Puget Sound Stream Benthos: Monitoring Status and Data Management

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King County

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Prepared for:

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Table of Contents

Figures

Tables

Appendices

EXECUTIVE SUMMARY

This report presents the methods and results of an assessment and gap analysis of stream benthic macroinvertebrate monitoring programs in the Puget Sound region, and the collation of available data into a central database. The stream benthos data management system used for this project was developed jointly in 2007 and 2008 by King, Pierce and Snohomish Counties, and the City of Seattle, and is maintained and operated by King County. Data are available on the web at: http://www.pugetsoundstreambenthos.org/. This project was funded by Washington State Department of Ecology as a pilot project to meet a pressing need for improved stream benthos data management and coordination and to enhance overall regional coordination of environmental monitoring.

As part of this project, 96 organizations in the Puget Sound region were contacted regarding availability of stream benthos monitoring data collected from 2002 - 2007. Raw taxonomic macroinvertebrate data from 17 organizations were entered into the data management system. Data from three other organizations were not entered because the data were collected prior to 2002, because adequate metadata were not available, and/or because the organization could not meet the data submittal deadline. Over 50,000 records were entered into the data management system. The stream benthos data management system includes a standardized data-loading feature for taxonomic laboratories, ensuring that future datasets could be automatically loaded into the system in a standardized and efficient manner.

A geographic review of data availability reveals that substantial coverage of the Puget Sound region has been obtained by compiling data from multiple organizations. The largest areas with no data include Skagit, Island, and San Juan Counties. Sampling sites in 16 additional watersheds were added to the database by this effort. However, distribution of the data is skewed to a few areas. Approximately 80% of the sampling locations are concentrated in 5 (Cedar-Sammamish, Green Duwamish, Elwha-Dungeness, Snohomish and Kitsap) of 21 watersheds represented by the database. More that 80% of the sampling locations are located in three counties (King, Snohomish and Clallam).

Overall, there was tremendous interest by many organizations in using this system, as no other data management system allows for the comparison of stream benthos data between taxonomic laboratories, between years, and between monitoring programs. Key recommendations for next steps include:

- Assessing the comparability of various stream benthos monitoring and data analysis protocols.
- Incorporating multiple enhancements and improvements to the data management system, including an ability to automate predictive modeling techniques (e.g., RIVPAC).
- Establishing a stream benthos coordination program for ensuring monitoring protocol and method consistency between monitoring programs.
- Analyzing the compiled datasets to assess stream health region-wide and to further research the use of stream benthos as a monitoring tool.
- Expanding the data management system to include other disparately managed data sets, such as weather, precipitation, stream flow and temperature, and water quality.

- Developing a long-term funding source to ensure successful operation and maintenance of the data management system for long-term use.

1.0. INTRODUCTION

In 2007, the Washington State Legislature established and funded the Puget Sound Coordinated Monitoring Program (PSCMP) within the Washington State Department of Ecology. The purpose of this effort was to establish a coordinated multi-party structure to provide scientifically based information about the Puget Sound ecosystem. It was anticipated that this program would guide the Puget Sound Partnership's, Ecology's, and others' monitoring efforts and improve policy and management decisions. Responsibility for monitoring coordination has since been transferred from Ecology to the Puget Sound Partnership. The Partnership Leadership Council has agreed to move forward to establish a coordinated ecosystem monitoring program for the Puget Sound Region. As part of the PSCMP, a Technical Advisory Committee (TAC) was identified. The TAC scoped a number of potential pilot projects; four were selected and scheduled to be completed by June 30, 2009. The selected pilot projects were intended to test working relationships, meet pressing needs for coordination, expand existing initiatives, and provide input to development of the organizational structure and decision-making process for coordinating regional monitoring and assessment. The four pilot projects are:

- Development of Standard Operating Procedures (SOPs) and Quality Assurance Project Plans (QAPPs) for Stormwater
- Stream Benthos Gap Analysis, Coordination, and Data Management
- Inter-calibration Pilot Study
- In-Line Ditch Stormwater Treatment Best Management Practice Program

Benthic macroinvertebrates are valuable indicators of water quality and watershed health because they have limited mobility and spend most or all of their lives in the stream bed. Thus, they are effective integrators of environmental health. They are easy to collect and different species have varying degrees of tolerance for degraded water quality and habitat conditions. Various metrics (diversity, pollution tolerance etc.) representing a variety of ecological characteristics can be calculated from benthic macroinvertebrate community data. The Benthic Index of Biotic Integrity (BIBI) is a commonly used index that integrates 10 different metrics to derive a score (10-50) that represents the general health of the stream. The Puget Sound Lowland BIBI was derived from stream benthic macroinvertebrate data that were calibrated to conditions of the Puget Sound Lowland region (Fore et al. 1996, Karr & Chu 1999, Kleindl 1995). Multiple adaptations have been developed of this approach (SalmonWeb http://www.cbr.washington.edu/salmonweb/bibi). The Washington Department of Ecology (Ecology) has developed two multi-metric indices for the Cascade and Puget Lowland ecoregions that are adapted to their biological monitoring methods (Wiseman 2003). These indices are generally similar to the BIBI with the exception of two of the 10 metrics. In addition, Ecology also uses the River Invertebrate Prediction and Classification (RIVPAC) multivariate model (Wright et al. 1993, Norris and Georges 1993, Reynoldson et al. 1995, Wright 1995) to analyze some of their benthic monitoring data.

King County and other jurisdictions routinely monitor stream benthic macroinvertebrate communities as a tool for monitoring stream health. In general, many of these jurisdictions use the BIBI as a biological indicator. However, no nexus exists in the Puget Sound region that allows data sharing or standardized storage of benthic taxonomic data. Some of the challenges that prevent ease of benthic data comparison between jurisdictions are: the rapidly changing taxonomy classifications that require frequent updating, inconsistencies in naming and reporting conventions between analysts and analytical laboratories, lack of a coordinating body for monitoring programs to track site locations and avoid double-sampling and slight variations in BIBI calculation methods. To overcome some of these challenges and fulfill the demand for data sharing and standardization at a local level, a data management system for stream benthic macroinvertebrate data (http://www.pugetsoundstreambenthos.org/) was developed jointly by King, Pierce, and Snohomish Counties, and the City of Seattle (i.e. partners). The system is maintained by King County Water and Land Resources Division (KC WLRD). The City of Everett recently joined the other partners in establishing individual operations and maintenance contracts with KC WLRD for a three-year period through 2011. During this three-year period, the partners plan to explore various long-term funding options and the potential for system expansion to add data from other jurisdictions.

This system allows the partners to share, analyze and store their benthic macroinvertebrate data. The architecture includes a Microsoft® SQL Server database and a web interface built using the Microsoft®.NET Framework and Google® Maps Application Programming Interface. The database and web servers are hosted and managed by a third party service provider.

Key features of this system include:

- Any jurisdiction, agency, or other entity that contributes data retains ownership of their data, with the exclusive right to edit or delete their existing data.
- Where feasible, taxonomic names are standardized according to Integrated Taxonomic Information System (ITIS) conventions (http://www.itis.gov/). However, additional, non-ITIS names and groupings are also included to reflect standard laboratory practices and existing taxa attribute information.
- Data can be uploaded directly from the taxonomic labs via a standardized input application.
- Numerous filters are available on the web interface for selecting data, including temporal, geographic, jurisdictional and project filters, as well as filters with more advanced criteria such as minimum number of organisms counted per sample.
- Data are displayed via maps and tables and can also be downloaded as text files (Figures 1 and 2).
- Key metadata are presented with the taxonomic data, including surface area sampled, compositing information, lab quality assurance and quality control (QA/QC) results, lab sub-sampling, etc.
- Data analysis presented via the web includes Puget Sound Lowland BIBI and associated individual metrics (Figure 3). Multiple options for calculating BIBI scores and individual metrics are available and allow for different methods for handling replicate samples and differing taxonomic resolution.
- Data can be averaged at different hydrological scales, including stream, sub-basin, basin, and Watershed Resource Inventory Area (WRIA).

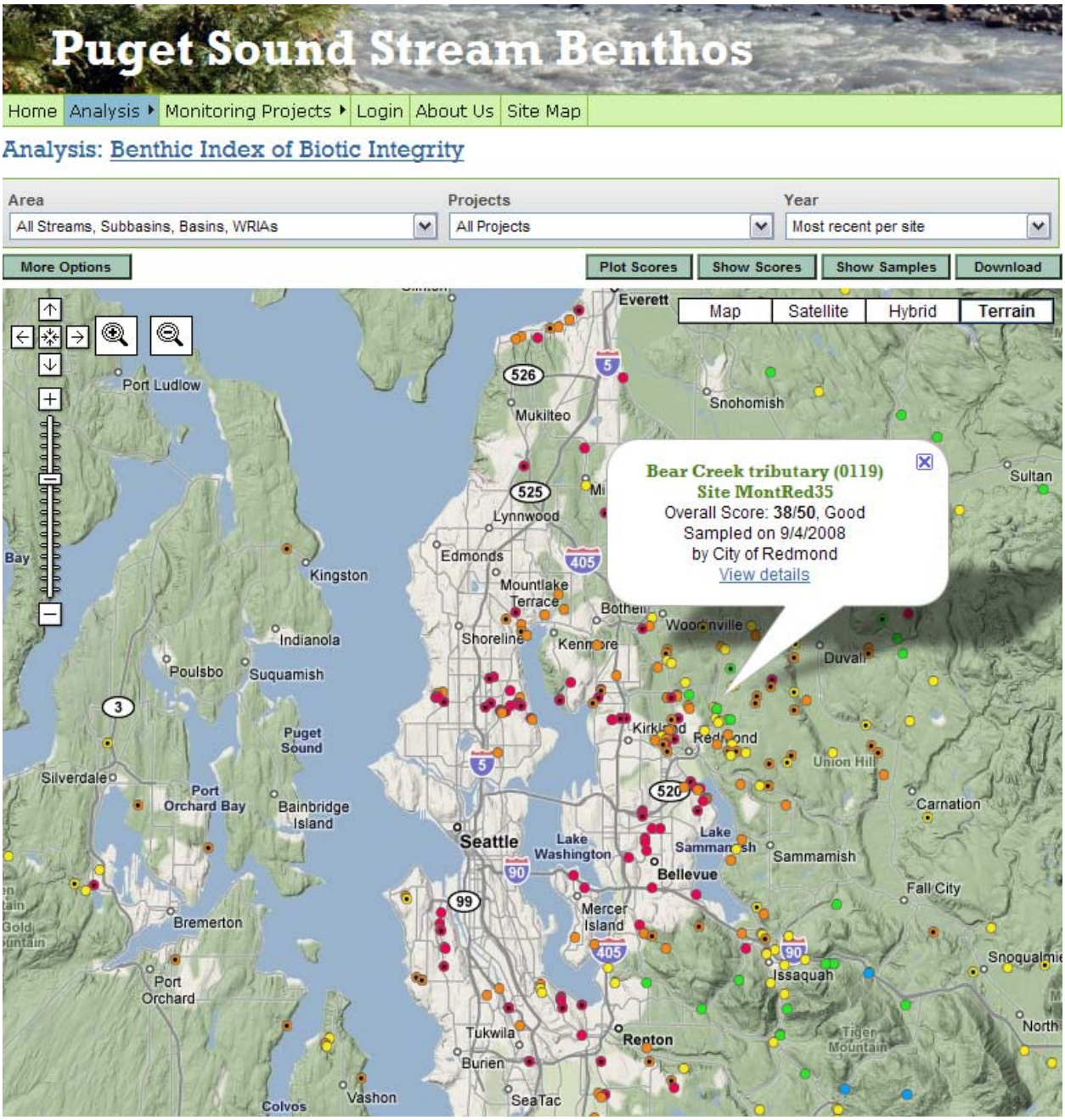


Figure 1. Example map from benthos data management system

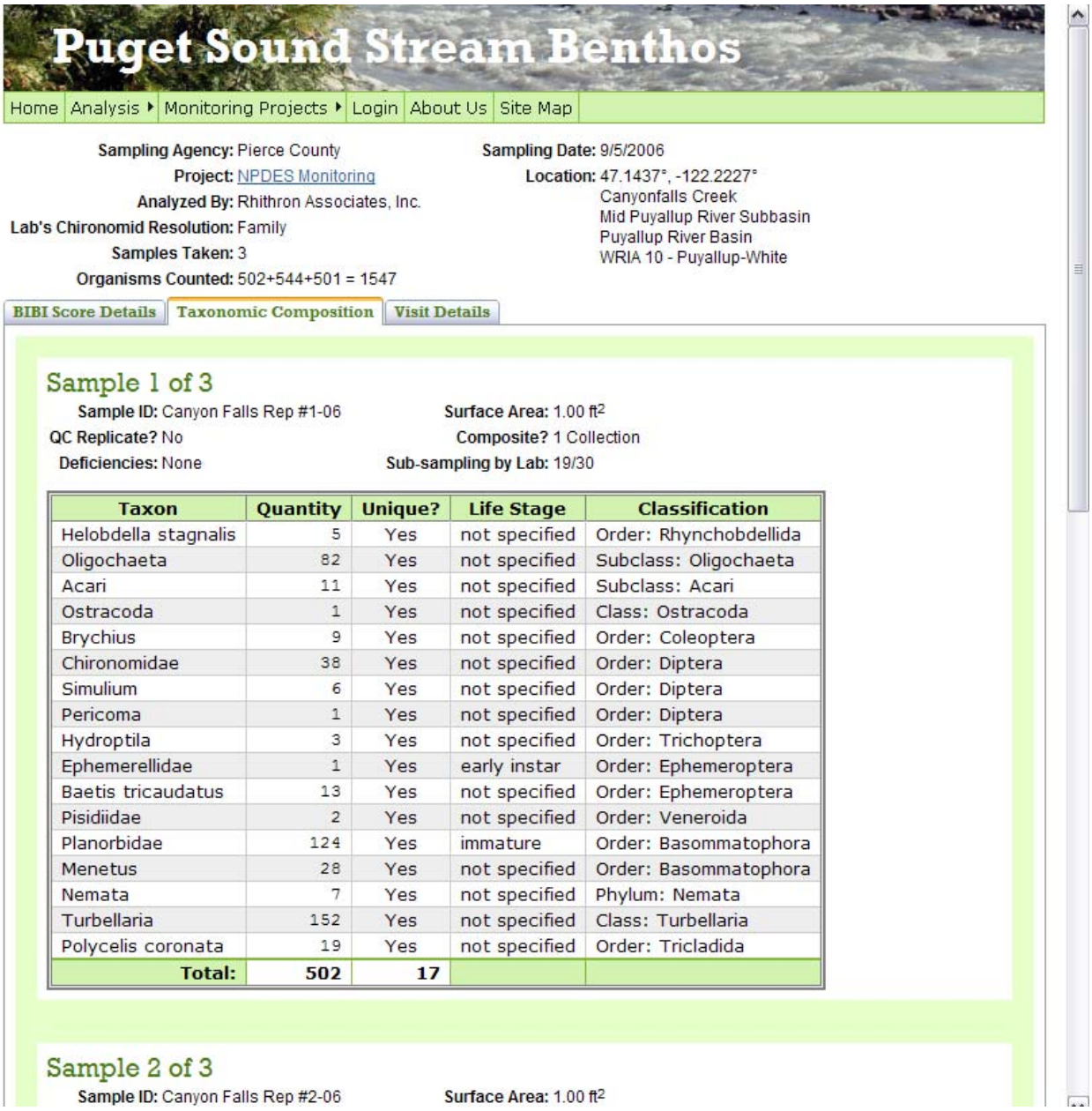
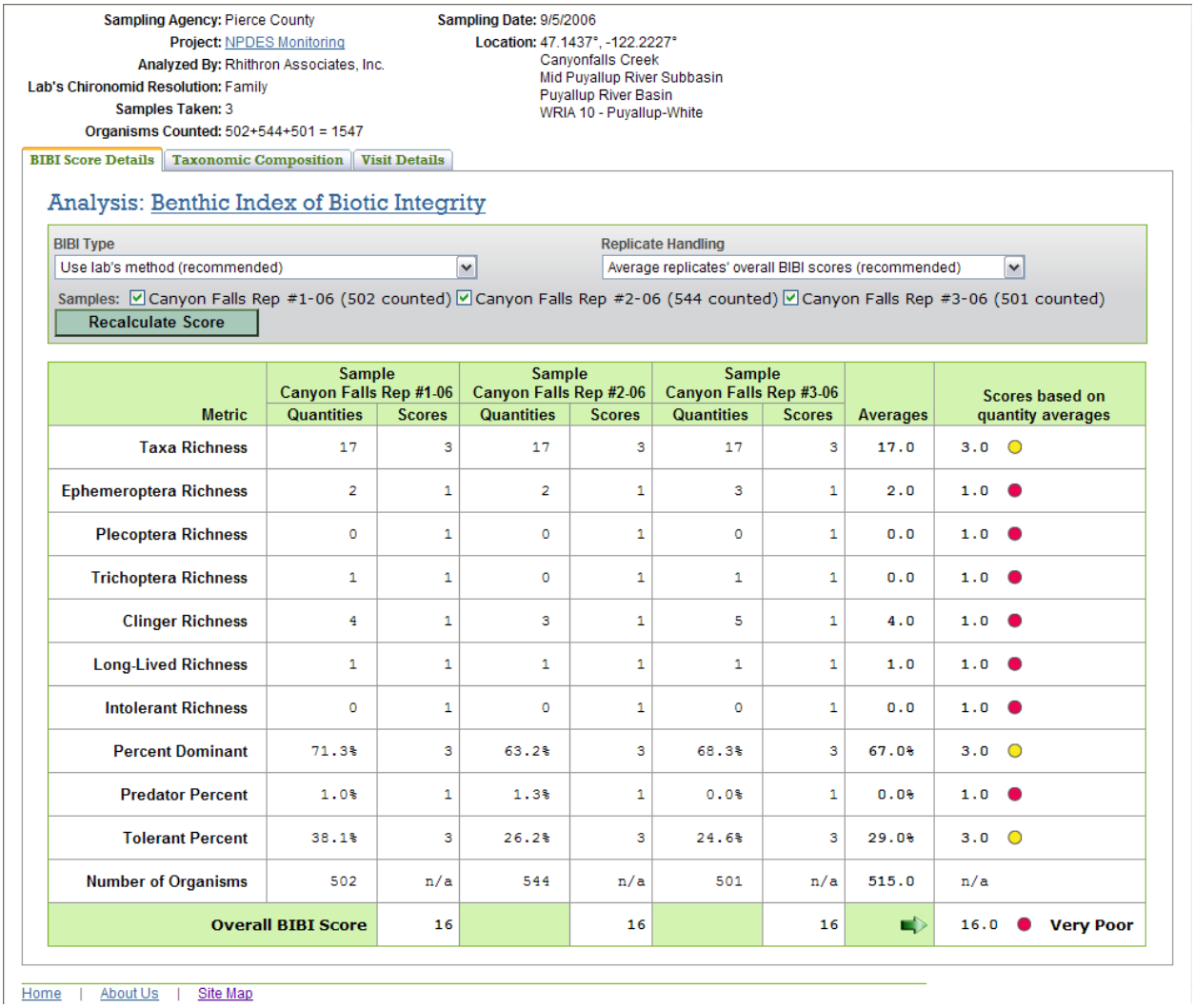


Figure 2. Example Table from Benthos Data Management System



Sampling Agency: Pierce County
Project: NPDES Monitoring
Analyzed By: Rhithron Associates, Inc.
Lab's Chironomid Resolution: Family
Samples Taken: 3
Organisms Counted: 502+544+501 = 1547

Sampling Date: 9/5/2006
Location: 47.1437°, -122.2227°
Canyonfalls Creek
Mid Puyallup River Subbasin
Puyallup River Basin
WRIA 10 - Puyallup-White

BIBI Score Details | Taxonomic Composition | Visit Details

Analysis: Benthic Index of Biotic Integrity

BIBI Type: Use lab's method (recommended)
Replicate Handling: Average replicates' overall BIBI scores (recommended)
Samples: Canyon Falls Rep #1-06 (502 counted) Canyon Falls Rep #2-06 (544 counted) Canyon Falls Rep #3-06 (501 counted)
Recalculate Score

Metric	Sample Canyon Falls Rep #1-06 Quantities	Sample Canyon Falls Rep #1-06 Scores	Sample Canyon Falls Rep #2-06 Quantities	Sample Canyon Falls Rep #2-06 Scores	Sample Canyon Falls Rep #3-06 Quantities	Sample Canyon Falls Rep #3-06 Scores	Averages	Scores based on quantity averages
Taxa Richness	17	3	17	3	17	3	17.0	3.0
Ephemeroptera Richness	2	1	2	1	3	1	2.0	1.0
Plecoptera Richness	0	1	0	1	0	1	0.0	1.0
Trichoptera Richness	1	1	0	1	1	1	0.0	1.0
Clinger Richness	4	1	3	1	5	1	4.0	1.0
Long-Lived Richness	1	1	1	1	1	1	1.0	1.0
Intolerant Richness	0	1	0	1	0	1	0.0	1.0
Percent Dominant	71.3%	3	63.2%	3	68.3%	3	67.0%	3.0
Predator Percent	1.0%	1	1.3%	1	0.0%	1	0.0%	1.0
Tolerant Percent	38.1%	3	26.2%	3	24.6%	3	29.0%	3.0
Number of Organisms	502	n/a	544	n/a	501	n/a	515.0	n/a
Overall BIBI Score		16		16		16		16.0 Very Poor

Home | About Us | Site Map

Figure 3. Example Metrics and BIBI Scores Table from Benthos Data Management System

This data management system is unique in the region and has the capability to expand features and data storage. There are a number of other benthic macroinvertebrate monitoring programs in the Puget Sound region; however, the regional extent and level of effort associated with these programs are unknown. This project was designed to address two primary goals as described in the Interagency Agreement No. C0900024 between King County and Ecology. The first goal was to assess the status of stream benthic macroinvertebrate monitoring efforts in the Puget Sound region. The second goal was to expand the existing stream benthic macroinvertebrate data management system to include data from other regional monitoring organizations. The temporal scope of the agreement covered data collected during the years 2002 through 2007.

This report presents the approach used to meet these goals and the results of the status assessment of regional monitoring efforts and regional data expansion. In addition, the conclusion section provides a summary of organizations that have ongoing benthic macroinvertebrate monitoring programs, regions not covered by these programs, and feedback

received regarding the need for the data management system. Lastly, recommendations follow to expand and improve benthic monitoring coordination in the future.

2.0. METHODS

To determine the extent of benthic macroinvertebrate monitoring programs in the region, organizations in the Puget Sound Region were solicited by email regarding their benthic macroinvertebrate monitoring program and interest in participating in having their data included in this regional data management system project. Historical data and associated metadata transfer was arranged with those who responded positively and information was loaded into the data management system. Details of these methods are described herein.

2.1 Data Acquisition

King County initiated the data acquisition process by creating a list of contacts in the Puget Sound Region for solicitation. The contacts were targeted from local, state and federal governments, tribes, and non-profit organizations which may currently or have historically collected freshwater macroinvertebrate data.

Representatives from these organizations (Table 1) were contacted via email (Attachment A). The email introduced the data management system, queried the status of their monitoring program, and whether they were interested in participating. In some cases, multiple people at the same organization were contacted because there was uncertainty around which contact was most appropriate. A second, reminder email was sent to those who had not responded within four weeks of the initial contact. Any non-responsive organizations likely to possess substantial datasets were contacted to identify the appropriate contact person and establish their data status.

Table 1. Summary of organizations contacted.

Organization Contacted	Date Contacted	2nd Attempt?	Response
Adopt-A-Stream Foundation	2/19/2009		Has data
City of Algona	2/19/2009	Yes	No data
City of Anacortes	2/19/2009	Yes	No data
City of Arlington	2/19/2009		No data
City of Auburn	2/19/2009	Yes	No response
City of Bainbridge Island	2/19/2009		Has data
City of Battle Ground	2/19/2009	Yes	No response
City of Bellevue	2/19/2009		Has data
City of Bellingham	2/19/2009	Yes[a]	Has data
City of Black Diamond	2/19/2009	Yes	No response
City of Bothell	2/19/2009		Has data
City of Bremerton	2/19/2009	Yes	No response
City of Brier	2/19/2009		Has data
City of Burien	2/19/2009	Yes	No response
City of Burlington	2/19/2009	Yes	No response
City of Clyde Hill	2/19/2009	Yes	No response
City of Covington	2/19/2009	Yes	No response
City of Des Moines	2/19/2009	Yes	No response

Organization Contacted	Date Contacted	2nd Attempt?	Response
City of Duvall	2/19/2009	Yes	No response
City of Edgewood	2/19/2009	Yes	No response
City of Edmonds	2/19/2009	Yes	No data
City of Enumclaw	2/19/2009	Yes	No data
City of Federal Way	2/19/2009	Yes	Has data
City of Ferndale	2/19/2009	Yes	No response
City of Fife	2/19/2009	Yes	No response
City of Granite Falls	2/19/2009	Yes	No response
City of Issaquah	2/19/2009	Yes[a]	Has data
City of Kenmore	2/19/2009	Yes	No response
City of Kent	2/19/2009	Yes	No response
City of Kirkland	2/19/2009		Has data
City of Lacey	2/19/2009	Yes	No response
City of Lake Stevens	2/19/2009	Yes	No response
City of Longview	2/19/2009	Yes	No response
City of Lynnwood	2/19/2009	Yes	No response
City of Maple Valley	2/19/2009		No data
City of Marysville	2/19/2009		No data
City of Mercer Island	2/19/2009		Part of King County data
City of Mill Creek	2/19/2009		No data
City of Milton	2/19/2009	Yes	No response
City of Monroe	2/19/2009		No data
City of Mount Vernon	2/19/2009		No response
City of Mountlake Terrace	2/19/2009	Yes	No data
City of Mukilteo	2/19/2009	Yes	No data
City of Newcastle	2/19/2009	Yes	No response
City of Oak Harbor	2/19/2009	Yes	No response
City of Pacific	2/19/2009		No data
City of Puyallup	2/19/2009	Yes	No data
City of Redmond	2/19/2009		Has data
City of Renton	2/19/2009	Yes	No data
City of Sammamish	2/19/2009		No data
City of SeaTac	2/19/2009		No data
City of Sedro-Woolley	2/19/2009	Yes	No response
City of Shoreline	2/19/2009	Yes	No response
City of Snohomish	2/19/2009		No data
City of Stanwood	2/19/2009	Yes	No data
City of Sumner	2/19/2009	Yes	No response
City of Surrey, British Columbia	2/19/2009		Has data; Out of scope
City of Tacoma	2/19/2009	Yes	No data
City of Tukwila	2/19/2009		No data
City of Tumwater	2/19/2009	Yes	No response
City of Woodinville	2/19/2009		No data
Clallam County	2/19/2009	Yes	Has data
Clark County Public Utilities	2/19/2009		Has data; Can't meet deadline
Clark County Stream Team	2/19/2009		No response

Organization Contacted	Date Contacted	2nd Attempt?	Response
Department of Ecology	2/19/2009		Has data
EPA Region 10	2/19/2009	Yes	No response
Hylebos Stream Team	2/19/2009		Part of City of Federal Way data
Kitsap County	2/19/2009		Has data
Kitsap County Stream Team	3/30/2009		Has data
Lake Forest Park Streamkeepers	2/19/2009	Yes	Has data
Lewis County Conservation District	2/19/2009		No Data
Mason County	2/19/2009		No Data
Muckleshoot Indian Tribe	3/3/2009		Pre-2002 Qualified data
National Oceanographic and Atmospheric Administration (NOAA)	2/19/2009		Has data
Northwest Indian Fisheries Commission	3/6/2009		Distributed message to others
Olympia Stream Team	2/19/2009	Yes	No response
Port of Seattle	2/19/2009	Yes	No response
Puyallup Tribe of Indians	3/3/2009	Yes	No response
Skagit County	2/19/2009		No Data
Skagit Stream Team	2/19/2009	Yes	No response
Skokomish Tribal Nation	3/20/2009		Has data
Snoqualmie Tribe	3/3/2009		No response
Seattle Public Utilities	2/19/2009		Part of City of Seattle data
Stilly-Snohomish Fisheries Enhancement Task Force	3/19/2009		Part of Snohomish County data
Thurston Conservation District	2/19/2009	Yes	No response
Thurston County	2/19/2009	Yes[a]	Has data
Tulalip Tribes	3/3/2009	Yes	No response
US Fish and Wildlife Service (US FWS)	2/19/2009	Yes	Part of City of Seattle data
Western Washington US FWS Office	2/19/2009		Pre-2002 data
US Geological Survey	2/19/2009		Has data; Building own database
University of Washington	2/19/2009		No response
Washington State Association of Counties	2/19/2009	Yes	No response
Whatcom County	2/19/2009	Yes	No response
Whatcom County Public Works	2/19/2009	Yes	No response
Wild Fish Conservancy	2/19/2009	Yes	No response

Notes:

Yes[a] This organization was contacted again by telephone in early April after no response because they are known to possess historical data

Each representative who responded positively was contacted to obtain electronic copies of raw benthic macroinvertebrate data (i.e., taxonomic identification and tax count information) as well as associated metadata. Metadata requested were often extracted from various document files provided by the organization (Table 2). The most common metadata not supplied by organizations were sample location coordinates. When coordinates were unavailable, GIS shape files or map graphic files were requested and used to obtain or estimate coordinates. Sample site coordinates are required for the data management system. Therefore, if coordinates were not provided, or could not be derived by one of these methods, the data could not be included. This issue did not result in exclusion of whole datasets, but infrequently resulted in some locations or years of data that could not be entered.

Table 2. Requested metadata, fields in italics were required, others were optional.

Project Metadata	Site Metadata	Sample Metadata
Jurisdiction Name	*Site Code*	*Sample ID*
Project Name	Site Name	*Date Collected*
Project Description	Site Description	QC Replicate Of
Method	*Latitude*	Sampling Personnel
Contact Name	*Longitude*	Sampling Notes
Contact Phone Number	Coordinate System	*Collection Count*
Contact e-mail	*Stream Name*	Positions In Stream
Organization Links	Site Notes	*Surface Area*
Lab Name		*Surface Area Units*
Chironomid Resolution		Deficiency Notes
Other Taxa Resolution		

Data from some organizations who responded positively to the data request, were not included in this effort because samples were collected prior to 2002, data quality did not meet their own standards for public distribution, and/or they could not meet the data submittal deadline. Data excluded for one or more of these reasons were from Clark Public Utilities, Muckleshoot Tribe, and the Western Washington Office of the US FWS. In addition, the City of Bothell responded expressing interest in participating; they will be initiating a monitoring program in 2009. During the data acquisition phase, it was determined that data from several organizations were already included in the existing database under contract by Snohomish County, Pierce County, or Seattle Public Utilities; data acquisition from these organizations was not pursued further.

2.2 Data Preparation

When data and documentation files were received, they were reviewed to extract metadata and identify missing information. Organizations were contacted as necessary to obtain missing data or information or to clarify questions. Data from 2002-2007 were identified for data preparation. Submitted data collected prior to 2002 were archived for potential later use. Two exceptions were 2001 data from the cities of Bellingham and Bellevue which were loaded in error. If 2008 data were provided and complete, they were also loaded into the data management system because it seemed prudent to include the most recent historical data. To prepare for data entry, new project tables were populated with project, site and sample metadata.

New station (Site Code) and sample (Sample Code) identifiers were created to ensure uniqueness in the database. The following formulas were developed and used for consistency.

Site Code = Shortened stream name + Shortened data source organization + Original Station ID

> "Original Station ID"= station name or identification code supplied by the organization. This was shortened if it was comprised of a text description instead of a code. If the station name was simply a stream name, the original station ID was dropped from the Site Code to prevent duplicative information.
>
> *Example: AndrsnKitsCoKC01*
> Stream name = Anderson Creek
> Data source = Kitsap County,
> Original Station ID = KC01

Sample Code = Site Code +"_" + 4-digit year of sample collection + replicate # (if needed)

> Replicate # = "R" only, means that the sample is a quality control (QC) replicate; use "R"+ # if replicates were collected and treated as individual samples with # identifying the replicate number; If no R is present, then only one sample was collected, singly or as a composite
>
> *Example: AndrsnKitsCoKC01_2002R3 = Site Code +*
> Year = 2002
> Replicate = third

2.3 Data Loading

Stream benthic macroinvertebrate data and metadata were entered manually into customized Microsoft® Access applications. Subsequently, these data were exported from Access in .xml format and uploaded to the data management system. Total counts by lowest taxonomic identification were entered for each sample or replicate. Lifestage, unique taxa, damaged state, and descriptive text (e.g., sand case, reference number) were also entered.

2.4 Data Quality Assurance

In development of the data management system, it was recognized that BIBI is not an appropriate tool for all benthos data. However, the various metrics calculated by the system could be appropriately used. In addition, enabling regional data sharing is a key objective of this data management system. Given these uses, King County included other organizations' data as long as the organization was comfortable posting their data publicly and as long as they could supply the minimum required information. King County does not vouch for the quality of data from other organizations beyond the accurate display of received data and associated metadata. The minimum standards required for accepting data and the QA/QC protocol for data entry are described in this section.

2.4.1 Source Data Quality

The quality of data received was assumed to meet King County data entry standards if individual sample results (i.e. count by taxonomic ID) were provided and the following metadata were available – waterbody name, unique sample ID, sampler type, surface area sampled, coordinates or information for derivation of coordinates, and sample type (replicate or composite).

2.4.2 Data Entry QA/QC

The risk of data entry error was limited by multiple QC features in the data entry tool. The data entry interface design standardized taxonomic names, station names, and sample IDs, thereby preventing misspellings. In addition, the data entry tool refused to accept duplicate entries of project names, site ID's or taxon names. These two features alone prevented the most common human errors. The data entry screen also provided a total count for each sample which the data entry operator cross-checked against the same provided on the original data sheet. If discrepancies were found, the source of the error was identified and corrected. Sometimes the source was due to summation errors in the source file. This ensured that the number of individuals entered for a sample was accurate. Quality assurance for taxonomic name accuracy was incorporated as a 5% review of raw taxonomic data after uploading.

Metadata entry information was checked for quality assurance during the uploading process. Data entry operators were assigned to upload metadata from organizations for which they had not previously completed metadata entry. Before metadata were uploaded, they were reviewed for accuracy, cross-checked with original documents, and cross-checked with Table 4 in this report.

3.0. RESULTS

The results of the status assessment and spatial gap analysis are presented in this section. In addition, enhancements made to the data management system as a result of this project are summarized.

3.1 The Data Acquisition and Entry Process

Out of 96 organizations contacted in the Puget Sound Region, adequate information was supplied by 17 for entry of historical stream macroinvertebrate data (Table 3). Four organizations provided one year of data, but most provided data for three or more years. Over 50,000 records were manually entered into mdb files and uploaded to the data management system. The City of Bellevue will remotely enter their 2008 data directly to the system using the data entry application developed by King County for use by analytical laboratories. The QA process resulted in 12 of 2448 records with one or more of the following errors: wrong species name was entered, the lifestage was not entered, or "unique" value was incorrect. This equates to an error rate of 0.57%.

Table 3. Organizations that provided historical data

Data Sources	Sample Years Entered
Adopt-A-Stream Foundation	2008
City of Bainbridge Island	2008
City of Bellevue	2001-2003, 2005-2008 [a b]
City of Bellingham	2001-2003, 2007 [b]
City of Federal Way	2003-2008
City of Issaquah	2002,2003,2005-2008
City of Kirkland	2002,2003,2005-2008
City of Redmond	2002-2008
Clallam County Streamkeepers	2003-2008
Department of Ecology	2002-2004
Hylebos Stream Team for City of Federal Way	2002
Kitsap County	2002-2003
Kitsap Stream Team for Kitsap County	2003-2006
Lake Forest Park Streamkeepers	2006-2008
NOAA	2005-2007
Skokomish Tribal Nation	2006
Thurston County Water Resources	2002-2008

[a] Bellevue will enter their 2008 monitoring data. King County entered data from all other years.
[b] Data for 2001 was loaded in error

3.2 Sampling Methods Summary

A review of sampling protocols used by the participating organizations reflected use of three different samplers. The surber sampler was the most commonly used followed by the D-frame kicknet and the slack sampler (Table 4). Sampling designs varied from one to five samples per

site. Twelve programs follow the sampling design of Karr, collecting and analyzing three replicate samples per site. Compositing of three samples before analysis occurred sometimes in two programs and consistently in eight programs. Less consistency exists for programs using the D-frame kicknet (protocol by Plotnikoff and Wiseman 2001). The number of samples collected and analyzed and the use of composites vary between programs. Despite differences in sampling design and stream size, all programs targeted riffle habitat.

Table 4. Summary of sampling protocols used by participating agencies/groups

Data Source	Sampler	# Reps/Site	# Grabs/Rep	Use BIBI?
Adopt A Stream Foundation	Surber	1	3	Yes
City of Bainbridge Island	Surber	3	3	Yes
City of Bellevue	Surber	3	3	Yes
City of Bellingham	D-frame kicknet	4	1	No
Clallam County Streamkeepers	Surber	3	3	Yes
Department of Ecology	D-frame kicknet	1 composite of 4 or 4 single reps	4 or 1	No
City of Federal Way	Surber	3	<2003 - 1 >2003 - 3	Yes
Hylebos Stream Team	Surber	3	1	Yes
City of Issaquah	Surber	3	1	Yes
City of Kirkland	Surber	3	1	Yes
Kitsap County	Surber	3	1	Yes
Kitsap Stream Team	Surber	3	3	Yes
Lake Forest Park Streamkeepers	Surber	3	1	Yes
National Oceanic and Atmospheric Administration	Slack sampler	1 composite of 5 or 5 single reps	5 or 1	No
City of Redmond	D-frame kicknet	1	3	Yes
Skokomish Tribal Nation	D-frame kicknet	1 composite of 4 or 4 single reps	4 or 1	Yes
Thurston County	Surber	3	3	Yes

Reps = replicates
BIBI = Benthic Index of Biotic Integrity derived from Fore et al. 1996, Karr & Chu 1999, Kleindl 1995

3.3 Spatial gap analysis

The sampling sites from participating organizations that supplied historical data are displayed in Figure 4. Generally, these data add substantial spatial coverage to the data management system in the northern Olympic Peninsula, Bellingham Bay, Bainbridge Island, Kitsap Peninsula, Olympia area and the cities on east side of Lake Washington. Fewer sites were included near Federal Way, the Quinault River, Lake Forest Park, and the southwestern state border.

The newly added sites cover 21 WRIAs (Table 5). The density of the new coverage is highest for the Elwha-Dungeness and Cedar-Sammamish watersheds and on the Kitsap Peninsula. When combined with the previous coverage, there are currently a total of 856 sampling locations represented by 20 jurisdictions/agencies (Table 6) and 13 counties (Table 7) in the database.

Sampling sites in 15 additional watersheds were added to the database by this effort. Spatial distribution and density of sampling locations tends to be skewed to a small number of watersheds. Approximately 80% of the sampling locations are concentrated in 5 (Cedar-Sammamish, Green Duwamish, Elwha-Dungeness, Snohomish and Kitsap) of 21 watersheds represented by the database (Table 5).

Table 5. WRIAs represented in the database.

WRIA Name	WRIA Number	Number of Sampling Locations
Cedar-Sammamish	8	305
Chambers-Clover*	12	1
Deschutes*	13	14
Duwamish-Green	9	93
Elwha-Dungeness*	18	99
Grays/Elochoman*	25	1
Kitsap*	15	75
Lewis*	27	2
Lyre-Hoko*	19	28
Nisqually	11	8
Nooksack*	1	14
Puyallup-White	10	24
Queets-Quinault*	21	17
Quilcene-Snow*	17	10
Salmon-Washougal*	28	1
Skokomish-Dosewallips*	16	14
Snohomish	7	105
Soleduc*	20	9
Stillaguamish	5	33
Willapa*	24	2
Wind-White Salmon*	29	1
Grand Total		**856**

* Represents addition of new watershed by this effort

Sites sampled by 15 additional jurisdictions were added to the database by this effort (Table 6). King (285) and Snohomish (129) Counties have the greatest number of sampling sites represented in the database (Table 6). The remaining counties each have less than 140 sites in the database (Table 6). Samples from 10 additional counties are now represented in the database. The spatial distribution of sampling locations within these counties is skewed. More that 80% of the sampling locations are located in three counties (King, Snohomish and Clallam).

Table 6. Jurisdictions/ agencies represented in the database.

Jurisdiction	Number of Sampling Sites
Adopt-A-Stream Foundation*	9
Bainbridge Island*	18
City of Bellevue*	16
City of Bellingham*	14
City of Everett	8
City of Federal Way*	11
City of Issaquah*	11
City of Kirkland*	7
City of Lake Forest Park*	4
City of Redmond*	32
City of Seattle	51
Clallam County*	88
Ecology*	22
King County	285
Kitsap County*	29
NMFS*	69
Pierce County	24
Skokomish Tribal Nation*	13
Snohomish County	129
Thurston County*	16
Grand Total	**856**

* Represents addition of jurisdiction/agency by this effort

Table 7. Counties represented in the database.

County	Number of Sampling Locations
Clallam County*	131
Clark County*	2
Cowlitz County*	1
Jefferson County*	32
King County	403
Kitsap County*	49
Mason County*	17
Pacific County*	3
Pierce County	26
Skamania County*	1
Snohomish County	161
Thurston County*	16
Whatcom County*	14
Grand Total	**856**

- Represents addition of County by this effort.

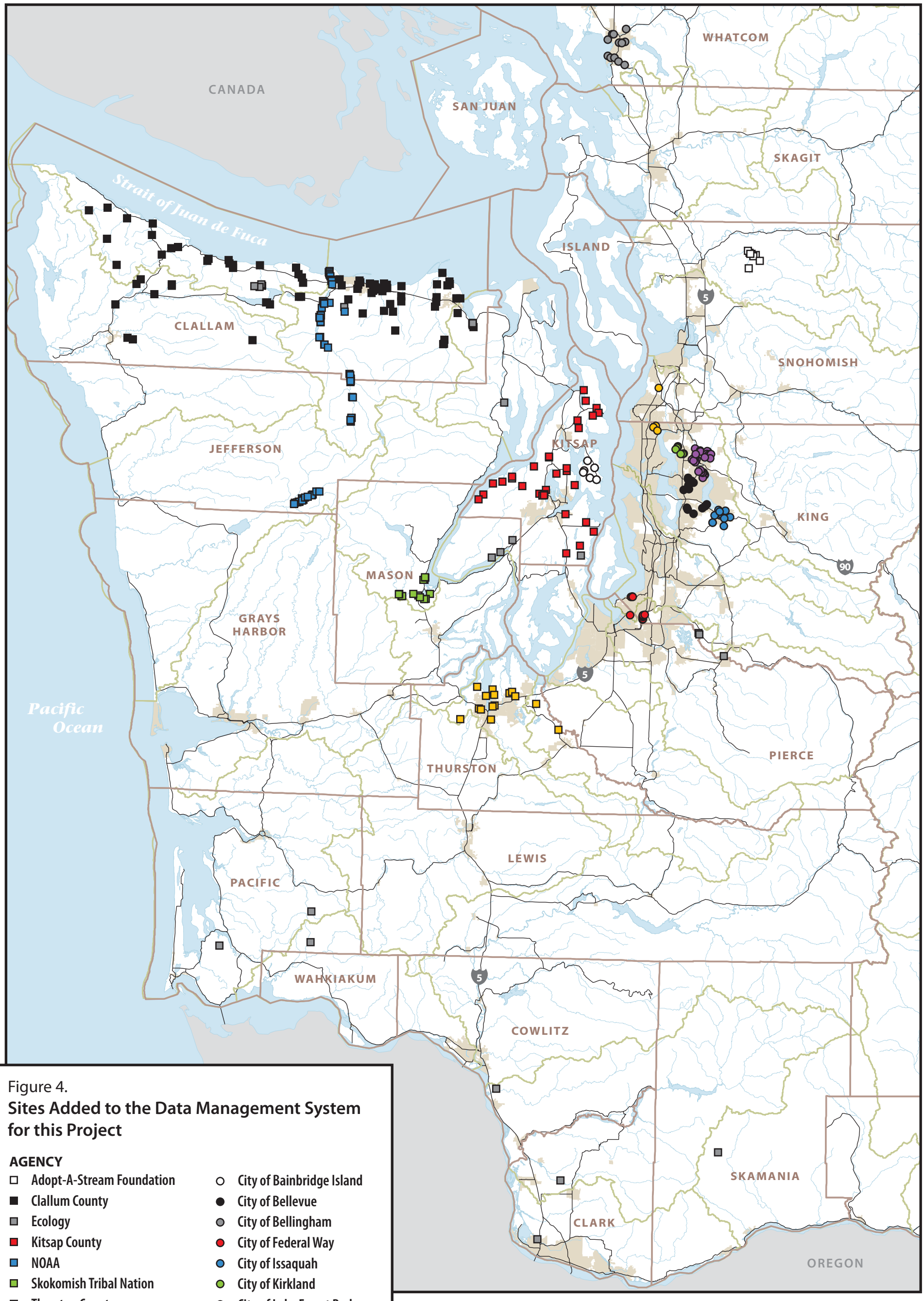


Figure 4.

Sites Added to the Data Management System for this Project

AGENCY

- Adopt-A-Stream Foundation
- Clallum County
- Ecology
- Kitsap County
- NOAA
- Skokomish Tribal Nation
- Thurston County
- City of Bainbridge Island
- City of Bellevue
- City of Bellingham
- City of Federal Way
- City of Issaquah
- City of Kirkland
- City of Lake Forest Park
- City of Redmond

- WRIA Boundary
- County Boundary
- Major Highway
- Major Waterbody
- Incorporated Area

King County
Department of
Natural Resources and Parks
Water and Land Resources Division

N

0 10 20 Miles

July 2009

Data source:
King County GIS Database

Produced by:
King County DNRP GIS and
Visual Communications & Web Unit,
0908benthosMAPwa.ai wgab

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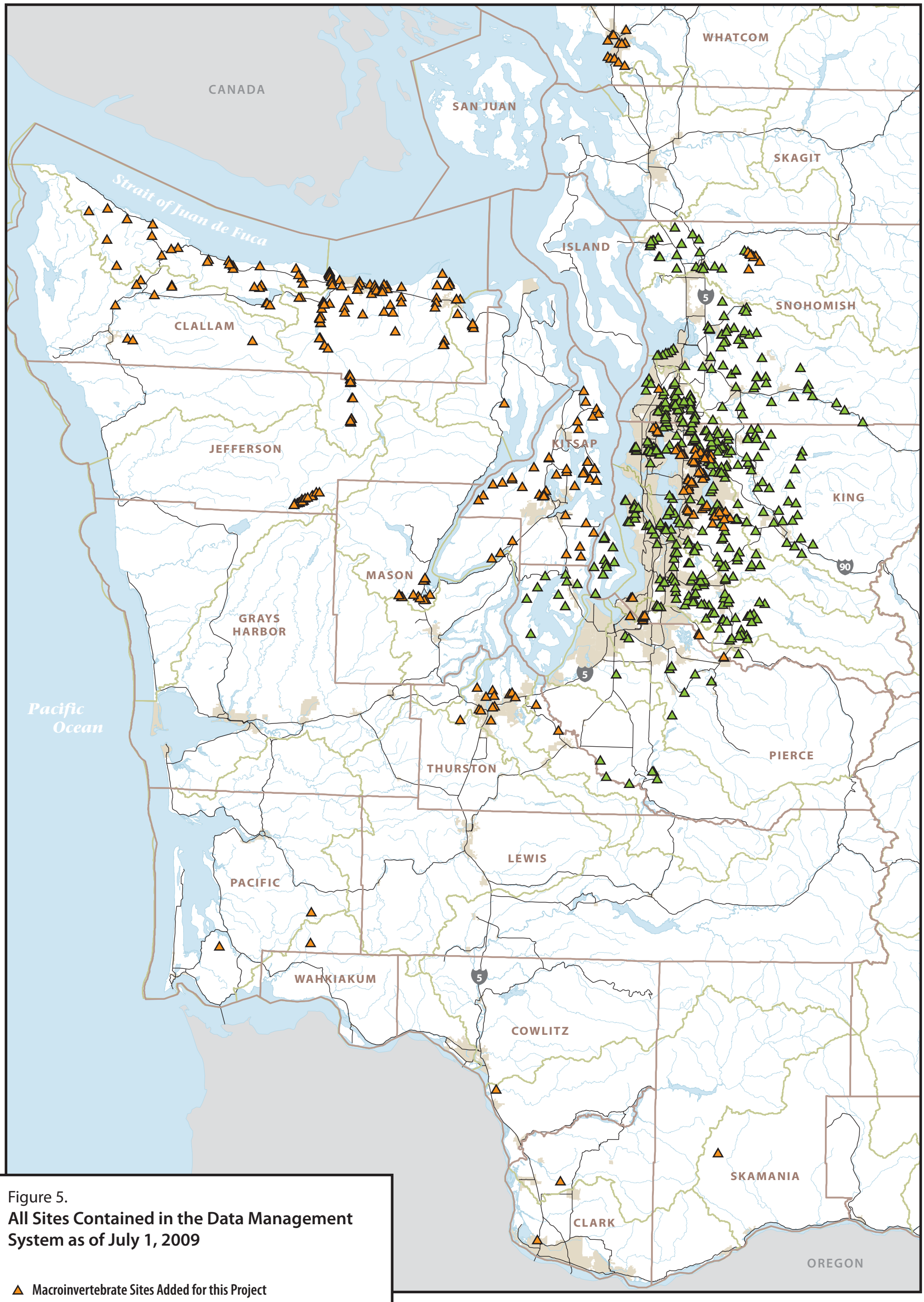

Figure 5.
All Sites Contained in the Data Management System as of July 1, 2009

- Macroinvertebrate Sites Added for this Project
- Pre-Existing Macroinvertebrate Sites

- WRIA Boundary
- County Boundary
- Major Highway
- Major Waterbody
- Incorporated Area

King County
Department of
Natural Resources and Parks
Water and Land Resources Division

N

0 10 20 Miles

July 2009

Data source:
King County GIS Database

Produced by:
King County DNRP GIS and
Visual Communications & Web Unit,
0908benthALLsitesMAP.ai wgab

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3.4 System Enhancements

As part of this project, a number of changes were made to the data management system. Some were improvements and others were adaptations to accommodate the new data entered. The changes included:

- Addition of a user option to include/exclude any sample replicate(s) from score calculation.
- Addition of a user option to flag or omit sample results based on user-defined minimum number of organisms per sample.
- The ability to have multiple projects and/or jurisdictions "share" a sample was added.
- Improvements were made to the user interface for laboratory data input application.
- The standard taxon list was expanded to add more organisms.
- Addition of integrated tooltips to assist end users not familiar with system.
- Additional cities, projects, and hydrological values were added to filters.
- Performance optimization completed.

In addition, a feature will be added to accommodate benthic macroinvertebrate data for which the BIBI may not be an appropriate analysis tool. The feature will identify this type of data and prohibit calculation and display of BIBI scores. Data supplied by the National Oceanographic and Atmospheric Administration (NOAA) included stations in larger rivers on the Olympic Peninsula. NOAA agreed to assist in assessing the applicability of BIBI methods for these data. Until this assessment is complete, the NOAA historical data will not be publicly viewable on the website.

4.0. CONCLUSIONS

Ongoing stream benthic macroinvertebrate monitoring programs were identified in eleven jurisdictions. These jurisdictions were Bellevue, Bellingham, Bothell (monitoring begins in 2009), Clallam County, Federal Way, Issaquah, Kirkland, Kitsap County, Lake Forest Park, Redmond, and Thurston County. All of these organizations expressed interest in long-term participation and use of the data management system as a resource and tool. Clark Public Utilities (Vancouver, Washington) and Surrey, B.C. also expressed interest. Most of these jurisdictions calculate BIBI scores as an environmental health assessment metric.

Many people who responded to the project solicitation provided enthusiastic support and were interested in using the tools provided by the data management system, even if they did not have an ongoing monitoring program or data to share. Upon discussion of the potential for maintaining the data management system into the future, many representatives with ongoing monitoring programs indicated there was a definite need for such a resource; however, they were unsure if they could provide financial support. Overall, the response from the status assessment indicated high demand for a data management system that could warehouse and analyze data, as well as allow for data sharing in the region.

This effort resulted in the addition of 359 new sampling locations represented in the database. In general, the sampling locations tend to be concentrated in a few areas, while coverage in other areas is somewhat sparse. The greatest spatial coverage of sampling locations in the region is concentrated in King and Snohomish Counties, the Kitsap Peninsula and the Clallam County/Elwha area. Although not all benthic macroinvertebrate data collected in region may be represented by this effort, these data illustrate the limited coverage in many parts of the region.

5.0. RECOMMENDATIONS

Completion of this project has highlighted various ways of improving monitoring coordination in the future. Recommendations are described below.

5.1 Stream Benthos Monitoring

Currently there are two primary methods for collecting stream benthos data, those designed to collect data to generate BIBI or other multi-metric index scores, and those designed to generate predictive modeling (e.g., RIVPAC). The primary methodological difference is the area sampled (3 square feet vs. 8 or 10 square feet). We recommend that studies be conducted to determine the comparability of data collected by both sampling protocols in addition to evaluating the potential to interchange sampling methodologies with both scoring methods.

Stream benthic macroinvertebrate monitoring is currently conducted by multiple organizations throughout the Puget Sound region. The monitoring efforts are conducted by a variety of professional staff, temporary staff, volunteers, and student interns. We also recommend that an effort to standardize the sampling methods for total area sampled be undertaken to increase data comparability potential across different programs.

5.2 Stream Benthos Data Management

There are a variety of upgrades, improvements, and features that we recommend adding to the stream benthos data management system to enhance its utility, including:

- Adding data from additional organizations as they become available.
- Establishing a web-based data loading program for taxonomic laboratories, to ensure ease and consistency in data loading as more entities use the system, and to simplify the deployment of updates and improvements.
- Adding Hilsenhoff Biotic Index, and EPT (Ephemeroptera, Plecoptera, Trichoptera) index scoring for stream benthos samples.
- Adding additional attribute tables to allow for comparison between different BIBI scoring systems.
- Adding predictive modeling analysis (e.g., RIVPAC) for appropriate stream benthos samples.
- Adding graphs showing changes over time for sites, subbasins, and WRIAs.
- Developing formatted, downloadable pdf reports for data tables, maps, and graphs to allow for easy reporting by project.

Due to logistical and budgetary constraints, this project focused on collating stream benthos data collected between 2002 and 2008. We recommend that data collected prior to 2002 be collated and entered into this system to ensure a comprehensive data set is developed.

We also recommend that an annual system users-group meeting be conducted every winter to discuss status of the monitoring programs, status of the data management system, results from previous monitoring efforts, monitoring plans for the following summer, and to prioritize and recommend any changes to monitoring protocols, the data management system, and data analysis methods.

5.3 Stream Benthos Data Analysis

As the data management system is populated with additional data sets, the ability to analyze these data sets increases. It is recommended that specific efforts be made to conduct more detailed analyses of the stream benthos data contained within the system, with respect to differences between different areas, changes over time, and relationship to other data sets, such as flow, land use, and water quality.

5.4 Data Management for Other Data Types

In conducting this project, it was recognized that most jurisdictions collect many types of environmental data and cannot devote sufficient IT resources to managing and sharing these data with others. This limitation is a direct barrier to improved monitoring coordination in the Puget Sound region. Expansion of the stream benthos data management system, or development of other systems with a similar operating paradigm, would alleviate this issue and substantially add to monitoring coordination efforts. Specific data types that are commonly collected include weather parameters, stream flow (and stage), lake level, continuous water temperature, continuous pH, conductivity, turbidity, and dissolved oxygen, and laboratory parameters such as bacteria, metals, TSS, organic chemicals, nutrients, etc. We recommend development of data management system(s) for these data types. We also recommend that the database(s) for these systems be centrally housed with a web interface, that jurisdictions maintain ownership of their data, that all data are shared with other users and the public, and that costs for maintaining these systems are shared among all users. Most importantly, we recommend that these system(s) become the primary systems each jurisdiction uses for actually managing their data. This would differ from the current situation where data may be submitted to a secondary system after collection but data analysis occurs separately at each jurisdiction.

5.5 Funding

King County is in the process of establishing a three-year interagency agreement with the Cities of Seattle and Everett, and Snohomish and Pierce Counties, for operation and maintenance of the Puget Sound Stream Benthos Data Management System. To date, no other jurisdictions or entities which have expressed interest in using this system have agreed to enter into such an agreement. As many of these entities have extremely limited funding and rely on volunteers for collecting samples, it is not realistic to expect every organization to enter into an agreement with

King County to manage their data. In addition, the level of effort by King County staff for developing, tracking, and maintaining these agreements is substantial, and it is unrealistic for King County to pursue an agreement with every organization collecting stream benthos data. For these reasons, it is recommended that a centralized funding source be developed to coordinate management of stream benthos data. This funding might come from Washington State, various federal agencies, or possibly, starting in 2012, local jurisdictions themselves as part of a monitoring fee included in the next municipal NPDES stormwater permit.

6.0. REFERENCES

Fore, L. S., J. R. Karr, and R. W. Wisseman. 1996. Assessing invertebrate responses to human activities: evaluating alternative approaches. Journal of the North American Benthological Society 15:212-231.

Karr, J. R., and E. W. Chu 1999. Restoring life in running waters: better biological monitoring. Island Press, Washington, DC.

Kleindl, W. J. 1995. A benthic index of biotic integrity of Puget Sound lowland streams. College of Forest Resources. University of Washington, Seattle.

Norris, R.H. and A. Georges. 1993. Analysis and interpretation of benthic macroinvertebrate surveys. Pages 234- 286 in D.M. Rosenberg and V.H. Resh (editors). Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York, NY.

Plotnikoff, R.W. and C. Wiseman. 2001. Benthic Macroinvertebrate Biological Monitoring Protocols for Rivers and Streams: 2001 Revision. Washington Department of Ecology, Olympia, WA. Ecology Publication no. 01-03-028.

Reynoldson, T.B., R.C. Bailey, K.E. Day, and R.H. Norris. 1995. Biological guidelines for freshwater sediment based on BEnthic Assessment of SedimenT (the BEAST) using a multivariate approach for predicting biological state. Australian Journal of Ecology. 20: 198- 219.

SalmonWeb. Online resource site. http://www.cbr.washington.edu/salmonweb/bibi

Wiseman, C.D. 2003. Multi-Metric Index Development for Biological Monitoring in Washington State Streams. Washington Department of Ecology, Olympia, WA. Publication No. 03-03-035.

Wright, J.F. 1995. Development and use of a system for predicting the macroinvertebrate fauna in flowing waters. Australian Journal of Ecology. 20: 181- 197.

Wright, J.F., M.T. Furse, and P.D. Armitage. 1993. RIVPACS: A technique for evaluating the biological quality of rivers in the UK. European Water Pollution Control. 3 (4): 15- 25.

Appendix A

Introductory Email

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My name is Doug Henderson, and I am an IT Project Manager at the King County Department of Natural Resources and Parks. I obtained your contact information either via referral or from a list maintained for the Puget Sound Coordinated Monitoring Program (http://www.ecy.wa.gov/programs/wq/psmonitoring/). The Coordinated Monitoring Program representatives recommended a number of monitoring related projects to Ecology for funding, including this project. As a result, Ecology has contracted King County to coordinate regional stream macroinvertebrate monitoring. I am contacting you because you may be interested in participating in this project, and because we would like to request a small amount of information from you.

As you may well know, macroinvertebrates are a key indicator for stream health. For this reason, they are routinely monitored by many organizations. Monitoring programs typically involve collecting samples annually, identifying and enumerating the macroinvertebrates in the samples, and then analyzing the results using either multimetric or predictive modeling approaches. However, although many different organizations collect these data, compiling data across different monitoring programs and across years can be difficult due to differences in the electronic formats and the analyses used.

To support this coordination project, we are tasked with identifying which organizations in the Puget Sound region collect macroinvertebrate data. In addition, for those organizations that are interested in participating, we would like to include these data in a regional data management system.

Over the past two years, King County has worked jointly with several other jurisdictions, including Pierce and Snohomish counties and the City of Seattle, to develop a data management system dedicated to stream macroinvertebrate data. The system includes a managed data repository with a web interface. The web interface includes presentation of the data in tables and on maps, data download capabilities, as well as an administrative interface for data owners. The system can be found at www.pugetsoundstreambenthos.org. Analytical functions currently include multiple Puget Sound Lowland Benthic Index of Biotic Integrity (BIBI) options, with advanced features for filtering and aggregating data and replicates. More analytical features will be added over time. Overall, the system provides a major improvement in stream benthos data management, analysis and use of the data, as it allows for:

- Collaborative data management with a robust, enterprise solution for managing stream benthos data,
- Enhanced data sharing and comparability between data sets,
- Improved documentation,
- Transparent and repeatable analyses,
- Updating of taxonomic data according to official Integrated Taxonomic Information System (ITIS) nomenclature, as well as unofficial conventions used by the taxonomic experts
- Automatic data loading directly from taxonomic laboratories, and
- Data ownership by entities collecting the data.

To coordinate stream macroinvertebrate regional monitoring and to extend the utility of the existing system and its analytical power, we are interesting in incorporating more regional data.

Therefore, we would greatly appreciate it if you would please answer the following questions to assist us with this effort:

1. Does your organization collect stream macroinvertebrate data (either historically, ongoing or in the future)?
2. How many samples do you collect per year?
3. Are you interested in having your data included in this regional data management solution?

Please let me know if you are interested in participating in the expansion of this regional resource. I would greatly appreciate a response, even if your organization does not collect stream macroinvertebrate samples or is not interested in participating. If you are not the appropriate person to respond to this request, I would be grateful if you could forward this message to the proper individual, with a cc to me as well. If you let me know that you have data and that you are interested in participating, I will follow up with you to discuss how we can include your data.

Thank you very much for your consideration of this request. If you have any questions or concerns, please feel free to contact me.

Sincerely,

Doug Henderson

IT Project Manager

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