2010 Stream Health Assessment for City of Bothell Streams

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City of Bothell™

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Appendix A

2010 Stream Ambient Monitoring Data
Electro-fishing Methodology and Study Design

Introduction

The City of Bothell's Comprehensive Plan, *Imagine Bothell*…, calls for actions to "protect, preserve, and enhance those features of the natural environment which are most sensitive to human activities." Collection of data and observations (i.e. monitoring) is one means to determine attainment of that goal.

The City of Bothell has adopted ordinances and Department goals to protect, maintain, and restore its waters through knowledge of past, current, and future trends and conditions. The City of Bothell's Municipal code 18.01.010 (18) defines Storm and Surface Water Management Services in part as "…water quality and environmental monitoring…." Ordinance 1968 (2006) effective in 2007 stipulates the expenditure of Surface Water Management fees be used to conduct Storm and Surface Water Management Services.

The monitoring effort will facilitate the City's commitment to wise management of land and water for the benefit of current and future generations. A primary measure of success will be attainment of beneficial uses as designated by city, state, and federal water quality standards.

Goal

The goal is to provide a means by which the City of Bothell can measure and describe in a quantitative and qualitative manner, whether it has achieved its objective to protect and restore the chemical, physical, and biological integrity of the City's surface waters.

Objective

Monitor surface waters along select water quality measures to develop baseline data for future trend identification. Assess data for occurrences of degraded conditions and quantify levels observed. Document stream channel conditions, habitat, water quality, macroinvertebrates, and fish populations. Use information to facilitate City policy and land use rules, prioritize restorative actions, and direct future program monitoring efforts. Use the assessment to measure compliance with the Federal National Pollutant Discharge Elimination System (NPDES) Phase II permit, Endangered Species Act, and Clean Water Act.

Methods

Sample Station Selection

Selection of sites was determined through in-office review of maps and follow-up field surveys. Sites were selected based on their representativeness of the stream and upstream land use patterns. Sites were located as far downstream as was practical.

Chemical

At each site, monthly water quality measures were taken of dissolved oxygen, temperature, turbidity, conductivity, specific conductivity, and salinity. The samples

were collected in the field using portable handheld meters. If deemed appropriate from initial sample results, future water sampling could include samples for laboratory analysis. Elements to be assessed might include measures of fecal coliform, copper, zinc, lead, cadmium, hardness, pesticides, and TSS.

Temperature

Stream temperatures were taken using two methods. One method required an instantaneous measure collected at the time of general water quality sample with YSI 85 meter. The second method involved use of a continuous instream temperature data logger. The data loggers were installed in each stream and were set to record continuous temperature every 15 minutes.

Physical

Hydrology Flows

Visual estimates of flow were made during monthly water quality sampling events. Flows were estimated and recorded in cubic feet per second (CFS) or, if flows were slight, estimates were made in gallons per minute (gpms). Macroinvertebrate sampling events had flows measured using a timed floating object over a measured area of homogenous width and depth profile.

Pebble Counts

A Wolman pebble count was conducted at each stream reach sampled for macroinvertebrates. At each riffle sampled for stream insects, a measuring tape was placed perpendicular to stream flow across the selected riffle. A minimum count and measure of 50 pebbles were collected at each riffle. The four riffles sampled were cumulatively summed for each reach for a composite of one 200-pebble count. Analysis of data used transformation of the pebble counts to phi values. The phi values are then converted to D_{50} and D_{84} values and expressed as percent cumulative frequency. A D_{50} value of 5 can be interpreted as 50% of the substrate being 5mm or smaller, whereas a D_{84} value of 5 can be read as 84% of the substrate being 5mm or smaller.

Channel Morphology

At each of the four riffles sampled for macroinvertebrates, a cross section was taken of bankfull depth and width. A laser level was placed on top of the bankfull, leveled, and aimed perpendicular to the channel. Depth measures were read off of stadia rod at evenly-spaced intervals to obtain channel profile. Two ratios, bankfull width (BFW) to depth (D) and a wetted width (WW) to BFW, were calculated to assess channel characteristics.

Canopy

Canopy density is a measure of one's view to the sky while standing in the middle of the stream channel. A densitometer was used with the view taken from four orientations, then summed and averaged for a percent closure. It is a measure of how much sky is obstructed by the surrounding canopy. The measures were taken at each riffle sampled

for macroinvertebrates and then averaged for a single measure for the sampled stream reach.

Instream Habitat

A simple instream habitat assessment was conducted as recommended by Scholz and Booth, 1999. Only pools meeting TFW 1993 manual for minimum size and depth criteria were included in this report. Pool measures collected include pool residual width and depth. All other stream habitat (i.e. riffles and glides) were not included in the surveys.

Large Wood

Large wood surveys stratified the count of pieces into four categories: Whether the wood was primarily a root wad or log and whether the wood was located in primarily wetted channel or within the bankfull width. To be counted, the wood needed to be a minimum of one meter (~3 feet) in length and greater than 25 cm (10 inches) in diameter.

Riparian/Watershed Condition

This exercise consists primarily of office assessment using GIS. Riparian areas were to be categorized into cover type (i.e. forested, shrubs, grasses, road, or parking lot) out a distance of 300 feet along both stream banks. The number of crossings of roads or trails is tallied and expressed as number of crossings per square mile. Lengths of roads per square mile or road density are calculated. Total impervious surface is determined for each watershed and expressed as a percentage of area. This work was not performed due to time limitations.

Biological

Macroinvertebrate

Streams had a reach delineated that ranged from shortest of 27 wetted channel widths to 40 wetted channel widths in length. Standard methodology for reach is 40 wetted channel lengths. Urban streams often lack a clear uninterrupted reach of 40 wetted channel lengths.

Within the reach, four riffles were selected that were representative of the reach. Each riffle was sampled using a Surber Sampler and all four riffles were composited into one sample for lab assessment. The samples were shipped to a lab to perform a sort and 500-count of macroinvertebrates. Macroinvertebrates were identified to species and genus when possible. The results were scored using Fore 1999 Biotic Index of Biological Integrity (B-IBI) metrics.

Fish

Fish were captured using an electro-fisher gear. A onetime pass-through was conducted within the stream reach. Block nets were installed at the down and upstream ends of the sampled reach. All fish captured were identified to species, counted, and measured for fork length.

QA/QC

To ensure accurate and precise data, all meters are calibrated at a minimum of once per month or per manufacturer's recommendations. Calibration records were kept of water quality meters. Meters were checked for accuracy prior to each monthly sampling event. Meters were calibrated according to manufacturer's recommendations.

Field data collection is supervised by a professional aquatic ecologist. A 10 percent replicate sample was collected for macroinvertebrate survey. Samples sent to outside laboratory were subject to the laboratory's QA/QC methods.

Data Analysis

Attributes Used to Diagnose Stream Health

Measured parameters provided a characterization of the stream's health status. Streams were assessed and described noting how and where impaired conditions occur.

The following measures were used to describe watershed and stream attributes. The measures were derived from study results of regional and local research, State water quality standards, and relative measures observed for streams in City of Bothell. For example, B-IBI scores are converted to their ranking and then assigned a numerical value to the ranking. For a stream that scored B-IBI of 22, severe impairment is scored as an esoteric impairment score of 2. The esoteric scores are solely for the use of comparing City of Bothell streams to each other and may have no broad regional use in other Puget Sound streams.

1) ***Road Density*** > 5.3 mi/mi^2 (May et al., 1996) can negatively impact stream health.
2) ***Total Imperviousness Area (TIA)*** > 10% and % forested < 65% (May et al., 1996) indicates potential for healthy conditions instream.
3) ***Stream Channel Condition*** % of length as natural stream channel vs. ditch vs. piped. The amount of piped and ditched stream channel network can negatively impact stream health.
4) ***Riparian Management Zone/Riparian Area:*** < 70% of total riparian corridor vegetated at or > 30m from stream bank (May, 1996) affects stream health.

Attribute scoring for streams that received Bioassessment Surveys

5) ***Channel Substrate Conditions*** where % of fines < 2mm at > 15% of substrate (Scrivener and Browlee, 1989), score 1 if true; 2 if false.
6) ***Aquatic Habitat Diversity*** target condition ranking (May, 1996), score 5 if good; 3 if fair; 1 if poor.
7) ***Fish Diversity*** (relative measure based on City of Bothell stream survey results)

- Score 5 = only native species present and number of salmonid age classes is > 3.
- Score 4 = only native species present and number of salmonid age classes is ≤ 3.
- Score 3 = native and non-native species present and number of salmonid age classes is ≥ 2.
- Score 2 = no salmonids present; may have other non-native and/or native species.
- Score 1 = no fish present.

8) ***B-IBI, Biological Integrity of Macroinvertebrate Community***:
   - Score 5 = B-IBI value of ≥ 43 to ≤ 50, no impairment detected.
   - Score 4 = B-IBI value of ≥ 35 to ≤ 42, slight impairment.
   - Score 3 = B-IBI value of ≥ 28 to ≤ 34, moderate impairment.
   - Score 2 = B-IBI value of ≥ 20 to ≤ 27, severe impairment.
   - Score 1 = B-IBI value of ≥ 10 to ≤ 19, extreme impairment.

9) ***Large Organic Wood*** where large organic wood (LOD) frequency to BFW spacing target condition classified (May, 1996), score 5 if good; 3 if fair; 1 if poor.

10) ***Stream Temperature*** based on WDOE WQ standards:
   - Score 5 = no excursion of WDOE WQ standards.
   - Score 4 = excursion of WDOE WQ standards for 13 C 7DADMax between September 15th through May 15th.
   - Score 3 = excursion of 16 C WDOE WQ standards.
   - Score 2 = excursions of 13 C and 16 C WDOE WQ standards.
   - Score 1 = any occurrence of lethal level temperatures to salmonids (> 23 C 1-day max or 7DADMax > 22 C), or between September 15th through May 15th 1-day max > 17.5 C (lethal to developing fish embryos).

11) ***Dissolved Oxygen***, based on WDOE WQ standards and scientific literature concerning reduced growth and lethal levels to salmonids.
   - Score 5 = no measures below WDOE WQ standards.
   - Score 4 = minimum measure > 8.0 to < 9.5 mg/l.
   - Score 3 = minimum measure > 5.0 to < 8.0 mg/l.
   - Score 2 = minimum measure > 3.3 to < 5.0 mg/l.
   - Score 1 = minimum measure < 3.3 mg/l.

12) ***pH Levels***, if above or below WDOE WQ standards, score 1 if true; 2 if false.

13) ***Conductivity Levels***, based in part on May 1996.
   - Score 5 = monthly average < 100 *u*S/cm.
   - Score 4 = 1 to 4 months of monthly average ≥ 100 *u*S/cm.
   - Score 3 = 5 to 8 months of monthly average ≥ 100 *u*S/cm.
   - Score 2 = 9 to 11 months of monthly average ≥ 100 *u*S/cm.
   - Score 1 = 12 months monthly average ≥ 100 *u*S/cm.

An overall score, Esoteric Impairment Score (EIS), was tabulated for each watershed that received a bioassessment. The score was based on measured attributes within each watershed as described previously in categories 5 through 13. The matrix (Table 1) is preliminary and may change based on further investigation of its ability to discern various levels of impaired waters. No scientific theoretical study was performed to verify whether each score's level of impairment is unequivocally an absolute true measure of stream's level of impairment. Hence, the chart is restricted to a relative use of comparing each of the small number of sampled streams in the study to each other. The attributes used to construct the level of impairment are based on best available science typically used to measure health of streams.

The table can be used to rank streams for future actions based on the individual impaired attributes and/or a water body's overall score. The lowest score possible is 13; the highest score possible is 44.

Esoteric Impairment	Number of Attributes Impaired
Unimpaired	≥ 36 to ≤ 42
Low	≥ 29 to ≤ 35
Moderate	≥ 22 to ≤ 28
Severe	≥ 16 to ≤ 21
Extreme	≥ 9 to ≤ 15

Table 1. Esoteric impairment score for City of Bothell streams

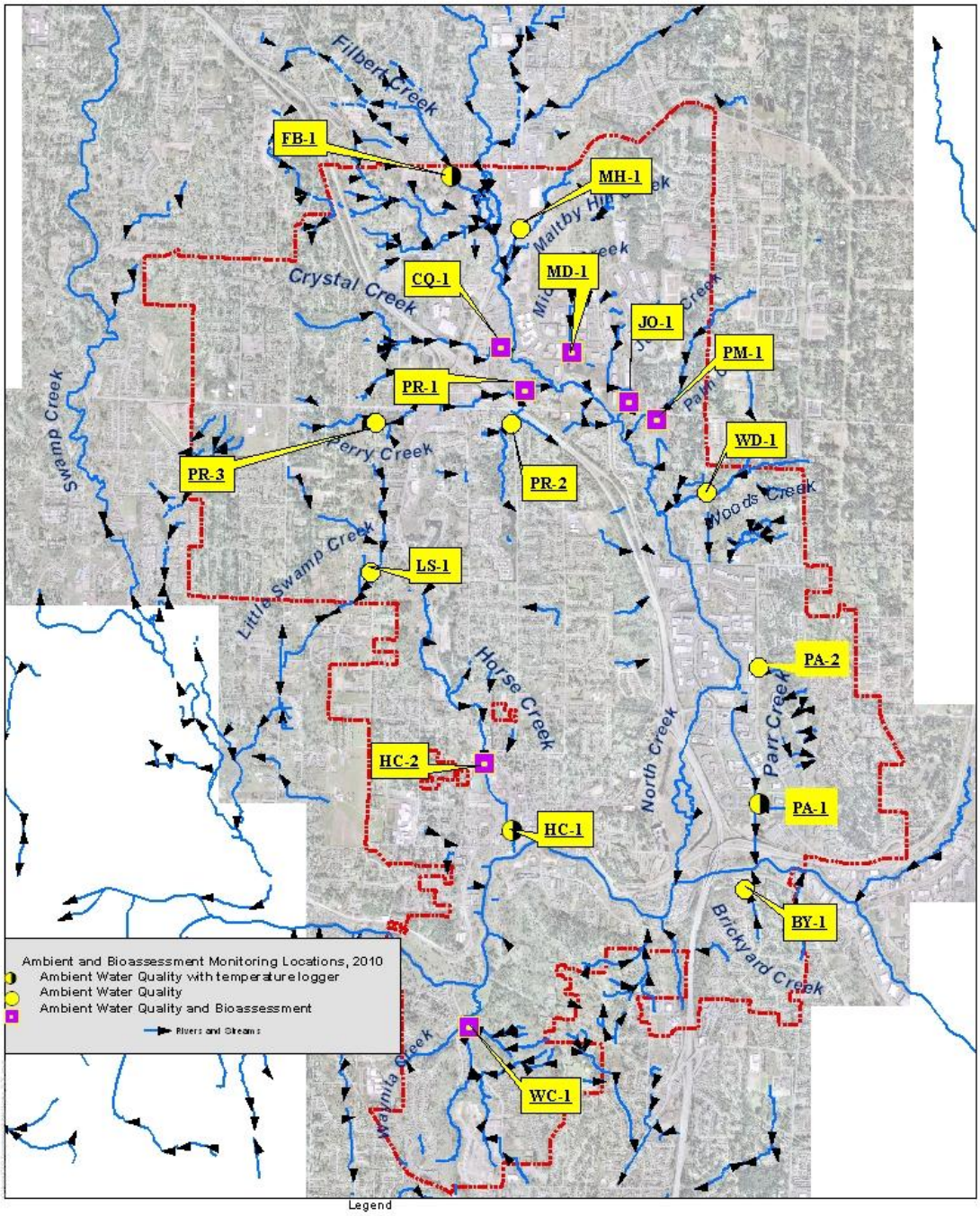

Figure 1. Sample locations.

Results

Sample Station Selection

A total of 17 sites (Figure 1) were selected for sampling in 2010. The sites were sampled for either water quality parameters or a mix of bioassessment, water quality, and temperature logger data. Two of the sites selected are part of the City's long term fecal coliform bacteria sampling efforts. The results of bacteria sampling may be found in Loch, 2010.

Basin Descriptions:

Thirteen sub-basins were sampled among the 17 sample sites (Figure 1). Their basins' general characteristics are summarized in Table 1. Within three basins, two or more sample locations were established. The three basins had dissimilar land use between their upper basin (single family residential) to their lower reaches (commercial businesses). Locations were selected to detect any significant difference in their stream water quality conditions. The complete ambient monitoring data set for all sample locations may be found in Appendix A.

Table 2. City of Bothell's Watershed Characterization profile.

Stream	Watershed Characteristics					Stream Characteristics, miles (% of Length)			
	Basin Size Acres	% Impervious	Road Length mi/mi sq.	Lakes/Ponds Acres	% basin Wetlands	Piped	Artificial Open Ch.	Stream Natural Ch.	General Land use Zoning
N Sammamish Tribs.									
Cougar Creek	253								SFR and Bothell High School
Parr Creek	747								Commericial and Lt. Industrial
Horse Creek	712					.46 (48%)		0.49 (52%)	SFR and Commercial
Little Swamp									Prm.SFR to Multi dwelling
S. Sammamish Tribs									
Waynita Creek	560								SFR and Multi dwlngs
Blythe Creek	21								Park and SFR
RiverSide Creek	123								SFR
E. Riverside Creek	65								SFR and I-405
Brick Yard Creek	229								SFR
North Creek									
Perry Creek	697								SFR and commercial
Junco Creek	124								Commericial and some SFR
Crystal/ Queensborough Cr	384								I-405, 228th, and SFR
Middle Creek	266								Commericial and Lt. Industrial
Palm Creek	437								SFR
Woods Creek	423								SFR
Royale Anne Creek	468								SFR
Filbert Creek	420								SFR
Maltby Hill Creek	322								SFR and commercial
Spring Stream	211								SFR
Boy Scout Creek	106								SFR and I-405
Basins Drainages									
Red Basin	34								SFR and 228th
Park'nRide Basin	160								Commerical

Blanks, no data available

Chemical

Monthly measurements typically began in March 2010. Measurements included dissolved oxygen, specific conductivity, salinity, pH and NTUs. These same measures were taken during macroinvertebrate sampling events.

Dissolved Oxygen (DO)

Dissolved oxygen levels for all but one stream recorded readings below Washington State Department of Ecology's water quality standard of ≥ 9.5 mg/l (Figure 2). Palm Creek (PM-1) was the only stream to remain above the 9.5 mg/l standard. Parr Creek (PA-1), Middle Creek (MD-1), Maltby Hill Creek (MH-1), and Little Swamp Creek (LS-1) all had averages below State standards. Lower Parr Creek (PA-1) had DO lethal levels for salmonids from July through October (critical times for juvenile rearing and adult spawner migration). Middle Creek had lethal levels during August. (Lethal level to salmonids is: < 3.3 mg/l, Spence et. al. 1996.)

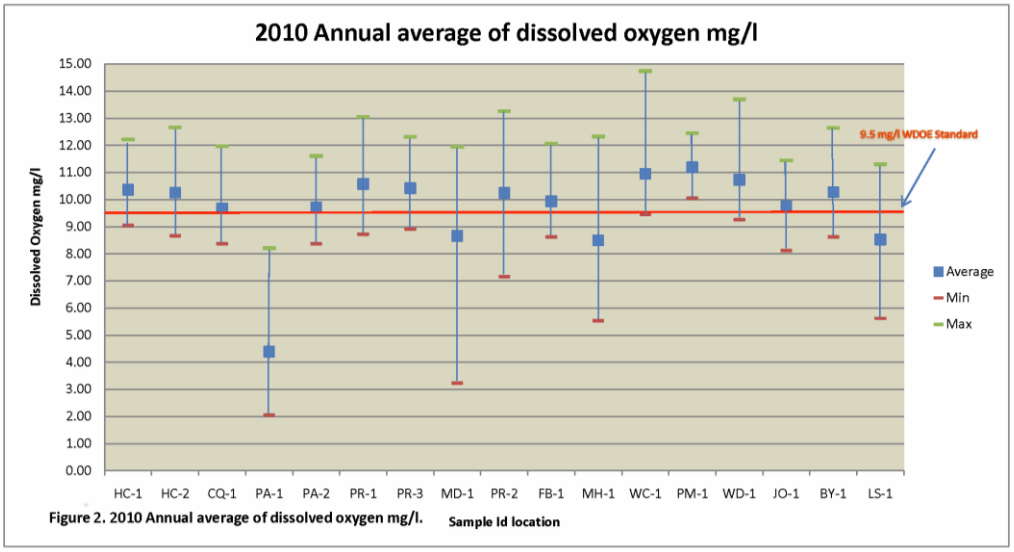

Figure 2. 2010 Annual average of dissolved oxygen mg/l.

Conductivity

Specific conductivity throughout the City was seasonally influenced. Highest readings occurred in the summer and lowest readings in late spring (Figure 3). The highest readings for specific conductivity occurred on Parr Creek's lower reach and at Waynita Creek. Woods Creek at 158.9 *us*/cm had the lowest annual average out of the 17 stream locations sampled.

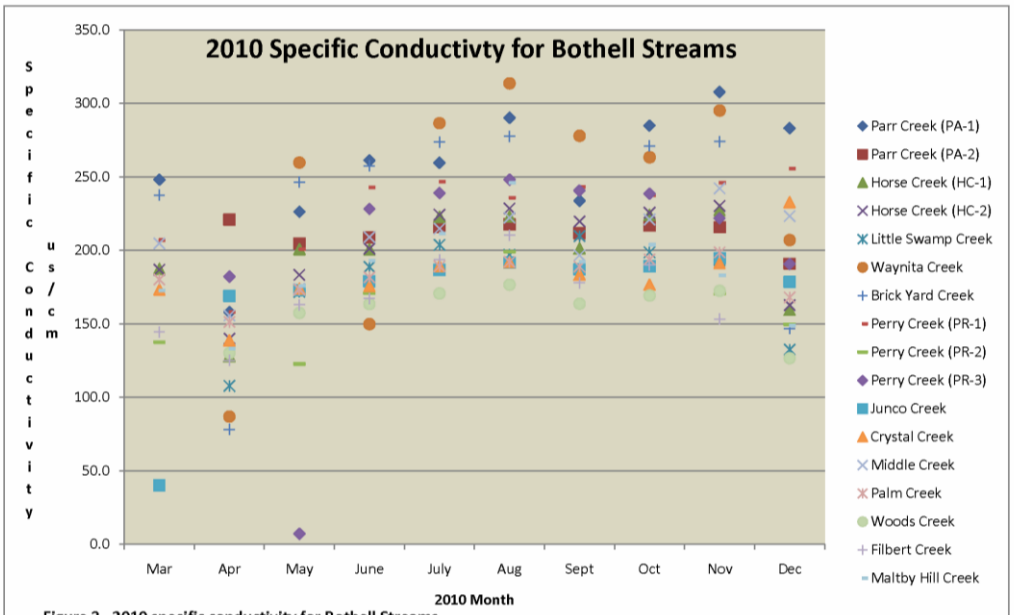

Figure 3. 2010 specific conductivity for Bothell Streams.

pH

Values of pH followed the same seasonal trend as conductivity. No site had recorded measures below or above State water quality standards. The lowest annual average pH was recorded in Parr Creek (7.21 pH), and the highest was recorded at Palm Creek (7.98 pH).

NTUs (Nephelometric Turbidity Units)

Turbidity levels were typically positively correlated to rain events. Parr Creek tended to have highest turbidity readings throughout the year due to algae diatom blooms from an upstream wetland pond. Two streams, Horse Creek and Waynita Creek, with active construction or demolition work upstream of the sample locations at times had elevated levels of turbidity that were unrelated to rain events. Perry Creek was affected by an illicit discharge that caused the highest reading among all sites for the year at 50.7 NTUs.

Temperature

Temperature loggers were deployed at ten sites in late April 2010. The loggers measured stream temperature at 15-minute intervals. One deployed logger failed to record temperatures at Waynita Creek. Loggers were retrieved in May 2011. The results in this assessment are limited to the period of April 24, 2010 to December 31, 2010. Data was cropped pre-retrieval and post-deployment to allow for same start and finish time for all streams. This allowed direct comparison of logger data for all streams for 2010.

Figure 4 depicts the number of days a site exceeded Washington State Department of Ecology (WDOE) water quality standards, 7DADMax. The 7DADMax is a running average of maximum daily temperature over a 7-day period. The State standards for streams vary depending on time of year and use designation. For all streams in Bothell, the aquatic life temperature criteria is salmon and trout spawning not to exceed 7DADMax of 13 C from September 15th to May 15th, and core summer salmonid habitat not to exceed 7DADMax of 16 C any time of year.

All streams exceeded WDOE standards in May, August, and September 2010, except for Palm Creek (PM-1) which never exceeded WDOE standards throughout the entire recording period. All streams met temperature standards for November and December, 2010. Middle Creek (MD-1) and Parr Creek (PA-1) had the most days exceeding WDOE standards, 156 and 118 days respectively (this is not straight count because one day could count as two days if both 13 and 16 C 7DADMax were recorded).

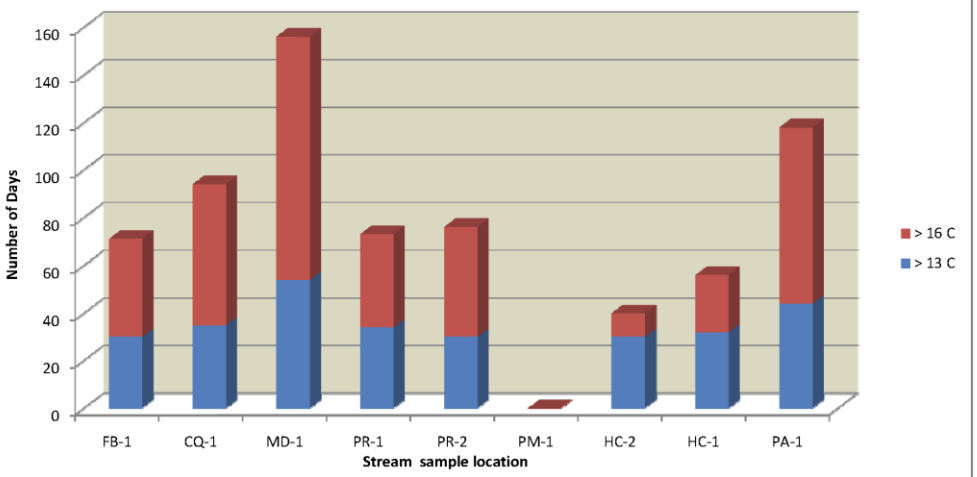

Figure 4. 2010 stream temperature by number of days exceeding WDOE standards.

An anomaly was observed on May 4, 2010 (Figure 5). On this date all streams experienced a sudden drop in temperatures. Two streams, Crystal Creek (CQ-1) and Filbert Creek (FB-1) experienced a rapid drop in stream temperature of 5.1 and 5.0 C within 30 minutes. National Oceanic Atmospheric Administration weather records for the day recorded clouds and rain. KOMO TV News station's archives describe a windstorm and convergence zone on May 3, 2010 which was "followed up by impressive hail storms on Tuesday" (May 4, 2010). There are several web cams (Figure 6) that depict accumulation of hail in the area of these two streams' watersheds. Temperature declines in November were slower in developing as they were in response to a weeklong drop in air temperature and light accumulations of snow during this period.

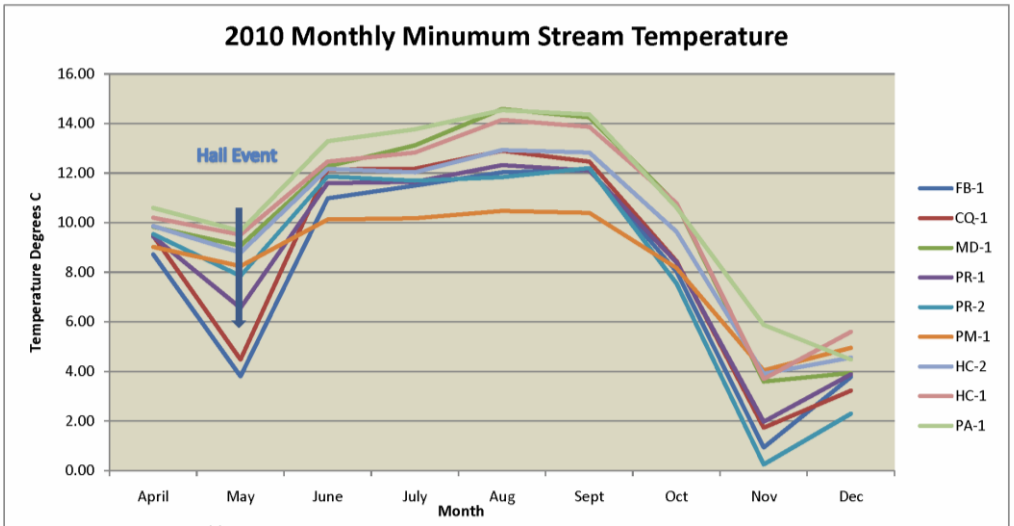

Figure 5. 2010 Monthly average minimum stream temperature .

Figure 6. Washington State Department of Transportation web cam image of I-405 in the vicinity of northwest Bothell, 4:59 PM on May 4th, 2010.

Physical

Hydrology Flows

Instantaneous flow estimates were made visually during routine monthly sample events. Flows were measured using floating object technique during macroinvertebrate sampling events. All flow measures were plotted on a monthly basis for the annual summary of flow measures (Figure 7). Palm Creek (PM-1) had the highest estimated average annual flow, followed by Horse Creek. Waynita Creek showed the largest range between minimum and maximum flows with an overall yearly difference of 2.98 cubic feet per

second (cfs). Most streams tended to exhibit a nonsymmetrical behavior of having peak flows disproportionately higher than the annual average flow of that observed towards low flows.

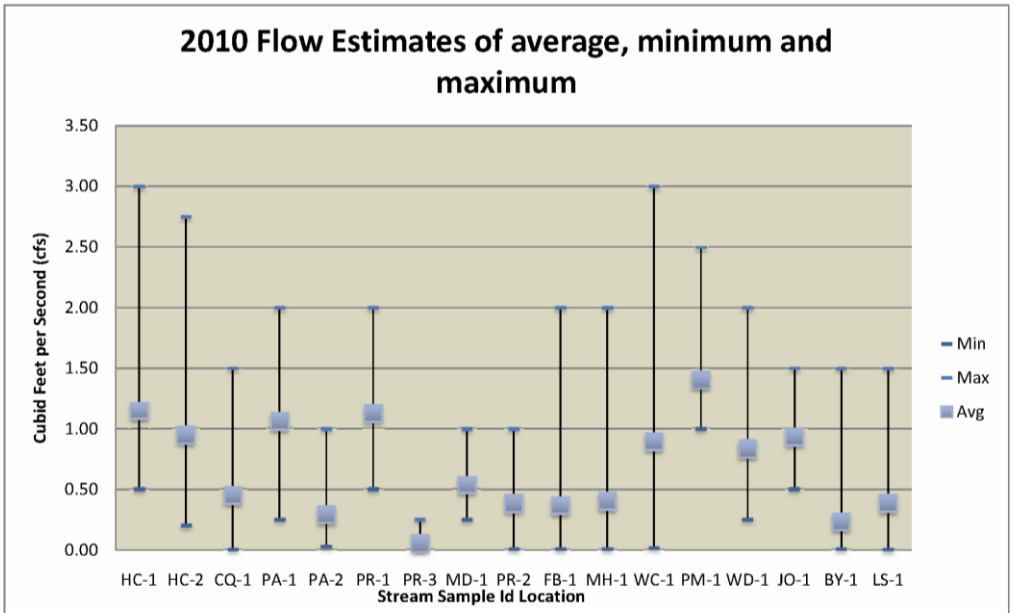

Figure 7. 2010 annual flow average from monthly sample events.

Pebble Counts

Sediment pebble counts were conducted at all seven bioassessment sites. Each site's four riffles sampled for macroinvertebrates were surveyed with a minimum count of 50 sediment particles equally spaced across the channel between ordinary high water marks. The count from four riffles was then summed cumulatively for a 200-count (Figure 8). Each site was assessed for D50 and D84 values and graphed by percent cumulative finer.

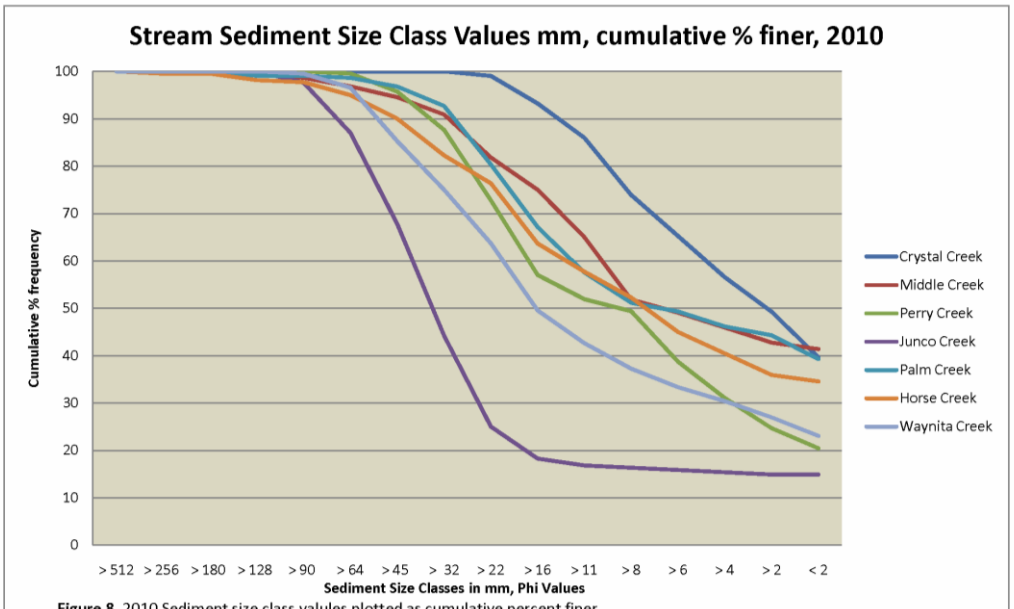

Figure 8. 2010 Sediment size class valules plotted as cumulative percent finer.

All streams contained 15% or greater of fines < 2mm. Middle Creek and Crystal Creek had the highest percentage of < 2mm at 41% and 40% respectively. Fines > 15% of < 2mm tend to have negative effects on aquatic biota. The D50 and D84 values for Junco Creek had the highest percentage of sediment size class with a D50 value of 32mm and D84 of 64mm indicating larger gravels being present. Crystal Creek had the lowest percentage of large sediment size class with D50 value of 2mm and D84 of 11mm.

Channel Morphology

Two ratios, bankfull width (BFW) to depth (D), and a wetted width (WW) to BFW, were calculated to assess channel characteristics. Channels with BFW/D ratios of < 12 are highly entrenched, Rosgen 1994. All streams were strongly entrenched with only Junco Creek being relatively less so. On average, streams had BFW/D ratio of 5.21, excluding Junco Creek which had BFW/D ratio of 11.98. Entrenchment typically indicates downcutting of the stream channel, thus orphaning it from its flood plain. Wetted width (WW) to BFW expresses how the stream occupies the channel at low flow. Is it narrowly confined or is it spread out across the channel? A WW/BFW of > 40% indicates widths approaching the entire bankfull channel. All the streams exhibited widths that tended to occupy large portions of their bankfull widths (Table 2).

Table 3. 2010 physical stream attributes.

Channel and Riparian Stream Surveys (Meters)

Stream	Reach Length M	% Gradient	WW Width	Average Bankfull Measures		BFW / Depth	WW / BFW
				Width	Max Depth		
Junco Creek	75	1	2	3.78	0.32	11.98	0.53
Crystal Creek	38	1	1.4	3.1	0.58	5.34	0.45
Palm Creek	70	4	1.8	2.7	0.41	6.59	0.67
Perry Creek	66.8	2	1.9	2.43	0.65	3.74	0.78
Middle Creek	42	2	1.4	2	0.45	4.44	0.7
Waynita Crk	51	2.5	1.52	3.2	0.56	5.71	0.48
Horse Creek	51	3	1.3	2.18	0.4	5.45	0.60

Canopy Closure, Instream Habitat, and Large Wood

Canopy closure readings were taken as part of the bioassessment surveys. Stream canopy closure levels ranged from a low of 30% closure on Middle Creek to a high of 97% closure on Junco Creek (Table 3).

Table 4. 2010 stream channel and instream habitat survey results.

Stream	Pools				Wood			% Canopy Closure
	% Pool Area	RPD*	Pools / 100 M	Pools / BFW	#Pcs / BFW Zone 1	#Pcs / BFW Zone 2	Total Pcs / BFW	
Junco Creek	0	0	0	0	0.3	0.2	0.5	97
Crystal Creek	N/A	N/A	N/A	N/A	0	0	0	79
Palm Creek	4.7	0.23	1.4	26	0.3	0.2	0.5	64
Perry Creek	20.8	0.2	7	6	0	0	0	91
Middle Creek	13.1	0.2	2.4	21	0	0	0	30
Waynita Crk	17.6	0.2	7.8	8	0	0	0	70
Horse Creek	12.9	0.2	7.5	16	0	0	0	35

**Residual Pool Depth (RPD)*

Instream habitat measured as percent pool area and BFW spacing between pools are indicators of habitat diversity. High diversity of habitat can allow for a healthy diverse biological community. May, 1996 developed target conditions for instream habitat for Puget Sound Lowland (PSL) streams. Conditions of instream habitat were classified as: good, fair, and poor. We assigned a numerical value to the conditions where 5 = good, 3 = fair, and 1 = poor.

All streams scored poor ranking for pool habitat (Table 4). Junco Creek had no well-defined pools despite it having been a stream restoration site with installation of large wood and excavated depressions. The pool tail-out depths in Junco Creek were too deep such that pools failed to meet the minimum pool tail-out depths needed to be defined as a pool. Contributing to poor pool habitat was the lack of wood in all the streams. The lack of instream obstructions can impede formation of pools. Habitat surveys on Crystal Creek were not conducted due to changes in stream flows from a rain storm event. Habitat quality was assessed using photographs taken prior to the rain event from the day of macroinvertebrate surveys.

Table 5. 2010 stream channel and instream habitat score results.

Stream	% Pool Area	Pools/ BFW	Wood #pcs/ BFW	Sediment D10
Junco Creek	Poor	Poor	Poor	Poor
Crystal Creek	Poor*	Poor*	Poor	Poor
Palm Creek	Poor	Poor	Poor	Poor
Perry Creek	Poor	Poor	Poor	Poor
Middle Creek	Poor	Poor	Poor	Poor
Waynita Crk	Poor	Poor	Poor	Poor
Horse Creek	Poor	Poor	Poor	Poor

Target condition scoring based on May, 1996.
**Based on photographs taken day of macroinvertebrate survey.*

Large wood counts found most streams devoid of large wood (Table 3). Instream wood, fallen trees with and without branches, promote complex habitat and storage of sediment and flow energy dissipaters. Only two streams, Junco Creek and Palm Creek, had wood of sufficient size to be measured. Junco Stream's wood was installed and pinned in place as part of a stream restoration project. Only Junco Creek had instream wood that interacted with the wetted channel. Palm Creek's wood was located out of the wetted width but within BFW, thus interacting with flows only during high flow events. All streams were ranked as poor using May, 1996 targeted conditions for PSL streams (Table 4).

Riparian/Watershed Condition

Riparian and watershed condition was to be a geographic information system (GIS) exercise. However, due to time constraints and lack of a suitable database, the following was not performed on a basin by basin query in 2010 (Table 2): road density, total impervious surface and forested canopy levels, stream channel conditions (natural vs. piped/ditch), and Riparian Zone conditions. It is anticipated that at some point in 2012, it will be possible to run the needed data queries.

Biological

Macroinvertebrate Metrics

Macroinvertebrate samples were conducted in late August and early September 2010. One replicate sample was collected for quality assurance at Junco Creek. The replicate sample was averaged with the non-replicate for overall average score for Junco Creek. The B-IBI metrics counts for all metrics showed overall general decline in stream biota health (Table 5).

Table 6. 2010 macroinvertebrate metric values and score results.

METRIC VALUES	Perry Creek	Middle Creek	Palm Creek	Junco Creek*	Horse Creek	Waynita Creek	Crystal Creek	Dog Creek
Taxa richness	29	29	26	27	20	28	29	29
E richness	2	1	2	2	2	3	2	2
P richness	3	0	4	3	1	4	3	4
T richness	4	2	5	4	2	1	1	4
Intolerant taxa richness	0	1	0	2	0	0	0	0
Clinger richness	13	6	11	9	5	11	10	12
LL richness	4	1	1	2	1	4	4	1
% tolerant	6.13%	14.20%	3.31%	14.00%	1.05%	2.07%	2.77%	20.08%
% predator	4.28%	17.16%	9.36%	3.00%	2.46%	6.56%	10.55%	5.98%
% dominance (3)	50.56%	48.92%	53.02%	55.60%	89.28%	56.82%	61.94%	46.53%
METRIC SCORES								
Taxa richness	3	3	3	3	3	3	3	3
E richness	1	1	1	1	1	1	1	1
P richness	1	1	3	1	1	3	1	3
T richness	1	1	3	1	1	1	1	1
Intolerant taxa richness	1	1	1	1	1	1	1	1
Clinger richness	3	1	3	1	1	3	1	3
LL richness	3	1	1	1	1	3	3	1
% tolerant	5	5	5	5	5	5	5	3
% predator	1	3	1	1	1	1	3	1
% dominance (3)	3	5	3	3	1	3	3	5
SAMPLE SCORE	**22**	**22**	**24**	**18**	**16**	**24**	**22**	**22**

**Replicate Dog Creek*

Total number of taxa on any one stream did not exceed 29. A typical unimpaired stream would have had from 53 to 60 or more present. Mayfly taxa was primarily represented by *Baetis tricaudatus.* The two are considered relatively tolerant and colonize disturbed habitat. Overall, streams showed low mayfly diversity indicating chemical pollution. This was evident on Palm Creek with low mayfly diversity relative to moderate stonefly and caddisfly diversity. This combination often indicates chemical pollution as stonefly and caddisfly tend to be more tolerant of chemical pollution (Fore, 1999).

Stonefly diversity was low for most streams with Junco, Palm and Waynita Creeks having moderate diversity. Depending on the species, many stoneflies are predators using crevices in between gravel to hide and stalk prey. All streams were heavily impacted by high levels of fine sediment with D50 value of < 2mm (50% of the channel substrate was < 2mm in size). Stonefly decline can indicate warm water temperatures and low dissolved oxygen.

Caddisfly diversity was low for all streams except for Palm Creek which had moderate diversity. Caddisflies are diverse in how they feed and where they live in streams. Their decline signals overall drop in stream habitat complexity. Aquatic habitat diversity for all documented streams was low.

Intolerant taxa are the most sensitive to instream changes and are the first to disappear following human disturbances. All streams had no intolerant taxa present, except Middle Creek where one species was present. The lack of intolerant taxa speaks to the pervasive effect that human disturbances have had across all sampled watersheds.

Clinger taxa have physical adaptations that allow them to hold onto smooth substrates in fast water (Fores, 1999). They are particularly sensitive to high levels of fine sediment that fill the spaces between gravel and cobble. Most streams had moderate levels of clinger taxa present with the minority of streams having low clinger taxa present. All streams were heavily impacted by high levels of fine sediment with D50 value of < 2mm.

Long-living taxa require more than one year to complete their life cycles. They are exposed to all the human activities that influence the stream throughout one or more years. They are good indicators of low flow conditions and catastrophic events that can reduce or eliminate all stream insects within a short period of time. Examples of catastrophic events could include a chemical spill or discharge, low dissolved oxygen levels, periodic dewatering, and temperature extremes. All streams signaled a likelihood of previous catastrophic events. The most affected streams included Middle, Junco, Palm, and Horse Creeks. Horse Creek and Middle Creek have had documented recent catastrophic events consisting of a kerosene spill and a propylene glycol spill.

Tolerant taxa were observed at all streams. Stream degradation favors those taxa tolerant to impaired conditions. All the streams had a low percentage of the assemblage of tolerant species, except for Junco Creek which showed a slight increase in tolerant species.

Predator stream insects are at the top of the food web. Low diversity in predators indicates low diversity of available habitat and prey items. Two streams, Crystal Creek and Middle Creek, had a moderate amount of predator diversity while the other streams had low amounts. Indications suggest that all streams are being influenced by low diversity of habitat and prey.

The last macroinvertebrate metrics considers the percent dominance of the three most abundant taxa. Those streams with high abundance of just a few taxa signal overall low diversity of stream insects. Horse Creek had the highest measure with 89% dominance for its three top taxa. Middle Creek and Junco Creek had good levels of dominance at 49% and 47% respectively. The other streams had moderate levels of percent dominance.

General observations were that blackfly larvae, *Simulium*, were common among most streams and often represented the largest percentage of taxa present. On Horse Creek they represented 57% of all taxa present. Blackfly larvae abundance typically indicates heavy nutrient enrichment. They are collector filter feeders using sticky hair-like fans. They represent more generalist species, as opposed to those which require special foods or particular types of physical habitat. Most streams had no wood-consuming macroinvertebrates. This correlates with the findings of most streams being devoid of instream wood.

Crangonyx (non-insect taxa) was seen at three streams, Perry Creek (12%), Middle Creek (6%), and Horse Creek (25%). The amphipoda's common name is scud. They are mainly detritivorous crustaceans. They prefer small acidic lakes and/or other lentic boggy areas. Their presence indicates potentially high pH and elevated water temperatures > 20˚C. All three streams historically had bogs in their watersheds. Bogs were known to exist at Lake Pleasant which drains south to Horse Creek and north to Perry Creek. North Creek's off-channel flood plain wetlands of Middle Creek have recorded peat soils at or near the surface. Currently, these bogs have been altered such that their hydrology no longer supports bog formation and function. Rather, they act like shadows of their former selves. Only their peat soils continue to exert an influence on downstream waters.

A comparison of B-IBI scores, macroinvertebrate integrity, is found in Figure 9. Streams were assessed to be categorized as either severely impaired or extremely impaired. This indicates strong landscape influences have and continue to have negative influences on a stream's aquatic biota.

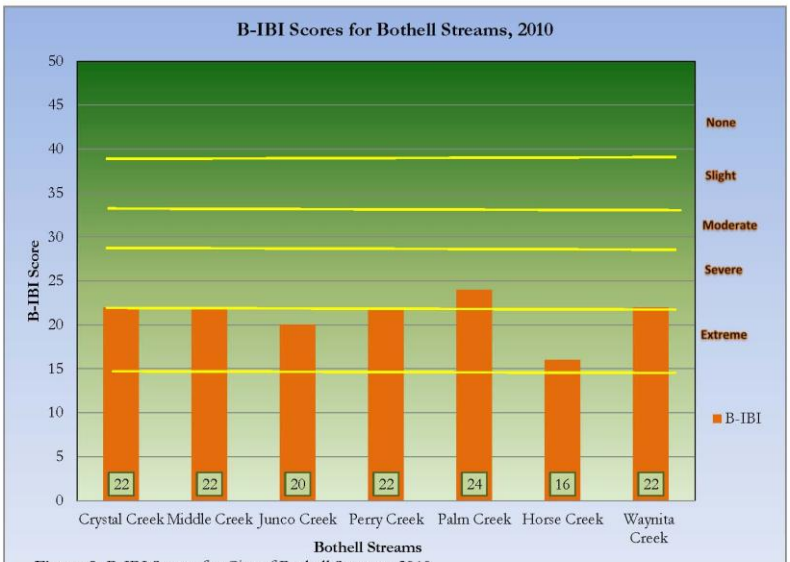

Figure 9. B-IBI Scores for City of Bothell Streams, 2010.

Fish

Electro-fishing surveys occurred in early October 2010. Species diversity was relatively low with only two species found at any one site. Combined, all seven sites had a total of five species with one of those species being non-native. No juvenile Coho Salmon were captured and Cutthroat Trout were the most frequent species found at five out of the seven sites. Horse Creek had no fish. Anadromous upstream fish migration blocks are known to exist downstream of sample locations for Horse, Palm, and Middle Creeks; possible blocks exist at Junco and Waynita Creeks. Crystal and Perry Creeks were the only two streams thought to not have any known anadromous upstream migration blockages.

Table 7. 2010 electro-fish surveys results.

	Perry Creek	Middle Creek	Palm Creek	Junco Creek	Horse Creek	Waynita Creek	Crystal Creek
Cutthroat Trout *Onchorhyncus clarki*	23	0	27	17	0	5	6
Reticulated Sculpin *Cottus perplexus*	0	0	5	0	0	0	1
3-Spine Stickleback *Gasterosteus aculeatus*	0	119	0	0	0	0	0
W. Brook Lamprey *Lampetra richardsoni*	1	0	0	0	0	0	0
Minnow Family *Cyprinidae*	0	11	0	0	0	0	0
Crayfish *(Species unidentified)*	2	0	0	2	0	0	0

Length frequency data of Cutthroat Trout was assessed using common size classification (Whiteway et al., 2010) to determine age classes: < 100mm in length, fish aged 0+ as fry; 100-150mm in length, fish aged 1+ and those classified as parr, and > 150mm which includes age 2+. Of the five streams with Cutthroat Trout, all had at least two age classes present, and one had three age classes present (Crystal Creek). Waynita Creek had no 0+ aged young of the year class. This could indicate spawning and/or rearing constraints causing downward pressure on future fish populations with no future young fish available to mature and reproduce. For general comparison purposes, Table 8 summarizes the fish diversity integrity score for each stream.

Table 8. 2010 summary of fish diversity and salmonid age classes.

Stream	# of Native Species	# Non-Native Species	# of Salmonid Age Classes	Diversity Score
Crystal Creek	2	0	3	**4**
Middle Creek	1	1	N/A	**2**
Junco Creek	1	0	3	**4**
Perry Creek	2	0	2	**3**
Palm Creek	2	0	2	**3**
Horse Creek	0	0	0	**1**
Waynita Creek	1	0	2	**3**

Fish Diversity Score Ranking

1 = No fish

2 = No salmonids and only non-native species present

3 = Native and non-native species present and salmonid age class ≤ 2

4 = Native and non-native species present and salmonid age glass ≥ 3

5 = Only native species present, > 3 species

Stream Health

Overall stream health derived from nine Esoteric Metrics (Table 9) showed some consistency with B-IBI scores. Only streams that received bioassessment surveys are included in Table 8. The esoteric score showed slightly more differentiation between streams than did the B-IBI scores. Palm Creek is ranked the least impaired by both score methods. Most impaired included Horse, Middle, and Junco Creeks. The other streams, Crystal, Waynita, and Perry Creeks, showed similar levels of impairment with all three being severely impaired.

Table 9. 2010 esoteric impairment score results.

Creek	Channel Substrate	Aquatic Habitat	Fish	Macro-invertebrate Integrity	Large Organic Wood	Stream Temp.	Dissolved Oxygen	pH	Cond. Level WQ	EIS
Crystal Creek	1	1	4	2	1	1	4	5	1	20
Middle Creek	1	1	2	2	1	1	1	5	1	15
Junco Creek	1	1	4	2	1	1*	4	5	1	19
Perry Creek	1	1	3	2	1	1	4	5	1	19
Palm Creek	1	1	3	2	1	5	5	5	1	24
Horse Creek	1	1	1	1	1	1	4	5	1	16
Waynita Creek	1	1	3	2	1	2*	4	5	1	18

**Junco and Waynita Creek temperature based on general monitoring monthly records.*
Cond. = Conductivity
EIS = Esoteric Impairment Score

All streams had the lowest possible score for the following: little to no large wood in the active stream channel, high levels of fine sediment and conductivity, severe to extreme impaired macroinvertebrate communities, and high stream temperatures (with the exception that Palm Creek did not experience high stream temperatures).

Summary

Results for ambient water quality monitoring and bioassessment surveys found degraded conditions throughout the City. Best available science has frequently found such levels of degradation to be related to common and pervasive urban development. Urban development is often characterized as having: dense road network, high levels of impervious surfaces, loss of riparian corridor (treed stream sides), increase in peak storm flows, inadequate storm runoff controls, reduced wetland acreage, modified stream channel networks, and degraded water quality. It may also include an increase in heavy metals concentrations, nutrients, pesticides and herbicides, and a loss of instream and terrestrial habitat, as well as a decrease (and in some cases extirpated) of native species.

Future

To address the impairments noted in this study, the following are recommended actions:

- ✓ Reduce peak flows, discharge of fine sediment, and polluted storm water to streams.
- ✓ Identify means to retrofit direct discharge of storm water that has been inadequately treated for pollutants and flow volumes.
- ✓ Encourage landowners to enhance and increase riparian zones along streams and wetlands, while limiting future encroachment.
- ✓ Develop and prioritize watershed-based restoration schedule to address instream deficiencies.
- ✓ Allow for and protect stream channel migration zones within floodplains.
- ✓ Educate landowners on improved vegetation management techniques that reduce applications of fertilizers, herbicides, and pesticides.
- ✓ Develop City plans to reduce road-generated pollutants from reaching streams.
- ✓ Continue to monitor the condition of streams for future trend and effectiveness analysis.
- ✓ Increase forested canopy throughout the City that promotes hydrologic maturity runoff conditions.
- ✓ The City's National Pollution Discharge Elimination System Phase II permit should be closely structured around the identified sources of degradation identified in this report.

The City is currently carrying out actions to address the problem of degraded stream conditions. Some of these actions have been ongoing for years, such as the Shoreline Management Plan and Critical Areas Ordinance and the storm water design controls. In 2007, the National Pollution Discharge Elimination System (NPDES) permit issued by Washington State Department of Ecology mandated that the City begin implementation of measures and programs to address storm water impacts on streams. The results here provide a means to measure over time whether the new storm water programs are effective towards meeting the goal to protect and restore the chemical, physical, and biological integrity of the City's surface waters.

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APPENDIX A

2010 Stream Ambient Monitoring Data

Electrofishing Methodology and Study Design

Little Swamp Crk: dwnstrm side of 7th Ave 24200 7th Ave SE

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow
4/8/2010	LS-1	11:00 AM	10.4	7.7	72	107.8	0.1	7.01	lite turbidity	1.5
5/21/2010	LS-1	2:05 PM	9.36	13	132.5	171.8	0.1	7.41	meter off	0.03
6/24/2010	LS-1	2:32 PM	7.81	15.8	155.8	188.8	0.1	7.73	3.31	0.01
7/15/2010	LS-1	2:10 PM	5.62	16.9	172.3	203.7	0.1	6.98	n/a	0.01
8/19/2010	LS-1	11:05 AM	6.34	16.5	165.6	197	0.1	n/a	1.49	0.007
9/28/2010	LS-1	10:20 AM	6.41	16.5	175.5	209.7	0.1	7.62	3.5	0.1
10/21/2010	LS-1	12:55 PM	8.39	11.6	147.7	198.7	0.1	7.91	4.49	0.07
11/29/2010	LS-1	11:16 AM	11.3	8.1	131	193.3	0.1	7.17	2.84	1
12/17/2010	LS-1	10:08 AM	11.12	7.3	87.7	132.5	0.1	6.8	5.17	0.75
		Avg	8.53	12.60	137.79	178.14	0.10	7.33	3.47	0.39
		Std	2.15	4.07	36.61	35.08	0.00	0.40	1.29	0.56
		Min	5.62	7.3	72	107.8	0.1	6.8	1.49	0.007
		Max	11.3	16.9	175.5	209.7	0.1	7.91	5.17	1.5
		Count	9	9	9	9	9	8	6	9

Perry Creek: N of 228th, 30' dwn strm of det/ret pond in retail shopping area.

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/18/2010	PR-1	9:55 AM	12.31	6.7	134.8	207.1	0.1	7.82	4.22	1
4/8/2010	PR-1	11:45 AM	10.84	8.4	108.1	158.2	0.1	7.41	n/t	2
5/21/2010	PR-1	10:40	10.42	11.3	148.1	200.8	0.1	7.54	3.15	1
6/24/2010	PR-1	1:58 PM	9.91	15	196.3	242.9	0.1	8.22	4.64	0.75
7/16/2010	PR-1	2:03 PM	9.86	14.8	198.3	246.7	0.1	7.77	6.83	0.5
8/19/2010	PR-1	1:36 PM	9.27	15.3	192.1	235.8	0.1	n/a	2.12	1
8/23/2010	PR-1	3:45 PM	9.42	15.7	199.8	243.2	0.1	n/a	clr	1.2
9/28/2010	PR-1	10:45 AM	8.73	15.3	193.5	237.5	0.1	7.83	1.93	1
10/21/2010	PR-1	2:53 PM	10.01	11.7	183.7	246	0.1	7.75	2.94	1.2
11/24/2010	PR-1	11:25 AM	12.54	6.7	166	255.6	0.1	7.52	1.57	1.25
12/29/2010	PR-1	10:52 AM	13.05	7.9	12.2	195.4	0	7.57	10.49	1.5
		Avg	10.58	11.71	157.54	224.47	0.09	7.71	4.21	1.13
		Std	1.44	3.71	56.89	30.02	0.03	0.24	2.87	0.39
		Min	8.73	6.7	12.2	158.2	0	7.41	1.57	0.5
		Max	13.05	15.7	199.8	255.6	0.1	8.22	10.49	2
		Count	11	11	11	11	11	9	9	11

Perry Creek: upstream of 19th Ave about 70', above log weirs.

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/18/2010	PR-2	9:30 AM	12.26	6.4	88.6	137.6	0.1	8.41	2.44	1
5/21/2010	PR-2	10:30	10.58	11.3	90.6	122.7	0.1	7.5	2.04	0.25
6/24/2010	PR-2	2:15 PM	9.45	15.9	141.2	170.9	0.1	8.23	7.3	0.25
7/16/2010	PR-2	2:17 PM	8.37	15.1	150.9	186	0.1	7.66	8.68	0.02
8/19/2010	PR-2	1:00 PM	7.16	15.7	163.9	199.2	0.1	n/a	1.33	0.01
9/28/2010	PR-2	11:05 AM	8.31	16.6	157.2	187.5	0.1	7.94	0.61	0.1
10/21/2010	PR-2	3:17 PM	9.76	10.9	138	188.5	0.1	7.82	50.7	0.07
11/29/2010	PR-2	11:34 AM	13.26	5.6	107.3	170.6	0.1	7.64	0.61	0.75
12/29/2010	PR-2	11:07 AM	13.11	4.9	92.3	149.7	0.1	7.79	1.44	1
		Avg	10.25	11.38	125.56	168.08	0.10	7.87	8.35	0.38
		Std	2.21	4.75	30.70	26.04	0.00	0.31	16.15	0.42
		Min	7.16	4.9	88.6	122.7	0.1	7.5	0.61	0.01
		Max	13.26	16.6	163.9	199.2	0.1	8.41	50.7	1
		Count	9	9	9	9	9	8	9	9

Perry Creek: upstrm side of 7th Ave, 2nd strm in from north off of 228th Ave

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
4/8/2010	PR-3	11:30 AM	10.65	8.5	124.6	182.2	0.1	7.47	n/t	0.25
5/21/2010	PR-3	2:17 PM	10.64	10.9	5.7	7.2	0	7.7	clear	0.02
6/24/2010	PR-3	1:46 PM	10.33	13.6	178.7	228.2	0.1	8.35	4.74	0.02
7/16/2010	PR-3	2:34 PM	9.88	13.4	186.2	239	0.1	7.85	err4	0.01
8/19/2010	PR-3	11:19 AM	9.77	13.9	195	248.1	0.1	n/a	2.38	0.01
9/28/2010	PR-3	10:32 AM	8.92	14.2	190.6	240.6	0.1	7.9	1.16	0.08
10/21/2010	PR-3	1:06 PM	9.88	10.4	171.7	238.6	0.1	7.78	4.57	0.05
11/29/2010	PR-3	3:00 PM	11.42	6.6	143.8	221.8	0.1	7.66	0.81	0.05
12/17/2010	PR-3	10:40 PM	12.32	5.8	120.7	190.7	0.1	7.26	0.58	0.03
		Avg	10.42	10.81	146.33	199.60	0.09	7.75	2.37	0.06
		Std	1.00	3.24	59.71	75.68	0.03	0.32	1.87	0.08
		Min	8.92	5.8	5.7	7.2	0	7.26	0.58	0.01
		Max	12.32	14.2	195	248.1	0.1	8.35	4.74	0.25
		Count	9	9	9	9	9	8	6	9

Middle Creek: south of 223rd at CMP outfall about 15' downstream

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/18/2010	MD-1	10:30 AM	10.73	7.9	138	204.7	0.1	7.77	4.15	0.75
4/8/2010	MD-1	3:40 PM	9.79	11.4	115.3	155.7	0.1	7.45	clear	1
5/21/2010	MD-1	11:23	9.02	12.9	133.6	173.9	0.1	7.27	5.93	0.25
6/24/2010	MD-1	11:48 AM	8.57	16.3	174.4	209	0.1	7.77	6.05	0.3
7/16/2010	MD-1	12:48 PM	7.84	16.4	179.6	214.8	0.1	7.68	5.29	0.5
8/19/2010	MD-1	4:03 PM	6.93	17.6	190.7	222.2	0.1	n/a	2.16	0.25
8/25/2010	MD-1	1:30 PM	3.23	19.5	200.4	223.8	0.1	6.99	clr	0.72
9/27/2010	MD-1	2:18 PM	7.69	17.4	168.2	196.6	0.1	7.56	2.63	0.5
10/21/2010	MD-1	2:25 PM	8.26	13	170.6	221	0.1	7.51	clr	0.25
11/29/2010	MD-1	1:44 PM	11.95	8.2	164.3	242.2	0.1	7.36	1.22	1
12/17/2010	MD-1	11:35 AM	11.26	7.9	150.4	223.3	0.1	7.32	2.86	0.4
		Avg	8.66	13.50	162.32	207.93	0.10	7.47	3.79	0.54
		Std	2.40	4.24	25.64	24.72	0.00	0.24	1.83	0.29
		Min	3.23	7.9	115.3	155.7	0.1	6.99	1.22	0.25
		Max	11.95	19.5	200.4	242.2	0.1	7.77	6.05	1
		Count	11	11	11	11	11	10	8	11

Filbert Creek: 20' dwnstrm of rt 524 strm xing

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow
3/18/2010	FB-1	3:15 PM	10.74	8.6	99.3	144.5	0.1	7.73	0.22	0.3
4/8/2010	FB-1	4:26 PM	10.34	9.3	87.4	125.2	0.1	7.48	clear	2
5/21/2010	FB-1	2:45 PM	10.22	11.7	121.7	163	0.1	7.75	clear	0.06
6/24/2010	FB-1	1:00 PM	9.67	15.1	135.6	167.3	0.1	8.08	3.4	0.02
7/16/2010	FB-1	2:55 PM	9.2	15	156.6	193.7	0.1	7.93	2.23	0.01
8/19/2010	FB-1	11:47 AM	8.75	15.6	172.4	210.3	0.1	n/a	4.77	0.01
9/27/2010	FB-1	3:25 PM	8.62	16.8	149.8	177.9	0.1	7.84	2.46	0.1
10/21/2010	FB-1	1:40 PM	9.83	11	139	190	0.1	7.86	1.04	0.03
11/29/2010	FB-1	2:34 PM	12.07	6	97.6	153.3	0.1	7.66	1.68	0.75
		Avg	9.94	12.12	128.82	169.47	0.10	7.79	2.26	0.36
		Std	1.07	3.72	29.31	26.55	0.00	0.18	1.51	0.66
		Min	8.62	6	87.4	125.2	0.1	7.48	0.22	0.01
		Max	12.07	16.8	172.4	210.3	0.1	8.08	4.77	2
		Count	9	9	9	9	9	8	7	9

Horse Creek: about 50' upstrm of confluence with Sam. R.

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/18/2010	HC-1	2:40 PM	10.58	9.4	131.6	187.4	0.1	7.54	3.3	1
4/8/2010	HC-1	9:50 AM	11.3	7.5	85.2	128	0.1	7.25	slightly turbid	3
5/21/2010	HC-1	1:45 PM	10.16	12.2	151.5	200.8	0.1	7.68	meter off	0.75
6/24/2010	HC-1	9:55 AM	9.98	13.8	157.4	200.7	0.1	8.01	2.64	0.75
7/16/2010	HC-1	10:28 AM	9.53	14.3	177.4	222.9	0.1	7.38	4.28	0.5
8/19/2010	HC-1	9:38 AM	9.28	15.5	182.5	223	0.1	n/a	2.8	0.25
9/27/2010	HC-1	1:05 PM	9.05	16.1	167.2	201.3	0.1	7.84	10.38	0.75
10/21/2010	HC-1	12:01 PM	9.38	12	168	224.1	0.1	7.07	1.93	1
11/24/2010	HC-1	10:38 AM	12.22	6.1	145.1	227.3	0.1	7.63	1.98	1
12/29/2010	HC-1	2:00 PM	12.2	6.6	103.5	159.6	0.1	7.54	6.52	2.5
		Avg	10.37	11.4	146.9	197.5	0.1	7.55	4.23	1.15
		Std	1.18	3.7	31.8	32.1	0.0	0.29	2.90	0.88
		Min	9.05	6.1	85.2	128	0.1	7.07	1.93	0.5
		Max	12.22	16.1	182.5	227.3	0.1	8.01	10.38	3
		Count	10	10	10	10	10	9	8	10

Horse Creek: **immediately upstrm of 188th NE strm xing**

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/18/2010	HC-2	2:40 PM	10.27	9.7	132.3	186.8	0.1	7.63	4.92	0.75
4/8/2010	HC-2	10:00 AM	10.95	7.9	94.2	140	0.1	7.25	slightly turbid	2.75
5/21/2010	HC-2	1:30 PM	10.05	12.3	138.8	183.3	0.1	7.54	3.33	0.75
6/24/2010	HC-2	10:06 AM	9.87	13.6	157.3	201.1	0.1	8.03	1.97	0.75
7/16/2010	HC-2	10:53 AM	9.71	13.8	176.5	224.3	0.1	7.72	4.34	0.25
8/19/2010	HC-2	10:17 AM	9.25	14.8	184.3	228.5	0.1	n/a	2.12	0.2
9/14/2010	HC-2	9:30 AM	9.39	14.1	173.7	219.6	0.1	8.08	clr	0.5
9/27/2010	HC-2	12:50 PM	8.67	16.1	168.1	202.8	0.1	7.72	1.6	0.5
10/21/201	HC-2	12:19 PM	9.79	11.1	165.6	225.6	0.1	7.83	2.02	1
11/24/2010	HC-2	10:52 AM	12.66	4.6	140.5	230.2	0.1	7.56	2.88	1
12/29/2010	HC-2	1:50 PM	12.18	6.4	105.1	162.7	0.1	7.52	7.09	2
		Avg	10.25	11.31	148.76	200.45	0.10	7.69	3.36	0.95
		Std	1.22	3.72	29.51	29.67	0.00	0.25	1.80	0.77
		Min	8.67	4.6	94.2	140	0.1	7.25	1.6	0.2
		Max	12.66	16.1	184.3	230.2	0.1	8.08	7.09	2.75
		Count	11	11	11	11	11	10	9	11

Crystal/Queens Borough Creek: about 60' upstrm of confluence with N. Crk.

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/18/2010	CQ-1	3:55 PM	10.39	9.6	122.2	173.3	0.1	7.53	N/R	0.5
4/8/2010	CQ-1	4:18 PM	9.88	9.7	98.1	138.8	0.1	7.4	light turbdity	1.5
5/21/2010	CQ-1	10:52	9.83	11.3	128.6	173.9	0.1	7.07	2.85	0.007
6/24/2010	CQ-1	12:15 PM	9.02	15.6	144	175.7	0.1	8.12	2.76	0.25
7/16/2010	CQ-1	12:58 PM	8.78	15.5	154.9	189.4	0.1	7.68	5.29	0.25
8/19/2010	CQ-1	2:30 PM	8.63	16.2	159.7	192	0.1	n/a/	3.08	0.02
9/2/2010	CQ-1	10:30 AM	9	14.2	145.1	183.5	0.1	7.74	clr	0.15
9/27/2010	CQ-1	3:10 PM	8.37	16.8	149	176.6	0.1	7.71	2.56	0.25
10/21/2010	CQ-1	3:04 PM	9.43	11.4	141.6	191.2	0.1	7.72	1.86	0.25
11/29/2010	CQ-1	2:20 PM	11.22	6.8	152	232.8	0.1	7.42	1.6	0.75
12/17/2010	CQ-1	10:51 AM	11.97	6.4	107.5	166.7	0.1	7.42	1.14	1
		Avg	9.68	12.14	136.61	181.26	0.10	7.58	2.64	0.45
		Std	1.13	3.75	20.03	22.64	0.00	0.28	1.27	0.46
		Min	8.37	6.4	98.1	138.8	0.1	7.07	1.14	0.007
		Max	11.97	16.8	159.7	232.8	0.1	8.12	5.29	1.5
		Count	11	11	11	11	11	10	8	11

Junco Creek: TMDL study site along N. side of 228th 15' dwn strm of ped. Bridge

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/19/2010	JO-1	1:20 PM	11.28	10.2	28.7	40.1	0	7.47	n/r	0.75
4/8/2010	JO-1	3:30 PM	10.08	10.2	121.3	168.9	0.1	7.42	clear	1.5
5/21/2010	JO-1	11:32	9.75	11.4	127.9	173	0.1	7.44	5.16	0.5
6/24/2010	JO-1	11:40 AM	9.31	13.8	90.4	179.1	0.1	8.03	5.31	0.75
7/16/2010	JO-1	12:38 PM	8.96	14.1	148	186.8	0.1	7.6	4.25	0.5
8/20/2010	JO-1	9:27 AM	9.55	13.6	149.9	191.7	0.1	n/a	2.16	0.75
9/1/2010	JO-1	1:30 PM	8.12	13.6	134.6	171.7	0.1	7.54	clr	1.26
9/27/2010	JO-1	2:08 PM	8.34	14.5	149.6	187	0.1	7.84	0.2	1
10/21/2010	JO-1	2:41 PM	9.27	10.8	138.1	189.3	0.1	7.67	clr	1
11/24/2010	JO-1	1:55 PM	11.23	4	116.6	194.6	0.1	7.58	7.65	1.25
12/17/2010	JO-1	2:18 PM	11.45	7.5	118.9	178.6	0.1	7.61	1.43	1
		Avg	9.76	11.25	120.36	169.16	0.09	7.62	3.74	0.93
		Std	1.15	3.24	35.19	43.65	0.03	0.19	2.59	0.32
		Min	8.12	4	28.7	40.1	0	7.42	0.2	0.5
		Max	11.45	14.5	149.9	194.6	0.1	8.03	7.65	1.5
		Count	11	11	11	11	11	10	7	11

Palm Creek: TMDL study site at Whole Earth Montesorri School, dwn strm of 228th St

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/19/2010	PM-1	1:30 PM	11.47	9.9	128.1	180.2	0.1	7.94	n/r	1
4/8/2010	PM-1	3:20 PM	10.68	10	108.1	151.3	0.1	7.66	clear	2.5
5/21/2010	PM-1	12:01 PM	11.36	10.4	124.7	173.2	0.1	7.86	4.21	1
6/24/2010	PM-1	11:32 AM	11.16	12	136.6	181.7	0.1	8.33	0.97	1.25
7/16/2010	PM-1	12:30PM	11.2	11.9	141.6	189.1	0.1	7.94	2.82	1
8/20/2010	PM-1	9:40 AM	11.12	11.6	142.8	192.2	0.1	n/a	4.04	1
8/26/2010	PM-1	8:30 AM	10.05	11.4	144.7	196.2	0.1	8.34	clr	2.47
9/27/2010	PM-1	2:00 PM	10.61	13.1	145.8	188.9	0.1	8.12	0.73	1
10/22/2010	PM-1	10:26 AM	11.17	10.9	141.4	193.8	0.1	8.07	1.53	1.5
11/24/2010	PM-1	1:44 PM	12.45	5.5	122.7	198.6	0.1	7.79	clr	1.25
12/17/2010	PM-1	2:12 PM	11.84	8.2	113.9	167.9	0.1	7.72	2.07	1.5
		Avg	11.19	10.45	131.85	183.01	0.10	7.98	2.34	1.41
		Std	0.63	2.10	13.13	14.25	0.00	0.24	1.40	0.57
		Min	10.05	5.5	108.1	151.3	0.1	7.66	0.73	1
		Max	12.45	13.1	145.8	198.6	0.1	8.34	4.21	2.5
		Count	11	11	11	11	11	10	7	11

Woods Creek: upstrm of 35th Ave SE xing.

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow
4/8/2010	WD-1	3:10 PM	10.5	10.2	93.2	130.1	0.1	7.58	clear	2
5/21/2010	WD-1	12:14 PM	10.13	11.8	117.6	157.4	0.1	7.74	5.88	1
6/24/2010	WD-1	11:14 AM	9.9	14.7	131.1	163.4	0.1	8.14	3	0.5
7/16/2010	WD-1	12:12 PM	9.68	14.8	137.4	170.7	0.1	7.86	2.73	0.5
8/20/2010	WD-1	10:00 AM	10.25	13.9	139	176.6	0.1	n/a	2.23	0.75
9/27/2010	WD-1	1:45 AM	9.26	16.2	136.3	163.7	0.1	7.88	2.37	0.5
10/22/2010	WD-1	10:35 AM	10.77	11.3	124.7	169.2	0.1	7.95	2.65	1
11/24/2010	WD-1	1:32 PM	13.7	2.5	98.1	172.4	0.1	7.76	1.11	0.25
12/17/2010	WD-1	2:03PM	12.36	6.9	82.7	126.6	0.1	7.66	4.41	1
		Avg	10.73	11.37	117.79	158.90	0.10	7.82	3.05	0.83
		Std	1.42	4.37	21.29	18.23	0.00	0.18	1.46	0.52
		Min	9.26	2.5	82.7	126.6	0.1	7.58	1.11	0.25
		Max	13.7	16.2	139	176.6	0.1	8.14	5.88	2
		Count	9	9	9	9	9	8	8	9

Parr Creek: dwnstrm of clvrt at strm xing at N. Crk Prkwy S.

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow
3/19/2010	PA-1	1:45 PM	7.1	10.8	180.4	248.1	0.1	7.16	n/r	1.5
4/8/2010	PA-1	2:00 PM	8.21	9.3	110.7	158	0.1	6.65	turbid	2
5/21/2010	PA-1	12:41 PM	3.27	13.3	175.5	226.3	0.1	7.07	10.71	0.25
6/24/2010	PA-1	10:37 AM	4.12	16.1	216.3	261.3	0.1	7.73	9.54	1
7/15/2010	PA-1	11:16 AM	3.03	17.2	219.7	259.6	0.1	7.01	5.2	1
8/20/2010	PA-1	10:18 AM	2.27	15.6	237.9	290.2	0.1	n/a	7.45	0.7
9/27/2010	PA-1	1:25 PM	2.06	17	197.8	233.7	0.1	7.29	5.56	1
10/21/2010	PA-1	4:13 PM	2.79	12.3	215.6	284.9	0.1	7.41	10.69	0.25
10/22/2010	PA-1	10:50 AM	3.22	12.6	202.4	265.3	0.1	7.16	10.7	1
11/24/2010	PA-1	11:20 AM	5.04	4	184.5	307.8	0.1	7.48	8.29	1
12/17/2010	PA-1	1:41 PM	7.23	7.9	190.5	283.1	0.1	7.13	6.54	2
		Avg	4.39	12.37	193.75	256.21	0.10	7.21	8.30	1.06
		Std	2.18	4.15	33.47	40.74	0.00	0.29	2.23	0.58
		Min	2.06	4	110.7	158	0.1	6.65	5.2	0.25
		Max	8.21	17.2	237.9	307.8	0.1	7.73	10.71	2
		Count	11	11	11	11	11	10	9	11

Parr Creek: Upper E.Frk, 19099 120th Ave SE opposite side of rd along black cyclone fe

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow
4/8/2010	PA-2	3:00 PM	8.63	9	153.6	221	0.1	7.04	clear	0.07
5/21/2010	PA-2	12:30 PM	9.88	11.2	150.7	204.7	0.1	7.45	4.11	0.25
6/24/2010	PA-2	10:52 AM	9.8	12.8	160.2	208.9	0.1	8.08	3.72	0.3
7/15/2010	PA-2	11:32 AM	8.84	13.5	168.6	215.9	0.1	7.49	3.96	0.03
8/20/2010	PA-2	10:08 AM	9.88	13.1	168	217.6	0.1	n/a	2.14	0.25
9/27/2010	PA-2	1:35 PM	8.37	14.7	169.9	211.8	0.1	7.73	0.57	0.1
10/22/2010	PA-2	10:45 AM	9.19	11.5	160.8	216.9	0.1	7.69	1.05	0.5
11/24/2010	PA-2	11:32 AM	11.61	4.6	131.8	215.8	0.1	7.54	0.79	0.11
12/17/2010	PA-2	1:51 PM	11.15	7.9	128.6	190.9	0.1	7.43	1.74	1
		Avg	9.71	10.92	154.69	211.50	0.10	7.56	2.26	0.29
		Std	1.10	3.21	15.38	9.16	0.00	0.30	1.47	0.30
		Min	8.37	4.6	128.6	190.9	0.1	7.04	0.57	0.03
		Max	11.61	14.7	169.9	221	0.1	8.08	4.11	1
		Count	9	9	9	9	9	8	8	9

Brick Yard Creek: at access road to Shop 1 PW crossing on upstream side.

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow
3/19/2010	BY-1	2:00 PM	10.83	9.3	166.2	237.6	0.1	7.73	n/r	0.02
4/8/2010	BY-1	10:30 AM	11.67	6.7	50.8	78.2	0	7.3	light turbid	1.5
5/21/2010	BY-1	3:30 PM	9.71	11.7	183.8	246.5	0.1	7.86	clear	0.03
6/24/2010	BY-1	10:25 AM	9.65	14.2	204.4	257.5	0.1	8.27	4.88	0.02
7/16/2010	BY-1	11:36 AM	9.31	14.6	219	273.8	0.1	8	9.34	0.02
8/19/2010	BY-1	10:05	8.78	15.4	226.7	277.7	0.1	n/a	2.58	0.01
9/28/2010	BY-1	9:10 AM	8.62	16.3	200.3	240.7	0.1	7.93	2.58	0.1
10/21/2010	BY-1	12:38 PM	9.21	11.4	200.6	271.1	0.1	7.93	1.5	0.07
11/24/2010	BY-1	11:03 AM	12.32	4.3	165.8	274.1	0.1	7.6	0.92	0.06
12/29/2010	BY-1	11:41 AM	12.65	6.4	94.9	146.9	0.1	7.76	20.7	0.5
		Avg	10.28	11.03	171.25	230.41	0.09	7.82	6.07	0.23
		Std	1.48	4.20	56.48	65.81	0.03	0.27	7.05	0.47
		Min	8.62	4.3	50.8	78.2	0	7.3	0.92	0.01
		Max	12.65	16.3	226.7	277.7	0.1	8.27	20.7	1.5
		Count	10	10	10	10	10	9	7	10

Maltby Hill Creek: upstream of 214th SE, 10' upstream of stream xing

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
3/19/2010	MH-1	2:20 PM	11.48	9.3	120.9	172.6	0.1	7.7	n/r	0.25
4/8/2010	MH-1	4:10 PM	9.4	10.8	97	133.3	0.1	7.51	clear	2
5/21/2010	MH-1	11:45	7.86	11.6	129.9	175.8	0.1	7.37	4.3	0.03
6/24/2010	MH-1	12:30 PM	6.8	16.4	161.3	193	0.1	7.91	5.98	0.01
7/16/2010	MH-1	1:05 PM	5.59	16.4	175.7	211.6	0.1	7.4	err4	0.03
8/19/2010	MH-1	3:45 PM	5.54	17.1	208.7	246	0.1	n/a	1.66	0.03
9/27/2010	MH-1	2:45 PM	6.45	17.3	163.7	192.2	0.1	7.44	1.96	0.5
10/21/2010	MH-1	2:00 PM	7.97	9.3	142.9	203.9	0.1	7.79	1.2	n/d
11/29/2010	MH-1	02:00PM	11.6	4.7	112	183	0.1	7.38	1.39	0.25
12/17/2010	MH-1	11:25 AM	12.33	4.5	90	148.8	0.1	7.52	0.89	0.5
		Avg	8.50	11.74	140.21	186.02	0.10	7.56	2.48	0.40
		Std	2.56	4.92	37.44	31.83	0.00	0.20	1.91	0.63
		Min	5.54	4.5	90	133.3	0.1	7.37	0.89	0.01
		Max	12.33	17.3	208.7	246	0.1	7.91	5.98	2
		Count	10	10	10	10	10	9	7	9

Waynita Creek: 16204 Waynita Way immediately upstrm of prv bridge but dwn strm

Date	Site Code	Time	DO mg/L	Temp. C	Conduct. *u* s/cm	Specific Conduct. *u* s/cm	Salanity ppt	pH	Turbidity NTUs	Flow cfs
4/8/2010	WC-1	9:40 AM	11.63	7.2	53.6	86.9	0	7.3	turbid	3
5/21/2010	WC-1	3:05 PM	10.74	11.6	192.5	259.7	0.1	8.04	clear	1
6/24/2010	WC-1	9:30 AM	10.61	13.7	116.6	149.8	0.1	8.27	4.59	1
7/16/2010	WC-1	10:41 AM	10.16	14.3	227.9	286.5	0.1	8.04	4.68	0.25
8/19/2010	WC-1	9:18 AM	9.46	15.2	254.2	313.6	0.2	n/a	2.97	0.02
9/15/2010	WC-1		9.5	13.7	218	277.9	0.1	8.22	clr	0.11
9/28/2010	WC-1	9:25 AM	9.51	15.6	203.2	247.8	0.1	8.13	1.36	0.3
10/21/2010	WC-1	11:47 AM	10.32	9.7	180.8	263.3	0.1	7.96	1.85	1
11/24/2010	WC-1	10:15 AM	14.74	2	194.5	Lerr*/295.1	0.2	7.88	1.04	0.75
12/29/2010	WC-1	11:22 AM	12.85	5.8	131.2	207	0.1	7.7	16.9	1.5
		Avg	10.95	10.88	177.25	232.50	0.11	7.95	4.77	0.89
		Std	1.70	4.58	60.05	72.60	0.06	0.30	5.55	0.88
		Min	9.46	2	53.6	86.9	0	7.3	1.04	0.02
		Max	14.74	15.6	254.2	313.6	0.2	8.27	16.9	3
		Count	10	10	10	9	10	9	7	10

Electrofishing Methodology Study Design:

BioAssessment Monitoring

Version 2009.01

City of Bothell™

1909 CENTENNIAL CELEBRATION 2009

Prepared by Surface Water Management
City of Bothell
Public Works
9654 NE 182nd Street
Bothell, WA 98011

Introduction
The bioassessment monitoring will integrate different measures to determine condition and status of surface waters within the City of Bothell. One measure to be collected is fish usage within stream reaches. The measure is one of presence and absence by species. It is not a population estimate but a measure of type of fish present, a length measurement, and a count by species of all fish captured. This will allow creation of several metrics, ratios. The metrics shall be used to measure the health and condition of sampled stream reaches.

Methodology
Streams shall be selected as described in Surface Water Quality Monitoring: BioAssessent, Version 2009.3-02. All electrofishing shall be lead by trained certified electrofisher. At a minimum at least two people shall be present to conduct electrofishing. Electrofishing will be the last activity on streams being sampled. Prior to electrofishing, macroinvertebrate surveys shall be conducted. Other surveys such as pebble counts, habitat, and channel dimensions shall be conducted after macroinvertebrate surveys are performed.

Equipment:
2- Block Nets of 1/8" (0.3cm) mesh nylon net.
3 or more 5-gallon buckets with slots, ¼" by 2" cut 1 to 2" below the bucket rim.
Battery powered aerator
Thermometer, Conductivity meter, YSI-85 Oxygen Meter
Club Soda
Electrofishing unit (Smith-Root LR-20 model)
2-Instream knotless nylon Dip Nets
2- Aquarium dip nets (4" and 6")
2- wash pans
Rubber gloves
Fish length board
Small clear plastic containers
Polarized glasses
First aid kit

Step 1.
Determine fish reach to be sampled. Place block nets across the stream at the upper and lower ends of stream reach to be sampled. Avoid stepping into the stream while walking up and down stream to place block nets. Set up and record information on data sheets.

Step 2.
Using conductivity meter measure conductivity and set electrofisher based upon conductivity readings. Do not electrofish if stream temperatures are below 4-degrees Celsius (C) or above 18-degrees C.

Step 3.

Start at the furthest point downstream and work in an upstream direction. Ensure support staff is prepared and ready to net fish. The intent of the survey is not to capture every fish in the stream. Once a habitat has been shocked and fish captured move immediately upstream to next available habitat. All habitat types should be sampled with equal measure of effort.

Fish captured shall immediately be placed in buckets and monitored for health. If fish are too numerous for more than two 5-gallon buckets, stop electrofishing effort and process fish. The number of fish per bucket is reliant upon size of fish. Avoid placing mature adult trout with juvenile fish. Adult trout may prey on juvenile fish. Once processing is complete and prior to placing fish back into stream, move downstream block net upstream to last point electrofished. After block net is secure, release captured fish back into the stream. Fish should be placed as close to location from which they were captured.

If during electrofishing any mortality is observed, electrofishing shall cease. Electrofisher operator shall inspect settings and adjust to lower settings. If mortality occurs again, electrofishing efforts shall cease. Operator shall inspect electrofisher and recheck conductivity and stream temperature. Electrofishing operations shall not commence until operator makes report on what might of lead to mortality and what if any corrective actions can be taken. If no corrective actions can be taken the electrofishing effort shall cease. When in-stream conditions improve, as determined by electrofisher operator, the stream can be electrofished at a later date.

Place the bucket into the stream while tilting the top of the bucket in a downstream direction to allow stream water to gently swirl into the bucket. Allow fish time to orient themselves to enter the stream current.

If adult anadromous salmonids are encountered cease electrofishing. Do not resume until such time that a stream walk survey finds the stream reach to be free of adult anadromous salmonids. If salmonid redds are present neither walk in the stream nor conduct electrofishing.

Step 4

Upon completion of electrofishing process captured fish. In small wash pans place stream water and bicarbonate soda water to anesthetize fish for measuring. Ensure fish are not stressed by prolonged holding. Note the number of fish by species and length if applicable. Not all fish need to be measured but at a minimum 50% of each species should be length measured. If numbers are fish is small, < 20, take length measures of each.

- Those handling fish should ensure their hands are free of lotions, sunblocks, and insect repellant. Minimize handling fish and do so only with wet hands.

Step 5

Prior to releasing fish back to stream remove block nets and check nets for trapped fish. Release fish back to as near as possible to point of capture.

Step 6

Note length of time fished, electrofisher settings, and any other pertinent comments.

Data
Fish data will be summed and reported by species for total numbers captured, length range with their average and standard deviations, and other pertinent facts. A stream's health shall be assessed based on fish species diversity, number of non-native species present, age diversity, and relative density.

Annual scientific collection reports shall be submitted to Washington Department of Fish and Wildlife. Reports shall detail exact location of electrofishing and fish captured by number and species.

Staff
Andy Loch has used a variety fish capture techniques including but not limited to: beach seines, smolt traps, gill nets and electrofishers since 1984. Since 1984, he has worked as an Aquatic Ecologist for several Native American tribes, State agencies (WDFW and WDOE) and is currently employed with the City of Bothell. In 2002 Mr. Loch is certified electrofisher, Applied Electrofishing and Other Fish Removal Techinques, BIO-407, Seattle WA, 2002.