Long Creek Monitoring Plan

Original Plan: April 2010

Revision 1: March 2011

Revision 2: June 2013

Revision 3: September 2018

TABLE OF CONTENTS

Section **Page Number**

TABLE OF CONTENTS

Section **Page Number**

Tables

Figures

Appendix

1. INTRODUCTION

Long Creek is a freshwater urban stream system in southern Maine. The Long Creek Watershed is approximately 3.45 square miles and is located in Portland, South Portland, Westbrook, and Scarborough, Maine. The stream currently does not meet Maine water quality standards due to the influences of increased concentrations of metals, chloride, phosphorus, nitrogen, polycyclic aromatic hydrocarbons (PAHs), and reduced dissolved oxygen (DO) concentrations. The degraded water quality is caused by substantial nonpoint source (NPS) discharges to Long Creek. Water quality is also adversely affected by altered hydrological conditions and increased water temperatures from lack of shading in certain areas. The health of Long Creek is important to the health of Clark's Pond, the Fore River, and ultimately, the Casco Bay Estuary.

Development over the past several decades has converted the landscape from mostly forests and fields to commercial, light industrial, retail, and transportation uses. One of the primary results of this conversion process has been the creation of impervious cover (IC) such as roads, driveways, parking lots, sidewalks, rooftops, and any other impermeable surfaces of the built environment. IC prevents water from infiltrating into the ground and acts as a conveyance method for a wide variety of pollutants commonly carried into adjacent surface waters by stormwater or melting snow.

A direct correlation has been established between IC and the health of aquatic ecosystems. In general, stream watersheds with less IC exhibit stream flows that are less variable, which encourages a healthier biotic community. It has been shown that as IC increases above 10% there is a corresponding increase in stormwater flows and degradation in water quality, stream habitat, and diversity of aquatic life. Some areas of the Long Creek Watershed have an IC of greater than 60%. This impervious cover alters the hydrology of Long Creek and acts as a conveyance for pollutants into adjacent surface waters by stormwater or melting snow. High IC increases the volume of runoff directed to Long Creek by decreasing filtration through soils and directing of overland flows to ditches and storm drains.

The *General Permit – Post Construction Discharge of Stormwater in the Long Creek Watershed* (MEPDES Permit #MEG190000/Wastewater Discharge License #W-9052-5Y-B-N) issued by the Maine Department of Environmental Protection (MEDEP) on October 29, 2009, and renewed on April 21, 2015, provides for the implementation of the *Long Creek Watershed Management Plan* (Management Plan).[1] The Management Plan is implemented by the Long Creek Watershed Management District (LCWMD). Implementation of the Management Plan is overseen by the Maine Department of Environmental Protection (MEDEP) and the U.S. Environmental Protection Agency (EPA). The Management Plan lays out a course of action toward improving water quality in Long Creek and meeting water quality goals by 2020.

[1] FB Environmental Associates, Inc. (2009), *Long Creek Watershed Management Plan*, July 2009.

As a means of evaluating progress toward this goal, the Management Plan requires the establishment of a monitoring and assessment program to evaluate water quality conditions in Long Creek. This *Long Creek Monitoring Plan* (Monitoring Plan) establishes the monitoring and assessment program to evaluate water quality conditions in Long Creek in accordance with the Management Plan.

This Monitoring Plan is supported by the associated *Long Creek Quality Assurance Project Plan* (Project QAPP) and *Long Creek Data Loading Quality Assurance Program Plan* (Data Loading QAPP). In the event of overlap with either the Project QAPP or Data Loading QAPP, the more-specific provision applies.

1.1. Project Background

The Management Plan stipulates that its goal is to improve conditions in the Long Creek Watershed sufficiently to attain applicable water quality classification standards by 2020. As a means of evaluating progress toward this goal, the Management Plan established a monitoring and assessment program to evaluate water quality conditions in Long Creek. The requirements of the monitoring and assessment program are detailed in this Monitoring Plan, as amended.

The purpose of the monitoring and assessment program is to:

- Determine whether Long Creek meets applicable water quality standards
- Gather information to improve management of Long Creek
- Document progress toward meeting standards

Implementation of the monitoring and assessment program began in June of 2010, and is ongoing. Data collection activities occur under the following programs:

- Grab Sampling for Water Quality Monitoring
- Continuous Sampling for Water Quality Monitoring
- Hydrology and Flow Monitoring
- Weather Monitoring
- Biological Monitoring
- Sediment Investigation

Since 2010, a significant volume of grab sample and continuous sample water quality data have been compiled in the project water quality monitoring database maintained by LCWMD. Grab samples are collected during periodic sampling events conducted in Long Creek under spring-melt, base-flow, and storm-flow conditions. Historically, grab sample water quality data has included laboratory analytical results for phosphorus, metals, hardness, and chloride. In 2017, analysis for metals and hardness was eliminated for spring-melt samples because prior monitoring results show that metals have not been near toxic levels based on the surface water quality criteria for metals set forth in Table 2. Furthermore, analysis of these samples required that they be sent to an out-of-state laboratory resulting in a significant expense for information of limited value. In 2018, synoptic storm-flow sampling was discontinued and replaced with the opportunity to conduct targeted storm-flow sampling. Synoptic storm-flow sampling was discontinued because it was determined that the method of conducting storm-flow sampling was not being conducted in a manner in which useful data was being acquired.

Water quality field parameters are collected concurrent with each grab sampling event using a hand-held meter. Historically, water quality field parameters included specific conductance, DO, oxidation reduction potential, pH, turbidity, and temperature. In 2017, turbidity, oxidation reduction potential, and pH were eliminated as field parameters. Turbidity was eliminated as a field parameter because adequate data had been collected by this point to serve as a baseline for turbidity in the Long Creek Watershed, therefore, further data collection would not have a significant return on the investment of collecting this information. Experience has shown that oxidation reduction potential and pH vary very little in Long Creek and, therefore, were eliminated given they will have little operational impact. Elimination of turbidity, oxidation reduction potential, and pH as field parameters also allowed the use of simpler and less expensive monitoring equipment. Water quality field parameters were measured with a Horiba U50 until 2017, at which time the Horiba meter was replaced with a YSI Pro2030.

Continuous samples for water quality monitoring data are collected using sondes deployed at various locations in Long Creek. Parameters monitored include specific conductance, DO, and temperature. The project initially used YSI-600 OMS series meters. In 2015, the YSI meters were replaced with parameter-specific HOBO data loggers.

Hydrologic monitoring is performed at several locations along Long Creek to document changes in stream geomorphology and flow. Data collection includes continuous measurements of stream stage (water surface elevation) using *in situ* HOBO Level Logger dataloggers, in-field measurements of stage and stream flow (velocity), and measurements of the stream channel. This information is used to develop stream-discharge curves for each hydrologic monitoring location. In addition, cross sections of the stream channel and floodplain are surveyed and measured to document changes in stream geomorphology.

Two weather stations were originally used to monitor precipitation and temperature within the Long Creek Watershed. These included a National Oceanic and Atmospheric Administration (NOAA) weather station located at the Portland International Jetport and a HOBO H-21 Microstation Datalogger situated on the western edge of the watershed. Use of the HOBO H-21 Microstation Datalogger was discontinued in 2017 because the data at this station was not significantly different from the data collected by the NOAA weather station. Weather monitoring data are evaluated in conjunction with hydrologic monitoring data to evaluate stream response to precipitation events.

Biological monitoring is completed by either the Maine Department of Environmental Protection (MEDEP) or LCWMD twice during a five-year period at specified locations. The MEDEP biological monitoring program consists of benthic macroinvertebrate sampling using rock bags under MEDEP protocols.

In accordance with the Management Plan, the Monitoring Plan was executed using an "adaptive management" approach, which allows for updates and modifications, as deemed necessary and appropriate, during the course of its implementation. The Monitoring Plan presented herein was developed using the adaptive management approach, and presents the monitoring and assessment program that will be implemented in the Long Creek Watershed until future updates and/or modifications are deemed necessary and appropriate.

2. TECHNICAL APPROACH

2.1. Monitoring Locations

The original monitoring locations used to evaluate water quality conditions in Long Creek included sites S01 through S07 as primary monitoring locations for the grab and continuous water quality monitoring programs. Tertiary sites S08, S09, and S10, and secondary sites S11 and S12, were monitored for limited constituents (such as phosphorus and PAHs). Continuous monitoring for conductivity and temperature was conducted at temporary sites S13 and S14 during 2012, and at temporary sites S15 and S16 in 2013.

In 2014 and 2015, Pennsylvania State University conducted monitoring for specific conductance at two stations in Long Creek, at S18 in the South Branch, and at S19 in the Main Stem near Clark's Pond. LCWMD is in possession of the raw data files for these sites, but the data has not been, and was not intended to be, uploaded into the project water quality monitoring database maintained by LCWMD.

The sample locations have been modified since the inception of the Monitoring Plan with current monitoring locations identified in **Table 1** and **Figure 1**. Monitoring locations have been modified to provide a consistent dataset that specifically targets grab analytical sampling and continuous monitoring to provide a better understanding of the long-term health of the Long Creek Watershed.

2.1.1. Primary Monitoring Locations

Water quality, stream hydrology, and biological monitoring are conducted at six primary monitoring locations within the Long Creek Watershed — sites S01, S17 (which replaced S02 in 2014), S03, S05, S06B (S06 was moved to this location in 2013), and S07. Each of these locations is situated at the downstream end of sub-watersheds identified within the Long Creek Watershed.

Stream characteristics at S02 were shallow and wide during storm events and, therefore, did not provide adequate stream stage information. In 2014, site S17 was established as a primary monitoring location in the Main Stem of Long Creek upstream of Foden Road to replace S02.

Site S04, located in the South Branch, was included in the original set of primary monitoring locations, however, site S04 was removed from the list of primary monitoring locations in 2013 because it exhibits wetland conditions including low flow rates and dense wetland vegetation. Site S04 is currently monitored as part of the secondary monitoring location program. This location may be reinstated as a primary monitoring location after the implementation of best management practices (BMPs) or in-stream/riparian restoration in the South Branch.

In 2013, site S06 was relocated approximately 600 feet upstream to a location that has a more clearly defined stream channel. This location is identified as site S06B to differentiate the data collected at this location from data historically collected at site S06.

Sample sites S01, S17, S03, S05, S06B, and S07 are sampled continuously with in-stream water quality instruments and stream height is continuously gauged using in-stream pressure transducers. Grab samples are collected for laboratory analysis during spring-melt and base-flow regimes for phosphorus, metals, hardness, and/or chloride. Water quality field parameters are collected concurrent with each round of grab sampling. Stream flow rates will be measured once annually. Primary monitoring locations will be employed during Biological Monitoring.

2.1.2. Secondary Monitoring Locations

Secondary monitoring locations include sites S04, S11, and S12. Site S04 has historically been monitored for water quality field parameters (DO, pH, temperature, ORP, and specific conductance), Target Analyte List (TAL) metals (total copper, lead, nickel, and zinc), phosphorus, and chloride, and sites S11 and S12 have historically been monitored for phosphorus including orthophosphate and total phosphorus. Secondary sampling locations are sampled twice each in May, July, and September during base-flow conditions, concurrent with grab analytical sampling of the primary monitoring locations, to create a synoptic dataset of the watershed. Base-flow samples are analysed for phosphorus, metals, hardness, and chloride. Water quality field parameters are collected concurrent with each grab sampling round.

2.1.3. Tertiary Monitoring Locations

Grab samples have historically been collected from tertiary sites S08, S09, and S10 for PAHs. PAHs are a class of organic compounds found in a variety of petroleum products and produced as a by-product of combustion of hydrocarbons. They tend to be found in higher concentrations in areas with heavy automobile use. During 2010, 2011, and 2012, PAHs were sampled in water at tertiary sites where elevated levels are most likely to occur. These monitoring data showed PAHs to be below detection limits with the exception of several constituents commonly associated with coal tar-based asphalt sealants which were detected at low levels. Since the PAH detections in surface water are likely associated with coal tar-based sealants and are transient in the system monitoring was suspended at these locations in 2012. Targeted aqueous sampling may be undertaken by LCWMD in the future to study the effects to coal tar sealants at specific locations.

2.1.4. Temporary Monitoring Locations

Temporary monitoring locations may be established at the discretion of LCWMD to provide flexibility to the monitoring program. Temporary monitoring locations may be utilized to monitor the effectiveness of BMPs within the watershed that are not currently bookended by primary or secondary monitoring locations, or for any other purpose deemed appropriate by LCWMD.

Continuous monitoring for conductivity and temperature was conducted at temporary sites S13 and S14 during 2012, and at temporary sites S15 and S16 in 2013.

2.2. Water Quality Criteria

Based on MEDEP and EPA water quality standards for freshwater or urban streams, LCWMD has identified water quality criteria for target metals and general water chemistry in Long Creek, as presented in **Table 2**.

2.2.1. Metals

All five of the Target Analyte List (TAL) metals (i.e., cadmium, copper, lead, nickel, and zinc) were analyzed in the first monitoring year (2010). The second monitoring year (2011) incorporated a combined metals analytical program that includes eight events where the complete TAL metals list was analyzed and six events where Cu and Zn, the most common metals in urban runoff (Driscoll et al. 1990), were tested as indicator metals. The 2011 dataset did not indicate that there was good statistical correlation between the concentrations of TAL metals and indicator metals; therefore, the full TAL metals list will be retained with the exception of cadmium. Due to the difficulty in obtaining a detection limit that is below the ecological criterion for cadmium, this metal has been eliminated from the program. If future data indicates that cadmium sampling is necessary, additional data will be collected. To determine appropriate regulatory criteria for TAL metals, samples will be analyzed for hardness.

2.2.2. Specific Conductance and Chloride Regression

In most urban watersheds not influenced by ocean waters, chlorides are highly correlated with specific conductance, which is measured nearly continuously with water quality data loggers at primary monitoring locations (except for Site 06B). Specific conductance is also a field parameter collected during grab-sampling events using a hand-held meter.

Specific conductance is not a water quality parameter governed by a water quality standard, but is instead used as a proxy for chloride. LCWMD has developed a chloride-specific conductance statistical model and regression analysis using chloride results from grab water quality samples and corresponding specific conductance water quality field parameter readings (see **Appendix A**). Chloride analytical grab samples and water quality field parameter measurements of specific conductance will continue to be collected as part of the Long Creek monitoring program and these data will be used to update the regression on an annual basis. The regression equation will be used to estimate chloride concentrations from cumulative specific conductance data collected via the continuous monitoring program and water quality field parameter measurements to provide a more in-depth picture of potential chloride fluctuations within Long Creek seasonally and across flow regimes.

2.2.3. Total Phosphorus

Total phosphorus levels are measured periodically by in-stream grab sampling. Data is collected at primary and secondary monitoring locations during synoptic monitoring rounds.

2.2.4. Dissolved Oxygen

Dissolved oxygen is a water quality parameter that is directly linked to the overall health of Long Creek. Low DO values are caused by respiration of excess algal and other in-stream plant growth due to high nutrient load, high bacteria load or high concentrations of plant material in decomposition in the stream, high water temperatures, or a lack of turbulence. Values below 5 milligrams per liter (mg/l), or 60 percent saturation, are considered to be below the State of Maine Class C water quality criteria for DO.

Dissolved oxygen is measured nearly continuously with water quality data loggers at primary monitoring locations (except for Site 05). Dissolved oxygen is also a field parameter collected during grab-sampling events using a hand-held meter.

2.2.5. Macroinvertebrates

The benthic macroinvertebrate community is used as a surrogate to determine conformance with statutory aquatic life standards. Related statutory definitions, and statutory provisions for the implementation of biological water quality criteria to quantify aquatic life standards for Classes AA, A, B, and C waters are defined in MEDEP's rule *Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams*, 06-096 CMR 579. Methods described in this rule will be used to make decisions about classification attainment.

3. GRAB SAMPLING FOR WATER QUALITY MONITORING

Because concentrations of known contaminants in Long Creek vary seasonally, between flow regimes, and across the watershed, grab sampling will be conducted to provide LCWMD with samples representative of the variable conditions and locations found throughout the watershed. An overview of the grab sample water quality monitoring program is included in **Table 3** and a more detailed list of the analytical sampling program is included in **Table 4**. Information regarding spring-melt, base-flow, and storm-flow monitoring is detailed below. These data are intended to provide a representative dataset for the evaluation of stream water quality conditions and for use in statistical analysis.

Three general flow regimes have been identified in the Long Creek Watershed: (1) melt flows during late winter to spring months when warm weather or rain contribute to the melting of snowpack and snow banks along the impervious surfaces in the watershed; (2) base flow during dry days in the spring through fall annually; and (3) storm flow during and following precipitation events.

3.1. Spring-Melt Sampling

Spring melt contains significant amounts of salt from winter ice treatment on roadways, pedestrian walkways, and parking areas. A minimum of three, and a maximum of four, rounds of analytical samples will be collected at all primary monitoring locations from February through April (or from the beginning of consistent melting temperatures until no snow remains in the watershed). Samples will be collected on days with temperatures above freezing when either warm weather conditions or spring rain have contributed to the melting of any remaining snowpack or snow piles and the introduction of runoff to Long Creek.

Analytical methods and quantitation limits for spring-melt grab samples is limited to total chlorides.

Water quality field parameters will be collected concurrent with each grab sampling round.

3.2. Base-Flow Sampling

Base-flow samples will be collected at all primary and secondary monitoring locations once each in May, July, and September of each calendar year.

Specific conductivity data from Long Creek reflects that conductivity in Long Creek is sharply supressed after a rain event and increases quickly after a rain event. On eleven occasions between 2010 and 2012 data was collected at seven locations in Long Creek to estimate the number of days it takes for specific conductivity in Long Creek to return to base flow levels after a rain event to inform the timing of base-flow monitoring events. According to data obtained from the conductivity study, dry weather conditions (base flow) for the Long Creek Watershed are achieved within three days after a storm event.[2] Based on this data, base-flow samples will be collected during dry weather conditions with a minimum of 72 hours without precipitation preceding sample collection. Laboratory analysis for base-flow samples include the following constituents:

- Total Phosphorus
- TAL Metals (total copper, lead, nickel, and zinc)
- Hardness (as $CaCO_3$)
- Total Chloride

Water quality field parameters will be collected concurrent with each synoptic grab sampling event.

3.3. Storm-Flow Sampling

Targeted storm-flow (an event exceeding 0.25 inches of precipitation) sampling may be conducted to answer specific questions with a tailored sampling design that ensures collection of usable data. Storm samples will be retrieved as soon as stream conditions allow and will be submitted for laboratory analysis for constituents which may include, but are not limited to:

- Total Phosphorus
- TAL Metals (total copper, lead, nickel, and zinc)
- Hardness (as $CaCO_3$)

[2] *See* Frederik Schuele, URS Corporation, memorandum to Kate McDonald, Long Creek Watershed Management District, April 15, 2013, Long Creek Monitoring Program, Estimation of baseflow conditions in Long Creek based on in-stream specific conductance data for the purpose of defining timing of baseflow monitoring events.

- Total Chloride

Water quality field parameters will be collected concurrent with each synoptic grab sampling event.

3.4. Polycyclic Aromatic Hydrocarbons Sampling

During 2010, 2011, and 2012, PAHs were sampled in water at tertiary sites where elevated levels are most likely to occur. These monitoring data showed PAHs to be below detection limits with the exception of several constituents commonly associated with coal tar-based asphalt sealants which were detected at low levels. Since the PAH detections in surface water are likely associated with coal tar-based sealants and are transient in the system monitoring was suspended at these locations in 2012. Targeted aqueous sampling may be undertaken by LCWMD in the future to study the effects of coal tar sealants at specific locations.

3.5. Quality Assurance/Quality Control and Data Management

All grab samples submitted for laboratory analysis will be collected in method-specified containers and with method-specific equipment. Samples will be submitted to the laboratory under proper chain of custody procedures.

Duplicate samples will be collected at a rate of one duplicate per ten samples (1:10) for each sampling event. If less than ten samples are collected for a sampling event, one duplicate sample will be collected for the sampling event.

Laboratory analytical results and water quality field parameter readings will be added to the project water quality data database maintained by LCWMD. An updated database file will be transmitted to LCWMD within one month of each significant data collection event.

4. CONTINUOUS SAMPLING FOR WATER QUALITY MONITORING

Specific conductance, DO, and temperature continue to be significant constituents of concern within Long Creek. HOBO U-24 data loggers (specific conductance and temperature) and HOBO U-26 data loggers (DO and temperature) are used for the continuous water quality monitoring program.

Continuous monitoring of specific conductance, DO, and temperature is conducted at primary monitoring locations S01, S17, S03, and S07. Site S05 will only be monitored for specific conductance and temperature. Site S06B will only be monitored for DO and temperature. Site S05 is not monitored for DO and Site S06B is not monitored for specific conductance because data show there has been little fluctuation of these parameters at these locations, therefore, it was determined that resources for monitoring these parameters would be better allocated elsewhere.

4.1. Equipment Deployment and Maintenance Schedule

All continuous monitoring meters will be installed securely as early in the calendar year as is practicable according to manufacturer’s guidelines, typically March, and will be removed from the stream before freezing conditions may damage the equipment, typically late November or early December. At installation, the meters will be programmed to log results at 30-minute intervals. Continuous monitoring meters will be retrieved, maintained, data downloaded, and reinstalled approximately once every six to eight weeks, depending on battery life, data storage capabilities, and calibration drift.

4.2. Quality Assurance/Quality Control and Data Management

Upon data retrieval, all continuous monitoring data files will be evaluated for completeness. Data will be evaluated to identify any instances when the meters were logging data but were not installed in the stream (i.e. when meters are set to log parameters but have been removed from the stream channel for recalibration, or when high storm events could have pushed the meters onto the stream bank and then receded) and these data will be noted for deletion. Data will also be evaluated for accuracy, using pre-and-post-installation calibration data, and the dataset will be adjusted for any calibration drift.

Continuous monitoring data will be added to the project water quality data database maintained by LCWMD. An updated database file will be transmitted to LCWMD within one month after each significant data collection, or data download, event.

5. HYDROLOGY AND FLOW MONITORING

Stream flow affects the geomorphology of the stream which has significant effects on habitat structure and function for invertebrate and vertebrate species. Due to the high percentage of IC in the Long Creek watershed, as well as the low transmissivity of local shallow soils, the stream’s height and flow rates increase rapidly and intensively in response to rain events. This has an effect of scouring sediment from the stream’s bottom and banks, depositing sediment behind natural dams, and covering gravel and cobble substrate (which are the preferred spawning material for brook trout and growth substrate for several invertebrate species) with finer material. During base-flow conditions, the stream height becomes shallow and in-stream temperatures and contaminant concentrations increase; these conditions are inhospitable to the growth and survival of invertebrate and fish species. Ultimately, one of the goals of the Long Creek Restoration Project is to reduce the amount of runoff being discharged directly into the stream channel during, and after, precipitation events, and to normalize stream height and in-stream flow rates.

5.1. Hydrology

Typical elevation survey procedures will be utilized to generate stream cross sections along which stream response will be measured. Cross-sections of the stream channel and floodplain will be surveyed once annually with a rod and level at all primary locations (except at location S07 where flow is measured in a culvert). The survey data will be collected relative to the existing elevation benchmark at each monitoring location.

5.2. Stream Stage Monitoring

Stream stage (water surface elevation) is monitored at all primary monitoring locations at 30-minute intervals using HOBO U-20 pressure transducers. The meters will be deployed securely at each location as early in the calendar year as is practicable according to the manufacturer’s guidelines, typically March, and will be removed from the stream before freezing conditions may damage the equipment, typically late November or early December. Data will be downloaded every six to eight weeks, based on data storage capabilities of the equipment and battery life.

5.3. Stream Discharge Measurement

Stream discharge (volume) will be monitored throughout the Long Creek Watershed at primary monitoring locations. Stream discharge is based on measurements of stream flow (velocity) and stream channel cross-sectional area. These measurements will be made using a velocity meter and staff gauges. Data will be gathered following standard USGS methods.[3]

5.4. Stage-Discharge Relation

Stream stage and stream discharge information gathered during hydrologic monitoring events will be used to modify and update existing empirical stage-discharge relationship curves that have been developed for each primary monitoring location. These relationships are statistically derived based on simultaneous field measurements of stage (water surface elevation) and discharge. As data points are added to the existing curve, the regressions will be updated according to methods outlined in Book 3, *Applications of Hydraulics*, *Techniques of Water-Resources Investigations of the U.S. Geological Survey*[4].

5.5. Quality Assurance/Quality Control and Data Management

Upon data retrieval from pressure transducers, data files will be evaluated for completeness. Data will be evaluated to identify any instances when the meters were logging data but were not installed in the stream (i.e. when meters are set to log parameters but have been removed from the stream channel for recalibration, or when high storm events could have pushed the meters onto the stream bank and then receded) and these data will be noted for deletion. Data will also be evaluated for accuracy, using pre-and-post-installation calibration data, and the dataset will be adjusted for any calibration drift.

Hydrologic monitoring data will be added to the project water quality database maintained by LCWMD. An updated database file will be transmitted to LCWMD within one month after each significant data collection, or data download, event.

6. WEATHER MONITORING

Weather monitoring data, including temperature, precipitation, and snowfall are used to contribute to the overall understanding of conditions affecting the watershed. Weather information including temperature (daily maximum, minimum, and average),

[3] Techniques of Water-Resources Investigations of the U.S. Geological Survey, http://pubs.usgs.gov/wdr/WDR-WA-03-1/pdf/ADR_O.pdf.

[4] Techniques of Water-Resources Investigations of the U.S. Geological Survey, http://pubs.usgs.gov/wdr/WDR-WA-03-1/pdf/ADR_O.pdf.

precipitation (hourly and daily total), and snowfall (daily total) from the NOAA weather station located at the Portland International Jetport is available on-line.[5] NOAA weather data will be downloaded from the NOAA website and added to the project database maintained by LCWMD every six to eight weeks and will include weather data for each full calendar year.

6.1. Quality Control/Quality Assurance and Data Management

Upon data retrieval, data files will be evaluated for completeness and accuracy. NOAA's QA/QC procedures will be relied on for the accuracy of data obtained from NOAA.

7. BIOLOGICAL MONITORING

7.1. Invertebrates

Invertebrate monitoring will be performed in proximity to primary monitoring locations in accordance with MEDEP Biological Monitoring Program protocols[6] twice every five years (i.e., 2010, 2013, 2015, and 2018). MEDEP performed invertebrate monitoring in Long Creek in 2010 and 2015. LCWMD performed invertebrate monitoring in 2013 and is responsible for the event to be performed in 2018.

7.2. Fish

Fish monitoring will be performed at all primary monitoring locations in accordance with MEDEP Biological Monitoring Program Electro-Shock protocols every three to five years.

7.3. *In Situ* Toxicity Testing

In situ toxicity testing evaluates the survivability of aquatic invertebrates. *In situ* testing may be used at monitoring locations in Long Creek that have historically shown elevated levels of chloride, and relatively lower levels of chloride.

LCWMD conducted *in situ* testing in Long Creek in September and October of 2014. Nine macroinvertebrate chambers were deployed, three chambers each at two locations in Long Creek and three chambers at one location in a reference stream. Each chamber was populated with 10 mayflies. It was found that 67% of mayflies survived in the reference stream, with survivorship of 50% and 40% at the Long Creek locations. Although the Long Creek survivorship rates were lower than the reference stream, the study reflects that macroinvertebrates were able to survive in Long Creek, at least for short periods of time.

---

[5] NOAA historic data website: https://www.ncdc.noaa.gov/cdo-web/search; NOAA discrete data website: https://www7.ncdc.noaa.gov/CDO/cdopoemain.cmd?datasetabbv=DS3505&countryabbv=&georegionabbv=&resolution=40.

[6] Davies, Susan, P. and Tsomides, Leonidas (2002), Methods for Biological Sampling and Analysis of Maine's Rivers and Streams, Maine Department of Environmental Protection, Bureau of Land and Water Quality, January 1987, revised August 2002, http://www.maine.gov/dep/water/monitoring/biomonitoring/materials/finlmeth1.pdf.

Future *in situ* toxicity testing events may be conducted in Long Creek at LCWMD's discretion. If testing occurs, one test will be performed during spring-melt conditions (acute exposure) and one test will be performed during base-flow conditions (chronic exposure). If utilized, this program will be implemented in accordance with the protocols and procedures provided in the QAPP, modified as necessary to meet the specific circumstances encountered in Long Creek.

Activities to be performed as part of the *in situ* toxicity testing program include:

- Collection of stream velocity and water depth at all locations to standardize exposure conditions between sites, to the extent possible.
- Collection of micro-habitat data at each location during initial station characterization.
- Daily water quality field parameter collection during the exposure period at each testing location. The water quality field parameter collection will be performed twice a day (once in morning and once in the late afternoon) from a sampling port of each test chamber to determine any potential changes to water quality within the chambers.

7.4. EPA Rapid Bioassessment Program

A physical habitat characterization to evaluate differences in stream and riparian habitat quality between monitoring locations in Long Creek may be performed at LCWMD's discretion in accordance with Chapter 5 of the EPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers*[7], modified as necessary to meet the specific circumstances encountered in Long Creek.

LCWMD conducted a rapid biological assessment in Long Creek in 2014.[8] One-hundred meter reaches at the six primary monitoring locations were evaluated. Selected parameters were evaluated and rated on a numerical scale, of up to 200 points, and then compared to a reference condition representing the "best attainable" condition for a given study. Red Brook in Scarborough, Maine served as the reference stream for this assessment. In this study, the reference site scored a 134 out of a possible 200. The lowest score documented for the Long Creek sites was a score of 53 and the highest was a score of 110.

8. SEDIMENT INVESTIGATION

8.1. Sediment Sampling

Targeted sediment sampling may be conducted in the Long Creek Watershed to address specific questions generated by evaluation of the biological community.

---

[7] Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling (1999). *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition*. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water, Washington, D.C., http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm.

[8] *See* Jeremy Deeds, FB Environmental, memorandum to Kate McDonald,CCSWCD, September 29, 2014, Rapid Biological Assessment Habitat Survey of Long Creek.

Sediment sample collection methodology will be dependent upon site conditions. Sediment quality benchmarks for Long Creek are presented in **Table 5**. Sediment data will be screened against the Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Data will be evaluated in context of the range of conservative sediment quality screening guidelines ranging from threshold effect concentrations (TECs, NECs, *etc.*) to probable effects thresholds (PECs, PELs, *etc*.).

For constituents not included in the consensus-based guidelines, sediment quality benchmarks may be obtained from additional sources, including but not limited to:

- U.S. EPA Assessment and Remediation of Contaminated Sediments Program[9]
- EPA Region 3 Biological Technical Assistance Group (BTAG) freshwater sediment benchmarks[10]
- Environment Canada's Canadian Environmental Quality Guidelines[11]

8.2. Quality Assurance/Quality Control and Data Management

Sediment samples submitted for laboratory analysis will be collected in method-specified containers and with method-specific equipment. Samples will be submitted to the laboratory under proper chain of custody procedures.

Duplicate samples will be collected at a rate of one duplicate per ten samples (1:10). If less than ten samples are collected for a sampling event, one duplicate sample will be collected for the sampling event.

Sediment analytical results will be added to a standalone Microsoft Excel spreadsheet file maintained by LCWMD.

[9]EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL., http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html; http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html.

[10]Region III BTAG Freshwater Screening Benchmarks. 2006, https://www.epa.gov/sites/production/files/2015-09/documents/r3_btag_fw_sediment_benchmarks_8-06.pdf.

[11]Persaud, D.,.R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Onatario Ministry of the Environment. Queen's Printer of Ontario, http://www.itrcweb.org/contseds-bioavailability/References/guide_aquatic_sed93.pdf.

Tables

Table 1
Monitoring Locations
Long Creek Monitoring Plan
Long Creek Watershed Management District

Site Type	Site No.	Monitoring Location	Installation Period (temporary locations only)	DEP Biomonitoring Site Code
Primary	S01	South Branch above Clarks Pond access road	--	Station 753
	S02 (inactive)	Main Stem above confluence with North Branch	--	Station 415
	S17	Main Stem above Foden Road crossing	--	Station 752
	S03	North Branch above confluence with Main Stem	--	Station 414
	S05	Main Stem above Maine Turnpike	--	Station 570
	S06 (inactive)	Main Stem above confluence with Blanchette Brook	--	Station 411
	S06B	Main Stem above confluence with Blanchette Brook	--	Station 1015
	S07	Blanchette Brook above confluence with Main Stem	--	Station 409
Secondary	S04	South Branch below Econolodge Motel	--	Stations 408, 581
	S11	Upper Main Stem above Spring Street crossing	--	--
	S12	Blanchette Brook above Spring Street crossing	--	--
Tertiary	S08	Main Stem above Foden Road crossing	--	--
	S09	North Branch above Foden Road crossing	--	--
	S10	Main Stem below Maine Mall Road/Maine Turnpike	--	Station 410
Temporary	S13 (inactive)	Main Stem above S05, below Portland snow storage	Spring-Fall 2012	--
	S14 (inactive)	Main Stem above S05, above Portland snow storage	Spring-Fall 2012	--
	S15 (inactive)	Blanchette Brook downstream of B-21 BMP	Spring-Fall 2013	--
	S16 (inactive)	Blanchette Brook upstream of B-21 BMP	Spring-Fall 2013	--

Table 2
Surface Water Quality Criteria
Long Creek Monitoring Plan
Long Creek Watershed Management District

Constituent	Units	CMC	Source	CCC	Source
METALS					
Copper	ug/L	3.07	1	2.36	1
Lead	ug/L	10.52	1	0.41	1
Nickel	ug/L	120.2	1	13.4	1
Zinc	ug/L	30.6	1	30.6	1
GENERAL WATER CHEMISTRY					
Chloride	ug/L	860,000	1	230,000	1
Hardness (as CaCO3)	--	--	--	--	--
Phosphorus	ug/L	--	--	30	2
FIELD PARAMETERS					
Dissolved Oxygen	mg/L	--	--	5	2

Notes:
ug/L = Micrograms per liter
mg/L = Milligrams per liter
-- = Not applicable, no criteria published or defined for Long Creek project.

Sources:

[1]Freshwater Criterion Continuous Concentration (CCC) and Criteria Maximum Concentration (CMC), from MEDEP Chapter 584, Surface Water Quality Criteria for Toxic Pollutants, Appendix A, Table I - Criteria for Priority Pollutant Listed Pursuant to 304(a) of the Clean Water Act, and Table 2 - Criteria for Non-priority Pollutants. For the CCC and CMC criteria that are hardness dependent, the value provided in Table I (corresponding to a hardness of 20 mg/L) was used.

[2]Criteria for phosphorous and dissolved oxygen as specified by the Long Creek Watershed Management District.

Table 3
Monitoring Program Summary
Long Creek Monitoring Plan
Long Creek Watershed Management District

	Grab Water Quality Monitoring						Continuous Water Quality Monitoring			Hydrology		Weather Monitoring	Biomonitoring			Habitat Evaluation
	TAL Metals	Hardness	Chloride	Total Phosphorus	PAHs	Water Quality Field Parameters (Sp. Cond., DO, Temperature)	Dissolved Oxygen	Temperature	Specific Conductivity	Stream Gauging	Flow Monitoring and Site Hydrologic Condition Evaluation	NOAA Jetport: Temperature (daily maximum, minimum, and average); Precipitation (hourly and daily total); and Snowfall (daily total)	Invertebrates	In-situ Toxicity Testing	Fish	EPA Rapid Bio-Assessment Program
Primary Monitoring Locations - S01, S03, S05, S06B, S07, S17																
February	--	--	0-1 Melt Round	--		0-1 Melt Round	--	--	--		--					
March	--	--	2 Melt Rounds	--		2 Melt Rounds	--	--	--		--					
April	--	--	1 Melt Round	--		1 Melt Round	--	--	--		--					
May	1 Baseflow Round	1 Baseflow Round 1 Stormflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round					--					
June						--										
July	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	--	1 Baseflow Round	S01, S03, S06B, S07, S17	All Primary Locations	S01, S03, S05, S07, S17	All Primary Locations	Once between June and October annually to refine flow curves and provide stream cross-sections	January - December	Monitoring to be performed in accordance with ME DEP Biological Monitoring Program protocols twice every five years (2010, 2013, 2015, and 2018)	--	Maine DEP Electro-Shock Protocol to be implemented every 3 to 5 years. Start date to be determined by the LCWMD.	--
August	--	--	--	--		--										
September	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round										
October	--	--	--	--		--										
November	--	--	--	--		--					--					
December	--	--	--	--		--					--					
Secondary Monitoring Locations - S04, S11, S12																
February	--	--	--	--		--										
March	--	--	--	--		--										
April	--	--	--	--		--										
May	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round										
June	--	--	--	--		--										
July	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	--	1 Baseflow Round	--	--	--	--	--	January - December	--	--	--	--
August	--	--	--	--		--										
September	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round	1 Baseflow Round		1 Baseflow Round										
October	--	--	--	--		--										
November	--	--	--	--		--										
December	--	--	--	--		--										

Notes:
TAL Metals = copper, lead, nickel, zinc.
Base flow is defined as a sampling event with no precipitation for the preceeding 72 hours (minimum).

Table 4
Analytical Sampling Schedule
Long Creek Monitoring Plan
Long Creek Watershed Management District

Draft

Year	Month	Type	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus	Total Cu,Pb,Ni,Zn	Hardness	Chloride	Total Phosphorus
		Site ID	**S01**				**S17**				**S03**				**S04**				**S05**				**S06B**				**S07**				**S11**				**S12**				**TOTAL SAMPLES/EVENT**			
2015	Feb-Mar	Melt	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	6	6	6	0
2015	Feb-Mar	Melt	2	2	2	0	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	7	7	7	0
2015	Feb-Mar	Melt	2	2	2	0	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	7	7	7	0
2015	Mar-Apr	Melt	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	6	6	6	0
2015	May	Baseflow	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	14	14	10
2015	May	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2015	July	Baseflow	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	14	14	10
2015	July	Storm	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10	10	10	10
2015	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	13	13	13	9
2015	Sept	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2015	15	15	15	9	10	10	10	6	10	10	10	6	6	6	6	6	10	10	10	6	10	10	10	6	10	10	10	6	6	6	6	6	6	6	6	6	95	95	95	57
																																							95	**95**	**95**	**57**
		Site ID	**S01**				**S17**				**S03**				**S04**				**S05**				**S06B**				**S07**				**S11**				**S12**				**TOTAL SAMPLES/EVENT**			
2016	Feb-Mar	Melt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	Feb-Mar	Melt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	Feb-Mar	Melt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	Mar-Apr	Melt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2016	May	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2016	July	Baseflow	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10	10	10	10
2016	July	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1	1	10	10	10	10
2016	Sept	Baseflow	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	10	10	10	10
2016	Sept	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	5	5	5	5
		Subtotal 2016	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	5	6	6	5	5	5	5	5	7	6	6	7	5	5	5	5	5	5	5	5	53	53	53	53
																																							53	**53**	**53**	**53**
		Site ID	**S01**				**S17**				**S03**				**S04**				**S05**				**S06B**				**S07**				**S11**				**S12**				**TOTAL SAMPLES/EVENT**			
2017	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2017	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2017	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2017	Mar-Apr	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2017	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	May	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	July	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	July	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2017	Sept	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2017	6	6	10	6	6	6	10	6	6	6	10	6	6	6	6	6	6	6	10	6	6	6	10	6	6	6	10	6	6	6	6	6	6	6	6	6	54	54	78	54
																																							54	**54**	**78**	**54**
		Site ID	**S01**				**S17**				**S03**				**S04**				**S05**				**S06B**				**S07**				**S11**				**S12**				**TOTAL SAMPLES/EVENT**			
2018	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2018	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2018	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2018	Mar-Apr	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2018	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2018	May	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2018	July	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2018	July	Storm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2018	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2015	5	5	9	5	5	5	9	5	5	5	9	5	5	5	5	5	5	5	9	5	5	5	9	5	5	5	9	5	5	5	5	5	5	5	5	5	45	45	69	45
																																							45	**45**	**69**	**45**
		Site ID	**S01**				**S17**				**S03**				**S04**				**S05**				**S06B**				**S07**				**S11**				**S12**				**TOTAL SAMPLES/EVENT**			
2019	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2019	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2019	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2019	Mar-Apr	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2019	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2019	July	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2019	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2016	3	3	7	3	3	3	7	3	3	3	7	3	3	3	3	3	3	3	7	3	3	3	7	3	3	3	7	3	3	3	3	3	3	3	3	3	27	27	51	27
																																							27	**27**	**51**	**27**
		Site ID	**S01**				**S17**				**S03**				**S04**				**S05**				**S06B**				**S07**				**S11**				**S12**				**TOTAL SAMPLES/EVENT**			
2020	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2020	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2020	Feb-Mar	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2020	Mar-Apr	Melt	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0
2020	May	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2020	July	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
2020	Sept	Baseflow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	9	9	9
		Subtotal 2017	3	3	7	3	3	3	7	3	3	3	7	3	3	3	3	3	3	3	7	3	3	3	7	3	3	3	7	3	3	3	3	3	3	3	3	3	27	27	51	27
																																							27	**27**	**51**	**27**

Primary Monitoring Locations
Secondary Monitoring Locations
* 2016 reflects actual samples collected

Table 5
Sediment Quality Benchmarks
Long Creek Monitoring Plan
Long Creek Watershed Management District

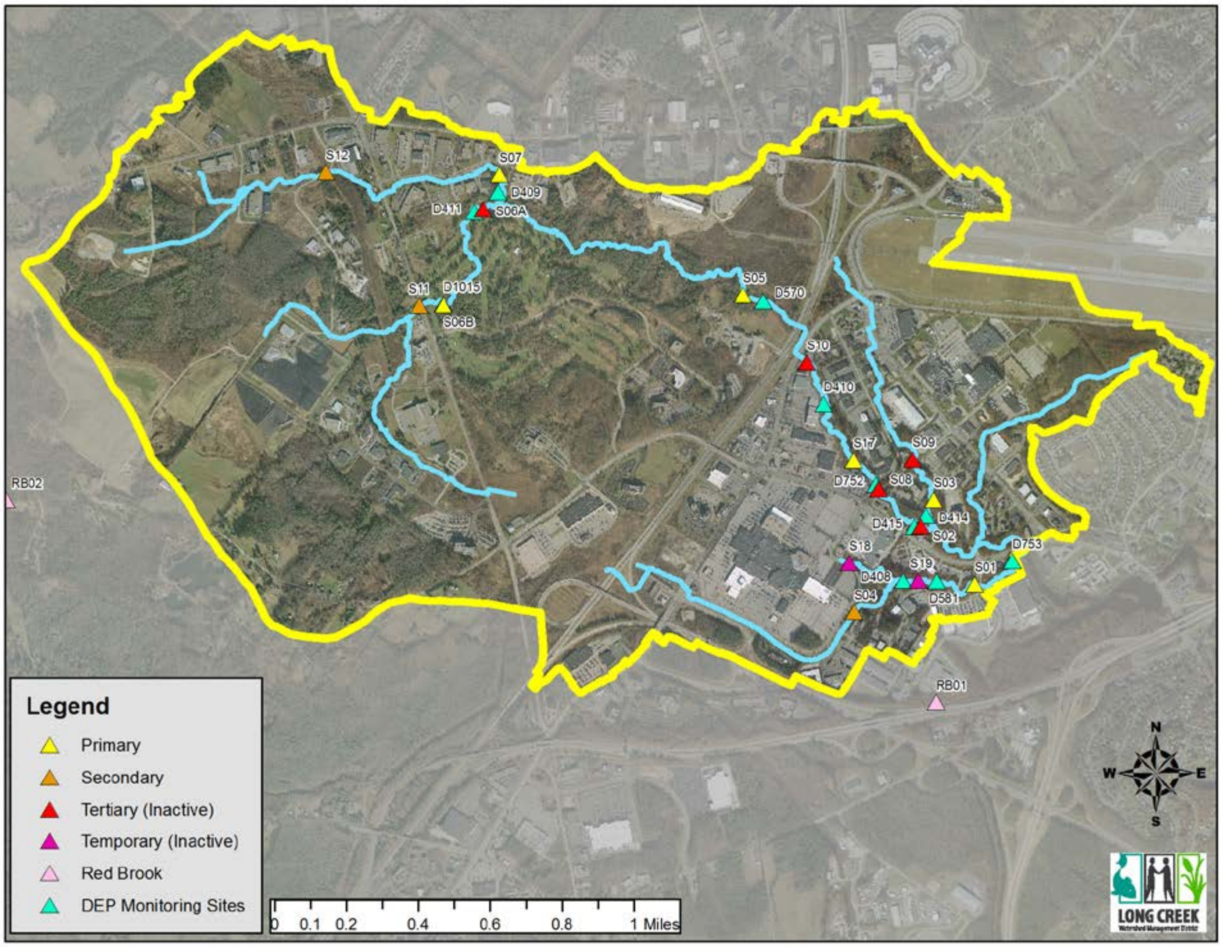
Analyte	Screening Value	Literature Based Potential Effects Threshold	Units	Source
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)				
Acenapthene	6.7	88.9	ug/kg	Canadian PEL[3]
Acenapthylene	5.9	128	ug/kg	Canadian PEL[3]
Anthracene	57.2	845	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Fluoranthene	423	2230	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Fluorene	77.4	536	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Napththalene	176	561	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Phenanthrene	204	1170	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Benzo(a)anthracene	108	1050	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Benzo(g,h,i)perlyene	170	6300	ug/kg	ARCS PEC[1]
Benzo(k)fluoranthene	240	*	ug/kg	EPA Region III BTAG[4]
Benzo(a)pyrene	150	1450	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Chrysene	166	1290	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Diebenzo(a,h)anthracene	33	135	ug/kg	Canadian PEL[3]
Indeno(1,2,3-cd)pyrene	17	837	ug/kg	ARCS PEC[1]
Pyrene	195	1520	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Total PAHs	1610	22800	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
METALS				
Arsenic	9.79	33	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Cadmium	0.99	4.98	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Chromoium	43.4	111	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Copper	31.6	149	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Lead	35.8	128	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Nickel	22.7	48.6	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
Zinc	121	459	mg/kg	Consensus-Based Sediment Effect Guidelines[2]
PESTICIDES				
Heptachlor Epoxide	2.47	2.47	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Chlordane	3.24	17.6	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
BHC, alpha	6	*	ug/kg	EPA Region III BTAG[4]
BHC, beta	5	*	ug/kg	EPA Region III BTAG[4]
BHC, delta	6400	*	ug/kg	EPA Region III BTAG[4]
Dieldrin	1.9	61.8	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Sum DDD	4.88	28	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Sum DDE	3.16	31.3	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Sum DDT	4.16	62.9	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Total DDTs	5.28	572	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Endrin	2.22	207	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Heptachlor	68	*	ug/kg	EPA Region III BTAG[4]
Lindane (gamma-BHC)	2.37	4.99	ug/kg	Consensus-Based Sediment Effect Guidelines[2]
Aldrin	2	*	ug/kg	EPA Region III BTAG[4]
Toxaphene	0.1	*	ug/kg	EPA Region III BTAG[4]

Notes:
Screening Values = Concentration below which adverese effects are not expected to occur.
Potential Effects Threshold = Concentration above which adverese effects are expected to occur.
* = Potential Effects Thresholds not available
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

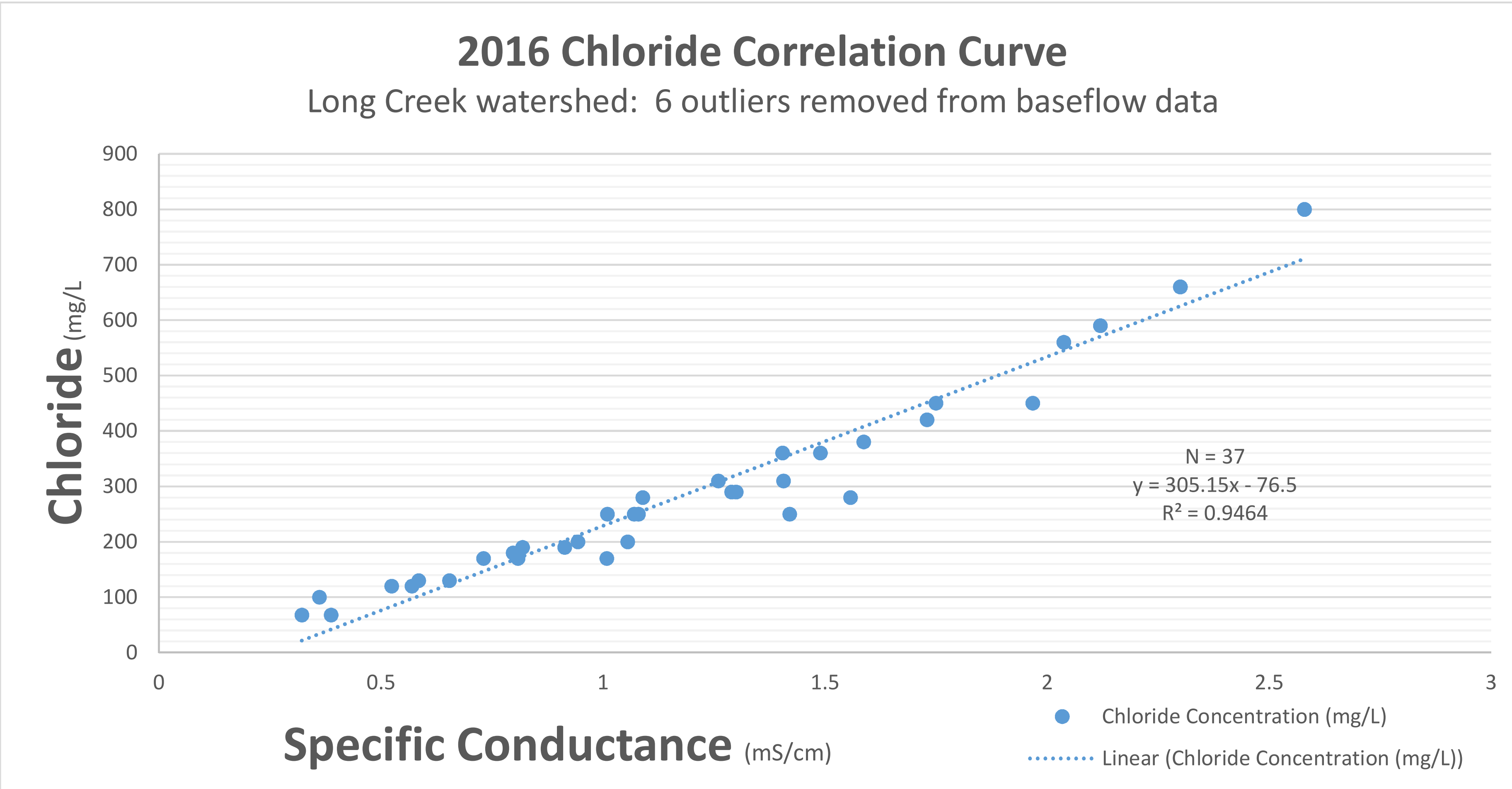
Sources:
1 - EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL., http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html) (http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html.
2 - MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater Contam. Toxicol. 39: 20-31. ecosystems. Arch. Environ.
3 - Persaud, D.,.R. Jaagumagi and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Onatario Ministry of the Environment. Queen's Printer of Ontario, http://www.itrcweb.org/contseds-bioavailability/References/guide_aquatic_sed93.pdf.
4 - Region III BTAG Freshwater Screening Benchmarks. 2006, https://www.epa.gov/sites/production/files/2015 09/documents/r3_btag_fw_sediment_benchmarks_8-06.pdf.

Figures

Figure 1: Sample Location Plan



Appendix A


2016 Chloride Correlation Curve
Long Creek watershed: 6 outliers removed from baseflow data
Chloride (mg/L
900
800
700
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
3
Specific Conductance (mS/cm)
N = 37
y = 305.15x - 76.5
R² = 0.9464
Chloride Concentration (mg/L)
Linear (Chloride Concentration (mg/L))