2010 Stormwater Monitoring and Assessment Strategy for the Puget Sound Region: Appendices

June 30, 2010

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Appendix A The Process and Steps to Develop a Regional Stormwater Monitoring and Assessment Strategy

Running steadily in the background behind the visible production of documents and the articulation of goals are the meetings and discussions and experiences of the people involved. The ultimate success of a regional monitoring and assessment program depends on cooperation of individuals and the agencies and groups they represent; therefore, we have tried to organize, involve and engage people in a way that is as inclusive and transparent as possible.

The risk associated with creating a regional stormwater monitoring and assessment program is that the complexity of the effort can overwhelm its purpose. Our efforts to date provide an example: because a large number of professionals and stakeholders participated in workshops designed to identify the most important questions that a regional monitoring program should address, the process generated more questions about stormwater than we can answer in a reasonable time. Similarly, the list of actions proposed to reduce stormwater impacts is also long. Prioritizing which hypotheses to test and which actions to take is very difficult in the absence of more complete information; but if we wait until we know everything, or even 'enough', no action will ever be accomplished. In our case, the potential complexity associated with testing for what we don't know threatens to distract us from our purpose, which is to reduce the effects of stormwater.

The remainder of this appendix provides the interested reader a history of the Puget Sound Stormwater Work Group (SWG), an overview of the ways we have worked to engage the tremendous assets of the region in solving our problem, and a description of our relationship and connections to other key efforts to restore Puget Sound.

A.1 Creating the Stormwater Work Group

In 2006, a group of interested parties were brought together by the Washington Department of Ecology (Ecology) to consider development of a coordinated regional monitoring program for the Puget Sound region. This group evolved into the Puget Sound Monitoring Consortium (Consortium), funded by the Washington State Legislature. Information about the Consortium, including its reports, can be found at http://www.ecy.wa.gov/programs/wq/psmonitoring/index.html.

The Consortium developed a set of recommendations for organizing and establishing a coordinated ecosystem recovery monitoring program for Puget Sound. The Consortium proposed a *Puget Sound Coordinated Regional Monitoring and Assessment Program* with authority to assure funding; ensure high-quality science, including adequate study design, QA/QC, and peer review; track projects; develop and maintain databases; conduct cross-topic synthesis and analysis; and more. The Consortium's proposal was taken on by PSP, which is in the early stages of implementing the first recommendations and establishing an ecosystem monitoring program to coordinate and manage this effort and connect it to other topic-driven monitoring coordination and prioritization efforts.

The structure the Consortium recommended provided an umbrella for topical work groups that provide a forum for key stakeholders to determine monitoring and assessment needs by geography or issue and to oversee collection of the data that help improve our understanding of the ecosystem. The Consortium anticipated work groups comprised of members involved in monitoring and assessment activities. Some work groups already existed in other forms but a work group for stormwater was identified as a priority need. At the request of the Puget Sound Science Panel, the executive director of the Puget Sound Partnership, and the director of Ecology, the Consortium oversaw the establishment and launching of the SWG.

In addition to launching the SWG, the Consortium launched pilot projects to meet pressing needs for coordination and improved credibility of the monitoring data that is routinely collected in the Puget Sound region, including: developing standard operating procedures for automated sampling of stormwater and subsequent analysis of the data; standardizing reporting methods and expand a database for stream benthos information that can be populated by all entities in Puget Sound that collect this information; and conducting an inter-laboratory calibration exercise. The SWG is building upon these efforts, and the lessons learned in conducting the pilot projects, in developing a monitoring and assessment strategy for Puget Sound.

The Consortium committees' recommendations (Surface Water and Aquatic Habitat Monitoring Advisory Committee 2007 and Puget Sound Monitoring Consortium 2008) are reflected in SWG mandates: transparency of the process, inclusivity of discussions and decision-making, specific focus on improving stormwater management to protect and restore designated uses, making an explicit connection to Clean Water Act NPDES permit monitoring requirements for municipal stormwater, clear connection to and coordination with other efforts, effective use of resources, meaningful and credible data and analyses produced and used by decision-makers.

The SWG is now a formal effort that has the support of the Partnership, Ecology, and others. A draft charter, bylaws, and caucus-based system of representation on an oversight committee were formally adopted in December 2008. An initial work plan was adopted in January 2009 and formally amended in April 2009; and numerous amendments and adjustments have been agreed upon at SWG meetings since then but not yet reflected in the formal work plan due to competing priorities for staff time. These living, founding documents and all SWG meeting agendas and summaries are available at http://www.ecy.wa.gov/programs/wq/psmonitoring/swworkgroup.html. Interim working documents, supporting information, and agendas for the SWG's working subcommittees are posted at http://sites.google.com/site/pugetsoundstormwaterworkgroup/.

The SWG is working to address the following specific agency needs:

- For Ecology:
    - Define efficient and effective monitoring protocols and priorities to inform permits;
    - Serve as a part of a bigger effort to better articulate and quantify the region's stormwater funding needs, particularly for local governments, including ongoing maintenance and operational practices, new capital facilities, strategic retrofit,

technical assistance, pollution prevention source control and safer alternatives, and education and outreach programs, and other ways; and
    - In the future, continue to develop a water quality monitoring program that leverages the participation of governments and the private sector to inform adaptive management actions.

- For the Partnership:
    - Define efficient and effective monitoring protocols to inform ecosystem monitoring program;
    - Implement Action Agenda NTA C.2.N1 Create a regional stormwater monitoring program;
    - Inform the effort to establish credible benchmarks and threat reduction objectives to inform the Puget Sound Action Agenda; and
    - Provide a resource-based measure of whether the suite of best practices for stormwater management that are intended to address high priority pollutants (*e.g.*, low impact development, treatment systems, pollution prevention and safer alternatives, *etc.*) are successful in reducing loadings.

- For both agencies:
    - Identify steps to implement information technology to support the storage, management, and sharing of this monitoring data and findings.

The SWG is formally comprised of 22 representatives of business, environmental, agriculture, tribal, local, state, and federal government agency caucuses. The members are listed on the reverse side of the cover page of this document. All SWG members accept responsibility for communicating with their caucuses about the progress and upcoming decisions to be made by the SWG. Each meeting agenda provides time for other parties in attendance to comment on decisions that are on the table. The SWG's efforts since October 2008 have been focused on the development of the draft *Stormwater Monitoring and Assessment Strategy for the Puget Sound Region*.

A.2 Steps to Achieve our Goals

- **Creation and vetting of Assessment Questions (Appendix C) by experts and stakeholders.**
    - February 17-19, 2009 technical expert workshops. Participants: Allison Butcher (Master Builders Association of King and Snohomish Counties); David Batts (King Co.); Jill Brandenberger (PNNL); Scott Collyard (Wash. Dept. of Ecology); Ken Currens (NWIFC, for Puget Sound Partnership); Tim Determan (Wash. Dept. of Health); Karen Dinicola (Ecology); Jeff Fisher (Environ, for NMFS/NOAA); Mindy Fohn (Kitsap Co.); Jonathan Frodge (Seattle); Thom Hooper (NOAA Fisheries); Doug Hutchinson (Seattle); Bob Johnston (U.S. Navy); Heather Kibbey (Everett); DeeAnn Kirkpatrick (NOAA Fisheries); Andrea LaTier (U.S. Fish and Wildlife Service); Joan Lee (Parametrix); Jim Maroncelli (Wash. Dept. of Ecology); Doug Navetski (King Co.); Char Naylor (Puyallup Tribe); Dale Norton (Wash. Dept. of Ecology); Ed O'Brien (Wash. Dept. of Ecology); Kit Paulsen (Bellevue); Tom Putnam (Puget Soundkeeper Alliance); Randy Shuman (King Co.); Jim Simmonds (King Co.); Carol Smith (Wash. State Conservation

Commission); Tom Sibley (NMFS); Heather Trim (People For Puget Sound); Gary Turney (USGS); Dean Wilson (King Co.); and Bruce Wulkan (Puget Sound Partnership).

- May 19, 2009 public workshop. About 170 people participated; the workshop facilitator produced a summary of the feedback provided. The report is posted at http://www.ecy.wa.gov/programs/wq/psmonitoring/ps_monitoring_docs/SWworkgroupDOCS/SWGWorkshopFinalReport.pdf.

- **June 11 and 16, 2009 "Sprint" workshops of technical experts to translate assessment questions into hypotheses.** (Appendix D, also see link to the document at http://www.ecy.wa.gov/programs/wq/psmonitoring/swworkgroup.html.) Participants: Howard Bailey, Nautilus; Abby Barnes, Kennedy/Jenks; David Batts, King County; Derek Booth, Stillwater Sciences; Jill Brandenberger, PNNL; Scott Collyard, Ecology EAP; Cat Curran, Nautilus; Jay Davis, U.S. Fish & Wildlife Service; Curtis DeGasperi, King County; Dana de Leon, City of Tacoma; Tim Determan, WA Dept of Health; Damon Diessner, ESAction; Karen Dinicola, Ecology; Mark Ewbank, Herrera; Jeff Fisher, Environ; Mindy Fohn, Kitsap County; Leska Fore, Statistical Design; George Fowler, Independent Consultant; Jonathan Frodge, City of Seattle; Dick Gersib, WA Dept of Transportation; Eric Greenwald, The Boeing Company; Julie Hampden, Herrera; Curtis Hinman, WA State University; Heather Kibbey, City of Everett; Joan Lee, Parametrix; John Lenth, Herrera; Julie Lowe, Ecology WQP; Tetyana Lysak, The Boeing Company; Curtis Nickerson, Taylor & Associates; Dale Norton, Ecology EAP; Mel Oleson, The Boeing Company; Kit Paulsen, City of Bellevue; Rob Plotnikoff, TetraTech; Steve Ralph, Stillwater Sciences; Scott Redman, Puget Sound Partnership; Rich Sheibley, U.S. Geological Survey; Jim Simmonds, King County; Glen Sims, Puget Soundkeeper Alliance; Bill Taylor, Taylor & Associates; Scott Tobiason, Brown & Caldwell; Heather Trim, People for Puget Sound; Gary Turney, U.S. Geological Survey; Dean Wilson, King County; and Bruce Wulkan, Puget Sound Partnership.

- **Small team identified to develop draft scientific framework document:** Derek Booth, Stillwater Sciences; Karen Dinicola, Ecology; John Lenth, Herrera; and Jim Simmonds, King County

- **Oversight and direction of writing team by subgroup:** Scott Collyard, WA Dept. of Ecology; Jay Davis, U.S. Fish and Wildlife Service; Dana de Leon, City of Tacoma; Tim Determan, WA Dept. of Health; George Fowler, Independent Consultant; Dick Gersib, WA Dept. of Transportation; Jonathan Frodge, City of Seattle; Heather Kibbey, City of Everett; Julie Lowe, WA Dept. of Ecology; Dale Norton, WA Dept. of Ecology; Kit Paulsen, City of Bellevue; Gary Turney, U.S. Geological Survey; Bruce Wulkan, Puget Sound Partnership

- **Dynamic process of integration:** Oscillation from the small to the large; dynamic tension between structure and initiative; dynamic tension between process and content
  - This document provides the recommended starting point and approach to achieving a comprehensive regional understanding of the impacts of stormwater and the effectiveness of our management actions to prevent, reduce, or mitigate those impacts.
  - We anchor the strategy in adaptive management structure to support and evaluate alternative actions with scientific monitoring and hypothesis testing.
  - We still need to refine indicators, targets, and benchmarks as we better understand the relationships among ecosystem components and the impacts of stormwater on the Sound. Part of this process requires identifying any new indicators and

developing indicator indices. Selection of the final set of indicators will be based on several factors, such as data availability, how well the set captures the full range of ecosystem functions impacted by stormwater, and the costs of monitoring and analysis.

- **Peer review and stakeholder comments on draft scientific framework document:** Five formal peer reviewer reports from Rich Horner, Bob Pitt, Tom Schueler, Jean Spooner, Steve Weisberg) and more than 800 stakeholder comments from 22 agencies and individuals, and more than 100 participants at the November 10, 2009 public workshop.
- **Entire work group discussion of major themes in comments:** December 2009 through April 2010 work group decided how to change the scientific framework in response to the input received. Subgroups were formed to develop new sections and to tie the scientific framework to the implementation plan. Subcommittees of work group work to revise chapters on status and trends, source identification, effectiveness, and regional program implementation.
- **Stakeholder review by outside experts and stakeholders**
    - Review of strategy by stakeholders at public workshop on May 19, 2010.
    - Public comment period continues through May 28, 2010.
- **Final strategy completed June 2010.**
    - Includes broadly approved priority starting point for a regional monitoring program as well as specific next steps to launch the program, including mechanics of monitoring (*i.e.*, SOPs and data management requirements) and effective use of the region's collective capacity and resources to collect and analyze data:
        - Commitment of agencies and individuals to implement the strategy,
        - Better understanding of the roles of individuals and agencies,
        - Better understanding of the relationships between individuals and agencies.

A.3 Example of a Detailed Conceptual Model of Stormwater Impacts

The integrated success of various efforts to avoid impacts to water features can only be determined by evaluating the condition of integrating attributes, best evidenced by biological responses or endpoints. Other such integrators relating to human health and well-being have been suggested in the course of developing the *Action Agenda*, the Partnership's plan for recovering the Puget Sound ecosystem by 2020 (Partnership 2008); they occupy the same conceptual position in this strategy.

Within the broad conceptual model described in section 4.2 in the strategy (see Figure 2), each element can be further deconstructed. Figure A.1 shows an example of a more specific conceptual scientific model for comprehensively evaluating stormwater. We consider this to be a useful approach to inform our thinking and future development and refinement of monitoring

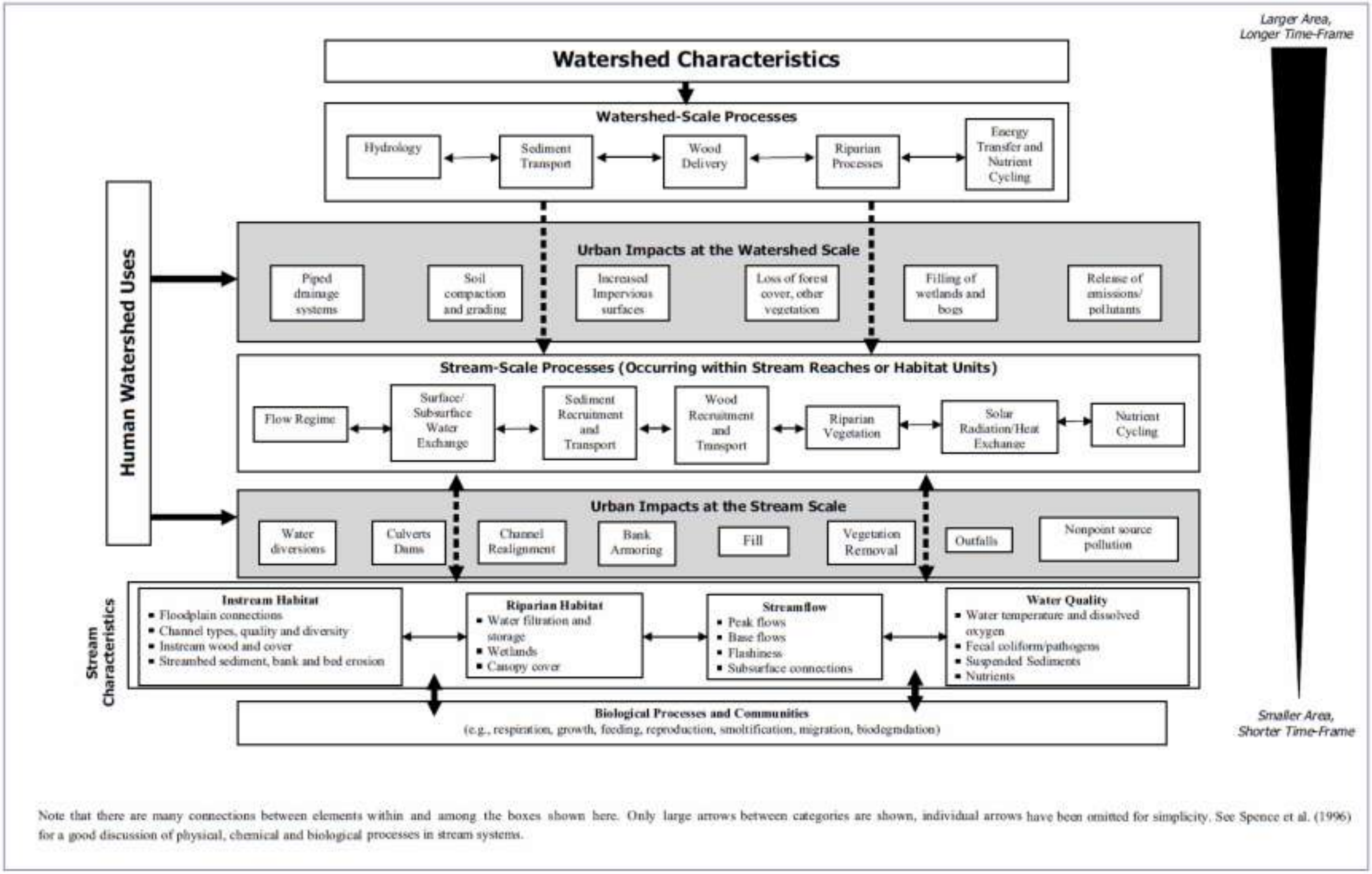

Figure A.1. Conceptual model of a stream ecosystem functioning in an urban environment (Seattle, 2007). The model includes many but not all areas targeted for investigation by the proposed regional stormwater monitoring and assessment strategy.

efforts. It provides a good starting point for guiding monitoring efforts to evaluate progress toward ecosystem recovery. A similar specific conceptual model for nearshore areas should be developed and utilized in guiding the monitoring efforts in that part of the ecosystem, putting the specific habitat and other features supporting the biological endpoints selected as indicators should in broader context.

A.4 Connections to Other Efforts

A.4.1 Puget Sound Partnership

The Puget Sound Partnership (PSP) is charged with overseeing the efforts to restore Puget Sound and is also accountable for measuring the progress made towards ecosystem recovery goals by implementing specific activities articulated in the "Puget Sound Action Agenda: Protecting and Restoring the Puget Sound Ecosystem by 2020" (PSP, 2008). The SWG's development of a regional approach for monitoring stormwater is listed as a Near Term Action in the *Action Agenda* among many other key stormwater management activities.

Continued collaboration with the many governments and interests in Puget Sound will be essential in implementing solutions and sustaining actions that support a healthy ecosystem while moving forward with a vibrant economy. The *Action Agenda* calls for large-scale regional approaches and the creation of consistent protection and restoration standards for the region; reducing pollutant inputs at the source; prioritizing and retrofitting existing stormwater management facilities (particularly in areas that were urbanized long ago); and ramping up low impact develop techniques in urbanizing areas. The *Action Agenda* also calls for the reform of environmental regulatory programs as well as improvements to the capacity of local partners to implement actions and compliance efforts across Puget Sound.

The *Action Agenda* states the need to establish priorities and resource needs for creating a coordinated water quality monitoring program under National Pollutant Discharge Elimination System (NPDES), and the need to coordinate with the overall regional monitoring program identified in the Action Agenda. Utilizing the NPDES permit structure will enable the development of a regional program that works synergistically with the multiple local stormwater monitoring efforts and address both the local stormwater impacts and develops a program to address the cumulative Puget Sound wide stormwater impacts.

A.4.2 Puget Sound Coordinated Ecosystem Monitoring and Assessment Program

As part of its mandate to oversee efforts to recover Puget Sound, PSP is establishing a coordinated ecosystem monitoring program to guide recovery efforts and provide feedback about progress toward recovery (see section A.1). The ecosystem monitoring program is envisioned to provide an umbrella under which multiple, topical monitoring efforts are overseen in three key ways: first, a science-policy interface is created and maintained whereby scientific knowledge can better inform key decisions and policies; second, efficiencies are gained by prioritizing and coordinating the work done by multiple entities operating under multiple mandates; and third, a better understanding of the complex ecosystem is achieved through cross-topic analysis and synthesis of information.

The Stormwater Work Group (SWG) is among the first work groups envisioned to be formally incorporated into this structure. The SWG is a test pilot model for setting priorities and developing a strategy to gather and analyze key data to solve the biggest problems facing the Puget Sound basin. Other Work Groups include but are not limited to:

- Chinook Recovery monitoring;
- the Puget Sound Assessment and Monitoring Program (PSAMP);
- Cooperative Monitoring Evaluation and Research (CMER); and
- the Toxics Loading Steering Committee that is coordinating ongoing efforts to fill gaps in knowledge and understanding of toxic pollutant sources, fate, and transport in the Puget Sound region.

All of these efforts are coordinated under the umbrella of the Puget Sound Action Agenda, populated with "Near Term Actions" to recover the Puget Sound Ecosystem.

A.4.3 The Clean Water Act and National Pollutant Discharge Elimination System Permit Monitoring Requirements

The primary objective of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. 1251, sec. 101). Reducing the impact of stormwater on receiving waters has been notoriously difficult because stormwater is produced everywhere that the landscape has been developed; stormwater is episodic and its impact on the natural hydrology is difficult to reduce; and stormwater accumulates and transports the toxins, waste, and sediment associated with developed lands (NRC, 2009). Under the CWA, are required to control urban and industrial stormwater through the National Pollutant Discharge Elimination System (NPDES) permit program (sec. 402) and effective BMPs to control nonpoint source pollution (sec. 208).

The Washington State Department of Ecology (Ecology) is delegated by the U.S. Environmental Protection Agency (EPA) to implement the CWA in Washington. Ecology requires monitoring as a condition of granting NPDES permits. In recent years, disagreements over permit monitoring requirements have motivated the permittees, the regulators, and other interested parties to work together to find a more efficient, meaningful and scientifically-based approach to monitoring. This strategy will include monitoring and assessment that can be used to formulate requirements in future stormwater permits.

Monitoring is a presumptive element of most CWA-permitted stormwater management programs. It can demonstrate compliance with regulations, identify sources and loadings of pollutants and characterize their effects on receiving waters, evaluate the effectiveness of stormwater control measures, and provide feedback to managers and the public about whether ecosystem improvements are occurring. As an example, the types of monitoring typically contained in NPDES Phase I municipal stormwater permits include:

(1) wet weather outfall screening and monitoring ("source identification"),

(2) dry weather outfall screening and monitoring ("illicit discharge detection and elimination" or IDDE),

(3) biological monitoring to determine stormwater impacts ("status and trends"),

(4) ambient water quality monitoring ("characterization"), and

(5) measuring the efficacy of stormwater control measures ("effectiveness") (NRC, 2009).

Industrial and construction stormwater general permits require sampling of discharges from outfalls but not monitoring of the quality of the receiving water. Other types of stormwater monitoring have existing statutory requirements and others are responding to very local or site-specific needs. Ideally, a monitoring and assessment strategy will provide guidance on how all prescribed and local efforts can contribute to an increased, data-supported understanding of how stormwater affects receiving waters and what are the most effective, or most promising, stormwater management approaches.

Recent Pollution Control Hearing Board rulings on the municipal stormwater permits issued in Puget Sound endorsed the SWG's process as a means of informing future permit monitoring requirements. This has provided additional incentive for permittees, environmental groups, regulators, and other interested parties to work collaboratively to create a solution.

Future efforts of the SWG may address specific NPDES stormwater general permits, specifically those for: construction sites, industrial activities, confined animal feeding operations, the WA State Dept. of Transportation, and others.

Appendix B Applying Lessons Learned from Adaptive Management at a Regional Scale

By Derek Booth, Ph.D., Stillwater Sciences

Land and water resource management agencies routinely make decisions that affect natural processes and ecological functions. Developing successful, large-scale management and restoration programs requires not only the identification of knowledge gaps but also a commitment to robust monitoring programs that are modeled on the concept and implementation of what is broadly termed "adaptive management."

It is not within the scope of this strategy to describe the institutional framework for the full adaptive management cycle: that task is assigned to the Partnership. In parallel with our development of this strategy, an adaptive management approach is being pursued by the Partnership to implement the *Action Agenda* to recover the Puget Sound ecosystem by 2020 (Partnership 2008). The Partnership's evolving framework can be informed by our Key Recommendations.

Nor is it within the scope of this strategy to define a comprehensive suite of stormwater monitoring actions. This strategy establishes an overarching scientific framework for stormwater-related monitoring that will allow otherwise independent efforts or whole programs to contribute to a greater understanding and evaluation of progress.

B.1 What is Adaptive Management, and How Does it Apply to our Problem?

Adaptive management, as first outlined by Holling (1978) and later revised, renamed, and recast by others (*e.g.*, Walters 1986; Lee 1999), is an approach for overcoming uncertain ecological outcomes associated with land-use and natural resource management actions by treating management activities as experimental components within the larger structure of a monitoring program (Ralph and Poole 2003). Specific management decisions that affect ecological processes and functions are systematically evaluated in ways that affirm or refute expected outcomes. Uncertainty is embraced and serves as a focal point for more specific evaluations. The process of adaptive implementation is iterative and continuous; new knowledge is actively incorporated into revised experiments, a practice best described as "learning while doing" (Lee 1999). The key difference between this approach and other environmental management strategies that are often implemented is the application of scientific principles, such as hypotheses-testing, to explicitly define the relationships between policy decisions and their measured ecological outcomes. Further, the adaptive implementation approach provides a means to understand and document these cause-and-effect relationships, as well as to evaluate alternative actions that may produce more desirable outcomes.

Scientifically credible and relevant information can only be generated when the monitoring "experiments" are designed with clear hypotheses about the effects of proposed management prescriptions. These hypotheses must be testable at multiple scales using available technology and methods (Conquest and Ralph 1998; Currens *et al*. 2000). Hypotheses that cannot be tested, or only account for site-specific conditions, are not useful in considerations of cumulative effects.

In order to retain clear linkages between key questions, hypotheses, and monitoring protocols, the experimental approach must be designed before determining which goals and targets are appropriate (Ralph and Poole 2003) since appropriate goals should be *outcomes* of the effort, not a precondition; and the approach must explicitly tie stated hypotheses to the key ecological questions. For example, in order to judge the relative capacity of rivers, lakes and marine waters to support "beneficial uses," existing state regulatory programs for water quality typically use a suite of evaluation criteria that provide specific thresholds above (or below) which it is assumed that the water quality is "unacceptable." In this case, there is a water quality indicator, and a target value to judge acceptability. In recent years, comprehensive monitoring programs are beginning to be developed to provide statistically valid designs to characterize water quality across state waters. New programs will be able to provide more clear insights into the ultimate and proximate causes when water-quality criteria are exceeded. Thus when the management objectives are stated, the underlying assumptions and hypotheses can be better articulated and more systematically tested.

Wagner (2006) asserts that [stormwater] regulatory programs in the past often failed because they were designed in ways that ignored technological and scientific limitations. "Science-based" does not simply mean the monitoring of status and trends followed by responding to imposed benchmarks and goals, but rather that scientific principles must be the foundation of regulatory program design, and that these programs must rely on scientific methods to demonstrate results. Wagner suggests that regulations can still be designed despite incomplete or developing knowledge, but that gaps and limitations must be acknowledged and used to inform ongoing investigations. His argument clearly echoes those of scientists who insist that monitoring experiments and testable hypotheses must frame management decisions and land-use objectives.

B.2 What are Some Pitfalls to Avoid?

In natural resource management, the following process traditionally dominates:

(1) a problem is identified, but not translated into a well-defined key question, and a cause is simultaneously assigned (*e.g.*, "increased sediment inputs into a stream are negatively impacting salmonid survival");

(2) a solution or set of solutions is proposed (*e.g.*, timber harvest is restricted and riparian buffer width is increased), but the prescription is not translated into a testable hypothesis associated with the problem or question;

(3) if the problem is not solved within an arbitrarily reasonable period of time (*e.g.*, a few years) then a different solution is proposed (*e.g.*, "augmented upland and riparian restoration must be implemented").

Although simplified, even this outline displays its divergence from adaptive management and from the basic principles of the scientific process, and the resulting process is perpetually reactive.

Recent efforts to build large, collaborative programs are commonly characterized by increasing stakeholder involvement, information sharing, outreach, and voluntary participation. These reflect the movement to extend natural resource management decision-making processes beyond just technical experts in order to reflect evolving social values (Pahl-Wostl *et al*. 2007). This shift implies "an adaptive co-management of social and ecological systems in which combines the dynamic learning of adaptive management with the linkage characteristics of cooperative management" (Berkes *et al*. 1998), but it does not require it. Greater participation does not necessarily mean that true adaptive management is occurring, or that scientific principals are being applied to either the choice of management actions or their evaluation. If successful, however, it also opens a path to achieving the best of both realms, namely scientific rigor with a broad base of community support. This document reflects such an effort.

B.3 Applying Lessons Learned from Previous Efforts

Numerous large-scale ecological monitoring efforts have been implemented around the nation, and they offer recommendations for the key elements of a successful program:

- Identifying clear and relevant goals.
- Setting measureable objectives.
- Using the best available science.
- Establishing an accountable organizational and funding structure that facilitates clear communication of stated objectives, methods, and results at all applicable levels.

Recent summaries of these "lessons learned" include the Puget Sound Nearshore Partnership's Application of the "Best Available Science" in Ecosystem Restoration: Lessons Learned from Large-Scale Restoration Project Efforts in the USA (Van Cleave *et al*. 2004)); the Surface Water and Aquatic Habitat Monitoring Advisory Committee's Report and Recommendations (2007); and PSAMP's Keys to a Successful Monitoring Program: Lessons Learned by the Puget Sound Assessment and Monitoring Program (2008). All of these syntheses echo the need for integrated monitoring programs and adaptive management mechanisms that provide not just a tracking of "success" or "failure," but insight into why objectives are or are not being met. The development of and the implementation of this stormwater monitoring and assessment strategy for the Puget Sound region attempt to apply the lessons articulated from comparable programs to frame a scientifically credible and useful approach based on the tenants of adaptive management and hypothesis-testing.

B.4 Large-scale Ecosystem Programs Around the Nation

Nationally and regionally, many systematic monitoring programs have been implemented over the past 1–2 decades. These programs vary in their adherence to the principals of adaptive management, and both their successes and their shortcomings provide instructive examples for the region. These examples are grouped into those that are broadly construed "ecosystem management/monitoring" programs (both nationwide and local to our regional) and those that focus explicitly on stormwater management programs. These examples were selected based on our perception of their relevancy to the proposed stormwater monitoring and assessment strategy for the Puget Sound region, but they are by no means exhaustive.

Chesapeake Bay Program (CBP)

The Chesapeake Bay Program (CBP) was established in 1983 and has evolved as a voluntary partnership between states, local and inter-state advisory and steering committees, and the EPA with the stated goal of restoring and protecting the Chesapeake Bay and its tidal tributaries. A Science and Technical Advisory Committee was formed shortly after CBP's inception to facilitate scientific communication between academic institutions, engineering and technical professionals, and organizations within the program, as well as to identify research needs and provide overall assessments and recommendations. The Monitoring and Analysis Subcommittee is comprised of five technical working groups that are charged with implementing monitoring and modeling programs, managing data, etc. This organizational structure is commonly cited for its successful "vertical and horizontal coordination and integration" of science (Van Cleave *et al*. 2004) and its effectiveness at maintaining sustainable funding and participation commitments by providing readily accessible and scientifically credible monitoring data (Surface Water and Aquatic Habitat Monitoring Advisory Committee 2007).

Although widely recognized as a potential analog, if not a leader, for efforts in Puget Sound, we note that "No organized monitoring system currently exists in the [Chesapeake] Bay to conduct critical stormwater research and feed it back into the design process" (Schueler 2008, p. 11). Similar to most regions, local and state jurisdictions have been responsible for stormwater management and implementation of municipal and industrial stormwater regulations to meet NPDES permit requirements. Only recently has a new organization, the Chesapeake Stormwater Network, been created to encourage more sustainable stormwater and environmental site design practices and align the efforts of individuals, municipalities, and watershed resource organizations such as the Center for Watershed Protection. As noted in the Bay-Wide Stormwater Action Strategy (Schueler 2008), the Chesapeake Stormwater Network could provide stormwater management guidance beyond permitting assistance, but as yet an overall stormwater monitoring strategy has not been conceived.

San Francisco Estuary Institute (SFEI)

The San Francisco Estuary Institute (SFEI) is a non-profit organization established in 1986 to advance the development of the scientific understanding needed to protect and enhance the San Francisco Estuary by conducting monitoring and research. The Regional Monitoring Program for Water Quality (RMP) is a collaborative effort between scientists, the San Francisco Bay Regional Water Quality Control Board, and discharging industries to "collect data and communicate information about water quality in the San Francisco Estuary to support management decisions" (see SFEI's RMP website). Annual "Pulse of the Estuary" reports present selected monitoring results to a wide audience, and all reports and data are publicly available.

The RMP is subject to independent science review every five years to ensure that it is meeting its objectives and that appropriate adjustments are made in response to past reviews. For example, major elements of the status and trends monitoring program were modified in 2007 to better address pollutant source and distribution monitoring objectives, including the refinement of the episodic toxicity program goal to address the key question "what is causing the sediment toxicity in the Bay?" (SFEI 2009).

The mercury TMDL for the San Francisco Bay demonstrates a clear adherence to the process of adaptive implementation as outlined by the National Research Council's 2001 TMDL program review. The primary challenge for establishing a TMDL is to identify and implement actions that will solve the water quality problem in light of uncertainty about cumulative effects and technological and economical constraints (SFEI 2004). Recognizing that there are inherent shortcomings to a mercury TMDL based solely on management and measures of total mercury, the adaptive implementation plan includes provisions for: (1) immediate actions, (2) monitoring, (3) management questions, associated hypotheses, and a schedule for measuring benchmarks, (4) reviewing and incorporating monitoring and study results into the TMDL. Using urban runoff as one mercury source example, immediate actions include evaluating the benefits of specific management practices in terms of reduced loads and quantifying load reductions as a function of specific practices using interim benchmarks (SFEI 2004). This approach allows for quantitative results to inform practical management decision moving forward while research aimed to better understand methylation and other processes contributing to overall mercury loads continues.

The SFEI has been mentioned as a model for the Puget Sound regional monitoring and assessment effort because of the third party nature of the institute and their focus on "getting everyone to agree on the facts" in an objective manner.

Louisiana Coastal Area Ecosystem Restoration

Ecosystem restoration efforts in the Louisiana coastal area have received increasing attention due in part to annual coastal wetland losses that exceed 60 km^2 per year, as well as large weather events such as Hurricanes Katrina and Rita. The 1989 Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA; or "Breaux Act") served as a catalyst for small projects, and the 1998 federal and state and federal plan "Coast 2050: Toward a Sustainable Coastal Louisiana" proposed integrating restoration and protection measures to restore natural processes that build and maintain the coast (USACE 2009). Since that time the US Army Corps of Engineers (USACE) (in concert with Louisiana State DNR and other agencies) conducted the Louisiana Coastal Area Ecosystem Restoration Study (see USACE website) to identify the most critical human and ecological needs, establish near-term prioritization of restoration and protection projects, and present a strategy for addressing long-term ecological and protection concerns. Following Hurricane Katrina, USACE was directed to reexamine, assess, and present recommendations for a comprehensive approach to coastal restoration, hurricane storm damage reduction, and flood control. The Coastal Protection and Restoration Authority of Louisiana (state) released its Comprehensive Master Plan for a Sustainable Coast in 2007 and is still in the process of soliciting public input on concerns and proposed solutions for implementing outlined actions (letter from Governor Bobby Jindal's office to concerned citizens dated August 17, 2009).

While there have been numerous starts and stops along the way to implementing a large-scale ecological restoration strategy for the Louisiana coastal area, there have been and currently are several monitoring efforts of note. The Coastwide Reference Monitoring System uses a multiple reference approach consisting of hydrogeomorphic functional assessments and probabilistic sampling in order to provide information that can be used for effectiveness monitoring and assessing cumulative effects of management prescriptions (see CRMS website). In 2002, CWPPRA scientists conducted an adaptive management review of constructed projects to improve the linkages among planning, engineering, and monitoring. Constructed projects were studied as they evolved from the concept stage through construction and several years of monitoring.

The CWPPRA review demonstrated the value of comprehensive information at multiple scales, from project-specific, to project-type, to ecosystem-wide. Notable recommendations consisted of asking key questions tied to ecological function and setting quantifiable objectives at the project inception phase. Monitoring programs are certainly recognized as an important component of restoration and protection of the Louisiana coastal area and copious resources are committed to research and monitoring. However, a cursory inspection of current efforts suggests that monitoring has not been the predominant framework of an experimental management design; thus, adaptive implementation is not fully integrated.

National Park Service Vital Signs Monitoring Program

Th National Park Service Vital Signs Monitoring Program has established long-term ecological monitoring for 270 parks in 32 identified ecoregional networks, with status and trends systems-based monitoring for a broad understanding to inform land management decisions. The authors of a recent publication outlining the program conclude that:

> "one of the most critical steps in designing a complex interdisciplinary monitoring program is to clearly define the goals and objectives of the program and get agreement on them from key stakeholders. In our evaluation of "lessons learned" by other monitoring programs, we found that *differences in opinion regarding the purpose of the monitoring* [emphasis added] as the program was being developed often led to significant problems later during the design and implementation phases" (Fancy *et al*. 2009, p. 4).

Monitoring, adaptive management, and the iterative assessment of management actions should be viewed as integrated parts of a long-term restoration program. Education about the scientific process of adaptive implementation and discussion amongst participants is an important component of program and project design (Van Cleve *et al*. 2004).

As a result of education and collaboration at program inception, objectives for vital signs monitoring evolved from general statements such as, "Determine trends in the incidence of disease and infestation in selected plant communities and populations," to objectives that met the test of being realistic, specific, and measurable (*e.g.*, "Estimate trends in the proportion, severity, and survivorship of limber pine trees infected with white pine blister rust at Craters of the Moon National Monument," Garrett *et al*. 2007)." In the context of the Puget Sound effort, we note that information from the local network of parks *(i.e.*, North Coast and Cascades) could provide useful baseline conditions from which to judge the extent of changes in altered landscapes.

B.5 Stormwater-specific Monitoring Programs

California Stormwater Monitoring: a comparison of land-use and industrial programs

Lee and Stenstrom (2005) and Lee *et al*. (2007) evaluated various stormwater monitoring programs within the state of California to determine their usefulness to planners and policy makers charged with abating stormwater pollution. The foci of the monitoring program evaluations were on data collection methods and the utility of data collected to identify discharge sources. General relationships between water quality and land use were confirmed (*e.g.*, highways convey a different suite of pollutants than residential lots); however, distinctions between industrial land uses were not defensible. The authors assert that the data reviewed did not allow for hypothesis-testing and therefore could not be used to indentify high dischargers with any confidence. Furthermore, Lee *et al*. suggest that regulators must recalibrate their expectations about how they use stormwater data if statistical inferences are not well-founded.

The overarching conclusion of these studies is that that design and execution of many monitoring programs may not produce data with sufficient precision for decision-making, because the methods are not explicitly linked to goals and objectives within a scientifically sound monitoring structure. Data-collection methods and sampling strategies that produce statistically meaningful inferences can only succeed when framed by hypotheses.

Tahoe Basin Regional Stormwater Monitoring Program (RSWAMP)

The Tahoe Basin Regional Stormwater Monitoring Program (RSWAMP) is a collaboration between the Tahoe Science Consortium and other Tahoe Basin agencies to design and ultimately implement a science-based program to track progress and guide stormwater management revisions to improve and protect water quality within the Lake Tahoe watershed. A conceptual plan was completed in 2008 and the monitoring design is currently being developed, but no document is yet available for review (September 2009).

The conceptual development plan calls for monitoring and data analysis based on a unified set of key management questions generated within an adaptive management framework that can be applied to multiple projects and at multiple scales (see Heyvaert *et al*. 2008). While the Tahoe Basin RSWAMP acknowledges that it is only one piece of the greater "Tahoe Basin adaptive management system," it asserts that it will facilitate evidence-based management by presenting statistically robust and scientifically credible data and information. The plan states that the monitoring design will incorporate a well-articulated connection between different monitoring "sub-programs"—implementation, effectiveness, targeted, and status and trends monitoring—and overall critical questions identified for TMDL development (*e.g.*, are the expected reductions of each pollutant to Lake Tahoe being achieved?).

City of Seattle, Seattle Public Utilities, Street Edge Alternatives (SEA) Project

The Street Edge Alternatives (SEA) Project was conceived as a neighborhood-scale retrofit using low-impact design techniques, primarily impervious-area reduction and shallow infiltration, to reduce runoff rates and volumes. It was initiated following construction of the Viewlands Cascade Drainage System, which replaced traditional ditches with a series of wide, stepped pools. Pre- and post-construction monitoring indicated a one-third reduction in runoff volume during the wet season, and consequently the City increased its efforts to curtail runoff volume by reconstructing the entire street area of 2nd Avenue NW (adjacent to the Viewlands Cascade). They applied before- and after-treatment water quality and quantity monitoring of total site stormwater runoff following reconstruction of neighborhood stormwater conveyance facilities to evaluate effectiveness, and the overall success shown by these results has provided the basis for additional, expanded efforts in other parts of the city (Horner *et al*. 2002; see the City of Seattle website). This is an example of a clear linkage between an initial management action being an acknowledged experiment, with the measured results (in this case, showing a successful outcome) being reflected in a programmatic change (*i.e.*, expansion of the effort to other parts of the city).

B.6 Ecologically-based Monitoring Programs in the Puget Sound Region

Cooperative Monitoring Evaluation and Research (CMER)

The Cooperative Monitoring Evaluation and Research (CMER) committee is the "science branch" of Washington State Forest Practices Board Adaptive Management Program (which also consists of a Policy group, Independent Science Panel and Program Administrator). The CMER research and monitoring strategy is outlined in the CMER Work Plan, which is revised annually. The goal of the CMER Work Plan is to "present an integrated strategy for conducting research and monitoring to provide credible scientific information to support the Forest Practices Adaptive Management Program" (CMER 2008). Critical questions about forest practice rules and their effectiveness at meeting resource objectives are the cornerstone of CMER's *effectiveness*, *status and trends*, and *intensive* monitoring programs, and rule implementation tool development programs.

While prioritization of research efforts to evaluate whether forest practice rules achieve resource protection objectives and integration of study results continue to challenge CMER, the organization and operation of the Forest Practices Adaptive Management Program is consistent with the goal of science informing policy and generating a timely feedback loop.

In early 2009, the Washington Department of Natural Resources commissioned a comprehensive review of studies completed for the adaptive management program under CMER (Stillwater Sciences 2009) associated with the ten-year-old Forest and Fish Agreement. CMER is charged with evaluating the effectiveness of the forest practices rules in protecting public resources (*e.g.*, fish, wildlife, and water quality), and it has initiated or completed over 80 individual studies to that end. These studies were evaluated in light of their stated objectives, key questions, hypotheses, and interim performance targets.

The overarching finding of the 2009 CMER review was that the monitoring framework approach is well-founded but its implementation over the first ten years of the program has not been uniformly well-executed, primarily because of a preference for site-scale studies over integrative (status-and-trend) evaluations, and from insufficient cross-coordination amongst the various components of the program.

Puget Sound Nearshore Estuary Partnership (PSNRP)

The Puget Sound Nearshore Ecosystem Restoration Project (PSNRP) is a partnership between the U.S. Army Corps of Engineers (Corps), state, local, and federal government organizations, tribes, industries, and environmental organizations. PSNRP's goals are to identify significant ecosystem problems, evaluate potential solutions, and restore and preserve critical nearshore habitat in Puget Sound. While early restoration efforts have been encouraging, these efforts have paled in light of widespread on-going environmental deterioration. The agencies and tribes involved with this effort are determined to define and apply a much broader and systematic approach to reverse and prevent the harm by establishing a sound scientific basis to understand fundamental ecological processes and functions, establish reliable measures of current conditions, define and implement a research agenda to fill in knowledge gaps, and to identify and prioritize specific restoration actions that address the root causes of environmental damage.

While the focus of the project is on restoration, the group has embraced the application of scientific principals as the foundation of their work. Already, PSNRP has accomplished a considerable amount of research, including a comprehensive geomorphic classification of marine shorelines in Puget Sound; a comprehensive evaluations of marine biota including Orca whales and marine forage fish, shoreline and submerged marine vegetative communities, nearshore processes; a comprehensive research strategy for coastal habitats and a conceptual model to better understand restoration efforts of nearshore ecosystems; an historical change analysis of marine shorelines; and a report on best available science and "lessons learned" from large scale restoration efforts throughout the nation. The research agenda they have defined uses a hypotheses-based approach to defining appropriate indicators and laying out the logic of their inquiry.

PSNRP provides an example of an organizational structure with the inherent capacity to address environmental change and restoration needs at multiple spatial scales within Puget Sound. Their program, as of yet, does not appear to have a formal adaptive management component that would ensure that the outcomes of their efforts are well connected to inform policy makers.

To provide scientific direction for PSNRP, a "lessons learned" exercise (Van Cleve *et al.* 2004) characterized the role of science in five large-scale restoration programs beyond the Pacific Northwest: the Chesapeake Bay Program, the Comprehensive Everglades Restoration Plan (CERP), the California Bay-Delta Authority, the Glen Canyon Adaptive Management Program, and the Louisiana Coastal Areas Ecosystem Restoration Program. Many of those findings are already included in the discussions above. Overall, their review strongly suggests that using science as a foundation for making decisions will greatly improve a restoration program's ability to successfully conceptualize, design, and implement large-scale restoration efforts over the long term.

Puget Sound Assessment and Monitoring Program (PSAMP)

The Puget Sound Assessment and Monitoring Program (PSAMP) is a program established to coordinate research and monitoring in the Puget Sound marine waters by state, federal and local agencies. In 2008, the Steering Committee and Management Committee produced a review document of their process: Keys to a Successful Monitoring Program: Lessons Learned by the Puget Sound Assessment and Monitoring Program (PSAMP 2008). This report's purpose is well-aligned with the intention of the SWG's effort, namely to articulate:

> "…what organizational features and what technical elements are most important for a successful regional monitoring program. We believe that a successful monitoring program could be developed under any one of a variety of potential governance structures, so long as that structure supports and provides the necessary organizational features and technical elements…" (PSAMP 2008, p.7)

Their key relevant recommendations are: To be successful, a coordinated, regional monitoring program must have:

Clear monitoring objectives derived from clear management goals through ecosystem-based assessment.

Integrated monitoring, research and modeling activities, implemented at appropriate scales, including:

a. Status and trends monitoring,
b. Compliance and effectiveness monitoring,
c. Implementation and validation monitoring,
d. Cause-and-effect studies,
e. Process and landscape models to synthesize monitoring and provide feedback, and
f. An adaptive management framework that targets restoration and conservation activities which improve environmental condition.

PSAMP has been collecting such data for over 20 years, and it has contributed much to our understanding of the decline in certain species and the increasing accumulation of toxicants in the environment and in biota. Unfortunately, this has not catalyzed a significant change in the way shoreline areas are managed nor how pollutants enter the system. The precautionary lesson here is that even a well-orchestrated program that tracks status or trends over time or space in key ecological indicators, if not directly linked to management decisions nor based on testable hypotheses about the underlying causal mechanisms, may not ultimately influence those decisions needed to forestall further decline in those indicators. Also, if the monitoring is conducted at too large a scale, it may also fail to provide much insight into how to reverse the trends of decline.

Appendix C Assessment Questions to Guide Regional Stormwater Monitoring

The following priority assessment questions were officially adopted by the Stormwater Work Group on June 3, 2009. These questions were developed and vetted through a series of committee meetings and technical and public workshops culminating in the spring of 2009 (see Appendix A). Although interest was expressed in having an even larger number of questions, the final assessment questions were narrowed down in order to provide a manageable scope for this near-term strategy development effort.

Overarching questions:

1. Given limited resources, what combination of targeting new development and retrofitting existing development is most effective in minimizing the impact of land use/stormwater to receiving waters?
2. How effective are the Clean Water Act permit-mandated municipal (including highways), industrial, construction, livestock, and dairy stormwater programs?

For efficacy of management actions, the priority questions are:

- Among the most widely used practices and promising new practices that are available, what specific retrofits or restoration practices are most effective in reducing pollutant loads, restoring hydrologic function, and recovering damaged habitat?
    - To what extent can retrofits and application of BMPs at redevelopment sites reverse past impacts? To what extent can the water and sediment quality and hydrologic conditions necessary to support beneficial uses of water bodies be restored in sub-basins that already have some degree of development? At what degree of development, or under what other specific conditions, is a particular retrofit strategy most likely to be successful?
- Are our stormwater management actions preventing and reducing future disruption of natural hydrologic conditions and minimizing pollutant loads in areas of new development in Puget Sound?
    - What is the effectiveness of subbasin-scale to watershed-scale combinations of stormwater management actions (techniques) at reducing impacts?
- How effective are source control and other programmatic stormwater management practices in reducing pollutant loads from existing development and from other specific land use activities such as agriculture?

For impacts to beneficial uses, the priority questions are:

- *Where* does stormwater significantly impact receiving waters, resources, species, or beneficial uses in the lowland streams, lakes, rivers, ground, and marine waters of the Puget Sound basin?

    - What is the current condition of streams, lakes, rivers, and nearshore marine waters, by representative land use?
        - What are the worst spots, when, and why?
        - What are the impacts to biota?
        - What areas should be targeted for protection?
- Over time, how effective are source control, prevention, and retrofit efforts? Are beneficial uses improving in response to our stormwater management actions?

For characterization and pollutant loadings, the priority questions are:

- How does land use influence pollutant concentrations, flow volumes, and loadings? What land uses or land use combinations are of greatest interest for applying and improving our stormwater management actions?
    - What is the variability in stormwater pollutant concentrations and flow volumes by land use and geographic area?
    - What is the variability within and among WRIA level basins for similar land uses?
    - What factors within a land use control pollutant concentrations and flow volumes?
        - How do differences in stormwater infrastructure (*i.e.*, pipes versus ditches, developments built at different times under different standards) affect pollutant loads and flows from similar land uses?
        - What proportion of the pollutant loads reach receiving waters and what are the explanations for the differences (*i.e.*, due to losses)?
    - What proportions of the pollutants in stormwater are from various sources such as air deposition and transport, spills, erosion and resuspension?
- What are the seasonal variations and long term trends in pollutant loads and what variables influence the temporal distributions?

For research, the priority questions are:

- What are the best indicators of stormwater impacts to water or sediment quality, streamflow, habitat, and biota?
    - What are the best indicators of various categories of chemical pollutants? Of solid-phase versus dissolved phase chemical pollutants?
- What are the synergistic effects of pollutants from stormwater?
- What is the toxicity in surface waters impacted by stormwater?
    - What is the seasonal and annual variation and the variation within the hydrograph?
- What are the effects of stormwater up through the food chain/food web?

Appendix D: Status and Trends Monitoring Design

Status and trends monitoring is included in this strategy to provide key indicators for stormwater impacts over time. Two water body types were selected for detailed status and trends monitoring plans: small streams and nearshore areas. The monitoring designs that are proposed for each water body are described in the following sub-sections.

D.1 Status and Trends Monitoring in Small Streams

The proposed priority hypotheses for status and trends monitoring in small streams are as follows, from Section 2.6.1:

1. Salmon (focusing on appropriate life stages) in small streams show improving population health over time throughout the Puget Sound region in concert with increased and improved stormwater management efforts.
2. In-stream biological metrics (e.g., benthic index of biotic integrity [B-IBI]) show statistically significant improving trends in Puget Sound lowland streams in concert with increased and improved stormwater management efforts.
3. Bacteria levels limiting primary human contact show decreasing trends over time throughout the Puget Sound region in concert with increased and improved stormwater management efforts.

Small streams (here defined as second- and third-order streams) are a critical component of this strategy because the health of the biota can be more directly linked to land use patterns and stormwater management activities. Status and trends monitoring of small streams will involve measuring a targeted suite of biological, chemical, hydrologic, and physical indicators for stormwater impacts at a randomly selected group of sites from a list of sites found in the Washington Master Sample. Selection of stream sites will follow U.S. Environmental Protection Agency (EPA) protocols that have been adopted by the Washington Department of Ecology (Ecology) for the Watershed Health and Salmon Recovery Status and Trends (WHSRST) monitoring program (Ecology 2006). This approach and protocols have been endorsed by the Washington Forum on Monitoring and the Puget Sound Partnership to provide information on salmon recovery and watershed health. Specifically, stream sites will be selected from the list of random sites found in the Washington Master Sample (www.ecy.wa.gov/programs/eap/stsmf/); Ecology also used this list for the WHSRST monitoring program.

Use the same approach that was used for Ecology's WHSRST monitoring program, the experimental design for small stream status and trends monitoring under this strategy includes a fairly large number of randomly selected sites in the Puget Sound lowlands. These sites will be grouped into two categories: permanent and rotating. In general, this design represents an attempt to balance limited monitoring resources between a fewer number of permanent sites that will be sampled intensively over time to detect trends in stormwater pollutant concentrations and loads, and a larger number of rotating sets of sites that will be sampled less intensively but provide broader spatial coverage for assessing impairment from stormwater.

The proposed stream monitoring would include sub-basin sampling at the Water Resource Inventory Area (WRIA) level, except for island-based watershed, for the water quality index, aquatic macroinvertebrates, fish diversity and abundance, stream physical features, and sediment chemistry for metals and petroleum. Additional sampling at the Puget Sound scale would include sediment chemistry (phthalates, PCBs, hormone disrupting chemicals, and other toxics of concern), flow, temperature, and a pilot study for periphyton. As shown in Table D-1 below, the Stormwater Work Group (SWG) recommends that a subset of these monitoring activities be required by future National Pollutant Discharge Elimination System (NPDES) permits for municipal stormwater discharges. However, the SWG believes that the NPDES and non-NPDES monitoring should be coordinated to maximize efficiency and reduce overall monitoring costs.

The status and trends monitoring program will provide an indication of current status in the first monitoring cycle. As noted in Chapter 3, trend information will not be available in this first monitoring cycle or in the typical planning horizon for individual projects or NPDES permits. Trends not only require sufficient sampling to determine significant changes from natural variability, but also require the system has sufficient time to respond to actions or lack of action. Where possible without compromising the statistical design of the approach, historical water quality and biological monitoring sites will be incorporated. This will provide information on site variability and may provide the opportunity to detect trends earlier.

D.1.1 Site Selection

As noted above, all sites for small streams status and trends monitoring will be selected from the list of random sites found in the Washington Master Sample. The first step in this process will define a sampling frame for these sites (i.e., the spatial domain over which the sites are selected). For small streams status and trends monitoring the sampling frame is the set of second- and third-order streams draining to Puget Sound. The site selection can be stratified so that two-thirds of the sites will be located within UGAs in more urban watersheds. This would serve to focus the monitoring at streams within lowland areas where adverse stormwater impacts are known to be more prevalent. In more rural watersheds, development patterns may not warrant this focus on urban areas.

The next step is assignment of probabilities of selection to all stream reaches in the sampling frame. This is done through the generalized random tessellation stratified (GRTS) method, an EPA-approved statistical model for probabilistic survey designs. The GRTS method has an advantage over a uniformly random sample set because selected sites are spatially balanced. Uniform random spatial distributions tend to be more clumped than GRTS samples. After defining the target population, the GRTS model will be used to select approximately 30 permanent sites and 90 rotating sites, which will allow for three rotating sets of 30 sites each. Some of the selected sites may be on private land and accessible only if the property owner grants permission. Therefore, we will evaluate the initial sites and select alternatives for those deemed legally or physically inaccessible. The specific number and location of sites (and frequency of sampling) may be adjusted upward or downward in order to meet the statistical goals for this status and trend monitoring.

Status monitoring and trend monitoring are often described as a single design, particularly in recent years as a result of widespread EPA support for probabilistic sampling as part of EMAP. For regional assessment of condition, *i.e.*, status assessment, probabilistic or some other type of random sampling, is the only design (besides a full census) that will provide an unbiased estimate of resource condition. Trend monitoring is somewhat different because the intention is to capture information about both regional condition and change through time, in other words, to answer the question, How is the resource changing through time at the regional scale?

For the Puget Sound region, many sites have a long record of sampling. Some of these sites were selected randomly, e.g., within King County, while others were not. When designing a trend monitoring program, the question arises, Which is more important, trend information at the regional scale or trend information over a long period of time?

For a trend monitoring design for Puget Sound, three types of trend monitoring sites exist.

1) Randomly selected sites that have never been visited.

Advantages associated with these sites is that will yield unbiased regional estimates of trends through time. The primary disadvantage it may take 5-10 years to obtain information about temporal trends.

2) Randomly selected sites that were sampled in years past.

An example of this would be benthic macroinvertebrate samples collected from random stream locations in King County beginning in 2002. Advantages associated with using these sites to test for trend is that the sites were randomly selected and, therefore, provide trend information about the entire sample area. In addition, these sites were sampled in the past and will yield trend information if revisited within the next few years. One disadvantage is that they were not randomly selected using EPA's EMAP protocol; the random methods are comparable, but not identical. In addition, the sites are only representative of the area that they were selected from (*e.g.*, King Co., not Puget Sound). Jurisdictions from other areas have similar type of sites.

3) Non-randomly selected sites sampled over many years.

These sites are referred to as "legacy" sites or "historic" sites. The advantage of these sites is that they provide long-term data that can be used to assess change through time. They can be used to estimate variability and provide pilot data to determine the best survey designs for detecting future trends. Disadvantages include the data do not represent regional trends, only trends at the sites sampled and measurements collected in the past may not provide the data needed in the present or future.

It is necessary to determine how many long term monitoring sites are active in the Puget Sound basin, the geographic distribution of the sites, what parameters have been and are currently sampled, sampling methodology and data quality of these existing monitoring sites. Once this dataset has been identified it can be evaluated relative to the geographic distribution around the Puget Sound basin. While the distribution of these monitoring sites was not established to conduct trend analysis on a Sound wide basis, these datasets represent the only source of historic data, and comprise the only opportunity to do trend analysis immediately. There would need to be an evaluation of what value and/or bias would be included by using any of these existing monitoring sites for a Puget Sound basin tend monitoring effort.

A sampling design using existing long term monitoring sites is potentially a transitional issue and will likely become less critical as a new monitoring program establishes a sufficient record to detect trends. Based on information from some of these existing sites, it will likely take a minimum of ten years of data collection at the new sites before there will be sufficient data available to do statistically valid trend analysis. In the interim, trend analysis will be continued at a set of monitoring sites with currently existing long term datasets. The randomly selected trend monitoring sites could minimize the bias potentially inherent in a design using existing long term monitoring sites that were not randomly selected from the Puget Sound basin.

It may be prudent to continue monitoring at a set of sites that have current, long term datasets, and is the only dataset that allows for immediate trend analysis while a new set of Puget Sound wide randomly selected becomes established and accumulates the necessary long term dataset for trend analysis.

The inclusion of non-random legacy sites will be identified and reviewed for statistical power within the next 4 months and evaluated based on value and cost for inclusion in the Status and Trends and potential NPDES municipal permit recommendations.

D.1.2 Data Types and Indicators

Table E.1 lists the parameters, frequencies, and site selection procedures for the small streams regional monitoring program, which is WRIA-based. Table D.2 summarizes the rationale for each parameter included in the small streams monitoring program.

D.1.3 Sampling Procedures Will Be Consistent with State Status and Trends Monitoring

Water quality samples will be collected and analyzed for the chemical indicators identified in Table E.1. Sample sets will consist of single grab samples that are collected at the 30 permanent and 390 rotating monitoring sites (30 sites in each of the 13 non-island based WRIAs in the Puget Sound basin). The permanent sites will be sampled monthly and the rotating sites will be sampled twice during the 5-year NPDES permit cycle, if possible. Water samples will be collected in accordance with the procedures described in Ecology's Environmental Assessment Program's standard operating procedures (SOPs). Benthic macroinvertebrate samples will be collected from the rotating monitoring sites twice during the 5-year NPDES permit cycle, if possible. The samples will be collected in the late summer or early fall (August through October) in order to provide adequate time for the in-stream environment to stabilize following natural disturbances (e.g., spring floods). In addition, representation of benthic macroinvertebrate species typically reaches a maximum during this period. Benthic macroinvertebrate collection, processing, and analysis will follow Ecology protocols for in-stream biological assessment (Publication 94-113).

Fish diversity and abundance will be surveyed at the 390 rotating sites. The fish surveys will be conducted twice during the 5-year NPDES permit cycle, if possible. The fish surveys will be conducted in accordance the Environmental Monitoring and Assessment Program (EMAP) wadeable streams protocols.Sediment samples for metals analyses will be collected once per year from the 390 rotating monitoring sites, if possible. Samples from 30 of these sites will be analyzed for a suite of organic contaminants, in addition to metals. Because contaminants are more likely to be concentrated in fine sediments with high organic matter content, sample locations will focus on depositional areas where fines are present. Sediment samples will be

Table D.1. Summary of WRIA-Based Freshwater Status and Trends Monitoring

Parameter	Frequency*	Site Selection	State Status and Trends Protocols	NPDES
Water Quality Index --Rotating Sites**	Two grab samples during 5-year permit term	30 per WRIA (390 total), random stratified UGA/rural 2nd & 3rd order streams.	√	√
Water Quality Index --Permanent Sites**	Monthly grab samples during 5-year permit term	30 randomly selected WQI sites. After analyses, may recommend some non-random sites to aid trend assessment.		√
Aquatic Benthic Macroinvertebrates —B-IBI/RivPac, individual metrics	2 samples within 5-year permit	30 sites per WRIA, random, stratified UGA/rural, 2nd & 3rd order streams.	√	√
Periphyton	Pilot in 2 WRIAs	Co-locate with benthic/WQI sites. Select one rural and one urban basin within Puget Sound; follow Ecology study design and protocols.	√	√
Fish Diversity, Abundance	2 samples within 5-year permit	30 sites per WRIA, random, stratified UGA/rural, 2nd & 3rd order streams.	√	
Stream Physical Features -- EMAP wadeable streams parameters	2 samples within 5-year permit	30 sites per WRIA, random, stratified UGA/rural, 2nd & 3rd order streams.	√	
Flow	Continuous	Non-random, GIS analysis of current distribution of next 9–12 months. Minimum of 13 sites associated with permanent sampling locations.	√	√
Temperature	Continuous	Non-random, associated with flow gauges.	√	√
Sediment Metals** --arsenic, cadmium, chromium, copper, lead, mercury, silver, zinc	Annual grab	30 sites per WRIA (390 total), random, stratified UGA/rural, 2nd & 3rd order streams.	√	√
Sediment Toxics** --metals, PAHs, pesticides, PCBs, phthalates, PBDEs, hormone-disrupting chemicals	Annual grab	Randomly select 30 of the 390 Sediment Metals sites across the Puget Sound basin		√
*** actual sampling frequency to be determined in final design based on statistical goals and feasibility**				
****See Table E.2 for parameter descriptions**				
NOTE: Information from historical monitoring information and the first sampling cycle will be used to determine the sampling frequency necessary for trend assessments. Trend assessment is anticipated to be conducted on a regular, but not annual basis.				

Table D.2. Parameters for WRIA Based Status and Trends Monitoring in Freshwater

Parameter	Rationale
Water Quality	
Total phosphorus	Nutrients are a pollutant of concern from residential development (Ecology 2005a). High concentrations can lead to accelerated plant growth, algal blooms, low dissolved oxygen, decreases in aquatic diversity, and eutrophication in freshwater systems. TP is needed to calculate Water Quality Index (WQI) value.
Total nitrogen	Nutrients are a pollutant of concern from residential development (Ecology 2005a). TN is a concern in the Puget Sound, since nitrogen is typically the limiting nutrient in marine systems. TN is needed to calculate Water Quality Index (WQI) value.
Turbidity	Primary indicator of water quality and metric of stormwater management systems. Needed to calculate Water Quality Index (WQI) value.
Total suspended solids	Pollutant of concern from a variety of land uses including residential development (Ecology 2005a). Key indicator used to measure the basic treatment effectiveness of a stormwater treatment technology. Can reduce light penetration and lead to a smothering effect on fish spawning and benthic biota. Associated with other pollutants that adsorb to particles such as nutrients, bacteria, metals, and organic compounds. Inexpensive to monitor, minimal field and QA problems, and a reliable indicator. Needed to calculate Water Quality Index (WQI) value.
Conductivity	Easily measured and correlates to the total dissolved solids. Needed to calculate Water Quality Index (WQI) value.
pH	Principal driver of aqueous chemical reactions including effects on ammonia volatilization, nitrification, and the precipitation of metals. Needed to calculate Water Quality Index (WQI) value.
Chloride	Elevated levels of chloride usually indicate the presence of other chemicals. Road salt application can result in chloride concentrations in stormwater at levels that may harm aquatic life. Needed to calculate Water Quality Index (WQI) value.
Fecal coliform	A common indicator of urban stormwater pollution or failing septic systems. Needed to calculate Water Quality Index (WQI) value.
Temperature	Key parameter affecting the health and survival of biological communities. Needed to calculate Water Quality Index (WQI) value.
Dissolved oxygen	Key parameter affecting the health and survival of biological communities that is affected by biological and chemical oxygen demand. Needed to calculate Water Quality Index (WQI) value.
Aquatic Biology	
Aquatic benthic macroinvertebrates: B-IBI/RivPac, individual metrics	Integrates water quality and habitat impacts from stormwater over time (Karr 1998; Karr and Rossano 2001; Fore et al., 2001).
Periphyton	Valuable indicators of short-term impacts. Directly affected by physical and chemical factors. Sensitive to some pollutants which may not visibly affect other aquatic assemblages, or may only affect other organisms at higher concentrations (e.g., herbicides).
Fish diversity, abundance	Species diversity and abundance directly correlate to the stress of an ecosystem.

Parameter	Rationale
Stream Physical Features	
Channel type and shape, riparian condition, sediment, LWD (EMAP wadeable streams parameters)	Urban development can alter basin hydrology and adversely affect stream channels (e.g., accelerated bank erosion, loss of LWD, reduced baseflow).
Flow	Needed to discern hydrologic trends related to land use and stormwater management measures. Can be used to calculate a variety of metrics (e.g., peak winter flows, summer base flows, storm pulses) that may aid in trend detection, interpretation of biological parameters, and stressor identification.
Temperature	Key parameter affecting the health and survival of aquatic communities.
Stream Bottom Sediment	
Heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, silver, zinc)	A group of ecologically consequential heavy metals with defined sediment management standards in WA. Heavy metals contribute to toxic effects on aquatic life and impact the beneficial use of a water body.
PAHs	Associated with urban runoff and characteristic measure for roadway impacts. Can accumulate in aquatic organisms and are know to be toxic at low concentrations. Can be persistent in sediments for long periods, resulting in adverse impacts on benthic community diversity and abundance.
Pesticides	Common in residential and agricultural runoff.
Phthalates	Pervasive sediment contaminant in the Puget Sound region.
PCBs	Corollary to industrial/urban stormwater impacts. Salmonid fish are highly susceptible to PCB accumulation (fatty tissue deposition/accumulation).
PBDEs	Correlates to urban impacts. Growing evidence of PBDE persistence and accumulation in the environment.
Hormone disrupting chemicals	A broad indicator of pollution from urban development. Commonly detected in Puget Sound sediments, with some monitoring stations observing increases in concentrations over recent years (Ecology 2005b).

collected following the guidelines set forth in Ecology's Environmental Assessment Programs SOPs.

Sampling procedures for physical habitat indicators (percent substrate by size, embeddedness, bed stability, and bank instability) will be adopted from the WHSRST monitoring program (Ecology 2006).

D.1.4 Expected Outcomes

The small stream status and trends monitoring program will:

- Summarize the current condition of streams with an estimated level of statistical precision at watershed and Puget Sound levels.
- Allow regional comparisons of stream conditions within and across WRIAs.

- Support prioritization of areas for protection and restoration in terms of physical, chemical and biological condition at the Puget Sound scale.
- Recognize temporal and geographical variability and environmental response time to management practices.
- Provide regional estimates of water quality and flow conditions that support salmon recovery endpoints and other water resource issues.
- Answer at a spatial scale that often better matches the scale of decisions needed for stormwater management issues.
- Identify common problems due to land use impacts or sources of pollutants that may need common solutions.
- Provide consistency over time even if jurisdictional boundaries change.
- Consider entire watersheds without the constraints of jurisdictional boundaries.
- Provide a baseline for documenting longer-term and larger scale impacts, such as climate change.
- Provide useful results even if some monitoring sites are lost due to changes in land ownership or other factors.
- Provide flow and water quality data that could be used for hydrologic and water quality modeling.

D.2 Status and Trends Monitoring in Nearshore Marine Areas

The proposed priority hypotheses articulated in Section 2.6.1 for status and trends monitoring in the nearshore are:

1. Bacteria levels in water and bacteria and/or toxics in shellfish along the nearshore limiting primary contact and harvest show decreasing trends over time throughout the Puget Sound region in concert with increased and improved stormwater management efforts.
2. Measured constituents related to stormwater are decreased in marine sediments over time.
3. Resident fish in nearshore areas show improving population health over time throughout the Puget Sound region in concert with increased and improved stormwater management efforts. – (Addressing this hypothesis is reserved as future work)
4. Forage fish in nearshore areas show improving population health over time throughout the Puget Sound region in concert with increased and improved stormwater management efforts. – (Addressing this hypothesis is reserved as future work)

Nearshore areas are the aquatic interface between fresh and marine waters. Nearshore areas are generally considered to include the areas commonly known as shore, beach, intertidal, and subtidal zones to a depth of about 20 meters relative to mean lower low water (average depth limit of photic zone). Due to the variations in physical processes such as wave, wind, and sediment transport, the nearshore zone supports a wide diversity of habitats and is considered the "nursery zone" of Puget Sound. Examining the nearshore marine area is a critical component of status and trends monitoring for ecological health. In addition, the nearshore area is directly associated with human health concerns because many of the fish and shellfish we consume are harvested from this part of the ecosystem and because our recreational activities are also concentrated in the nearshore zone.

Marine nearshore sampling would focus at the Puget Sound scale on probabilistic sampling for fecal coliform, sediment chemistry, and caged mussel toxic accumulation. Because chemical data are not always reliable indicators of biological effects, direct biological testing (sediment toxicity testing) is often used in conjunction with sediment chemistry and infaunal community structure analysis (diversity and abundance of organisms living in the bottom substrate) to determine the biological significance of the chemicals measured in the sediments. This series of monitoring is known as the Sediment Quality Triad. However, as a tool for monitoring status and trends, using two (invertebrates sampling and sediment chemistry) of the three parts of the triad are recommended in this initial plan.

D.2.1 Site Selection

Similar to the small streams strategy, a random approach will be used to select 30 sites sites for monitoring toxic constituents in the bottom sediment and 50 sites for monitoring fecal coliform in the water column. The sediment sites will be randomly selected from protected embayments. The fecal coliform sites will be spatially distributed across Puget Sound. Fecal coliform data from the state and county health departments will be used in areas of overlap. Approximately 10 percent of the bacteria and sediment stations will be identified as permanent sites and the remainder will be rotating sites. The permanent sites will be continually and consistently monitored, while the rotating sites will be monitored twice in every 5 years. This approach provides the benefits of consistent long-term monitoring at some sites, while also allowing for many more sites and more spatial coverage through the system of rotating sites. This frequency of sampling is suggested and will be determined in final study design based on statistical goals and feasibility. Where possible, existing monitoring locations will be incorporated into the design to provide historical continuity and support earlier detection of trends.

Mussel Watch (http://ccma.nos.noaa.gov/about/coast/nsandt/musselwatch.html) is our nation's longest running continuous contaminant monitoring program in coastal waters. It was designed to monitor the status of toxic contaminants in coastal waters and track changes in contamination through time. Mussel Watch efforts are focused on a sentinel group of organisms, the blue mussel (*Mytilus* spp), and it currently tracks 26 stations in Washington State, including Puget Sound, the Straits of Juan de Fuca and Georgia, the Pacific Coast, coastal estuaries, and mouth of the Columba River. Mussel Watch monitoring is recommended to be performed at 30 sites located near randomly selected stormwater outfalls across Puget Sound.

The existing suite of toxics monitored by Mussel Watch include PCBs, organochlorine and other pesticides, polycyclic aromatic hydrocarbons and their alkylated homologs, and a large suite of metals. It is anticipated that polybrominated diphenyl ethers (PBDEs) will be added to the analyte list permanently this year. It is possible that bis-phenol-A, nonylphenol, ethynylestradiol, and pharmaceuticals and personal care products could be added to the list.

D.2.2 Data Types and Indicators

Table D.3 lists the indicators that have been selected for monitoring in the nearshore marine area and a general summary of the monitoring approach that will be applied for each. The indicators focus largely on toxic contaminants. Table D.4 summarizes the rationale for selecting each indicator.

D.2.3 Sampling Procedures

Grab samples for fecal coliform analysis are recommended to be collected monthly from the water column at 30-50 randomly selected sites. Sediment samples will be collected once per year from 30 sites randomly selected from protected embayments. Sediment sampling will follow procedures developed for the Puget Sound Assessment and Monitoring Program (PSAMP, Ecology 2007). "Mussel Watch" sites will be established at 30 sites near stormwater outfalls in order to assess potential toxicity to shellfish. These sites will be monitored once per year. All sampling frequencies are draft recommendations and subject to modification based on statistical goals after reviewing existing data. In addition, sampling frequency requirements under the next NPDES municipal stormwater may have to be adjusted to accommodate new institutional structures, approaches, protocols, site access issues, and other new monitoring program issues that must be addressed.

D.2.4 Expected Outcomes

The nearshore status and trends monitoring program will:

- Help identify the current condition related to swimming and shellfish harvest beneficial uses of the marine nearshore in Puget Sound.
- Help identify nearshore areas that may be affected by toxic constituents from nearby stormwater outfalls.
- Summarize contaminant concentrations in bottom sediments with an estimated level of statistical precision.
- Support prioritization of nearshore areas for protection and restoration in terms of physical, chemical and biological condition at the Puget Sound scale.
- Recognize temporal and geographical variability in sediment chemistry.
- Answer at a spatial scale that often better matches the scale of decisions needed for stormwater management issues.

Table D.3. Summary of Puget Sound Based Status and trends Monitoring of Nearshore Areas

Parameter	**Frequency***	**Site Selection**	**NPDES**
Water Quality Parameters			
Fecal coliform	Monthly	50 randomly selected sites at Puget Sound scale; use shellfish monitoring data in areas of overlap.	√
Mussel Watch: bioaccumulation toxicity	Annually	Mussel Watch – 30 sites, consisting of existing sites and randomly selected new sites near selected stormwater outfalls (specific design to be determined).	√
Sediment Quality Parameters			
Sediment Metals & Toxics** --antimony, arsenic, cadmium, chromium, copper, lead, mercury, silver, zinc, PAHs, pesticides, phthalates, PCBs, PBDE, hormone-disrupting chemicals, total organic carbon	Annual grab	30 sites randomly selected from protected embayments; depositional areas with fine sediments.	√
*actual sampling frequency to be determined in final design based on statistical goals and feasibility			
****See Table E.4 for parameter descriptions**			

Table D.4. Parameters for Puget Sound Based Status and Trends Monitoring in Marine Nearshore Areas

Parameter	Rationale
Water Quality	
Fecal coliform	A common indicator of urban stormwater pollution or failing septic systems.
Mussel watch	Indicator of bioaccumulation toxicity. Build on existing data set.
Bottom Sediment	
Heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, silver, zinc)	A group of ecologically consequential heavy metals with defined sediment management standards in WA.
Antimony	Used in brake pads. Can be difficult to analyze. Results should be reviewed at the end of the first monitoring cycle.
PAHs	Associated with urban runoff and characteristic measure for roadway impacts. Can accumulate in aquatic organisms and are know to be toxic at low concentrations. Can be persistent in sediments for long periods, resulting in adverse impacts on benthic community diversity and abundance.
Pesticides	Common in residential and agricultural runoff.
Phthalates	Pervasive sediment contaminant in the Puget Sound region.
PCBs	Corollary to industrial/urban stormwater impacts. Salmonid fish are highly susceptible to PCB accumulation (fatty tissue deposition/accumulation).
PBDEs	Correlates to urban impacts. Growing evidence of PBDE persistence and accumulation in the environment.
Hormone disrupting chemicals	A broad indicator of pollution from urban development. Commonly detected in Puget Sound sediments, with some monitoring stations observing increases in concentrations over recent years (Ecology 2005b).
Total organic carbon	Good indicator of general mercury contamination in Puget Sound.

Appendix E Source Identification and Diagnostic Monitoring Design

Existing monitoring data is available to determine many problem sources/impairments. The following steps outline a process for (1) utilizing this information and setting priorities to address the most important problems first; (2) gathering additional information as needed; and (3) planning the necessary actions to remove stressors and other sources of pollutants and ultimately improve beneficial uses in the receiving waters.

Step 1. Evaluate existing data to determine problem sources/impairments

Determine which problems to work on first. This can be accomplished by evaluating data linked to stormwater from existing programs including, but not exclusively: TMDLs, Category 4 and 5 303(d) impaired listings, Shellfish Protection Districts, Superfund sites, MTCA sites, Industrial permit Discharge Monitoring Reports, CSO discharge data and Phase I stormwater characterization data and regional and local monitoring data. It is understood that most local jurisdictions are aware of not only regional, federal and state monitoring historically or concurrently and this step should be performed at the local level. However, coordination through a regional monitoring entity could provide more efficient and effective coordination of evaluation of the sources of data. It is recommended that this step be performed at the WRIA or watershed level, rather than at the Action Area or larger scale in order to evaluate information at a manageable scale.

Step 2. Prioritize sources/impairments

It is recognized that not all sources/impairments identified in Step 1 can be addressed concurrently. Therefore, prioritization must be performed in order to determine which problems to work on first, *i.e.*, which source control/removal programs are to be continued, which new programs should be planned, funded and implemented, and which programs should be addressed at a later time. Examples of prioritization categories include: human health, salmon health, forage fish health, watershed health, toxics body burden and drinking water. It is recommended that a prioritization method be developed with consideration of local priorities as well as priorities for the Puget Sound region.

Step 3. Set a target for source reduction

It is important to determine to what level the source is to be controlled. For example, is the goal to meet a water quality or sediment criteria or a specific productivity goal for out migration of juvenile salmon? Without a target or goal, source control activities could be performed to a level with little benefit. There needs to be a scientifically valid target for the future source removal actions. Additionally, biological endpoints need careful assessment since an ideal endpoint may not be achievable and that an optimum or interim endpoint for the condition may be set.

Step 4. Locate sources/causes

In some cases further monitoring may be necessary to refine the location of the sources. Examples of additional monitoring upstream or upland of the identified impairment stations such as upstream segment water quality samples or sediment sampling of catch basin material upstream. Location of sources may be not require monitoring but may simply be an assessment of land use practices or activities. An example may be a farm with uncontrolled animal waste entering a stream tributary or an industrial site discharging wastewater into the storm system.

Step 5. Plan actions to remove the source(s)

This step is not monitoring but is a management action necessary for Source Identification Monitoring. It is a key step in the process and must occur in order to continue the monitoring. It is recommended that a communication system be implemented to relay successful source removal programs, actions, strategies and successes be shared across Puget Sound. Removing many sources locally will result in overall improvement of the health of Puget Sound.

Step 6. Implement source removal actions/programs

Source removal actions are implemented. Implementation is not a focus of this Scientific Framework but is a necessary step in the process.

Step 7. Monitor to provide feedback on status of source

Monitoring is to be performed during the implementation phase of source removal to provide a feedback loop on the status of the actions. Are the actions resulting in reduced sources at the upstream locations? Are short-term reductions observed? This step may not be necessary but should be included to provide feedback.

Step 8. Implement a framework to prioritize watersheds where the watershed health is unknown

It is recognized that concurrently with historical data and data from existing programs, an additional Diagnostic Framework must be implemented to determine the priority of watersheds or sub-basins where impairment is expected and no previous monitoring or assessment has been performed. Status and Trend monitoring within each WRIA will generate the information necessary for this assessment.

Step 9. Incorporate results from effectiveness and status and trends monitoring into the prioritization process

- Provide a framework for stormwater monitoring from Effectiveness Monitoring and Status and Trends Monitoring to be available in a timely manner to feedback into the prioritization step of Source Identification Monitoring.

Figure E.1 shows the stepwise process that may be necessary for a source identification and removal plan. The monitoring framework that is specified will be dependent upon the defined impairment, biological endpoint or exceedance: different approaches and steps are needed for approaching different types of impairments (see Appendix E). Not all sources will fit neatly into this recommended framework. However, our goal is to describe a framework that can be used not only locally at the WRIA or watershed level, but at the Puget Sound regional level.

Source identification and diagnostic monitoring provide an organized, step-wise approach to restore receiving-waters that have been identified as impaired by stormwater impacts. This approach provides tools to:

- Set priorities for investigation.

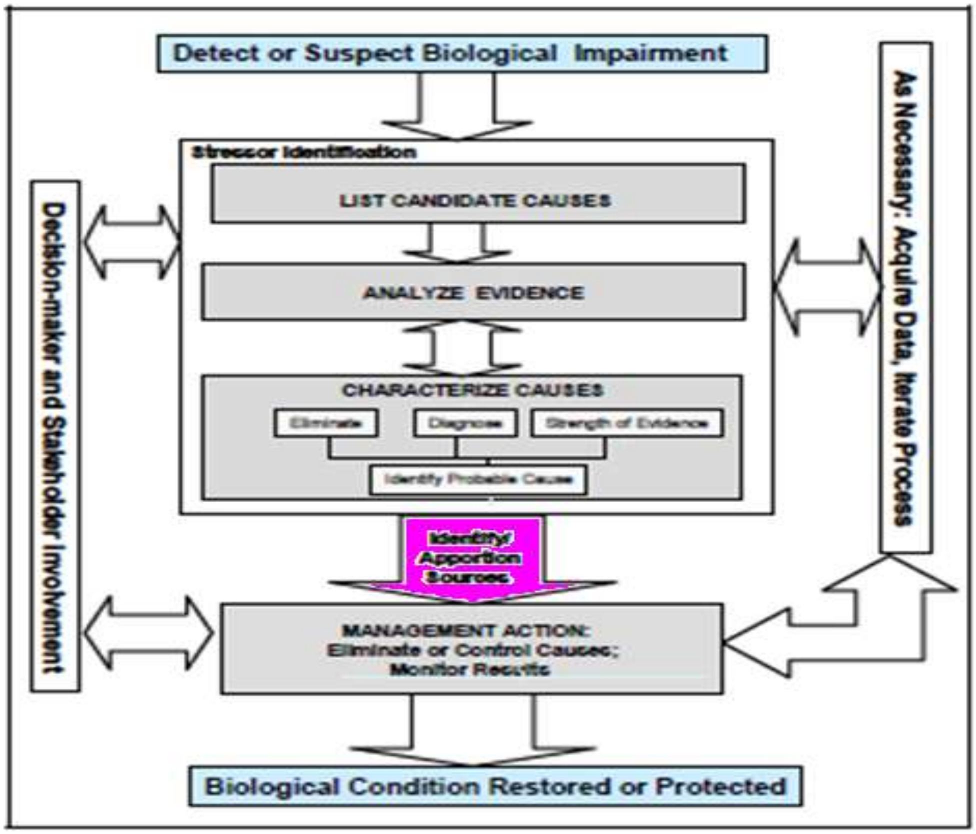

Figure E.1. The stressor identification process (EPA, 2000).

- Determine the locations and sources of stressors causing impairments.
- Identify the corrective action(s).
- Monitor to assess progress.
- Achieve the targeted goal of improved receiving-water conditions.

Stormwater adaptive management strategies are an integral key to the source identification and diagnostic monitoring framework.

Below are two example projects in the Puget Sound area of Source Identification Monitoring: City of Tacoma Thea Foss Source Control Strategy and Kitsap County Surface and Stormwater Management Dyes Inlet Fecal Coliform Reduction Project. The initial monitoring will focus on problems identified based primarily on existing water or sediment quality data that can be compared to water quality criteria or biological data that can be compared to regional reference conditions or other sites with similar development levels. Initially, flow and physical channel data will be used primarily for causal analysis (rather than problem identification). As flow and physical channel data are collected over time, trend analyses may identify additional problems related to stormwater. Basic approaches will be different based on the identified impairment being addressed.

Source Identification Example 1:

The Thea Foss Waterway is a high priority receiving water body in the City of Tacoma. Tacoma developed a stormwater monitoring and source control program for the municipal storm drains entering the waterway to help provide long-term protection of bottom sediment quality. The chemicals of concern were basin specific and included mercury, aromatic petroleum hydrocarbaons (PAHs), and phthalates. The goals of the monitoring programs were to measure the effectiveness of program activities, identify trends in stormwater quality, provide early warning of new sources and trace sources for correction/removal. Monitoring for this program included outfall characterization for both storm and baseflow events and storm system in-line sediment traps. See Figure E.2 for a flowchart of the steps followed.

Source Identification Example 2:

Kitsap County Surface and Stormwater Management responded to a TMDL study performed by the US Navy that indicated stormwater was a contributor of fecal coliform bacteria to the marine waters of northern Dyes Inlet. Kitsap County developed and implemented a fecal coliform source control program which identified the contaminated stream segments, implemented enhanced storm system maintenance in the public areas, and encouraged commercial property owners to improve system maintenance, inspected private septic systems, and performed source control of dumpster and grease storage areas. These efforts resulted in statistically significant bacterial reductions in the streams and nearshore marine estuary.

E.1 Problems Identified Based on Constituent Concentrations

For problems identified based on water or sediment quality constituent concentrations, follow the IDDE-type approach outlined below:

1. Obtain relevant County and/or City GIS data and aerial photos for area that drains to identified problem location. Obtain other potentially relevant information if available (e.g., comp. stormwater plans, CIP plans, TMDL studies, H&H models). Identify key natural and manmade drainage systems. Prepare base maps for source tracking.
2. Screen available data, such as stormwater outfall monitoring data, to see if there's an obvious source/cause for observed problem. Focus on areas close to drainage systems.

Thea Foss Post-Remediation Source Control Strategy

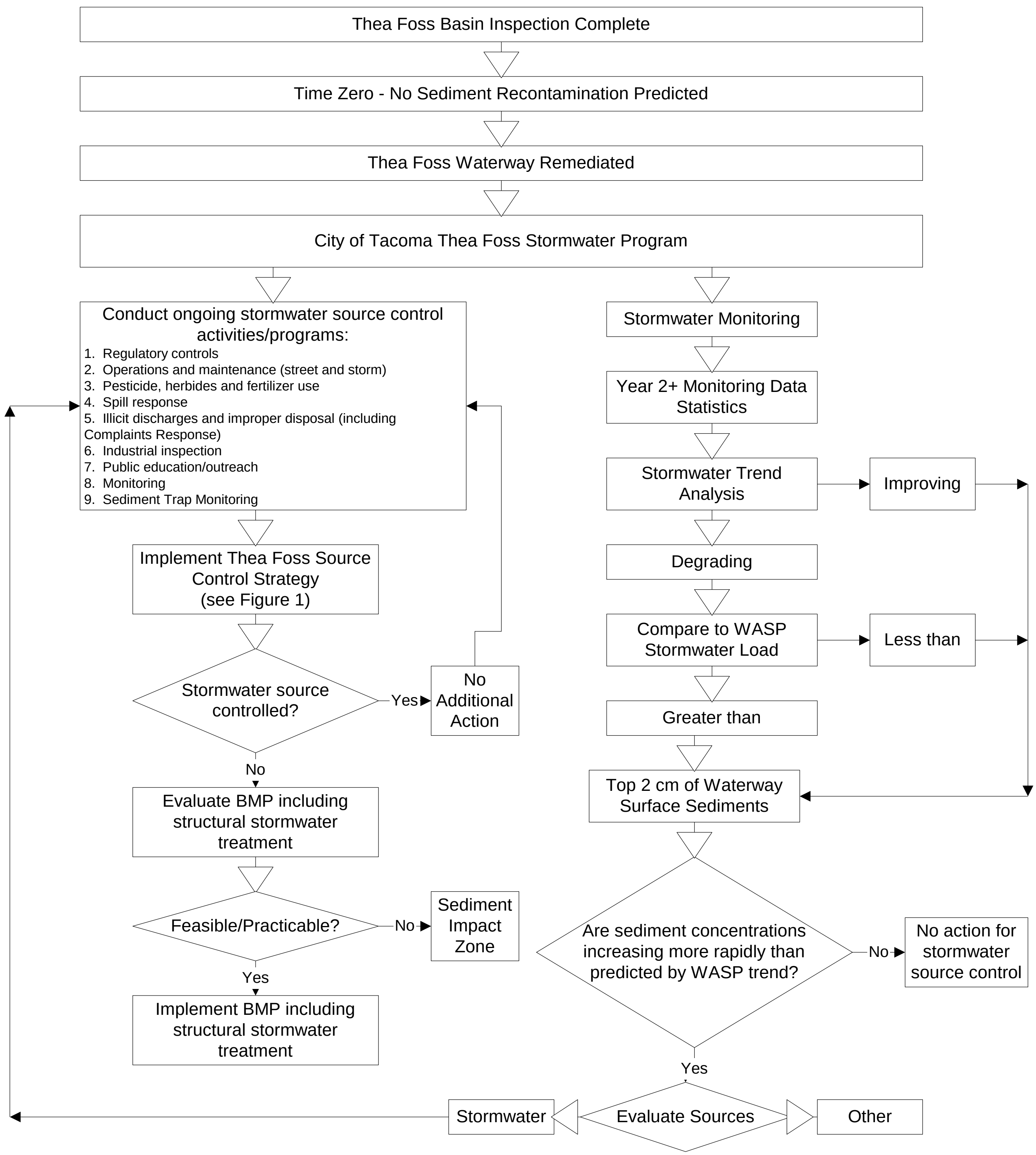

Figure E.1 Example process to develop and implement a source identification and removal plan.

3. Identify potential source indicators for observed problems (e.g., large stormwater outfalls, land use/land cover, soils, road density, road crossings, road miles within stream buffers, eroding areas visible on aerials, planned CIP, baseflow data, etc.). Meet with municipal O&M staff to review preliminary maps and evaluations, identify other known or suspected sources, confirm priorities, and develop a field reconnaissance approach. Delineate areas to be included in field reconnaissance.
4. Conduct field reconnaissance to look for visual evidence of potential sources along key transport pathways. Meet with owners/operators of potential source areas.
5. Evaluate the results of Steps 1-4 to determine the next steps.
   - If the key source or cause of the problem is evident and the entity has the necessary resources, develop and implement an early action source control plan (need a reference here). The control plan should include post-implementation monitoring to confirm that source control objectives have been met.
   - If the key source or cause of the problem is evident but not controllable within the entities' available resources, prepare a capital project scope and budget for development of a source control plan. After the requisite funds have been secured, prepare the source control plan. If the plan calls for capital improvements or additional staff, prepare a capital project scope and budget for implementation of the recommended measures.
   - If more comprehensive monitoring is needed to trace or confirm sources, develop a monitoring plan tailored to local conditions and the constituents of concern. Follow the general procedures outlined in the IDDE manual or similar regional approved protocols. Consider the full range of potentially applicable monitoring approaches (e.g., dry weather sampling of sediments in catch basins and ditches; synoptic water sampling during runoff events; passive samplers; continuous conductivity or turbidity monitoring; microbial source tracking).

E.2 Problems Identified Based on Biological Monitoring

Poor biological conditions can be related to a wide range of stressors. Therefore, a more comprehensive approach is generally needed to identify the likely sources or causes for biological impairment and support development of corrective actions. The general steps are outlined below:

1. Obtain relevant County and/or City GIS data and aerial photos for area that drains to identified problem location. Obtain other potentially relevant spatial information if available (e.g., comp. stormwater plans, CIP plans, TMDL studies, H&H models). Identify key natural and manmade drainage systems. Prepare base maps for source tracking.
2. Review available data to see if there's an obvious source/cause for observed impairment. Focus on areas close to the receiving water body and its natural and man-made tributaries.

3. Perform an initial screening to identify potential stressors as described in EPA's Stressor Identification guidance manual (EPA 2002). Figure E.1 above shows EPA's recommended approach for diagnosing the causes for biological impairments and developing management actions to address them.
4. Evaluate the results of Steps 1-2 to determine the next steps.
    - If the key stressor is apparent and the entity has the necessary resources, develop and implement an early action stressor reduction plan. The plan should include post-implementation monitoring to confirm that plan objectives have been met.
    - If the key stressors are evident but not controllable within the entities' available resources, prepare a capital project scope and budget for development of a stressor reduction plan. After the requisite funds have been secured, prepare the plan. If the plan calls for capital improvements or additional staff, prepare a capital project scope and budget for implementation of the recommended measures.
    - If the key stressors are evident but there are no technolog for effective treatment, then work for source elimination. If the key stressors are evident but are not within the purview of the permittee, coordinate efforts with the responsible party and regulatory agencies.
    - If more additional monitoring is needed to trace or confirm stressors, develop a capital project scope and budget for preparation of a stressor investigation plan tailored to local conditions and the stressors of concern.
    - Entities that do not have sufficient staff time and/or technical expertise will need to engage outside help for stressor identification investigations, development of response plans, etc. Perhaps the entities engaged in the status and trends monitoring program could assist with these activities.

E.3 Estimated Cost to Implement Source Identification and Diagnostic Monitoring

The cost to develop a source identification and removal plan is dependent upon several factors including the size of the sub-basin, the source, the management actions and the extent of the impairment. Two cost estimate examples are provided below:

<u>Example 1</u>: City of Tacoma Thea Foss Basin Source Control Program (De Leon and Thornburgh 2009)

Impairment: Metals, PAHs, DEHP in sediment.

Implementation Activities: Source tracing investigations, business inspections, data analyis/reporting, program management.

Cost: $260,000 annually 2007-2011.

Monitoring: Stormwater outfall and storm system sediment trap 2007-2009 $5 million, 2009-2010 $6 million.

<u>Example 2</u>: Kitsap County Health District North Dyes Inlet Restoration (Bazzell 2009)

Impairment: Fecal coliform bacteria, marine nearshore receiving water body and stream.

Implementation activities: Septic system inspections, commercial property inspections, source control tracing and correction.

Cost: $350 per septic inspection, $160 per commercial property inspection, $1,000 per source control tracing. Total program cost for 250 properties $110,000 2003-2006.

Monitoring: $10,000 annually for fecal coliform trend monitoring and tracing.

Appendix F Selecting and Developing Designs for Effectiveness Studies

This chapter provides additional details needed for selecting and developing study designs to assesss effectiveness of management approaches. This chapter also lists initial example questions that can be used to develop working hypotheses for each of the five effectiveness monitoring focus areas, acknowledging that additional hypotheses could be added over time. It also presents detailed cost information for a range of possible types of effectiveness studies.

F.1 Collecting the Right Information: Data Quality Objectives for Effectiveness Studies

After a specific question has been selected and an appropriate monitoring design developed to answer the question, the next step is to identify the type and amount of data to be collected. Data Quality Objectives (DQOs) refer to the precision and accuracy of the data needed to answer the question. Too much data (oversampling) is unnecessarily expensive, and too little data can doom a project to irrelevance.

DQOs can be interpreted in a strictly statistical sense, for example, in terms of the acceptable uncertainty associated with estimates (e.g., the error bars around estimates), or in terms of the probability of making a wrong decision (e.g., false positives or false negatives). DQOs may also be interpreted more broadly in the sense of an overall process to collect reliable data that will answer the question in a meaningful and complete way (EPA, 2006).

Law *et al*. (2008) provide a series of questions to guide the development of effectiveness studies. Several of their questions support thinking around what types of data to use and the quality of the expected data.

- *What factors should be considered when selecting study sites?*

  The study sites should be representative of conditions or situations that the study is designed to address. Alternatively the study sites should be representative of the most commonly found conditions; one way to insure this type of representativeness is to sample randomly. Other covariates that could affect the outcome should be considered, e.g., surrounding land use for a street sweeping study, age of structure for a retrofit study, or demographics for an education survey.

- *What minimum data are needed to characterize site conditions?*

  Often the preparatory work is equal to the amount of effort spent collecting the data. Desktop analysis may be extensive to locate appropriate study sites that are representative and safe to sample. This step focuses on the ancillary data needed to describe, select, and later evaluate the data collected from the sites. Only data that will contribute to the final analysis or interpretation of the study question should be collected. At this step the indicator list is carefully pruned.

- *How much sampling effort is needed to get reliable data?*

  The most important outcome of this step is that the data collected are adequate to answer the study question with an acceptable level of precision; in other words, to avoid collecting data that are too imprecise to answer the study question in any definitive way.

  The number of site-visits and samples are easier to define for some studies than for others. To estimate the needed number of data points for a specified level of statistical confidence, the statistical model must be defined (e.g., a paired design to compare toxic concentrations upstream and downstream of the LID development) and an estimate of variance must be available. National databases are available to obtain estimates of variance from similar projects.

  Statistical power analysis can be used to estimate the confidence associated with different outcomes and different sample sizes. Law et al. (2008) provide table values and other sources for calculating sample sizes for standard statistical tests. For projects that have no variance estimates available, the statistical test should still be specified and applied to some good guesses of what the data will be in order to evaluate whether the statistical approach will be appropriate.

  Although statistical texts often specify a $p\text{-value} < 0.05$ and a statistical power of 0.80, the acceptable confidence limits can vary widely depending on the study. Nonetheless, expectations should be specified for the type of difference that would be statistically significant or meaningful to the investigator before collecting the data. An assessment of the study design should be made to determine whether the data collected will meet the expectations.

- *What are the special data management and quality control considerations?*

  This step summarizes any unusual considerations for the type of data being collected. Examples might include chain of custody requirements, limited access to selected sites, or sample handling instructions. Any problems that are likely to occur and can negatively impact the value of the data should be emphasized during the data collection process.

F.2 Indicators to Track Effectiveness of Stormwater Management

Effectiveness studies provide unbiased information about whether specific stormwater management actions and programs are reducing, preventing or mitigating stormwater impacts to beneficial uses in receiving waters. Effectiveness studies' goals are:

- Providing data for adaptive management.

- Demonstrating compliance.

Effectiveness indicators have constraints: They are meant to provide information about the success or failure of specific management actions. As such they must be of appropriate scale to screen out other possible causes of observed effects.

A proper effectiveness study assessment and prioritization scheme will be applied first to existing programs and data in the form of a comprehensive literature review and a review of findings from existing programs.

Indicators for effectiveness studies will be highly dependent on the practice, scale, and scope of the technique, program, or landscape being evaluated. The goals of effectiveness studies are to provide data for adaptive management and to demonstrate compliance with applicable regulations.

In this context several factors can be identified for assessment as hypotheses are defined and study designs are developed, finalized, and approved.

- Reference Conditions
    - Paired watershed approach- the paired watershed monitoring protocol compares the response of two watersheds, with a documented relationship, when subjected to different management strategies and/or development patterns. One watershed usually serves as the control, where no changes occur, while the other watershed receives some kind of treatment. (From Watershed Protection Techniques 2(2): 587-594)
    - Pre- and post-treatment
    - Upstream/downstream treatment
- When to measure: consider intermittent nature of flows
- Spatial approach: to be successful, effectiveness studies must be highly aware of the spatial scale involved, and relatively small spatial scales (e.g., site or catchment) will be most effective in reducing influences from natural conditions or other actions.
- What to measure
    - Water quality (chemical and physical)
    - Biological indicators
    - Behavioral and attitudinal changes
- How to measure: standards and criteria
    - Human health criteria
    - Aquatic species criteria
        - Fish
        - Macroinvertebrates
        - Plankton and algae
    - Habitat criteria
    - Other

F.3 Example Questions to Guide Designs for Initial Effectiveness Studies

For each of the hypotheses-driving questions below, we recommend that the following information be developed in detail to allow refinement of questions into working hypotheses: 1) who will be responsible for implementation; 2) when is implementation recommended; 3) what are the recommended methodologies for implementation; 4) where is the geographic scope for implementation; and 5) how will this be funded?

1) **The proposed initial example questions for testing the effectiveness of LID techniques to minimize impacts from new development and redevelopment are:**
   i. How effective are LID BMPs at flow control and pollutant removal for stormwater, and are they protective of groundwater?
   ii. Flow in small streams over time – Is application of Ecology manual, or local technical equivalents, making a difference?
   iii. Can a full complement of the LID approach and techniques, used throughout a sub-basin, prevent measurable harm to sub-basin (as measured by flow changes and/or pollutants)?
   iv. On a basin basis, what percentage of LID infiltration enters the local aquifers and what percent is interflow that enters the municipal separated storm sewer system.
   v. What is the relative effectiveness, in terms of flow control and/or pollutant control, of certain land use planning practices (e.g., retention of native vegetation, reduction of impervious surfaces, clustering, reduced building footprint, etc.)
   vi. How effective is LID along state highways, for flow control and treatment?
   vii. For LID, what are the costs of construction sequencing and inspections; operations and maintenance inspections and enforcement; source control education; and long term maintenance and replacement when compared to other management approaches?
2) **The proposed initial example questions for testing the effectiveness of retrofit techniques to decrease impacts from the built environment are:**
   i. Flow in small streams over time – Is application of Ecology manual, or local technical equivalents, making a difference?
   ii. Does retrofit of older residential development (no or inadequate flow control, no water quality) produce statistically significant results for flow control and pollutant removal over one with no retrofits?
   iii. Which mix of BMPs (LID and conventional) provide the greatest flow control and pollutant removal benefits in retrofit projects for the best cost?

3) **The proposed initial example questions for testing the effectiveness of operational and programmatic approaches used in stormwater programs are:**

   i. Are current erosion and sediment control programs effective?

      When: can be started immediately as it is a predominantly a paper exercise.

   ii. Are targeted education programs significantly changing behaviors to reduce stormwater pollutants?

      When: already required in current Phase I-II permits, but finding it very difficult and expensive to do individually and makes more sense as a regional approach rather than by individual. Could potentially be done by enhancing the STORM program.

   iii. Beyond counting catch basins cleaned, are "pounds- removed" an adequate measure of protection (removed from environment), habitat protection (sand away from fish gills), or is more needed, such as particle size distribution, depth of sump, etc.?

   iv. What is the optimum level/regime of ditch maintenance to protect water quality?

   v. Is the current set of implemented Natural Resources Conservation Service Best Management Practices (BMPs) at existing agricultural sites achieving long-term reductions in pollutants and meeting water quality standards at points of discharge?

      a. **Who:** The Conservation Commission will work with Puget Sound conservation districts, the Washington Department of Agriculture, and members of the Agriculture/Water Quality Workgroup (NRCS, DOE, EPA, WA Dept. Ag) to further refine the methodology and implementation of the effectiveness monitoring of agricultural BMPs. The Conservation Commission will seek funding, lead, and coordinate the project.
      b. **When:** This is a high priority need as elevated by the Agriculture/ Water Quality Workgroup, and the results of this study are germane to the Stormwater Work Group. Work should start as soon as funds and a more complete study design are obtained.
      c. **Methodology:** Either a paired-watershed or an upstream/ downstream, before/after design would be used (Clausen and Spooner 1993; Plotnikoff *et al.* 2006). Suggested parameters are: water temperature, dissolved oxygen, conductivity, pH, total suspended solids, nitrogen, nitrate/nitrite, phosphorus, turbidity, fecal coliform, ammonia, and pesticides with more refined tailoring after choosing the specific monitoring areas and

examining the current land use and type of agriculture production at each site.

d. **Geographic Scope:** It is recommended that monitoring target areas of more intense agricultural activity. The results and methodology used to determine these priority areas can be found in Appendix 1.

e. **Ideas for resources:** Natural Resources Conservation Service, Puget Sound Partnership, Department of Ecology, Conservation Commission.

vi. What is the optimal mix of industrial non-structural/operational BMPs to reduce targeted pollutants at point of compliance?

vii. What are the optimal industrial structural BMPs and/or mix of BMPs for reducing targeted pollutants at point of compliance?

viii. What is the relative effectiveness of street cleaning?

ix. How effective are business inspection programs?

4) New and emerging techniques and technologies:

i. Investigate the effectiveness of new fecal coliform and metals treatment techniques, such as mycological remediation.

5) **Fill Key Data Gaps:**

i. What is the relative effectiveness, in terms of flow control and/or pollutant control, of certain land use planning practices (e.g., retention of native vegetation, reduction of impervious surfaces, clustering, reduced building footprint, etc.).

F.4 Cost Estimates for Effectiveness Studies

Costs for effectiveness studies can vary dramatically depending on the spatial and geographic scale and the type and scope of the study. Definitive hypotheses must be chosen, and therefore site distribution determined, in order for it to be possible to estimate specific costs for the initial effectiveness studies that will be conducted by SWAMPPS.

However, based on the work of others, we can give approximate costs for types of studies that fit into the categories of monitoring that are being proposed. This section includes cost tables from the Center for Watershed Protection report entitled *Monitoring to Demonstrate Environmental Results: Guidance to Develop Local Stormwater Monitoring Studies Using Six Example Study Designs, August 2008*.

The following five tables provide planning-level cost estimates for conducting various types of effectiveness studies. These tables are offered to provide a range of the possible level of effort that will be required to conduct not only the proposed studies but also the overall regional stormwater monitoring and assessment program. The information in the tables comes from the Center for Watershed Protection 2008. The estimates shown are for studies that range from about $30,000 to $250,000 each. It is anticipated that this range of costs will encompass the majority of the stormwater effectiveness studies conducted in the Puget Sound region.

Table F.1 describes a two-year budget for studies that can provide baseline data prior to an action taken and data after the action taken. Examples of the types of studies could include catchbasin cleaning efficacy, education programs (pesticide use, pet waste pickup, for example), roof pollutant loadings prior to disconnection, etc.

Table F.2 describes a two-year budget for studies that examine the effectiveness of stand-alone structural treatment practices. This would be applicable for constrained LID practices, such as rain gardens or bioretention facilities, or for testing new practices, such as mycological remediation.

Table F.3 describes a discreet project that performs implementation and longevity surveys of STPs. This would be applicable for studies such as implementation of erosion and sediment control practices on construction sites, maintenance of LID techniques, and catchbasin maintenance adequacy, for example.

Table F.4 gives costs for a three-year study that is designed to evaluate the changes in behavior resulting from a stormwater education program. This is a survey exercise.

Table F.5 shows the budget for a traditional paired watershed study conducted over four years to assess the effectiveness of treatments or practices in one basin to a basin in which no treatments or practices were used. It is cautioned that costs can run much higher that the amount given (their example was up to $1.3 million dollars).

Table F.1. Example budget for residential law fertilization source area monitoring study (CWP 2008)			
Source Area Sampling	**Staff Resources**	**Unit Cost**[1]	**Total Cost**
Monitoring 12 sites (10 lawns, 2 control), 20 storms			
PLANNING (25%)			
Background Research (incl. data acquisition)	40 hours		$2,000
Desktop analysis	32 hours		$1,600
Field reconnaissance for final site selection (incl. homeowner interview and permissions)[2]	80-100 hours		$4,000-5,000
Project scope and sample design	40-80 hours		$2,000-4,000
Develop monitoring plan	40 hours		$2,000
Planning Subtotal			**$11,600-14,600**
IMPLEMENTATION (75%)			
Equipment and supply costs[3] (e.g. latex disposable gloves, sample bottles, sample collection device, coolers for sample storage)			$6,250
Training(staff and/or volunteers)	3 day, 2 staff		$1,600
Sample collection, storage and transfer[4]	240 hours		$12,000
Sample analyses 5 (TSS, BOD, TP, TN, TKN, NO2, NO3)		$120	$14,400
Data analysis and interpretation	80 hours		$4,000
Final Report	80 hours		$4,000

IMPLEMENTATION SUBTOTAL			**$36,250**
TOTAL			**$53,850-56,850**

[1]Assume $50/hr

[2]Allows about 1-hour per site to include travel

[3]will vary based on method(e.g. grab bottle to complex sampler design), assume a 25% replacement cost

[4]20 samples, collected per site. Allows 1-hour per site to included travel, site maintenance, rainfall measurements

[5]10 of the 20 sampler are "keeper" samples, see Appendix C for cost estimates

Table F.2. Individual Structural STP Monitoring Budget for Simple and Complex Situations						
	Simple STP Monitoring Situation			**Complex STP Monitoring Situation**		
	Staff Resources	Unit Cost	Total Cost	Staff Resources	Unit Cost	Total Cost
PLANNING	5%			6%		
Background Research (identify potential STPs, determine data needs and monitoring parameters)	40 hours	$50/hour	$2,000	40 hours	$50/ hour	$2,000
Desktop Analysis (major tasks include: preliminary site selection, preliminary site characterization, generate field maps)	32 hours	$50/hour	$1,600	32 hours	$50/hour	$1,600
Field Reconnaissance and Site Selection	32 hours	$50/hour	$1,600	32 hours	$50/hour	$1,600
Project Scope and Sample Design	16 hours	$50/hour	$800	32 hours	$50/hour	$1,600
Develop monitoring plan	8 hours	$50 hour	$400	16 hours	$50/hour	$800
Planning Subtotal			**$6,400**			**$7,600**
IMPLEMENTATION	**95%**			**95%**		
Equipment [1]			$15,000			$17,000
Equipment Installation and Maintenance[2]	256 hours	$50/hour	$12,800	512 hours	$50/hour	$25,600
Training	32 hours	$5/ hour	$1,600	32 hours	$50 /our	$1,600
Sample Collection[3]	512 hours	$5/ hour	$25,600	512 hours	$50/hour	$25,600
Sample Storage and Transport			$10,000			$10,000
Chemical Analysis[4]		$200/ per sample	$8,800			$8,800

Data QA/QC	40 hours	$5/ hour	$2,000	40 hours	$50/hour	$2,000
Data Analysis and Interpretation	80 hours	$5/ hour	$4,000	80 hours	$50/hour	$4,000
Final Report	80 hours	$50/hour	$4,000	80 hours	$50/hour	$4,000
IMPLEMENTATION SUBTOTAL			**$83,800**			**$98,600**
TOTAL			**$90,200**			**$106,200**

[1]Simple = 2 automatic samplers, triggering sensors, pump, lumber, concrete, battery waders, clipboards, field books, first aid kits Complex = 2 automatic samplers, triggering sensors, pump lumber, concrete, battery, pipe for underdrain, flow concentrator at inlet.

[2]Maintenance for simple assumes 1 person, 2 hours per week, for 2 years. Maintenance for complex assumes 1 person, 4 hours per week, for 2 years. Installation for simple assumes 3 people for 2 days. Installation for complex assumes 3 people for 4 days.

[3]Sample collection assumes 2 people for 8 hours for each storm event. A total of 30 storm events will be sampled and 2 base flow events. Out of the 30 sampled events, only 20 are expected to meet QA/QC standards.

[4]Chemical analysis assumes contract lab analysis for standard pollutants/constituents. One composted inflow and one composited outflow sample will be analyzed for a total of 20 storm events and 2 base flow events.

Table F.3. Budget for Monitoring the Performance of Population of STPs (CWP 2008)			
	Staff Resources	**Unit Cost**	**Total Cost**
PLANNING (17%)			
Background Research (compile local STP inventory, secure GIS mapping layers)	40 hours	$50/hour	$2,000
Desktop analysis (major tasks include: preliminary site selection, preliminary site characterization, generate field maps)	32 hours	$50/hour	$1,600
Site visit to verify STP information prior to making the final site selection	32 hours	$50/hour	$1,600
Project Scope	16 hours	$50/hour	$800
Develop Monitoring Plan	8 hours	$50/hour	$400
Develop Field Forms	16 hours	$50/hour	$800
PLANNING SUBTOTAL			**$7,200**
	IMPLEMENTATION (83%)		
Travel and Supplies			$2,000
Conducting the Study	4 hours/site investigation	$50/hour	$10,000[1]
Data Management (entering field data)	2 hours /site investigation	$50/hour	$5,000[1]
Data Evaluation	40 hours	$50/hour	$2,000
Final Report	100 hours	$50/hour	$5,000
IMPLEMENTATION SUBTOTAL			**$24,000**
TOTAL			**$31,200**
[1]Assumes 25 sites with 2 investigations per site (wet and dry weather conditions)			

Table F.4. Example monitoring budget for a rooftop disconnection program (CWP 2008)		
Monitoring 12 sites (10 lawns, 2 control, 20 storms	**Staff Resources**[1]	**Total Cost**
PLANNING (16%)		
Background research (data acquisition incl. studies)	3 days	$1,200
Desktop analysis (major tasks include: preliminary site selection, survey sample population, generate field maps)	7 days	$2,800
Project scope and sample design	3 days	$1,200
Develop monitoring plan	5 days	$2,000
Subtotal		**$7,200**
IMPLEMENTATION (over 3-year period 84%)		
(note see Profile Sheet 1 for example source area monitoring budget)		
Supplies (GPS, cameras, street maps, postage* etc)		
Field Survey		
Perform USSR	16 staff days	$6,400
Survey		
Survey development	10 staff days	$4,000
Pilot survey[2,3]	25 hours	$1,250
Revise survey as needed	1 day	$400
Implement survey[2] & follow-up	2 staff, 60 hours each	$6,000
Training (both field and watershed behavior surveys)	2 staff, 24 hours each	$2,400
Data Management		
Data QA/QC	16 hours	$1,300
Data analysis and interpretation	10 days	$4,000

SUBTOTAL YEAR 1		**$26,750**
Repeat survey and source area monitoring Year 2[4]		$3,000
Repeat survey and source area monitoring Year 3[4]		$3,000
Final Report	5 days	$1,000
TOTAL		**$40,950**

[1]Assume $50/hr

[2]Allows 15 minutes per survey plus travel to site, cost will vary on survey method

[3]Administer 50 surveys, in person

[4]Cost of survey implementation

Table F.5. Budget for Monitoring the Cumulative Treatment Effect (CWP 2008)			
	Staff Resources	**Unit Cost**	**Total Cost**
PLANNING (20%)			
Background research (determine the control and treatment catchments)	40 hours	$50/hour	$2,000
Desktop analysis (site characterization, generate field maps, determine cross-section locations)	40 hours	$50/hour	$2,000
Project Scoping	32 hours	$50/hour	$1,600
Develop Monitoring Plan	32 hours	$50/hour	$1,600
Project Management	200 hours/year	$50/hour	$50,000
Planning Subtotal			**$57,200**
IMPLEMENTATION (80%)			
ISCO sampler with flow meter (2)		$10,000	$20,000
YSI6000 Turbidity optical sensor (2)		$5,000	$10,000
Sokkia Total Survey Station (1)		$6,000	$6,000
Digital camera (1)		$200	$200
Equipment Installation	64 hours	$50/hour	$3,200
Calibration Monitoring (2 years)	400 hours/year	$50/hour	$40,000
Treatment Monitoring (2 years)	400 hours/year	$50/hour	$40,000
Laboratory Analysis (for 10 storm events per year)		$1,500/year	$7,500

Data Management	100 hours/year	$50/hour	$25,000
Data Evaluation	200 hours/year	$50/hour	$50,000
Final Report	250 hours	$50/hour	$12,500
IMPLEMENTATION SUBTOTAL			**$201,600**
TOTAL			**$258,800**

Appendix G Data Collection and Data Management

For a functioning coordinated and integrated Puget Sound wide stormwater monitoring program, an initial and essential first step is to develop a coordinated and integrated data management system. A regional data management system is essential for collecting the data necessary at the quality necessary for monitoring stormwater impacts to Puget Sound, and would simultaneously provide a technical resource for data collectors. We strongly recommend that each data collector should not be required to independently to develop a data management system. Instead, monitoring data should be stored regionally in one primary database that is locally accessible. Monitoring data that is collected locally is far more valuable if it can be combined and compared so it can be put into a regional context. The data management should be available on-line to all entities in the region that collect stormwater monitoring data.

Multiple entities, including the Puget Sound Partnership, Department of Ecology, United States EPA, US Geologic Service, Snohomish County, King County, and others, have deployed, and/or are developing data management systems relevant to the stormwater monitoring and assessment strategy. Coordination between efforts is essential for successful implementation of a data management system.

G.1 Steps and Structures Needed to Ensure that Quality, Credible Data are Collected

G.1.1 Data Management

An online data management system initially comprised of locally collected monitoring data will provide an incremental method for the development of a regional database. Data collected for multiple local programs collectively will not provide a comprehensive dataset necessary to carry out the regional analyses necessary, whether effectiveness, status and trends, or source identification. But local data in an organized and accessible location will provide the necessary background data that the regional monitoring programs can be built upon. Additional data collections specifically designed to answer specific hypotheses and fill data gaps for these regional efforts can provide the data density and specificity necessary for hypotheses testing, and will provide additional data useful in evaluating the impact of stormwater on Puget Sound.

For a regional database to be of sufficient quality to be applicable to the hypothesis driven approach outlined in the Strategy report, data needs to be collected using a consistent level of precision and accuracy. The use of a Data Quality Objective (DQO) approach, developing Quality Assurance Project Plans (QAPP) is the appropriate level of organization and documentation to assure collecting data at the necessary level of quality. Acceptance of approved standard operation procedures (SOP) for both the local and regional monitoring is mandatory, and should provide a useful service to all permit holders.

G.1.2 Data Quality Objectives (DQOs)

Data Quality Objectives (DQOs) describe and document the type, quality and quantity of data needed to support the intended use of the data. Data requirements are established after understanding the context for which the data will be used to address a specific hypothesis. It is important to establish data requirements in advance of data collection and analyses to ensure that the right information is collected, using the appropriate methodologies and appropriate levels of accuracy. It is important to document the intended use of the data, quantitative measures and thresholds for decisions. While it may not be possible or necessary in all cases to develop quantitative thresholds, investigators are encouraged to think in these terms when possible and where it adds value to do so. This information also provides the basis for determining if the data is useful for addressing additional future and potentially not yet defined monitoring requirements.

While monitoring data is often collected to provide the quantitative information to answer a local or specific question (e.g. metal concentration in oysters in a particular bay, location of a fecal coliform source in specific creek), the documentation process established in the DQO allows an evaluation to determine if the data may be useful for multiple projects. The requirements for a piece of data to be useful in multiple contexts, the documentation, or metadata attached to the monitoring data needs to be collected and stored along with the quantization.

Planning for data collection that supports decisions involving large investments, high risk or political sensitivity will be more extensive and rigorous than for those studies where there is less at stake. It is important to complete the DQO process before a study is begun and identify the level of effort associated with responses necessary to collect data at the level of significance and nature of the study. For studies where environmental information will be used to make decisions with high risk and/or where a significant investment is made in the collection of environmental data, the DQO process should be followed comprehensively. For situations where environmental information will be used to make decisions that are low to moderate risk or the investment in data collection is limited, the DQO process can be less detailed.

G.1.3 Spatial Data

High quality, accurate spatial data is essential for implementation of a Geographic Information System (GIS), and it is also important to know if the spatial data will meet user needs. Metadata is a summary document providing content, quality, type, creation, and spatial information about a data set. It represents the who, what, when, where, why and how of the source data.

Keeping spatial metadata records is important and has multiple benefits an organization collecting or using spatial data. From a data management perspective, metadata is important for maintaining an organization's investment in the accuracy of spatial data. . Data users need metadata both to assess the quality of the data and to locate appropriate data sets. Metadata provides information about the data available within an organization or from catalog services, clearinghouses, or other external sources. Once data has been located, metadata defines how to interpret and use data. Any regional spatial analysis will require a review of data comparability that can only be carried out if the appropriate level of metadata is associated with the spatial data.

In 2003 the Washington State Information Services Board accepted a new Geographic Information Technology Standard that designated the State's preferred Horizontal Datum and Coordinate Systems. The standard mandates that all significant geographic data sets maintained by executive and judicial branch agencies and educational institutions … must store, or make their data readily available in, the North American Datum 1983 (1991 adjustment)," in addition, the data must be provided in the Washington Coordinate System of 1983 (a.k.a., Washington State Plane) or in a NAD 83 (1991) based Geographic Coordinate System. This should be the standard required for all geographic datasets collected as part of NPDES permit compliance. If any spatial data is not collected as part of a GIS, the data needs to have the same level of spatial accuracy as the Washington State Standards for electronic spatial data.

For a comprehensive integrated monitoring program for Puget Sound, a DQO for monitoring data should be developed to identify the standard protocols and necessary levels of data quality necessary so all monitoring data collected is comparable and has the necessary level of metadata associated with the data to make a data quality determination. Additionally, data collectors implementing each of the three monitoring components (Status and Trends, Effectiveness and Source Identification) should develop monitoring project-specific DQOs for each Quality Assurance Project Plan (QAPP). The project specific DQOs and QAPP should use the approved SOPs or provide documentation demonstrating comparable levels of MDLs, precision, and accuracy.

G.1.4 Quality Analysis Project Plans (QAPPs)

A Quality Assurance Project Plan (QAPP) is a written document that describes the quality assurance procedures, quality control specifications, and other technical activities that must be implemented to ensure that the results of the project or task to be performed will meet project specifications. Primary data collection, data usage, and data processing (such as modeling) project activities can be described and documented in QAPPs. A QAPP should be developed before beginning collecting data so that the desired quality in sample collection, laboratory analysis, data validation and reporting, and documentation and record keeping is achieved and maintained. A QAPP provides a written document that acts as a blueprint for the entire project and each specific task to ensure that the project produces reliable data that can be used to meet the project's overall objectives and goals. The QAPP defines specifically how the DQO will be implemented. Most monitoring programs require QAPP to be developed and approved prior to implementation of a sampling program. QAPPs typically contain the following elements, further description of these elements is found in (USEPA, 2001, EPA Requirements for Quality Assurance Project Plans):

- Title and Approval page
- Table of Contents and Distribution List
- Background of the Project

- A Project Description
- Organization and Project Schedule
- Data Quality Objectives (DQOs)
- Sampling Process Design or Experimental Design
- Sampling Procedures (or SOPs)
- Measurement Procedures
- Quality Control
- Data Management Procedures
- Audits and Reports
- Data Verification and Validation
- Data Quality Assessment/Usability

QAPPs should be designed to answer question related to data quality. The purpose of a QAPP is to provide a design that adequately displays whether or not data of sufficient quality and quantity are collected to meet the use for which they are intended.

G.1.5 Standard Operating Procedures (SOPs)

Data generated from stormwater monitoring is highly variable and often difficult to use to describe long term trends, determine the effectiveness of management actions, or determine source contributions occurring in Puget Sound. A Standard Operating Procedure (SOP) is a set of written instructions that can be used to describe a routine or repetitive data collection activity. SOPs can ensure reliable and representative monitoring data is collected. A series of SOPs often forms the backbone of a QAPP. Using SOPs to collect Puget Sound related monitoring data from various locations can assist with data pooling and data usability. The use of SOPs by all data collectors increasing the comparability of the data set and creates a common, larger dataset which increases the statistical robustness, accuracy, and predictive capabilities of the data analysis results. Additionally, by making a larger dataset directly comparable, smaller dataset benefit financially from the cost savings associated with comparisons with existing comparable data. By creating SOPs, data utility is maximized to ensure clear interpretation and comparability of results. SOPs provide a training tool (a written procedure) for field staff and/or consultants conducting monitoring that can help prevent unnecessary resource deterioration and enable stormwater managers to make management decisions with greater confidence. SOPs developed with this strategy can be made publicly available to assist other similar efforts State for stormwater data collection.

Anticipated outcomes of developing and implementing SOPs include:

- SOPs help ensure work is performed at a consistent and high level of quality in Puget Sound;
- Data are reliable and scientifically defensible;
- Data utility is maximized making it possible to clearly interpret monitoring results and compare data collected from multiple sources;
- Reliable monitoring data can be used to identify concerns early, while cost-effective solutions are still available;

- Common datasets with statistical robustness, accuracy, and predictive capabilities of the data analysis results; and
- Early detection of issues prevents further deterioration of Puget Sound.

For implementing this Monitoring Strategy, development of a list of needed sampling and analytical SOPs is important. This Puget Sound program will provide a robust monitoring design and implementation strategy. As part of the implementation strategy, SOPs should be identified and developed for each monitoring component (Status and Trends, Effectiveness and Source Identification) for use by data collectors.

G.1.6 Quality Control and Assessment

Once SOPs, QAPP and DQOs are developed for a specific monitoring program checks and compliance assurance is needed. While each QAPP has a Quality Control chapter, sometimes it is difficult for data collectors to ensure data is collected properly in accordance with a QAPP, SOPs or DQOs. This insurance is crucial for data comparability and usability. In provide such insurance would require compliance checks or quality control checks. To perform quality control check without bias, this is typically done by a third party or someone with knowledge of the program and data collection skills not tasked with data collection.

To insure data are collected properly, quality control for *field data* checks should be required. Frequency of quality control checks should be at the best professional judgment of the data collecting agency. The checks can help to evaluate if data are collected properly and in accordance with appropriate QAPPs, SOPs and DQOs.

G.2 Key Considerations for Developing a Data Management System

Listed below are some key considerations for developing a data management system to store and provide access to the information generated by the regional stormwater monitoring and assessment program.

1) Who are the data providers?

- What leverage does one have to get them to cooperate? (Making their life easier is a good one.)
- What resources do they have?
- What internal procedures do they have that impact when and how they deliver data?
- What political needs must be met?
- What would make them "happy customers"?

2) Who are the data consumers?

- What tools do they use?
- How do they want to interact with the data?
- What output formats do they prefer?
- Are there requirements to interact with other software systems? (e.g. "web services")

- What would make them "happy customers"?

3) Who is responsible for managing the data management system?
   - Is their responsibility mandated or voluntary.
   - What resources does this individual/team have?

4) What resources exist that are specifically dedicated to data management?
   - Money
   - People
   - Hardware

5) What kinds of Authentication & Authorization are needed at which levels?
   - Who is allowed to enter data?
   - Who is allowed to extract data?
   - What should be open to the general public?
   - What kind of secure technology is mandated/desired?

6) What categories of raw data exist?
   - sampling at a site
   - time series (e.g. stream flow gauges)
   - gridded fields generated from models
   - other?

7) What other data needs to be kept track of?
   - textual metadata
   - GIS layers
   - model output
   - text documents
   - other?

8) Validation
   - How is the raw data currently being validated?
   - Is it being done with software or by visual inspection?

9) Versioning
   - How is raw data being versioned? (e.g. How are changes to the data store being tracked?)
   - Can earlier versions be retrieved?
   - How is released data ("output data", "summary data") "sous chef" concept being versioned. (Monthly release is one system.)

10) Provenance
   - How is the history and origin of each data point being tracked as data goes from individual submissions to larger aggregations?

11) Transactional/Archival

- How frequently does data come in? (need precision at the second/minute/hour/day/month/year scale)
- How up-to-date should the released data. (Everything up to the last minute/hour/day/month/year?)

12) Raw Data Volumes
- How many actual measurements (not ancillary- or meta-data) are made and stored in a year? (thousand, million, billion, trillion?)

13) What sorts of interactive access should be provided?
- subsetting
- querying
- reformatting
- analysis
- visualization

Appendix H Response to Formal Peer Reviews and Public Comments on November 2009 Draft Scientific Framework

The SWG's current proposed scientific framework for regional stormwater monitoring is substantially revised from the November 2009 draft. Changes were based on the formal peer reviews and over 800 stakeholder comments we received, and on other new information. The SWG discussed the reviews and comments as a committee in five all day meetings over the course of December 2009 through March 2010 and continued making decisions about the details of the monitoring framework and the implementation plan through April 2010. Many subgroups of the committee addressed specific topics that were identified as key themes. New work was done to address some of the gaps identified by reviewers, to hone our priorities, and to improve our experimental designs.

H.1 Response to Formal Peer Reviews

The scientific framework is substantially revised from the November 2009 draft. Changes were based on discussions of the five formal peer reviews; consideration of the more than 800 stakeholder comments we received; and new work that was done to address some of the gaps identified by the reviewers, to clarify our purpose and scope, to hone our priorities, and to improve our experimental designs. Here is a summary of the SWG's response to the formal peer reviewers' comments. Appendix H includes the details of our discussions and decisions made to address these issues together with the issues raised in stakeholder comments.

Scientific peer reviews on the *Draft Stormwater Monitoring and Assessment Strategy for the Puget Sound Region Volume 1: Scientific Framework* were conducted by Rich Horner, Bob Pitt, Jean Spooner, Tom Schueler, and Steve Weisberg. Their complete written reports are posted at http://sites.google.com/site/pugetsoundstormwaterworkgroup/home/strategy-document-comments/formal-scientific-peer-reviews. Below are the major themes of their collective reports that the SWG discussed early in the process of revising the scientific framework. As a group, the SWG came to agreement as to whether and how to address each of these issues.

Gaps in the document, and thoughts on our approach and categories of monitoring:

- Need a more descriptive discussion of the problems caused by stormwater, their specific sources, and objectives of categories of management actions (i.e. to improve conditions or to prevent degradation). Do a gap analysis relating to specific sources/stressors/ controls prior to designing effectiveness studies, and focus on filling those gaps. <u>Response</u>*: We do need the gap analysis, and have taken initial steps to do conduct one. However we do not need another white paper on stormwater.*

- Biological focus is good, but be sure to measure indicators that have quicker and more direct responses to stormwater management actions, like pollutant loads, sediment contamination, and hydrology.
  <u>Response</u>: Agreed. We have included both types of indicators.
- Connect all three types of monitoring. Put more focus on status assessment and what specific stressors are being evaluated, and include baseline or reference conditions.
  <u>Response</u>: Agreed. Although the categories of monitoring serve very different purposes it was important that we think about and describe their relationships for our readers.
- Source identification approach is too limited: tie in compliance monitoring, characterization data, and illicit discharge survey information to help diagnose reasons water quality/beneficial use conditions are not met. Connect this to receiving water monitoring and do this prior to designing effectiveness studies to help define goals and get a better idea of how much control may be needed to achieve a biological response. Good idea to inform region-wide source control efforts.
  <u>Response</u>: Agreed. We have developed a new approach to this category of monitoring and described it in the revised scientific framework.
- Describe the analyses that will be performed.
  <u>Response</u>: We agree that all of the data that will be collected needs to serve a particular purpose, but we disagree that the specific analyses need to be described in this document. QAPPs are yet to be developed for all of the monitoring described herein and those documents will describe analyses that will be performed.
- Describe how the adaptive management framework will be used both to inform the monitoring and after reporting monitoring findings.
  <u>Response</u>: Agreed. We have intended to do this to the extent possible during development of the full institutional framework for adaptive management of ecosystem recovery efforts.
- Add a research category to help improve overall mechanistic understanding of stormwater effects and controls.
  <u>Response</u>: Agreed. We added the category but have neither identified priority topics for this category nor articulated a process by which those topics should be identified. This merits future work.
- Identify and include descriptive ancillary data about watershed conditions such as specific development land use/land cover metrics to help explain monitoring results.
  <u>Response</u>: Agreed. These details need to be articulated in each experimental design as QAPPs are developed.
- Explain the important role and application of various types of modeling to help managers use the data collected.

Response: Agreed. We have added a brief section and next steps to address modeling needs.

Conceptual model and priorities for monitoring:

- Fix the mix of beneficial uses and stressors listed in the table summarizing current understanding of the most significant stormwater impacts to beneficial uses (categorized by receiving water and major land-use category). It is confusing to readers and if made more stressor-effect specific can be better used to inform monitoring priorities. A few specific cells in the table were of concern.
  Response: The table served its purpose in helping the SWG articulate its priorities but was not sufficiently backed up by scientific references. We modified our approach to the conceptual model and offer a different table that we believe is less confusing.
- Overall, reviewers support an initial emphasis on small streams and nearshore, and probably would add lakes next.
  Response: Thank you. We have augmented our best professional judgment with a look at existing data that is presented in our revised section on monitoring priorities. We would like to address other water bodies besides small streams and nearshore areas in the future and also emphasize that water bodies of local concern still warrant local attention.
- Need to look at mosaic pattern of land development, including changes in infrastructure and treatment over the past decades.
  Response: We agree with this statement and are primarily addressing this issue within our proposed focus areas for effectiveness studies: retrofitting will take place in areas with older infrastructure and LID will take place in new development. The proposed inventory could be a useful tool and we will look into this further in future development of the source identification category of monitoring.
- Definition of stormwater needs to include human activities.
  Response: Agreed. We added non-precipitation-generated flows to our definition.

Hypotheses:

- Reviewers made numerous specific comments about individual hypotheses. In general, they were concerned that the set of hypotheses in the November 2009 draft document oversimplified the situation and may not provide the best approach for designing a regional monitoring program. Some suggested fixes included rewriting in a way that: not all of the hypotheses should be assumed true unless otherwise proven; consider more neutral statements, and/or more quantitative, stressor-specific statements; and consider a rating or ranking system. Reviewers also suggested that we conduct a literature review and look at findings elsewhere.
  Response: Agreed. We took a more thoughtful approach to translating our assessment questions into hypotheses for this version of the scientific framework. As a result we are at different places in articulating the hypotheses for each category of monitoring. We also include literature reviews as early

implementation steps, most particularly to inform our selection of hypotheses for effectiveness studies.

- Need more definition of "increased or improved stormwater management efforts."
  Response*: Agreed, particularly for effectiveness studies. For status and trends monitoring we are looking at broad, programmatic efforts and therefore can be more general. In selecting testable effectiveness hypotheses, we will describe: the specific type of actions targeted for evaluation, why we are targeting each action (the potential relevance of the actions to correct regional problems), and assumptions about its effectiveness.*
- Effectiveness studies need more focus on specific beneficial use endpoints.
  Response*: Agreed in principle, however in practice we will initially focus on more proximate indicators and perhaps articulate research needs to tie reductions in stressors to improvements in beneficial uses.*
- Address construction phase impacts from which beneficial uses might not recover.
  Response*: We agree that these impacts are important to understand better, but beyond our highlighting impacts of hydrologic alterations these changes were not identified as a priority topic for investigation in the initial phase of the regional monitoring program.*

Experimental designs:

- Difficult to determine cause and effect for the chosen designs.
  Response*: We have substantially revised our experimental designs, and attempted to be more specific about what we can and cannot infer from findings of each type of monitoring.*
- Concerns about probabilistic design, analyses, and about parameters selected need to be addressed in evaluating and rewriting Experimental Design sections and appendices.
  Response*: This section has been revised and the concerns addressed to the extent that we were able. Future work will need to address unresolved issues.*

The reviewers also offered many comments about implementation planning, including the importance of having an overarching strategy to assign roles and responsibilities, establish standard methods, and coordinate/manage the information that is collected. The reviewers' input related to implementation planning was considered in developing the following chapter of this document and will continue to inform later work by the SWG.

H.2 Key Themes in Public Comments

This section provides more detailed information about how we discussed the stakeholder comments and how we decided to revise the scientific framework.

To help manage the large number of public comments received on the November 2009 draft, a subgroup of the SWG members divided up the stakeholders' comments among themselves for compilation and each identified and summarized the key themes in the sets of comments they reviewed. Here is the list we collectively compiled:

1. Table 1 - blanks and potential flaws in linkages, inconsistent entries (beneficial uses vs impacts). Suggest transportation as land use, rivers a main source of mass loading of pollutants to PS (should be filled in for 3 land uses), runoff from commercial and industrial sources impacting marine water quality and contact recreation in small streams, runoff from residential, commercial and industrial land uses cause habitat damage and contribute to flooding. Chronic/sublethal toxicity is not mentioned. Highways should be own category. Concern that homogenous land covers do not exist and that there will be many confounding elements to any stormwater monitoring design. Inclusion of urban embayments/industrial areas as monitoring sites. Expand the list of categories evaluated. Wide agreement on forestry, but also divide residential into subcategories, and also add transportation.
2. Including transportation as a separate monitoring component. "How does this approach fit with the current regulatory (and monitoring framework), wherein the DOT is not permitted with the munis but instead receives its own NPDES Permit? Will excluding highways as a targeted land use for monitoring and assessment limit Ecology's ability to improve the WSDOT permit over time? Or are we missing an opportunity to engage the EO T more fully in this strategy?"
3. Like macroinvertebrates/biological end-points, but question whether stormwater impacts can be teased from other influences (salmon too removed) and need more clarity on statements like "population health." Support for using beneficial uses as indicators, but also concern about using salmon due to the many influences beyond stormwater. Difficult to tease out stormwater impacts when monitoring fish health for status and trends monitoring. "How will you measure "improving population health over time in Puget Sound" for the fish hypotheses in both streams and nearshore areas? The confounding variables that affect fish are quite numerous. In addition, what does "population health" really mean? The devil is in the details on this one for sure."
4. Need for explicit connection to decision making processes and managers. Coordination and information exchange needs better explanation, especially coordination with public and the link to decision-makers.
5. Not good understanding of linkages (or lack thereof) between types of monitoring (status and trends, effectiveness, source control – and how does Industrial permit monitoring fit?). Need better linkage to actions to be adaptive.
6. Clarify the use of "hypothesis." Discuss the definition and application of working vs. experimental hypothesis. "To further clarify the use of hypotheses in this document, it should be noted that in developing and using hypotheses there is a distinction between 'working hypotheses' and 'experimental hypotheses.' Working hypotheses are affirmative conjectures that propose a condition, affect, or outcome in the system being evaluated. Experimental hypotheses are the "null" hypotheses posed in experimental studies that attempt to falsify the working hypothesis. Working hypotheses cannot be 'proved' per se by the collection of experimental data. Rather, working hypotheses are increasingly supported by the accumulation of observational or experimental tests of the working hypothesis. If these tests fail to show evidence contrary to the working hypothesis, the working hypothesis continues to be

supported. This is the traditional use of working and experimental hypotheses in the scientific method."

7. Missing link of modeling, and loading and characterization of stormwater. Comments regarding utilizing modeling in place of some status and trends monitoring, because can't do everything everywhere, and also the loading characterization piece came back. Is there a relationship between these two in the desire to know how much is coming from where? and showing improvement over time? Can these be linked with permanent long term land use sites for loading/ characterization/status-trends/ and the desire to measure decline or improvement?
8. Need to summarize and use existing programs/knowledge in establishing the sampling design – feel that some of these hypotheses have already been answered or that we could refine the design better. Compilation/analysis/incorporation of current data. Starting to move forward with what we know now.
9. Technical questions about random approach to status and trends – whether it should be classified/stratified/some non-random/etc. – while they like the focus on small streams/nearshore, some concern that rivers/major river mouths are not specifically addressed (both in design and table 1).
10. Scale-a preference to monitor effectiveness and source control at the sub-basin scale. "We know that LID/Green Stormwater and source control work at the site scale, it is recommended to assess on the sub-basin scale whenever possible and not on the individual techniques."
11. Add operations and maintenance as a hypothesis "...at least some limited assessment of the benefits of inspecting and maintaining permanent BMPs." and "Any testing of BMPs should include an O&M component. A treatment device is useless if it requires constant operational care and/or frequent maintenance."
12. Flow as the primary measure of impacts on streams.
13. Source control hypothesis by contaminant of concern rather than site.
14. Lots of work needs to be done on the experimental designs, including developing QAPPs, agreeing on parameters, sampling sites, methods, data analysis methods, relationship to local monitoring efforts, etc. Lots of comments on specific technical sampling details to be added in Appendices E and F. How do we resolve the problems of automated samplers with regard to particle size.
15. Chemical and physical parameters for status and trends monitoring vs. biological endpoints, when the framework defines success as ecosystem integrity.
16. Commercial land uses in LID effectiveness.
17. Source control at permitted industrial sites or unpermitted parking lots and rooftops from big box stores.
18. Table 2 needs work – mix of outcomes, approaches, activities is confusing.
19. Skeptical about local governments supporting monitoring without changes in penalties (303d lists) and also need to recognize other factors in decision-making besides environmental data.

20. Concern about schedule for finishing, and the potential need for additional review or additional revisions to the scientific framework.

H.3 SWG Decisions to Revise Scientific Framework Based on Comments

The SWG grouped the key themes in the public comments with the themes in the peer review comments to ensure that we discussed all of the major issues as a group. Subgroups were assigned to address detailed technical issues raised. This section provides the record of the decisions made by the SWG in considering each of the key themes identified in the peer review and stakeholder comments. The complete 20-page documentation of the discussions and our 84 consensus decisions is available at http://sites.google.com/site/pugetsoundstormwaterworkgroup/home/strategy-document-comments/swg-decisions-on.

H.3.1 Scope and Purpose

Clarify the purpose of the SWG monitoring program and how the strategy document supports the SWG's purpose. Don't accept a task that was never ours to accomplish (nor could be accomplished). Use our charge from ECY and PSP, based on the Monitoring Consortium's recommendations, as our foundation (caucuses have accepted this). Remove contradictory statements in Task 4 of work plan and strategy – make sure documents are fully aligned. Modify based on all of the decisions we've made to this point.

All water bodies and land uses need to tie in. However, this document recommends the initial regional stormwater monitoring program focus on small streams, nearshore areas, and the full spectrum of urbanizing lands. Local priorities driven by other issues remain inherently supported.

Unregulated Stormwater: areas with no permits: These areas are covered by the scientific framework we've proposed. How to support and conduct any monitoring proposed for these areas will be addressed in implementation.

H.3.2 Conceptual Model (formerly Table 1 and Figure 2)

Include the elements in the subgroup's conceptual model: aquatic ecosystems, drivers, pressures, states, etc. – use the DPSIR model (and PSP indicator process) components and use open source language to describe how we'll use the monitoring information for adaptive management. Concern remaining that this doesn't depict stormwater impacts well

Include the arrows illustrating relationship between the elements. Make them all the same size except for the pathways (label added); add arrow from impacts to ecosystems

Include the specific examples included in each of the element boxes. Subgroup will continue to refine the content of the boxes. Figure in general is good enough to meet our purpose.

Include as a separate figure the "Watershed Characteristics" model ***as an example*** of a more specific conceptual scientific model for evaluating stormwater. Highlight areas where our hypotheses are targeted. Describe it as a useful approach and be clear about our intent.

H.3.3 Adaptive management

Restructure the primary document organization around types of monitoring, not adaptive management and retain adaptive management discussion.

- Acknowledge that the document did suffer from confusion and breakout: keep brief discussion of AM up front (it frames the entire strategy, not just the scientific framework). In Section 1 of our document, intro/purpose: Keep 1.4 and Reduce/edit 1.5 and 1.6 to key bullets and include in sidebars. And add transition text (how Adaptive Management applies to each type of monitoring)

Either describe the institutional framework for the full adaptive management cycle (that is, inform monitoring and report findings) **OR** say that the job of this document is not to define that institutional framework and let this go. This is governance, so state the latter in the scientific framework – goes in implementation plan.

H.3.4 Connect Trio of Monitoring Types

Use a watershed approach to tie the three types of monitoring -- this is one of the scales at which we could do monitoring

Tie the different types of monitoring together more closely in terms of stressors where we can, depending on the purpose of the monitoring. Don't restrict ourselves to a single list of indicators for the three types of monitoring. Do a better job of showing the linkages and how it all works together. Status and trends monitoring is biota-based and other types are stressor based. How do we link them (need to know what is causing negative impact to beneficial use)? Acknowledge this is an issue that we need to decide how to address in source identification monitoring. We are addressing this, needs to be in both volumes in parallel. Source id section was too slim in scientific framework.

Add Horner's ideas to our descriptions of our three categories: works for status and trends. We've described how monitoring applies, and need to link things together logically and clearly describe how change is made. Are there goals for all watersheds in PS that suit this approach? Do biotic endpoints suffice for this? Extrapolate based on what learning in certain areas?

Start with the stressors/problem for the region or in a particular watershed (use info from status and trends monitoring to direct source ID efforts and prioritize effectiveness monitoring). Prioritize monitoring across categories, based upon impact. Tie status and trends monitoring and management actions to the impacts in that watershed. See also figure 2/table 1 discussion topic.

Address uncertainty range as an overarching goal of the strategy – articulate credibility and confidence in each of our experimental designs.

- Add a paragraph: we need to address our collective/joint ability to sustain the effort to provide the answers we need with appropriate study designs and prioritized our efforts.
- Also articulate scale, how much, how often, and what we get for the effort. Be honest and transparent in approach to creating the overall study design, ensure that level of confidence is clearly articulated and appropriate for decision makers.

Focus on characterization is in source identification section [Define characterization (variation in relevant indicators/variables across the landscape and through time), the need for it in various studies, and what info we can get out of literature for a particular study. Relate back to an identified problem (status and trends, existing literature, etc). Where are sources of problems and how much is coming from each source, to inform actions.

- Will need a certain characterization study design to calculate loads (not currently in strategy). Different data gap.
- Might be included in a research category – separate discussion

State in text that the example hypotheses in the revised scientific framework (as modified per above decisions) will be a starting point, and that we recognize that they are not necessarily everyone's highest priorities, and likely will change. Acknowledge the prioritization process we went through, ensure we pick indicators that help us separate out stormwater impacts.

Include short discussion/definition/purpose of hypotheses in Strategy. As a base, consider Spooner's <u>Goals and Hypotheses</u> (in her peer review). Also consider Bill Taylor's comment about "working" hypotheses.

Include concept of "power" of statistical tests. Add to the text a discussion of data needs for specific hypotheses with experimental design.

  - Power analysis is important and should be done before studies implemented, but too early to provide this level of detail

Include discussion of necessity of a literature review. <u>Stress importance of using existing data (particularly local data) to inform stormwater monitoring efforts</u>.

Do not respond to each detailed critique of a particular hypothesis. Rather, consider a general response that the hypotheses in the draft strategy are starting points. Additional hypotheses will be decided after detailed discussions of issues (appropriate scale, level of confidence, study design, power analysis, QA/QC, etc.) among specific stakeholders.

Describe purpose of Indicator Monitoring? How will data be used?

- To measure the state of the system
  - Not to diagnose problems
- To determine if stormwater management actions are protective of, or restoring, resources.
- To measure improvements or decline in a biological endpoint.
- Useful:
  - To determine which water bodies are to be 303(d) listed.
  - To determine the miles of streams in poor health.
  - To provide data for modeling

- o To provide data for mass loading to PS.

Conduct ongoing Puget-Sound-wide analyses of stormwater-related indicators and syntheses of stormwater-related scientific knowledge

Start a "parking lot" for details and issues that could be helpful at a later phase of implementation.

Analysis of Phase I monitoring info should inform the starting point

Loadings/Characterization. Add text to document that says: We need a literature review before specific studies can be implemented

- We need to evaluate existing monitoring before implement more monitoring. Integrate existing outfall information where possible. As appropriate, evaluate data from Phase 1 monitoring and other NPDES permit-related monitoring (industrial, boatyard, shipyard, etc. for early identification of problem sectors, areas, and information gaps)
- As relates to Experimental Design: At some point in experimental design the assumptions being made should be clarified and explicitly stated. What is the "prevailing knowledge" about the relationship of concentrations, flow rates, volumes, loadings, sediment transport, particle size, etc.? Reference should be made to a prevailing theory, a reference, or perhaps some topics should be the subject of a white paper so that monitoring participants and study designers will be aware of background assumptions.

Do not adopt the structure in Horner's suggestions for a four-tiered approach that incorporates our three approaches and melds them with characterization and research but instead keep our three categories AND use his ideas.

H.3.5 Literature Review

Do initial step of reviewing existing data and programs must be a foundation for all later work. This analysis would include a thorough catalog of watershed land-use metrics, identification of stressors, a prioritization of at-risk watersheds, an identification of what techniques are most effective in which watersheds, and what are the data gaps and needed research. Already discussed and recognized need to do this. Should discuss how and when to do it (sooner than later). Categories include: review of existing data, compilation of programs, review of effectiveness (program approaches and BMPs), identification of data gaps and research needs (studies vs monitoring vs modeling); use other compilations from around the country (CASQWA, CWP). Pure probabilistic design won't get us all the answers in a timely fashion, need to prioritize. Need another discussion of monitoring design.

Investigate tying the monitoring to other existing Puget Sound long-term or short-term monitoring programs.

H.3.6 Status and Trends Monitoring

Distinguish between indicators with a quick and long term response to management actions. Both have value, but the November draft is too sparse on the former.

Include a baseline (status) or reference conditions, and identify stressors being evaluated. Need to address in experimental design, but this is inherent in status and trends.

Decide what hypotheses to address and what experimental design to use. Describe the process by which these decisions will be made. Do not include rigorous study designs. We need monitoring to answer specific questions and retain the hypothesis-based focus on streams and nearshore. Want to ensure that contribute to Adaptive Management framework.

- Start with status and trends hypotheses, best in draft, generally favorable comments, address concerns with indicators. Keep these (with modifications) in the scientific framework.

Describe where (geographic/water bodies) stormwater-related indicators will be evaluated for status and trends, and why?

- Start by establishing a regional stormwater monitoring program which focuses on small streams and nearshore marine environment (state of ecosystem health; pressures/stressors) within the context of the larger Puget Sound ecosystem.

  Explain why – how to measure progress in stormwater mgmt (testable, verifiable, actionable)

- Continue locally-identified and prioritized monitoring of other water bodies/resources to protect, such as lakes, groundwater/aquifers, wetlands, marine areas, or large rivers and integrate these efforts into the context of the larger Puget Sound ecosystem

Address where within the water bodies will indicators/endpoints be evaluated:

- Consider land use stratification and status of implementation of stormwater management programs in selecting status and trends sites.
- How will sites be selected?
  - Use the probabilistic design –OR–
  - Do not use the probabilistic design and position stations near problem areas and resources of interest to protect –OR–
  - Select locations that are representative of reference conditions and can provide paired watershed approach sites

Decide whether to (see John Lenth's write-up):

- Change text to say S & T is long-term
- Add text to describe nested probability designs within watersheds
- Modify design to balance status and trend monitoring
- Follow QAPP for WHRST monitoring program (Ecology 2006) to sample non-random reference sites

H.3.6.1 Indicators for Status and Trends Monitoring

Monitoring Parameter Selection: Look at stressors not being monitored currently – get recommendations from toxics loading committee (gaps id'd), address in communication and governance? Opportunity for SWG to lead.

Decide whether/how to prioritize development of benthic indicators and biological indices, especially for nearshore and marine environments.

Decide whether/how nutrient loading should be included as a parameter for monitoring and should be correlated to its possible impacts in fresh and marine waters.

Review programs and research currently dealing with the chemicals in Appendix E. Some of the parameters may warrant inclusion in the list for monitoring. We may modify the list in Appendix E in the future. Consider this as a list of examples and review as a group.

- Add sentence "Note not all of the parameters listed below will be monitored at all sites; see Table E.1 for which parameters are monitored at permanent and rotating sites."

Biological Indicators for Status and Trends Monitoring:

Good candidate indicators for stormwater impacts in small streams include:

- Salmon in small streams can be a good biological indicator for assessing stormwater impacts. Use various life stages for specific reasons. Examples:
  - Juvenile salmon
  - Pre-spawn mortality
  - In situ Salmonid Embryo toxicity testing
- Add coho to cutthroat ratio as an indicator in small streams.
- Juvenile salmon prey species
  - Vegetation
  - Terrestrial insects
- Benthic measurement (B-IBI) in small streams is a good biological indicator.
- Other

Good candidate indicators for stormwater impacts in nearshore areas include:

- Resident fish
- Forage fish
- Bacteria levels in water and shellfish
- Other

Determine indicators from among these lists (including "other") in process of writing the QAPPs for these two regional status and trends programs; done in coordination with effectiveness and source identification indicator selection

Sediment quality and WQ parameters/indicators to consider for status and trends monitoring (proximate to stormwater to support biotic monitoring):

- Use the Ecology WQI methodology for WQ parameters (Temp, DO, pH, FC, TN, TP, TSS and turbidity placed into a formula) so conform to this index.
  - Is Ecology's WQI SOP adequate or do we need more?

- Use the list of parameters on pages 63-64 of the strategy document (TSS, TP, TN, T and D Cu, T and D Zn, Hardness, Temp, TPH, SVOCs, FC, OrganoPhos Pesticides)
- Use peer review list of parameters: Toxicity (chronic not acute?), zinc, copper, lead, bacteria (FC, EC, enterococci), ammonia, nitrates, phosphates, pH, cond, turbidity, suspended solids, COD.
- Add organic carbon to small stream list.
- Focus less on WQ parameters and more sediment and energy.
- Eutrophication
- Focused toxics monitoring to fill in and complement toxics loading modeling work
- Other

Add table to text in Volume 1 (scientific strategy) with examples of stormwater-related indicators and parameters needed to assess indicators. Note that not all of these indicators will make it into the QAPPs.

Discussion: tables in draft doc appendix text not reviewed by committee. Strategy document needs to capture the examples we're thinking about for both proximate (stormwater-related, quicker timeframe) and long-term indicators and parameters.

Determine indicators from among this list (including "other") in process of writing the QAPPs for small stream and nearshore regional status and trends programs; do in coordination with effectiveness and source identification indicator selection; get input from toxics loading steering committee.

- Hydrologic Parameters
  - Keep what's there
  - Add energy
  - Use level and flow (continuous) as in the document
- Sediment parameters
  - Is this a priority?
  - Add sediment toxicity test for wet weather
  - Focus on sediment contamination
- Physical Habitat Parameters
  - Use list of parameters
  - Use Ecology Federal Pacific Fish/Interior Fish Biological Opinion stream physical habitat index

Decide whether to (see John Lenth's write-up):

- Identify short term indicators for detecting trends earlier

H.3.7 Source Identification Monitoring

Source identification needs a clearer articulation of purpose, a better framework, an appendix section, and a better explanation of how it interacts with status and trends and effectiveness monitoring. Tie in compliance data, use characterization data (e.g. Phase 1), and use illicit survey data, etc. Include CSOs. Add text to strategy.

Capture this in source id sections of both volumes, will review new proposal in implementation plan recommendations: Determining how much source control is needed to get a biological response is not needed necessarily. Doing this beforehand could impede progress. After source id, next step is source control. Need to continuously tie our work into the bigger picture of AM. Each source control activity needs a metric to measure its success, *i.e.*, roughly quantify load reduction targets to provide science-based recommendation (How clean is clean? What is dirty? Adaptive). Stormwater monitoring feeds into this bigger-picture discussion of targets.

Decide what hypotheses to address and what experimental design to use. Describe the process by which these decisions will be made: when ID a problem (or early warning signal) through status and trends or literature, design an appropriate study with appropriate indicators to address the problem. Short term process of describing the initial study design and long term process to add/connect. Process includes review/evaluation/vetting of new studies. Need a better discussion of what examples are included. Do not include rigorous study designs.

Include characterization in source identification section. Define characterization (variation in relevant indicators/variables across the landscape and through time), the need for it in various studies, and what info we can get out of literature for a particular study. Relate back to an identified problem (status and trends, existing literature, etc). Where are sources of problems and how much is coming from each source, to inform actions.

- Source ID hypotheses need background work and information (lit review). Be more vague about these in the revised scientific framework; include a couple of hypotheses as examples. Drop 4 Hypotheses in scientific framework. Perhaps have subgroup identify hypotheses for what are regionally significant source identification efforts? What collective analyses could be done? Connect to watershed specific efforts. Consider coming up with categories: e.g., copper, phthalates, fecal coliforms, locally-determined sources, specific land-use issues? Have source ID implementation plan section group work on this and develop hypotheses for each category.
- Add a sentence to Section 2.6.3 that "An essential component of the monitoring program will be to identify and characterize sources and loadings of pollutants in stormwater throughout the basin" in the source ID section. Need draft language – hybrid of source id and characterization discussions
- Add a sentence to Section 2.6.3 as follows: "Data from compliance monitoring, characterization data, and illicit discharge survey information will be used to help diagnose reasons water quality/beneficial use conditions are not met." With modification: change "compliance monitoring" term because it is confusing, it means both sampling data and implementation of actions to different people (both are needed). Also include idea of both source and conveyance of pollutants. Source ID is finding the problem.
    - Data management issues (local-regional) can only be resolved when the structure and relationships in the monitoring agency are clarified. Deal with this in the implementation stage section 6.3 in implementation plan

draft outline. Do a lit review and set up a framework for SOPs and data reporting for collective regional assessments.

- In text: Cite earlier successful studies as examples (for all categories of monitoring). Need to know what SOPs are needed. Look at toxics loading steering committee work to help identify initial areas of concern. Discuss known sources of key stressors in text. Separate sources and conveyances.

Loadings/characterization issues to discuss with indicators:

- Add to the text that we may identify a representative number of specific outfalls and perform monitoring. Weisberg recommended loadings and hydrographs as proximate indicators of management responses.
    - This may be a data gap
    - Study design question? How do you get representative outfalls to sample?

Propose: Stay with original decision and focus on collecting characterization data needed for effectiveness and source identification studies:

"Define characterization (variation in relevant indicators/variables across the landscape and through time), the need for it in various studies, and what info we can get out of literature for a particular study. Relate back to an identified problem (status and trends, existing literature, etc)."

Propose: get clarification from S Weisberg about his recommendation to get a better idea of proximate responses to stormwater management; i.e. is outfall monitoring needed to do this?

Discussion: Perhaps consider outfalls as an indicator to inform a probabilistic model? Phase I characterization data has come in with variability similar to that in the national data base. Do we need some outfall monitoring to support status and trends (with other ancillary data)? Source identification and effectiveness monitoring would likely include outfalls. Probabilistic status and trends monitoring of outfalls might be helpful to answer effectiveness hypotheses? Might have a different perspective with respect to industrial outfalls.

Add a sentence to Section 2.6.3 as follows: "Data from compliance monitoring, characterization data, and illicit discharge survey information will be used to help diagnose reasons water quality/beneficial use conditions are not met."

The document must acknowledge that part of experimental design will be to evaluate known source ID information, screen for stressors, and focus on receiving water monitoring where impacts may be greatest.

All four source ID Hypotheses were roundly trashed; Recommendations should be made by the chapter writing team.

Do a lit review and set up a framework for SOPs and data reporting for collective regional assessments

In the implementation plan we will <u>recommend</u> developing a standardized version of a stormwater infrastructure and BMP inventory tool (see Schueler's comment #5) for use across the region

Discussion: applies to diagnoses and targeting management approaches as well as to effectiveness studies – belongs more in source identification section. A possible approach; tool for a focused study? Would provide methodology for collective regional analyses. Not just public infrastructure.

H.3.8 Effectiveness Monitoring

Decide what hypotheses to address and what experimental design to use. Describe the process by which these decisions will be made. Do not include rigorous study designs.

Discussion: do we need to do a literature review to inform this? Got good feedback from public review and can do targeted searches. Or state that this can be refined as we do a literature review. Can we view hypotheses as questions we'd like to be able to answer, rather than these are the studies we're going to design? Stay with assessment questions, and move to credible, testable, actionable hypotheses later? Concern that examples infer priorities.

Effectiveness hypotheses were too detailed, too quickly, without background work and information (lit review). Be more vague about these in the revised scientific framework; include a hypothesis as an example for each category of effectiveness monitoring; refer back to assessment question process.

Add a 4th bullet/category for studies to test new and emerging techniques as needed (for both new and existing development). (Connect to TAPE)

Add a 5th bullet/category to continue to fill key data gaps for existing techniques. Say in text that it is not a current priority to recommend new studies, but… dependent on Phase I results and other research, we should evaluate needs for this type of information (fits into literature review and data management).

Add this wording/concept to the effectiveness monitoring framework and continue this idea in implementation plan: Identify effective stormwater management techniques (programs, methods, BMPs at a basin-wide level) that we know now, and work to implement them as soon as possible. "Work to implement ASAP" should be more along the lines of communication, AM. Ongoing feedback into management loop in addition to acting on what we already know. "As we learn from our monitoring and assessments, we apply what we've learned as quickly as possible." "Recommendations of what should be in the next permits will be decided in the process of writing the implementation plan."

Remove the phrase "increased/improved management actions" and instead describe the type of actions targeted for evaluation and the potential relevance of the actions to correct regional problems. Be specific enough to have a testable hypothesis.

- Before final hypotheses are collected/agreed upon, articulate why we are targeting each action, consider assumptions about its effectiveness (and perhaps available information about its costs and benefits); tie back to assessment questions.

State that we will do a literature review prior to designing a study.

Add section in scientific framework explaining the need to track municipal and other stormwater management activities and programs and the information will be used as ancillary data to support effectiveness and source ID monitoring and help us answer other questions

- Includes municipal, business, other activities in a basin
- Also need to track other land use planning/land acquisition activities that affect stormwater management
- In the implementation document, describe how these types of compliance/programmatic data are (or will be) cataloged and tracked

Add text saying that we will take advantage of the opportunity to design efficacy studies in basins with stormwater-related TMDLs where actions are targeted at a specific impairment and progress in the receiving water will be tracked.

Public Education and Outreach:

- Education/outreach activities as BMPs?: this is part of the effectiveness component of the strategy which includes programmatic activities as well as traditional facilities
- Education/outreach activities planned as part of our regional coordinated monitoring program for stormwater: this is a chapter proposed for the implementation plan, should address audiences and vehicles for communication – should also be briefly referenced in executive summary for both volumes. Address transfer of science information in AM section.

Include planning hypotheses: Means: approach to manage stormwater through land use/watershed planning. Could also address development/zoning rules; other strategies besides LID for developing lands to address. Sources that require regional approaches. Already covered expanding hypotheses to include evaluation of these tools (say: <u>range is broad and will expand over time</u>). Be specific. Scale question. Say: <u>Prioritization will occur in making effectiveness implementation chapter decisions</u>.

Decide whether/how to incorporate water quality analysis/hypotheses into LID monitoring (Ho in strategy is flow; experimental design in appendix is Q and WQ?)

Decide whether to (see John Lenth's write-up):

- Keep emphasis on receiving water monitoring and aggregate effects of stormwater BMPs rather than a focus on influent and effluent
- Add monitoring before and during construction phase of BMPs

H.3.9 Other Gaps in the Document

<u>Climate</u>: we have not discussed this, should this be part of effectiveness studies? These are different questions. Is this a priority for (1) the overall framework **<u>yes</u>** and (2) our initial prioritization and focus **<u>no</u>**. We should add a high level recognition that climate change impacts what we're doing, and our work needs to tie into a bigger picture over the long term.

Global pollutant levels: We should add a high level recognition that global pollutant loading impacts what we're doing, and our work needs to tie into a bigger picture. Bring in air deposition early for source identification.

H.3.10 Additional Science Needs/Ancillary Data

Do not add detail on land use/land cover metrics. This could be a potential outcome of the monitoring, depending on specific monitoring activities, but should not be a precondition. We don't need the breakdown – we need the overall activity:

Watershed characteristics: Land cover, impervious surface and other land-use characteristics must be surveyed. Extensive body of knowledge to build upon – another area for literature review. Screening and guiding mechanism for what to monitor.

- Need to continue to collect and maintain this data.
    - Meaning of "ancillary" – absolutely required information (find and use a different word?)
    - Might need to collectively integrate
- Land use/land cover (continue Ecology's 5-yr interval analyses)
    - Mapping
- Current Phase I permit requirements with requirement to use national GIS standards help with this and should continue throughout region – how?

Discuss whether to use VMT/ADT/Stream crossing/Street dirt/Urban simulation data and approaches that are available

- From Seattle street sweeping study: VMT could be surrogate for estimating pollutant loads up to a certain level (then traffic seems to dissipate pollutants)

H.3.11 Modeling

Make a better connection from our data to modeling. Modify the current section on models to say:

- There are different types of model that 1) model problems and mechanisms, 2) extrapolate results from small scale studies to regional (urban and rural) effects, and 3) extrapolate the benefits associated with different management actions.
- Our goal is to connect our monitoring to the models that support actions to restore watershed health, but the specifics of all the possible connections is outside the scope of this document.

In the meantime, author might describe an appropriate, relevant example of how we would connect to a program (for example, HSPF/WHM or others).

Process to determine what we need to collect. Go through/identify the list of most relevant models that are out there and identify their data needs. (What priorities have been identified by PS Science Panel? What suits focus of what we need for stormwater management?) State intention that we'll collect data under this monitoring plan that we know is needed for many stormwater-related models, and key relevant data gaps. Cross boundaries to see where our efforts inform other activities.

Discussion: work we're doing needs to feed into the modeling work that is needed (and vice versa). For example, Toxics Loading committee has a list of modeling needs. Need to identify this step and create this list for stormwater.

We will work with modeling experts to identify specific data needs for models. Incorporate a modeling-specific data collection plan into the strategy.

Add text to Modeling Activities – expansion of recommendations above

- Examples: need watershed runoff and loading, empirical models relating upstream land use and cover to stream and outfall quality, etc.
- Intent of strategy is to collect data that supports modeling activities and can be used to verify past efforts. This data collection must be targeted to modeling efforts that will be useful in providing insight to help answer our questions.

H.3.12 Research

Add a short section to the document that says: Research is important, agency support is needed to manage research projects, and list the projects above as examples. Add new category but don't necessarily prioritize it. Also, it is outside the scope of this document (scientific framework and implementation plan) to define the structure needed to make this happen. Our current goal is to implement best available science now, that is, connect management to results of earlier research; and address emerging issues and distribution of research dollars at a later time.

Discussion: we are adding a 4th category of monitoring. Do we endorse an activity of tracking research activities and emerging issues and recommending new studies relating to the other three categories? Does a comprehensive strategy necessitate this category under the big tent? Not necessarily prioritized in our starting point. Horner's comment was that problem diagnosis and research are confused in our document. Basic research that is not directly applied to what we're doing needs to be conducted. We had a research category of assessment questions in our initial document (decided not to prioritize those questions as part of initial starting point).

H.3.13 Experimental Designs

Appendices E and F: Remove the appendices and details from the scientific framework. Leave only high-level discussion and respond to higher-level comments (i.e., scale, paired watershed, etc.). Post all of the examples provided by the consulting team in an online library, separate out by category of monitoring, and summarize relevant comments on the ones that were included in draft vol 1. The status and trends, effectiveness, and source identification writing teams will address the relevant examples and decides explicitly to: use/modify/replace each example and dive down in the implementation plan where each chapter will propose whatever level of detail is appropriate for their category of monitoring):

- Propose/outline experimental designs for small stream and nearshore status and trends and how we would move forward to approve monitoring plans (recognize commitment to build on state/PS indicators and ECY small stream monitoring). If examples are used, address the detailed technical comments, contact specific commenters to help.

- Build specific tools/approach for source id (there was no Appendix in draft vol 1).
- For effectiveness, articulate a vision rather than study designs, and concentrate on who can do what.

ONLY the examples that are determined to be useful for the regional monitoring program will be retained in the strategy document.

Decline reviewers' request to specifically describe the analyses that will be performed. Include the monitoring designs as examples, but this is a "scientific framework" document, not the implementation document. We will include a broader set of designs as examples, over time. We will discuss which specific examples below with experimental design.

H.3.14 Yet to be Done/Discussed:

Not deciding whether/how to address compliance monitoring yet

Focus on the strict definition of stormwater (conveyance) and not non-point (other sources such as failing septic systems, historical sediment toxics, etc.). – different topic, doesn't belong here, hold for later discussion

Include new version of Table 1.

Economics and costs. Address in implementation (scientific framework is setting priorities acknowledging the need to prioritize); add big picture statement that monitoring needs to be sustainable – governance/implementation issue; recognize that it is expensive and we need to know what we can afford to do, also include benefits (what the investment saves us down the line). Vol 1 doesn't talk about cost, Vol 2 will executive summary for paired set should have this concept (keep management audience in mind).

Include in implementation strategy:

- SOPs and data management; data sharing
- Use monitoring data to define research needs

H.3.15 Governance Issues:

Include in Strategy the concept of a "monitoring consortium" (Horner/Schueler) with authority to assure funding, rule on adequacy of science, study design, QA/QC, peer review completed work, track projects, maintain databases, etc. Develop full proposal to include in implementation document.

A "lead entity" has to coordinate and manage this effort.

Public education/outreach; Including community in decision making

Strengthen diagnostic approach and elaborate on how adaptive management will work to get corrective feedback to managers. Do this primarily in the implementation plan. Add some text and perhaps a diagram to scientific framework: how do we make this useful? How do we apply the information? How do we communicate the information? We really need to work on this issue. Needs to dovetail with governance being developed by PSP.

Appendix I Issues that Remain to be Addressed

This is a summary of the unresolved issues raised in the public comment period on the April 30, 2010 revised scientific framework and draft implementation plan for the strategy. The SWG has struggled with most of these issues in the process of developing this strategy, and we realize that more work is needed to resolve these outstanding issues.

The SWG proposes to address as many of these issues as possible and deliver further recommendations to Ecology and the Partnership by the end of October. We will continue to work on other issues as we move forward.

The topics are:

- Costs and pay-in option.
- NPDES stormwater permit-related questions.
- Roles and responsibilities for implementing the strategy.
- Shortcomings/concerns about overall framework.
- Status and trends monitoring design and implementation.
- Source identification and diagnostic monitoring roles and implementation.
- Focus and process for selecting and implementing effectiveness studies.

Topic 1: Costs and Pay-In Option

1. COSTS: How will this be paid for? How funding responsibility be allocated among levels of government, among regions, and among monitoring types? Why should locals pay for ambient status and trends? What is the state/federal share?
    a. Overall cost is too high, and it is unclear how municipalities will pay for this, especially given existing economy. What *is* the total monitoring package cost, especially for permittees?
    b. Concern about increased cost in addition to existing monitoring costs – will layoffs occur? Will existing monitoring programs be cut?
    c. Instead of raising funds for monitoring, money is better spent providing services and implementing fixes/controls.
2. FUNDING ALLOCATION:
    a. Lack of specificity allocating costs between feds/state/municipalities – some activities should be funded by each.
    b. Need reasonable cost-sharing approach between municipalities.
3. PAY-IN OPTION: General (but not universal) support for pay-in option. Many issues remain. Include these ideas for consideration:

a. Possible conflict of interest. One concern is having the same entity operate as the coordinator/clearing house for the studies and funding and also conducting/competing for the funding to conduct the studies.

b. Increased overhead for independent entity is unnecessary.

c. Whether to require permittees to pay-in to the regional program.

d. Who provides oversight?

e. Funding of monitoring outside of jurisdiction (it is unclear whether funds from municipalities can be used for activities outside jurisdictional boundaries). Also, need for actual benefits to be received by every municipality contributing funds to the pay-in option, with a focus on actual monitoring within each municipality's boundaries.

f. More accounting and legal are detail needed for pay-in option: SCCWRP as model?

g. Use Interlocal Agreements if possible. MS4 Permittees should be able to use interlocal agreements to achieve economies of scale, to share resources and expertise, and to address watershed interests in performing their stormwater monitoring tasks. Through interlocal agreements, smaller Phase II Permittees and secondary Permittees could take advantage of the efforts and expertise of larger, more established stormwater management programs.

h. Consider Ecology having the responsibility for contracting with the Entity for the required services.

Topic 2: NPDES Stormwater Permit Related Questions

1. How does this fit with NPDES municipal stormwater permits?
    a. Is this beyond the legal purview of the Clean Water Act?
        i. Can permittees legally be required to use MS4 ratepayer funds for science not directly related to managing stormwater, or that benefits other jurisdictions?
    b. How do non-municipal-stormwater-permitted geographic areas fit in?
    c. Are watershed-based permits necessary to implement this program?
    d. How does this proposal affect MY permit? Will the regional program be 100% compliant or will municipal permittees have to monitor further?
    e. If problems are identified, will municipalities be required to fix them?
    f. This is a great idea, but why are you putting it in the permit? How is this stormwater? Aren't you stretching the definition of stormwater? How does sampling reference sites for status and trends relate to stormwater?
    g. How does this fit in a 5-year permit cycle? How does program inform adaptive management of stormwater?

  i. Requires more than five years to generate significant trends and lead to related follow-up actions.
  ii. Long term monitoring better conducted outside of the permits under longer term planning and budget cycles.

2. How will other types of NPDES permittees participate in this program?
3. What is the regional scope? How do the agencies fit together? Who does what? How will the regional plan incorporate existing programs? Will people lose their jobs?
4. What are the next steps? Who are the next people to involve? How does this work fit into Ecology's timeline for permits?
5. What are the full package costs for permittees?
6. Scope and costs are too ambitious, significant burden to municipalities.

Topic 3: Roles and Responsibilities for Implementing the Strategy

1. Key recommendations #10 – 16 lack a responsible party. Who is charged with these tasks?

   a. Key Recommendations 12 and 14 describe the need to formulate and support a process to develop and approve standard methods for regional monitoring efforts to follow. The current Standard Operating Procedures and Quality Assurance Project Plan Standardization Project (SOP work group) has developed four standard operating procedures (SOPs). Many more are needed, but funding to continue SOP development is in doubt. Is there another source of funding to support this effort in the near term? Articulate a clear strategy to fund and support SOP development.

   b. Key Recommendation 13, Consider the Partnership or Ecology as the lead entity for creating the IT infrastructure needed to compile and provide access to the data. Discuss issues related to and options for data management (where to house, who would analyze, etc). Data management, standards etc: Ecology or some other technical resource needs to provide a consulting service to help in this respect or it will not happen.

   c. Key Recommendation 14: Requiring "all data and findings to be submitted to a central data management system" may be problematic… The SWG should consider creating a much simpler portal… Building a portal could occur much more quickly and would allow individual data users to hook into the region-wide system at their own pace. The "independent entity" should be designed so that it is well suited as a repository for Municipal Stormwater Permit and other stormwater data. However, it should be recognized that there are some types of Permit-related data that are best collected and analyzed by local permittees.

2. OVERSIGHT ROLES:

   a. Roles of SWG, Independent Entity, Ecosystem Monitoring Program, PSP, Ecology need to be specified and/or clarified.

   b. It will be very important for stakeholders to have a role in oversight of the Entity, particularly with respect to lending practical stormwater management experience to potentially academic endeavors. SWG may not be the right organization, structure, or group to continue on with regional program *implementation*. It seems more appropriate that an independent monitoring and analysis entity (i.e. the SCCWRP model) be created to coordinate stormwater monitoring and broader efforts. Perhaps a “board of directors” or “advisory group” made up of jurisdictional, private, and regulatory representative is a better role for the current SWG representation? Other comments encourage an ongoing role of the SWG related to defining, implementing, and directing stormwater monitoring and assessment; that the SWG (or a similar representative body) serve as the oversight body for the monitoring program implemented by the independent entity.

3. Roles of state and federal agencies: The role of the ongoing state and federal monitoring programs needs to be better described relative to the level of effort intended, and the relationship to stormwater monitoring and assessment. Ecology believes that state and federal agencies will play a larger role in implementing this new regional stormwater monitoring and assessment program than is shown in the Key Recommendations.

   a. Ecology is committed to looking at existing funding sources and supporting new initiatives to the extent we are able under our statutory authority and as a cabinet agency.

Topic 4: Shortcomings/Concerns About Overall Framework

1. Underdevelopment of source identification and effectiveness components compared to status and trends: The strategy appears to place a majority of emphasis on Status and Trends relative to Source Identification and Diagnostic and Program Effectiveness efforts. This seems disproportionate given that the latter two have a stronger tie to the stormwater management adaptive management framework.

   a. Consider different sequencing of implementation.

   b. Need more detail on processes for both source identification and effectiveness and how each relates to current work done by permittees and others.

   c. Hypothesis testing is important and a robust scientific design is a must.

   d. Consider scaling back status and trends.

   e. Assess the larger scale condition status, perform large scale trend analyses and undertake research efforts necessary to forward the state of the art.

f. Data needs in managing stormwater for rural, agricultural and forest lands may be different from data needs for managing urban stormwater.

2. How do the parts of the monitoring program (effectiveness, status and trends, and source ID) interact with each other? How do the parts feed back into the adaptive management framework?

3. How to balance probabilistic sampling and targeted sampling? At what point along the continuum of monitoring does it make sense to switch from looking for problems vs. taking care of problems that have already been identified?

4. Should the strategy include agriculture and forestry? Opinion seems to be running about 50/50.

5. Modeling: More details on how modeling can and will be utilized needs to be included in this proposal. Modeling can save resources in many cases, but only if it is integrated into the monitoring program up front.

6. Connection to ecosystem monitoring: SWG should continue to work closely with Puget Sound science staff and the Science Panel to design this program in a way that will inform their efforts to conduct regional ecosystem monitoring.

Topic 5: Status and Trends Monitoring Design and Implementation

Overall summary of comments and issues raised on this component of monitoring:

1. A majority of the comments are in agreement with the proposed design, at least in part.

2. Responsibility and means to implement: Status and trends monitoring is a good idea and should be part of the monitoring program, but the assumption that the random EMAP design is appropriately linked to stormwater and confounding effects are accounted for needs to be more strongly defined. A minority did not think status and trends monitoring should be part of NPDES sampling and was beyond the purview of the NPDES permit. There is a minority theme of 'unfunded mandate' and local jurisdictions should not be required to do regional monitoring (spending money on large-scale ambient monitoring programs is a poor use of time and money if the stated objective is to clean up local stormwater). Several of these commenters also were in favor of the pay-in option to fund someone else doing the regional monitoring.

3. Biological end points are appropriate to use for status and trends. Should the program include fish? To what extent are fish abundance and diversity sufficiently linked to direct impacts of stormwater to include this in permits? Biological indicators respond to a number of different environmental stressors. Separating effects from stormwater will be difficult, especially in the nearshore environment. The extent of the challenge posed by confounding factors in the interpretation and analysis of monitoring results is not described in the status and trends implementation plan.

4. There were a large number of comments on the specifics of the sampling design, primarily related to location, allocation and timing of the proposed sampling. There was some skepticism that the probabilistic design presented will be able to tease out stormwater related influences from the many other confounding impacts that are present in Puget Sound, and that random sampling is not appropriate for monitoring the impacts of stormwater and far too expensive. Several suggestions were made for targeted sampling as opposed to random.

   a. Equal allocation of sampling by WRIA, non 'stormwater' sites

   b. Random vs. targeted sampling needs to be discussed and addressed.

      i. Choose sample sites based on targeting stormwater problems and determining the level of impact and changes based on implementation of corrective actions.

      ii. There is a serious disconnect between the desire to have a probabilistic design and the use of existing programs such as EMAP and existing Ecology sites based upon a judgment sample design.

   c. How do the regional random sites provide useful information to local jurisdictions?

   d. Timing: assess the value of adding additional sample collection during storm events to ensure that the impacts of storm events can be assessed.

   e. Where did the proposed number of samples come from?

5. The choice of bacterial monitoring and sediment chemistry in nearshore areas is good, but the choice of a random scheme is not appropriate.

   a. Use *E. coli* and *Enterococcus* as the indicator of choice.

6. Use of existing monitoring sites needs to be incorporated into the design. The availability of continuous flow data from existing non-random locations that are also located near water quality and benthic invertebrate monitoring sites should be weighted appropriately when considering the value of including existing non-random monitoring stations in the proposed status and trends monitoring framework. Currently maintain 20 long-term stream water quality sampling sites with over 20 years of monthly data. Value of these long-term data sets would warrant their inclusion in the new monitoring and assessment strategy.

7. Existing data collection efforts should be used for trend analysis.

8. Mussel Watch is a good program, but (again) the direct link to stormwater is hard to prove.

9. Add nutrients and benthic infauna to marine nearshore monitoring. Include a hypothesis for nutrient reduction to the nearshore along the lines of 'reducing nutrient enrichment to nearshore areas and decreasing macroalgae blooms through improved stormwater management efforts.'

10. Annual sediment sampling is too frequent – maybe every 5-10 years.

11. Expand program to lakes and large rivers.

12. Implementation: Who should do this work? Where are the Feds, where is the State? (Ecology's response was positive in that regard). Partnership staff commented that 'If the status and trends section retains elements of a more ecosystem-based monitoring program, those elements could be coordinated and administered by the Ecosystem Monitoring Program as it develops. This would allow the SWG to focus on the Source ID and Effectiveness monitoring elements. Make sure all three are directly linked.'

13. SWG should identify what a prioritized, scaled-back option for status and trends monitoring in case funding is problematic. (Is it too late, or is this feasible?)

14. Sequencing: Due to the extensive need for coordination and synthesis of data at a regional level associated with the status and trends monitoring, the formation/identification of an independent monitoring institution is essential for successful implementation and to achieve meaningful results. Until institution identified and supported, status and trends monitoring should not be undertaken.

Topic 6: Source Identification and Diagnostic Monitoring Roles and Implementation

1. Prioritization of problems by WRIA: Prioritization by WRIA is not compatible with the NPDES municipal permits, which are not watershed based. The current recommendation is problematic because not all jurisdictions may participate at the same level of commitment. Each jurisdiction should prioritize problems.
2. Linking source identification and diagnostic monitoring to status and trends ambient monitoring: The link with status and trends to source identification is problematic because status and trends uses a probabilistic design. Status and trends will miss water bodies in many smaller jurisdictions and not provide information for source identification. There may be better ways to link receiving water problems with source identification, such as in-line sediment monitoring, to find source problem areas.
3. Source ID on the regional scale and the local scale: Replicating successful programs is a good idea and there needs to be more clarity on what's local and what's regional.
4. Monitoring should include counting management activities: Assessment of source control activities and results can inform the benefits of stormwater management actions locally and regionally.
5. Source identification relationship to Illicit Discharge Detection and Elimination (IDDE) and Total Maximum Daily Loads (TMDLs); how to link with the permit: There is confusion regarding the roles of IDDE and TMDLs.
6. Funding: Jurisdiction funding vs. pay-in option for source identification: there should be more emphasis on source identification either in the permit or the pay-in option. Jurisdictions should be responsible for fixing identified sources, and

funding and implementing the source identification and diagnostic monitoring program.

Topic 7: Focus and Process for Selecting and Implementing Effectiveness Studies

1. Process to identify and prioritize effectiveness studies is not well defined. Beef up implementation section -this is where initial efforts should go, not status and trends- stakeholders are disappointed in progress to date. Consider what can get accomplished by October. Process for submitted proposals, guidance and criteria needed.
   a. Consider the current program effectiveness monitoring requirements in the Phase I permit. This program is acceptable; there is no need to replace it with a proposal from the SWG.
   b. Criteria for selecting effectiveness studies— specific comments:
      i. Item c. is confusing-should state that all prioritized topics for effectiveness studies are covered.
      ii. Item d. should expanded to include protecting beneficial uses, not just restoration.
      iii. Item e. is narrow, only for NPDES, will need to rewrite whole section when agricultural and industrial issues addressed, so broaden this out.
      iv. Eliminate reference to preference for projects that generate results within X years. It is impossible to evaluate impact of practices in one permit term, so do not tie to permit term.
      v. Add criteria of transferability.
      vi. Who defines important threats or impacts? Let permittees do it?
   c. Concern with caucus-based process determining direction of permit program.
   d. Comments on Topics: Retrofit good focus area, done at all scales. Non-structural BMPS (education and outreach, maintenance optimization, business inspection effectiveness) should be emphasized, and prioritized on a regional scale. Non-structural should be priority for effectiveness research. Low benefit of testing BMPs by SWG—already done by Ecology. Agriculture and forestry impacts important, but should not be addressed here.
   e. Provide examples of programmatic approaches and NPDES provisions that might be monitored
2. Identify feedback loops for management decisions. Agree with effectiveness as part of adaptive management, but if status and trends is random and not tied to problems, how is a connection possible?

3. The proposed cost estimates for effectiveness studies are too low; double them.
4. A timeline for all proposed actions should be included.
5. Need a national program for BMP effectiveness.