Quality Assurance Project Plan

Drayton Harbor/Semiahmoo Bay Water Quality Enhancement G 1400435

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2.0 Abstract

Drayton Harbor was a productive commercial, tribal and recreational shellfish growing area, however, fecal bacteria pollution disrupted safe harvest back to the 1950s. In 1988, portions were closed to harvest; the entire harbor was closed by 1999. While DOH upgraded 575 acres to *Conditionally Approved*, seasonal closure, remains from November through January.

Ecology's 2008 TMDL study of Drayton Harbor watershed indicated that Cain Creek, an urban drainage in Blaine, requires up to 95% fecal bacteria reduction to meet water quality standards for shellfish harvest and recreation. Past studies have identified human fecal biomarkers in Cain Creek.

The aim of the Drayton Harbor/Semiahmoo Bay Water Quality Enhancement project is improved water quality in Cain Creek and Drayton Harbor to restore shellfish harvest and recreation. Components include monitoring, identifying corrective actions, system improvements, raising and sustaining local awareness and building capacity to continue water quality improvement.

Monitoring will identify pollution sources, document effectiveness of initial corrective actions in reducing fecal coliform loads and support efforts to plan restoration of the Cain Creek corridor. Central to the project is video inspection of sewer and storm piping within 100 feet of Cain Creek. Sampling, conducted over two years, is designed to support the camera work and is comprised of three elements: 1) ambient monitoring (year one will collect baseline data and year two will monitor effectiveness of corrective actions), 2) storm monitoring and 3) "hot spot" monitoring associated with results of system video.

Monitoring will:

- Identify fecal bacteria sources that impact Drayton Harbor and Semiahmoo Bay.
- Monitor corrective action effectiveness.
- Provide results that inform planning of early actions, BMP,s and programmatic implementation.

By meeting the goals and objectives described herein, Blaine Public Works will collect information needed to improve water quality discharged from Blaine's surface waters, meeting TMDL goals.

3.0 Background

3.1 Study area and surroundings

Cain Creek is an urban basin that drains a large portion of the city of Blaine, Washington to Semiahmoo Bay which is contiguous with Drayton Harbor and Boundary Bay. The headwaters begin in a minimally developed wetland area just south of the Blaine Airport and drain into the main channel which parallels the I-5 freeway through town. The creek discharges to Semiahmoo Bay due west of the intersection of Peace Portal and Marine Drive, approximately ⅓ of a mile south of the international border with Canada. The creek has been heavily impacted by the development of Blaine and the construction of the I-5 freeway and serves as receiving waters to a number of storm drainages (City of Blaine, 1995, Mathieu and Sargeant, 2008).

The climate of the watershed is characterized by mild maritime weather, influenced by prevailing southwest winds from the Pacific Ocean and Puget Sound. Occasionally, the prevailing wind shifts to a northeasterly wind which brings brisk cold weather in the winter and hot dry weather in the summer. These cold episodes can drop temperatures to below 0˚ F with a wind-chill of 50 below zero (City of Blaine, 1995, Mathieu and Sargeant, 2008). The watershed is heavily influenced by precipitation, receiving approximately 40 inches a year. On average greater than 75% of the precipitation falls during the months of October to April. The Cain Creek basin covers approximately 1.1 square miles with a relief of 277 feet elevation and 3.09 % mean slope, (USGS, Streamstats, 2014). Mean precipitation is 41 inches annually, Cain Creek is about 3 miles in length.

The geology of the area was primarily influenced by the repeated advance and retreat of glacial ice sheets from Canada. When the Vashon Drift retreated the lowlands of the Drayton Harbor watershed were covered by the sea. Both the glacial ice and the sea deposited sediments. Since then stream erosion and deposition have shaped the landscape (City of Blaine, 1995, Hood and Mathieu, 2010). Soils mapping developed by the NRCS identifies three general landscape units, characterized by glacial tills and outwash in the higher elevations in the northeastern portion of the drainage basin, glaciomarine terraces in the middle elevations generally north of I5, and glacial outwash terraces the lower elevations along the current stream alignment (Goldin, 1992).

3.1.1 Logistical problems

Sampling sites were selected to segment the Cain Creek drainage into its sub-basins that represent specific locations and land covers. Sampling locations were also selected to capture areas with significant overlap between the storm and sewer systems. Several sites are overgrown since previous sampling efforts and in need of brushing to provide access. Some of the sites are on angled terrain and will require care while sampling. Two sites are relatively close to railroad tracks but within city right-of-way. At least one site is located on private property however permission has been granted to access the site. Sampling sites are primarily focused along the mainstem of Cain Creek both in open channel sections and at culvert crossings. Sample sites will also include catchbasins to capture specific inputs from the built drainage system. The varied sample locations will require several techniques of flow measurement. The site at the mouth of the creek is tidally influenced. During the dry season some of the sites may have inadequate flow to sample.

3.1.2 History of study area

Drayton Harbor

Historically, Drayton Harbor has been a productive commercial, tribal and recreational shellfish growing area. However, pollution from fecal coliform bacteria has disrupted a safe shellfish harvest back to the 1950s. In 1988, the Washington State Department of Health (DOH) began closing the shellfish growing areas in Drayton Harbor due to deteriorating water quality that resulted in closure of the entire harbor by 1999. In 2004, DOH upgraded the status of 575 acres in the central harbor from *Prohibited* to *Conditionally Approved* resulting in part from Blaine's repair of a segmented sewage collection forced main transmission line that crossed the mouth of Drayton Harbor. The Puget Sound Restoration Fund's Drayton Harbor Community Oyster Farm gained permission from DOH to plant and harvest Pacific oysters for commercial sale.
Blaine is served by a municipal sewage collection system and state of the art tertiary wastewater treatment plant. The Lighthouse Point Waste Reclamation Facility (LPWRF) was put online in 2012 at Marine Park and the old plant on Semiahmoo Spit was decommissioned. Transmission of raw sewage under the mouth of Drayton Harbor from Blaine was discontinued. Currently a sealed, double walled conveyance carries raw sewage to LPWRF from Semiahmoo for treatment and tertiary treated water is piped to the existing outfall at Semiahmoo Spit with undetected fecal coliform bacteria levels (Bullock, 2014).

Most recently, in November 2013, the *Conditionally Approved* seasonal closure, based upon rainfall, was adjusted to closure from November through January due to low fecal coliform bacteria numbers during the previous five Februaries (DOH, 2013). Shellfish growing area closures and water quality violations in Drayton Harbor and its tributaries continue to impact it's beneficial uses.

From December 2007 to December 2008 the Washington Department of Ecology (Ecology) conducted a Total Daily Maximum Load (TMDL) study to determine load allocations as the fecal coliform concentrations, and percent reductions, necessary to meet water quality standards throughout the Drayton Harbor watershed. Based upon the TMDL, Cain Creek requires up to 95% fecal coliform bacteria reduction (Hood and Mathieu, 2010).

Cain Creek

Cain Creek is an urban basin that drains a large portion of the city of Blaine, Washington to Semiahmoo Bay which is contiguous with Drayton Harbor and Boundary Bay. The Cain Creek basin covers approximately 1.1 square miles with a relief of 277 feet elevation and 3.09 % mean slope, (USGS, Streamstats, 2014). Mean precipitation is 41 inches annually, and the Cain Creek channel is about 3 miles in length.

The headwaters of Cain Creek begin in a wetland just south of the Blaine Airport, and has a low divide to the next drainage east and south. The subtle topography at the edges of the basin can allow for interbasin transfers of water along built ditches and pipes, which complicates accurate basin delineation. The majority of the Cain Creek corridor flows in a confined valley typically between Interstate 5 and surrounding developed areas. The Cain Creek corridor is bounded by I-5 to the East and runs through a residential neighborhood, through the commercial district and through a culvert system as it approaches the outfall to Semiahmoo Bay. The Burlington Northern railroad track is adjacent to the outfall. Interstate - 5, the Canadian border crossing and Peach Arch Park contribute storm drainage to Cain Creek. The lowest reach (approximately 4,000 feet) of the creek is contained with a culvert.

The creek discharges to an estuary of Semiahmoo Bay on the eastern fringe of Marine Park, due west of the intersection of Peace Portal and Marine Drive, approximately ⅓ of a mile south of the international border with Canada. Historically Cain Creek discharged to an estuary that is now occupied by Blaine Harbor marina however in the 1800's it was rerouted to Semiahmoo Bay. The creek has been heavily impacted by the development of Blaine and the construction of the I-5 freeway and it serves as receiving waters to a number of storm drainages (City of Blaine, 1995). The 1888 T-Sheet shows several stream channels in what is now the Cain Creek drainage, suggesting that many of the tributary channels have been captured within the pipe system.

Several sections of the creek flow underground and the outfall to Semiahmoo Bay is a culvert, only allowing fish access at extreme high tides (Eissinger, 2002). There is evidence that Cain Creek has supported a salmon run in the past and there is remaining signage near the creek. Anecdotes provided by the City of Blain Public Works employees suggest that fish can access the lower culvert, and the City Parks Plan indicates that residents have reported fish in the creek at Garfield Street (RM0.07).

The creek corridor includes, at a minimum, category two wetlands. Figure 1 shows the Cain Creek basin boundaries (USGS 2014, NOAA 2001), Table A-1 shows land cover statistics developed from the 2001 NOAA Coastal Change Dataset for Washington (NOAA 2001).

3.1.3 Contaminants of concern

Semiahmoo Bay and its tributaries (Cain Creek) carry Washington State's most stringent water quality designations to support safe shellfish harvest and primary contact recreation. From December 2007 to December 2008 the Washington Department of Ecology (Ecology) conducted a Total Daily Maximum Load (TMDL) study to determine load allocations as the fecal coliform concentrations, and percent reductions, necessary to meet water quality standards throughout the Drayton Harbor watershed. Based upon the TMDL,Cain Creek requires up to 95% fecal coliform bacteria reduction (Hood and Mathieu, 2010). Potential sources of human fecal coliform bacteria include breaches of the sewage collection system, failing septic systems and non-point sources such as homeless encampments and diaper disposal. Potential sources of animal fecal coliform bacteria are waste from pets, livestock, hobby farms, rodents and wildlife.

3.1.4 Results of previous studies

The mouth of Cain Creek has violated water quality standards consistently since at least 1995 as it discharges to Semiahmoo Bay (Eissinger, 2002). Cain Creek water quality influences Semiahmoo Bay and under certain tidal conditions, affects the mouth of Drayton Harbor (H.C.S and Doremus, 2010). Human biomarkers have been identified at Cain Creek sites repeatedly during two studies, indicating human fecal input (HCS, 2013, HCS and Doremus, 2010). During

the summer of 2009, microbial source tracking samples collected on two ebb tide events from Cain Creek, the Cain Creek outfall and from Semiahmoo Bay, identified human biomarkers in both freshwater and marine sites indicating that human fecal contamination from Cain Creek may impact Semiahmoo Bay, (HCS and Doremus, 2010). Impaired water quality affects tribal, commercial and recreational shellfish harvest in Drayton Harbor and in Semiahmoo and Boundary Bay and it presents a public health issue for primary and secondary contact.
The following paragraphs summarize data collected at Cain Creek since 2008.

2010 - Washington State Department of Ecology TMDL Study

Trend analysis conducted by Ecology prior to the TMDL study indicated that water quality standards were violated at the mouth of Cain Creek. During the TMDL study Ecology sampled four stations from the headwaters to the mouth of Cain Creek. They found that all of the sites with the exception of the location at the headwaters exceeded both the geometric mean and 90th percentile standards. This site met the geometric mean standard but exceeded the 90th percentile standard (Hood and Mathieu, 2010). The Cain Creek TMDL sample sites are shown in Figure 1. Three of four stations sampled by Ecology during the TMDL evaluation require from 58% to 95% fecal coliform bacteria reductions during both wet and dry seasons (Ecology, 2010). The site at the headwaters required no reduction during the wet season. Ecology observed large significant increases in fecal coliform (FC) geometric means on Cain Creek from mile 1.3 to 0.4 with 90% of the FC load from this stretch of creek occurring during the dry season. The TMDL study identified a human biomarker by PCR analysis at the Cain Creek storm drain near the out fall to Semiahmoo Bay.

TMDL Conclusion & Recommendations:

Cain Creek greatly exceeds FC water quality standards and, under certain conditions, contributes a relatively large FC load to Semiahmoo Bay. A large amount of bacteria pollution is entering the creek between CM 1.3 at Pipeline Rd (1-Cain-1.3) and CM 0.4 behind the Blaine Trade Center (1-Cain-0.4). Recent PCR MST sampling discovered multiple human biomarkers in Cain Creek indicating that human sewage is potentially entering the creek in this stretch, (Hood and Mathieu, 2010).

- FC source identification monitoring should start in the following drainages (in order of priority):
    - Cain Creek between CM 1.3 at Pipeline Rd and CM 0.4 behind the Blaine trade center. Very large FC loads originated in this relatively short stretch of creek.
    - Wet season sources in the North and South Forks of Dakota Creek. Over 50% of the FC load to Dakota Creek at Giles Rd came from the upper watershed.
    - Wet season sources upstream of California Creek at Bruce Rd (1-Cal-6.2).
    - Unmeasured wet season sources within the tidally influenced segments of Dakota and California Creek.
    - Tributary drainages for Dakota and California Creek.
    - Direct tributary drainages to Drayton Harbor.

Nooksack Indian Tribe Study - June-December 2009

To augment the Washington Department of Ecology's Drayton Harbor Total Maximum Daily Load study, the Nooksack Indian Tribe funded the collection of additional data from the waters around the mouth of Drayton Harbor including Cain Creek, between June and December 2009. This study included MST sampling by HSPCR donated by the EPA Region 10 Laboratory. Six sites on Cain Creek were sampled during this study including TMDL sites (Figure A-2) Sites CC 1.3 and 1.3A near the head waters of the sub-basin were the only freshwater locations that met applicable water quality standards in this study. Similarly to the TMDL results, marked deterioration in water quality occurred between CC1.3 near the headwaters, and the downstream site CC0.4 where the geometric mean for fecal coliform concentrations was more than 15 times the applicable standard of 50 cfu/100mL. Human DNA biomarkers were identified repeatedly at five of the six Cain Creek sample sites (HCS and Doremus, 2010). .

Puget Sound Restoration Fund Study January - May 2012

This project built upon work done by Ecology and NIT to identify sources of fecal bacteria contamination in the Cain Creek drainage. Through grant funding by the Whatcom Community Foundation and partnerships with the City of Blaine and EPA Region 10 Laboratory, the Puget Sound Restoration Fund and Hirsch Consulting Services conducted monitoring in 2012 to assist Blaine PW in prioritizing locations for corrective action. Sample stations in the mid portion of Cain Creek and at points near sewage collection lines were selected in consultation with Blaine Public Works staff to provide information that may indicate sewage collection leaks or other sources of fecal contamination. Sewer and stormwater conveyances in the vicinity of sample sites are shown in Appendix E. Sample sites were selected as long-term reference points for subsequent monitoring by Blaine Public Works and to direct corrective action. While fecal coliform densities were not as high as those observed in previous studies, human biomarkers were once again found. Three sites were sampled with human biomarkers identified at all three sites, (HCS, 2013).

Northwest Indian College - 1998 -2013

The Northwest Indian College began sampling the Cain Creek outfall and storm drain in 1998. Their results suggested that concentrations of fecal coliforms consistently violated state water quality standards. Data collected in 2013 by the NWIC show FC levels at Cain Creek outfall and storm drain consistent with data collected during the TMDL study (Whatcom County Natural Resources, 2014).

Drayton Harbor Community Shoreline Water Quality Sampling Program, Whatcom County, Puget Sound Restoration Fund, 2002

This project funded by Whatcom County involved citizen volunteers in sampling priority freshwater drainages into Drayton Harbor from the eastern shoreline (Menzies, 2002). The study conducted from July through December 2001 repeated sampling from sites that had been monitored for a dry season in 1995 (Cycler and Haggerty 1995). Several of the sites are located within Blaine city limit and discharge directly into Drayton Harbor (Figure 5.) Tributaries of Drayton Harbor must meet a freshwater water quality standard for a water use designation of *excellent*, with geometric means not to exceed fecal coliform content of 100 CFU/100 ml; and less than 10% may exceed 200 FC/100 ml. Geometric means for sites within Blaine City limits ranged from 162 -1327 FC/100 ml at Site #3, Peace Portal Dr. & 4th Street. The highest daily loading was observed at this location, (2.63E+07 – 2.38E+10 FC/day). The second highest daily loading within Blaine City limits was observed at Site #5, a concrete pipe at Peace Portal Dr. across from Liz's Restaurant.

3.1.5 Regulatory criteria or standards

Fecal coliform bacteria are indicators of the presence of enteric waterborne pathogens such as *Norovirus*, *Cryptosporidiumspp.*, *Giardia lamblia*, *Campylobacter jejuni*, *Salmonella enterica and E. coli O157:H7* (Soller et. al, 2010). Semiahmoo Bay and its tributaries (Cain Creek) carry Washington State's most stringent water quality designations to support safe shellfish harvest and primary contact recreation.

The Washington State fecal coliform bacteria standard for Cain Creek is 50 CFU/mL Table 2). The Cain Creek corridor encompasses category 2 wetlands and it is identified for recreational uses and wildlife habitat in Blaine's Comprehensive Parks and Recreation Plan (2004) and Wildlife Protection Plan (2002).

Washington State Water Quality Standards for fecal coliform bacteria designation for Semiahmoo Bay and its tributaries.

MARINE WATER QUALITY STANDARD

water use designation: shellfish harvest[1]

The geometric mean shall not exceed fecal coliform content of 14 CFU/100 ml; and less than 10% exceed 43 CFU/100 ml.

FRESH WATER QUALITY STANDARD

water use designation: extraordinary primary contact recreation

The geometric mean shall not exceed fecal coliform content of 50 CFU/100 ml; and less than 10% exceed 100 FCU/100 ml

[1]National shellfish sanitation program (NSSP, 1997) administered by Washington Department of Health uses the estimate 90% and requires at least 30 data points for shellfish growing area classification.

The Federal Clean Water Act requires that a Total Maximum Daily Load (TMDL) is developed for impaired water bodies and calculates the amount of a pollutant that a waterbody can receive and still safely meet water quality standards. In 2008, the Washington State Department of Ecology conducted the bacteria TMDL of the Drayton Harbor watershed (including Cain Creek) to improve water quality in support of safe primary contact recreation and shellfish harvest that calls for reductions in coliform bacteria in Cain Creek of up to 95%.

FC bacteria come from human and animal waste. Usually FC bacteria enter surface waters from treated sewage, failing septic systems, direct animal access (both wildlife and domestic animals) to streams, or deposition on the land that is washed into the streams by runoff from precipitation; however fecal coliform bacteria can also be found in stormwater and industrial effluent. Potential sources impacting Cain Creek include breaches of Blaine's sewage collection system, illicit discharges, non-point contributions from stormwater including pets, livestock, wildlife and even humans. Monitoring data collected by this project will be compared for compliance with applicable fresh water quality standards and against load reduction targets set in the TMDL.

4.0 Project Description

Cain Creek has violated water quality standards consistently back to 1995 as it discharges to Semiahmoo Bay (Eissinger, 2002). Discharge from Cain Creek influences water quality in Semiahmoo Bay and under certain tidal conditions, affects the mouth of Drayton Harbor (H.C.S and Doremus, 2010). Human biomarkers have been identified at Cain Creek sites repeatedly during two studies, indicating human fecal input (HCS 2013, HCS and Doremus, 2010). During the summer of 2009, microbial source tracking samples collected on two ebb tide events from Cain Creek, the Cain Creek outfall and from Semiahmoo Bay, identified human biomarkers in both freshwater and marine sites indicating that human fecal contamination from Cain Creek may impact Semiahmoo Bay, (HCS and Doremus, 2010). Impaired water quality affects tribal, commercial and recreational shellfish harvest in Drayton Harbor and in Semiahmoo and Boundary bays and it can pose a public health issue for primary and secondary contact.

From December 2007 to December 2008 the Washington Department of Ecology (Ecology) conducted a Total Daily Maximum Load (TMDL) study of the Drayton Harbor watershed. The draft Water Quality Improvement Report addresses impairments to shellfish harvest, primary and secondary contact recreation. Ecology’s recommendations give the Cain Creek basin top priority for bacteria source identification and elimination. Based upon TMDL findings, Cain Creek will require up to 95% fecal coliform bacteria reduction.

This project will enhance water quality in Cain Creek and Drayton Harbor watersheds to achieve restoration of shellfish and recreational uses in Drayton Harbor and Semiahmoo Bay; this includes monitoring, identifying corrective actions, system improvements, raising and sustaining local awareness and building capacity to continue pollution prevention and improvement efforts. Sources of fecal contamination from sewage and stormwater, will be identified, and evaluated. Actions to eliminate these sources will be planned and implemented, reducing bacteria loads at Cain Creek and discharges to Drayton Harbor that are within Blaine city limits. Restoration of the Cain Creek corridor will enhance awareness by providing access and education that promotes sustained community involvement and water quality stewardship. Efforts will be coordinated with concurrent TMDL and community activities that improve water quality, public health, shellfish harvest and recreation opportunities. Water quality monitoring is a central component of this project where the data produced will be used to guide and plan remaining project components.

4.1 Project goals

The Drayton Harbor/Semiahmoo Bay Water Quality Enhancement Project has the following overarching goals::

- Refine our understanding of spatial patterns of sources of fecal coliform contamination to Cain Creek and its neighboring drainages within Blaine city limits that flow into Drayton Harbor and Semiahmoo Bay.
- Provide a baseline of data to allow for effectiveness monitoring post-implementation.
- Develop an Action Plan and a prioritized list of corrective actions.
- Monitor the effectiveness of initial corrective actions.

4.2 Project objectives

The project has the following specific objectives:

- Characterize seasonal trends in bacteria concentrations along the length of Cain Creek and at direct discharges to Drayton Harbor (within Blaine City limits.
- Characterize bacteria loading to Cain Creek and direct discharges to Drayton Harbor within City Limits during storm events.
- Characterize the condition of the existing storm and sewer system, focusing on breaks, cross-connects, or other conditions that would contribute untreated sewage directly to the storm drain system.
- For sampling locations that do not meet state water quality standards, identify the probable sources and pathways of the contamination.

4.3 Information needed and sources

This project relies upon mapped data such as soils, topography, land cover, Blaine's sewer and storm line locations, and past sampling efforts. Mapped data will be used to develop a watershed characterization to understand water flow and water quality processes in the contributing basin to support interpretation of monitoring results. For this study, primary spatial data sets include:

1. Topography based on 2006 USGS Lidar coverage
2. Basin and subbasin delineation developed by ESA.
3. Land use and land cover based on NOAA CCAP data. Zoning provided by the City of Blaine.
4. Wetland and Stream Mapping from Blaine and WA DNR.
5. City of Blaine sewer and storm drainage mapping.

4.4 Target population

The primary population that will be sampled is fecal coliform bacteria under wet season and dry season (base flow) conditions. Temperature, dissolved oxygen and ph measurements will assess the stream for potential restoration.

4.5 Study boundaries

The Cain Creek drainage is within WRIA 1, the Drayton Harbor Shellfish Protection District and within Blaine City limits. The basin boundaries are shown in Figure A-2. Basin boundaries are preliminary, and based on regional topography and storm drainage mapping. The relatively flat gradients and long history of anthropogenic drainage adjustments combine to make accurate basin delineations challenging. There are several areas, particularly on the southern and eastern extents of the basin where the pipe network alters the topographic drainage basin. On the southern end, the pipe network reduces Cain Creek's historical basin, and to the east, drainage along major roads may expand the historical drainage basin.

The study area includes two major highways, Interstate 5 and SR543. The influence of both on bacteria concentrations is anticipated to be limited. However, they both likely have a significant hydrologic contribution to stream flow, particularly during storm events.

4.6 Tasks required

From consultant's scope of work with City of Blaine.

Task 2: Monitoring and Analysis - Ambient and Storm Event Monitoring

Assumption - Monitoring is a central component of this project where data produced will be used to guide and plan remaining project components. Therefore monitoring, planning and inspection components will be integrated to ensure adaptive management based upon monitoring data as the project progresses. The consultant(s) will conduct activities to ensure thorough planning, communications and training occur prior to sample collection and throughout the project.

1. The consultant will prepare a monitoring plan and a quality assurance project plan (QAPP) for Ecology approval by October 1, 2014.
2. Ambient receiving water quality samples of Cain Creek and direct discharges to Drayton Harbor (within Blaine City limits), will be collected monthly at no less than 10 locations for two years. Monitoring will coincide with sampling that was conducted for the Drayton Harbor Total Daily Maximum Load (TMDL) evaluation. Sampling will include wet season (November through March) and dry season (April through October) for the following water quality parameters: fecal coliform bacteria (membrane filtration), stream discharge (wadeable streams by current meter) temperature, dissolved oxygen, pH, and conductivity. Sampling will begin in November 2014 and be completed by October 31, 2016. Site selection will be based upon review of past data a windshield/ground survey and sewer and storm piping maps provided by the Blaine Public Works Department.

3. Storm event sampling will be conducted at approximately 10 storm-water outfalls to Cain Creek for 6-8 storm events including wet and dry season over the 2 year sampling period at specified rainfall thresholds.
4. Deficient results will be correlated with sample site locations to identify probable sources of contamination.
5. An interim baseline report monitoring report will be completed by January 31, 2016.
6. A final monitoring report will be completed by February 2017.
7. Data for all sampling events will be entered into Ecology's EIM system.
8. Monthly activity summaries will be submitted.

Task 3 - Sewer and pipeline inspection hot spot monitoring.

Assumption - Blaine Public Works staff will inspect piping within 100 ft of Cain Creek and review the video tape to identify probable defects. Concurrent hotspot samples will be collected by the consultant when potential sources of fecal contamination are identified. The consultant will coordinate sampling with Blaine PW and assist in analyzing results to correlate with deficiencies found in (sewer and storm) pipeline inspection.

1. The consultant(s) will conduct activities that ensure thorough planning, coordination, communications and training prior to sample collection and throughout that includes project meetings, training of sampling personnel and sample event scheduling with Blaine PW staff. Consultant will assist Blaine Public Works in planning sewer and pipeline inspections consistent with ambient and storm sampling locations.
2. Conduct sampling events according to pipeline survey schedule and analysis of inspection results provided by Blaine PW. When a defect can be implemented under the scope of the project, then post correction sampling will be conducted to evaluate effectiveness of the corrective action. Ambient samples collected prior to corrective action will be used to compare with post corrective action samples to evaluate the effectiveness of corrective action(s) in reducing fecal bacteria loads.
3. Analyze results and correlate with pipeline inspections.
   Work with Blaine PW to complete a storm and sewer line findings report Is this the same as the storm and sewer line survey findings report and complete an evaluation matrix with recommendations for corrective actions, BMPs and pollutant reduction by January, 2016.

Task 4- Implementation Planning and Program Development

Assumption#1- The planning element will be integrated throughout project tasks to ensure the City of Blaine's long term goals are served by all aspects of the project.
Assumption #2 - The consultant will assist Blaine Public Works in developing an action plan to correct identified deficiencies, strategies to implement and sustain solutions to contamination sources that impact water quality as identified in the water quality monitoring, analysis and

inspection. Blaine Public Works will utilize information provided by the consultant to develop their O& M maintenance program.
The consultant will assist in developing an evaluation matrix that prioritizes action items and approaches to Cain Creek restoration consistent with Blaine's long term planning process for the Cain Creek riparian corridor. Program Goals and Guidelines including initial evaluation matrix criteria, will be completed by January 2016.

1. An Implementation Action Plan and evaluation matrix will be completed by December, 2016, based upon results of monitoring, inspections, GIS mapping of land use and City of Blaine plans.

Task 5 - Corrective Action

1. The consultant will assist Blaine Public Works in planning and implementing corrective actions identified through the priority planning process as needed, including pet waste stations and interpretive signage.

Task 6- Local Awareness and Education Program

Assumption- The local awareness and education program will build on and be coordinated with the Garden of the Salish Sea Curriculum program in Blaine schools and coordinate with existing outreach and education efforts in Blaine such as the Drayton Harbor Shellfish Protection Advisory Council the Whatcom Marine Resources Committee (MRC) and others.

1. The consultant will develop an outreach and education plan and messaging that includes a Garden of the Salish Sea Challenge program for residents of the Cain Creek drainage (coordinated with the Puget Sound Restoration Fund's concurrent Garden of the Salish Sea Curriculum in Blaine schools) and interpretive sign development. Achieve at least 100 Challenge commitments. A local education and outreach plan will be completed by November, 2014.
2. The consultant will assist Blaine Public Works to format and locate interpretive signage and Mutt Mitt stations.
3. The consultant will make contacts through mailings, public service announcements, web page development on Blaine Public Works website, social networking and at least 1 neighborhood meeting.
4. The consultant will partner with the MRC to hold a community open-house that showcases local BMPs and TMDL implementation, education and planning efforts and serves Drayton Harbor oysters.

The consultant will evaluate success of the Challenge program and prepare an evaluation report by November, 2016.

4.7 Practical constraints

Sampling sites are selected along the mainstem of Cain Creek to sequentially capture specific subbasins and also capture areas where there is significant overlap between the sewer and storm systems.. Site access is a consideration and several sites are overgrown since previous sampling efforts and in need of brushing to provide access. Some of the sites are on angled terrain and will require care while sampling. Two sites are relatively close to railroad tracks but on city right-of-way. At least one site is located on private property however permission has been granted to access the site. Sampling sites are of a variety, from open channels to culverts or catch basins and require several techniques of flow measurement. The site at the mouth of the creek can be influenced by high tide. During the dry season some of the sites may have inadequate flow to sample.

4.7.1 Safety

The field checklist (Appendix D) includes safety items that must be carried when sampling. Safety is the foremost priority. Access to sampling sites can be on uneven and steep terrain or near transportation corridors in all weather conditions. Sampling during storm events will require access to the creek potentially during deep and fast flowing conditions, and safety of the sampling creeks will be considered. Safety procedures will be included in sampling training sessions and must be observed in the field.

4.8 Systematic planning process

Preparation of this Quality Assurance Project Plan field surveys of sample sites and field training constitute the planning process for the data collection component of the project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

The water quality monitoring team includes Blaine Public works Department and its contractors. Data collected will be used by the Blaine Public Works Department and the Blaine Community Development Services Department to assist in directing development of an action plan and strategies to implement and sustain solutions to contamination sources which impact water quality identified in the project analysis. Data users include members of the larger project team who will utilize the water quality data to plan corrective actions and riparian corridor restoration. Community partners and decision makers will utilize data to support watershed-wide outreach and planning.

Department Director:	Blaine Public Works Department Director, Ravyn Whitewolf
Project managers:	Blaine Public Works Department Assistant Director, Bill Bullock Hirsch Consulting Services (HCS), Julie Hirsch
Quality Assurance:	HCS, Julie Hirsch HCS, Eleanor Hines
GIS/Analysis:	ESA, Steve Winter
Field/EIM Lead:	Nooksack Salmon Enhancement Association (NSEA), Annitra Ferderer
Field Technicians	NSEA Interns
EIM Data Entry:	NSEA Interns
Laboratory:	Blaine Public Works, Lighthouse Point Water Reclamation Facility, Chrissie Ness and Frank Arnett
Laboratory:	EPA Region 10, Stephanie Bailey
Stormwater Location:	Blaine Public Works, Leroy Dougal
Stormwater Location:	Washington Department of Transportation, Stan Hanson Maintenance Lead Tech
GIS,	Blaine Public Works, Jane Juerling

Decision Makers: City of Blaine Department Directors and City Council

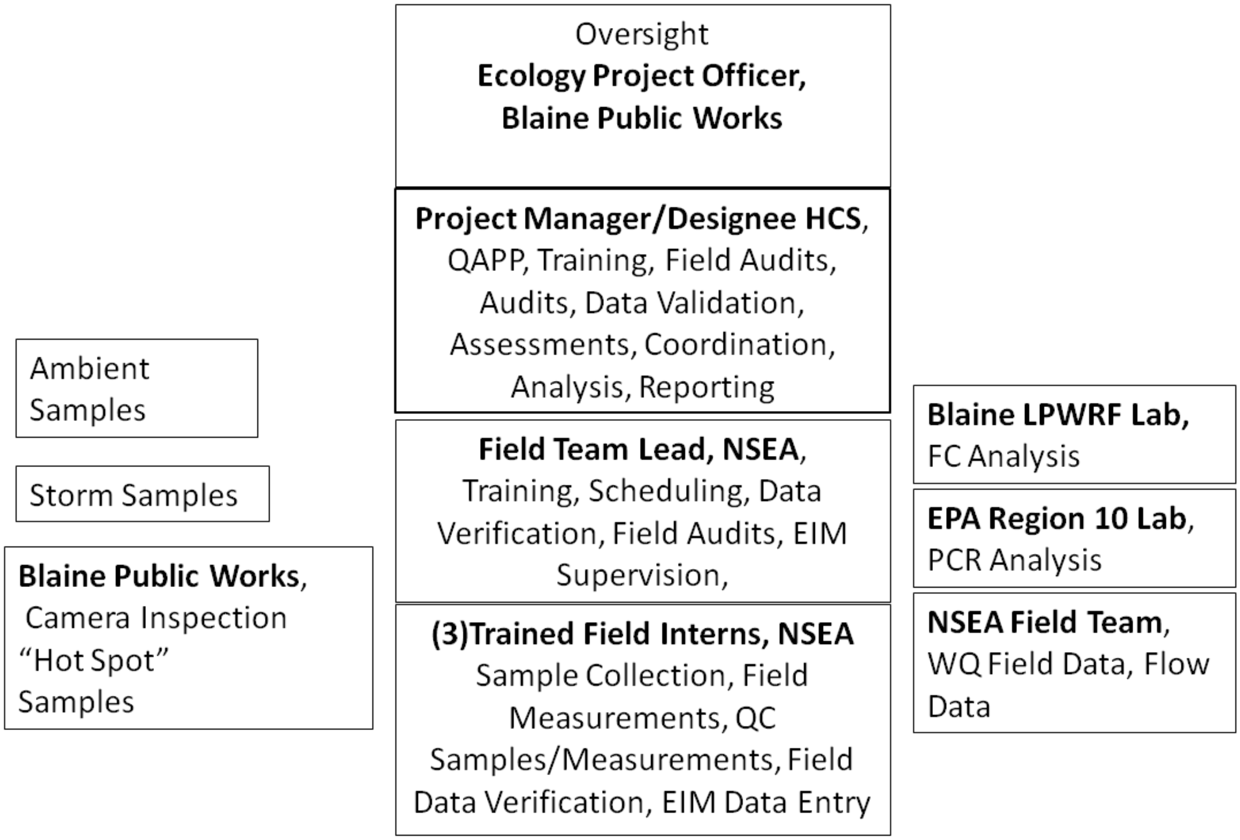
Community Partners:

- Drayton Harbor Shellfish Protection District Advisory Committee (DHSPDAC), Erika Douglas, Whatcom County
- Whatcom County Marine Resources Committee, Austin Rose, Whatcom County
- Whatcom County Health Department
- Drayton Harbor Oyster Company
- Puget Sound Restoration Fund
- Garden of the Salish Sea Curriculum

5.2 Special training and certifications

All key personnel have years (some have decades) of experience collecting this type of data in Whatcom County and the Puget Sound region. Field technicians are trained individually by the Field Team Lead and they must attend a field training session specific to this project. Both laboratories are certified.

5.3 Organization chart



5.4 Project schedule

Drayton Harbor/Semiahmoo Bay Water Quality Enhancement Project Schedule

Task	Subtask	Lead	Frequency and Duration
2	2.1Monitoring Plan /QAPP	HCS	October 1, 2014
	2.2 Training	HCS	October 2014
	2.3 Wet Season ambient sampling, EIM data entry	NSEA	November 2014-March 2015 & November 2015-March 2016
	2.4 Wet Season Storm sampling, EIM data entry	NSEA	November 2014-March 2015 & November 2015-March 2016
	2.5 Dry season ambient sampling, EIM data entry	NSEA	April - October 2015 and 2016
	2.6 Dry season storm sampling, EIM data entry	NSEA	April - October 2015 and 2016
	2.7 Interim Report	HCS	January 2016
	2.8 Final Report	HCS	February 2017
	2.9 Status Summaries	HCS	August 2014- December 2016
3	3.1 Inspection plan	Blaine/ESA	September -October 2014
	3.1 Field camera survey w/in 100 ft of Cain Creek	Blaine	November 2014 to November 2015
	3.2 Hot Spot Sampling	NSEA	November 2014 to November 2015
	3.3 Analyze Results	HCS/ESA	October and November 2015
	3.4 Storm & sewer line findings report	HCS/ESA	January 2016
4	4.1 Develop Preliminary goals & guidelines	ESA/HCS	January 2015
	4.2 Develop preliminary evaluation criteria	ESA, HCS	February 2016
	4.3 Prepare initial evaluation matrix	ESA/HCS	January 2016
	4.4 Prepare final evaluation matrix	ESA/HCS	December 2016
	4.5 Planning and Implementing BMPs	HCS/ESA /Blaine	March 2015; March 2016
5	Blaine Corrective action	HCS/ESA	April 2015 - December 2016

5.5 Limitations on schedule

Limitations on the project schedule originate from the laboratory and from site specific constraints. Blaine's LPWRF lab schedules analysis of project samples on Mondays, Wednesdays and Fridays. Because the laboratory closes at 3:30 PM, samples must be dropped off at about 2:00 PM. Two sample sites at the mouth of Cain Creek should be sampled when the sites are not inundated by tidal waters, and whenever possible during an ebb tide MLLW ≤ 4.00 ft. to minimize tidal influence on freshwater samples. Two samples sites are too overgrown to sample until they are brushed out, which is scheduled prior to the first sampling event in November.

5.6 Budget and funding

Funding for his project is provided through the Centennial Clean Water Program and in-kind donations of laboratory analysis provided by Blaine Public Works.

Approximate costs for services are provided below:

Sampling (Contract)	Analytic Laboratory (Blaine In-kind donation)	Data Management (Contract)	EIM (Contract)	QA/QC & Reporting (Contract)
$35,000	$45,000	$15,000	$10,000	$22,000

The grant purchased approximately $10,000 in laboratory equipment for Blaine Public Works to complete analysis. The monitoring component total cost is $137,000

6.0 Quality Objectives

6.1 Decision Quality Objectives (DQOs)

Data Quality Objectives are qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. Data generated by this project will be used by Blaine Public Works and its consultants in developing an evaluation matrix that develops and prioritizes action items and approaches to Cain Creek restoration consistent with Blaine's long term planning process for the Cain Creek riparian corridor. Through water quality monitoring, analysis and video camera inspection an Action Plan will be developed to correct identified deficiencies and plan long term straegies to implement and sustain solutions to fecal bacteria contamination sources that impact water quality. The MQOs stated in this QAPP will qualify the data generated by water quality monitoring for use in the priority planning process. Effectiveness monitoring will require a minimum of 5 samples per season (both pre and post corrective action) or downstream of the corrected potential source to determine whether FC concentrations are significantly changed. Significant change will be determined using a paired T-test of the logarithm of fecal coliform bacteria densities (alpha <0.05). The values for both pre and post datasets must fit a lognormal distribution, in order to meet the assumptions of the parametric statistical T-test.

6.2 Measurement Quality Objectives

Measurement quality objectives state the level of acceptable error in the measurement process. Field and laboratory errors can be minimized by adhering to strict protocols for sampling and analysis. The standards used for deriving the project measurement quality objectives (MQOs) for this study are intended to generate data of a comparable quality to allow comparison with previously collected data in the Drayton Harbor watershed. Data collected for this project should be comparable to Ecology’s TMDL evaluation data (Hood and Mathieu, 2010). Methods and quality control procedures developed in Whatcom County's Unified Fecal Coliform Monitoring QAPP are adopted by reference, (Whatcom County, 2012). Measurement quality objectives for field and laboratory analysis are presented in Table A-8.

6.2.1 Targets for Precision, Bias, and Sensitivity

6.2.1.1 Precision

Precision is a measure of variability in the results of replicate measurements due to random errors which are inherently associated with field sampling and laboratory analysis. Precision for replicates will be expressed as percent relative standard deviation (%RSD). Accuracy is the resolution at which the method can detect the desired constituent. The DQOs listed in the EPA QAPP for Drayton Harbor microbial source tracking (EPA, 2006) are adopted by reference for the MST portion of the project. Data quality objectives are method quality objectives, reporting limits and resolution presented in Table A-8.

6.2.1.2 Bias

Bias is the difference between the population mean and the true value. Bias (or accuracy for laboratory and field methods are presented in Table 8.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. Sensitivity for this study is expressed in Table 8 as the quantitation limit which is also the method detection limit.

6.2.2 Targets for Comparability, Representativeness, and Completeness

6.2.2.1 Comparability

To facilitate comparable data collected for this project with Ecology collected data, the procedures for data collection used by Ecology are incorporated into this document (Hood and Matheiu , 2010). Procedures documented herein are reviewed and approved by Ecology for further assurance that they will provide data comparable to those collected during the Drayton Harbor Watershed Fecal Coliform TMDL study.

6.2.2.2 Representativeness

The experimental design of this project is based upon a random sampling strategy over a two year period. The site location, schedule and frequency of samples should provide representation of a full variety of spatial, temporal, and hydrologic differences encountered in the Cain Creek drainage and selected discharges to Drayton Harbor within Blaine City limits. The experimental design is intended to capture wet and dry season conditions, ranging from baseflow and storm events. Samples will be collected at mid-stream locations or where there is adequate flow and mixing. A minimum of five samples per wet season and five samples per dry season, distributed throughout the sampling period will be required to adequately compare fecal coliform results with state water quality standards. Table A-9 describes the number of samples and seasonality of sample and measurement collection.

6.2.2.3 Completeness

Goals for completeness, or samples collected and analyzed correctly are adopted from Ecology's Drayton Harbor Watershed Fecal Coliform TMDL QAPP (Hood and Mathieu, 2010). A lower limit of five samples per season per site will be required for comparison to state criteria, which should easily be met with the current sampling design. The target for overall completeness is 95% .

WAC 173-201A states:

"*When averaging bacteria sample data for comparison to the geometric mean criteria, it is preferable to average by season and include five or more data collection events within each period….and [the period of averaging] should have sample collection dates well distributed throughout the reporting period*."

7.0 Sampling Process Design (Experimental Design)

7.1 Study Design

This monitoring effort is structured to provide Blaine Public Works with data needed to identify fecal coliform bacteria discharges and non-point sources to Cain Creek and to outfalls that enter Drayton Harbor within Blaine city limits. The Cain Creek basin and sub-basin boundaries are shown in Figure A-2. Monitoring conducted in tandem with video inspection of sewer and storm piping will provide data to characterize baseline conditions and track effectiveness of corrective actions. Site selection is based upon review of past data, a windshield/ground survey and sewer and storm piping maps provided by the Blaine Public Works Department (Appendix E). Cain Creek sample stations will combine the sites sampled in 2008 by the TMDL and in 2012, segmenting the mid portion of Cain Creek that was called out in the TMDL and points near sewage collection lines. Past sampling sites are shown in Figures A-3 and A-5. Fresh water is the media for all samples collected by this effort. Figure A-8 shows study sampling sites and sub-basin boundaries**.**

Water quality data collection will consist of three components: ambient monitoring, storm monitoring and coordinated "hot spot" sampling at video inspection locations. Information collected by this monitoring effort will be used to guide implementation of corrective actions, BMPs, and restoration of the Cain Creek riparian corridor. Sampling sites are tiered (1-3) and will be phased in over the first year. Data will assist in directing development of an action plan and strategies to implement and sustain solutions to contamination sources which impact water quality identified in the project analysis. Table A-9 shows sample sites, frequency and number of samples to be collected for ambient and storm sampling. Figures 3 and 5 include the sampling sites.

Ambient Sampling

Ambient receiving water quality samples of Cain Creek and direct discharges to Drayton Harbor (within Blaine City limits), will be collected monthly at approximately10 locations for two years. Sampling sites will coincide with sampling that was conducted for the Drayton Harbor Total Daily Maximum Load (TMDL) evaluation. Tier 1 sites, (Cain Creek) sites will be the most frequently sampled; Tier 2 sites (direct discharges to Drayton Harbor) will be added into the ambient sampling network during the first wet season.

The first year of data collection will characterize current baseline conditions. Assuming initial corrective actions are taken as a result of video camera inspection, the second year of monitoring will document post corrective action conditions. Sampling will include wet season (November through March) and dry season events (April through October). Samples will be collected for fecal coliform analysis at Blaine Public Work's LPWRF laboratory at each site during each monitoring event. Samples will be collected for microbial source tracking (MST) by host specific polymerase chain reaction (PCR) analysis at the EPA Region 10 laboratory at selected sites during the second year of monitoring. Sites and timing of MST sampling will be determined based upon FC loading results for the first year of sampling and results of video inspection and corrective action. MST sampling will be conducted to verify whether human fecal markers have been eliminated.

The following water quality parameters will be measured in situ using a YSI 556 water quality sensor: temperature, dissolved oxygen, pH, and conductivity. Fecal coliform loading will be assessed by instantaneous instream flow measurement collected using a Swoffer 2100 current meter and laboratory analysis of fecal coliform bacteria by membrane filtration at the LPWRF Laboratory. Sample locations are be recorded during field reconnaissance using a Trimble Geoexplorer 6000 XH with submeter accuracy after differential correction

Sampling will begin in November 2014 and be completed by October 31, 2016. Site selection is based upon review of past data, a windshield/ground survey and sewer and storm piping maps provided by the Blaine Public Works Department (Appendix E). Cain Creek sample sites for ambient and storm sampling are shown in Figure 8.

Storm Sampling

Storm event sampling will be conducted at approximately 10 Cain Creek sampling sites and direct discharges to Drayton Harbor for 6-8 storm events including wet and dry season over the 2 year sampling period at specified rainfall thresholds. Wet season and dry season storm events will be monitored at least 1 storm per season (2 per year) with rainfall at least 0.5 inches or greater during the preceding 24 hours. The rainfall threshold for the remaining events will be 0.25 inches or greater within the preceding 24 hours. Storm sampling will include the same field measurements as ambient sampling listed above.

Storm events at desired rainfall thresh holds can be difficult to capture given variability in storm frequency and laboratory timing constraints. Rainfall targets are set to capture small and large rainfall events with the recognition of potential constraints on capturing storm data at specified rainfall threshholds.

"Hot Spot" Sampling

Sewer and storm piping survey site specific monitoring will be coordinated with Blaine Public Works' robotic camera survey when a potential breach is identified. Sampling will be conducted at the site of the breach and at the site of repairs to monitor repair effectiveness in reducing fecal coliform bacteria loads. Samples will be analyzed for fecal coliform bacteria concentration. This sampling will occur at locations to be specified by Blaine PW and collected during the subsequent ambient sampling run. These single samples will be compared the 90th percentile standard to determine compliance which is 100FC/100 mL for Cain Creek. Loading will be documented at the downstream ambient sampling site.

7.1.1 Field measurements

The following water quality parameters will be measured in situ using a YSI 556 water quality sensor: temperature, dissolved oxygen, pH, and conductivity and salinity. Fecal coliform loading will be assessed by instantaneous instream flow measurement collected using a Swoffer 2100 current meter. Salinity will be recorded at the two sites at the mouth of Cain Creek that can be influenced by tide.

7.1.2 Sampling location and frequency

Table A-9 shows sample sites, frequency and number of samples to be collected for ambient and storm sampling.

7.1.3 Parameters to be determined-GPS

Sample site locations will be mapped using a Trimble GeoExplorer 6000 XT with submeter accuracy after differential correction.

7.2 Maps or diagram

Please see Attachment A for the figure set. The Cain Creek basin is shown in Figure A-2. Sampling sites are shown in A-8. A sketch of the basin, creek, and sampling points is included below:

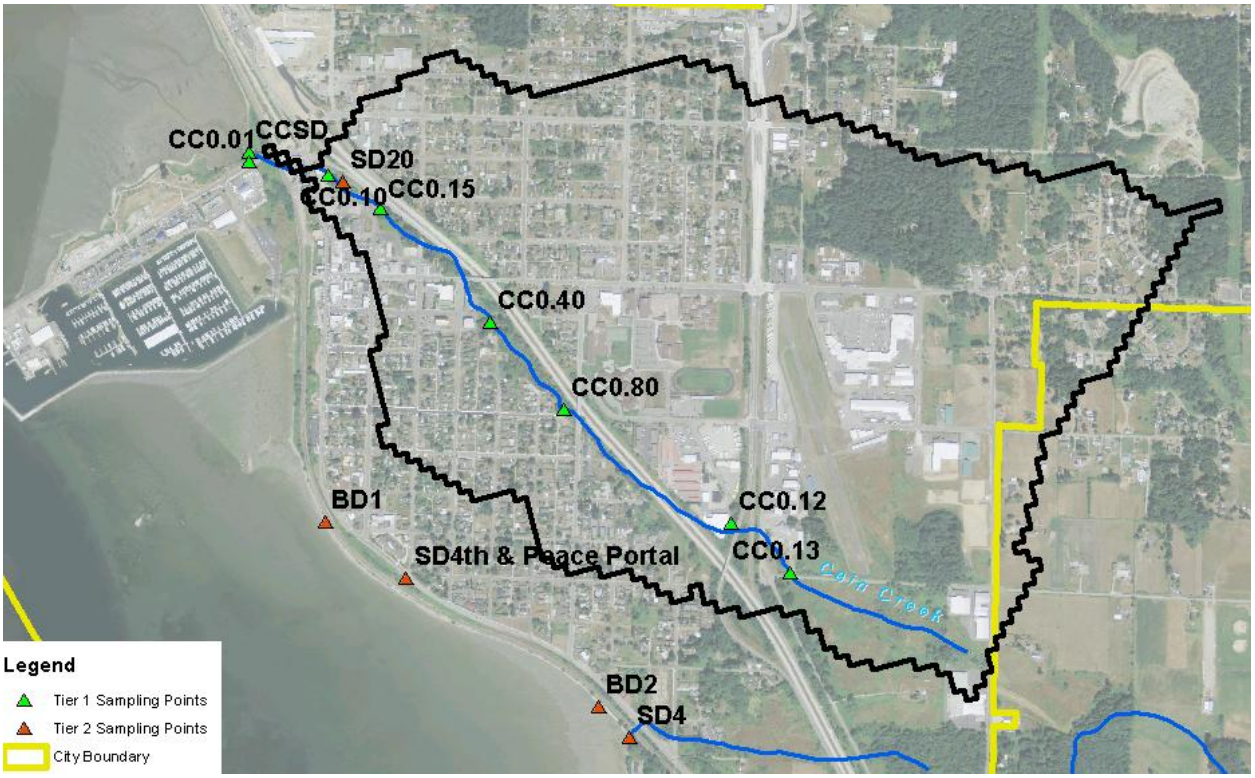


Figure 1. Cain Creek Basin and Sampling Locations

7.3 Assumptions underlying design

The first year of data collection will characterize current baseline conditions. We have assumed that the primary sources of bacterial contamination include point sources relating to aging sewer pipes, and non-point sources including residential, commercial, and industrial land uses.

Assuming corrective action is taken as a result of video camera inspection to address point sources, the second year of monitoring will document post corrective action conditions. Samples will be collected for microbial source tracking analysis (MST) by host specific polymerase chain reaction (PCR) analysis at the EPA Region 10 laboratory at selected sites during the second year of monitoring. Sites and timing of MST sampling will be determined based upon fecal coliform bacteria results for the first year of sampling and results of video inspection and corrective action. MST sampling will be conducted to verify whether human fecal markers detected in past studies have been eliminated.

For non-point sources, we assume that the monitoring results can be used to identify spatial patterns in how bacteria are introduced to the creek system. These results will then be used to develop Corrective Actions to span a range of possible solutions. Differences in bacteria concentrations between samples will be compared to the contributing drainage area to determine if loadings are consistent on a per unit area basis, or if there are portions of the contributing basin that are more significant contributors.

7.4 Relation to objectives and site characteristics

The Study Design has been developed to both: (1) relate new data to past sampling efforts, and (2) allow for interpretation of the results to identify Corrective Actions.

The study design includes the following sampling efforts:

- Collect ambient receiving water quality samples of Cain Creek and direct discharges to Drayton Harbor (within Blaine City limits), that supports sewer and storm system inspections by Blaine Public Works. The ambient sampling will characterize general seasonal trends in bacteria concentrations.
- Collect storm event samples of Cain Creek and direct discharges to Drayton Harbor (within Blaine City limits), that supports sewer and storm system video inspections by Blaine Public Works. Wet season and dry season storm events will be monitored at least 1 storm per season (2 per year) with rainfall at least 0.5 inches or greater during the preceding 24 hours. The rainfall threshold for the remaining events will be 0.25 inches or greater within the preceding 24 hours. Storm sampling will include the same field measurements as ambient sampling listed above. This sampling will help characterize storm flows to better characterize total loading during times of significant discharge to Drayton Harbor.
- Collect "hot spot" samples coordinated with Blaine Public Works sewer and storm system video inspections to support source identification. These samples are intended to determine if an observed pipe defect can be related to an increase in bacteria loading in the storm or creek system.

7.5 Characteristics of existing data

Results of previous studies presented in Section 3.14, originate from Ecology's TMDL evaluation and from studies associated with the TMDL evaluation that were vetted through the TMDL author in the case of the Nooksack Tribe's study. Data presented from other sources originate from agencies such as Whatcom County or sampling efforts associated with local government that follow their own QAPP that are commonly used to assess water quality in Whatcom County. The quantity and quality of existing data are more than adequate as a basis for this current effort. This conclusion taken from the DRAFT Drayton Harbor Water Quality Improvement Report describes a data gap that is being addressed by this study.

> "Cain Creek greatly exceeds FC water quality standards and, under certain conditions, contributes a relatively large FC load to Semiahmoo Bay. A large amount of bacteria pollution is entering the creek between CM 1.3 at Pipeline Rd (1-Cain-1.3) and CM 0.4 behind the Blaine Trade Center (1-Cain-0.4). Recent PCR MST sampling discovered multiple human biomarkers in Cain Creek indicating that human sewage is potentially entering the creek in this stretch.

FC source identification monitoring should start in the following drainages (in order of priority):

- Cain Creek between CM 1.3 at Pipeline Rd and CM 0.4 behind the Blaine trade center. Very large FC loads originated in this relatively short stretch of creek.
- Direct tributary drainages to Drayton Harbor."

(Hood and Mathieu, 2010).

This study will further segment Cain Creek through the reach described and assist in identifying fecal pollution sources in conjunction with video of sewer and storm lines. This study will assist in identifying potential breeches to sewer or storm lines and to track water quality improvements resulting from corrective actions.

8.0 Sampling Procedures

Sampling methods and sample handling requirements are presented in Table A-10.

8.1 Field measurement and field sampling SOPs

8.1.1 Fecal Coliform Bacteria

Samples collected during the study will use the following procedures. Grab samples will be collected using either a sampling wand or hand dipping in midstream and just below the surface. Samples will be collected only from flowing water that is deep enough to collect without entraining sediment, approximately six inches.

Fecal coliform samples will be collected prior to taking discharge measurements so that the sediment matrix is not disturbed. All sample containers will be provided by Lighthouse Point Water Reclamation Laboratory. FC samples will be collected in 125mL sterile plastic bottles, which will immediately be placed on ice in a cooler. Field replicates will be sampled side-by-side with the routine sample at the selected field duplicate site. The field duplicate will receive treatment identical to the routine sample and labeled FD. Samples will be delivered to the laboratory within 6 hours of sampling.

Samples will be collected according to the Whatcom County Fecal Coliform Monitoring Group Fecal Coliform Grab Sample SOP in Appendix C, (WC, 2013) and detailed in Standard methods 9060A and 9060B (APHA, 2006). Samples for analysis at the EPA Region 10 Laboratory will be collected in 250 mL bottles provided by the laboratory. Each bottle will be labeled with a site number prior to sampling and site numbers will be recorded into field notebooks prior to sampling. Site numbers, date, time sampled, and the name of the sampler will be transcribed onto the chain-of-custody log prior to submitting samples to the LPWTF laboratory. The LPWTF technician will sign the chain-of-custody log upon receipt of the samples and provide a copy of the signed log to the sample team for documentation.

Samples for analysis at the EPA Region 10 Laboratory will be labeled with sample identification number, project code and account code, pre-assigned by the EPA Regional Sample Control Coordinator (RSCC) and be accompanied by a chain-of-custody form issued by the laboratory.

NSEA's field lead and field team will be responsible for collection, chain of custody and delivery or shipment to the laboratory.

8.1.2 Water Quality Parameter Measurements

Field measurements will be taken using a calibrated YSI 556 Multi Probe System. Fresh water parameters that will be measured are: temperature, dissolved oxygen (DO), pH and conductivity. Procedures that will be used for calibration, maintenance and operation of the YSI 556 are described in the instrument operations manual which is attached in Appendix C. Replicate water quality measurements will be collected at the same time and place immediately following the routine measurements at the selected field duplicate site. All field data will be recorded on write-write-in- the-rain bound field notebooks. The YSI 556 Manual will be used as the SOP.

8.1.3 Stream Discharge Measurements

Instantaneous stream flows will be measured in wadeable streams using the USGS procedure for measurement of instantaneous discharge by conventional current meter method (Rantz et.al, 1982) using a Swoffer Model 2100 Series Current Velocity Meter. Ecology's standard operating procedure will be used for estimating discharge, EAP056 - Measuring and Calculating Stream Discharge. Procedures that will be used for calibration, maintenance and operation of the Swoffer current meter are described in the operations manual, (Appendix C). Cross-sectional area of stream units (cells) are multiplied by measured flow velocity to obtain discharge volume estimates. Measurement of discharge issuing through pipes or culverts may be conducted using timed flow volumes accumulation into a calibrated container (catchment) or culvert dimensions and velocity measurements, consistent with Ecology's SOP. Replicate discharge measurements will be collected at the same time and place immediately following the routine measurements at the selected field duplicate site. All field data will be recorded on write-in- the-rain field data sheets or in write-in- the-rain field notebooks.

For certain elements of the storm drainage system, approximate methods will be used to estimate discharge. These methods will be used in locations where it is not practicable to directly measure velocity, typically do to the depth and/or geometry of the catch basins. In these instances (primarily for the storm system sampling and the hot spot sampling) where an estimate of discharge is necessary, a local hydraulic model of the pipe network will be created in SWMM or similar model. This model will be built using surveyed inverts and measured pipe diameter and type. This information can then be used to develop a rating curve of water depth vs discharge. Field measurements would involve measuring down to the water surface from a consistent point on the catch basin rim. Sampling sites will be selected to capture catch basins where backwater is not anticipated to occur in most flows, which would negate the assumptions behind the rating curve.

8.2 Containers, preservation methods, holding times

Sample handling requirements are presented in Table A-10. All sample containers for fecal coliform bacteria will be provided by Lighthouse Point Water Reclamation Laboratory. FC samples will be collected in 125mL sterile plastic bottles, which will immediately be placed on ice in a cooler. Bottles will be prepared according to the laboratory's SOP (Appendix C). Sample bottles (250 mL) for PCR analysis at the EPA Region 10 Laboratory will be provided by the EPA laboratory and prepared according to their manual (Appendix C).

8.3 Invasive species evaluation

This freshwater study does not entail travel by water and should not result in invasive species transport. Ecology's Minimizing the Spread of Invasive Species Protocol will be followed.) Observation of invasive species (noxious weeds) will be documented during sampling events to plan for riparian corridor restoration. The Drayton Harbor watershed and Cain Creek drainage are not areas of extreme concern for New Zealand mud snails according to Ecology's Minimizing the Spread of Invasive Species Protocol.

8.4 Equipment decontamination

This study does not involve sampling toxic substances and should not result in chemical contamination. Field personnel will clean their hands with an antibacterial sanitizer prior to leaving the sampling area to prevent contamination from contact with fecal bacteria contaminated water. All gear will be inspected and cleaned prior to leaving the study area. If felt soled boots are worn they will be decontaminated according to Ecology's Minimizing the Spread of Invasive Species Protocol when moving between different basins.

8.5 Sample ID

Each sample site has been assigned a location identification code shown in table A-9. This identification code will be used for all samples and measurements and chain of custody documentation originating from a given site. When the EPA Region 10 Laboratory has pre-assigned sample numbers, the location identifier will be added to the bottle and to the chain of custody documentation.

8.6 Chain-of-custody

Chain of custody procedures will be maintained for all samples collected during this study. Sample bottles will be labeled with a site number prior to sampling and site numbers will be recorded on write-in- the-rain field data sheets prior to sampling. Site numbers, date, time sampled, and the name of the sampler will be transcribed onto the chain-of-custody log prior to submitting samples to the LPWTF laboratory. The LPWTF technician will sign the chain-of-custody log upon receipt of the samples and provide a copy of the signed log to the sample team for documentation.

Samples for analysis at the EPA Region 10 Laboratory will be labeled with sample identification number, project code and account code, pre-assigned by the EPA Regional Sample Control Coordinator (RSCC) and be accompanied by a chain-of-custody form issued by the laboratory. Samples will be shipped for overnight delivery within 30 hours of sample collection.

NSEA's field lead and field team will be responsible for collection, chain of custody documentation and delivery or overnight shipment to each laboratory. These sample documentation procedures are standard and widely accepted.

8.7 Field log requirements

A bound, waterproof field notebooks with pre-numbered pages will be used to record sample information and site observations as required by Ecology and to provide site characterization as follows:

- Name and location of project
- Field personnel
- Type of sample, ambient, storm or "hot spot"
- Sequence of events
- Any changes or deviations from the QAPP
- Environmental conditions and changes at site
- Changes in stream channel
- Noxious weeds observations
- Date, time, location, ID, and description of each sample
- Field instrument calibration procedures
- Field measurement results
- Identity of QC samples collected
- Unusual circumstances that might affect interpretation of results

8.8 Other activities

- All field staff will attend an orientation and training session prior to first sampling event.
- Periodic maintenance for field instrumentation as per manuals and SOPs.
- Scheduling and coordinating of sampling events with lab personnel.
- Field audits by QA personnel will be conducted periodically to ensure correct procedures are used.

9.0 Measurement Methods

9.1 Field procedures table/field analysis table

Table A-8. Method quality objectives for field and laboratory analyses includes the methods for field measurements and laboratory analysis.

9.2 Lab Procedures Table. This includes:

Table A-8. Method quality objectives for field and laboratory analyses includes the methods for field measurements and laboratory analysis.

9.2.1 Analyte

Table A-8. Method quality objectives for field and laboratory analyses includes the analytes for field measurements and laboratory analysis.

9.2.2 Matrix

Freshwater is the matrix for all project samples.

9.2.3 Number of samples

Table A-9 includes sample site locations, frequency and number of that will be collected during ambient and storm sampling events. Field measurements for all samples will include temperature, dissolved oxygen (DO), pH and conductivity and discharge. "Hot spot" sampling will include collection of fecal bacteria samples only and the number of samples will be dependent on results of video camera inspections. When a deficiency is detected in camera footage, a corresponding "hot spot" sample will be scheduled in the subsequent sample run. A total of samples not to exceed 40, will be collected for microbial source tracking analysis by HSPCR at the EPA Region 10 Laboratory during the second year. Locations of HSPCR samples will be determined based upon ambient and "hot spot" fecal coliform bacteria results during year one.

9.2.4 Expected range of results

The expected range of results is derived from data presented in Table A-2, 2008 Cain Creek TMDL Data: FC geometric mean and 90th percentile statistics, including wet and dry season. Geometric means are expected to range from 25 CFU/100 mL at the upper watershed site, CC1.3 to 327 CFU/100 mL at the creek mouth. Expected 90th percentile concentrations are 191 CFU/100 mL at the upper watershed site, (CC1.3) to 2,500 CFU/100 mL at the creek mouth, CC0.01.

9.2.5 Analytical methods

Table A-8 includes the analytical methods for laboratory analyses. The EPA Region 10 Laboratory will follow the method developed by Office of Research and Development the DNA extraction, polymerase chain reaction and gel electrophoresis methods utilized in this study as Standard Operating Procedures as referenced in the EPA QAPP, Quality Assurance Project Plan for Drayton Harbor Microbial Source Tracking Pilot Study EPA Region 10, Washington Operations Office (MEL, 2006), including:

- Sample Preparation

- Sample Filtration
- DNA Extraction
- PCR and Electrophoresis
- Gel Visualization

9.2.6 Sensitivity/Method Detection Limit (MDL)

Table A-8 includes the analytical methods for laboratory MDL or quantitation limit for field measurements and laboratory analyses.

9.3 Sample preparation method(s)

Fecal coliform bacteria samples require mixing prior to analysis. Polymerase chain reaction samples require DNA extraction at the EPA Region 10 Laboratory as per their SOP for Recreational Water and Wastewater Filtration for DNA Extractions.

9.4 Special method requirements

Fecal coliform bacteria samples and polymerase chain reaction samples require transport at controlled temperature in the dark.

9.5 Lab(s) accredited for method(s)

The LPWRF is accredited for fecal coliform analysis by membrane filtration. The PCR method does not have an accreditation procedure to date.

10.0 Quality Control (QC) Procedures

10.1 Table of field and lab QC required

A summary of QC samples, types and frequency is shown in Table A-11. The MQOs for replicates are shown by method in Table A-8.

10.2 Corrective action processes

Laboratory and field results will be reviewed by the field lead and the project manager for missing or unusual data. If needed, laboratory staff will be contacted to verify reported results and/or estimated results. Data entry into spreadsheets will be double-checked with field sheets. Laboratory and travel blanks should equal zero. For each FC sample, countable numbers between 20 and 60 should be used to calculate the fecal coliform concentration (Standard Methods 9222B6b). Data will be flagged as estimates if these quality objectives are not met. The laboratory will notify the project manager of corrective actions taken. Field data will be qualified if DQOs are not met and a field notebook check will be conducted by the field lead to determine whether a field audit is needed to ensure correct procedures are used. The field lead will submit a corrective action report to the project manager documenting corrective actions taken.

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

Field data notebooks, Chain of Custody forms, and laboratory reports will be used to document and track sampling events and results. All of these forms will include sample site, sample date and time, and sampler's name. Field notes will also record weather conditions and observations regarding human and animal activity within the drainage. Field data and copies of the Chain of Custody forms will be provided to the project manager (HCS) within 1 week of each sampling event. Preliminary laboratory results will be sent electronically to the project manager (HCS) and to NSEA's project lead within 2 days of sample analysis completion. Laboratory results and field data will be entered into an Excel spreadsheet by NSEA staff within 1 week of the sampling event. The field team lead will review field data and laboratory data prior to entry into an Excel project spreadsheet for missing or unusual data. The project spreadsheet should be structured for ease of transferability of data into Ecology's EIM system. The Excel spreadsheet will contain a separate worksheet for each type of sample, ambient, storm and "hot spot". Data will be uploaded to the Project Manager (HCS) and Blaine Public Works within 1 week of each sampling event. Field sheets or field notebooks, Chain- of- Custody forms, sample receipt records , QC sample records, and laboratory reports will be stored on site at Blaine Public Works in project data files for a minimum of ten years in either a hardcopy or scanned format. The project manager will calculate geometric means, 90th percentile statistics and daily FC loads for comparison with water quality standards and TMDL allocations using Excel.

Due to higher variability with low results in bacteria analysis, duplicate pairs for analysis of field precision should be separated into two groups: 1) pairs with a mean less than or equal to 20FC/100mL and 2) pairs with a mean greater than 20FC/100mL (Mathieu 2006). Results exceeding objectives will be noted in the Excel dataset, quarterly, and final reports and values of individual samples or entire sets of samples will be flagged as estimates (J), where MQOs are exceeded for field or lab duplicates, respectively. Values that are two times the objectives will be rejected and noted in the dataset and reports. Until these data quality checks have been completed, data should be reported as preliminary.

11.2 Lab data package requirements

The LPWRF laboratory will provide an electronic laboratory report within 2 days of analysis completion. The lab report will include: name of sampler, name of analyst, time of sample collection, time analysis is completed, incubator temperature, blank result, dilutions performed and corresponding FC counts and a colony count per 100mLs of sample based upon the dilution that yields 20-60 colonies per plate. Results outside this range will be flagged as estimates.

The EPA Region 10 laboratory will provide an electronic package of all project analyses at the end of the sampling period. The package will include a summary of the method, QC tests performed, general conclusions and disclaimers and sample results. Sample results will include project identification information, method and method preparation information, sample identifiers and sample type (regular or duplicate), analytes (DNA primer identifiers) and presence/absence of primers.

11.3 Electronic transfer requirements

Field data will be entered into a project Excel spreadsheet from field notebooks. Laboratory data will be transferred electronically to the field team lead (NSEA) and to the project manager (HCS) in text or PDF files. All data will reside in a master project spreadsheet.

11.4 Acceptance criteria for existing data

Data will be qualified as estimates as per method requirements and DQO. All existing data originate from projects with approved QAPPs and are thereby accepted for use as background information.

11.5 EIM/STORET data upload procedures

The field team lead will review each field sheet prior to entry into an Excel project spreadsheet. Laboratory results and field data will be entered into an Excel spreadsheet by NSEA staff within 1 week of the sampling event. The project spreadsheet will be structured for ease of transferability of data into Ecology's EIM system. Data will be transferred to Ecology's EIM systems after verification by NSEA's field team lead or the project manager.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

Field audits will be conducted by the Project Manager QA officer or designee to ensure sampling and field QC procedures are followed correctly. During the first quarter of the project a field audit will be conducted during a portion of each sample run. Thereafter, field audits will be conducted at least quarterly or upon request from the Field Team Lead.

The LPWRF laboratory conducts *system audits* to assess personnel, equipment, facilities, and analytical procedures. The system audit is conducted periodically by the Department of Ecology and at least every six months by the senior operator.

The EPA Region 10 Laboratory will follow the following oversight for this project. A quality assurance assessment beyond routine QA procedures will be conducted during the course of this project. The quality assurance assessment performed during this project will include the following:

1) Oversight of field sampling activities.
2) Oversight of sample handling and chain-of-custody procedures.
3) Laboratory inspection

The EPA quality assurance assessment will be conducted by the EPA Region 10 Quality Assurance Officer or QA staff delegated by the Officer to conduct the assessment.

Corrective actions will be implemented in response to any QA results or detection of unacceptable data. These corrective actions will be developed in consultation with the Office of Research and Development, keeping the data user informed of any impacts on the data. If required, corrective actions will be documented in Appendix A-3.2, Corrective Action Form.

12.2 Responsible personnel

Field audits will be conducted by the Project Manager QA officer, designee or the Field Team Lead to ensure sampling and field QC procedures are followed correctly.
The LPWRF laboratory conducts *system audits* to assess personnel, equipment, facilities, and analytical procedures. The system audit is conducted periodically by the Department of Ecology and at least every six months by the senior operator.

12.3 Frequency and distribution of report

NSEA's Field Team Lead will be responsible for providing the Project Manager a monthly activity report. The Project Manager will be responsible for reviewing the monthly activity reports and for doing quarterly reviews of project activities and data. The Project Manager will be responsible for completing the interim and final reports for the monitoring project according to the project schedule. Quarterly data spreadsheets and project reports will be provided to staff listed on the distribution list. Reports will summarize project activities, results, data quality compared to data objectives and any significant quality assurance issues and corrective actions. NSEA's team lead and one additional team member will be responsible for peer review of reports along with a senior planner from Whatcom County Natural Resources. The final report will follow a format similar to this document in regard to a review of methods and data quality and it will include a summary of results, discussion and recommendations.

12.4 Responsibility for reports

The Project Manager will be responsible for completing the interim and final reports for the monitoring project. Quarterly data spreadsheets and project reports will be provided to staff listed on the distribution list. Reports will summarize project activities, results, data quality compared to data objectives and any significant quality assurance issues and corrective actions. NSEA's Team Lead and one additional team member will be responsible for peer review of reports along with a senior planner from Whatcom County Natural Resources. The final report will follow a format similar to this document in regard to a review of methods and data quality and it will include a summary of results, discussion and recommendations.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

All data for this project will be reviewed and verified against the quality objectives described in Table A-8 and the *Data Quality Objectives* and *Quality Control* sections. Field data will be reviewed by NSEA's Field Team Lead prior to leaving each sampling site for missing or unusual data. Field data will be cross-checked with Chain of Custody forms prior to submission to the laboratory. NSEA's Team Lead will compare data entry with field data to verify results. The project manager will compare field data sheets to data entered into the Excel spreadsheet and provide feedback to NSEA's team lead within 2 weeks of each sampling event. This will enable the field team to make any needed corrections in field methods prior to the next monthly sampling event. The project hydrologist (ESA) will review discharge measurement data to ensure selected measurement methods yield data appropriate to sites. Data entered in Excel files will be considered and marked draft/preliminary until data review and verification has been completed. Data will not be entered into Ecology's EIM system until data review and verification has been completed. Data will be uploaded to the WRIA1 Water Quality Monitoring Database (housed at Whatcom County Public Works- Natural Resources) annually.

13.2 Lab data verification

Laboratory results will be reviewed by the Field Lead and the Project Manager for missing or unusual data. If needed, laboratory staff will be contacted to verify reported results and/or estimated results. Data entry into spreadsheets will be double-checked with laboratory generated results. Preliminary laboratory results for fecal coliform will be verified within two working days of the sampling run and compared to the project objectives.

Laboratory blanks should equal zero. For each sample, countable numbers between 20 and 60 should be used to calculate the fecal coliform concentration (Standard Methods 9222B6b). Data will be flagged as estimates if these quality objectives are not met. Routine results will be compared with field replicates and lab duplicates to ensure that MQOs are met.

13.3 Validation requirements, if necessary

Methods used in this project are standard and a need for outside validation is not anticipated. Interim and final reports will be peer reviewed by a Whatcom County Planner and any issues will be brought to the Project Manager's attention.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

NSEA's Field Lead and the Project Manager (HCS) will verify that measurement and data quality objectives have been met for each monitoring station. If the objectives have not been met (such as percent RSD for bacteria replicates exceeds the MQO or a field meter was recording bad data) then the field lead and project manager will decide how to qualify the data and how it should be used in the analysis or whether it should be rejected. The data quality assessment process will be documented in individual project data files and summarized in the final report. The project manager will be responsible for reporting usability of data in the interim and final reports.

Data will be used to meet the study objectives, namely characterization of baseline and post corrective action conditions. It is important that the data characterize fecal bacteria concentration and loading against water quality standards and TMDL FC load reduction targets in order to support Blaine PW decisions regarding corrective actions and BMP implementation.

14.2 Data analysis and presentation methods

The primary data analysis needed to compare results with water quality standards are calculation of geometric means, 90th percentile statistics and daily FC loads for comparison with TMDL allocations using the Excel spreadsheet. Paired T-tests and Wilcoxon Sign Rank tests for statistical significance may be used to determine significant differences between each site on Cain Creek and the corresponding downstream site and to evaluate "Hot Spot" sample results. Data will be represented in tables and in graphs and maps. Summary statistics may be linked to GIS for a spatial presentation of results. Relative Standard Deviation (RSD) is the primary statistic that will be used to assess whether MQOs have been met. MST, PCR presence/absence results are presented by frequency of occurrence in table format. Fecal coliform values reported as non-detect values will not be used in the data quality assessment process; for example, a percent RSD value will not be calculated for a replicate pair with two non-detect values.
For certain elements of the storm drainage system a local hydraulic model of the pipe network will be created in SWMM or similar model.

14.3 Sampling design evaluation

The effectiveness of the sampling design will be evaluated by the Project Manager in the interim report and recommendations for adjusting the study design will be described. Completeness and acceptability of data will be used to evaluate sampling design.

14.4 Documentation of assessment

nal report will document project and data assessment. Project assessment will also be addressed in the interim report.

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16.0 List of Figures

17.0 List of Tables

18.0 Appendix A: Figures and Tables

Table A-1. *Preliminary Landcover Results for Cain Creek Basin (color coded land use to be used with Figure A-2.)

CLASS_NAME	Area_acre
Bare Land	0.22
Deciduous Forest	20.02
Developed Open Space	63.83
Evergreen Forest	18.90
Grassland	3.11
High Intensity Developed	85.18
Low Intensity Developed	249.53
Medium Intensity Developed	180.14
Mixed Forest	20.24
Palustrine Emergent Wetland	8.45
Palustrine Forested Wetland	6.00
Palustrine Scrub/Shrub Wetland	2.45
Pasture/Hay	29.13
Scrub/Shrub	9.34
Percent 'developed'	73.9%
Percent forest + wetland	8.0%

*These data are from the 2001 NOAA Coastal Change Dataset for Washington
http://www.csc.noaa.gov/digitalcoast
August 21 2014, from S.Winter, ESA

- Unclassified
- High Intensity Developed
- Medium Intensity Developed
- Low Intensity Developed
- Developed Open Space
- Cultivated
- Pasture/Hay
- Grassland
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Scrub/Shrub
- Palustrine Forested Wetland
- Palustrine Scrub/Shrub Wetland
- Palustrine Emergent Wetland
- Estuarine Forested Wetland
- Estuarine Scrub/Shrub Wetland
- Estuarine Emergent Wetland
- Unconsolidated Shore
- Bare Land
- Water
- Palustrine Aquatic Bed
- Estuarine Aquatic Bed
- Tundra
- Snow/Ice

Table A-2. 2008 Cain Creek TMDL Data: FC geometric mean and 90th percentile statistics, including wet and dry season, for the Cain Creek basin.

Station ID	All samples			Wet Season			Dry Season		
	n	Geo-mean	90th %tile	n	Geo-mean	90th %tile	n	Geo-mean	90th %tile
1-Cain-1.3	18	25	191	11	12	74	7	78	330
1-Cain-0.4	23	302	1941	11	260	1885	12	347	2123
1-Cain-0.01	23	327	1799	11	250	1424	12	417	1740
1-Cain-0.01-MPN	22	439	2498	10	363	2515	12	515	2606
1-Cain-SD1	23	109	362	11	105	356	12	90	256

Note: Highlighted (shaded) cells indicate sites above water quality criteria.

Table A-3. FC data for Cain Creek sampling sites, 2009 (HCS and Doremus, 2010).

Station	n	Geometric mean[1]	%>100[1]	%>43[2]	Min (FC/100mL)	Max (FC/100mL)	[4] Average load billion cfu/day	# Samples exceeding 1000FC/ 100mL	Mean discharge (cubic ft./second)
CC1.3	3	26	0	33	7	68	0.23	0	0.211
CC1.3A	3	23	0	33	10	48	0.25	0	0.200
CC0.4	9	**762**	**89**	100	58	6300	2.69	5	0.380
CC.0.2	6	**571**	**100**	100	110	5700	1.79	2	0.172
CC0.01	10	**599**	**90**	100	63	4600	34.71	3	6.200
CCSD	10	**149**	**80**	0	4	2100	0.18	2	0.269

[1] Bold indicates violation of Washington fecal coliform primary contact standard a) geometric mean of 50 FC/100mL and b) no more than 10% of samples exceeding 100 FC/100mL.

[2] Project indicator ; Washington marine fecal coliform standard no more than 10% of samples exceed 43 FC/100mL.

Table A-4. NIT Study, MST Biomarkers Identified by HSPCR, 2009

Sites	N*	Biomarkers				
		Human	Ruminant	H/R***	GB**	Absent
CC0.01	6	5/6	2/6	1/6	1/6	
CC0.2	3	2/3	2/3	2/3	1/3	
CC0.4	6	5/6	3/6	2/6		
CC1.3	3	2/3			1/3	
CC1.3A	3		1/3		1/3	1/3
CCSD	6	5/6	4/6	3/6		

* N = number of samples, **GB=general *Bacteroides*

***H/R=human and ruminant markers identified in the same sample.

Table A-5. Puget Sound Restoration Fund Study, January through May 2012.

Station	N	Geomean	%>100	Min (FC/100mL)	Max (FC/100mL)	Mean discharge (ft^3/sec)	Mean	Mean Load (billion FC/day)	Mean Load (billion FC/day)[1]
WQ Standard		**50**	**<10%**						
CC1.2 (Fir Ave. behind Propack Bldg.)	6	**58**	**17**	17	511	0.54	58.3	7.7E+08	0.77
CC0.8 (End of Boblett and Mitchell.)	6	**67**	**50**	10	176	0.90	80.5	1.8E+09	1.8
CC0.6(End Blaine Ave. & Steen Rd.)	**6**	**49**	**50**	**0**	**567**	**1.27**	**186.4**	**5.8E+09**	**5.8**
CC0.15 (At Peace Portal culvert.)	7	**57**	**50**	12	410	0.90	112.6	2.5E+09	2.5

Table A- 6. Northwest Indian College data for Cain Creek outfall and Cain Creek storm drain, 2013 (Whatcom County, 2014).

	CC		CCO	
Date	FC	Geomean	FC	Geomean
1/7/2013	480	81.1	390	216.4
2/20/2013	140	86.9	180	229.8
3/20/2013	870	101.9	930	242.3
4/2/2013	360	100.1	127	231.9
5/13/2013		106.3	600	239.5
6/13/2013	620	123.8	167	241.5
7/29/2013	700	144.9	640	235.1
8/12/2013	3600	175.7	4100	251.9
9/23/2013	920	199.4	460	254.7
10/15/2013	250	206.3	116	276.4
11/4/2013	250	215.2	220	267.7
12/2/2013	634	232.3	737	278.3

Table A-7. Sampling results of priority freshwater drainage into Drayton Harbor from the eastern shoreline, from Menzies, 2002.

Actual Count of Fecal Coliform Colonies / 100 ml of water							
Freshwater Site	24-July	22-Aug	12-Sep	23-Oct	13-Nov	12-Dec	Geomean
1	1,070	1,531	100	58	27	70	**162**
2	4,433E	2,800	600	254	40E	1,160	**667**
3	1,520E	6,100	--	600	247	3,000	**1,327**
4	800E	11,200	1,300	88	100E	80	**449**
5	--	12,000	181	40	80*	144	**251**
6	--	49,000	<100	139	85	380	**685**
7	--	--	--	--	--	--	--
8	28	270	<100	44	40	65	61
9	196	16,000	<100	246	53	20E	**241**
10	--	2,000	--	82	2E	29E	56
11	16	630	<100	29	35	74	60

Table A-8. Method quality objectives for field and laboratory analyses.

Parameter	Method	Range	Precision	Bias	Quantitation Limits
Water Temperature	YSI 556	-5 to 45 C	Median absolute difference of <0.2 std units	± 0.15 °C	NA
Specific Conductivity	YSI 556	0 – 200 mS/cm	Median RSD <5%)	± 0.5% of reading OR ± 0.001mS/cm, whichever is greater	/0.1 mS/cm, 0.01 units
Dissolved Oxygen	YSI 556	0 to 50 mg/L	Median absolute Difference of <0.2 mg/L	±0.2 mg/L or ± 2% of the reading, whichever is greater	*, 0-50mg/L/0.01mg/L
Discharge Volume	Swoffer 2100	0.1-25 ft/sec	10% RSD	0.01 ft/sec	0.1-25 ft/sec
Fecal coliform bacteria	Membrane filter APHA 9222D	< 2 to 1,600 cfu/100 mL	20% RSD*	20% RSD*	>2 cfu/100 mL
HSPCR	EPA Region 10 Lab Procedures				10-100 DNA strand

* RSD-Relative standard deviation, standard deviation divided by the mean, 50% of (field) replicate pairs < 20% RSD, 90% of (field) replicate pairs <50% RSD, and 20% for laboratory replicates (Blaine, LPWRF).

Table A-9. Sample site locations, tier and sampling frequency.

Site ID	Tier	Description	Latitude (˚N)	Longitude (˚W)	Monthly Ambient Wet Season	Monthly Ambient Dry Season	Samples Storm Wet Season	Samples Storm Dry Season
CCSD [1]	1	Channel from storm drainage outfall to Semiahmoo Bay, north of the mouth of Cain Creek about 50ft downstream of outfall	48.99711	122.75465	12	12	3-4	3-4
CC0.01 [1]	1	Cain Creek mouth; 60" culvert off of Marine Dr, just north of boatyard	48.99689	122.75465	12	12	3-4	3-4
CC0.10 & SD20	1	Peace Portal culvert, behind Edaleen,bike path (SD20 is 18" CMP enters upstream of CC0.10, storm samples only to augment disharge measurements)	48.99660	122.75156	12	12	3-4	3-4
CC0.15 [2]	1	F St. culvert near Physical Therapy Office	48.99576	122.74952	12	12	3-4	3-4
CC0.4 [1]	1	Cain Creek behind Blaine Trade Center	48.99295	122.74513	12	12	3-4	3-4
CC0.8 [2]	1	End of Boblett and Mitchel, across walking bridge from Blaine High	48.99076	122.74220	12	12	3-4	3-4
CC1.2 [2]	1	Fir Ave Behind Propack	48.98797	122.73564	12	12	3-4	3-4
CC1.3 [1]	1	Cain Creek @ Pipeline Rd south of airport,plastic culvert	48.98674	122.73328	12	12	3-4	3-4
CC1.3A [1]	3	Cain Creek @ Pipeline Rd S. of airport, damaged concrete culvert enters channel from S., may be sampled based on initial results from CC1.3	48.98674	122.73328			3	3
BD1 [3]	2	Catch basin near Peace Portal and 4th, configuration	48.98774	122.75134	6		6	6
SD4[1]	2	36" by 42" concrete pipe across from Liz's Restaurant, access E. side of RR tracks, 120 meters N. at orange pole	48.98246	122.73935	6	6	6	6

[1] - TMDL 2008, NIT 2009, Whatcom County 2013,

[2] PSRF site, 2012

[3] Whatcom County 2002

Table A-10. Summary of methods and sample handling.

Parameter	Description	Method	Sample Container	Preser-vation	Holding Time, field/lab analysis
Water Temperature	YSI 556	YSI 556	None	None	None, field
Specific Conductivity	YSI 556	YSI 556	None	None	None, field
pH	YSI 556	YSI 556	None	None	None, field
Dissolved Oxygen	YSI 556	YSI 556	None	None	None, field
Discharge	Swoffwer 2100	Swoffer 2100	None	None	None, field
Fecal coliform bacteria	Membrane filtration	APHA 9222D	PE, 125 mL, sterile	10 °C, dark	(max) 8-hours, lab
HSPCR	PCR-2marker	EPA Region 10 Lab Procedures	PE, 250 mL, sterile	10 °C, dark	(max) 30-hours, lab

19.0 Appendix B -- Glossary, Acronyms, and Abbreviations

19.1 Quality Assurance Glossary

Accreditation - A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy - the degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

Analyte - An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e. g. fecal coliform, Klebsiella, etc. (Kammin, 2010)

Bias - The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

Blank - A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

Calibration - The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. (Ecology, 2004)

Check standard - A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards, but should be referred to by their actual designator. (i. e. CRM, LCS, etc.) (Kammin, 2010; Ecology, 2004))

Comparability - The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

Completeness - The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator. (USEPA, 1997)

Continuing Calibration Verification Standard (CCV) - A QC sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run. (Kammin, 2010)

Control chart - A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system. (Kammin, 2010; Ecology 2004)

Control limits - Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean. (Kammin, 2010)

Data Integrity- A qualitative DQI that evaluates the extent to which a dataset contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

Data Quality Indicators (DQI) - Data Quality Indicators (DQIs) are commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity. (USEPA, 2006)

Data Quality Objectives (DQO) - Data Quality Objectives are qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. (USEPA, 2006)

Dataset - A grouping of samples organized by date, time, analyte, etc (Kammin, 2010)

Data validation - An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the dataset. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation
- Use of third-party assessors
- Dataset is complex
- Use of EPA Functional Guidelines or equivalent for review

Examples of data types commonly validated would be:

- Gas Chromatography (GC)
- Gas Chromatography-Mass Spectrometry (GC-MS)
- Inductively Coupled Plasma (ICP)

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier, data is usable for intended purposes
- J (or a J variant), data is estimated, may be usable, may be biased high or low
- REJ, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004)

Data verification - Examination of a dataset for errors or omissions, and assessment of the Data Quality Indicators related to that dataset for compliance with acceptance criteria (MQO's). Verification is a detailed quality review of a dataset. (Ecology, 2004)

Detection limit (limit of detection) - The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

Duplicate samples - two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

Field blank - A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

Initial Calibration Verification Standard (ICV) - A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples. (Kammin, 2010)

Laboratory Control Sample (LCS) - A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. (USEPA, 1997)

Matrix spike - A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

Measurement Quality Objectives (MQOs) - Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness. (USEPA, 2006)

Measurement result - A value obtained by performing the procedure described in a method. (Ecology, 2004)

Method - A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

Method blank - A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

Method Detection Limit (MDL) - This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

Percent Relative Standard Deviation (%RSD) - A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010)

Parameter - A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all "parameters" (Kammin, 2010; Ecology, 2004)

Population - The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

Precision - The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

Quality Assurance (QA) - A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

Quality Assurance Project Plan (QAPP) - A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

Quality Control (QC) - The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

Relative Percent Difference (RPD) - RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples - two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

Representativeness - The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

Sample (field) – A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

Sample (statistical) – A finite part or subset of a statistical population. (USEPA, 1997)

Sensitivity - In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)

Spiked blank - A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

Split Sample – The term split sample denotes when a discrete sample is further subdivided into portions, usually duplicates. (Kammin, 2010)

Standard Operating Procedure (SOP) – A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010)

Surrogate – For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis. (Kammin, 2010)

Systematic planning - A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning. (USEPA, 2006)

Transfer Blank - Microbiology field blank prepared by aseptically pouring sterilized reagent water from a full bottle into a sterile empty bottle midway through a microbiology field sampling activity. (USEPA, 2009)

References

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USEPA Region 3, 2009. Quality Control Tools, Blanks. http://www.epa.gov/region3/esc/qa/pdf/blanks.pdf

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USGS, 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636. http://ma.water.usgs.gov/fhwa/products/ofr98-636.pdf

19.2 Glossary – General Terms

Ambient: Background or away from point sources of contamination.
Baseflow: The component of total streamflow that originates from direct groundwater discharges to a stream.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Eutrophic: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

Fecal coliform: That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Hyporheic: The area beneath and adjacent to a stream where surface water and groundwater intermix.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities. This includes, but is not limited to, atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination is considered a nonpoint source. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act is a nonpoint source.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or is likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Reach: A specific portion or segment of a stream.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Any fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char is considered a salmonid. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Synoptic survey: Data collected simultaneously or over a short period of time.

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Total suspended solids (TSS): Portion of solids retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standard, and are not expected to improve within the next two years.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists.

19.3 Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.
Please delete any of the following that aren't used in this QAPP

BMP	Best management practices
DOC	Dissolved organic carbon
e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others

GIS	Geographic Information System software
GPS	Global Positioning System
i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
MST	Microbial source tracking
NPDES	(See Glossary above)
PCR	polymerase chain reaction
QA	Quality assurance
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
SRM	Standard reference materials
TMDL	(See Glossary above)
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resources Inventory Area
WWTP	Wastewater treatment plant

19.4 Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cms	cubic meters per second, a unit of flow.
dw	dry weight
ft	feet
g	gram, a unit of mass
kcfs	1000 cubic feet per second
kg	kilograms, a unit of mass equal to 1,000 grams.
kg/d	kilograms per day
km	kilometer, a unit of length equal to 1,000 meters.
l/s	liters per second (0.03531 cubic foot per second)
m	meter
mg	milligram
mgd	million gallons per day
mg/d	milligrams per day
mg/Kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mg/L/hr	milligrams per liter per hour
mL	milliliters
mm	millimeter
pg/L	picograms per liter (parts per quadrillion)
psu	practical salinity units
s.u.	standard units

ug/g	micrograms per gram (parts per million)
ug/Kg	micrograms per kilogram (parts per billion)
ug/L	micrograms per liter (parts per billion)
um	micrometer
uS/cm	microsiemens per centimeter, a unit of conductivity

20.0 Appendix C - SOPs and Manuals

- Whatcom County Fecal Coliform Monitoring Group Fecal Coliform Sampling SOP - 2013
- YSI 556 Instruction Manual - Attachment
- Swoffer 2100 Instruction Manual - Attachment
- EPA_MSTQAPP_APPDX_D-CCupdate
- ECY_EAP_SOP_Measuring_and_CalculatingStreamDischarge_v1_1EAP056
- ECY_EAP_SOP_WQSUSstreamflow_v2_0EAP024

21.0 Appendix D - Forms

- EPA Region 10 Lab Sample_Custody_Form[1]
- LPWRF Custody Log
- Field Check List
- Sample Discharge Form
- Sample Field Form

22.0 Appendix E - Blaine Sewer & Storm Piping Maps of Cain Creek Basin

23.0 Appendix F - Existing Studies

Hood and Mathieu, 2010. Draft *Drayton Harbor Watershed Fecal Coliform Total Maximum Daily Load: Water Quality Improvement Report*. Washington State Department of Ecology, Environmental Assessment Program.

Hirsch Consulting Services, Llynn Doremus and Geoff Menzies, 2010. *Drayton Harbor TMDL Support Project: Drayton Harbor Mouth and Semiahmoo Bay*. Prepared for Nooksack Indian Tribe, July 2010.

Hirsch Consulting Services, Cain *Creek Water Quality and Microbial Source Tracking*, 2013. Prepared for Puget Sound Restoration Fund. December 2013.

24.0 Appendix G - Sample Site Survey Tables

25.0 Appendix H - Sample Site Photos