STATE OF OUR WATERS
FOURTH REPORT

Issaquah Aquatic Resources Monitoring Report 1999-2010

City of Issaquah
Public Works Engineering Department and Resource Conservation Office

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Acknowledgements

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SECTION 1
PROJECT OVERVIEW

1.1 INTRODUCTION

This report updates the results of stream water quality monitoring that was conducted between 2009 and 2010 under the City of Issaquah (City) Aquatic Resource Monitoring Program, which is a long-term surface water program that monitors the water quality conditions in streams within the City of Issaquah. The Program is managed by the Public Works Engineering Department, with assistance from the Resource Conservation Office. Funding is provided by the City stormwater and water utilities, which are funded by utility fees, as well as other City funds and periodic grants from State agencies. This program is also supported by the efforts of the volunteer Issaquah Stream Team.

In 1998, water quality monitoring as part of the Aquatic Resource Monitoring Program was launched to assess water quality conditions in streams within the City of Issaquah. Three earlier reports have been prepared to report the findings since monitoring began. The last report was prepared in 2007 and included monitoring results between 2003 and 2006. Stream Team monthly data collection has been ongoing since the last report, however, the City's storm and baseflow monitoring was suspended between 2006 and 2009. In 2009 additional pollutants of concern were added to the storm and baseflow testing, and the number of sampling stations were reduced to concentrate the effort given the available budget. This report largely focus on this monitoring period, with references to conclusions from the previous reports.

The Aquatic Resource Monitoring Program documents the physical, biological, and chemical stream conditions to 1) assess current conditions of aquatic resources as streams enter and leave the City limits, 2) measure changes in aquatic resource health, 3) evaluate the effectiveness of stormwater management and habitat restoration programs, 4) provide information for compliance with state water quality standards, and 5) educate the community about water quality issues.

1.2 AQUATIC RESOURCE MONITORING COMPONENTS

The Aquatic Resource Monitoring Program includes three components 1) storm and baseflow water quality monitoring, 2) volunteer StreamTeam water quality monitoring, and 3) benthic macroinvertebrate monitoring.

Storm and Baseflow Water Quality Monitoring

City of Issaquah staff collected storm and baseflow water samples quarterly beginning in June 2009. A total of nine stations were monitored between June 2009 and November 2010 (down from 17 stations and 11 outfalls in previous years). Although the number of stations were reduced in 2009 to better assess stream health, the number of water quality parameters being measured increased. The additional parameters included dissolved copper, dissolve lead, dissolved zinc, nitrate-nitrogen, ammonia-nitrogen, surfactants and pesticide/herbicide screen (to supplement total suspended sediment, turbidity, total phosphorus, total zinc, and fecal coliform, which was the testing program prior to 2009). In addition, previous storm and baseflow monitoring had not collected in-situ parameters, dissolved oxygen, pH, conductivity, and temperature. These were added to the storm and baseflow monitoring program. This data is also sampled as part of the volunteer monitoring, but is not necessarily conducted as part of a storm and baseflow event. All stormwater and baseflow samples were tested by AmTest, Inc., of Kirkland, Washington, an analytical laboratory accredited by the Department of Ecology.

Volunteer Stream Team Monitoring

The Issaquah Stream Team has involved community members in the Aquatic Resource Monitoring Program with many members participating in more than one monitoring activity. The Issaquah Stream Team is coordinated and managed by the Stewardship & Resource Conservation Coordinator who recruits, trains, and coordinates volunteers; reviews, manages, and evaluates data; assures monitoring efforts are generating quality data; develops or adapts monitoring methods; and troubleshoots as needed. City staff provide guidance on data needs and uses, share technical knowledge and expertise, and evaluate data for City uses.

Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrates (stream bugs) are clams, snails, crustaceans, worms, and insects (e.g., caddisflies, mayflies, and stoneflies) that live along the bottom of a stream and are visible to the unaided human eye. They provide food for fish, birds, amphibians, reptiles, and other insects. The numbers and kinds of organisms living in a stream are good indicators of the stream's overall health. Macroinvertebrates vary widely in their life history requirements and tolerance of specific types of human disturbance, such as changes in streambed siltation, and changes in water oxygenation levels and temperature. The composition and richness of taxa can thus indicate the condition of a stream.

Measurements of specific attributes of macroinvertebrate populations found at any location on a waterbody given a particular species' sensitivity, will predict the level of human impact there. Conversely, the state of a stream at a particular location will predict the number, diversity, and the type of macroinvertebrates that can live there. Teams of trained volunteers collect benthic macroinvertebrate samples in late summer or early fall.

1.3 BACKGROUND

This document updates monitoring results of streams in the Issaquah Creek Basin within City limits. Monitoring data collected between 1998 and 2010 were used to document current conditions, assess trends and health of the streams.

Issaquah Creek Basin

The Issaquah Creek basin is a 61-square mile basin that includes Issaquah Creek, Tibbetts Creek, and their tributaries. All water in the Issaquah Creek basin drains into Lake Sammamish. The Issaquah Creek basin is considered one of the three most significant basins in King County and a core area for salmon conservation in Water Resource Inventory Area No. 8 (WRIA 8). More than 75 percent of the Issaquah Creek basin is forested, with the remainder in wetlands, pastures, urban (less than 10 percent), and cleared areas. The streams, wetlands, and forests provide habitat for a great variety of fish and wildlife species, including eight species of salmonids, six of which are anadromous. This includes Environmental Species Act (ESA) listed Chinook salmon, steelhead, and bull trout. Currently, 30 percent of the basin is zoned forest production, 12 percent within the urban growth boundary (including City of Issaquah), and the remaining 58 percent in rural zoning. Over 40 percent of the land is owned and managed by public agencies, including the Washington Department of Natural Resources, Washington State Parks Department, King County Parks Department, and City of Issaquah Parks Department (King County Department of Natural Resources 1996).

A portion of the City of Issaquah is located in the floodplains of Issaquah Creek and Tibbetts Creek. Erosion and deposition that occur as part of bank erosion and channel migration are important natural processes in the floodplain. The predominant substrates, which are sand and silt, are highly mobile, especially during storm events. The basin is naturally sediment rich. A study published by the University of Washington Center for Urban Water Resources Management determined that 50 percent of stream sediment is derived from natural landslides, 20 percent from in-stream erosion and 15 percent from road surface erosion. Less significant sources of sediment include agriculture, construction, and landfill and quarry operations. The current sediment production in the Issaquah Creek basin is estimated at 44 tons per square kilometer per year, which is a 33 percent increase over pre-developed conditions (Nelson 2002).

The City of Issaquah accounts for the most urbanized portion of the Issaquah Creek basin. Aquatic resources in the basin have been affected both physically and indirectly by current urbanization impacts such as stormwater runoff and stream/riparian corridor encroachment, as well as past agricultural, drainage, farming, and mining activities. In previous years, it was common practice to use rock riprap to stabilize the banks of streams to prevent impacts on property and structures from meandering stream courses. Straightening of channels, dredging of streambeds, ditching and draining of wetlands, construction of levees, and removal of stream wood also occurred in certain areas. Such stream channel-disturbing activities have largely ceased in recent years, and development activities are now required to minimize or mitigate adverse impacts.

1.4 CITY EFFORTS AT IMPROVING CONDITIONS

The City continues to construct habitat restoration projects to restore natural channel processes that improve habitat and water quality conditions. During the Summer 2010, the City implemented a stream restoration project upstream of Juniper Street, known as Bernsten Park, to restore a small section of Issaquah Creek and associated stream buffer functions that were disturbed by bank hardening and past land uses, improve fish and wildlife habitat, and create a community gathering place and education opportunity within the downtown corridor. The restoration project removed existing rip rap from 160 feet of stream bank, excavated off-channel embayment areas for flood storage and habitat, installed large woody debris (LWD) in the stream and floodplain, and planted native vegetation in the buffer where little vegetation currently existed

The Squak Valley North Restoration Project, located along Issaquah Creek near the City limits along Issaquah-Hobart Road, was also constructed in 2010. This restoration project includes approximately eight acres of stream, riparian and adjacent uplands along Issaquah Creek in and adjacent to Squak Valley Park North. The total area of restoration includes approximately 4.5 acres of stream and riparian habitat enhancements along 1,100 linear feet of Issaquah Creek, approximately 1.1 acres of upland habitat enhancements, and approximately 0.7 acres of wetland habitat enhancement. This restoration project was completed to restore Issaquah Creek and associated floodplain functions that were disturbed by the levee and past land uses, improve fish and wildlife habitat, and maintain and improve flood protection for the surrounding properties.

Future projects will continue, in coordination with regional salmon habitat restoration that is being guided by the WRIA 8 Chinook Salmon Conservation Plan and the City's Stream and Riparian Areas Restoration Plan.

Stormwater management programs have improved since the last State of the Waters Report in 2007 through a variety of efforts designed to improve the quality of stormwater runoff. The goal of the NPDES Phase II Municipal Stormwater Permit, which was issued in February 2007, is to reduce the discharge of pollutants from the City's Municipal Separate Stormwater Sewer System to protect water quality and protect beneficial uses in receiving waters. This goal is accomplished through implementing the City's Stormwater management Program, which includes public education and outreach, illicit discharge detection and elimination (IDDE), controlling runoff from new development, redevelopment, and constructions sites, pollution prevention and operation and maintenance for municipal operations, and annual reporting and record keeping components. All of the City's Annual Stormwater Management Program Reports can be found on the City's web page at http://www.ci.issaquah.wa.us/StormwaterPermit.

SECTION 2
AQUATIC RESOURCE MONITORING PROGRAM

2.1 STORM AND BASEFLOW WATER QUALITY MONITORING

MONITORING PROGRAM OBJECTIVES

The primary goal of the Aquatic Resource Monitoring Program is to continue to collect long-term information on local streams to refine knowledge of water quality conditions. Continued collection of water quality monitoring data and conditions assists the City of Issaquah and watershed forums implement water quality and stream habitat improvement programs. In addition, federal, state and local agencies can use the data to evaluate the condition of water resources within their jurisdictions, assist in management decisions to preserve existing fish and wildlife populations, and to restore water resources to their potential.

The City of Issaquah intends to use the data for the following purposes:

- Assess baseline conditions of water quality in the creeks and storm discharges in the City of Issaquah.
- Detect illicit discharges and other pollution problems.
- Measure changes and trends in aquatic resource health.
- Evaluate the effectiveness of current and future stormwater management and habitat restoration programs.
- Provide information for compliance with state and federal stormwater programs that require monitoring (such as the National Pollutant Discharge Elimination System (NPDES) Phase II stormwater permitting,
- Involve citizens and community groups via education about resource and water quality issues.
- Gather information to be used in planning decisions.

The City's storm and baseflow monitoring program was suspended in June 2006 due to the unknown regulatory and reporting requirements under the NPDES Phase II Permit. In Summer 2009 the storm and baseflow monitoring program resumed with several modifications. Additional pollutants of concern were added, and the number of sampling stations were reduced to concentrate the effort given the available budget.

The primary change instituted in 2009 was the testing for dissolved metals and hardness. Previous testing for metals included total zinc only. State water quality standards are in the form of dissolved, rather than total metals, and thus this data was needed to allow an accurate comparison to water quality standards. In addition, testing for additional nutrients - nitrate-nitrogen and ammonia nitrogen - were added to supplement total phosphorus.

A pesticide screen and herbicide screen was also added to the sampling program at two locations, Issaquah Creek downstream (IC-D) and Tibbetts Creek downstream (TC-D) during spring and fall sampling. This was done to determine if any chemicals of this nature, which can significantly affect aquatic life, were present in the major drainages. Sampling during spring and fall were selected since wet weather was anticipated to coincide with chemical use on lawns and wash-off into storm drainage. Surfactants were also tested at these locations to determine whether it is detectable at levels of concern in the major drainages. While testing for pesticides, herbicides, and surfactants was limited to these two locations only, this was primarily a screening level exercise to find out whether they are present in the major drainages at levels of concern. Evaluation of the screening data would determine whether additional testing for these parameters should be expanded to other water bodies.

PARAMETERS

Baseflow and stormflow water quality samples were collected by City staff. Samples were analyzed by AmTest analytical laboratory for the following parameters:

- Dissolved zinc,
- Dissolved lead,
- Dissolved copper,
- Nitrate-nitrogen,
- Total phosphorus,
- Ammonia-nitrogen,
- Fecal coliform,
- Hardness,
- Pesticide screen (spring and fall storms, IC-D and TC-D only)
- Surfactants (spring and fall storms, IC-D and TC-D only)

In-situ measurements include temperature, conductivity, pH, dissolved oxygen and percent saturation, and turbidity.

SAMPLING EVENTS

Storm and baseflow samples were collected seasonally, and include one storm sample and one baseflow sample during each of the four seasons (i.e., spring, summer, fall and winter). The monitoring was re-initiated in June 2009, which allowed time for a sample to characterize spring baseflow, but a storm sample was unable to be collected to characterize a spring storm at the start of the program. Storm samples were collected during significant rainfall events (greater than 0.25 inches/24 hours) that result in urban runoff and/or stream erosion, and baseflow samples represent dry weather flows in the streams. A total of 13 events were sampled.

Storms:
*9/05/09-summer
*10/29/09-fall
1/10/10-winter
*4/21/10-spring
8/31/10-summer
*10/25/10-fall

Baseflow:
06/03/09-spring
7/28/09-summer
10/07/09-fall
1/28/10-winter
5/14/10-spring
7/21/10-summer
11/4/10-fall
*Surfactants, pesticides and herbicides were sampled during a total of 4 storms. Since the sampling program did not initiate in time to grab a spring storm in 2009, a summer storms was tested for these additional parameters.

MONITORING STATIONS

The Water Quality Monitoring Program focuses on primary streams within the City of Issaquah boundaries. Monitoring station locations selected for monitoring are located on Figure 1. This arrangement allows correlation of changing pollutant levels conditions as a stream enters the City of Issaquah and after it has passed through the City of Issaquah. Intermediate stations allow an additional comparison point to determine impacts based on changing land uses and levels of human impact. Monitoring stations were selected using the following criteria:

- Reasonable and safe access by staff.
- Publicly owned land or permission of landowner to access stream.
- Is representative of the stream as it passes through the City of Issaquah. There may be several reaches on one stream to assess different conditions.
- Effort to replicate monitoring stations used in the past or existing monitoring efforts by regional partners.

A total of nine stream sampling locations were monitored between 2009 and 2010:
(1) Issaquah Creek upstream (IC-U)
(2) Issaquah Creek downstream (IC-D)
(3) Tibbetts Creek upstream (TC-U)
(4) Tibbetts Creek downstream (TC-D)
(5) Trib. 0170 (T0170)
(6) E. Fork Downstream (EF-D)
(7) Lewis Creek Downstream (LC-D)
(8) N. Fork Downstream (NF-D)
(9) Laughing Jacobs Creek Downstream (LJ-D)

Table 1 Storm and Baseflow Monitoring Plan

Monitoring Element	Stations	Analysis Parameters
Base-Storm Stream Sampling	IC-U IC-D TC-U TC-D T-0170 LC-D LJ-D NF-D EF-D	Dissolved Metals (Pb, Zn, Cu) Total Phosphorus Fecal Coliform Nitrate Nitrogen Ammonia-Nitrogen Hardness Temp, pH, DO, Conductivity Turbidity Surfactants- *IC-D and TC-D Only Pesticide Screen- *IC-D and TC-D Only
Sampling Condition	4 storms (quarterly) 4 baseflow (quarterly)	Storm sampling conducted from storms resulting in 0.25 inches of rain in 24 hrs. Surfactants: 2 stations (fall and spring storms) Pesticide Screen: 2 stations (fall and spring storms)

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Following sample collection, samples are packaged in coolers and driven to the analytical laboratory (AmTest in Kirkland). Samples are delivered to the laboratory after completion of sampling on the same day.

The analytical laboratory does not receive samples after 4 pm on weekdays (earlier on Fridays) or anytime on weekends, unless prior arrangements are made. Therefore, sample collection is most often completed in the morning to allow delivery by mid-afternoon.

After samples are handed over to the laboratory, a triplicate chain of custody form is completed by and then signed and dated when transferred to laboratory staff or couriers. The final chain of custody form, with all signatures, is returned with lab results. City staff receive copies of analytical results from the analytical lab within 4 weeks of sample collection. Staff compile the results in electronic form and file the hardcopies.

2.2 VOLUNTEER STREAM TEAM MONITORING

The volunteer Stream Team Program consists of volunteer-collected water samples that are analyzed for temperature, dissolved oxygen, pH, conductivity and turbidity. Monitoring protocols are detailed in the Issaquah Stream Team Training Manual (available upon request from the Resource Conservation Office). All Stream Team members go out during the second weekend of each month to collected *in situ* data.

A total of 27 volunteer sampling stations were monitored monthly by Stream Team members. Of the 27 stations, a total of 16 stations were monitored through 2010. Data are available from another 11 stations that were in operation prior to 2010, before they were terminated(Figure 1) (Tables 2 and 3).

Table 2 Stream Team Sampling Record Through 2010

Volunteer Sampling Station	Sampling Record
0199-D	8/11/02 to 11/14/10
0199-U	2/10/07 to 11/14/10
0200	8/11/02 to 11/14/10
EF-S	11/10/00 to 11/13/10
EF-D	12/13/98 to 11/13/10
EF-U	11/10/00 to 10/15/10
NF-D	12/13/98 to11/7/10
NF-U	11/10/00 to 11/7/10
BN-D	11/10/00 to 11/7/10
15 mile-D	7/13/01 to 11/11/10
IC-D	12/13/98 to11/15/10
IC-J	12/13/98 to 11/15/10
IC-U	12/13/98 to 11/15/10
T-0170 (L)	1/11/03 to 11/14/10
T-0170 (N)	1/11/03 to 11/14/10
TELS	11/9/01 to 11/14/10

Table 3 Stream Team Sampling at Stations Operating Prior to 2010

Volunteer Sampling Station	Sampling Record
CC-D	2/14/99 to 1/22/09
LL-D	12/14/98 to 1/22/09
LJ-D	12/12/03 to 6/14/09
MP-D	12/14/02 to 9/15/08
LJ-U	12/12/03 to 5/13/08
T-0170	11/11/00 to 2/8/08
TC-D	12/13/98 to 2/8/08
TC-M	11/11/00 to 2/9/08
TC-U	12/13/98 to 2/9/08
MH-D	2/14/99 to 11/9/07
WW2-D	1/11/03 to 5/12/07

2.3 BENTHIC MACROINVERTEBRATE MONITORING

Benthic macroinvertebrates are good measures of the health of the streams they inhabit because they are relatively stationary until their adult stage when the insects sometimes travel away as flying adults (such as mayflies, caddisflies, and stoneflies). Measurements of specific attributes of macroinvertebrate populations found at any location on a waterbody given a particular species' sensitivity, will predict the level of human impact there. Conversely, the state of a stream at a particular location will predict the number, diversity, and the type of macroinvertebrates that can live there.

Teams of trained volunteers collect benthic macroinvertebrate samples in late summer or early fall. This is the time of year least likely to have sampling interrupted or delayed by rainfall, as an increase in stream flow can cause macroinvertebrates to crawl deeper into the substrate, making the samples invalid. Samples are preserved, and then sent to a laboratory for identification. The Benthic Index of Biological Integrity (B-IBI) is used to evaluate the biological condition of a stream and to monitor changes over time.

Macroinvertebrate sampling locations closely match the water quality sampling locations unless the site does not meet biological sampling conditions. The sampling and analysis procedures were developed by Dr. James Karr and his colleagues (Karr and Chu 1999). The species level scoring criteria used for this report were developed by Leska Fore (1999). Assistance in development of the Issaquah biological monitoring program was provided by SalmonWeb. In 2002, collection procedures were changed to ensure samples contain at least 300 organisms to meet statistical needs. All previous years data were recalculated to reflect the new collection procedures which extended through 2009 (The 2010 results were not available for this report). The macroinvertebrate analyses were performed by Rithron Associates of Missoula, Montana.

SECTION 3
AQUATIC RESOURCE EVALUATION CRITERIA

3.1 STORM AND BASEFLOW WATER QUALITY

The following three criteria are used to evaluate ambient water quality:

1) State water quality standards (Chapter 173-201A-030 WAC),
2) Background water quality (where available),
3) Sublethal criteria for salmonids derived from the literature.

STATE WATER QUALITY STANDARDS

The Water Quality Standards are the basis for protecting and regulating the quality of surface waters in Washington. The standards implement portions of the federal Clean Water Act by specifying the designated and potential uses of waterbodies in Washington State. They set water quality criteria to protect those uses and acknowledge limitations. The standards also contain policies to protect high quality waters (antidegradation) and in many cases specify how criteria are to be implemented, for example in permits. The water quality standards are established to sustain public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife. Surface waters in the State of Washington are regulated for quality by Chapter 173-201A WAC, administered through the Washington State Department of Ecology (Ecology). The state water quality standards are intended to protect all beneficial uses of surface waters, including the protection of aquatic biota.

Issaquah Creek and its tributaries are categorized as Core Summer Salmonid habitat for aquatic life use. In addition, Issaquah Creek has been assigned as having a Supplemental Spawning and Incubation Protection temperature criteria of 13°C applied September 15th through June 15th. Issaquah Creek is designated as primary contact for recreational use.

Issaquah Creek is on the 2008 Washington Department of Ecology's (Ecology) 303(d) list for violation of dissolved oxygen criteria. In addition the State Department of Ecology is in the process of developing a bacteria water cleanup plan for Issaquah Creek and Tibbetts Creek, termed the "Issaquah Creek Basin Fecal Coliform Total Maximum Daily Load (TMDL)".

Tibbetts Creek and its tributaries are designated as Core Summer Salmonid habitat for aquatic life use; extraordinary primary contact recreation (Table 3). Tibbetts Creek is a relatively short creek (4.3 miles long) that originates on Squak Mountain at an elevation of 1,080 feet. The stream flows through a steep headwater area, then in midcourse opens up to a broad flood plain that empties into Lake Sammamish. Though not a tributary to Issaquah Creek, it shares a common floodplain with the mainstem during large flood events. Tibbetts Creek is on the 2008 Ecology 303(d) list for dissolved oxygen and temperature.

Table 4 Issaquah Creek and Its Tributaries Core Summer Salmonid Habitat Water Quality Standards (Chapter 173-201A-600 WAC)

Parameter	State Water Quality Standard
Dissolved oxygen	The lowest 1-day minimum is **9.5** mg/L. Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.
Temperature	Shall not exceed a **16**°C measured by the 7-day average of the daily maximum temperatures (7-DADMax) due to human activities. The 7-DADMax is the arithmetic average of 7 consecutive measures of daily maximum temperatures. When a water body's temperature is warmer than 16°C, and that condition is due to natural conditions, than human actions considered cumulatively may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C. **Supplemental Spawning and Incubation Protection temperature criteria of 13 ºC to be applied from September 15th through June 15th.**
pH	Shall be within the range of **6.5 to 8.5** with a human-caused variation within a range of less than 0.2 units.
Turbidity	Shall not exceed **5** nephelometric turbidity units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.
Fecal coliforms	**Primary Contact Recreation**: Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies /100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies /100 mL

Ecology 2006

Table 5 Tibbetts Creek and its Tributaries salmonid Spawning, Rearing, and Migration Water Quality Standards (Chapter 173-201A-600 WAC)

Fecal coliforms	**Extraordinary Primary Contact Recreation:** Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies /100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies /100 mL

Ecology 2006

Freshwater aquatic life criteria for certain metals, such as dissolved copper, lead, and zinc discussed in this report, are expressed as a function of hardness because harness can affect the toxicities of these metals. Increasing hardness has the effect of decreasing the toxicity of metals. Water quality standards are calculated at different concentrations of hardness to protect aquatic life.

SUBLETHAL CRITERIA FOR SALMONIDS DERIVED FROM THE LITERATURE

Sublethal effects include water chemistry-induced changes in physiology and/or behavior that affect the competitive vitality or reproductive potential of a fish population without direct lethal effect. This criterion is presented in Table 6 as the literature based "desirable limit". The state water quality standards on the other hand, include a factor of safety to avoid lethal effects, but are not necessarily tied to sublethal effects data. The state water quality standards are intended to protect all beneficial uses of surface waters, not just the protection of aquatic biota. Because Issaquah Creek and its tributaries support native and non-native fish species, the sublethal criteria for salmonids was added to more completely evaluate the health of Issaquah's water quality.

Fish sensitivity to water quality changes is assessed by evaluating data in the literature for behavioral and physiological fish responses to sublethal concentrations of typical water quality contaminants. The following information summarizes the literature review on water quality and fish health. For each parameter, the more restrictive of either the literature review or the state water quality standards is used as the "desirable limit".

Dissolved copper is known to affect survival, growth, behavior, osmoregulation, sensory function and others reviewed by Eisler 1998. Given the ecological significance of these behaviors to salmonids, it is important to characterize the potential effects from dissolved copper. Scientific literature indicates dissolved copper is a potent neurotoxicant that directly damages the sensory capabilities of salmonids any low concentrations (NOAA 2007). Direct exposure to dissolved copper can impair and destroy olfactory sensory neurons in salmonids. In addition, Sandahl *et al* (2007) presented evidence that impaired olfactory (smell) resulted in a direct suppression of predator avoidance behavior (alarm response) by juvenile coho salmon at dissolved copper exposures of 2.0 μg/L (3-hr exposure). The study concluded that juvenile salmon exposed to dissolved copper concentrations at 2 μg/L above a background level of 3.0 µg/L (or less) might not recognize and respond to a predation threat, and therefore have an increased risk of being eaten by other fishes and birds (NOAA 2007). Based upon this finding, the National Marine Fisheries Service (NMFS) uses a biological threshold in their Endangered Species Act (ESA) Section 7 Consultation of 2.0 µg/L above a background level of 3.0 µg/L (or less) dissolved copper (Pacific EcoRisk 2007).

An upper limit of 30 µg/L total lead (16 µg/L dissolved lead) was recommended by Wedemeyer (1977) for continuous exposure in soft water for hatcheries, where stress and crowding can make fish susceptible to disease and impaired physiological processes. NMFS does not have a threshold established for dissolved lead.

NMFS uses a biological threshold of 5.6 µg/L above a background of 3.0 dissolved zinc in their ESA consultations (EcoRisk 2007). For this report, this range is 7.2 to 13.8 µg/L. This is based on Sprague (1968) literature that reported salmonids exhibit avoidance responses to increase zinc concentrations at this concentration.

Ammonia and nitrite-nitrogen can be toxic to fish (Russo and Thurston 1991). Nitrite-nitrogen does not occur naturally or in stormwater runoff at concentrations that are toxic, but can be high in hatcheries when ammonia is also high due to fish crowding (Russo and Thurston 1991). Nitrate-nitrogen is rarely reported in the hatchery literature, reflecting the fact that conventional flows through fish hatcheries do not have nitrate- or nitrite-nitrogen problems. Nitrate-nitrogen is relatively nontoxic to fish, although concentrations in excess of 2 mg/L nitrate-nitrogen may have potential to affect salmonid egg development, based on one study by Kincheloe *et al*. (1979). Generally, nitrate is more likely to be involved in eutrophication problems before being involved in toxic problems for fish. A maximum allowable concentration of 370 mg/L nitrate-nitrogen was recommended for hatcheries based on bioassay studies for chinook (*Oncorhynchus tshawytscha*) (250 mg/L nitrate-nitrogen for trout) by Westin (1974).

Ammonia toxicity rises with pH and temperature, due to the increasing fraction of unionized ammonia that occurs with increasing pH and increasing temperature. Ammonia toxicity is also reported to increase when DO concentrations fall (Russo and Thurston 1991). A 5-year life-cycle test on rainbow trout (*Oncorhynchus mykiss*) was performed over three generations at five ammonia exposure concentrations in the range of 0.01 to 0.07 mg/L unionized ammonia. Lesions were common in fish at 0.02 mg/L ammonia and higher concentrations, however no other major effects were observed, including egg viability, numbers of eggs spawned and produced, growth of progeny, or mortality of parents or progeny of any of the tested generations (Thurston *et al*. 1984). Wedemeyer (1977) recommended 0.02 mg/L unionized ammonia be used as the limit for continuous exposure, which is lower than the toxicity-based state standards under Chapter 173-201A-040-WAC (Ecology 2006).

There have been numerous studies to determine the effects of turbidity on fish. High turbidity can change fish behavior, growth, physiology, and egg development, or indirectly affect fish by decreasing food supply and cover. Species responses to increased turbidity differ. Some fish stop feeding and seek cover, whereas others migrate into tributaries or up or downstream to clearer water (Chapman and Bjornn 1969; Hartman 1965; Olson *et al*. 1973; Ruggles 1966). Physiological reactions to turbidity can include excessive mucus secretion, excretory interference and respiration interference that can lead to suffocation (Ellis 1944; Trautman 1933). One year and older fish can survive high-suspended sediment for considerable periods (Sorenson *et al*. 1977). However, suspended sediment ranging from 100 to 6,000 mg/L were found to be limiting to rearing fish, and concentrations greater than 20,000 mg/L are considered acute lethal concentrations for salmonids (Cordone and Kelly 1961; Sorenson *et al*. 1977). Sigler *et al*. (1984) exposed coho (*Oncorhynchus kisutch*) and steelhead salmon (*O. mykiss*) to varying turbidity over 14 days. After being exposed to turbidity greater than 165 nephelometric turbidity units (NTU), no study fish remained in the channel; 35 percent remained at 143 NTU, and 100 percent remained at turbidity ranging from 57 to 77 NTU.

Turbidity and total suspended solids can indirectly affect fish through their food supply, which is frequently a limiting factor (Leonard 1948). Trout feed on aquatic invertebrates year-round and exhibit an annual cycle of growth that closely corresponds to invertebrate numbers (Brown 1946; Maciolek and Needham 1952). The existing Washington State standard of 5 NTU above background provides a relatively high level of protection, based on a review of studies on habitat alterations due to reductions in light penetration and direct effects of sediment and turbidity on aquatic life (Lloyd 1987). The literature based suggested criteria for total suspended solids is 80 mg/L or less (Wedemeyer 1977), to 100 mg/L or less (Cordone and Kelly 1962; Sorenson 1977).

The suggested criterion for salmonid fisheries for pH is between 6 and 9 (Piper *et al.* 1982 and Wedemeyer 1977). Many fish species can live in waters having a pH greater than 9, even for extended periods, but at the cost of reduced growth and reproduction. Fish species have less tolerance of pH extremes at higher temperatures, and as discussed previously, ammonia toxicity becomes an important consideration at high pH (Piper *et al*. 1982). Trout species could experience mortality at pH greater than 9 (Piper *et al*. 1982).

At very low alkalinities, water loses its ability to buffer against changes in acidity, and pH may fluctuate quickly and widely to the detriment of fish. Therefore, at least 20 mg/L as $CaCO_3$ is the suggested lower limit for continuous exposure to salmonids (Wedemeyer 1977).

Table 6 Water Quality Standards and Guidelines for Sublethal Effect Avoidance for Salmonids

Parameter	Issaquah Creek Drainages Core Summer Salmonid Water Quality Standards	Tibbetts Creek Drainages Salmonid spawning rearing, and migration Water Quality Standards	Literature-Based Fisheries "Desirable Limit" for Sublethal Effects
Temperature (°C)	Less than 16	Less than 17.5	Same as water quality standard
Diss. Copper (µg/L) [1]	4.51-7.54	5.73-16.9	4.3-4.4 [2]
Diss. Lead (µg/L) [1]	0.76-1.49	1.04-4.18	11 to 16 [4]
Diss. Zinc (µg/L) [1]	41.9-69.7	53.1-155.6	6.9 [3]
Ammonia-N, Unionized (mg/L)	2.2 0.006 [7]	2.2 0.006 [7]	7.3 0.020 [7]
Nitrate plus nitrite-N (mg/L)	None	None	Less than 250 [8]
Total Phosphorus (mg/L)	None	None	No direct adverse effects
pH	6.5-8.5	6.5-8.5	6.0-9.0 [5,6]
Diss. O_2 (mg/L)	Greater than 9.5	Greater than 8.0	Same as water quality standard
Hardness (mg/L)	None	None	At least 20 [5]
Turbidity (NTU)	Less than 5 over background	Less than 5 over background	<77
TSS (mg/L)	None	None	<80 [10]
Fecal Coliforms (CFU/100 mL)	100 [9]	100 [9]	--

Note: Dissolved metals water quality standards are based on the average range of hardness within Core Summer Salmonid waters and Salmonid spawning, rearing, and migration waters.

(1) Issaquah Creek downstream station hardness ranged between 34 and 62 mg/L CaCO3. Tibbetts Creek downstream station hardness ranged between 45 and 160 mg/L CaCO3.

(2) EcoRisk (2007); NOAA (2007). Fisheries sublethal limit 2 µg/L above average background of 2.3 µg/L for Tibbetts Creek upstream and 2.4 µg/L Issaquah Creek upstream.

(3) EcoRisk (2007). Fisheries sublethal limit is 5.3 µg/L above background which is 1.6 µg/L at both the Issaquah Creek upstream and Tibbetts Creek upstream stations.

(4) Wedemeyer 1977

(5) Piper *et al*. 1982.

(6) Chronic total and unionized ammonia criterion for 15°C and pH of 7.0 and based on the EPA Gold Book (EPA 440/5-86-001).

(7) Westin 1974.

(8) The standard is for a geometric mean of multiple samples, with not more than 10 percent exceeding 200 CFU/mL.

(9) Wedemeyer 1977; Lloyd 1987.

3.2 BENTHIC MACROINVERTEBRATE EVALUATION

Macroinvertebrates vary widely in their life history requirements and tolerance of specific types of human disturbance, such as changes in streambed siltation, and changes in water oxygenation levels and temperature. The composition and richness of taxa can thus indicate the condition of a stream.

Benthic macroinvertebrates are good measures of the health of the streams they inhabit because they are relatively stationary until their adult stage when the insects sometimes travel away as flying adults (such as mayflies, caddisflies, and stoneflies). Measurements of specific attributes of macroinvertebrate populations found at any location on a waterbody given a particular species' sensitivity, will predict the level of human impact there. Conversely, the state of a stream at a particular location will predict the number, diversity, and the type of macroinvertebrates that can live there.

Macroinvertebrates can give an indication of stream health by:

- Presence or absence of tolerant or intolerant organisms. For example, the presence of many tolerant insects and the absence of intolerant forms suggest an unhealthy stream.
- Diversity (many different kinds) of species. High diversity, often called richness, usually indicates a healthy system. Total taxa richness and the diversity of mayflies, stoneflies, and caddisflies are particularly indicative of the condition of the stream.
- Feeding ecology. Macroinvertebrates include a diversity of "feeding types": scrapers, shredders, collectors, and predators. The relative abundance of predators indicates the number of appropriate prey species in the stream.
- Long-lived macroinvertebrate species. Some species live in stream for over a year. The relative abundance of these species indicates the level of cumulative impacts to a stream.
- Percent dominance of the three most abundant taxa. As physical and chemical characteristics of the stream change due to human activities, often only a few species can adapt to the changes and these opportunistic species start to dominate a stream.
- Relative abundance of macroinvertebrates adapted to specific habitats common in undisturbed streams. Taxa defined as clingers have physical adaptations that allow them to hold onto the smooth substrates in fast water. These animals typically occupy the open areas between rocks and cobbles along the bottom of the stream and thus are sensitive to the filling in of these spaces by sediment.

The B-IBI (Benthic Index of Biological Integrity) was used to assess biological communities as indicators of stream health. An index of biological integrity is a synthesis of diverse biological information that numerically depicts associations between human influence and biological attributes (Karr 1998). The index was created from ten different measured attributes, called metrics that are sensitive to changes in biological integrity caused by human activities. Site conditions are compared to what is expected using a regional baseline condition that reflects little or no human impact (Karr and Chu 1999). One year of benthic macroinvertebrate sampling is sufficient to make an accurate assessment of biological condition of streams but it is not adequate to define trends accurately. A change in seven or more (across an index range of 10-50) is required to represent a statistically significant and biologically meaningful change in the condition of a stream's biota (Fore et al., in press). When evaluating B-IBI scores, information that is more detailed can be determined by examining individual metrics and species composition.

The ten metrics tested and developed for the Pacific Northwest synthesize information on taxonomic richness and composition, tolerance and intolerance (to disturbance), habitat, reproductive strategy, feeding ecology, and population structure into a single index value. A B-IBI sample consists of three replicate samples from one riffle in a stream. The metric values for each replicate sample are calculated and averaged across the three replicates. Averaged raw metric values are given a score of 1, 3, or 5 based on scoring criteria established by previous research in the region. B-IBI values can be interpreted qualitatively and approximately by using the following classes of biological condition:

B-IBI	Biological Condition
46-50	Excellent
38-44	Good
28-36	Fair
18-26	Poor
10-16	Very Poor

A brief description of the metrics in B-IBI and why they are used is presented in Table 7.

Table 7 Description of Metrics used in the Benthic-Index of Biological Integrity

Metric	Description and Purpose
Total Taxa Richness	This is the mean number of invertebrate taxa identified from three replicate samples. The overall diversity of macroinvertebrates declines with human disruptions to a stream system.
Mayfly Richness	This is the mean number of mayfly taxa identified from three replicate samples. The diversity of mayflies declines in response to most types of human influence.
Stonefly Richness	This is the mean number of stonefly taxa identified from three replicate samples. Stoneflies are the first to disappear from a stream as human disturbance increases.
Caddisfly Richness	This is the mean number of caddisfly taxa identified from three replicate samples. Caddisflies feed in a variety of ways. The number of caddisfly taxa decreases as natural habitat complexity declines.
Intolerant Taxa Richness	This is the mean number of taxa identified from three replicate samples. Intolerant taxa are those known to be very sensitive to human disturbance.
Clinger Taxa Richness	This is the mean number of clinger taxa identified from three replicate samples. Clinger taxa are those that have physical adaptations that allow them to hold onto smooth substrates in fast water. Clingers are known to be very sensitive to inputs of fine sediment since they live between spaces in stream bottom rocks.
Long-lived (semi-voltine) Taxa Richness	This is the mean number of long-lived taxa identified from three replicate samples. These invertebrates require more than one year to complete their life cycles, thus they are exposed to all the human activities that influence the stream throughout one or more years. Irregular water flows and on-going problems that interrupt life cycles affect this metric.
Percent Tolerant Taxa	This is the percentage of the invertebrate community made up of taxa tolerant to disturbance. Divide the number of individuals in tolerant taxa by the total number of organisms sorted from the sample, multiply by 100, and average across three replicate samples.
Percent Predator	This is the percentage of the invertebrate community made up of predators averaged across three replicate samples. As the top of the invertebrate food chain, their presence measures the complexity supported by the site. A greater percentage of predators indicate a less disturbed site with appropriate prey species and a variety of habitats in which to find them.
Percent Dominance (Three Taxa)	This is the abundance of the three most abundant taxa in the sample divided by the total number of organisms sorted from the sample, multiplied by 100, and averaged across three replicate samples. A high percent age of the three most abundant taxa indicates some disturbance has likely occurred to the invertebrate community.

SECTION 4
WATER QUALITY RESULTS AND DISCUSSION

The results of water quality sampling on the major creek systems in Issaquah are summarized in the sections below. A summary of volunteer data and complete history of storm and baseflow data for the stations discussed in this report are available in the Appendix Section.

Table 8 summarizes the exceedences of water quality standards for the primary water quality constituents. This summarized how often the standard are exceeded, in terms of percent of samples tested.

Tables 9-15 summarize all data collected during the past two years, with results of each sampling event. The parameters of concern for each stream location are listed at the beginning of each discussion. The entire history of water quality sampling (1998-2010) is contained in Appendix A; separate tables contain the storm/base flow monitoring and the stream team monitoring.

Table 8 Summary of Exceedences of State Water Quality Standards[1]
1998-2010 Data (all data sets)

Location/Station ID	pH	Temp	Dissolved Oxygen	Fecal Coliform	Dissolved Zinc	Dissolved Lead	Dissolved Copper
Issaquah Creek							
Issaquah Creek Upstream (IC-U)	6/147 (4%)	2/149 (13%)	27/148 (18%)	12/61 (20%)	0/13 (0)	2/13 (15%)	1/13 (8%)
Issaquah Creek Juniper (IC-J)	0/139 (0)	0/140 (0)	18/140 (13%)	NM	NM	NM	NM
Issaquah Creek Downstream (IC-D)	5/152 (3%)	4/153 (3%)	34/153 (22%)	23/61 (38%)	0/13 (0)	1/13 (8%)	2/13 (15%)
East Fork Issaquah Creek							
East Fork Upstream (EF-U)	0/108 (9%)	0/108 (0)	11/108 (10%)	NM	NM	NM	NM
East Fork Sunset (EF-S)	0/115 (0)	0/115 (0)	3/115 (3%)	NM	NM	NM	NM
East Fork Downstream (EF-D)	9/154 (6%)	2/148 (1%)	9/146 (6%)	17/61 (28%)	0/13 (0)	2/13 (15%)	1/13 (8%)
North Fork Issaquah Creek							
North Fork Upstream (NF-U)	0/109 (0)	9/109 (8%)	83/108 (76%)	NM	NM	NM	NM
North Fork Downstream (NF-D)	5/147 (3%)	12/146 (8%)	76/147 (52%)	17/60 (23%)	0/13 (0)	3/13 (23%)	1/13 (8%)
Small Tributaries							
Kees Creek Upstream (0199-U)	0/42 (0)	0/42 (0)	9/40 (23%)	NM	NM	NM	NM
Kees Creek Downstream (0199-D	2/99 (2%)	0/99 (0)	35/99 (35%)	NM	NM	NM	NM
Tributary 0200	0/51 (0)	1/51 (2%)	5/49 (10%)	NM	NM	NM	NM
Cabin Creek Downstream (CC-D)	0/110 (0)	5/110 (5%)	19/110 (17%)		NM	NM	NM
Black Nugget Downstream (BN-D)	0/110 (0)	0/110 (0)	36/110 (33%)	NM	NM	NM	NM

(1) [1] State Water Quality Standards for dissolved metals based on Issaquah Creek downstream station hardness range between 34 and 62 mg/L CaCO3. Tibbetts Creek downstream station hardness range between 45 and 160 mg/L CaCO3.

Location/Station ID	pH	Temp	Dissolved Oxygen	Fecal Coliform	Dissolved Zinc	Dissolved Lead	Dissolved Copper
15 mile Downstream (15 mile-D)	1/100 (1%)	2/97 (2%)	22/98 (22%)	NM	NM	NM	NM
Trib East Lake Sammamish (T-ELS)	0/96 (0)	15/88 (17%)	94/96 (98%)	NM	NM	NM	NM
Mountain Park Downstream (MP-D)	2/62 (3%)	2/62 (3%)	23/60 (38%)	NM	NM	NM	NM
Laughing Jacobs Downstream (LJ-D)	3/63 (3%)	1/58 (2%)	25/59 (42%)	5/17 (38%)	0/13 (0)	0/13 (0)	1/13 (8%)
Laughing Jacobs Upstream (LJ-U)	13/47 (27%)	4/47 (9%)	45/47 (95%)	NM	NM	NM	NM
Lewis Creek (LC-D)	0/12 (0)	1/12 (8%)	6/12 (50%)	4/17 (24%)	0/13 (0)	0/13 (0)	1/13 (8%)
Lewis Lane downstream (LL-D)	5/108 (5%)	6/110 (5%)	51/110 (46%)	NM	NM	NM	NM
Mine Hill Downstream (MH-D)	1/104 (1%)	2/104 (2%)	25/101 (25%)	NM	NM	NM	NM
Tibbetts Creek							
Tibbetts Creek Upstream (TC-U)	2/121 (2%)	1/117 (1%)	22/118 (18%)	23/60 (38%)	0/13	1/13	0/13
Tibbetts Creek Manor (TC-M)	0/84 (0)	1/80 (1%)	27/85 (29%)	NM	NM	NM	NM
Tibbetts Creek Downstream (TC-D)	4/123 (3%)	10/108 (9%)	54/121 (44%)	27/60 (45%)	0/13	0/13	1/13
Tributary 0170	6/104 (6%)	10/98 (10%)	97/101 (97%)	32/61 (52%)	0/13	2/13	1/13
Tributary 0170 L	5/69 (7%)	4/69 (6%)	65/67 (97%)	NM	NM	NM	NM
Tributary 0170N	0/67 (0)	4/68 (6%)	50/67 (75%)	NM	NM	NM	NM

Key:
Green 0-15%;
Yellow 15%-35%;
Red >35% above water quality standard;
NM – not measured

4.1 ISSAQUAH CREEK

Parameters of Concern: Dissolved Oxygen, Fecal Coliforms, and Dissolved Copper

Table 16 below summarizes data collected during storm and baseflow conditions since 1998.Table 9 summarizes storm and baseflow data collected with additional parameters between 2009 and 2010 in Issaquah Creek at the upstream and downstream stations. In summary, the following was observed:

- Issaquah Creek upstream and downstream water quality tends to be similar in quality with the exception of higher average fecal coliforms, dissolved copper, dissolved zinc and ammonia-nitrogen at the downstream station.
- Data over the past two years was similar to the previous years data set (Table 16). No trends or significant differences were observed.
- This is the first year dissolved metals have been sampled. The dissolved copper measurements at the downstream station were above the state water quality standard and fisheries sublethal limit for 2 of the 13 samples (15%) (Table 8).

Fecal coliform concentrations entering the City during storm events are relatively high, and remain relatively unchanged as the creek flows through the City. Baseflow fecal coliforms, although not necessarily exceeding water quality standards, are elevated at the downstream station versus the upstream station. The State Department of Ecology is in the process of developing a bacteria water cleanup plan for Issaquah Creek and Tibbetts Creek, termed the "Issaquah Creek Basin Fecal Coliform Total Maximum Daily Load (TMDL)", since fecal coliforms have been a long-term issue within the basin.

Total phosphorus is also responsive to storm events. Total phosphorus concentrations are tied closely to total suspended solids concentrations in the creek, which increase significantly during storms, because phosphorus readily binds to sediment or is naturally present in soil minerals.

Dissolved oxygen concentrations exceeded the water quality standard of 9.5 mg/L during baseflow and storm events. As mentioned previously in this report, Issaquah Creek is listed on the 2004 Washington Department of Ecology's (Ecology) 303(d) list for violation of dissolved oxygen criteria.

pH values were below the water quality standard of 6.5 during 5 of the 13 (38% samples not meeting samples) sampling events, most often during storms. Interestingly the Stream Team volunteer data did not show violations of pH in the historical sampling record (Table 14 Stream Team and City Data Combined).

Dissolved metals, lead, copper and zinc were measured starting in 2009. The Issaquah Creek downstream station exceeded water quality standards on two occasions for dissolved copper and one time for dissolved lead (Table 8). The Issaquah Creek upstream station had two samples of dissolved lead and one sample of dissolved copper above the water quality standard, respectively. Although dissolved zinc was within the water quality standards, one sample of the 13 samples collected at the downstream station was above the fisheries sublethal limit.

Pesticides, herbicides, and surfactants were monitored at the Issaquah Creek downstream station during spring and fall storms (4 samples total) in 2009 and 2010. The laboratory did not detect any of these constituents.

4.2 NORTH FORK ISSAQUAH CREEK

Parameters of Concern: Dissolved Oxygen, pH, Dissolved Lead, and Fecal Coliforms

Table 10 summarizes storm and baseflow data collected between 2009 and 2010 in North Fork Issaquah Creek at the downstream station. The lower portion of North Fork Issaquah Creek typically dries up during late summer in most years, which was the case during the summer 2009 but not 2010.

Overall (Tables 8 and 16) the water quality in North Fork Issaquah Creek displays elevated concentrations of dissolved metals, total phosphorus, ammonia-nitrogen, and in exceedances of fecal coliform concentrations. A majority of the water quality exceedances occur during storm events for turbidity, dissolved metals, and fecal coliforms. Low dissolved oxygen levels are independent of storms. Both the upstream and downstream stations are characterized by low dissolved oxygen (Table 8), likely resulting from the significant groundwater component to this drainage, which typifies lower dissolved oxygen, in addition to the large wetland complex immediately upstream of the North Fork upstream station.

Fecal coliforms were consistently higher during storms than that experienced during baseflow, which is not surprising due to the urban drainage it serves.

pH values were below the water quality standard of 6.5 during 5 of the 13 (38% samples not meeting samples) sampling events collected between 2009 and 2010 (Table 10 below), most often during storms. The Stream Team volunteer data did not show violations of pH during the 2009 and 2010 timeframe or within the historical record (Table 14 Stream Team and City Data Combined). This parameter will be watched in future monitoring to determine if a decreasing trend is resulting.

Dissolved metals increase during storm events. A total of 3 of the 13 samples (23%) collected exceeded the water quality standard of dissolved lead and one sample exceeded the water quality standard for dissolved copper, which also exceed the fisheries sublethal limits derived from the literature (Table 8). Dissolved zinc was within the water quality standard for all the samples analyzed, however roughly 4 of the 13 samples were at or slightly above the fisheries sublethal limit for zinc.

4.3 EAST FORK ISSAQUAH CREEK

Parameters of Concern: Dissolved Oxygen and Fecal Coliforms

Table 11 summarizes storm and baseflow data collected between 2009 and 2010 in East Fork Issaquah Creek at the downstream station. Much of the East Fork Issaquah Creek basin is undeveloped land in Tiger Mountain State Forest, Lake Tradition Plateau Natural Resource Conservation Area, and Grand Ridge open space. Current land use impacts are limited to residential development along the lower reach in the City and highway runoff from I-90 along much of the remaining portion of the creek.

Overall (Table 16 for historical data) East Fork Issaquah Creek water quality remains good. Fecal coliforms tend to increase during storm events in spring and summer. Dissolved oxygen and pH values measured during storm and baseflow event sampling differed than those measured in previous years by the Stream Team. More recent data had violations of the water quality standards more frequently than previously measured.

Dissolved lead was reported above the water quality standard two times (15% of the samples) and dissolved copper was above the water quality standard and fisheries sublethal limit one time (8% of the samples). Dissolved zinc was above the fisheries sublethal limit of 6.9 two times (15%of the samples).

4.4 LAUGHING JACOBS CREEK

Parameters of Concern: Dissolved Oxygen, and Fecal Coliforms

Laughing Jacobs Creek does not have an extensive historical monitoring record. Table 16 summarizes storm and baseflow data collected between 2006 and 2010 in Laughing Jacobs Creek at the downstream station (Table 12 shows results for 2009 and 2010). Laughing Jacobs Creek drains a open water wetland system located East Lake Sammamish Plateau. The drainage basin consists mainly of low-density residential development. The creek discharges to Lake Sammamish in the state park near the boat launch.

Fecal coliforms and dissolved oxygen are the pollutants of concern for this small drainage system. Fecal coliforms increase during storm events. Dissolved oxygen exceeded the water quality standard in 95% of the samples collected at the upstream station and 42% of the samples at the downstream station (Table 8). Low dissolved oxygen seems to be a natural condition in this drainage associated with wetland headwater component.

Dissolved copper was measured above the water quality standard one time out of thirteen samples (8% of the samples) and was taken after an extended period of dry weather (first flush). This sample and one other sample were also above the fisheries sublethal limit. Three of the 13 samples (24%) were at or above the fisheries sublethal limit for dissolved zinc.

Laughing Jacobs Creek drainage appears to have moderate to elevated concentrations of nutrients, total phosphorus, ammonia-nitrogen and nitrate-nitrogen.

4.5 LEWIS CREEK

Parameters of Concern: Dissolved Oxygen, Fecal Coliforms, Dissolved Copper and Zinc

Lewis Creek, like Laughing Jacobs water quality station was newly added to record storm and baseflow water quality in 2006. Table 13 and 16 summarizes storm and baseflow data collected at Lewis Creek at the downstream station. The Lewis Creek Basin drains a 1,209 acre area from the north slopes of Cougar Mountain. Lewis Creek flows northeasterly through approximately 1.5 miles into the southern end of Lake Sammamish within the Meadowbrook Pointe neighborhood. The dominant land use in the watershed is low density residential. Lewis Creek passes through a steep canyon at Cougar Mountain (near Lakemont Boulevard). Reports of high turbidity in the stream, resulting in plumes in Lake Sammamish, have been reported by a lakeshore resident during large storm events. The City of Bellevue operates a large detention pond at the top of the hill, and high flows in the creek are influenced by a trash rack at the upper end of the culvert that passes under I-90. During major storms this trash rack can become clogged with debris; a surge of water is released into lower Lewis Creek when State crews remove the debris with a grappling hook.

Elevated total suspended solids and turbidity concentrations during storm events are the result of this active stream system. Elevated sediment concentrations correlate naturally to elevated phosphorus concentrations.

Fecal coliform concentrations, as well as low dissolved oxygen did not meet water quality standards at times. Fecal coliforms were above the water quality standard in 24% of the samples. Dissolved oxygen was lower than the standard in half of the samples collected in 2009 and 2010, independent of storm/baseflow conditions. Because this drainage is considered a kokanee system near the mouth of Lake Sammamish, dissolved oxygen is a parameter to watch and track in future monitoring.

Dissolved copper was the only dissolved metal measured above the water quality standard. Two samples of dissolved copper out of 13 samples was above the fisheries sublethal limit (Table 8 and 13). This exceedance coincided with a first flush event. During storm events, dissolved zinc concentrations in the creek increase well above baseflow concentrations, and although within the water quality standard, dissolved zinc exceeded the fisheries sublethal threshold 4 times (31% of the samples).

4.6 TIBBETTS CREEK

Parameters of Concern: Dissolved Copper and Dissolved Zinc, Dissolved Oxygen, and Fecal Coliforms

Table 14 and 16 summarizes storm and baseflow data in Tibbetts Creek at the upstream and downstream stations. Tibbetts Creek Basin is characterized as having relatively high sedimentation and subsequent high turbidities, high nitrate and ammonia concentrations, elevated fecal coliforms, and low dissolved oxygen concentrations. Tibbetts Creek is on the Department of Ecology's 2008 303(d) list for the parameters of dissolved oxygen and temperature.

A total of 11 of the 13 samples measured for dissolved oxygen during storm and baseflow conditions were below the water quality standard for dissolved oxygen at the Tibbetts Creek downstream station. Volunteer data reported roughly 44% of the samples were above the water quality standard at the downstream station. Elevated nutrients in the water is likely causing an increase in biological activity, therefore increase of respiration, including that related to the decomposition process, reducing dissolved oxygen at the downstream station. This is the assumed reasoning since the upstream station dissolved oxygen is above the water quality standard on most occasions.

Fecal coliform are elevated above the water quality standard at both the downstream (45% above standard) and upstream stations (38% above standard). Tibbetts Creek fecal coliforms tend to experience extreme peaks in concentrations, very responsive to storm events. Residential development, not served by city sewer, are present in the Tibbetts Creek basin and may be the source of the fecal coliform spikes.

Dissolved metals, lead, copper and zinc were within the water quality standard in the creek at the upstream and downstream stations on all but two occasions. One sample of the 13 samples collected for dissolved lead was above the water quality standard at the upstream station. One sample of dissolved copper at the downstream station was above the water quality standard.

Both dissolved copper and dissolved zinc concentrations were higher at the downstream station relative to the upstream station. A total of 3 of the 13 samples for dissolved copper and dissolved zinc, respectively, collected at the downstream station were above the fisheries sublethal limit.

The Tibbetts Creek downstream station was sampled during the spring and fall for herbicides, pesticides, and surfactants. All the samples were reported below the laboratory detection levels, with the exception of the herbicide 2,4-D, which was at the detection limit of 0.50 µg/L on September 5, 2009. The LC50 for rainbow trout is 1,100 µg/L (1.1 mg/L) which is well above the value detected in Tibbetts Creek. It is noted that a previous study tested 10 urban watersheds in the Puget Sound and 2,4 D and two other chemicals were detected in 100 percent of the samples (USGS 1999).

4.7 TRIBUTARY 0170

Parameters of Concern: Turbidity, Dissolved Oxygen, Metals, and Fecal Coliforms.

Table 15 and 16 summarizes storm and baseflow data in Tributary 0170. Tributary 0170 drains into Tibbetts Creek which enters Lake Sammamish through Lake Sammamish State Park. Tributary 0170 (known locally as “Pickering Creek”) was originally part of Drainage District #4, and now drains stormwater from much of downtown Issaquah between SR-900 and Issaquah Creek. It also receives overbank floodwaters from both Issaquah and Tibbetts Creeks during extreme flooding conditions. A small amount of natural flow is present in this system, from groundwater seepage and a few small natural drainages on lower Squak Mountain.

Tributary 0170 flows in a straight, low-gradient channel. Over time, this dredged channel has become partially sedimented in, and its banks lined primarily with weedy vegetation. Dissolved oxygen is the most significant water quality constituent of concern within this drainage due to continued violation of the water quality standard (Tables 8 and 15). Nutrient rich water, similar to the discussion above for Tibbetts Creek is expected to play a significant role in contributing to low dissolved oxygen levels in this drainage. In addition, during the summer months, the ditch becomes stagnant and experiences elevated temperatures, further resulting in low dissolved oxygen during the summer months. Concentrations below 5 mg/L may adversely affect the functioning and survival of biological communities, and below 2 mg/L may lead to death of most fish. During the summer months it is not uncommon for these low concentrations to occur.

Fecal coliforms, pH and turbidity were above water quality standards during storm events. Fecal coliforms were above the water quality standard 52 percent of the time. Fecal coliforms measured within the Tributary 0170 drainage spike significantly during storm event. The tributary drains the western portion of the City located between Issaquah Creek on the east and SR-900 on the west. The drainage area is developed urban residential and commercial development, majority of which is impervious, which leads the significant peaks in fecal coliforms, as well as other parameters washed off pavement during storm events.

Dissolved metals were within water quality standards for a majority of the samples with the exception of dissolved lead for two samples and dissolved copper for one sample. As mentioned above, Tributary 0170 receives drainage from much of downtown Issaquah west of Issaquah Creek, and the storm event water quality reflects this with elevated concentrations of metals, fecal coliforms and turbidity. Dissolved zinc concentrations were above the fisheries sublethal threshold for 6 of the 13 (46%) samples collected.

Table 9 Storm and Baseflow Water Quality Data Collected in Issaquah Creek 2009-2010

IC-D

Date	***Event Type***	***DO (mg/l)***	***pH***	***Cond (uS/m)***	***Temp (deg C)***	***Fecal Coliform (CFU/ 100ml)***	***TP (mg/l)***	***TSS (mg/l)***	***Turbidity (NTU)***	***Total Zinc (ug/l)***	***Diss Zinc (ug/l)***	***Diss Lead (ug/l)***	***Diss Copper (ug/l)***	***Ammonia -N (mg/l)***	***Nitrate+ Nitrite-N (mg/l)***	***Hardness (mg/l CaCO3)***
6/3/2009	Base	12.6	8.26	132	14.9	170	0.014	2	1.7	0.5	2.0	0.5	1.0	0.098	1.1	48
7/28/2009	Base	12.0	8.50	153	17.8	160	0.033	2	2.13	0.5	0.5	0.5	0.5	0.083	0.73	57
10/7/2009	Base	12.5	7.95	159	9.5	190	0.027	2	2.6	0.5	3.0	1.0	21.0	0.0025	0.96	62
1/28/2010	Base	8.1	6.63	111	6.3	20	0.013	12	5.76	0.5	0.5	0.5	0.5	0.095	1.1	42
5/14/2010	Base	10.2	6.36	110	8.4	60	0.016	2	2.38	0.5	0.5	0.5	0.5	0.0025	0.75	34
7/21/2010	Base	10.4	7.10	130	12.3	10	0.020	2	3.1	1.0	0.5	0.5	0.5	0.0025	0.46	NM
11/4/2010	Base	12.5	6.76	97	8.8	52	0.018	12	7.5	1.9	1.8	0.08	0.9	0.100	1.2	37
9/5/2009	Storm	11.4	7.29	140	14.7	NM	0.035	7	7.2	6.0	5.0	1.0	11.0	0.042	0.67	53
10/29/2009	Storm	11.8	6.43	108	8.4	210	0.033	29	9.5	6.0	0.5	2.0	0.5	0.03	0.85	42
1/11/2010	Storm	9.2	6.30	87	7.9	40	0.016	10	12.9	3.0	3.0	0.5	0.5	0.034	0.43	37
4/21/2010	Storm	9.4	6.67	74	8.0	700	0.087	140	72.2	15.0	0.5	0.5	2.0	0.005	0.61	34
8/31/2010	Storm	10.5	6.26	140	15.8	260	0.022	2	1.81	1.0	0.9	0.03	0.3	0.023	0.67	61
10/25/2010	Storm	12.2	6.22	110	9.8	380	0.038	19	9.5	17.0	10.3	0.50	1.7	0.021	0.59	39

IC-U

Date	***Event Type***	***DO (mg/l)***	***pH***	***Cond (uS/m)***	***Temp (deg C)***	***Fecal Coliform (CFU/ 100ml)***	***TP (mg/l)***	***TSS (mg/l)***	***Turbidity (NTU)***	***Total Zinc (ug/l)***	***Diss Zinc (ug/l)***	***Diss Lead (ug/l)***	***Diss Copper (ug/l)***	***Ammonia -N (mg/l)***	***Nitrate+ Nitrite-N (mg/l)***	***Hardness (mg/l CaCO3)***
6/3/2009	Base	11.7	7.91	120	15.3	100	0.017	1	1.21	0.5	0.5	0.5	0.5	0.052	0.89	44
7/28/2009	Base	11.3	8.40	138	16.6	140	0.012	0.5	2.13	0.5	0.5	16.0	4.0	0.089	0.72	50
10/7/2009	Base	12.1	8.28	141	9.6	62	0.008	0.5	3.41	0.5	2.0	0.5	5.0	0.0025	0.61	52
1/28/2010	Base	9.1	6.65	110	6.1	12	0.017	6	3.65	0.5	0.5	0.5	2.0	0.024	1.1	39
5/14/2010	Base	9.6	6.25	100	8.0	20	0.014	1	1.8	4.0	0.5	0.5	0.5	0.019	0.81	38
7/21/2010	Base	10.5	7.09	120	11.7	2.5	0.013	2	3.2	0.5	0.5	0.5	0.5	0.0025	0.59	NM
11/4/2010	Base	11.6	6.70	91	8.8	20	0.014	8	3.4	5.3	6.6	0.05	1.1	0.0025	1.3	34
9/5/2009	Storm	11.7	7.85	135	13.6	NM	0.021	2	2.81	0.5	0.5	2.0	8.0	0.023	0.12	51
10/29/2009	Storm	11.2	7.30	111	8.2	30	0.032	7	3.92	0.5	2.0	0.5	4.0	0.0025	0.78	45
1/11/2010	Storm	9.5	6.37	81	7.7	10	0.027	14	16.7	3.0	0.5	0.5	0.5	0.048	1.3	32
4/21/2010	Storm	9.4	6.29	83	7.8	1100	0.051	55	78.5	10.0	3	0.5	3.0	0.013	0.72	37
8/31/2010	Storm	10.1	6.45	140	15.1	350	0.018	1	3.0	1.2	0.11	0.03	0.33	0.010	0.73	53
10/25/2010	Storm	11.4	6.03	110	9.8	390	0.031	12	9.5	7.8	3.6	0.39	1.4	0.023	0.92	40

Notes: Grey ½ lab detection level ; yellow notes water quality standards exceeded

Table 10 *Storm and Baseflow Water Quality Data Collected in North Fork Issaquah Creek 2009-2010*

Date	Event Type	DO (mg/l)	pH	Cond (uS/m)	Temp (deg C)	Fecal Coliform (CFU/ 100ml)	TP (mg/l)	TSS (mg/l)	Turbidity (NTU)	Total Zinc (ug/l)	Diss Zinc (ug/l)	Diss Lead (ug/l)	Diss Copper (ug/l)	Ammonia-N (mg/l)	Nitrate+ Nitrite-N (mg/l)	Hardness (mg/l CaCO3)
6/3/2009	Base	9.7	7.70	179	16.3	130	0.054	1	2.41	1.0	0.5	0.5	2.0	0.071	0.19	71
7/28/2009	Base	7.2	8.10	86	21.9	240	0.090	7	19.9	6.0	0.5	9.0	3.0	0.706	0.50	91
10/7/2009	Base	10.5	7.89	199	10.1	34	0.025	17	2.08	0.5	1.0	0.5	2.0	0.018	0.090	74
1/28/2010	Base	7.5	6.75	145	6.2	10	0.037	17	4.81	3.0	0.5	0.5	0.5	0.014	0.53	58
5/14/2010	Base	8.5	6.37	160	9.1	10	0.026	3	1.89	5.0	0.5	0.5	0.5	0.0025	0.18	43
7/21/2010	Base	8.5	6.98	190	13.7	20	0.058	1	4.6	2.0	2.0	0.5	0.5	0.0025	0.16	NM
11/4/2010	Base	8.8	6.70	150	9.8	8	0.038	7	4.2	9.2	5.5	0.05	0.95	0.0025	0.39	56
9/5/2009	Storm	8.9	7.61	142	16.6	NM	0.051	38	7.8	7.0	9.0	4.0	13.0	0.066	0.24	77
10/29/2009	Storm	NM	6.47	140	NM	180	0.032	3	4.8	6.0	2.0	0.5	3.0	0.010	0.15	51
1/10/2010	Storm	9.6	6.37	108	7.6	30	0.026	8	14.6	9.0	7.0	1.0	3.0	0.060	0.40	42
4/21/2010	Storm	8.3	6.76	93	8.9	810	0.045	17	18.1	11.0	2.0	0.5	2.0	0.005	0.16	41
8/31/2010	Storm	8.4	6.36	230	15.8	240	0.054	9	3.67	3.0	9.0	0.03	0.6	0.026	0.13	90
10/25/2010	Storm	9.2	6.25	130	11.1	170	0.038	12	14.5	15.2	7.29	0.48	1.87	0.016	0.13	46

Notes: Grey ½ lab detection level; yellow notes water quality standards exceeded

Table 11 *Storm and Baseflow Water Quality Data Collected in East Fork Issaquah Creek (EF-D) 2009-2010*

Date	Event Type	DO (mg/l)	pH	Cond (uS/m)	Temp (deg C)	Fecal Coliform (CFU/ 100ml)	TP (mg/l)	TSS (mg/l)	Turbidity (NTU)	Total Zinc (ug/l)	Diss Zinc (ug/l)	Diss Lead (ug/l)	Diss Copper (ug/l)	Ammonia-N (mg/l)	Nitrate+ Nitrite-N (mg/l)	Hardness (mg/l CaCO3)
6/3/2009	Base	11.9	8.46	125	15.8	18	0.015	1	1.69	8.0	0.5	0.5	1.0	0.16	0.51	44
7/28/2009	Base	11.8	8.90	159	18.4	200	0.018	0.5	3.25	0.5	0.5	4.0	1.0	0.089	0.72	50
10/7/2009	Base	12.0	8.65	168	9.2	150	0.018	3	5.86	0.5	2.0	0.5	3.0	0.008	0.43	63
1/28/2010	Base	8.2	6.94	116	6.2	6	0.015	6	3.32	0.5	0.5	0.5	0.5	0.030	0.80	37
5/14/2010	Base	9.0	6.63	94	8.8	20	0.012	3	2.7	4.0	0.5	0.5	0.5	0.0025	0.60	30
7/21/2010	Base	9.2	7.24	130	12.0	5	0.028	1	3.4	0.5	0.5	0.5	0.5	0.0025	0.45	NM
11/4/2010	Base	11.6	6.86	97	9.8	6	0.007	4	2.3	5.3	16.8	0.13	0.75	0.0025	1.1	34
9/5/2009	Storm	11.4	8.26	149	15.0	NM	0.041	19	11.4	4.0	0.5	0.5	11.0	0.029	0.64	54
10/29/2009	Storm	NM	6.61	110	NM	62	0.016	0.5	3.6	4.0	0.5	1.0	2.0	0.0025	0.86	36
1/11/2010	Storm	9.8	6.48	83	8.2	20	0.013	10	11.3	6.0	4.0	0.5	2.0	0.0025	0.79	29
4/21/2010	Storm	8.7	6.74	64	8.1	920	0.035	26	24.4	7.0	0.5	0.5	2.0	0.005	0.47	27
8/31/2010	Storm	9.1	6.39	140	15.3	230	0.039	1	5.63	16.0	16.0	0.03	0.8	0.066	0.51	58
10/25/2010	Storm	11.1	6.36	95	11.5	240	0.04	17	8.5	9.18	6.2	0.52	2.2	0.017	0.58	34

Notes: Grey ½ lab detection level; yellow notes water quality standards exceeded

Table 12 Storm and Baseflow Water Quality Data Collected in Laughing Jacobs (LC-D) 2009-2010

Date	Event Type	DO (mg/l)	pH	Cond (uS/m)	Temp (deg C)	Fecal Coliform (CFU/ 100ml)	TP (mg/l)	TSS (mg/l)	Turbidity (NTU)	Total Zinc (ug/l)	Diss Zinc (ug/l)	Diss Lead (ug/l)	Diss Copper (ug/l)	Ammonia-N (mg/l)	Nitrate+ Nitrite-N (mg/l)	Hardness (mg/l CaCO3)
6/3/2009	Base	15.1	8.05	187	15.1	22	0.047	1	3.6	0.5	3.0	0.5	3.0	0.089	0.82	74
7/28/2009	Base	11.2	8.70	227	17.1	200	0.084	3	10.9	0.5	0.5	0.5	4.0	0.059	1.1	95
10/7/2009	Base	12.0	8.06	215	9.6	62	0.028	2	4.0	0.5	0.5	0.5	5.0	0.0025	0.96	84
1/28/2010	Base	7.9	6.85	120	6.2	1	0.024	6	4.7	0.5	0.5	0.5	2.0	0.042	0.61	45
5/14/2010	Base	9.1	7.95	150	7.5	20	0.030	4	2.1	5.0	0.5	0.5	0.5	0.014	0.080	45
7/21/2010	Base	9.6	7.05	200	13.1	20	0.049	7	2.6	2.0	0.5	0.5	1.0	0.0025	0.98	NM
11/4/2010	Base	9.8	6.87	140	9.5	10	0.034	3	4.3	7.4	4.7	0.11	1.1	0.081	1.3	56
9/5/2009	Storm	11.5	8.25	224	14.5	NM	0.093	36	22.0	24.0	7.0	0.5	15.0	0.047	0.91	89
10/29/2009	Storm	7.9	6.50	128	9.5	60	0.051	9	6.2	6.0	0.5	0.5	3.0	0.012	0.37	51
1/11/2010	Storm	10.1	6.33	95	7.3	80	0.048	30	27.8	9.0	3.0	0.5	2.0	0.034	0.43	37
4/21/2010	Storm	9.2	7.01	100	7.2	420	0.054	23	15.7	28.0	2.0	0.5	2.0	0.014	0.31	45
8/31/2010	Storm	9.5	6.46	220	15.8	1100	0.096	10	9.6	9.0	10.0	0.07	1.0	0.093	0.99	89
10/25/2010	Storm	9.6	6.19	130	10.2	140	0.038	14	10.3	14.2	7.72	0.54	2.0	0.018	0.13	46

Notes: Grey ½ lab detection level; yellow notes water quality standards exceeded

Table 13 Storm and Baseflow Water Quality Data Collected in Lewis Creek (LC-D) 2009-2010

Date	Event Type	DO (mg/l)	pH	Cond (uS/m)	Temp (deg C)	Fecal Coliform (CFU/ 100ml)	TP (mg/l)	TSS (mg/l)	Turbidity (NTU)	Total Zinc (ug/l)	Diss Zinc (ug/l)	Diss Lead (ug/l)	Diss Copper (ug/l)	Ammonia-N (mg/l)	Nitrate+ Nitrite-N (mg/l)	Hardness (mg/l CaCO3)
6/3/2009	Base	11.76	8.37	192	15.5	66	0.049	0.50	1.3	2.0	2.0	0.50	2.0	0.083	0.94	73
7/28/2009	Base	10.70	7.26	210	18.5	160	0.095	4	7.3	15.0	5.0	0.50	7.0	0.033	1.3	80
10/7/2009	Base	11.70	8.55	197	10.3	24	0.055	3	2.6	0.5	1.0	0.50	1.0	0.024	0.54	74
1/28/2010	Base	8.1	7.19	112	7.0	2	0.034	0.50	4.32	2.0	0.50	0.50	2.0	0.01	0.78	62
5/14/2010	Base	8.8	6.67	180	8.2	140	0.037	2	2.5	6.0	0.50	0.50	0.50	0.0025	0.89	43
7/21/2010	Base	8.8	7.28	200	13.9	10	0.067	4	3.9	0.50	0.50	0.50	2.0	0.032	0.65	NM
11/4/2010	Base	9.5	7.1	140	9.8	12	0.031	3	2.4	5.8	6.6	0.05	1.1	0.023	1.1	57
9/5/2009	Storm	11.36	8.12	110	15.3	NM	0.086	5	10.9	14.0	15.0	0.50	26.0	0.065	0.77	37
10/29/2009	Storm	NM	6.86	140	NM	100	0.048	21	5.2	12.0	2.0	0.50	3.0	0.0025	0.62	50
1/11/2010	Storm	7.9	6.53	120	8.1	240	0.121	180	99.4	30.0	15.0	0.50	2.0	0.061	0.83	38
4/21/2010	Storm	8.4	6.86	92	7.8	740	0.051	38	20.7	14.0	0.50	0.50	3.0	0.005	0.57	39
8/31/2010	Storm	8.3	6.53	170	15.4	4100	0.524	280	163	83.0	10.0	0.03	3.5	0.058	0.67	70
10/25/2010	Storm	9.1	6.63	120	10.5	100	0.038	6	38	9.09	10.1	0.35	2.6	0.009	0.64	42

Notes: Grey ½ lab detection level; yellow notes water quality standards exceeded

Table 14 Storm and Baseflow Water Quality Data Collected in Tibbetts Creek 2009-2010

TC-D

Date	Event Type	DO (mg/l)	pH	Cond (uS/m)	Temp (deg C)	Fecal Coliform (CFU/ 100ml)	TP (mg/l)	TSS (mg/l)	Turbidity (NTU)	Total Zinc (ug/l)	Diss Zinc (ug/l)	Diss Lead (ug/l)	Diss Copper (ug/l)	Ammonia-N (mg/l)	Nitrate+ Nitrite-N (mg/l)	Hardness (mg/l CaCO3)
6/3/2009	Base	11.4	7.86	264	16.7	120	0.026	4	5.28	2.0	0.5	0.5	2.0	0.18	0.56	110
7/28/2009	Base	6.9	8.05	373	23.8	120	0.039	10	7.8	2.0	3.0	0.5	6.0	0.082	0.28	160
10/7/2009	Base	8.8	7.83	348	10.4	40	0.017	3	9.8	0.5	3.0	0.5	3.0	0.0025	0.37	150
1/28/2010	Base	8.6	7.09	205	6.6	12	0.015	8	5.75	0.5	0.5	0.5	2.0	0.052	1.5	85
5/14/2010	Base	8.7	6.39	180	8.8	20	0.026	3	3.6	4.0	1.0	0.5	0.5	0.025	1.2	57
7/21/2010	Base	8.4	7.40	340	14.6	35	0.038	2	4.7	4.0	10.0	0.5	1.0	0.0025	0.33	NM
11/4/2010	Base	8.8	6.89	160	11.8	22	0.017	7	5.3	2.2	2.45	0.05	0.96	0.073	2.8	64
9/5/2009	Storm	6.9	7.31	291	16.5	NM	0.066	29	36	7.0	9.0	1.0	13.0	0.138	2.5	120
10/29/2009	Storm	NM	6.74	220	NM	3800	0.034	5	6.85	33.0	0.5	0.5	4.0	0.038	1.00	86
1/11/2010	Storm	10.1	6.42	116	8.1	130	0.051	46	53.5	8.0	4.0	0.5	3.0	0.0025	1.6	45
4/21/2010	Storm	8.3	6.59	110	8.6	900	0.053	41	48.5	12.0	2.0	0.5	2.0	0.018	0.83	50
8/31/2010	Storm	7.4	6.43	310	17.2	4900	0.115	35	76.1	10.0	7.5	0.03	12.0	0.207	0.42	140
10/25/2010	Storm	8.3	6.34	170	13.3	210	0.040	16	35	8.7	6.47	0.46	2.24	0.032	0.76	69

TC-U

Date	Event Type	DO (mg/l)	pH	Cond (uS/m)	Temp (deg C)	Fecal Coliform (CFU/ 100ml)	TP (mg/l)	TSS (mg/l)	Turbidity (NTU)	Total Zinc (ug/l)	Diss Zinc (ug/l)	Diss Lead (ug/l)	Diss Copper (ug/l)	Ammonia-N (mg/l)	Nitrate+ Nitrite-N (mg/l)	Hardness (mg/l CaCO3)
6/3/2009	Base	11.7	8.12	157	14.1	22	0.02	1	4.03	0.5	0.5	0.5	2.0	0.06	1.1	65
7/28/2009	Base	11.1	8.10	160	16.1	6	0.013	51	2.35	8.0	0.5	3.0	7.0	0.065	0.49	70
10/7/2009	Base	11.4	8.40	209	9.1	24	0.018	18	2.1	0.5	3.0	0.5	3.0	0.0025	0.80	88
1/28/2010	Base	9.0	7.08	170	6.2	2	0.008	6	3.12	0.5	0.5	0.5	0.5	0.030	2.0	56
5/14/2010	Base	9.6	6.25	200	8.1	40	0.027	5	1.7	5.0	0.5	0.5	0.5	0.023	1.2	40
7/21/2010	Base	10.2	7.47	340	8.9	25	0.051	10	2.1	12.0	2.0	0.5	2.0	0.0025	0.35	NM
11/4/2010	Base	10.9	7.20	180	10.8	45	0.053	7	2.5	2.8	2.2	0.05	2.0	0.08	1.8	68
9/5/2009	Storm	11.5	8.20	156	15.2	NM	0.035	8	4.2	11.0	2.0	0.5	2.0	0.072	0.88	78
10/29/2009	Storm	NM	6.75	170	NM	2200	0.025	8	15	6.0	0.5	0.5	3.0	0.007	2.1	63
1/11/2010	Storm	9.3	6.43	160	7.8	160	0.047	50	23	8.0	4.0	0.5	3.0	0.019	1.7	45
4/21/2010	Storm	8.1	6.70	85	7.4	1000	0.046	47	64.5	10.0	0.5	0.5	2.0	0.005	1.6	39
8/31/2010	Storm	9.6	7.20	320	13.2	600	0.064	29	4.2	8.0	2.0	0.03	2.0	0.023	0.88	80
10/25/2010	Storm	10.7	6.80	180	10.5	140	0.052	9	8.9	4.8	2.2	0.50	1.2	0.043	1.6	70

Notes: Grey ½ lab detection level; yellow notes water quality standards exceeded

Table 15 Storm and Baseflow Water Quality Data Collected in Tributary 0170 (T-0170) 2009-2010

Date	Event Type	DO (mg/l)	pH	Cond (uS/m)	Temp (deg C)	Fecal Coliform (CFU/ 100ml)	TP (mg/l)	TSS (mg/l)	Turbidity (NTU)	Total Zinc (ug/l)	Diss Zinc (ug/l)	Diss Lead (ug/l)	Diss Copper (ug/l)	Ammonia-N (mg/l)	Nitrate+ Nitrite-N (mg/l)	Hardness (mg/l CaCO3)
6/3/2009	Base	9.0	6.97	331	21.1	92	0.15	16	23.8	8.0	0.5	6.0	2.0	0.77	0.31	150
07/28/09	Base	6.5	8.12	295	23.3	24	0.063	3	7.5	2.0	4.0	3.0	4.0	0.093	0.30	110
10/7/2009	Base	9.2	7.95	357	10.1	50	0.078	1	4.21	3.0	2.0	0.5	3.0	0.090	0.40	97
1/28/2010	Base	5.6	6.76	248	6.9	10	0.14	21	34.6	12.0	3.0	0.5	3.0	0.526	0.21	100
5/14/2010	Base	6.7	6.14	240	9.3	20	0.078	6	7.2	9.0	0.5	0.5	0.5	0.39	0.36	54
7/21/2010	Base	6.2	7.00	340	15.5	6	0.054	7	16.2	2.0	0.5	0.5	2.0	0.102	0.21	NM
11/4/2010	Base	6.8	6.55	220	11.5	46	0.106	6	4.2	12.2	6.8	0.03	1.19	0.386	0.28	90
9/5/2009	Storm	5.7	6.94	160	17.5	NM	0.093	7	25.1	16.0	15.0	0.5	26.0	0.336	0.60	57
10/29/2009	Storm	NM	6.25	120	NM	120	0.052	6	11.8	23.0	11.0	0.5	2.0	0.093	0.19	44
1/11/2010	Storm	7.9	6.24	120	8.1	190	0.189	110	65.5	48.0	32.0	0.5	5.0	0.00025	1.6	45
4/21/2010	Storm	6.2	6.19	61	9.1	960	0.071	9	23.1	26.0	13.0	0.5	3.0	0.061	0.25	28
8/31/2010	Storm	5.3	6.26	320	19.5	2200	0.247	9	90.9	31.0	9.0	0.5	1.7	0.375	0.24	130
10/25/2010	Storm	6.1	5.93	185	13.5	120	0.057	9	50.4	36.8	9.26	0.38	2.59	0.065	0.29	31

Notes: Grey ½ lab detection level; yellow notes water quality standards exceeded

Table 16. Storm and Baseflow Water Quality Data Collected Between 1998 through 2010.

Location	Station	Dissolved Oxygen (mg/L)			Turbidity (NTU)			pH			Conductivity (umhos/cm)			Temperature			Fecal Coliforms (cfu/100 mL)			TSS (mg/L)			Total Zinc (ug/L)		
		Minimum	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*
Issaquah Creek Basin																									
Issaquah Creek Downstream	IC-D	8.1	11.1	12.9	0.30	12	170	6.2	7.0	8.5	74	114	159	6.3	10.6	17.8	<1	423	3800	<1	25	350	<1	6.1	29
North Fork Issaquah Creek	NF-D	7.2	9.0	12.6	0.10	8	74	6.3	7.0	8.1	86	141	230	6.2	11.9	21.9	<1	654	17000	<1	8	130	<1	12.9	320
East Fork Issaquah Creek	EF-D	8.2	10.4	12	0.06	7	160	6.4	7.3	8.9	64	109	168	6.2	11.3	18.4	<1	244	3200	<1	12	280	<1	10.1	220
Issaquah Creek Upstream	IC-U	9.1	10.9	13.3	0.15	14	260	6.0	7.1	8.4	79	108	141	6.1	10.5	16.6	<1	313	3500	<1	30	780	<1	9.3	260
Lake Sammamish Tributaries																									
Laughing Jacobs Creek Downstream	LJ-D	7.9	10.2	15.1	1.0	9	28	6.2	7.3	8.7	95	150	227	6.2	11.0	17.1	1	156	1100	<1	9	36	<1	13.1	80
Lewis Creek Downstream	LC-D	7.9	9.5	11.8	1.0	24	163	6.5	7.2	8.5	92	140	210	7.0	11.7	18.5	2	406	4100	<1	31	280	<1	12.7	83
Water Quality Standard			9.5			5 NTU over background			6.5 to 8.5			None			<16			< 100			None			None	
Fisheries Sublethal Limit			9.5			77.0			6.0 to 9.0			None			<16			None			< 80			None	
Tibbetts Creek Basin																									
Tibbetts Creek Downstream	TC-D	6.9	8.6	11.9	0.83	6.2	310	6.3	7.1	8.1	110	193	373	6.6	11.1	23.8	<1	83	12500	<1	5	780	<1	6	150
Tributary 0170	T-0170	5.3	6.5	12.5	1.9	11	130	5.9	8.1	6.7	61	215	357	6.9	10.8	23.3	6	114	10500	<1	7	160	<1	11	310
Tibbetts Creek Upstream	TC-U	8.1	12.3	10.7	0.51	2.9	6300	6.3	8.4	7.2	85	165	340	6.2	16.1	9.0	1	49	3800	<1	6	7000	<1	6	560
Water Quality Standard			8.0			5 NTU over background			6.5 to 8.5			None			<17.5			< 100			None			None	
Fisheries Sublethal Limit			8.0			77.0			6.0 to 9.0			None			<17.5			None			< 80			None	

Location	Station	Dissolved Zinc (ug/L)			Dissolved Copper (ug/L)			Dissolved Lead (ug/L)			Nitrate+Nitrite-Nitrogen (mg/l)			Ammonia-Nitrogen (mg/L)			Total Phosphorus (mg/L)			Hardness (mg/L)			Surfactants (mg/L)		
		Minimum	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*	*Minimum*	*Mean*	*Maximum*
Issaquah Creek Basin																									
Issaquah Creek Downstream	IC-D	<1	2.2	10.3	0.30	3.1	21	0.03	0.62	2	0.43	0.78	1.2	<0.005	0.040	0.10	<0.005	0.04	0.31	34	46	62	<0.05	<0.05	<0.05
North Fork Issaquah Creek	NF-D	<1	3.6	9	<1	2.5	13	0.03	1.4	9	0.09	0.25	0.53	<0.005	0.080	0.71	0.008	0.05	0.27	41	62	91	NM	NM	NM
East Fork Issaquah Creek	EF-D	<1	3.8	16.8	<1	2.1	11	0.03	0.74	4	0.43	0.65	1.1	<0.005	0.030	0.16	<0.005	0.03	0.47	27	41	63	NM	NM	NM
Issaquah Creek Upstream	IC-U	0.11	1.6	6.6	0.33	2.4	8	0.03	1.7	16	0.12	0.81	1.3	<0.005	0.019	0.089	<0.005	0.05	0.77	32	43	53	NM	NM	NM
Lake Sammamish Tributaries																									
Laughing Jacobs Creek Downstream	LJ-D	<1	3.1	10	<1	3.2	15	0.07	0.44	0.54	0.08	0.69	1.3	<0.005	0.040	0.090	0.018	0.048	0.10	37	63	95	NM	NM	NM
Lewis Creek Downstream	LC-D	<1	5.3	15	<1	4.3	26	0.03	0.42	0.5	0.54	0.79	1.3	<0.005	0.030	0.083	0.019	0.080	0.52	37	55	80	NM	NM	NM
Water Quality Standard			41.9 to 69.7			4.51 to 7.54			0.76 to 1.5			None			None			None			None			None	
Fisheries Sublethal Limit			6.9			4.4			11 to 16			less than 250			None			None			>20			None	
Tibbetts Creek Basin																									
Tibbetts Creek Downstream	TC-D	<1	3.8	10	<1	4.0	13	0.03	0.5	1	0.28	0.83	2.8	<0.005	0.038	0.207	<0.005	0.032	0.35	45	85	160	<0.05	<0.05	<0.05
Tributary 0170	T-0170	<1	8.2	32	<1	4.3	26	0.03	0.5	6	0.19	0.29	1.6	<0.005	0.10	0.77	<0.005	0.080	0.28	28	74	150	NM	NM	NM
Tibbetts Creek Upstream	TC-U	<1	1.6	4	<1	2.3	7	0.03	0.5	3	0.35	1.2	2.1	<0.005	0.023	0.08	<0.005	0.025	3.4	39	67	88	NM	NM	NM
Water Quality Standard			53.1 to 15.6			5.73 to 16.9			1.04 to 4.18			None			None			None			None			None	
Fisheries Sublethal Limit			6.9			4.3			11 to 16			less than 250			None			None			>20			None	

SECTION 5
BENTHIC MACROINVERTEBRATES RESULTS AND DISCUSSION

5.1 Benthic Monitoring Results

B-IBI scores for the period between 1999 and 2009 across all the sample sites within the Issaquah Creek basin are summarized in Table 17.

A total of 59 B-IBI scores were computed for 7 sample sites over 10 years. The data for Issaquah Creek Upstream (IC-U) Issaquah Creek Downstream (IC-D), and East Fork Issaquah Creek Downstream (EF-D) are the most extensive, whereas the other stations were visited less frequently. The City has begun sampling Lewis Creek in cooperation with the City of Bellevue only recently.

Tracking the changes in the B-IBI score at a site over time can give an indication of the trend in the health of the site. Various trends at the different sites are presented in the following figures. Besides human influences, many other factors can influence the B-IBI score of a particular site. Hydrological conditions, sustained periods of drought, natural cycles in the target populations, sediment pulses, and sampling methodology are potential factors influencing B-IBI scores. A long period of monitoring data, at least 10 years, is needed to smooth out this natural variability.

Issaquah Creek upstream (IC-U) is located furthest upstream in the watershed of all the sample sites, and thus is the least impacted by urban influences. Although this site has had excellent ratings it has shown variability in more recent years. Being the tenth year of monitoring it can be assumed that this station trends as a good to fair system. East Fork Issaquah Creek stands out as having the highest B-IBI scores in local streams. Lewis Creek was monitored for the first time in 2009. It received a poor B-IBI score, which as this point is expected, do to the flashy nature of this creek. Lewis Creek is highly responsive to storms and has a significant sediment load, which impacts invertebrates.

A trend analysis of the available data is illustrated in the following series of Figures 2 through 6. The Figures illustrated below show the B-IBI scores for sample sites on Issaquah Creek, East Fork Issaquah Creek and Tibbetts Creek respectively, through the 10 year monitoring period. Issaquah Creek sites and Tibbetts Creek sites are trending downward over the last 10 years while the East Fork of Issaquah Creek is trending upward. Year to year variability is high, possibly following a cycle whose causative factor or factors are unknown.

Table 17 Summary of Macroinvertebrate B-IBI Scores

Monitoring Station	***1999***	***2000***	***2001***	***2002***	***2003***	***2005***	***2006***	***2007***	***2008***	***2009***
Issaquah Creek Upstream (IC-U)	38(G)	42(G)	46 (E)	28(F)	40(G)	28(F)	36(F)	36(F)	38(G)	36(F)
Issaquah Creek Downstream (IC-D)	40(G)	44(G)	26(P)	32(F)	36(F)	32(F)	40(G)	26(P) *	34(F)	
Issaquah Creek Juniper (IC-J)		42(G)	36(G)	26(P)			42(G)	32(F)	38(G)	
Tibbetts Creek at Maple (TC-Maple)	26(P)	36(F)		40(G)			22(P)			32(F)
Tibbetts Creek at Manor (TC-Manor)	38(G)		28(F)				32(F)	32(F)	30(F)	
Tibbetts Creek Upstream (TC-U)			34(G)	34(F)			28(F)		32(F)	
North Fork Downstream (NF-D)	32(F)			18(P)						
North Fork Upstream (NF-U)					38(G)	26(P)				
East Fork Downstream (EF-D)	34(F)	36(F)	32(F)	32(F)	40(G)	38(G)	32(F)	38(G)	38(G)	30(F)
East Fork at Sunset (EF-S)			40(G)		38(G)	40(G)				
East Fork Upstream (EF-U)		34(F)	28(F)	32(F)	34(F)			42(G)	40(G)	40(G)
Laughing Jacobs Downstream(LF-D)							26(P)			
Lewis Creek Downstream (Elliot Property)										22(P)

*after a review of activity near the site to determine the low score, it was found that instream restoration work had occurred shortly before the sample was collected. This could explain the lower score for that year.

Color Shading Key: Excellent (E)-Blue; Good (G)-Green; Fair (F)-Yellow; Poor (P)-Red

Figure 2
Issaquah Creek Downstream (IC-D)

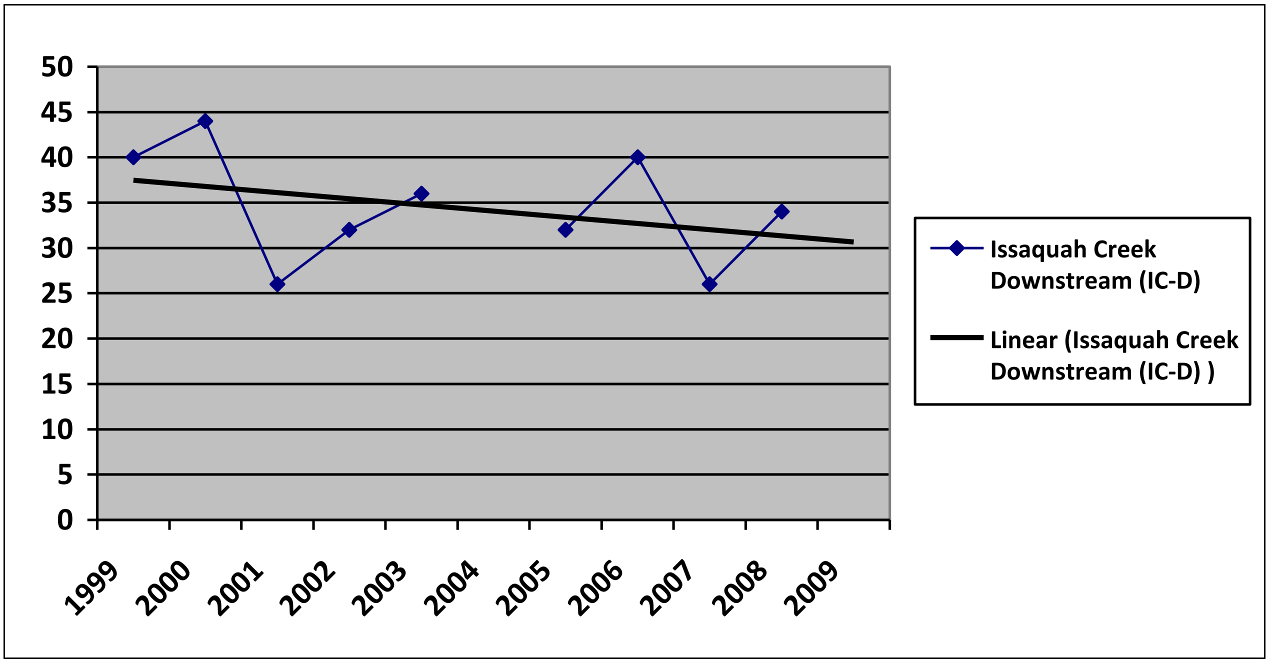


Figure 3
Issaquah Creek Upstream (IC-U)

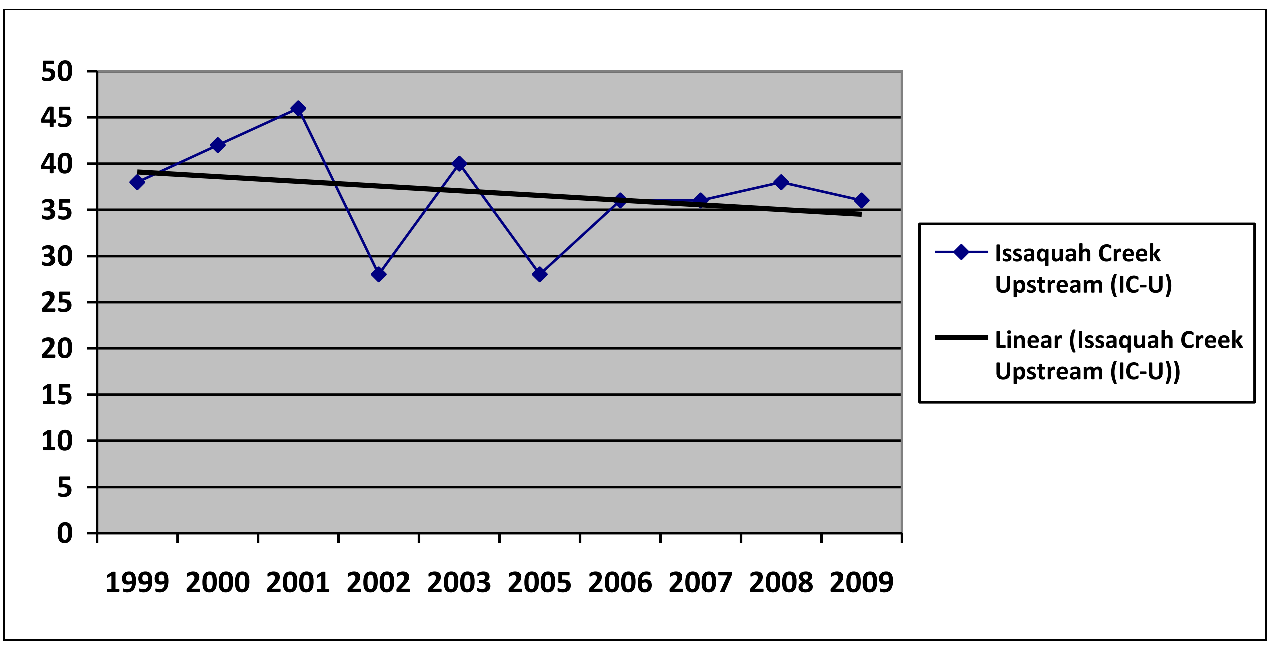


Figure 4
East Fork Issaquah Creek Downstream (EF-D)

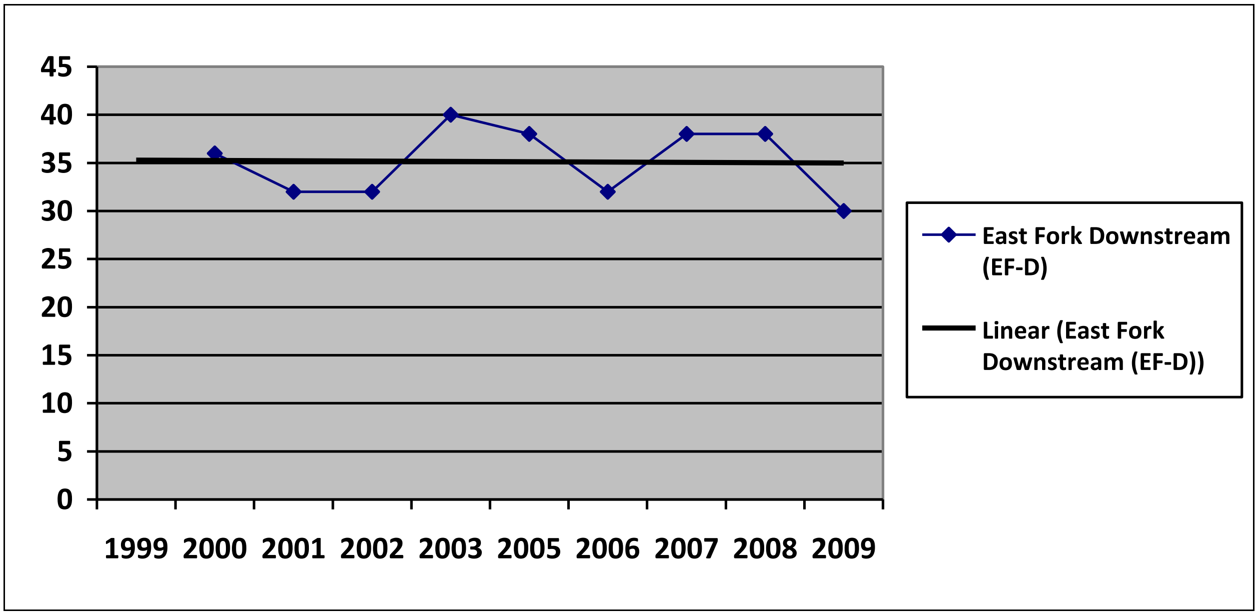


Figure 5
East Fork Issaquah Creek Upstream (EF-U)

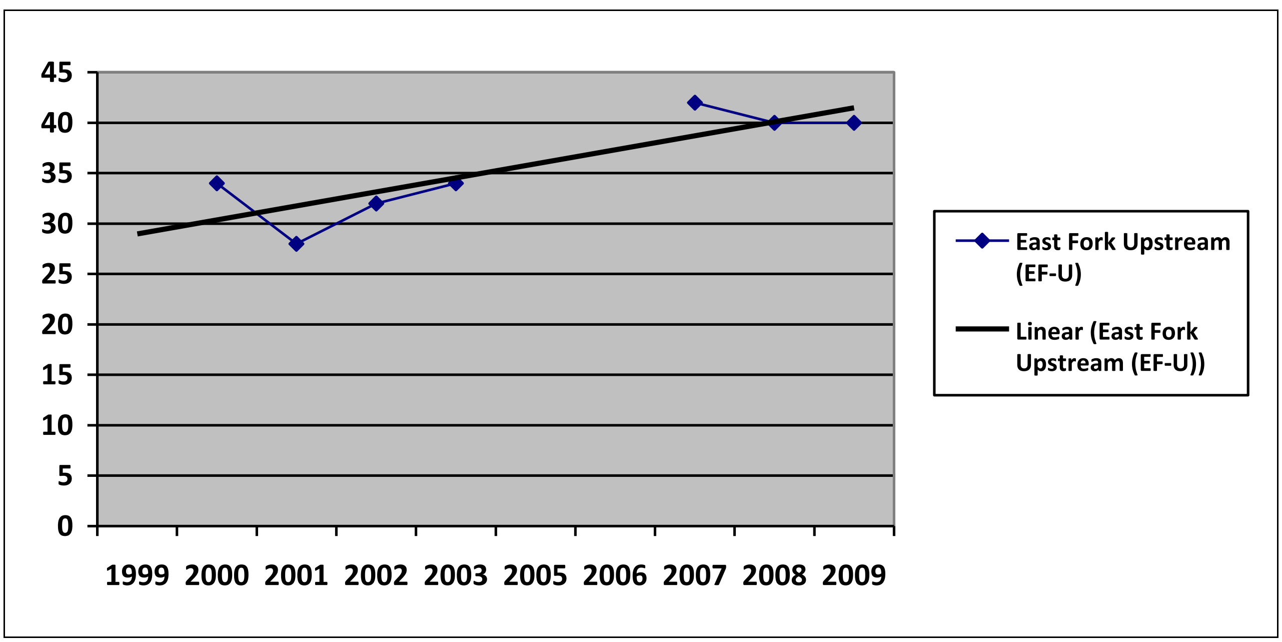
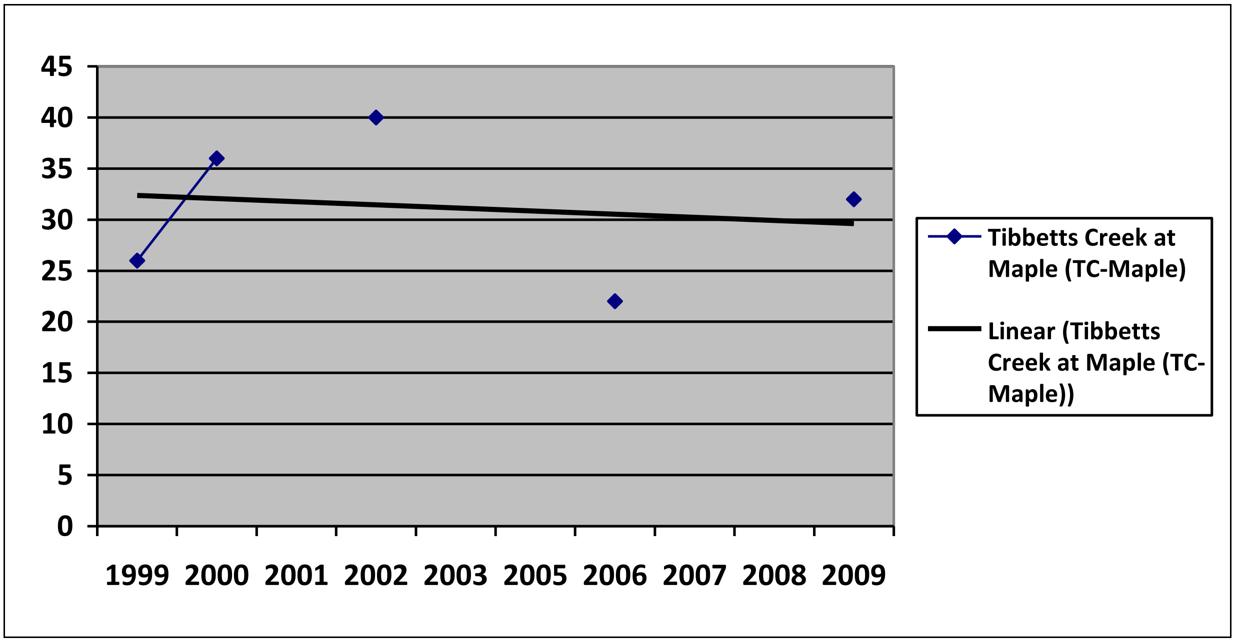


Figure 6
Tibbetts Creek At Maple



5.2 King County Macroivertebrate Sampling Program

King County has been conducting a macroinvertebrate sampling program since 1994. In 2009, this consisted of sites in 37 different sub basin watersheds (King County Department of Natural Resources and Parks). The Issaquah Creek sub basin scores relatively high compared to other sub basins in King County. The aggregate scores collected by King County for each sub basin are summarized in Table 18. Sub basins were selected across the County to show where the Issaquah Creek watershed scores in relation to other basins within the region. Using B-IBI, the Issaquah Creek sub basin is one of the highest scoring in the region. The B-IBI scores indicate that the Coal Creek and Issaquah Creek sub-basins are in relatively good biological condition, whereas most of the more urbanized watersheds have lower B-IBI scores.

All regional and local macroinvertebrate sampling data has been compiled on a regional website that can be mapped and viewed by the general public. The site is www.pugetsoundstreambenthos.org.

King County, with funding from an EPA grant, is currently embarking on a project to standardize testing methods across the region. This work will also allow more direct comparisons to be made across jurisdictions and sampling methodologies for historic and future data collection. The program is set to begin in the Spring of 2011.

Table 18 King County B-IBI Scores

Location	BI-IBI Score
Coal Creek (Green)	44
Issaquah Creek	38.5
Lower Cedar River	35.6
Bear Creek	32.7
E Lake Sammamish Basin	28
Evans Creek	25.4
W. Lake Sammamish Basin	23
Duwamish River	17.2
Thornton Creek	14
Kelsey Creek	14

SECTION 6
CONCLUSIONS

The most recent two years of monitoring continue to provide insight into the quality of our surface waters. The past two years of monitoring did not detect any new or significant trends that weren't apparent in earlier monitoring. Issaquah Creek water quality is generally good during baseflow events, but degrades during storm events. The same is true for Tibbetts Creek, although, the Tibbetts Creek drainage seems more affected during storms than Issaquah Creek.

The constituents of concern within Issaquah streams continue to be elevated fecal coliforms and low dissolved oxygen. High fecal coliform levels tend to be associated with storm events. The water quality standard for fecal coliforms was exceeded roughly 20 to 30 percent of the time in the Issaquah Creek drainages. Tibbetts Creek, Trib 0170 and Laughing Jacobs experience elevated fecal coliform concentrations over 30 to 50 percent of the time. It is important to note that fecal coliforms measured at the upstream stations entering the City are relatively the same in concentration as the downstream stations, indicating upstream rural areas are a source and are experiencing the same problems.

Dissolved oxygen is of moderate concern in Issaquah Creek, but is more of a concern in the smaller tributaries including Tibbetts Creek and Trib 0170. Concentrations of dissolved oxygen typically decrease slightly during the summer months when flows decrease and temperature increase. However, some of smaller drainages experience low dissolved oxygen during other times of the year as well. This may be caused by nutrients in the water and decomposition, which consumes oxygen, or by inflow of low-oxygen water from groundwater seepage or wetlands (such as on North Fork Issaquah Creek and Laughing Jacobs Creek).

Tributary 0170 is fed mostly by stormwater runoff from urban areas and thus shows the effects of this on water quality. Nutrient rich water in this drainage is expected to play a significant role in contributing to low dissolved oxygen levels. In addition, during the summer months, the ditch becomes stagnant and experiences elevated temperatures, further resulting in low dissolved oxygen. Like other locations in the city fecal coliforms increase during storm events. The tributary 0170 tends to experience significant peaks of fecals during storms. Since the drainage area is developed urban residential and commercial development, majority of which is impervious, the tributary is very responsive to stormwater.

The testing for dissolved metals found that all the creeks were in the good range with few if any violations of water quality standards. Samples collected at all the monitoring stations during a summer storm in September 2009 detected dissolved copper, and at some stations dissolved lead above the water quality standard. This sample was collected after a roughly 2.5 week stretch of dry days to characterize a “first-flush” event. A first-flush runoff normally carries higher than average contaminant concentrations, due to the long period between storms. Due to weather patterns in the Puget Sound Lowlands, first-flush runoff events are not common most of the year, but do occur typically in late summer to early fall.

While dissolved copper and zinc concentrations were typically below the water quality standard at the monitoring stations, the fisheries literature-based sublethal threshold was exceeded more often. The state water quality standard for dissolved metals include a factor of safety to avoid lethal effects, but are not necessarily tied to sublethal effects data, but rather are intended to protect all beneficial uses of surface waters, not just the protection of aquatic biota. The literature based sublethal concentrations include water chemistry-induced changes in physiology and/or behavior that affect the competitive vitality or reproductive potential of a fish population without direct lethal effect.

The screening for pesticides, herbicides, and surfactants in Issaquah Creek and Tibbetts Creek found no detections of these contaminants, except for a very low concentration of the herbicide 2,4-D in one sample from Tibbetts Creek.

The fair to good water quality in Issaquah streams also correlates to a fair to good macroinvertebrate B-IBI scores. As a whole, the Issaquah Creek watershed, especially East Fork Issaquah Creek, ranks near the top of all King County watersheds by B-IBI scores.

SECTION 7
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APPENDIX A
TABULATED WATER QUALITY DATA

STORM AND BASEFLOW MONITORING

STREAMTEAM MONITORING