EPA GRANT APPLICATION: SCIENTIFIC STUDIES AND TECHNICAL INVESTIGATION ASSISTANCE PROGRAM

PROJECT TITLE – Enhancement and Standardization of Benthic Macroinvertebrate Monitoring and Analysis Tools for the Puget Sound Region

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King County has no affiliation with ACORN. Informed of RFA through EPA's Website

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ABSTRACT – Many regional agencies use macroinvertebrate data to assess stream health. While similar sampling and analysis methods are used, inconsistencies and a lack of causal analysis tools prevent integrated reporting across agencies and jurisdictions. This project will develop standardized monitoring tools and an ecosystem indicator; two key Puget Sound Partnership goals, to address these issues. Key project outcomes will be (1) an updated list of sensitive and tolerant taxa derived from empirical testing of data collected from the Puget Sound lowlands; (2) a recalibration of the Puget Lowland Benthic Index of Biotic Integrity; (3) a cross-walk to reconcile data collection protocols; (4) application of EPA's Biological Condition Gradient framework to guide development of a freshwater ecosystem indicator and (5) expanded analytical capabilities of the existing Puget Sound Stream Benthos database. The project will enhance collaboration and partnerships throughout the region and provide essential tools to support funding, policy, and management decisions.

1. PROJECT SUMMARY – The proposed project builds on existing benthic macroinvertebrate (macroinvertebrate) monitoring data (>4000 site visits) and multi-jurisdictional collaboration to develop standardized and enhanced tools to create a stream macroinvertebrate based freshwater ecosystem indicator and a monitoring, analysis, and reporting program for the Puget Sound region; two key Puget Sound Partnership (PSP) goals. The ecosystem indicator will serve as a tool to measure regional stream health. To achieve these goals the project will develop:

- Taxa attributes derived from macroinvertebrate responses to local disturbances;
- A quantitative method to link different macroinvertebrate sampling, data analysis and storage methods throughout the region;
- Calibration of the Puget Lowland Benthic Index of Biotic Integrity (PL-BIBI) for Puget Lowland streams;
- Response signatures of the benthic macroinvertebrate community to specific stressor types.

A 2009 assessment of Puget Sound regional monitoring programs identified 21 local, state, and federal agencies, citizen and non-profit groups, and tribes that collect macroinvertebrate data to track biological integrity (King County 2009a). Since the mid 1990s, the multimetric PL-BIBI (used by 18 of the 21 entities) has been the primary analytical tool used to evaluate biological conditions in Puget Lowland streams (Fore et al. 2001, Karr & Chu 1999, Kleindl 1995, Morley & Karr 2002). Samples are typically collected from a 3 ft^2 riffle-targeted habitat area.

The Washington State Department of Ecology (Ecology) conducts ambient (Plotnikoff & Wiseman 2001) and status and trends macroinvertebrate monitoring (Cusimano et al. 2006), in addition to special study monitoring. Ecology has developed two BIBIs for the Cascade and

Puget Lowland ecoregions (Wiseman 2003) similar in concept to the PL-BIBI, however, the field protocols require sample collection from 8 ft^2 rather than the 3 ft^2 area used for the PL-BIBI. Ecology is also developing a predictive multivariate model[1] (Karen Adams, pers. comm., Feb. 2010). Multivariate model predictions are based on the expected taxonomic composition compared with observed taxa at a site to obtain an observed-to-expected taxa ratio (O/E), a measure of biological health (Wright et al. 2000). Like Ecology's multimetric indices, their O/E model requires sample collection from 8 ft^2. The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) and the US EPA (EPA) also recommend collecting macroinvertebrates from at least 8 ft^2 (Hayslip 2007, Klemm et al. 2006).

Although Ecology and EPA recommend sample collection from 8 ft^2, local entities are reluctant to shift sampling protocols due to the risk of orphaning their existing long-term data sets (> 4000 site visits) collected from 3 ft^2. Sample collection from a larger surface area generally results in collection of a greater variety of taxa and an increase in index values, regardless of analytical method used (Cazier 1993, Vinson & Hawkins 1996). Thus, there is a need to establish a cross-walk between methods to retain the ability to use existing long-term and future data to evaluate trends in biological integrity over time. Side-by-side samples will be collected to develop a conversion factor to translate PL-BIBI scores between the two sampling protocols (3 ft^2 and 8 ft^2 sample areas) to allow data comparison. Sample site selection will consider a number of factors (described below in Sec. 2, Task 4).

Interpreting biological condition from macroinvertebrate stream data is based on the functional and ecological traits of individual taxa. The BIBIs used within the region and interpretation of the proposed O/E diagnostic models require use of taxa attributes to interpret likely causes of biological impairment. Future O/E diagnostic models may involve integration of expected and observed frequencies of taxa detection with taxa ecological traits to aid in causal interpretation (Carlisle & Hawkins 2008). Current taxa attribute lists are inconsistent across projects, have not been subjected to peer review, and were developed in the 1990s from natural history records and best professional judgment (e.g., Barbour et al. 1992, Wisseman unpub.). As a result, metrics used to describe macroinvertebrate community structure, construct BIBIs and develop policy and regulations are based on out-of-date and incomplete information. The project will use existing data (>4000 site visits) to update the tolerant and intolerant attribute lists by testing for relationships between taxa and their response to disturbance. Habitat, trophic level and natural history based attributes will be updated based on the scientific literature. While BIBI's are reliable indicators of ecological condition, information derived from specific taxa has the potential to expand the ability to diagnose change associated with specific stressor types. An updated, comprehensive regionally based attribute list will strengthen the ability to detect change and diagnose causes of impairment (Statzner 2010, Carlisle & Hawkins 2008). This information will improve data confidence, and allow for data comparability and effective regional resource management.

The PL-BIBI was developed and calibrated in the early 1990s using data from approximately 200 stream site visits in Puget Sound; Clackamas River, Oregon; and the Olympic Peninsula (Karr 1998, Fore unpublished data). The PL-BIBI was derived from specific regional studies, but never calibrated for a broad application throughout the region. To increase its sensitivity and

[1] Ecology is looking to develop new O/E models for WA rather than rely on existing models (e.g., Western WA model (Ostermiller & Hawkins 2004) or Western States model (Yuan et al. 2009, Carlisle &Hawkins 2008).

regional applicability existing data (>4000 site visits in the Puget Sound basin, see attached map) will be used to recalibrate the PL-BIBI. The ten metrics used by the current PL-BIBI are scored as 5 (best), 3 (moderate) or 1 (poor); the sum represents the total index score (ranging from 0-50). The PL-BIBI will be recalibrated to score metrics continuously from 0-10, an approach which typically reduces variability in the final index values, which will range from 0-100. Metric values will be tested for correlation with natural variability (e.g., elevation, gradient) and metric expectations. Scoring will be adjusted as needed such that PL-BIBI values will represent comparable biological condition throughout the Puget Lowlands.

In 2008 King, Pierce and Snohomish counties, and the City of Seattle collaborated to develop a macroinvertebrate data management system (http://www.pugetsoundstreambenthos.org/). In 2009 data from 16 additional entities were added (King County 2009a). The system currently stores data from >4000 site visits collected by 20 entities at 918 sites from 1994-2009 (see attached map and link to database) and allows for data storage; calculation, and downloading of the PL-BIBI and associated metrics, and raw taxonomic data. The system uses standard taxonomic names, preserves project metadata, and maintains data ownership by the collection entity. The proposed project will enhance the database to incorporate the updated attributes and changes related to recalibration of the PL-BIBI described above. The existing database analysis tools will be expanded to include Ecology's multimetric indices (Wiseman 2003) and the O/E model currently in development, and individual metrics such as EPT taxa richness[2]. Currently only 6 of the 20 organizations that have contributed data to the database have established contracts for ongoing system use; the project will fund data submittal for 5 additional entities. Expanding and updating this multi-entity regional database will provide consistent data storage and analysis tools and allow for data flexibility and regional comparability. This comprehensive database will provide a key tool necessary to develop a regional coordinated macroinvertebrate monitoring program.

The Water Quality Index (WQI) is one of the freshwater ecosystem indicators currently used by the PSP (PSP 2010) to assess regional water quality. While the WQI provides a snapshot of general water quality conditions, it is based on conventional parameters (e.g., dissolved oxygen, nutrients, temperature) (Hallock 2002) and does not reflect impacts of other stressors or provide a measure of biological condition. Effects associated with contaminant input and hydrologic alteration associated with pulsed stormwater runoff are not likely captured by routine water quality monitoring. As such, additional freshwater indicators that measure biological response are necessary to complement the WQI and implement the PSP's performance management system (PSP 2009a).

The EPA has developed a conceptual model framework, the Biological Condition Gradient (BCG), to link Clean Water Act (CWA) goals to the quantitative measures used in biological assessment (Davies & Jackson 2006). The BCG establishes a scientific framework to interpret biological response to increasing levels of stressors, sets objectives for biological condition that support the structure and function of natural systems, and provides a foundation for non-scientists to identify targets and benchmarks for restoration and protection. The BCG framework will be used to derive index values, modified as needed to reflect regional expectations for the PL-BIBI and the O/E that match categories of the BCG. This effort will yield numerical index

[2] EPT Taxa Richness - number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa in a sample. EPT are typically most diverse in natural streams and decline with increasing watershed disturbance.

values, in addition to a regionally-appropriate interpretation to describe what the values indicate in terms of resource condition. This will provide a more precise evaluation of current and potential biological conditions and serve as an ecological indicator.

To encourage collaboration, a multi-jurisdictional Project Management Team (PMT) comprised of representatives of cities, counties, tribes and other regional agencies (Table 1, Sec. 7) will be developed. The PMT will bring together multiple entities to encourage collaboration and provide feedback on project study design and analysis methods and ensure the project fulfills regional needs for collecting, managing and sharing macroinvertebrate data. The PMT will work towards developing an ongoing regional monitoring partnership. Collaboration enables agencies to better focus management actions around ecological rather than political boundaries and communicate with the public in a meaningful and consistent manner

Outreach and communication are essential components of the proposed project. The project team (project manager and project staff) will work with the PMT to solicit feedback and encourage dialogue with other groups (e.g., PSP, Stormwater Work Group (SWG), PNAMP and Ecology). A project website will be established to serve as a portal to disseminate information and project material (additional details in Sec. 7 and Sec. 2, Task 8 below).

Nexus to Regional Priorities – The project outputs and outcomes support many of the priorities outlined by the PSP Action Agenda (AA) and Biennial Science Plan (BSP), and EPA's Strategic Goals. Development of a standardized set of macroinvertebrate monitoring and analysis tools based on the best available science is supported by AA Priority A (protection of ecosystems) and E (monitoring and accountability), BSP Goal 1 (2.11, analyze existing information and monitoring) and 3 (3.11, integrated monitoring to understand the ecosystem and monitor effectiveness) and EPA Goals 2, Objective 2.2.1 (watershed water quality) and 5 (compliance). Consistent regional monitoring data are critical to understand and track existing conditions, identify areas in need of protection and monitor the effectiveness of actions and regulatory efforts. The project provides the tools necessary to identify critical causal factors which are required to focus restoration goals and measure effectiveness, and improve the overall ecological understanding of Puget Sound streams. Enhancement of the existing Puget Sound Stream Benthos database enabling consistent analysis and data sharing indirectly supports the goals described above, and in particular AA Priority E.1.5 (develop a comprehensive data management strategy). In addition, the PSP is using "results chain" conceptual models to track outcomes of natural resource management actions (PSP 2009c) and two topics relevant to this project emerged across all six chains: (1) watershed scale assessments to inform strategy and activity development (e.g., identifying areas for protection or restoration); and (2) cross-agency and multi-scalar collaboration (the general recognition that many strategies cannot be successful at a basin wide level if strong collaboration and coordination do not exist.) See logic model below for additional connection to priorities.

2. PROJECT COMPONENTS

Task 1 - Quality Assurance Project Plan (QAPP) -Timeline: 2010. Milestones: EPA-approved QAPP; finalized sampling design; sample sites selected; site access granted. Description: The QAPP will be prepared following EPA guidance and submitted for EPA review; comments will be addressed and review will continue until the plan is approved by EPA. The approved QAPP will be reviewed and updated as needed.

Task 2 - Project Management Team and Regional Coordination - Timeline: Project Duration. Milestones: PMT established (2010); regional macroinvertebrate monitoring

partnership initiated (Summer 2013); draft report and recommendations reviewed by PMT (Fall 2013); presentation of interim/final results to PMT (project duration). Description: A multi-jurisdictional PMT comprised of representatives of cities, counties, tribes and other regional agencies (Table 1, Sec. 7) will be developed to encourage collaboration and provide feedback on project study design and analysis methods. The PMT will work closely with the project team to ensure the types of data collected and data interpretation methods identify and support the management actions to protect and restore streams. The PMT will meet quarterly in 2010/2011 and bi-monthly during 2012/2013.

Task 3 - Strengthen Diagnostic Capability of Metrics - Timeline: Fall 2010-2011. Milestones: Existing data collated; GIS and statistical analyses, and literature review complete; finalized attribute lists. Description: Historical data (>4,000 site visits) will be used to test for relationships between individual taxa and their responses to independent measures of human disturbance to update the tolerant and intolerant attribute lists. Human disturbance gradients will be derived primarily from GIS data and where available, other relevant data (e.g., water quality, flow and habitat data). Attributes for clinger, predator and long lived organisms will be updated based on the available scientific literature (e.g., Poff et al. 2006, Statzner et al. 1997, Wisseman unpub). These data will strengthen the ability to identify the cause of observed impairment.

Task 4 - Reconcile Differences in Sample Collection Methods – Timeline: Sample design Fall 2010, field work - Summer 2011/2012, data analysis 2012-2013. Milestones: Field work complete; taxonomic and data analysis, GIS analysis, draft/final report and recommendations complete; results presented to PMT. Description: This task will develop a quantitative algorithm to translate index values between sample area protocols (3 ft^2 and 8 ft^2) to ensure that results reported from each method can be compared and reported interchangeably. Side-by-side samples will be collected to calibrate index scores derived from the two protocols. Careful site selection will capture the potential confounding natural environmental factors (e.g., elevation, gradient and geographic location) that influence the relationship between taxonomic diversity and sample area. The sample design will cover the range of human development (less disturbed to highly urban) to ensure the cross-walk (algorithm) is applicable across land uses and other natural factors (e.g., elevation, gradient, etc.) that influence macroinvertebrate assemblages. If necessary, these factors will be included as covariates in the study design. Existing data will be used to identify the most important natural factors and determine the sample size necessary to provide a sufficient degree of confidence in the translation across methods (i.e., statistical power analysis). We anticipate collection of no more than 300 samples over 2 sampling seasons.

Task 5 - Expand the Puget Sound Stream Benthos Data Management System – Timeline: 2010-2013. Milestones: PMT Coordination, new data obtained and uploaded, database enhancements complete. Description: The existing database will be modified to incorporate updated attributes (Task 3) and changes related to recalibration of the PL-BIBI (Task 6). The database will be expanded to include calculation of Ecology's multimetric indices (Wiseman 2003) and the O/E model currently in development, in addition to individual metrics such as EPT Taxa Richness. The project will provide funding to include data from 5 additional entities.

Task 6 - Recalibrate the PL-BIBI – Timeline: 2011. Milestones: Existing data collated, GIS and statistical analysis complete, updated PL-BIBI. Description: Existing data (>4000 site visits) and the updated attribute lists (Task 3) will be used to recalibrate and update the PL-BIBI. The index will be recalibrated to score metrics continuously from 0-10, resulting in more precision in the final index values. Metric values will be tested for correlation with natural features, (e.g.,

elevation, and metric expectations) and scoring adjusted as needed, such that PL-BIBI values are comparable throughout the Puget Lowlands. Existing historical data (stored in the database) will be recalculated using this updated index.

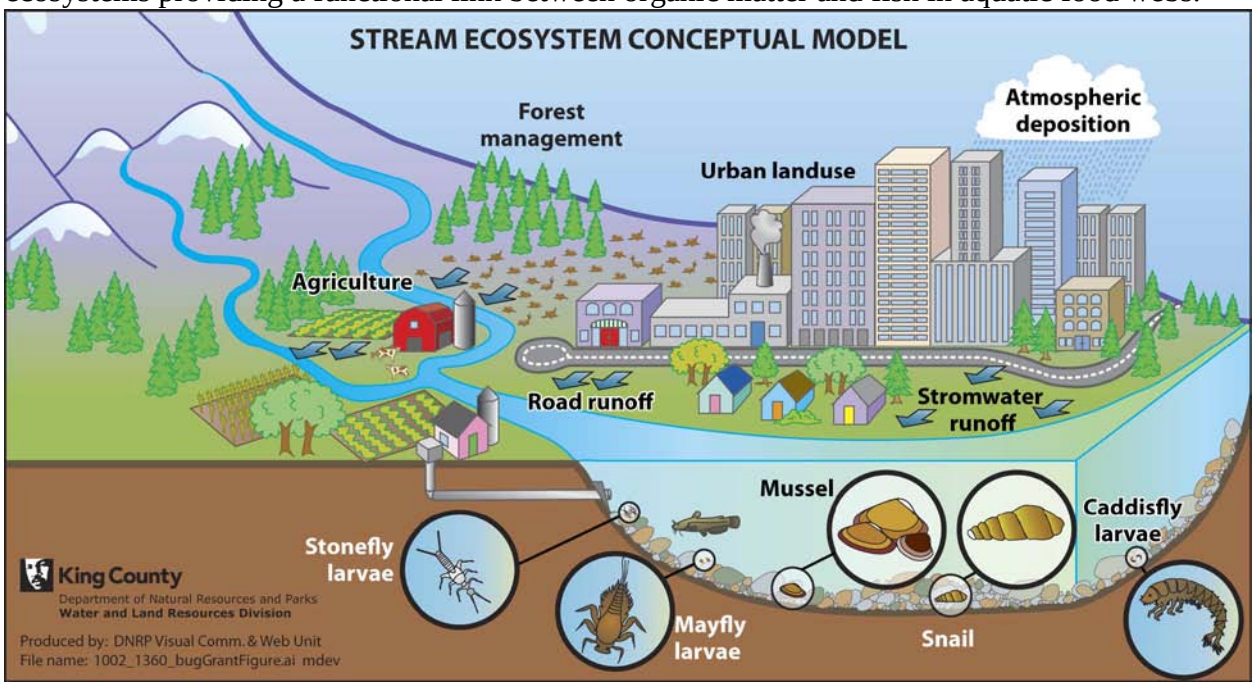
Task 7 - Develop a Puget Sound Ecosystem Stream Health Indicator – Timeline: 2012-2014. Milestones: Existing data collated, statistical analysis, draft/final report and recommendations complete; outreach to interested groups (e.g., SWG, PSP, Water Resource Inventory Area (WRIA) planning groups) conducted; peer reviewed journal article submitted. Description: The tools and database enhancements described above in Tasks 3-6 will be used, along with EPA's BCG framework, to develop a regional freshwater stream health indicator. Index values for the PL-BIBI and the O/E will be derived to match the categories of the BCG. Index values will be modified as needed to reflect regional expectations. Once completed, this task will yield numerical index values, in addition to a regionally-appropriate interpretation of what the indicators actually indicate in terms of resource condition.

Task 8 - Outreach and Communication - Timeline: Life of project. Milestones: PMT established, project website developed, ongoing outreach to other entities in the Puget Sound region complete, conference participation, grant results and outcomes reported. Description: This task builds on the success of this project to engage additional jurisdictions across the region to combine their macroinvertebrate data into a single database and collaborate on assessment of regional stream conditions. The project team will work with the PMT to expand the engagement to additional jurisdictions, solicit feedback and encourage dialogue between groups (e.g., PSP, SWG, WRIA's, PNAMP). The project team will also identify potential funding options to maintain future long term use of the database. A project website will be developed to allow access to documents, meeting agendas, and review comments by all members. Results will be presented locally and to regional groups (WRIA's, PSP, SWG) and at regional and national conferences. Grant outputs will be summarized in reports documenting the background, methods, and results for each process. In addition, a summary describing how these data and tools can be used for management purposes will be developed (e.g., testing effectiveness monitoring). All reports and data will be incorporated into the publicly available Puget Sound Stream Benthos web site/database, and where appropriate, published in peer reviewed scientific journals. See Sec. 9 below for additional discussion.

Task 9 - Project Management -Timeline: Life of project. Milestones: Reports to EPA as required by the grant. Description: This task includes tracking the project scope, schedule, budget and quality, coordinating the project team and the PMT, developing and processing contracts, agreements, and invoices, and reporting to EPA as required by the grant.

3. ENVIRONMENTAL SIGNIFICANCE- Running waters are critical components of the Puget Sound ecosystem. From a human perspective, streams provide drinking water, recreation and a pleasing aesthetic. Streams are conduits in the water cycle, transporting excess precipitation to estuaries and oceans and contributing to groundwater recharge. They are corridors for fish and wildlife migration connecting fragmented habitats and conserving biodiversity. They also play a key role in nutrient cycling and organic matter decomposition. Yet, streams are subject to multiple pressures including water withdrawal, stormwater runoff, invasive species, habitat degradation, land use change, overharvesting of resources, and impacts of climate change. These multiple, interacting threats have caused greater declines in freshwater biodiversity than seen in most terrestrial ecosystems (Sala et al. 2000, Dudgeon et al. 2006).

As illustrated in the conceptual model below, a key threat to Puget Sound and its freshwater resources is modification of land and water resources for human uses (e.g., urban development, loss off pervious surfaces, stormwater runoff, and land use conversion). These stressors result in alteration of the quality and quantity of water flowing in a stream channel such that organisms are exposed to flashier hydrographs, elevated levels of contaminants and nutrients, altered channel stability and morphology (Karr & Chu 1999, Walsh et al. 2005). These alterations are typically reflected in impacts to benthic communities which are key components of lotic ecosystems providing a functional link between organic matter and fish in aquatic food webs.



Biological measures have the advantage of providing a time and stressor-integrated response because biological communities, such as macroinvertebrates, integrate the effects of multiple stressors and reflect cumulative impacts (e.g., hydrologic and habitat alteration, water quality degradation and available food resources) (Plafkin et al. 1989; Karr 1991). Biological assessments provide an early warning signal by responding to intermittent stressors and subtle disruptions likely missed by periodic chemical analyses.

Macroinvertebrates are routinely used in biomonitoring programs to assess and report the ecological condition of streams. Their utility in this capacity is due to their high abundance and taxonomic diversity, limited migration patterns, response to environmental disturbances, and natural population structure (Fore et al. 1996; Rosenberg & Resh 1993). A 2009 assessment of monitoring programs in the Puget Sound region identified 21 local, state, and federal agencies, citizen and non-profit groups, and tribes that collect macroinvertebrate data (King County 2009a).

The increased cross-jurisdictional coordination, method standardization, improved ease of data access and manipulation, and more precise and accurate analysis tools evolving from this project will enable us to draw regionally based conclusions and begin to identify where and why biotic integrity is declining or improving. Based on this knowledge, scientists and planners can design more effective projects; track effectiveness of restoration and protection projects, and improve the focus of recovery plans. The knowledge and tools will allow for efficient use of limited

funding and development of policies and regulations backed by the best available science. All of which contribute to improved freshwater ecosystems, and ultimately a healthier Puget Sound.

Interrelated projects - Development of a regional ecosystem indicator of watershed health based on macroinvertebrates has been highlighted by the PSP (PSP 2009b) as a priortiy. Development of a Puget Sound stream monitoring program that includes macroinvertebrates has also been identified as a high priority by the SWG (Puget Sound SWG 2009) and prioritized as an important component of the monitoring recommended for salmon recovery efforts (WRIA 8 2005). This project will enhance existing macroinvertebrate programs throughout the region by providing improved analysis tools and a central data management system allowing for regional use and comparison of data. The tools developed by this project can be applied throughout the region to guide monitoring and produce consistent and comparable data that describe stream health and biotic integrity. This ecological condition information will allow for identification and prioritization of areas in need of protection and restoration and will be used to guide regional policy and management. These data are also critical for evaluating effectiveness of restoration actions and regulations. In addition, development of a macroinvertebrate ecosystem indicator will provide a mechanism to assess status and trends of stream health in the region. The collaboration of state and local entities associated with this project provides a direct link to the PSP AA goal of working together and efficiently on priority actions.

4. ANTICIPATED OUTPUTS AND OUTCOMES

Anticipated Outputs

- Project QAPP and Project Management Team
- Comprehensive and empirically derived list of taxa attributes to improve diagnostic capability of macroinvertebrate data and metrics, and recommendations for diagnostic interpretations of metric scores
- Expanded centralized macroinvertebrate web based data storage, visualization, analysis, and downloading tool accessible to all
- Standardization and ease of data dissemination including summary statistics and environmental indicators
- A suite of analysis tools including a re-calibrated PL-BIBI, and an algorithm to compare macroinvertebrate data collected using 8 ft^2 and 3 ft^2 methods.
- A macroinvertebrate ecosystem indicator for Puget Sound that summarizes stream biotic integrity across the region and links to EPA's BCG framework
- A standardized regional monitoring effort facilitated by a multi-entity regional benthic macroinvertebrate consortium that evolves out of the PMT
- Technical and peer-reviewed scientific publications documenting development of analysis tools described above
- Better documentation of data collection methods, data standards and improved data integrity and consistency
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Anticipated Outcomes

Overall environmental outcomes expected from this project include increased cooperation between jurisdictions and enhanced understanding of regional environmental conditions. This in turn leads to improved efficiency of implementation of environmental mitigation and restoration in addition to the effective use of limited funding to implement these projects.

Short Term Outcomes

- Improved regional coordination and communication necessary to implement a comprehensive macroinvertebrate monitoring program
- Increased understanding of and ability to detect and identify stressors causing degradation of Puget Sound's freshwater systems
- The ability to evaluate regional trends in biotic integrity
- Improved interactions between monitoring entities and the public
- Increased efficiencies in monitoring programs and data management across jurisdictions; fewer resources (staff time, dollars) required for an improved level of service or redirection of existing resources to expand monitoring programs
- More informed and timelier decisions based upon best available science and greater knowledge of the watershed
- Increased citizen awareness of ecological conditions due to ease of data access
- **Long Term Outcomes**
- Improved understanding of causal factors leading to focused and effective protection and restoration
- Improved water quantity and water quality conditions following focused attention on high priority locations identified through use of standardized monitoring program data and data management system
- Ability to track changes in freshwater biotic integrity at various scales (e.g., Sound-wide or sub-basin) throughout the Puget Sound region
- Provide scientific basis and continued data accrual to guide management actions including, but not limited to, development of ecological goals (restoration and protection), allocation of restoration and protection dollars, land use planning, and effectiveness monitoring

Please refer to the Logic Model for greater detail and connections to priorities

5. MONITORING AND MEASURING - Short and long term measures will be used to monitoring the progress of this project. Short term measures include reaching the milestones outlined in Sec. 2 above. The project manager will work with the project team and PMT to encourage collaboration and assure that all tasks are completed on time and within budget. Project management techniques will be used to measure progress toward outputs such as creating a project schedule, tracking project task and subtask status and completion, and delegating task leads. A key measure of long term success will be the adoption of the ecosystem indicator by PSP and the ultimate development of a regional macroinvertebrate monitoring program. The success of database improvements will be tracked by the number of participating jurisdictions and total number of site visits uploaded. An additional long term measure of success will be the degree to which entities have been able to transition sampling methods and retain the ability to use their historical data. The number of peer reviewed published journal articles will also serve as a medium term level of success.

6. INNOVATION –The project outputs and outcomes will provide innovative solutions to integrate existing macroinvertebrate monitoring programs and build on current analysis tools to improve their usefulness for policy and decision making. Taking full advantage of the wealth of regional macroinvertebrate data increases the power and application opportunities for the data and strengthens the regions' ability to identify status and trends. The project builds on existing analysis tools to update the ecological traits and strengthen the ability to detect changes in environmental condition and diagnose causes of impairment. This approach has been identified as an important emerging trend in the field of biological monitoring (Statzner 2010, Carlisle & Hawkins 2008, Plotnikoff & Wiseman 2001). Finally, this project will allow numerous regional

entities to better implement biological assessment of freshwater ecosystems and track the effectiveness of management actions to protect and restore Puget Sound lowland streams.

7. COLLABORATION

King County will partner with scientists and jurisdictions, agencies, tribes, and nonprofits throughout the Puget Sound basin. The project will build on previous collaboration developed through the recent Puget Sound Stream Benthos Monitoring and Data Analysis system project that included 20 entities (King County 2009a). Collaboration will enable these agencies to better focus management actions around ecological rather than political boundaries and to communicate with the public in a more meaningful and consistent manner. Participating entities (Table 1) have submitted letters of support and plan to assist with sampling site selection, study design, document review, and development of standardized protocols.

Table 1. Participating entities

Cities		Counties		State Agencies and Tribes
Bellevue	Federal Way	Kitsap	Snohomish	Ecology
Bellingham	Issaquah	Pierce	Clallam County Streamkeepers	Skokomish
Everett	Seattle	Thurston		
Redmond	King	King County		

In addition, the project team includes Leska Fore, a nationally recognized expert in bioassessment, stream ecology and statistical analysis of macroinvertebrate data, and Robert Wiseman a recognized authority on the taxonomy and ecological traits of western North American aquatic invertebrates. Karen Adams, who leads Ecology's Biological Monitoring and Assessment Program and Ed Chad manager of Clallam County's Streamkeeper Program, will also participate on the project team (see details below under Key Project staff).

The project team will coordinate with PSP staff to develop recommendations for using macroinvertebrates as an indicator of Puget Sound stream health and to track improvements at a regional level. In addition, project results will be presented to the PSP Ecosystem Coordination Board and the PSP Science Panel.

8. OUTREACH AND INFORMATION TRANSFER – This project will develop standardized methods and analysis tools for macroinvertebrate monitoring in the Puget Sound region. These protocols will be developed with participation from many of the regional entities that collect macroinvertebrate data. Outreach to other jurisdictions, tribes, state and federal agencies and nonprofits in the region that might participate in macroinvertebrate monitoring will be conducted. Information collected will be stored in the data management system available via the web. In addition, funding from this project will allow for up to 5 entities that currently have insufficient funds to use the stream benthos data management system to enter their data for the life of the project.

9. PROGRAMMATIC CAPABILITY AND PAST PERFORMANCE

Institutional Qualifications: King County's Department of Natural Resources and Parks (DNRP) Water and Land Resources division (WLRD) has a demonstrated capability managing large and complex biological and water quality monitoring programs. Our staff includes aquatic and fisheries biologists, wetland scientists, water quality scientists and modelers, statisticians, ecotoxicologists, and GIS specialists. We have a strong track record of collecting, managing, and analyzing technical information and are tasked to develop regulatory, policy, and project recommendations and implementation. We have a well established role in natural resource management in cooperation with cities and federal, tribal, and state agencies. Typical current

research capabilities include several complex grant-funded studies: 1) Evaluating the role of nitrogen in the risk of lethal, low-level oxygen events in Quartermaster Harbor on Vashon Island; 2) Effectiveness of land use regulations to protect aquatic environments in developing rural areas by assessing biophysical, hydrological, and water quality responses; 3) Hydrological study to identify future stormwater retrofit projects and other stormwater abatement actions. In addition, we currently manage approximately 80 grants valued at $16 million for the acquisition and/or restoration of resource lands including those directed to the recovery of Chinook salmon.

Key Project Staff Include

Deb Lester (MS, Univ. of Vermont, School of Natural Resources) will serve as Project Manager. Deb manages WLRD's Toxicology and Contaminant Assessment Group and has over 28 years of experience working on various aspects of aquatic ecology and water quality related projects. She manages WLRD's Benthic Macroinvertebrate and Stream Monitoring programs. Relevant Publications - King County 2009a, 2009b.

Jo Wilhelm (MS, Univ. of Michigan, School of Natural Resources and Environment) will serve on the project team and work on QAPP development, field collection, analysis, and reporting. Jo currently works in urban, agricultural, and forested watersheds to monitor and assess stream and wetland condition. She has over 14 years of experience working on ecology, restoration, and environmental education/outreach related projects. Relevant Publications - Wilhelm et al. 2005, Wessell et al. 2008, King County 2009b.

Leska Fore (MS, Univ. of Washington, Quantitative Ecology and Resource Management) has developed biological monitoring protocols and survey designs for fish, invertebrates and diatoms in rivers, streams, lakes, and coral reefs. Her company, Statistical Design, has worked with local, state and federal governments to bring science into the policy arena for 15 years. Leska will advise on study design, statistical and data analysis. Relevant Publications – Fore et al. 1994, 1995, 1996, 2001.

Robert W. Wisseman (MS, Oregon State Univ., Aquatic Entomology) is a Senior Scientist and president of Aquatic Biology Associates, Inc. He has completed > 300 freshwater invertebrate ecology and biomonitoring projects throughout western North America and is a recognized authority on taxonomy and ecological traits of aquatic invertebrates. Robert will assist with the update of the taxa attributes. Relevant Publications - Fore et al. 1996, Barbour et al 1992, Portland General Electric 2002.

Karen Adams (Ph.D., Univ. of Louisiana, Ecology and Evolutionary Biology) is a stream ecologist and leads the Biological Monitoring and Assessment Program at Ecology. She has 12 years of experience in the watershed, wetland, and freshwater ecology fields monitoring plant, animal and insect communities. Karen will serve in a QA/QC capacity reviewing the study designs and data sets.

Doug Henderson (BS, Univ. of Puget Sound, Biology) manages DNRP's Application Development Group. He has 16 years of experience as a project manager and was Project Manager for the multi- jurisdictional Puget Sound Stream Benthos Monitoring and Data Analysis system. Doug will oversee database enhancements. Relevant Publications - King County 2009b

James Develle (BS, Univ. of Washington, Computer Science) is a software engineer and Master Application Developer with over 15 years of design, architecture and software development experience. He was the architect and lead developer for the Puget Sound Stream Benthos Monitoring and Data Analysis system and will be the lead developer for database enhancements.

Jim Simmonds (BA, Williams College, Mathematics) is Supervisor of King County WLRD's Water Quality and Quantity Unit and serves as Chair of the SWG. He has over 20 years experience conducting and managing a wide variety of water quality and hydrologic monitoring and modeling investigations, and managing complex data sets. Jim will provide senior project oversight. Relevant Publications – PSP 2009b, Puget Sound WSG 2009, King County 2009a.

Ed Chadd - (BS, Western WA Univ., Huxley College) manages the Clallam County Streamkeeper program and has been involved with benthic macroinvertebrate sampling, calibration, and interpretation issues for the last 10 years. Ed will assist with site selection and sampling and provide input and review of the study design, and assist with the data analysis.

9. BUDGET AND FINANCIAL INTEGRITY - Successful Completion and Management of Federal/State Funded Assistance Agreements - All grants are assigned a project manager responsible for coordinating/managing staff, partners and consultants, carrying out the scope of work, preparing programmatic reports and ensuring agreement conditions. A Business Finance Officer "interfaces" with the County accounting system, ensures budget compliance, tracks expenses and authorizes grant-related expenses. The budget office compliance specialist coordinates federal reporting and assures compliance with Federal regulations. Examples of grants that met (or are meeting) or exceeded required conditions:

Cottage Lake Phosphorus Reduction ($291,728 CWA Sect. 319 state pass-through): Key elements: Shoreline buffer restoration on public & private lands, behavior change through education, social and environmental sampling. Post-test of behavioral change and trend analysis of phosphorus reduction due in 2010-2011. History meeting reporting requirements: Quarterly reports of scope of work progress validate payment requests. Final report includes, among other deliverables, phosphorus study (state approved SAP & accredited lab) and quantified behavioral changes of watershed residents.

Model Low Impact Development Strategies for Big Box Retail Stores ($96,002 EPA/AWPP grant): Costco case study (http://your.kingcounty.gov/dnrp/library/2007/kcr1968.pdf). captured in a LID reference document with recommendations jointly developed by Costco and King County. As a result, Costco has initiated several LID measures nationwide. EPA Reg. 10 using knowledge gained to promote better site designs with Whole Foods and Kohls. EPA Reg. 10 exploring same LID practices for enforcement and compliance settlements and negotiations. History of meeting the reporting requirements: Co-edited book with Costco consultants for large retail store LID practices with extensively illustrated prescriptions also web-available.

King County Shoreline Master Plan ($1.2 million NOAA/CZM state pass-through): Assessed current land use, public access and ecological conditions with GIS landscape modeling tools to update 30-year old Shoreline Master Plan. Public and agency input included interactive web, award winning videos and workshops. Plan will prioritize long term shoreline restoration and public access. Other cities use these tools for information collection and promoting countywide consistency in shoreline management. History of meeting the reporting requirements: Planning document formally submitted to King County Council as reference for new SMA legislation.

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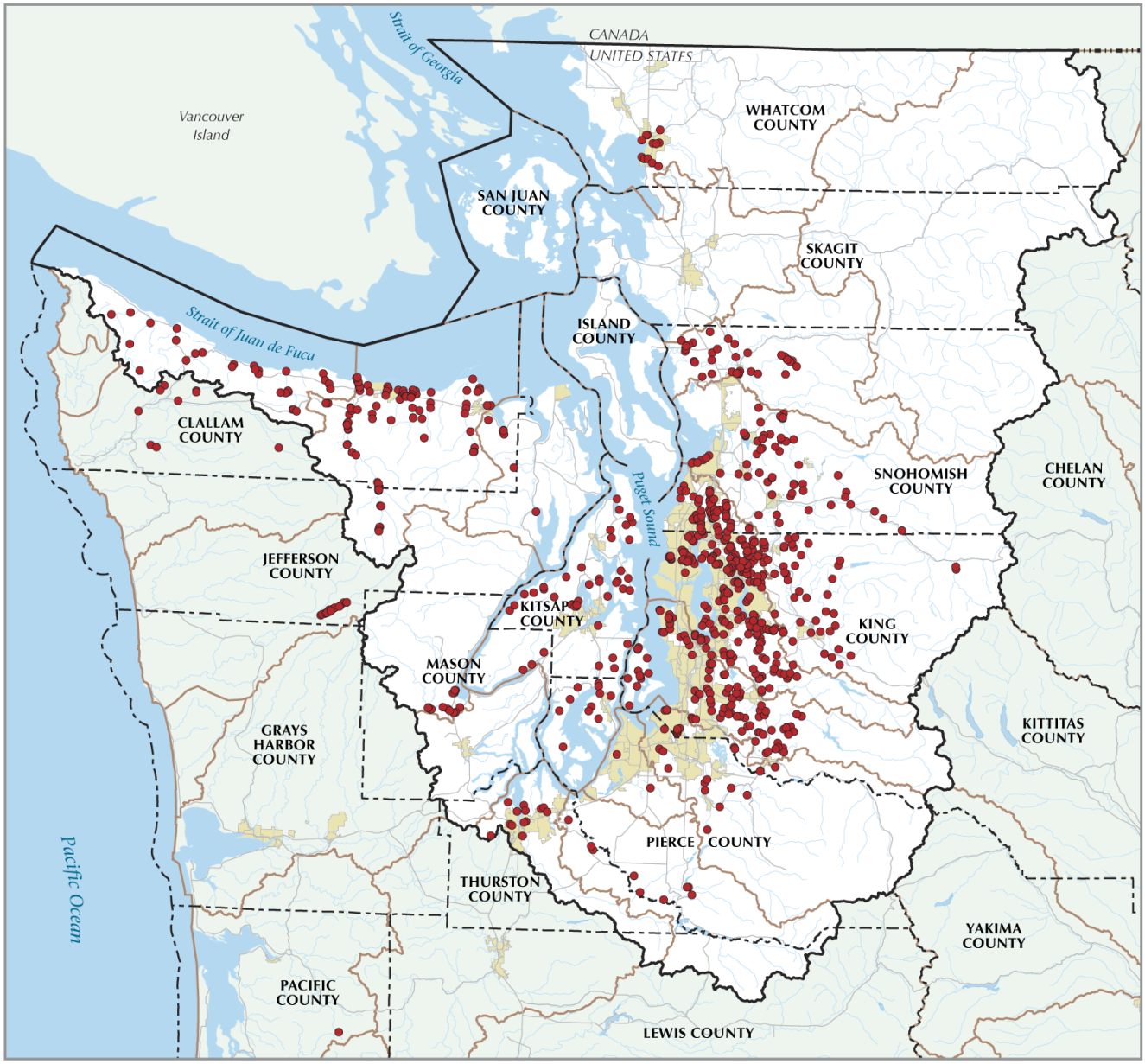
Logic Model - Enhancement and Standardization of Benthic Macroinvertebrate Monitoring and Analysis Tools for the Puget Sound Region

Strategy	Activity (Tasks)	Output	Connection to PSP AA, PSP BSP, or EPA Goals
Build effective, collaborative across agencies and organizations to effectively monitor stream health and provide information to decision makers	**(1)** Develop QAPP **(2**) Project Management Team and Regional Coordination **(4**) Reconcile Differences in Sample Collection Methods	Multi-agency collaboration to collect standardized macroinvertebrate data and a cross-walk tool for data comparison from different methods that avoids orphaning historical data	**PSP AA-D**: Work effectively and efficiently together on priority actions. The regional collaboration spearheaded by this project will decrease the current fragmentation of monitoring programs and promote data integration to evaluate ecosystem conditions across jurisdictional boundaries. **PSP AA-E**: Build an implementation, monitoring, and accountability management system. This project will result in comprehensive and consistent regional macroinvertebrate monitoring protocols that will enable development of a regional monitoring program.
Use best available science to improve precision of macroinvertebrate analysis tools and strengthen ability to determine sources of environmental impairment	**(3)** Strengthen Diagnostic Capability of Metrics **(6)** Recalibrate the PL-BIBI	Empirically derived tolerance attribute lists; Expanded and updated long-lived, predator, and clinger attribute lists; Re-calibrated PL-BIBI with adjusted scoring for increased sensitivity; ; Integration of tolerant and sensitive attributes with O/E models for impairment identification; Recommendations for diagnostic interpretations of metrics	**PSP BSP** 1: The innovative, scientifically defensible tools developed by this project, and integration of these tools into the existing database will result in improved data accessibility and the ability to analyze, integrate, and interpret data for decision making. The synthesis of historic and recently collected data will increase our understanding of freshwater stream ecosystems in the Puget Sound basin, identifying how biotic integrity has trended over time and how various stressors and land use actions affect the biotic community and stream health. **PSP BSP 4**: Through collaborative development of standardized methods, analysis tools, and a stream condition indicator, this project establishes an organizational structure and procedures for efficient, transparent, adaptable, and sustainable science-based decision making that feeds into restoration and protection.
Develop a scientifically defensible ecosystem condition indicator necessary to identify areas in need of protection to support, guide, and evaluate implementation programs, policies, and practices designed to protect and restore the functions and productivity of Puget Sound's aquatic ecosystems	**(7)** Develop a Puget Sound Ecosystem Stream Health Indicator	A Puget Sound Ecosystem Health Indicator based on macroinvertebrates that summarizes stream biotic integrity and links to EPA's Biological Condition Gradient	**PSP AA-A**: The enhanced and standardized regional monitoring program and ecosystem indicator developed by this project will provide consistent, scientifically defensible ecosystem condition information necessary to identify areas in need of protection. Additionally, this information will support, guide, and evaluate implementation programs, policies, and practices designed to protect and restore the functions and productivity of Puget Sound's aquatic ecosystems. **PSP BSP 2**: The data and tools developed by this project will provide critical information to measure effectiveness of actions and improve the ecological understanding of Puget Sound Streams. **EPA 2, Obj. 2.2.1**: This project will produce reliable regional monitoring data and an ecosystem indicator to identify impairment, which will support future water quality improvements. **EPA 4:** Streams are an integral part of healthy ecosystems, and this project will provide reliable ecosystem function data necessary to protect and restore these systems.

Strategy	Activity (Tasks)	Output	Connection to PSP AA, PSP BSP, or EPA Goals
Improve data accessibility allowing information to be readily available to the public, scientists, and decision makers	**(5)** Expand the Puget Sound Stream Benthos Data Management System **(8)** Outreach and Communication	Improved web based data storage, interface, and downloading system; Technical and peer-reviewed reports and publications documenting development of analysis tools; standardization and ease of data dissemination; improved data integrity and consistency	**PSP BSP 3**: This project will build technical and institutional capacity to generate, analyze, and communicate the information for effective and coordinated adaptive management of Puget Sound **EPA 5:** Comprehensive monitoring data are necessary to support compliance and environmental stewardship efforts

PSP AA = Puget Sound Partnership Action Agenda; PSP BSP = Puget Sound Partnership Biennial Science Plan;



BENTHIC MACROINVERTEBRATE SITES WITHIN THE PUGET SOUND BASIN

Data for these sites are stored in the Puget Sound Stream Benthos Database

- Benthic Macroinvertebrate Site
- Puget Sound Basin
- WRIA Basin Boundary
- River and Stream
- County Boundary
- Cities
- Open Water

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King County

Department of
Natural Resources and Parks
Water and Land Resources Division