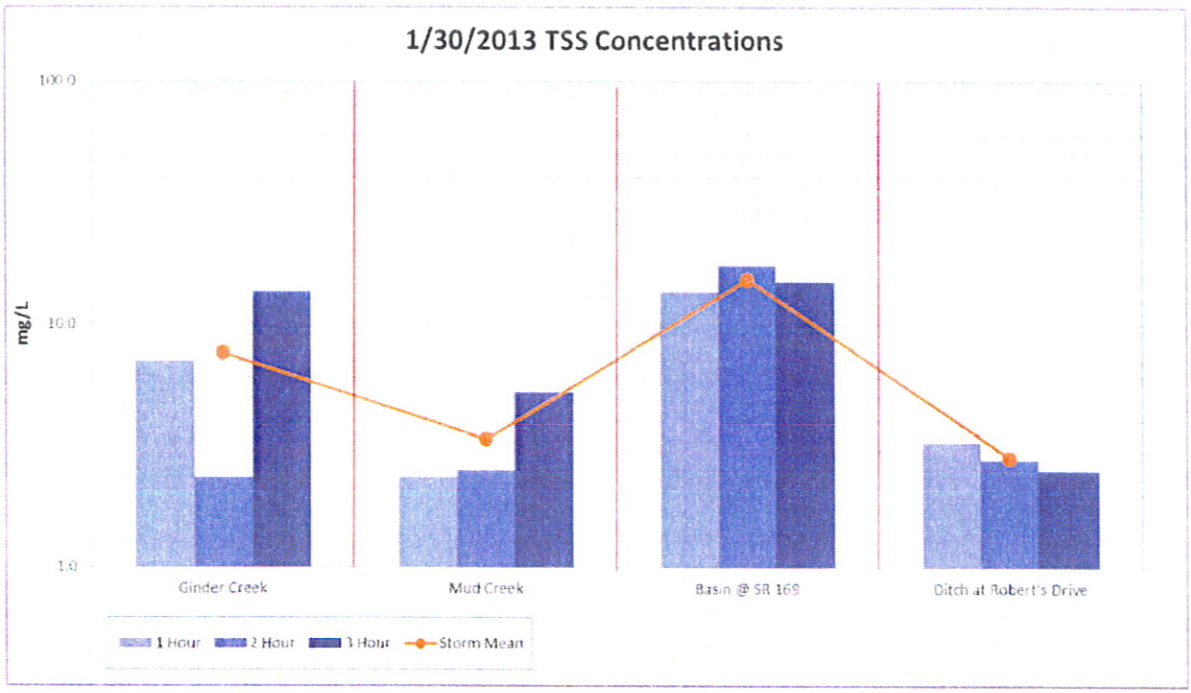

Figure 38. Total suspended solids concentrations in the Lake Sawyer drainage during the 1/30/2013 stormwater sampling event

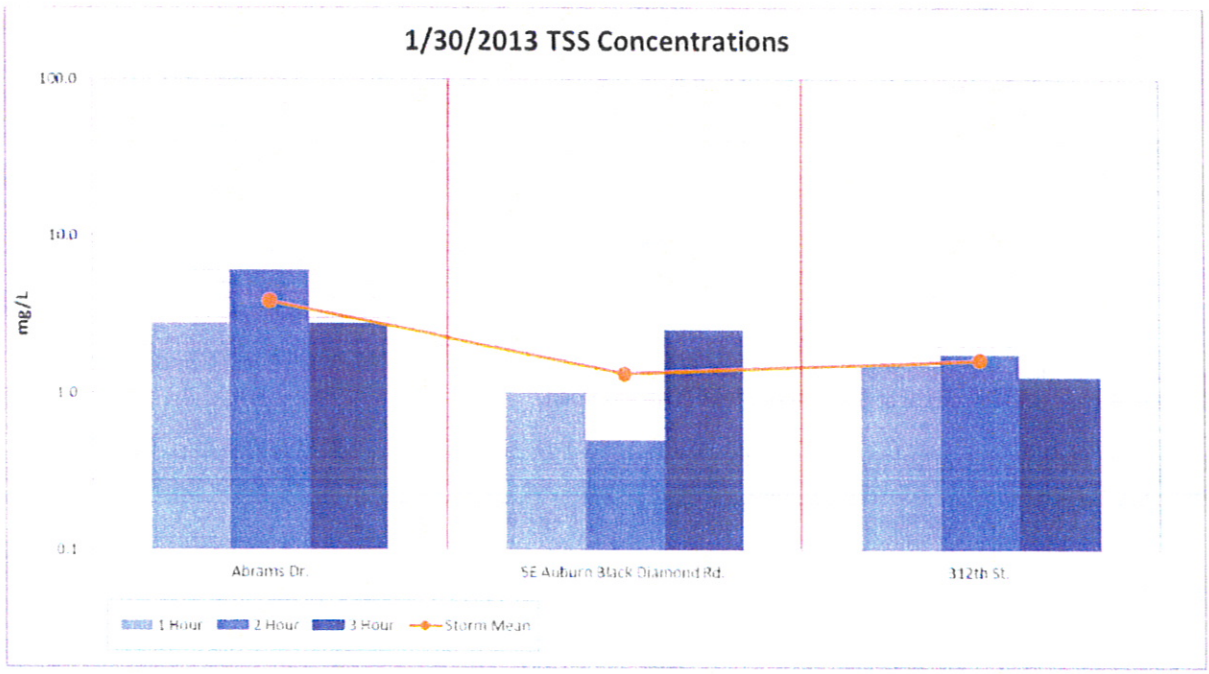

Figure 39. Total suspended solids concentrations in the Rock Creek drainage during the 1/30/2013 stormwater sampling event

2.5 Stormwater Results: Storm Event Sampling (February 28, 2013)

Stormwater samples were collected from 9:00 to 17:15 on February 28, 2013. Figure 40 shows precipitation at the Black Diamond I&I rain gage (operated by King County) during the sampling event compared to water level recorded in Rock Creek at SE Auburn Black Diamond Road. Precipitation for February 28, 2013 (for the 24 hour period) totaled 0.47 inches.

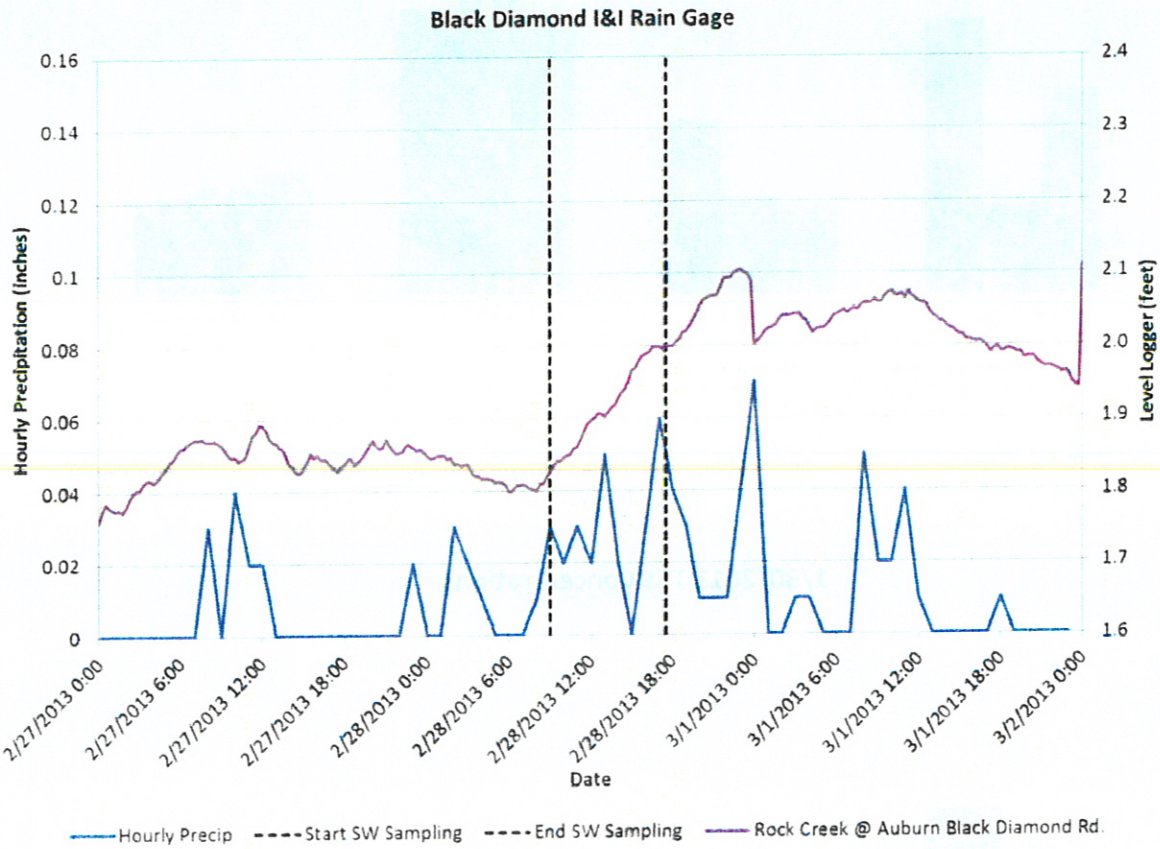

Figure 40. Precipitation at the Black Diamond I&I Rain Gage for the February 28, 2013 Sampling Event Compared to Rock Creek Water Level Recorded at SE Auburn Black Diamond Road.

Water quality data from laboratory analysis for the February 28, 2013 storm event are presented in Appendix 1, Table A8 and field water quality measurements are reported in Table A9. A comparison of TP, SRP, and TSS results among sites are found below in Figures 41-46.

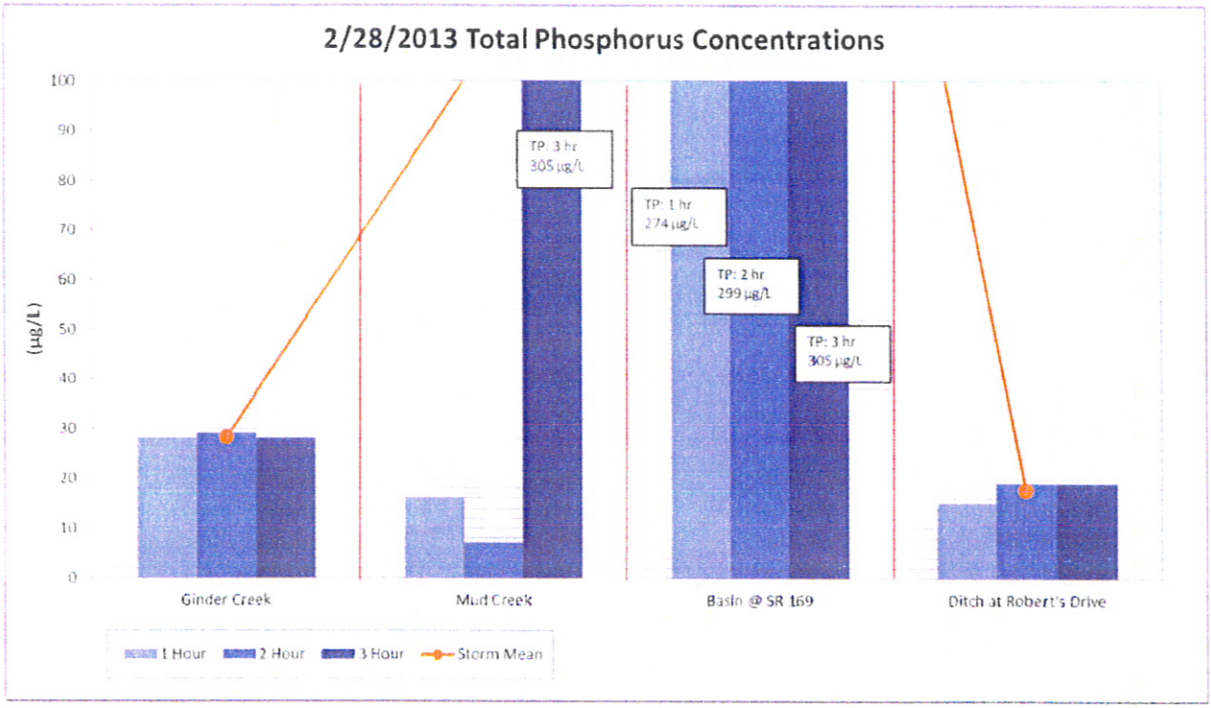

Figure 41. Total phosphorus concentrations for the Lake Sawyer drainage during the 2/28/2013 stormwater sampling event

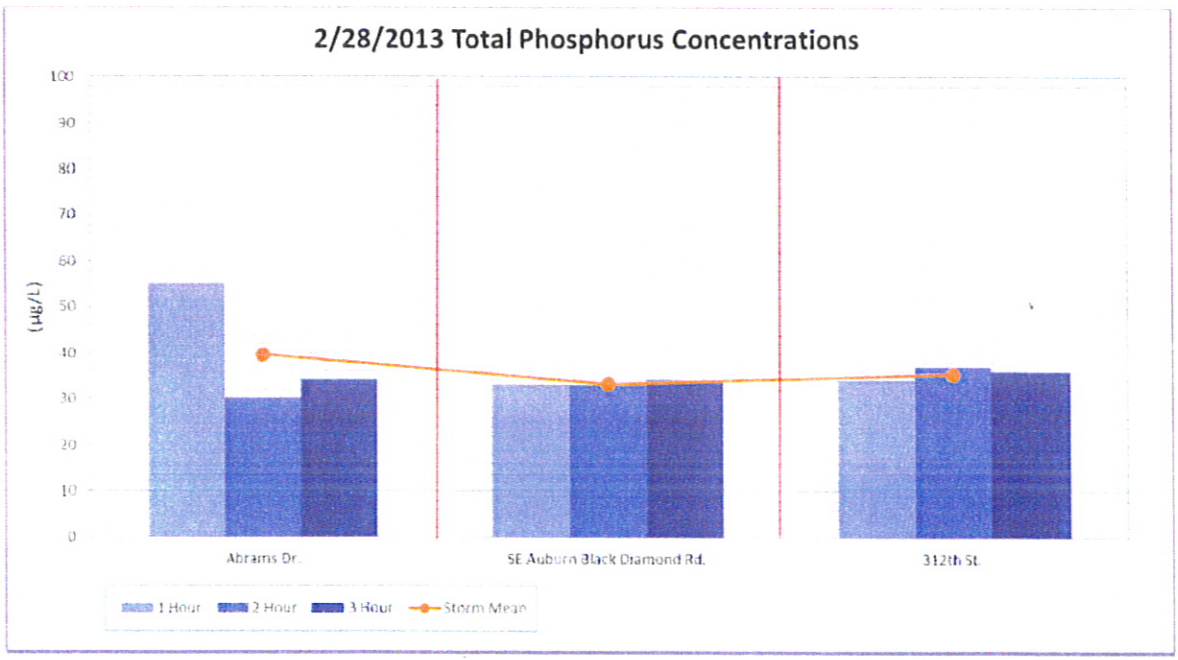

Figure 42. Total phosphorus concentrations for the Rock Creek drainage during the 2/28/2013 stormwater sampling event

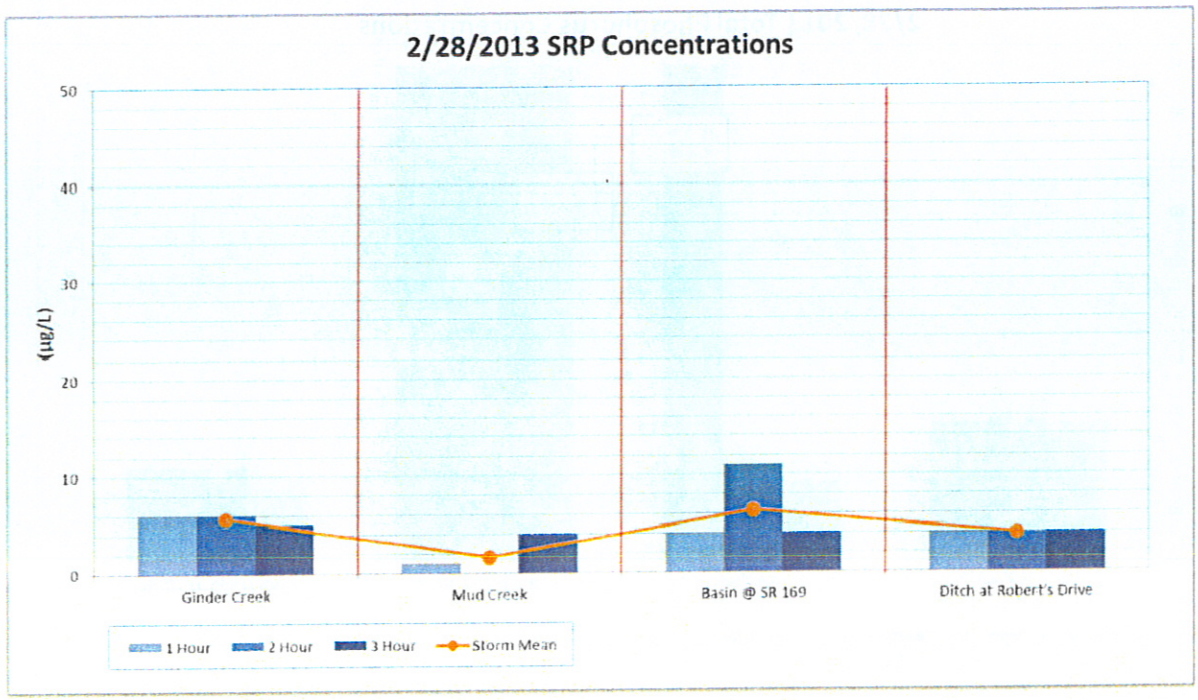

Figure 43. Soluble reactive phosphorus concentrations for the Lake Sawyer drainage during the 2/28/2013 stormwater sampling event

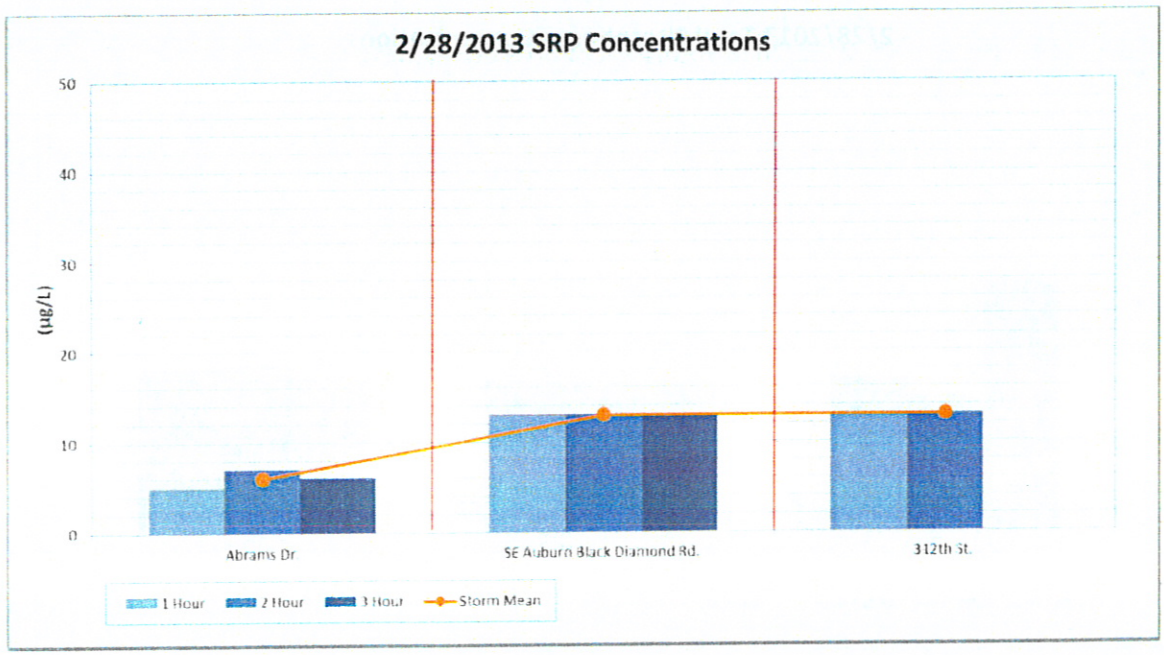

Figure 44. Soluble reactive phosphorus concentrations for the Rock Creek drainage during the 2/28/2013 sampling event

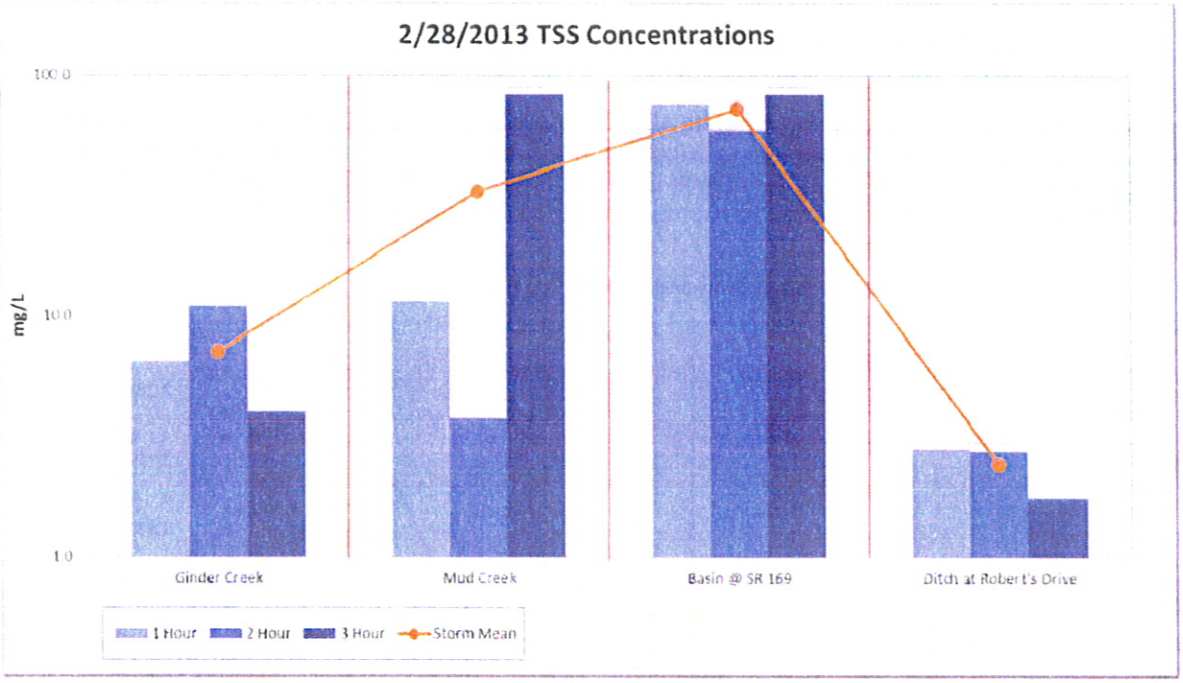

Figure 45. Total suspended solids concentrations in the Lake Sawyer drainage during the 2/28/2013 stormwater sampling event

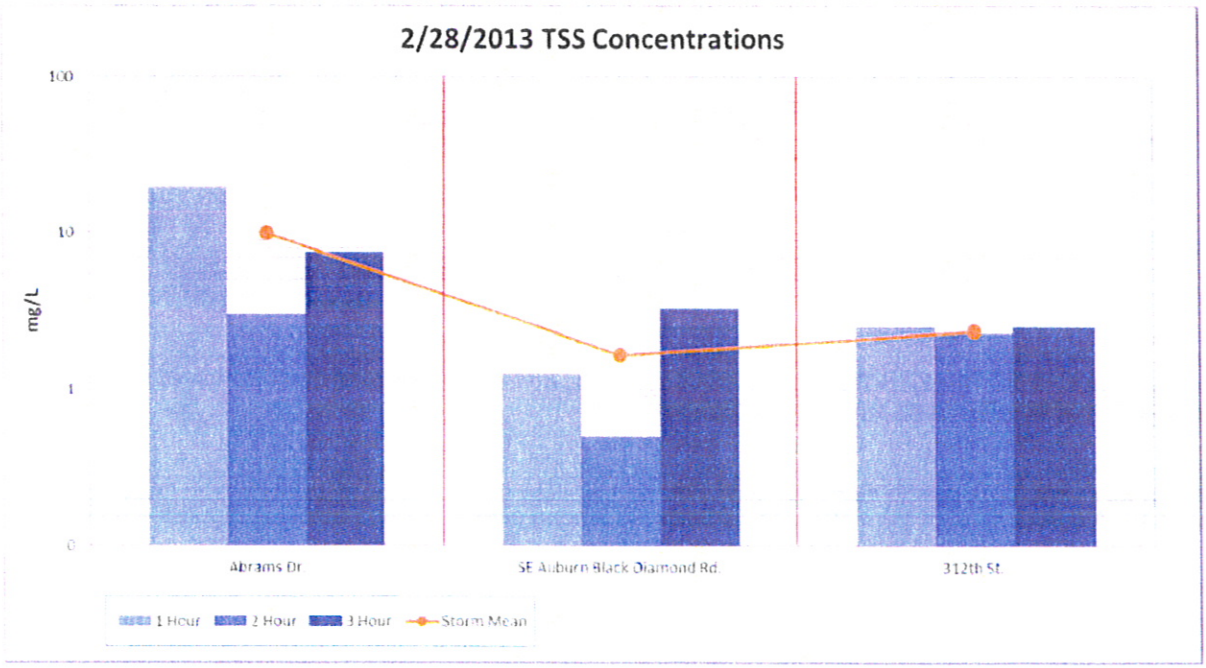

Figure 46. Total suspended solids concentrations in the Rock Creek drainage during the 2/28/2013 stormwater sampling event

2.6 Stormwater Results: Storm Event Sampling (April 4, 2013)

Stormwater samples were collected from 9:45 to 17:55 on April 4, 2013. Figure 47 shows precipitation at the Black Diamond I&I rain gage (operated by King County) during the sampling event compared to water level recorded in Rock Creek at SE Auburn Black Diamond Road. Precipitation for April 4, 2013 (for the 24 hour period) totaled 0.15 inches and represented conditions at the end of the wet season.

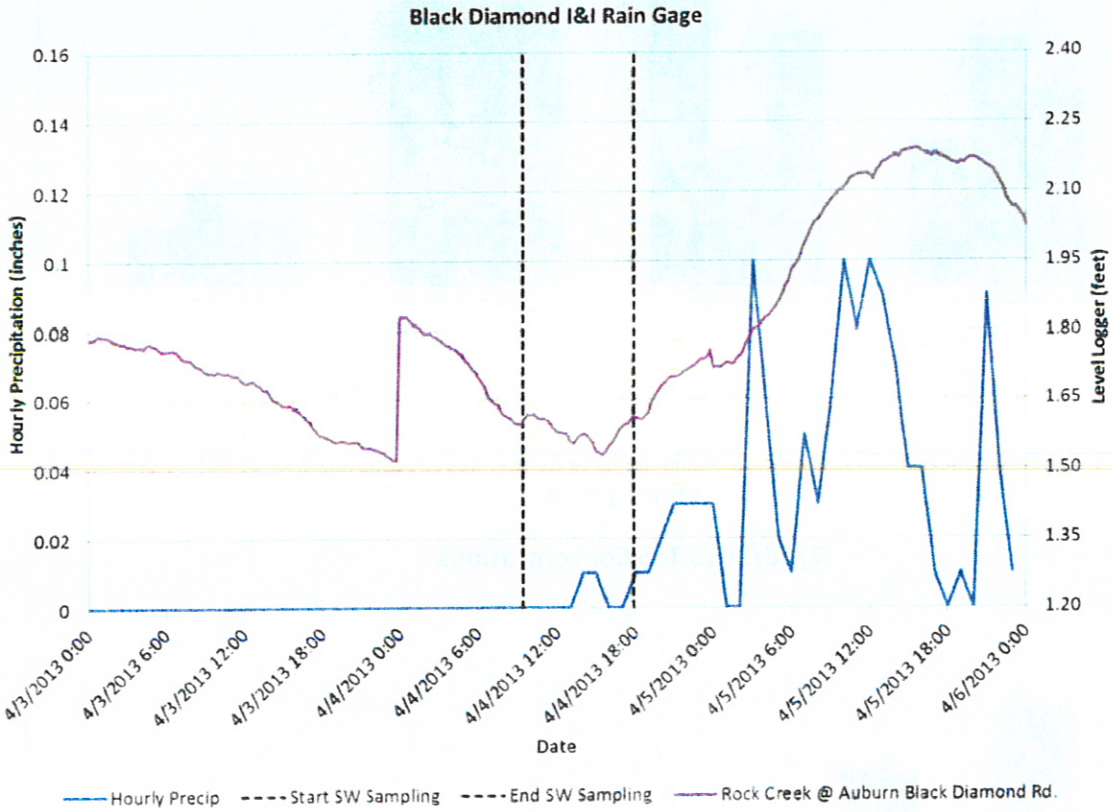

Figure 47. Precipitation at the Black Diamond I&I Rain Gage for the April 4, 2013 Sampling Event Compared to Rock Creek Water Level Recorded at SE Auburn Black Diamond Road.

Water quality data from laboratory analysis for the April 4, 2013 storm event are presented in Appendix 1, Table A10. A comparison of TP, SRP, and TSS results among sites are found below in Figures 48-53.

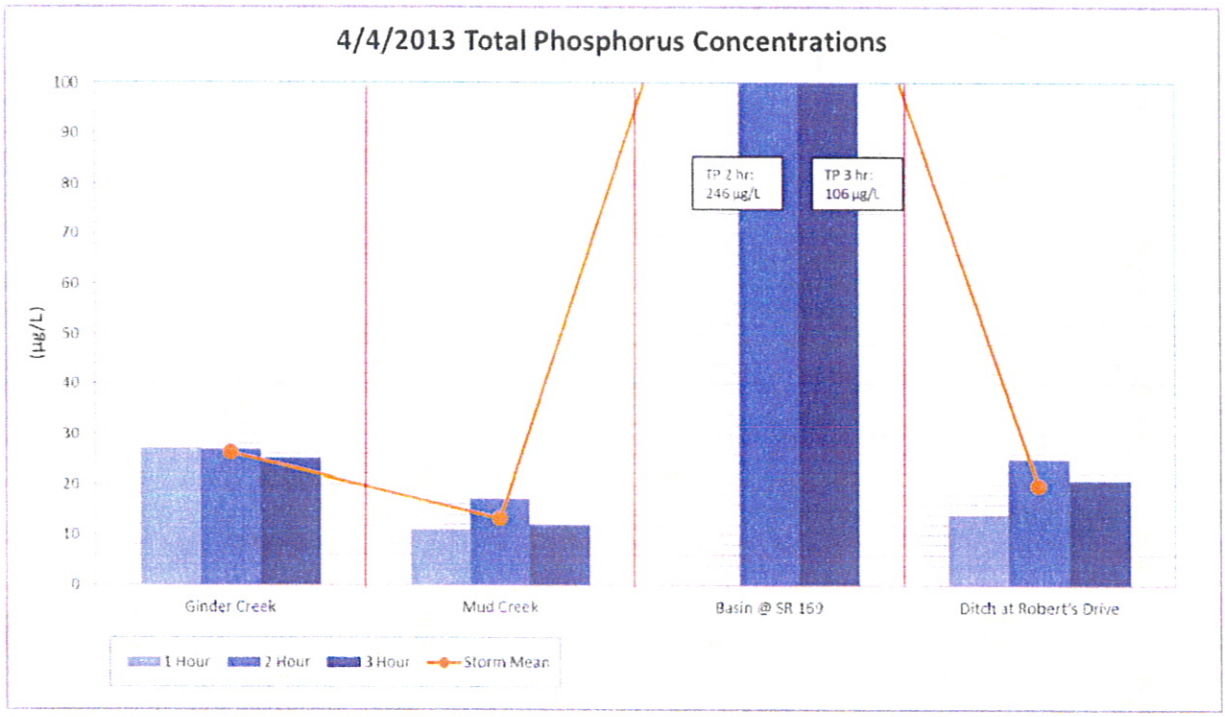

Figure 48. Total phosphorus concentrations for the Lake Sawyer drainage during the 4/4/2013 stormwater sampling event

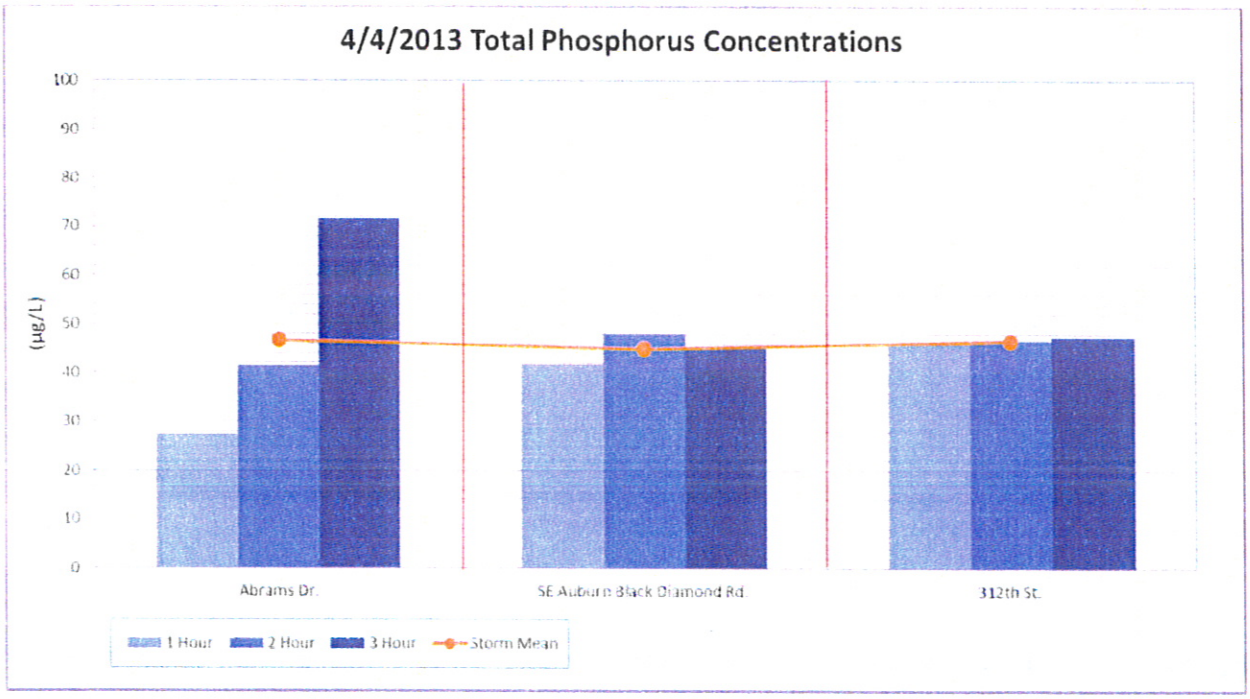

Figure 49. Total phosphorus concentrations for the Rock Creek drainage during the 4/4/2013 stormwater sampling event

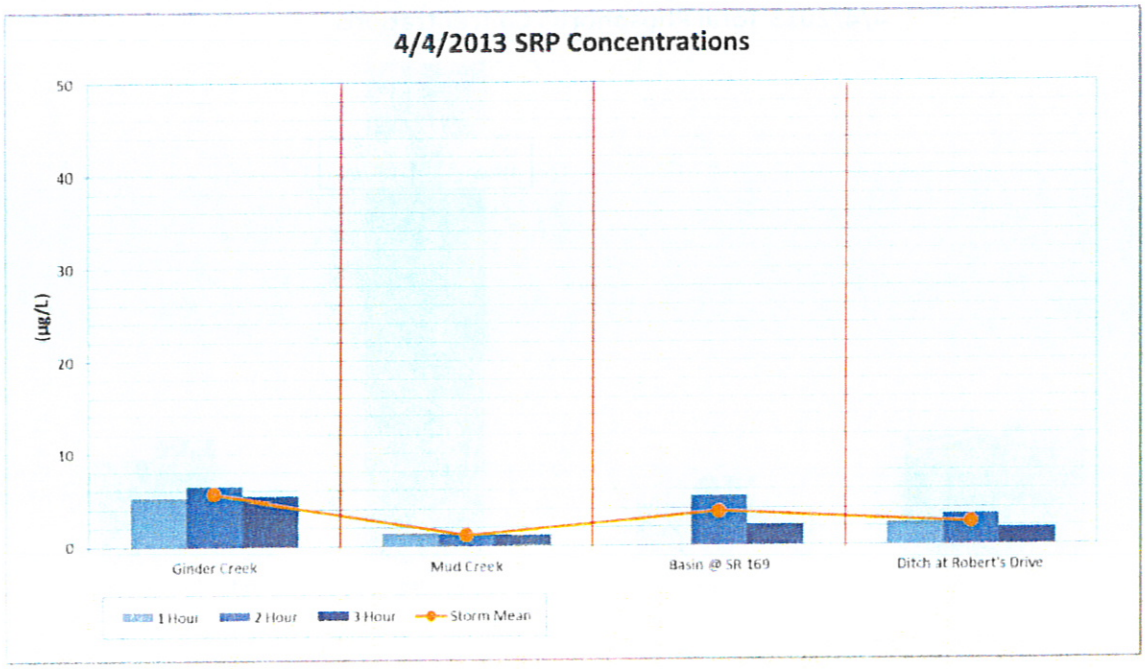

Figure 50. Soluble reactive phosphorus concentrations for the Lake Sawyer drainage during the 4/4/2013 stormwater sampling event

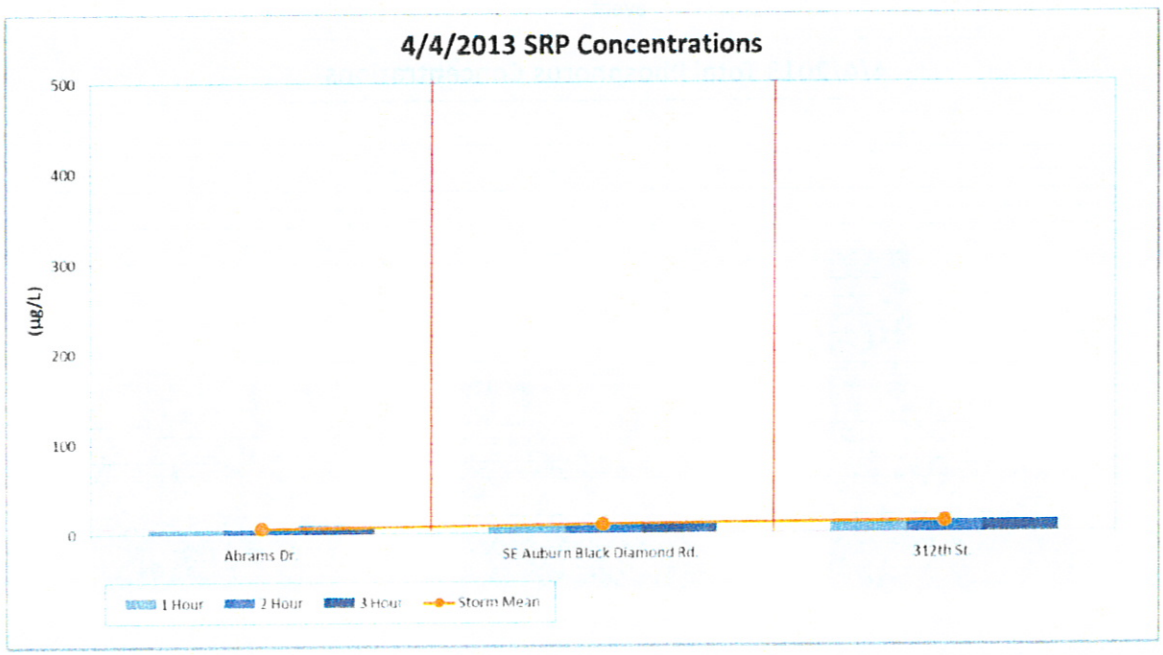

Figure 51. Soluble reactive phosphorus concentrations for the Rock Creek drainage during the 4/4/2013 sampling event

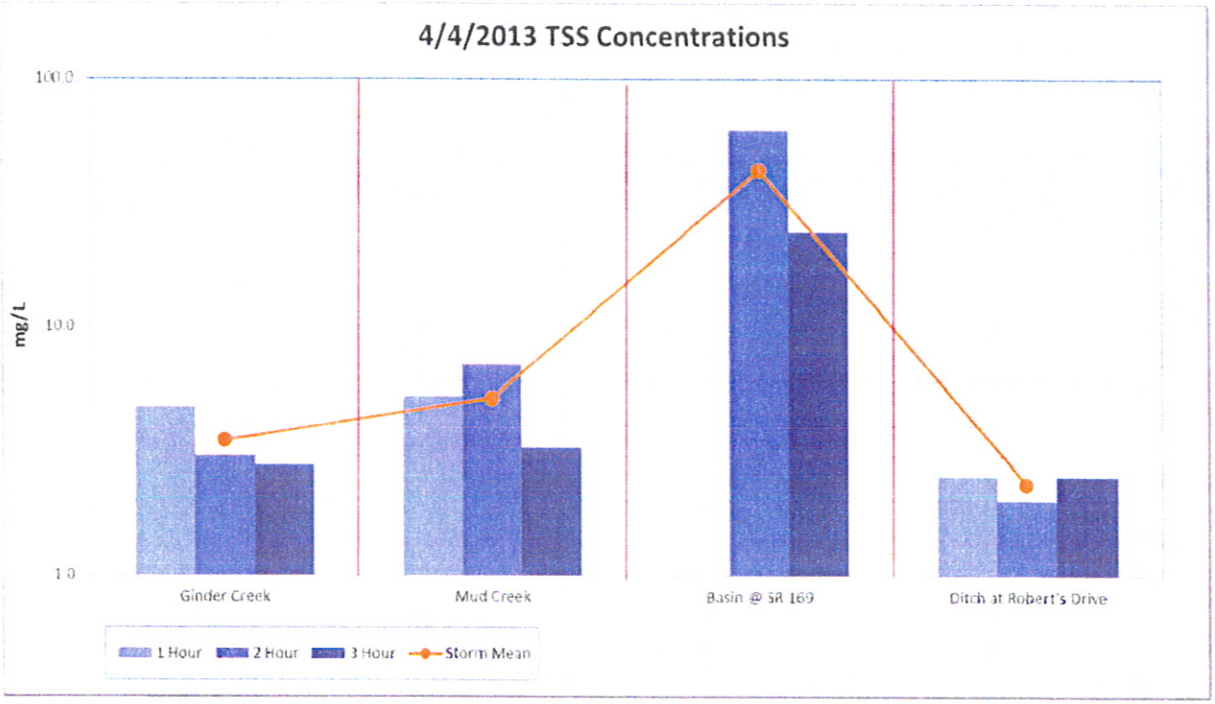

Figure 52. Total suspended solids concentrations in the Lake Sawyer drainage during the 4/4/2013 stormwater sampling event

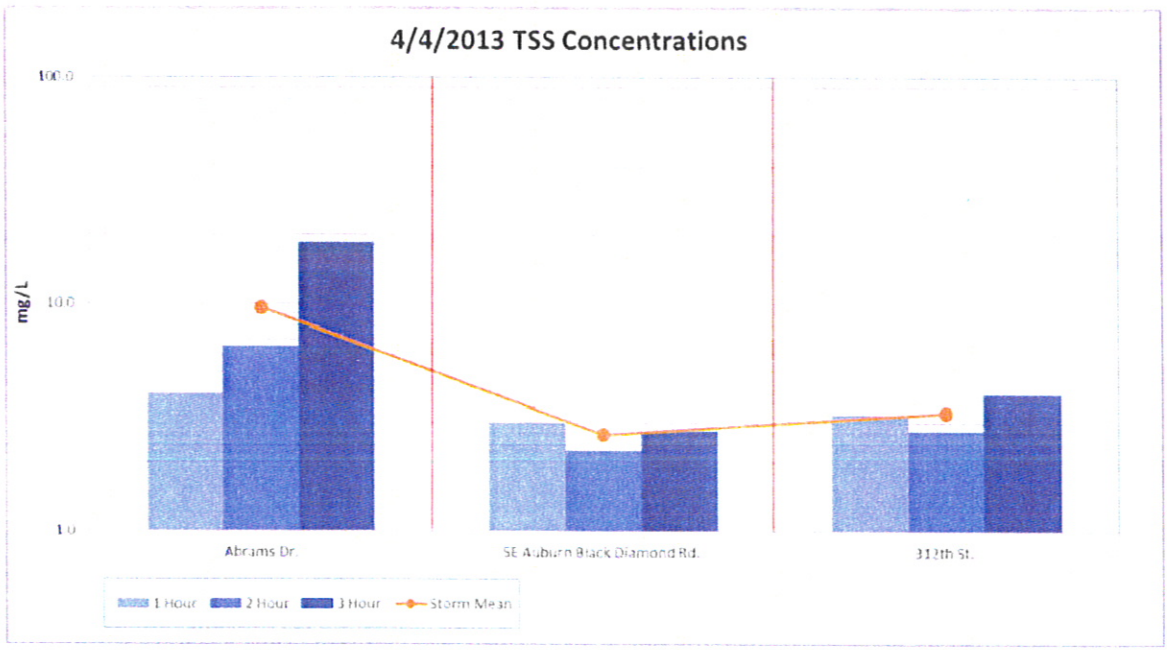

Figure 53. Total suspended solids concentrations in the Rock Creek drainage during the 4/4/2013 stormwater sampling event

2.7 Ambient (Baseline) Monitoring Results: November 30, 2012- October 21, 2013

Water quality data from laboratory analysis, as well as field data are presented in Appendix 1, Tables A11- A36. A comparison of TP, SRP, and TSS results among sites during each month, with averages, are found below in Figures 54-59.

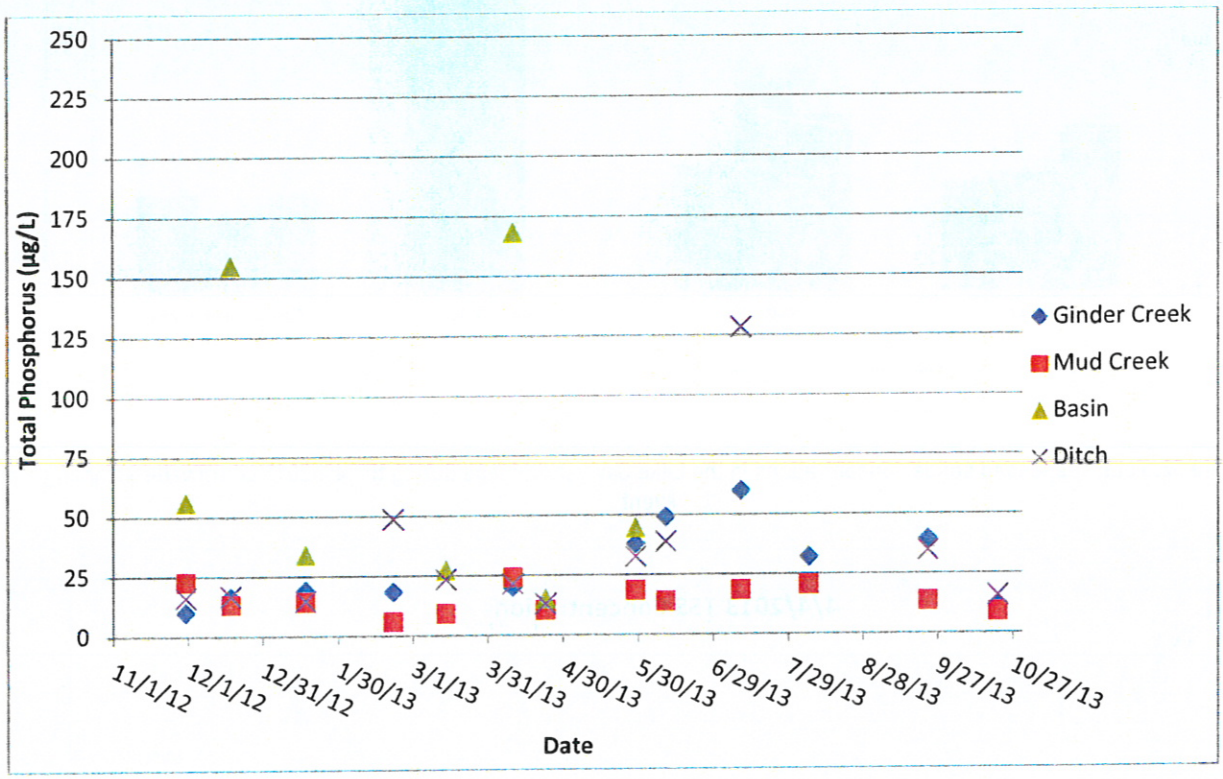

Figure 54. Total phosphorus ambient monitoring results for the Lake Sawyer drainage from November 2012- October 2013

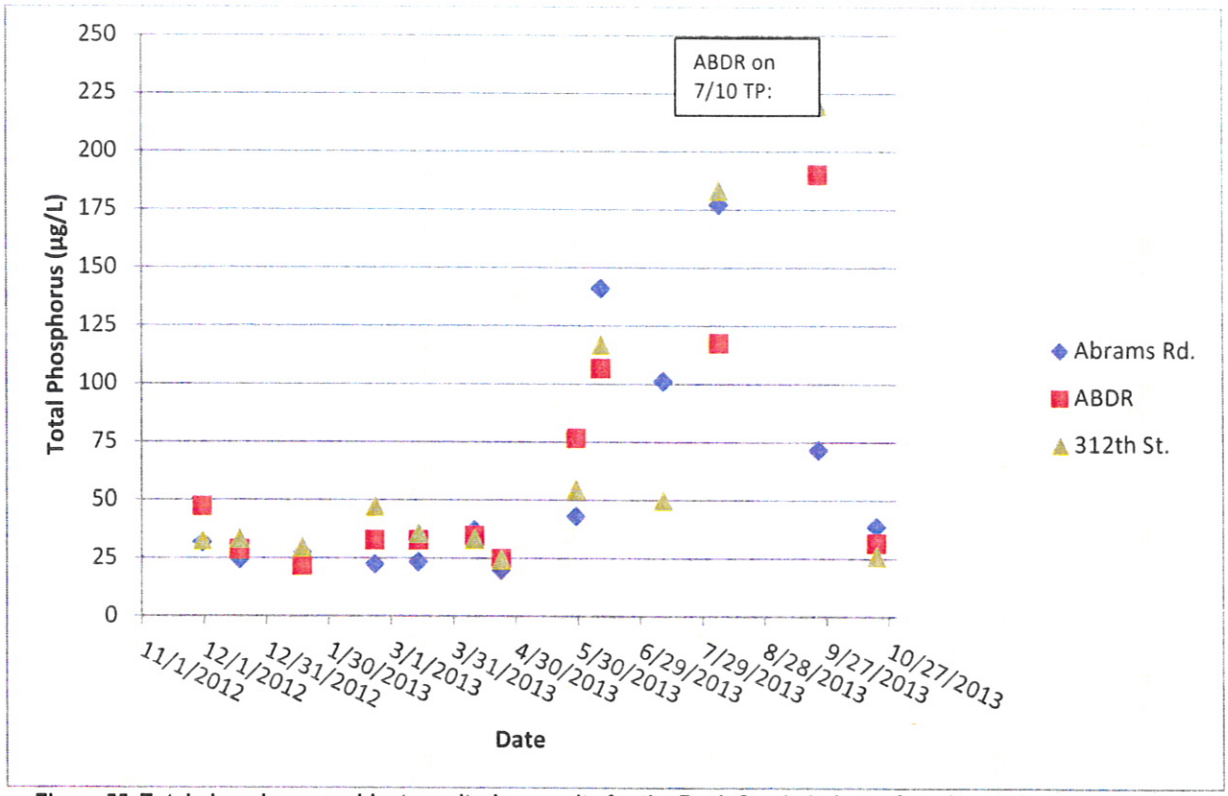

Figure 55. Total phosphorus ambient monitoring results for the Rock Creek drainage from November 2012 through October 2013

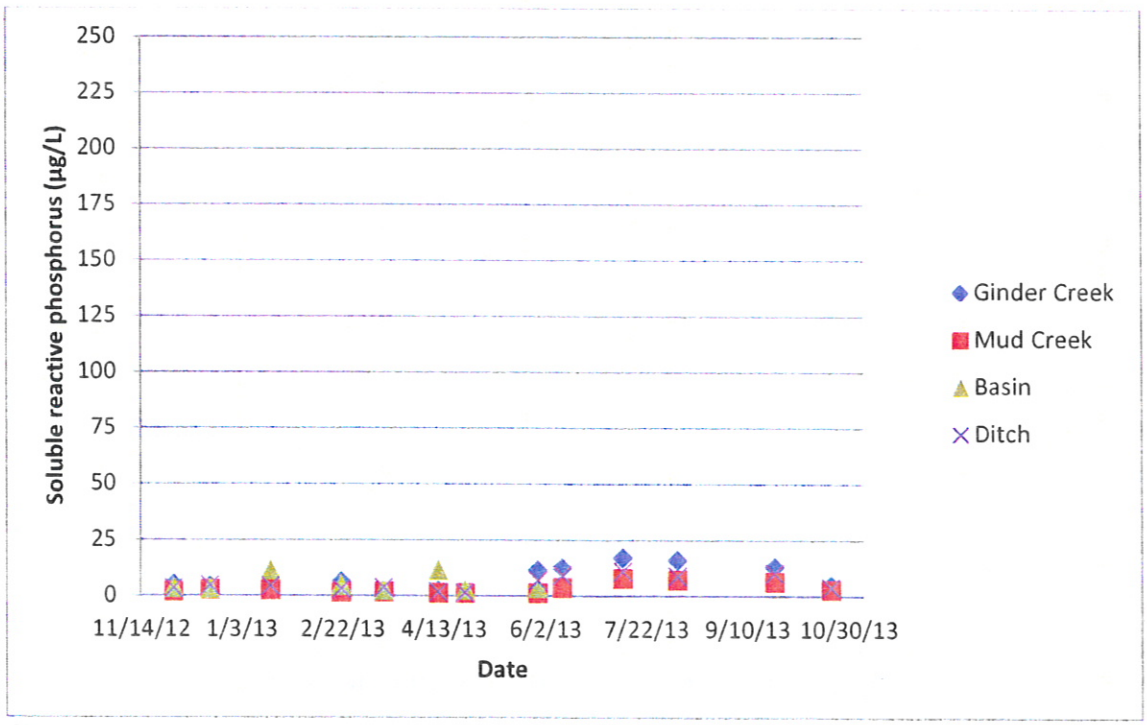

Figure 56. Soluble reactive phosphorus monitoring results from the Lake Sawyer drainage from November 2012 through October 2013

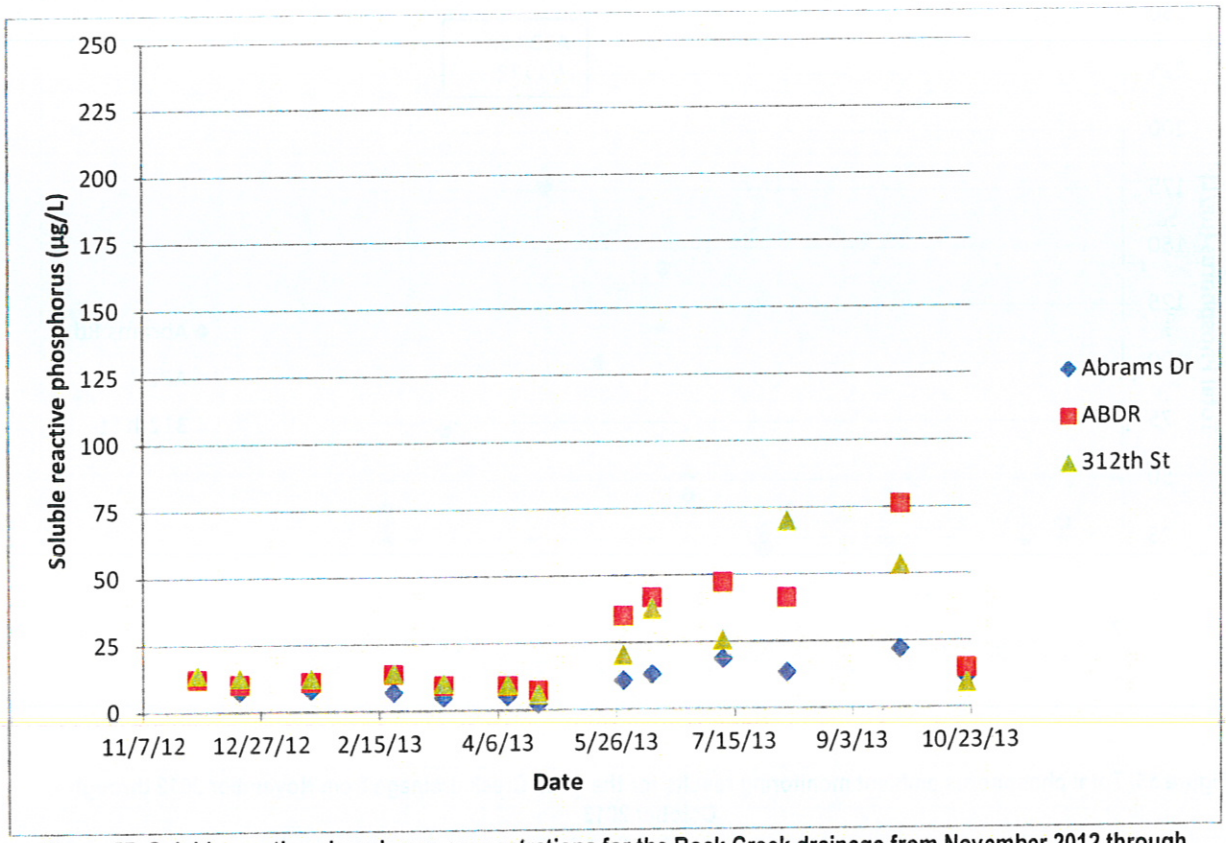

Figure 57. Soluble reactive phosphorus concentrations for the Rock Creek drainage from November 2012 through October 2013

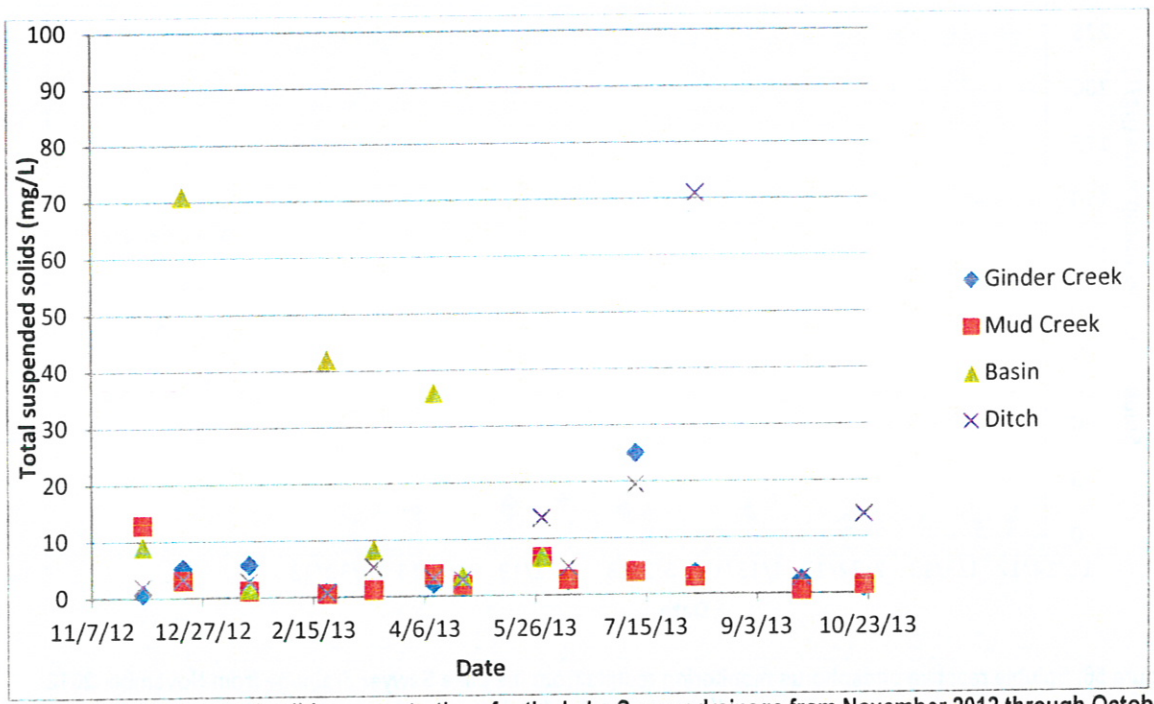

Figure 58. Total suspended solids concentrations for the Lake Sawyer drainage from November 2012 through October 2013

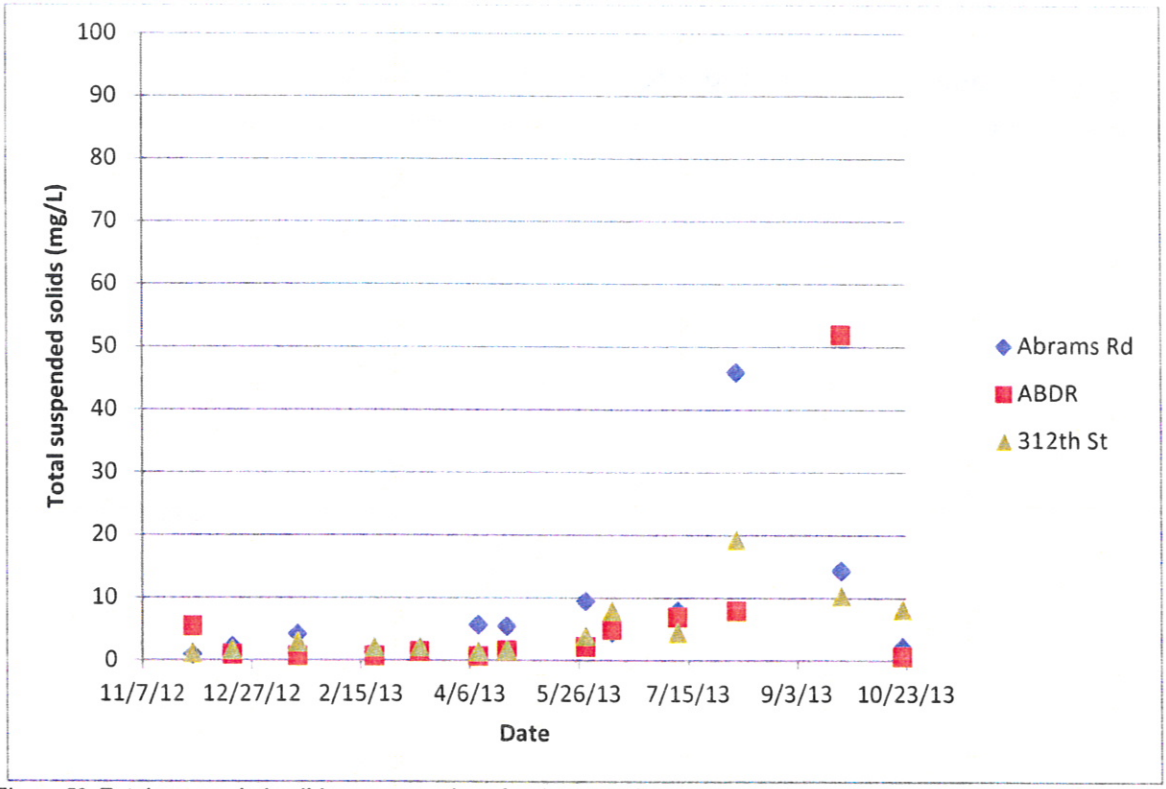

Figure 59. Total suspended solids concentrations for the Rock Creek drainage from November 2012 through October 2013

2.8 Ambient (Baseline) Monitoring: Flow vs. Concentration

The following figures show discharge for each site during the time of sampling events versus the concentration of TP (Figure 60) and TSS (Figure 61).

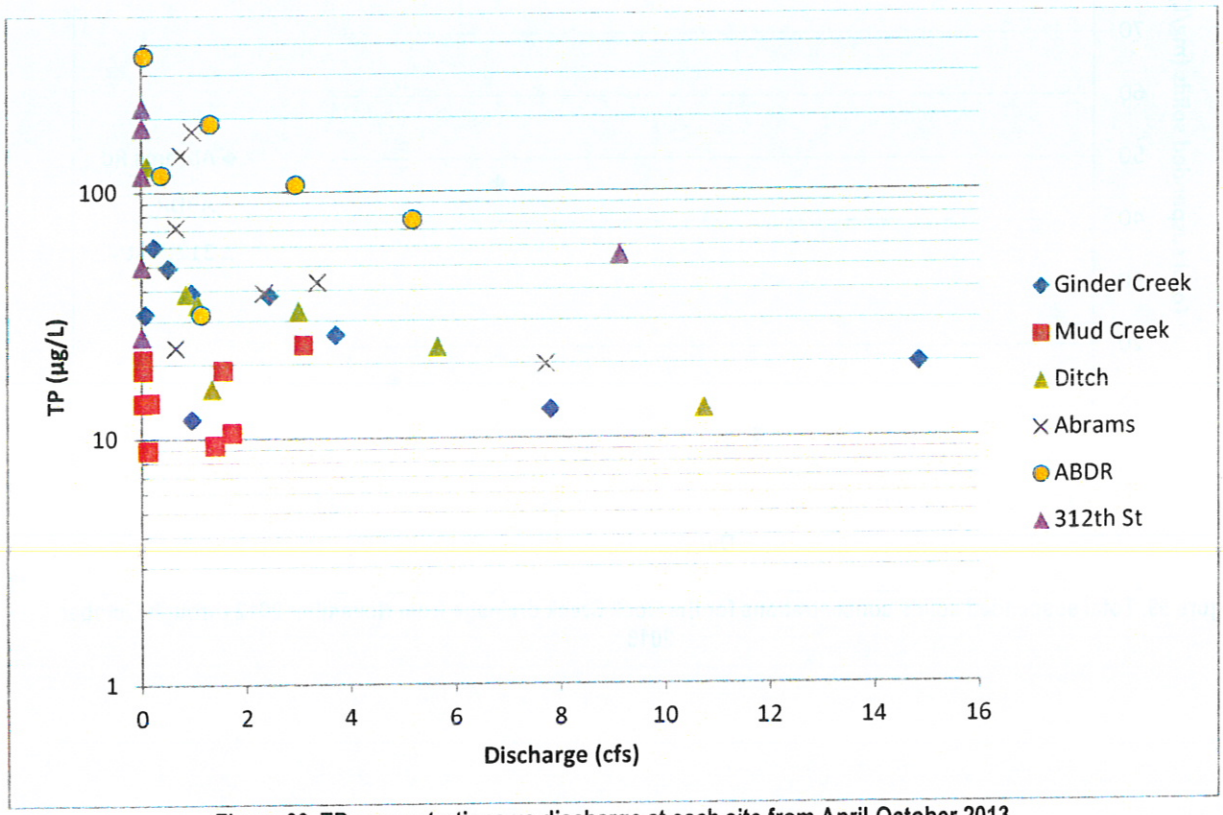

Figure 60. TP concentrations vs discharge at each site from April-October 2013

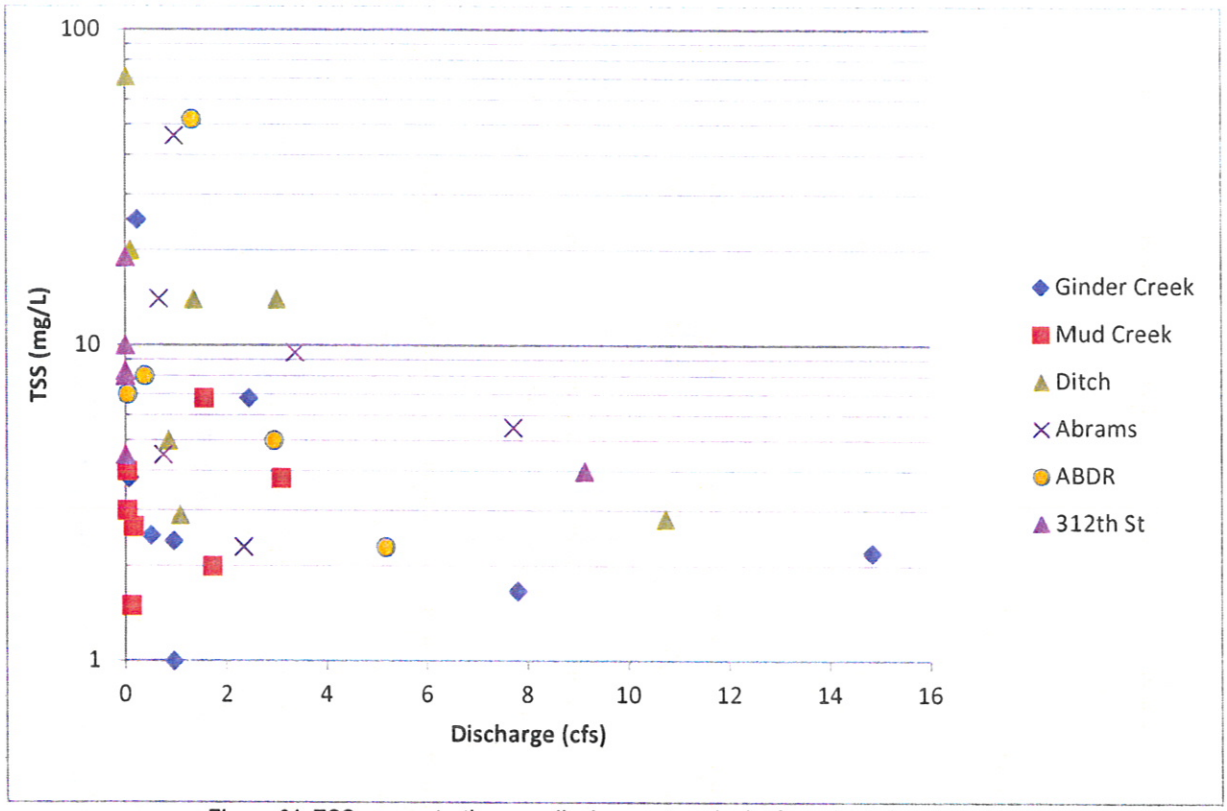

Figure 61. TSS concentrations vs discharge at each site from April-October 2013

2.9 Precipitation and a Rising Hydrograph

The following 3 figures (62-64) show total daily precipitation amounts from April-October 2013 and the corresponding water level rise at each site as measured by the stage height recorders. Sampling events are also noted along the stage height line graph.

A single storm event is reported in Figure 62 on April 4, 2013. The stage height recorded was deployed at this site (Abrams Avenue) during March 2013. Ambient (baseline) monitoring times are recorded with stage height during the recording period from March 2013 to October 2013.

All six storm events and twelve ambient (baseline) monitoring events are recorded with stage height in Figure 63. The stage height monitoring period at the Auburn-Black Diamond Rd. site extends from November 2012 through October 2013. Sampling dates for each type of monitoring program are listed on each graph.

Monitoring events characterized at the 312th Street site were reported for the length of the stage height record beginning March 2013 through October 2013. Additional storm event and baseline monitoring was completed extending from November 2012. The stage height recorded water levels above this site before and after appearance of beavers and their work. The water levels above the 312th Street sites were designated as before beaver dam (red line) and following establishment of a beaver dam (green line) in Figure 64.

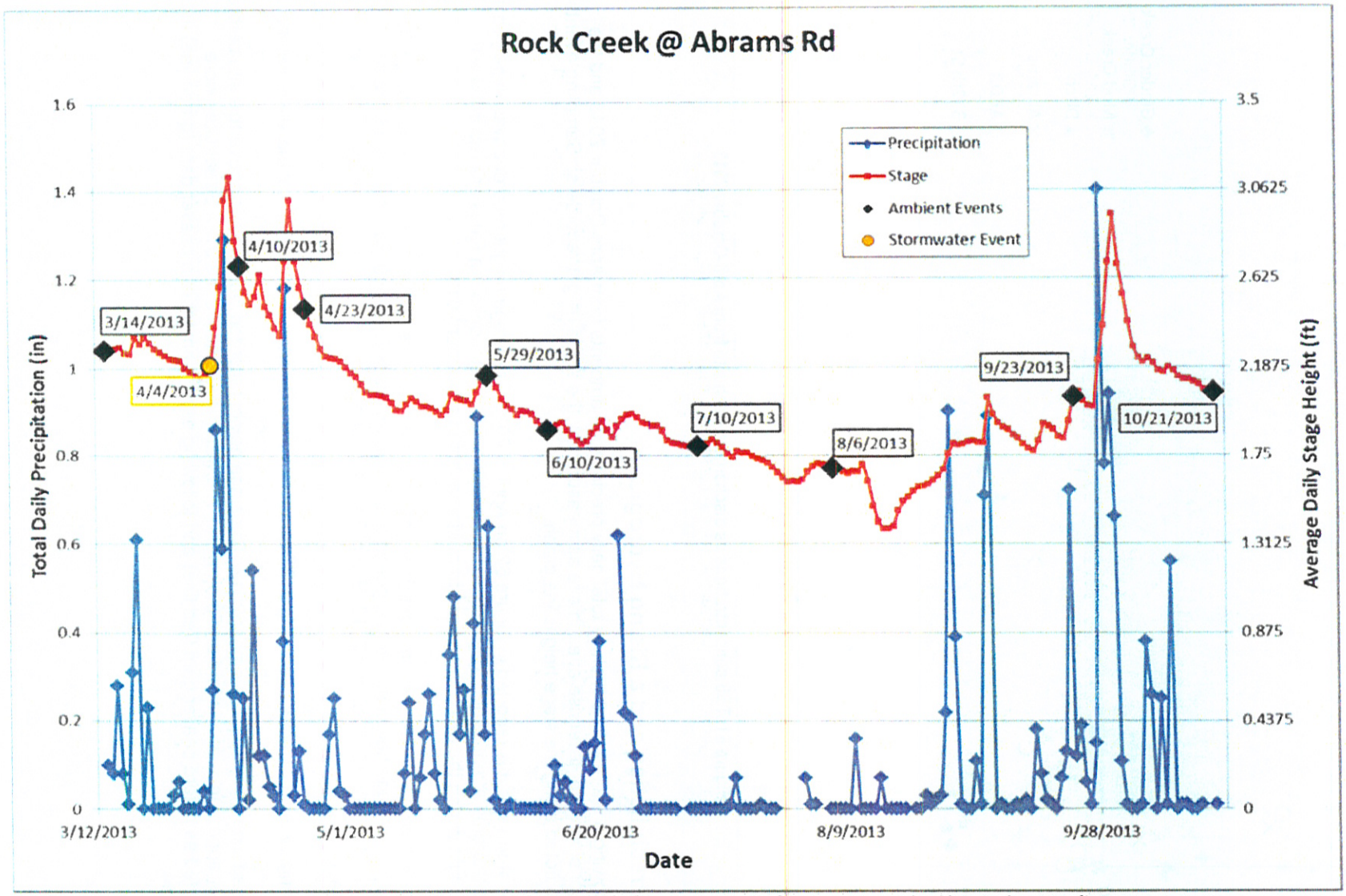

Figure 62. Precipitation versus Stage Height from March 2013-October 2013 at the Abrams Avenue site

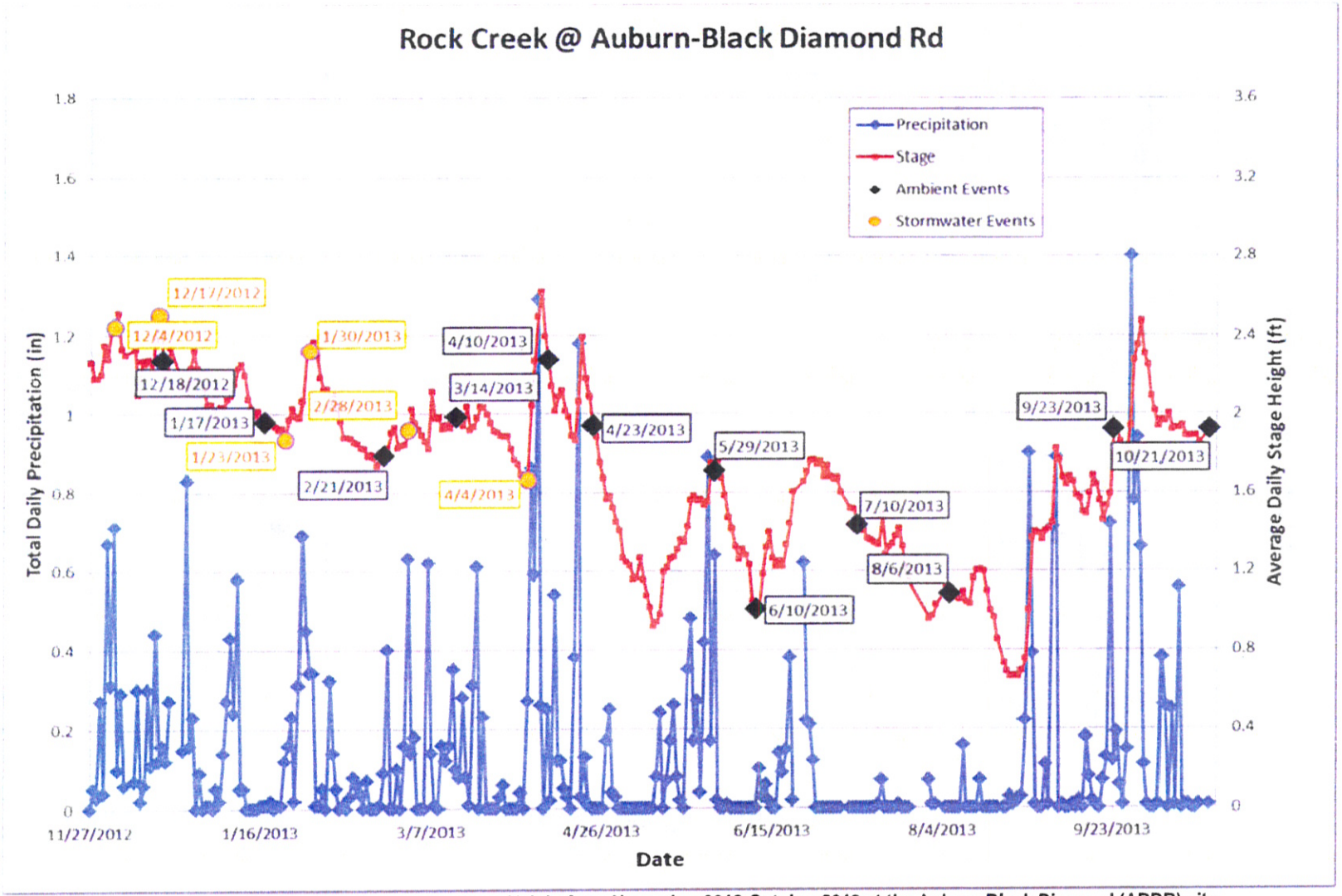

Figure 63. Precipitation versus Stage Height from November 2012-October 2013 at the Auburn Black Diamond (ABDR) site

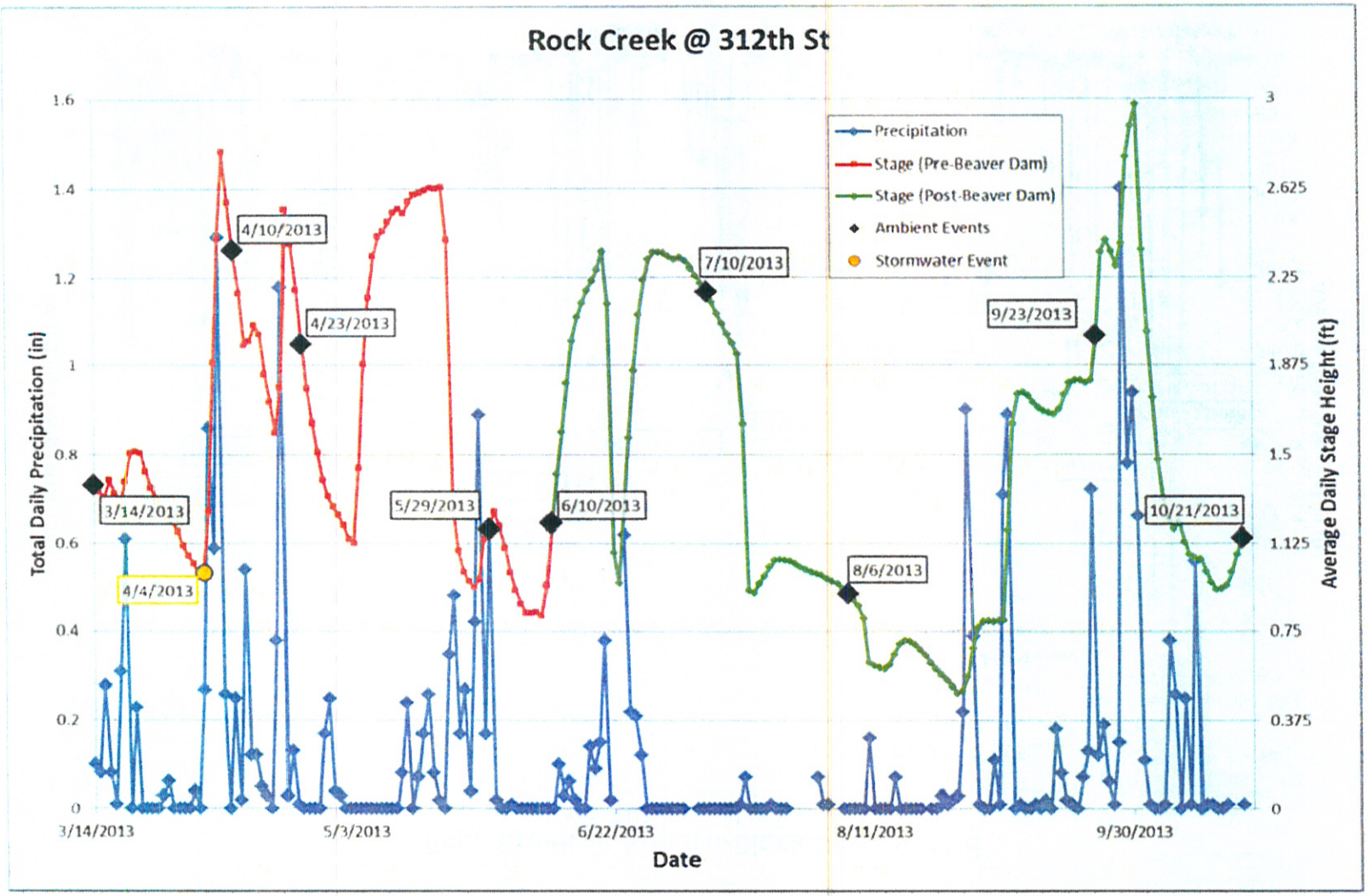

Figure 64. Precipitation versus Stage Height from March 2013-October 2013 from the 312th Street site

3.0 GENERAL OBSERVATIONS

Total Phosphorus (TP) concentrations in Rock Creek during spring and summer during base flows (ambient baseline), were mostly > 50 µg/L with some over 150 µg/L- much higher than during storm events (Fig 55). That probably resulted from low flows and higher concentrations from undiluted groundwater and/or decomposition of organic matter in wetlands. Rock Creek flows through wetlands; which represent an estimated 17 ha above the Abrams site, 37 ha above the Auburn BD site and 10 ha above the 312th St., the most downstream site. Wetlands are known to yield P during the summer. On the other hand, stormflow TP concentrations at the three Rock Creek sites were usually < 40 µg/L with the 3-sample site mean for each storm ranging from 21-45 µg/L (Table 3). Also, storm flow TP concentrations were usually lower at the upstream minor tributary sites than during base flow (Figure 54, Table 3). That pattern was also reflected by SRP with several base-flow values at the Rock Creek sites above 30 µg/L (Fig 57). However, during winter, there was little difference between storm P concentrations and non-storm, base flow samples. Also, TSS at the Rock Creek sites was not that different between storm and base flow conditions in winter. There were no TP and SRP concentrations in winter as high as in the summer. The slightly higher TSS in Rock Creek in summer may reflect periphyton sloughing and low dilution due to low flow, as well as decomposition products from upstream wetlands.

Rock Creek base flow and storm flow TPs during winter were relatively low and did not show the peaks that normally occur in urbanized watersheds. Therefore, volume-weighted concentrations from Rock Creek that include high flows should not be much different than those from base flows, because the TP concentrations are not that different. The higher concentrations in summer are accompanied with low flows, so those will not contribute much to annual, flow-weighted mean TP concentrations. In contrast to what seems to be the case on Rock Creek, highly developed watersheds produce high TP concentrations during winter storms. For example, Issaquah Creek, which is more urbanized, consistently produced 50% of its annual TP load in about two weeks of winter flows, because TP concentrations were very high during these large storms. Such is not the case in Rock Creek which has one of the least developed watersheds in the Puget Sound lowlands. Even the high storm TP concentrations produced in the tributaries to Rock Creek (e.g. Basin, Table 3) were diluted with the much higher flow and lower TP concentrations in Rock Creek, so they had little effect.

3.1 Flow-weighted concentrations

This monitoring program is focused on Rock Creek and tributary sites, but is designed to describe contributions of phosphorus from discrete land areas throughout the drainage. Any new development may change the phosphorus contribution from portions of the drainage and this monitoring program will be used to detect any change from background. Ultimately, the reason for managing phosphorus contribution to streams in the Lake Sawyer drainage is to protect the integrity of Lake Sawyer, the receiving water. Phosphorus concentration in lakes is the key determinant of algal production and biomass or chlorophyll concentration, which in turn defines lake quality. Inflow (stream) concentration of total phosphorus (TP), weighted for flow volume, determines the in-lake TP concentration, averaged over time, according to:

$$TP_{lake} = \frac{TP_{inflow}}{1 + \rho^{0.5}}$$

Where rho, ρ, is water residence time (years) in the lake. The flow-volume-weighted stream concentration is the best estimate of inflow TP. While groundwater and precipitation can also contribute to inflow TP, stream surface water inflows are usually the major source in undeveloped watersheds.

Therefore, establishing volume-weighted inflow TP concentration is appropriate for a base-line, pre-development condition. In addition to higher potential TP concentration, the volume and intensity of stormwater runoff can be increased with land-use changes. The higher runoff TP concentrations plus increased runoff volume, and their potential lake effect, is best represented by flow volume-weighting the measured TP concentrations. Volume weighting accounts for the large masses of TP that enter the lake during major storms unaccounted for by straight averaging TP concentrations. However, pre-development mean and median TP concentrations upstream and downstream of the development, shown in Table 3, can be compared with respective post-development concentrations.

TP loading and volume-weighted TP entering Lake Sawyer will be calculated as follows. Producing dependable load estimates is more dependent on flow than concentration. Thus, having continuous flow has been shown to be more important than continuous concentration, but both are actually necessary for computing actual total load. Nevertheless, continuous flow and grab samples for concentrations during storms and non-storms, loading can be calculated for storm flow and base flow conditions. In order to obtain the best estimate of TP concentration for a given storm flow, concentration should be regressed on flow. For each daily flow during a storm, a concentration from that relationship can be used to calculate daily and, hence, storm period load. However, the pattern of Rock Creek data do not show particularly higher TP concentrations during storms than during non-storms (base flow), so a useable concentration - flow relation may not exist. Low-flow TPs were also higher than those during high flow in 1989-1990, which resulted in a slightly inverse relation between flow and concentration (Caroll and Peletier, 1999). Without a TP-flow relation, TP concentrations during each storm event at each of the three sampling sites will be used to calculate a storm period load in kg/day for each of the six storm events. For other storm-flow periods during the year, a mean TP from all six events will be used to calculate loads for those periods. The procedure will be as follows:

1) For each site and sampled storm period (6 periods): Mean TP mg/m^3 x mean flow m^3/day x 10^{-6} mg/kg = kg/day. The sum of the six loads will represent the total load for that fraction of the year.
2) For all other storm periods (rainfall > 0.20 inches), use overall mean TP from each site for the seven sampled storms and the actual daily mean flow for each of the storm periods.
3) The sum of 1 and 2 = annual storm period load.
4) For non-storm, base-flow loads use the determined monthly TP concentrations and the mean monthly base flows, other than the storm-flow periods in #2.
5) Total annual load is then the sum of storm-flow and base-flow loads.
6) Mean annual, volume-weighted TP concentrations = $\frac{\text{TP load kg/year}}{\text{Flow } m^3\text{/year}}$

3.2 Baseline Phosphorus Load

Maximum TP concentrations from stormwater monitoring during the 2012-2013 water year (December 2012 through April 2013) were similar to background concentrations from several nearby drainages as reported in a memorandum prepared by Triad Associates titled "Estimated Total Phosphorous Loading from The Villages Completed MPD" dated January 10, 2011,. The maximum concentrations observed during the recent stormwater monitoring events in Rock Creek (December 2012 - April 2013) reflect runoff that is expected from multi-family and single family residential development (40 µg/L – 75 µg/L). Existing conditions in the lower Rock Creek drainage suggest that TP concentrations in a setting with mostly undeveloped land are slightly higher than would be expected.

With nutrient controls in place on future development and a goal of at least 50 percent reduction in TP by using stormwater best management practices (BMPs), effluent concentration from MPD storm ponds should not increase the pre-existing nutrient levels in Rock Creek. Reduction of stormwater runoff concentrations expected from multi-family and single family development by at least 50 percent may result in TP concentrations lower than existing conditions.

Influent TP concentrations to Rock Creek from the MPD development should not exceed 0.055 mg/L (55 µg/L). That goal from the MPDs (≤ 0.055 mg/L) should be achievable based on current stormwater characterization and should result in a load that reflects pre-developed conditions in compliance with the Lake Sawyer TMDL and the King County Lake Sawyer Monitoring Plan.

3.3 Monitoring Requirements and Next Steps

Pursuant to Exhibit "O" of The Villages and Lawson Hills MPD Development Agreements (DAs), the Master Developer, in conjunction with the City of Black Diamond, will review, plan and institute the following:

- Monitoring: Prior to construction of the first MPD Implementing Project, the Master Developer shall cause to occur three water quality samples in three separate months during the wet season at three locations within Rock Creek to be mutually agreed to by the City and Master Developer. This sampling data shall be provided to the City and be used to establish an interim baseline phosphorous load that will then be further refined by the Baseline Monitoring section below.

  Note: During the 2011-2012 water year, three water quality samples were collected in three separate months (December 2011, January 2012, and March 2012) during the wet season at three locations within Rock Creek to characterize pre-development conditions and establish an interim baseline phosphorus load that would then be further refined by the 2012-2013 Baseline Monitoring Program (set forth below). *See* TetraTech's Technical Memorandum titled "The Villages and Lawson Hills MPDs Pre-Construction Stormwater Monitoring in Rock Creek and the Establishment of an Interim Baseline Phosphorus Load" dated July 23, 2012 for more information.

- Baseline Monitoring: Prior to construction of the first implementing project within the Lake Sawyer drainage basin, the Master Developer, in conjunction with the City of Black Diamond shall review, plan and institute the following:

  1. Monitor pre-development phosphorus levels at pre-determined locations within the project drainage basins. Monitoring is to occur consistently over the course of at least one water year (October to September) in accordance with the procedures and criteria outlined in Chapters 6 through 12 of the QAPP (see Exhibit "O" to the DAs). Use data collected over the water year to establish a baseline phosphorus load from the project. This load should be factored to an average year rainfall volume for future comparisons of phosphorus loads for years where the rainfall is more or less than the average.

     Note: This Baseline Monitoring requirement (above) was satisfied by the 2012-2013 Baseline Monitoring Program that is summarized in this 2012-2013 Phosphorus Monitoring Report. However, pursuant to the City of Black Diamond Hearing Examiner's Decision for The Villages MPD Preliminary Plat 1A dated December 10, 2012, the Baseline Monitoring Program is required to be expanded for the Villages Preliminary Plat 1A beyond this Baseline Monitoring requirement set forth above (and in Exhibit "O" to the Villages and Lawson Hills MPD Development Agreements). Specifically, the Expanded Baseline Monitoring Program for the Villages Preliminary Plat 1A is required to include "a significant increase in the amount of sampling to provide for an acceptable error of 0.05 and the use of hydrograph separation, smearing and other techniques to estimate separate loadings for base flows." The Expanded Baseline Monitoring Program that was approved by the City on July 19, 2013 includes the following approach:
     - Storm event monitoring at three Rock Creek locations during three separate storm events in the 2013-2014 water year. Three samples collected at each site during each storm event (total of 9 samples for each of the three sites = **27 total samples**).
     - Flow monitoring data will be generated at the time of sampling and will be used to estimate separate loadings for base flows.
     - This expanded baseline monitoring program significantly increases the amount of sampling in Rock Creek and is sufficient to provide for an acceptable error of 0.05.
     - Analysis of the water quality sampling and flow data from water years 2011-2012, 2012-2013, and 2013-2014 will include development of hydrograph separation, smearing and other techniques to estimate separate phosphorus loadings for base flows.

  2. Select one or two possible compensation projects. Offsite compensation projects will be on land not being actively developed for the MPDs but that includes features that currently contribute phosphorous to Lake Sawyer that are amenable to reductions of phosphorous, such as roadway segments or intersections, pastures with farm animals, or existing developed property all lacking modern stormwater controls, or erosive slopes or streams. Monitor pre-mitigation phosphorous levels at pre-determined locations within the compensating project drainage basin. Monitoring is to occur consistently over the course of at least one water year (October to September) in accordance with the procedures and criteria outlined in Chapters 6 through 12 of the QAPP (see

Exhibit "O" to the DAs). Use data collected over the water year to establish a baseline phosphorous load from the compensating project. This load should be factored to an average year rainfall volume for future comparisons of phosphorous loads for years where the rainfall is more or less than the average.

Note: The SW-4 location (Ginder Creek at the north end of the culvert crossing under Roberts Drive) was selected as a monitoring site during the 2012-2013 water year pursuant to the Villages MPD Condition of Approval No 84 and Exhibit "O" for pre-mitigation phosphorus monitoring associated with a possible compensating phosphorus reduction project within the Lake Sawyer drainage basin. The compensating phosphorus reduction project that the Master Developer selected is the Ginder Creek Stormwater Treatment Pond.

- Project Design Phase: In conjunction with City of Black Diamond review, prepare on-site drainage designs with phosphorus mitigation solutions which include the following:

    1. Phosphorus control menu items from the 2005 DOE Manual (or later manuals if adopted and imposed for later Project phases).
    2. Any additional AKART (all known and reasonable technologies) not identified in 1. above, that are in compliance with The Villages MPD Permit Approval Condition No. 76 or the Lawson Hills MPD Permit Approval Condition No. 79.
    3. Drainage designs should include contingency planning for augmentation of treatment so that future interventions can be made if needed.

- Project Construction Phase: Upon commencement of implementing project construction the following shall be instituted:

    1. Monitoring shall be performed at all drainage facility outlet points to establish post-construction phosphorus levels. This monitoring is to occur consistently over the course of the water year in accordance with the procedures and criteria outlined in the QAPP (see Exhibit "O" to the DAs).
    2. Regular comparisons shall be made to determine if stormwater management strategies are achieving goals established in the design phase. If levels are exceeding goals, source control interventions shall be implemented within 30 days of obtaining a substandard sampling measurement.
    3. Upon completion of the water year compare actual loads to pre-development loads. If loads are exceeding pre-development loads, institute compensatory project(s) within 6 months (subject to City approvals). Mitigation projects can include on-site or off-site measures that reduce the Tp input to the Lake Sawyer Basin.

- Project Build-Out Phase: Continue monitoring of drainage outlets for five years following the completion of development that discharges into that facility to confirm compliance with the no net phosphorus goal as per procedures noted above. Completion shall be defined as the date the City's maintenance bond, as required by BDMC 14.04.360 and the Black Diamond Engineering Design and Construction Standards (Exhibit "E" to the DAs) Section 1.5, is released or expires for a given facility. If data show variations from the standard, institute source control or improved maintenance solutions. If these interventions are insufficient, institute alternate compensatory projects or mitigations.

The preceding 2012-2013 Phosphorus Monitoring Report for The Villages and Lawson Hills MPDs dated November 2013 was prepared for BD Village Partners, LP and BD Lawson Partners, LP ("YarrowBay") by TetraTech, Inc.

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APPENDIX:

STORM EVENT AND AMBIENT (BASELINE) SAMPLING DATA

Table A1. 12/4/2012 Stormwater sampling event lab results

Drainage	Sample Location	Sample Number	TP (mg/L)	SRP (mg/L)	Turbidity (NTUs)	Ammonia (mg/L)	NO_3 +NO_2 (mg/L)	Total Nitrogen (mg/L)	TSS (mg/L)
Lake Sawyer	Ginder Creek	1	0.019	0.007	0.80	0.013	0.383	0.637	1.5
Lake Sawyer	Ginder Creek	2	0.026	0.007	0.78	0.011	0.418	0.645	2.0
Lake Sawyer	Ginder Creek	3	0.018	0.005	0.88	0.010	0.406	0.666	3.5
Lake Sawyer	Mud Creek	1	0.021	0.003	2.6	<0.010	0.325	0.591	6.3
Lake Sawyer	Mud Creek	2	0.027	0.002	2.3	<0.010	0.292	0.543	3.5
Lake Sawyer	Mud Creek	3	0.017	0.001	2.5	<0.010	0.280	0.511	17
Lake Sawyer	Basin at SR 169	1	0.072	0.004	21	0.030	0.114	0.263	16
Lake Sawyer	Basin at SR 169	2	0.080	0.006	18	0.021	0.252	0.390	8.5
Lake Sawyer	Basin at SR 169	3	0.040	0.002	8.4	0.029	0.120	0.222	8.5
Lake Sawyer	Ditch at Roberts Drive	1	0.025	0.005	2.0	<0.010	0.407	0.633	3.5
Lake Sawyer	Ditch at Roberts Drive	2	0.013	0.004	1.7	<0.010	0.392	0.641	2.3
Lake Sawyer	Ditch at Roberts Drive	3	0.018	0.003	1.9	<0.010	0.394	0.662	2.8
Rock Creek	Abrams Ave	1	0.056	0.014	3.1	0.018	0.466	0.817	11
Rock Creek	Abrams Ave	2	0.044	0.015	2.8	0.019	0.483	0.846	7.0
Rock Creek	Abrams Ave	3	0.036	0.011	2.6	0.023	0.445	0.753	5.5
Rock Creek	SE Auburn Black Diamond Rd	1	0.040	0.016	0.90	0.012	0.294	0.574	1.8
Rock Creek	SE Auburn Black Diamond Rd	2	0.028	0.014	0.91	0.012	0.295	0.591	1.5
Rock Creek	SE Auburn Black Diamond Rd	3	0.033	0.014	0.96	0.012	0.299	0.585	1.0
Rock Creek	SE 312th St	1	0.042	0.016	0.82	0.018	0.234	0.548	2.0
Rock Creek	SE 312th St	2	0.033	0.015	0.86	0.015	0.237	0.539	2.5
Rock Creek	SE 312th St	3	0.035	0.015	0.76	0.016	0.236	0.526	1.3

Table A2. 12/17/2012 Stormwater sampling event lab results

Drainage	Sample Location	Sample Number	TP (mg/L)	SRP (mg/L)	Turbidity (NTUs)	Ammonia (mg/L)	NO_3+NO_2 (mg/L)	Total Nitrogen (mg/L)	TSS (mg/L)
Lake Sawyer	Ginder Creek	1	0.016	0.005	0.70	0.023	0.474	0.853	1.3
Lake Sawyer	Ginder Creek	2	0.015	0.005	0.71	0.019	0.473	0.968	1.3
Lake Sawyer	Ginder Creek	3	0.016	0.005	0.66	0.021	0.465	0.658	1.3
Lake Sawyer	Mud Creek	1	0.015	0.003	2.3	0.015	0.265	0.635	3.5
Lake Sawyer	Mud Creek	2	0.016	0.003	2.0	0.014	0.271	0.669	2.8
Lake Sawyer	Mud Creek	3	0.013	0.003	2.2	0.013	0.283	0.534	3.2
Lake Sawyer	Basin at SR 169	1	0.060	0.015	4.9	0.021	0.280	0.495	2.5
Lake Sawyer	Basin at SR 169	2	0.032	0.007	2.9	0.017	0.390	0.628	<0.50
Lake Sawyer	Basin at SR 169	3	0.019	0.005	1.9	0.013	0.481	0.551	1.2
Lake Sawyer	Ditch at Roberts Drive	1	0.020	0.005	2.0	0.026	0.436	0.841	2.8
Lake Sawyer	Ditch at Roberts Drive	2	0.018	0.004	1.7	0.022	0.440	0.919	1.8
Lake Sawyer	Ditch at Roberts Drive	3	0.018	0.005	1.8	0.018	0.443	0.780	2.0
Rock Creek	Abrams Ave	1	0.041	0.009	2.9	0.042	0.585	1.09	7.0
Rock Creek	Abrams Ave	2	0.033	0.010	2.5	0.020	0.563	1.06	3.3
Rock Creek	Abrams Ave	3	0.031	0.008	2.3	0.020	0.552	0.859	2.5
Rock Creek	SE Auburn Black Diamond Rd	1	0.031	0.012	0.98	0.018	0.406	0.890	1.2
Rock Creek	SE Auburn Black Diamond Rd	2	0.030	0.011	0.96	0.015	0.408	0.807	1.2
Rock Creek	SE Auburn Black Diamond Rd	3	0.031	0.012	0.99	0.022	0.432	0.743	0.67
Rock Creek	SE 312th St	1	0.031	0.013	0.79	0.026	0.378	0.847	1.7
Rock Creek	SE 312th St	2	0.032	0.013	0.89	0.021	0.381	0.689	0.83

Table A3. 12/17/2012 Stormwater sampling event field results

Sample ID	Time	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)	pH	Temp (deg C)	Total Flow (CMS)	Total Flow (cfs)	Total Flow (GPM)	Notes	Staff Gage Height (ft)
SW-1A	9:45:00 AM	10.34	179.5	1.64	7.00	5.5	0.135	4.78	2100	Temp from DO probe used	
SW-1B	2:00:00 PM	11.03	188.8	1.74	7.15	5.2	0.091	3.21	1400	Temp from DO probe used	
SW-1C	5:00:00 PM	11.28	201.7	4.61	7.44	4.9	0.164	5.79	2600	Temp from DO probe used	
SW-2A	10:15:00 AM	12.02	418	3.96	7.37	5.0	0.091	3.21	1400	Temp from DO probe used	
SW-2B	2:30:00 PM	12.18	411	3.88	7.3	5.4	0.068	2.40	1100	Temp from DO probe used	
SW-2C	5:30:00 PM	12.32	415	3.97	7.55	5.0	0.038	1.34	600	Temp from DO probe used	
SW-3A	10:55:00 AM	11.1	85.9	10.3	7.24	5.4	1.79E-04	6.32E-03	2.8	Temp from DO probe used	
SW-3B	2:45:00 PM	11.29	98.8	5.29	7.41	5.6	6.66E-05	2.35E-03	1.1	Temp from DO probe used	
SW-3C	5:45:00 PM	11.48	111.5	3.71	7.75	5.3	4.44E-05	1.57E-03	0.7	Temp from DO probe used	
SW-4A	9:15:00 AM	11.83	277.2	3.66	7.1	5.1	0.28	9.78	4400	Estimated Flow depths recorded, Temp from DO probe.	
SW-4B	1:35:00 PM	11.94	276.9	2.76	7.16	5.4	0.19	6.61	3000	Temp from DO probe used	
SW-4C	4:50:00 PM	11.95	283.5	2.85	7.38	5.1	0.36	12.71	5700	Temp from DO probe used	
SW-5A	12:00:00 PM	10.34	184.1	2.09	7.01	4.9	0.70	24.6	11000	Temp from DO probe used	3.36
SW-5B	3:30:00 PM	9.42	187.4	2.11	7.36	4.9	0.87	30.8	14000	Temp from DO probe used	3.32
SW-5C	6:15:00 PM	10.61	186.3	2.31	7.63	4.7	0.81	28.4	13000	Temp from DO probe used	3.29
SW-6A	11:15:00 AM	10.61	184	6.55	7.12	5.2	1.51	53.325046	24000	Added 5% to flow for water flowing over road. Temp from DO probe used	1.04
SW-6B	3:00:00 PM	10.33	195	3.7	7.36	5.5	1.284	45.3439464	20400	Temp from DO probe used.	1.1
SW-6C	6:20:00 PM	10.28	203.3	3.61	7.59	5.1	1.41	49.793586	22300	Temp from DO probe used.	---
SW-7A	1:00:00 PM	10.24	194.9	2.03	7.05	4.7	0.7	24.72	11100	Temp from DO probe used	2:38
SW-7B	4:00:00 PM	10.4	194.3	3	7.36	4.8	0.807	28.50	12800	Temp from DO probe used	2.12
SW-7C	6:00:00 PM	---	---	---	---	---	---	---	---	Flow not measured, ran out of daylight.	---

Table A4. 1/23/2013 Stormwater sampling event lab results

Drainage	Sample Location	Sample Number	TP (mg/L)	SRP (mg/L)	Ammonia (mg/L)	NO_3 +NO_2 (mg/L)	Total Nitrogen (mg/L)	Turbidity (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	1	0.016	0.003	<0.010	0.285	0.485	0.55	2.3
Lake Sawyer	Ginder Creek	2	0.015	0.003	<0.010	0.293	0.522	0.55	0.83
Lake Sawyer	Ginder Creek	3	0.020	0.003	0.016	0.261	0.594	0.60	2.2
Lake Sawyer	Mud Creek	1	0.013	0.001	<0.010	0.135	0.344	0.75	4.2
Lake Sawyer	Mud Creek	2	0.007	<0.001	<0.010	0.143	0.339	0.45	1.2
Lake Sawyer	Mud Creek	3	0.105	0.016	0.063	0.556	0.934	5.8	50
Lake Sawyer	Basin at SR 169	1	0.015	0.003	<0.010	0.249	0.456	0.65	3.0
Lake Sawyer	Basin at SR 169	2	0.014	0.003	0.012	0.240	0.507	0.54	1.0
Lake Sawyer	Basin at SR 169	3	0.015	0.003	0.015	0.246	0.528	0.69	1.8
Lake Sawyer	Ditch at Roberts Drive	1	0.025	0.008	0.016	0.371	0.603	0.86	<0.50
Lake Sawyer	Ditch at Roberts Drive	2	0.026	0.009	0.024	0.351	0.688	0.86	1.2
Lake Sawyer	Ditch at Roberts Drive	3	0.026	0.009	0.025	0.350	0.662	0.81	0.83
Rock Creek	Abrams Ave	1	0.031	0.006	0.029	0.475	0.747	2.0	5.5
Rock Creek	Abrams Ave	2	0.025	0.006	0.037	0.468	0.794	2.0	2.8
Rock Creek	Abrams Ave	3	0.033	0.006	0.038	0.458	0.789	2.4	8.3
Rock Creek	SE Auburn Black Diamond Rd	1	0.028	0.010	0.021	0.332	0.609	0.86	2.5
Rock Creek	SE Auburn Black Diamond Rd	2	0.034	0.010	0.026	0.322	0.648	0.90	4.3
Rock Creek	SE Auburn Black Diamond Rd	3	0.029	0.010	0.029	0.339	0.683	0.82	2.0
Rock Creek	SE 312th St	1	0.028	0.010	0.020	0.346	0.602	0.85	1.5
Rock Creek	SE 312th St	2							
Rock Creek	SE 312th St	3							

Table A5. 1/23/2013 Stormwater sampling event field results

Sample ID	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)	pH	Temp (deg C)	Total Flow (CMS)	Total Flow (cfs)	Total Flow (GPM)	Notes	Staff Gage Height (ft)
SW-1A	11.51	262.1	1.12	7.83	3.3	0.0968	3.42	1500		
SW-1B	11.94	255.8	1.18	7.69	4.1	---	---	---		
SW-1B	---	---	---	---	---	0.03	1.06	480	DATA LOST; Equip. malfunction'	
SW-1C	11.91	258.6	2.04	7.68	4.2	---	---	---		
SW-1C	---	---	---	---	---	0.0227	0.80	360		
SW-2A	12.79	706	1.24	8.62	4.0	0.029	1.02	460		
SW-2B	12.62	686	0.99	8.56	4.4	---	---	---		
SW-2B	---	---	---	---	---	---	---	---	DATA LOST; Equip. malfunction'	
SW-2C	12.69	390	1.3	8.88	3.9	---	---	---		
SW-2C	---	---	---	---	---	0.0322	1.14	510		
SW-3A	6.77	154.8	3.6	7.22	3	---	---	---	No flow; No water	
SW-3B	7.27	156	23.3	7.21	3.4	---	---	---	No flow; No water	
SW-3B	---	---	---	---	---	---	---	---	No flow. Estimated time.	
SW-3C	12.31	1218	296	7.07	4.6	---	---	---	From drain pipe	
SW-3C	---	---	---	---	---	1.00E-03	3.54E-02	15.9	2.85 quarts in 2.7 seconds	
SW-4A	12.62	434	2.44	7.94	3.2	0.09	3.28	1500		
SW-4B	12.65	432	3.54	8.06	4.5	---	---	---		
SW-4B	---	---	---	---	---	---	---	---	DATA LOST; Equip. malfunction'	
SW-4C	12.56	433	6.12	8.1	4.2	---	---	---		
SW-4C	---	---	---	---	---	0.10	3.43	1500		
SW-5A	9.91	305	1.84	7.38	1.4	0.14	5.0	2200		2.87
SW-5B	10.7	298.9	2.97	7.56	1.5	---	---			2.89
SW-5B	---	---	---	---	---	---	---		DATA LOST; Equip. malfunction	---
SW-5C	10.94	298.4	3.31	7.58	1.6	---	---			2.88
SW-5C	---	---	---	---	---	0.12	4.2	1900		2.89
SW-6A	11.77	316	3.86	7.36	3.5	0.3	11.3	5100	Rain Begins	
SW-6B	11.35	311	3.45	8.07	3.9	---	---	---		
SW-6B	---	---	---	---	---	---	---	---	DATA LOST; Equip. malfunction	
SW-6C	11.33	306	5.48	7.68	4	---	---	---		
SW-6C	---	---	---	---	---	0.3	12.3	5500		
SW-7A	11.56	287.4	1.6	7.39	1.8	0.244	8.62	3900		1.14
SW-7B	11.8	287.5	3.47	7.57	2.1	---	---	---	DATA LOST; Equip. malfunction	1.14
SW-7C	11.86	287.2	2.91	---	1.9	---	---	---	Error with pH probe, did not collect pH at this time.	1.14
SW-7C	---	---	---	---	---	---	---	---	Staff gauge only; Safety concern for flows.	1.15

Table A6. 1/30/2013 Stormwater sampling event lab results

Drainage	Sample Location	Sample Number	TP (mg/L)	SRP (mg/L)	Ammonia (mg/L)	NO_3 +NO_2 (mg/L)	Total Nitrogen (mg/L)	pH	TSS (mg/L)
Lake Sawyer	Ginder Creek	1	0.021	0.004	0.010	0.526	0.830		7.0
Lake Sawyer	Ginder Creek	2	0.029	0.004	0.010	0.539	0.880	7.36	8.8
Lake Sawyer	Ginder Creek	3	0.018	0.003	0.014	0.534	0.864	7.47	2.5
Lake Sawyer	Mud Creek	1	0.012	0.002	<0.010	0.338	0.572		2.3
Lake Sawyer	Mud Creek	2	0.011	0.001	<0.010	0.355	0.650	7.91	2.5
Lake Sawyer	Mud Creek	3	0.015	<0.001	<0.010	0.374	0.668	8.08	5.3
Lake Sawyer	Basin at SR 169	1	0.016	0.004	0.012	0.503	0.777		3.3
Lake Sawyer	Basin at SR 169	2	0.016	0.004	<0.010	0.511	0.808	7.33	2.8
Lake Sawyer	Basin at SR 169	3	0.014	0.003	0.012	0.513	0.866	7.69	2.5
Lake Sawyer	Ditch at Roberts Drive	1	0.025	0.010	0.012	0.474	0.760		1.0
Lake Sawyer	Ditch at Roberts Drive	2	0.025	0.010	0.012	0.474	0.835	7.31	0.50
Lake Sawyer	Ditch at Roberts Drive	3	0.026	0.010	0.012	0.498	0.879	7.38	2.5
Rock Creek	Abrams Ave	1	0.028	0.009	0.013	0.640	0.894		2.8
Rock Creek	Abrams Ave	2	0.029	0.009	0.016	0.634	1.03	7.30	6.0
Rock Creek	Abrams Ave	3	0.027	0.008	0.038	0.685	1.08	7.33	2.8
Rock Creek	SE Auburn Black Diamond Rd	1	0.028	0.012	0.022	0.405	0.679		1.5
Rock Creek	SE Auburn Black Diamond Rd	2	0.028	0.012	0.037	0.417	0.811	7.37	1.8
Rock Creek	SE Auburn Black Diamond Rd	3	0.028	0.012	0.019	0.427	0.806	7.43	1.3
Rock Creek	SE 312th St	1							
Rock Creek	SE 312th St	2							
Rock Creek	SE 312th St	3	<0.002	<0.001	<0.010	0.011	0.092	6.17	<0.50

Table A7. 1/30/2013 Stormwater sampling event field results

Sample ID	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)	pH	Temp (deg C)	Total Flow (CMS)	Total Flow (cfs)	Total Flow (GPM)	Notes	Staff Gage Height (ft)
SW-1A	11.25	125.6	2.38	7.19	5.3	0.22	7.70	3500		
SW-1B	11.42	127.1	4.66	8.26	5.5	0.29	10.2	4600		
SW-1C	11.19	136.2	2.94	7.96	5.6	0.255	9.012	4000		
SW-2A	12.65	252.2	4.60	7.19	4.5	0.142	5.01	2300		
SW-2B	12.36	245.8	4.59	8.37	5.5	0.212	7.49	3400		
SW-2C	11.92	275.1	5.61	8.11	5.5	0.14	4.94	2200		
SW-3A	11.60	72.8	29.1	6.90	6.2	6.82E-04	2.41E-02	10.8	3.5 lit in 5.1 second	
SW-3B	11.34	42.6	45.8	7.85	7.4	1.43E-03	5.05E-02	22.7	3 liters in 2.1 seconds	
SW-3C	10.87	74.9	37.8	7.91	6.6	3.16E-04	1.12E-02	5.0	3 liters in 9.5 seconds	
SW-4A	12.30	183.3	4.46	7.76	5.3	0.49	17.16	7700		
SW-4B	12.20	180.2	3.47	8.39	5.6	0.52	18.19	8200	Suspect pH ?	
SW-4C	12.12	182.6	3.93	8.06	5.6		0.00	0	NO FLOW; SAFETY CONCERN	
SW-5A	10.10	143.3	2.78	7.40	5.4	1.02	35.9	16100		3.29
SW-5B	10.18	138.7	3.73	8.30	5.5	0.97	34.3	15400		3.29
SW-5C	10.00	136.7	3.40	7.91	5.7	1.11	39.0	17500		3.29
SW-6A	11.10	132.1	3.83	7.33	5.4	1.6	57.3	25700	ADD 10% to Flow = 2630 GPM	0.99
SW-6B	10.98	132.0	4.34	7.95	5.7	1.8	63.4	28400	ADD 3% to Flow = 2780 GPM	1.02
SW-6C	10.73	129.1	4.2	7.89	5.7	NA	NA	NA	NO FLOW; EXCESSIVE BYPASS	1.25
SW-7A	10.50	145.9	2.50	7.40	5.3	0.9263	32.71	14700		2.23
SW-7B	10.57	145.8	2.90	7.98	5.5	0.9466	33.43	15000		2.25
SW-7C	10.35	144.8	2.34	7.79	5.4	---	---		NO FLOW; SAFETY CONCERN	2.25

Table A8. 2/28/2013 Stormwater sampling event lab results

Sample Location	Sample Number	TP (mg/L)	SRP (mg/L)	Turbidity (NTUs)	Ammonia (mg/L)	NO_3 +NO_2 (mg/L)	Total Nitrogen (mg/L)
Ginder Creek	1	0.028	0.006	N/A	<0.010	0.139	0.466
Ginder Creek	2	0.029	0.006	N/A	<0.010	0.163	0.438
Ginder Creek	3	0.028	0.005	N/A	<0.010	0.155	0.378
Mud Creek	1	0.016	0.003	N/A	<0.010	0.071	0.291
Mud Creek	2	0.027	0.002	N/A	<0.010	0.081	0.292
Mud Creek	3	0.017	0.001	7.39	0.112	0.093	0.598
Basin at SR 169	1	0.274	0.004	N/A	0.089	0.075	0.607
Basin at SR 169	2	0.299	0.011	N/A	0.099	0.173	0.702
Basin at SR 169	3	0.305	0.004	N/A	0.112	0.093	0.598
Ditch at Roberts Drive	1	0.015	0.004	N/A	<0.010	0.131	0.348
Ditch at Roberts Drive	2	0.019	0.004	N/A	<0.010	0.132	0.347
Ditch at Roberts Drive	3	0.019	0.004	N/A	<0.010	0.134	0.340
Abrams Ave	1	0.055	0.005	N/A	0.020	0.283	0.709
Abrams Ave	2	0.030	0.007	N/A	0.017	0.263	0.528
Abrams Ave	3	0.034	0.006	N/A	0.015	0.280	0.548
SE Auburn Black Diamond Rd	1	0.033	0.013	N/A	0.017	0.124	0.431
SE Auburn Black Diamond Rd	2	0.033	0.013	N/A	0.015	0.120	0.406
SE Auburn Black Diamond Rd	3	0.034	0.013	N/A	0.014	0.117	0.373
SE 312th St	1	0.034	0.013	N/A	0.021	0.118	0.481
SE 312th St	2	0.037	0.013	N/A	0.021	0.110	0.414
SE 312th St	3	0.036	0.013	N/A	0.020	0.113	0.399

Table A9. 2/28/2013 Stormwater sampling event field results

Sample ID	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)	pH	Temp (deg C)	Total Flow (CMS)	Total Flow (cfs)	Total Flow (GPM)	Notes	Staff Gage Height (ft)
SW-1A	8.44	208.0	3.5	7.60	6.6	0.0274	0.968	430	Rain; 45 deg F	
SW-1B	7.70	192.7	6.11	7.17	6.9	0.0367	1.296	580	50 deg F; Light Rain	
SW-1C	6.98	191.3	2.64	7.85	7.1	0.0301	1.063	480	Drizzle.	
SW-2A	7.75	444.0	5.44	8.28	6.4	0.0314	1.11	500	Rain; 45 deg F.	
SW-2B	8.38	432.0	2.82	8.17	6.9	0.0434	1.53	690	50 deg F.; Light Rain	
SW-2C	8.25	427.0	2.10	8.38	6.9	0.0422	1.49	670	45 deg F., Rain w/ Hail.	
SW-3A	9.51	12.19	113.0	7.71	7.0	0.005	1.77E-01	79	5 liters per second	
SW-3B	9.13	35.1	136.0	7.78	7.9	0.0010466	3.70E-02	17	1.57 Lit per 1.5 sec	
SW-3C	7.87	12.31	135.0	8.26	8.7	6.67E-03	2.36E-01	110	10 Lit per 1.5 sec; 45 deg Rain	
SW-4A	9.12	322.0	2.51	8.04	6.4	0.13	4.69	2100	Rain, 45 deg F.	
SW-4B	8.92	326	4.75	7.64	6.7	0.12	4.26	1900	Rain, 50 deg F.	
SW-4C	8.52	295.7	3.46	8.04	7.1	0.12	4.39	2000	Rain, 45 deg F.	
SW-5A	6.67	222.4	2.23	7.68	6.9	0.21	7.3	3300	Rain; 50 deg F.	2.86
SW-5B	6.53	223.2	1.85	7.65	7.2	0.23	8.2	3700	50 deg. F; Drizzle	2.88
SW-5C	5.59	223.1	2.02	7.84	7.3	0.28	10.0	4500	45 deg. F; Rain (Drizzle)	2.90
SW-6A	7.98	224.6	11.6	7.51	6.8	0.4	14.2	6400	Suspect Bridge meas.	1.31
SW-6B	7.86	199.0	5.15	7.68	7.2	0.6	22.0	9900	Confirmed @ mark.	1.31
SW-6C	7.86	191.4	5.07	7.89	7.3	0.6	19.4	8700	45 deg. F; Rain	1.50
SW-7A	6.92	211.6	2.51	7.63	6.9	0.1849	6.53	2900	50 deg. F. Rain	1.10
SW-7B	6.50	212.1	2.40	7.79	7.3	0.2051	7.24	3300	50 deg. F. Moderate Rain	1.10
SW-7C	7.13	212.7	2.36	7.79	7.4	0.2204	7.78	3500	45 deg. F. Drizzle	1.12

Table A10. 4/4/2013 Stormwater sampling event lab results

Sample Location	Sample Number	TP (mg/L)	SRP (mg/L)	Turbidity (NTUs)	Ammonia (mg/L)	NO_3 +NO_2 (mg/L)	Total Nitrogen (mg/L)
Ginder Creek	1	0.027	0.005	N/A	<0.010	0.094	0.303
Ginder Creek	2	0.027	0.006	N/A	<0.010	0.090	0.276
Ginder Creek	3	0.025	0.005	N/A	<0.010	0.091	0.294
Mud Creek	1	0.011	0.001	N/A	<0.010	0.046	0.194
Mud Creek	2	0.017	0.001	N/A	<0.010	0.042	0.220
Mud Creek	3	0.012	0.001	N/A	<0.010	0.048	0.216
Basin at SR 169	1			N/A			
Basin at SR 169	2	0.246	0.005	N/A	0.279	0.499	1.64
Basin at SR 169	3	0.106	0.002	N/A	0.170	0.208	0.672
Ditch at Roberts Drive	1	0.014	0.002	N/A	0.011	0.091	0.241
Ditch at Roberts Drive	2	0.025	0.003	N/A	<0.010	0.090	0.280
Ditch at Roberts Drive	3	0.021	0.002	N/A	<0.010	0.094	0.273
Abrams Ave	1	0.027	0.005	N/A	0.023	0.089	0.377
Abrams Ave	2	0.041	0.006	N/A	0.015	0.080	0.372
Abrams Ave	3	0.072	0.009	N/A	0.092	0.085	0.565
SE Auburn Black Diamond Rd	1	0.042	0.010	N/A	0.018	0.021	0.307
SE Auburn Black Diamond Rd	2	0.048	0.011	N/A	0.013	0.019	0.308
SE Auburn Black Diamond Rd	3	0.045	0.011	N/A	0.013	0.019	0.324
SE 312th St	1	0.046	0.013	N/A	0.027	0.028	0.344
SE 312th St	2	0.047	0.013	N/A	0.024	0.025	0.342
SE 312th St	3	0.047	0.013	N/A	0.026	0.027	0.348

Table A11. 11/30/2012 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.01	0.005	0.017	0.183	0.443	0.60	0.63
Lake Sawyer	Mud Creek	0.023	0.002	<0.010	0.166	0.400	3.0	13
Lake Sawyer	Basin at SR 169	0.056	0.003	0.024	0.063	0.323	8.9	9.0
Lake Sawyer	Ditch at Roberts Drive	0.016	0.004	<0.010	0.209	0.441	0.71	2.0
Rock Creek	Abrams Ave	0.032	0.013	0.038	0.179	0.477	0.71	1.0
Rock Creek	SE Auburn Black Diamond Rd	0.047	0.012	0.035	0.360	0.797	2.6	5.5
Rock Creek	SE 312th St	0.033	0.014	0.026	0.183	0.501	0.69	1.3

Table A12. Summary of field water quality measurements for the 11/30/2012 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Water Level (ft)
Lake Sawyer	Ginder Creek	7.8	9.93	7.27	326	N/A
Lake Sawyer	Mud Creek	8.45	11.03	8.37	660	N/A
Lake Sawyer	Basin @ SR 169	9	N/A	7.54	N/A	N/A
Lake Sawyer	Ditch on Roberts Drive	8.2	11.03	8.01	439	N/A
Lake Sawyer	Abrams Rd.	7.8	8.38	7.57	235.1	N/A
Rock Creek	SE Auburn Black Diamond Rd	6.2	6.42	7.03	288.1	N/A
Rock Creek	SE 312th St	7.5	8.89	7.03	2	N/A

Table A13. 12/18/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.016	0.004	0.030	0.426	0.703	0.69	5.2
Lake Sawyer	Mud Creek	0.013	0.003	0.014	0.348	0.548	2.4	3.0
Lake Sawyer	Basin at SR 169	0.155	0.003	0.097	0.091	0.807	30	71
Lake Sawyer	Ditch at Roberts Drive	0.017	0.005	0.021	0.429	0.647	1.6	3.3
Rock Creek	Abrams Ave	0.024	0.008	0.022	0.559	0.877	2.1	2.3
Rock Creek	SE Auburn Black Diamond Rd	0.029	0.010	0.016	0.433	0.716	0.87	1.0
Rock Creek	SE 312th St	0.033	0.013	0.038	0.400	0.745	0.87	1.8

Table A14. Summary of field water quality measurements for the 12/18/2012 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Water Level (ft)
Lake Sawyer	Ginder Creek	3.89	9.84	7.53	241.7	N/A
Lake Sawyer	Mud Creek	4.17	10.78	8.63	448.2	N/A
Lake Sawyer	Basin @ SR 169	2.82	10.74	9.03	48.2	N/A
Lake Sawyer	Ditch on Roberts Drive	4.06	10.8	8.3	8.4	N/A
Lake Sawyer	Abrams Rd.	4.22	9.7	8.1	214.9	N/A
Rock Creek	SE Auburn Black Diamond Rd	3.51	8.64	8.15	175.8	2.9
Rock Creek	SE 312th St	4.04	9.21	8.12	172.5	1.96

Table A15. 1/17/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.019	0.005	<0.010	0.339	0.557	0.82	5.8
Lake Sawyer	Mud Creek	0.014	0.003	<0.010	0.241	0.410	0.84	1.2
Lake Sawyer	Basin at SR 169	0.034	0.012	0.021	0.466	0.607	0.83	1.5
Lake Sawyer	Ditch at Roberts Drive	0.015	0.004	<0.010	0.325	0.522	0.89	2.8
Rock Creek	Abrams Ave	0.028	0.008	0.020	0.566	0.803	2.5	4.3
Rock Creek	SE Auburn Black Diamond Rd	0.022	0.011	0.012	0.460	0.706	0.84	0.75
Rock Creek	SE 312th St	0.030	0.012	0.020	0.431	0.701	1.8	3.0

Table A16. Summary of field water quality measurements for the 1/17/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Water Level (ft)
Lake Sawyer	Ginder Creek	1.88	11.74	7.17	156.6	N/A
Lake Sawyer	Mud Creek	2.99	11.96	8.29	550.2	N/A
Lake Sawyer	Basin @ SR 169	**3.02**	**5.76**	**7.5**	**115.6**	**N/A**
Lake Sawyer	Ditch on Roberts Drive	**2.32**	**12.04**	**7.73**	**294.5**	**N/A**
Lake Sawyer	Abrams Rd.	**4.22**	**9.7**	**8.1**	**207.7**	**N/A**
Rock Creek	SE Auburn Black Diamond Rd	**0.61**	**9.03**	**7.23**	**207.3**	**2.9**
Rock Creek	SE 312th St	**2.45**	**9.55**	**7.45**	**197.5**	**1.28**

Table A17. 2/21/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.018	0.006	<0.010	0.183	0.443	5.3	0.76
Lake Sawyer	Mud Creek	0.006	0.002	<0.010	0.070	0.272	0.83	0.53
Lake Sawyer	Basin at SR 169	0.338	0.005	0.273	0.205	1.51	102	42
Lake Sawyer	Ditch at Roberts Drive	0.049	0.003	0.014	0.140	0.377	3.3	0.75
Rock Creek	Abrams Ave	0.023	0.007	0.036	0.290	0.584	1.3	0.88
Rock Creek	SE Auburn Black Diamond Rd	0.033	0.014	0.022	0.158	0.454	2.0	0.80
Rock Creek	SE 312th St	0.047	0.014	0.037	0.128	0.613	11	2.2

Table A18. Summary of field water quality measurements for the 2/21/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Water Level (ft)
Lake Sawyer	Ginder Creek	5.87	8.01	7.84	.1 (shallow)	N/A
Lake Sawyer	Mud Creek	4.88	10.79	8.57	607.8	N/A
Lake Sawyer	Basin @ SR 169	4.41	10.83	8.8	69.8	N/A
Lake Sawyer	Ditch on Roberts Drive	4.66	10.82	8.91	431.8	N/A
Lake Sawyer	Abrams Rd.	4.75	9.76	8.29	282.8	N/A
Rock Creek	SE Auburn Black Diamond Rd	4.23	7.47	6.83	281.1	2.74
Rock Creek	SE 312th St	4.7	7.95	7.92	262.2	1.02

Table A19. 3/14/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.026	0.005	<0.010	0.167	0.327	0.62	3.5
Lake Sawyer	Mud Creek	0.009	0.002	<0.010	0.095	0.213	0.64	1.2
Lake Sawyer	Basin at SR 169	0.027	0.003	0.017	0.096	0.219	2.6	8.3
Lake Sawyer	Ditch at Roberts Drive	0.024	0.004	<0.010	0.163	0.340	0.74	5.2
Rock Creek	Abrams Ave	0.023	0.005	<0.010	0.284	0.472	0.85	2.0
Rock Creek	SE Auburn Black Diamond Rd	0.033	0.009	0.013	0.132	0.384	0.71	1.5
Rock Creek	SE 312th St	0.036	0.010	0.016	0.121	0.347	0.76	2.3

Table A20. Summary of field water quality measurements for the 3/14/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Water Level (ft)
Lake Sawyer	Ginder Creek	8.87	9.1	7.15	.1 (shallow)	N/A
Lake Sawyer	Mud Creek	8.67	10.36	8.3	511.1	N/A
Lake Sawyer	Basin @ SR 169	9.2	9.22	8.72	53.2	N/A
Lake Sawyer	Ditch on Roberts Drive	8.86	10.14	7.93	334.8	N/A
Lake Sawyer	Abrams Rd.	9	8.9	7.84	228.3	N/A
Rock Creek	SE Auburn Black Diamond Rd	9.4	6.91	7.67	238.6	2.788
Rock Creek	SE 312th St	9.25	7.59	7.48	239.4	1.34

Table A21. 4/10/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.020	0.002	<0.010	0.294	0.597	2.2	1.3
Lake Sawyer	Mud Creek	0.024	0.001	<0.010	0.540	0.905	3.8	3.9
Lake Sawyer	Basin at SR 169	0.168	0.012	0.025	0.112	0.482	36	18
Lake Sawyer	Ditch at Roberts Drive	0.022	0.002	<0.010	0.327	0.615	3.2	1.8
Rock Creek	Abrams Ave	0.037	0.005	0.013	0.368	0.781	5.8	2.1
Rock Creek	SE Auburn Black Diamond Rd	0.035	0.009	0.014	0.272	0.679	0.75	1.2
Rock Creek	SE 312th St	0.033	0.009	0.018	0.246	0.605	1.5	1.4

Table A22. Summary of field water quality measurements for the 4/10/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Water Level (ft)
Lake Sawyer	Ginder Creek	10.15	9.18	7.45	130.9	N/A
Lake Sawyer	Mud Creek	10.07	9.97	7.89	312.1	N/A
Lake Sawyer	Basin @ SR 169	10.84	8.57	7.29	80.8	N/A
Lake Sawyer	Ditch on Roberts Drive	10.07	9.91	7.32	174.2	N/A
Lake Sawyer	Abrams Rd.	10.15	8.37	7.16	141.7	N/A
Rock Creek	SE Auburn Black Diamond Rd	9.98	7.58	6.89	150.2	3.15
Rock Creek	SE 312th St	10.15	7.83	6.29	152.3	1.94

Table A23. 4/23/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.013	0.002	<0.010	0.188	0.357	1.7	1.1
Lake Sawyer	Mud Creek	0.011	0.001	<0.010	0.171	0.367	2.0	1.5
Lake Sawyer	Basin at SR 169	0.015	0.003	0.063	0.226	0.409	3.5	1.2
Lake Sawyer	Ditch at Roberts Drive	0.013	0.002	<0.010	0.182	0.372	2.8	1.3
Rock Creek	Abrams Ave	0.020	0.002	0.016	0.303	0.599	5.5	1.4
Rock Creek	SE Auburn Black Diamond Rd	0.025	0.007	<0.010	0.174	0.417	1.7	1.1
Rock Creek	SE 312th St	0.024	0.006	0.012	0.168	0.442	1.7	1.3

Table A24. Summary of field water quality measurements for the 4/23/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Instant Logger Reading (ft)
Lake Sawyer	Ginder Creek	9.57	9.4	6.22	143.8	1.1
Lake Sawyer	Mud Creek	10.32	9.98	7.88	411.9	.75
Lake Sawyer	Basin @ SR 169	10.63	8.93	7.95	126.8	N/A
Lake Sawyer	Ditch on Roberts Drive	9.92	10.13	7.35	216.4	.75
Lake Sawyer	Abrams Rd.	9.99	9.42	7.55	163.7	3.05
Rock Creek	SE Auburn Black Diamond Rd	9.37	8.02	7.92	141.6	1.1
Rock Creek	SE 312th St	10.96	8.96	7.31	151.2	1.94

Table A25. 5/29/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.038	0.012	<0.010	0.029	0.332	6.8	2.1
Lake Sawyer	Mud Creek	0.019	0.001	<0.010	0.033	0.251	6.8	2.5
Lake Sawyer	Basin at SR 169	0.045	0.004	0.041	0.074	0.311	6.8	7.6
Lake Sawyer	Ditch at Roberts Drive	0.033	0.007	<0.010	0.038	0.285	14	2.0
Rock Creek	Abrams Ave	0.043	0.011	0.031	0.053	0.391	9.5	3.9
Rock Creek	SE Auburn Black Diamond Rd	0.077	0.035	0.031	0.021	0.394	2.3	2.4
Rock Creek	SE 312th St	0.055	0.021	0.012	<0.010	0.321	4.0	1.9

Table A26. Summary of field water quality measurements for the 5/29/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Instant Logger Reading (ft)
Lake Sawyer	Ginder Creek	13.3	N/A	6.82	242.1	.58
Lake Sawyer	Mud Creek	14.04	N/A	8.29	572.5	.50
Lake Sawyer	Basin @ SR 169	14.2	N/A	8.62	8.34	N/A
Lake Sawyer	Ditch on Roberts Drive	13.49	N/A	7.92	363.5	.395
Lake Sawyer	Abrams Rd.	13.45	N/A	7.59	227.3	2.14
Rock Creek	SE Auburn Black Diamond Rd	13.22	N/A	7.67	219.4	2.0
Rock Creek	SE 312th St	14.3	N/A	7.62	240.6	1.18

Table A27. 6/10/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.049	0.013	<0.010	0.047	0.360	2.5	2.5
Lake Sawyer	Mud Creek	0.014	0.004	<0.010	0.112	0.343	2.7	1.2
Lake Sawyer	Ditch at Roberts Drive	0.039	0.010	<0.010	0.055	0.333	5.0	1.5
Rock Creek	Abrams Ave	0.141	0.013	0.046	0.046	0.730	4.5	6.6
Rock Creek	SE Auburn Black Diamond Rd	0.107	0.042	0.055	0.021	0.416	5.0	2.8
Rock Creek	SE 312th St	0.117	0.038	0.044	0.016	0.553	8.0	4.0

Table A28. Summary of field water quality measurements for the 6/10/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Instant Logger Reading (ft)
Lake Sawyer	Ginder Creek	14.79	8.95	7.3	285.2	.392
Lake Sawyer	Mud Creek	13.93	9.33	8.21	633.3	2.35
Lake Sawyer	Basin @ SR 169	Not Flowing				
Lake Sawyer	Ditch on Roberts Drive	15.23	9.24	8.07	371	.395
Lake Sawyer	Abrams Rd.	15.36	6.43	7.71	273.1	1.884
Rock Creek	SE Auburn Black Diamond Rd	16.82	2.9	7.47	337.4	1.1
Rock Creek	SE 312th St	8.55	6.64	6.85	284.5	1.22

Table A29. 7/10/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.060	0.017	<0.010	0.071	0.506	25	2.4
Lake Sawyer	Mud Creek	0.019	0.008	<0.010	0.368	0.807	4.0	0.76
Lake Sawyer	Ditch at Roberts Drive	0.128	0.011	<0.010	0.072	0.815	20	5.6
Rock Creek	Abrams Ave	0.101	0.019	0.136	0.048	0.820	8.0	6.5
Rock Creek	SE Auburn Black Diamond Rd	0.358	0.047	0.013	<0.010	0.871	7.0	4.9
Rock Creek	SE 312th St	0.050	0.026	<0.010	<0.010	0.692	4.5	2.1

Table A30. Summary of field water quality measurements for the 7/10/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Instant Logger Reading (ft)
Lake Sawyer	Ginder Creek	17.16	7.93	7.49	338.8	.28
Lake Sawyer	Mud Creek	15.36	8.66	7.57	710.6	.12
Lake Sawyer	Basin @ SR 169	Not Flowing				
Lake Sawyer	Ditch on Roberts Drive	17.63	7.98	7.36	389.2	0
Lake Sawyer	Abrams Rd.	17.64	3.67	6.73	302.1	1.80
Rock Creek	SE Auburn Black Diamond Rd	18.02	0.78	6.56	358.4	1.5
Rock Creek	SE 312th St	19.67	1.89	6.45	342.3	2.19

Table A31. 8/6/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.032	0.016	<0.010	0.183	0.660	3.8	1.7
Lake Sawyer	Mud Creek	0.021	0.007	<0.010	0.369	0.787	3.0	1.1
Lake Sawyer	Ditch at Roberts Drive	0.913	0.009	<0.010	0.098	2.38	71	15
Rock Creek	Abrams Ave	0.177	0.013	0.162	0.021	1.23	46	5.0
Rock Creek	SE Auburn Black Diamond Rd	0.118	0.041	0.031	<0.010	0.713	8.0	2.7
Rock Creek	SE 312th St	0.183	0.070	<0.010	<0.010	0.809	19	4.6

Table A32. Summary of field water quality measurements for the 8/6/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Instant Logger Reading (ft)
Lake Sawyer	Ginder Creek	15.5	6.6	7.1	379	.169
Lake Sawyer	Mud Creek	15.21	7	7.45	857.4	0
Lake Sawyer	Basin @ SR 169	Not Flowing				
Lake Sawyer	Ditch on Roberts Drive	19.3	7.01	7.51	488.5	0
Lake Sawyer	Abrams Rd.	17.62	1.56	6.95	1252	1.69
Rock Creek	SE Auburn Black Diamond Rd	19.39	3.55	6.85	430.6	1.3
Rock Creek	SE 312th St	20.9	1.19	6.78	413.8	N/A

Table A33. 9/23/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.039	0.013	<0.010	0.048	0.558	2.4	1.4
Lake Sawyer	Mud Creek	0.014	0.007	<0.010	0.429	0.834	0.53	0.81
Lake Sawyer	Ditch at Roberts Drive	0.035	0.010	<0.010	0.100	0.605	2.9	1.5
Rock Creek	Abrams Ave	0.072	0.022	0.033	0.042	0.745	14	4.0
Rock Creek	SE Auburn Black Diamond Rd	0.190	0.076	0.013	0.012	0.806	52	3.9
Rock Creek	SE 312th St	0.220	0.054	0.024	0.011	1.23	10	3.9

Table A34. Summary of field water quality measurements for the 9/23/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Instant Logger Reading (ft)
Lake Sawyer	Ginder Creek	14.01	7.89	6.78	342.3	.488
Lake Sawyer	Mud Creek	13.33	7.96	7.53	1190	.174
Lake Sawyer	Basin @ SR 169	Not Flowing				
Lake Sawyer	Ditch on Roberts Drive	13.92	8.56	7.49	420.6	.184
Lake Sawyer	Abrams Rd.	13.67	4.92	7.09	249.3	2.003
Rock Creek	SE Auburn Black Diamond Rd	14.58	2.23	6.66	354.9	3.1
Rock Creek	SE 312th St	14.35	1.78	7.01	328.4	N/A

Table A35. 10/21/2013 Ambient sampling event lab results

Drainage	Sample Location	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	TURBIDITY (NTU)	TSS (mg/L)
Lake Sawyer	Ginder Creek	0.018	0.006	<0.010	0.183	0.443	5.3	0.76
Lake Sawyer	Mud Creek	0.006	0.002	<0.010	0.070	0.272	0.83	0.53
Lake Sawyer	Basin at SR 169	0.338	0.005	0.273	0.205	1.51	102	42
Lake Sawyer	Ditch at Roberts Drive	0.049	0.003	0.014	0.140	0.377	3.3	0.75
Rock Creek	Abrams Ave	0.023	0.007	0.036	0.290	0.584	1.3	0.88
Rock Creek	SE Auburn Black Diamond Rd	0.033	0.014	0.022	0.158	0.454	2.0	0.80
Rock Creek	SE 312th St	0.047	0.014	0.037	0.128	0.613	11	2.2

Table A36. Summary of field water quality measurements for the 10/21/2013 ambient sampling event

Drainage	Sample Location	Temperature (°C)	DO (mg/L)	pH	Conductivity (µmhos/cm)	Instant Logger Reading (ft)
Lake Sawyer	Ginder Creek	8.75	10.19	6.87	314.3	.44
Lake Sawyer	Mud Creek	8.44	11.03	7.14	544.2	.24
Lake Sawyer	Basin @ SR 169	Not Flowing				
Lake Sawyer	Ditch on Roberts Drive	8.83	11.2	7.17	359.6	.2
Lake Sawyer	Abrams Rd.	8.94	7.8	7.09	271	2.06
Rock Creek	SE Auburn Black Diamond Rd	8.67	5.12	6.8	290	2.1
Rock Creek	SE 312th St	8.55	6.64	6.85	284.5	1.22