Puget Sound Partnership – Setting Targets for Pressure Reductions
Technical Memorandum

Pressure: Runoff from the Built Environment

Author: Bruce Wulkan, Puget Sound Partnership
Project participants/Document reviewers: Alison Butcher (Master Builders Association of King and Snohomish counties); Julie Lowe (Washington State Department of Ecology); Chris May (Kitsap County); Doug Navetski (King County); John Palmer (U.S. EPA Region 10); Dave Peeler, (People for Puget Sound); Tom Putnam (Puget Soundkeeper Alliance); Larry Schaffner (Washington State Department of Transportation); Jim Simmonds (King County); Naki Stevens (Washington State Department of Natural Resources); Chris Wilke (Puget Soundkeeper Alliance)

Project Support: Nick Salafsky, Foundations of Success and Kari Stiles, Jones and Jones.


1. Introduction

To guide recovery efforts and to assess progress toward recovery, the Partnership will adopt ecosystem recovery targets for its Dashboard of ecosystem indicators and for reductions in key ecosystem pressures as a key element of the 2011 revision of the Action Agenda. These targets will describe desired conditions for the year 2020 for specific aspects of the Puget Sound ecosystem. The Partnership’s ecosystem recovery targets will be policy statements that reflect scientific understandings of the ecosystem and the region’s commitments to and expectations for recovery by 2020.

In early 2011, Partnership staff convened teams to assess the scientific knowledge, assumptions, and uncertainties and develop technical background information to guide the Partnership’s policy discussions and decisions about desired future conditions for the Puget Sound ecosystem. This document summarizes the technical background information available to initiate the Partnership’s discussions of targets for Runoff from the Built Environment. The team convened to develop this document was commissioned to develop information on possible objectives and indicators related to the Partnership’s concerns about and interests in the pressures associated with runoff from the built environment. Three other teams were convened to develop similar information and technical memos regarding land development, wastewater, and nearshore restoration and shoreline alteration.

The Partnership staff-convened teams were asked to build from prior work, especially that developed in “Using Results Chains to Develop Objectives and Performance Measures for the 2008 Action Agenda” (Neuman et al., 2009), the comments on the objectives and results chains presented in the 2009 Results Chains technical memorandum, and the Puget Sound Science Update. Other materials that served as the basis for the information presented in this document are introduced in the methods and approach section below.
2. Methods/Approach

Staff from the Puget Sound Partnership convened a small group of regional technical and policy specialists in this field to meet to discuss and develop information for this technical memo – Runoff from the Built Environment. Specialists were invited from numerous stakeholder groups, including business; local, state and federal agencies; environmental organizations; and tribes. The group, for the purpose of this work, was termed the “Interdisciplinary Team for Runoff from the Built Environment” (Team).

Participants from business; local, state and federal agencies; and environmental organizations participated at three half-day meetings during February and March 2011 (see list of participants above). The meetings were held February 4, 2011 at Center for Urban Waters, Tacoma; February 24, 2011 via telephone; and March 10, 2011 at Center for Urban Waters, Tacoma.

The purpose of the meetings was to discuss and develop information regarding: 1) Candidate objectives (i.e., desired future conditions) with indicators that could be tracked to provide meaningful feedback regarding our region’s progress at reducing harm from runoff from the built environment; and 2) Development of a conceptual model to serve as a tool to track progress in completing key management actions and strategies aimed at reducing harm from runoff from the built environment.

The Team’s primary goal was to identify and describe candidate objectives related to runoff from the built environment. All objectives developed were to have numeric targets associated with them with a target date of 2020. The Team was encouraged to offer options (or ranges) for numeric targets. This work forms the basis for this draft technical memorandum, which was due March 23, 2011.

The Team’s scope was limited to runoff from the built environment, or “urban runoff”. This includes runoff from developed lands (residential, commercial, industrial and municipal). Due to the very short time frame, the Team’s assignment did not include developing objectives related to rural runoff (e.g., commercial agriculture and forestry). The Team’s assignment also did not involve developing objectives related to where development occurs, as that task is assigned to the Land Development pressure reduction work group.

The Team’s geographic focus mirrored that of the Puget Sound Partnership’s: the marine waters of Puget Sound and the freshwater that drains to those marine waters.

Due to the short time frame, the Team primarily concentrated on #1 above (developing candidate objectives with numeric targets). If the Team had been given more time, supporting documentation on the candidate objectives and the conceptual model would have been more fully discussed and developed.

All meetings were facilitated by Partnership staff (Bruce Wulkan). Staff from Foundations of Success and Jones and Jones helped strategize the project’s steps, develop meeting agendas, and participated at one meeting.

A Google project site was developed to share working documents with the Team: https://sites.google.com/site/psppressurereductionworkgroups/home/wg1-runoff-from-the-built-environment. The Google site contains a list of Team members, a project timeline with milestones, meeting agendas, working documents, and background documents.
At meeting #1 The Team was introduced to the project, the timeline and a draft conceptual model. The meeting also allowed time to begin discussing candidate objectives. During meeting #2 the Team brainstormed a list of potential candidate objectives and inserted the objectives into the draft conceptual model. At meeting #3 the Team narrowed the list of candidate objectives (to no more than 6) and provided supporting information for the objectives on the Team’s short list.

Following meeting #3, Bruce Wulkan, as author for this technical memorandum, developed a draft for the Team to review and comment on, revised the draft memo based on comments, and delivered the draft technical memorandum to Scott Redman, overall project lead, on March 23, 2011.

Notes:
1. As the Team only had one meeting to discuss the numeric targets described in this memo, these numeric targets are offered as a starting point to launch more extensive conversations on the subject.
2. Due to the short timeline and limited process allowed for this project, the Team wishes to be recognized as participants in this project and reviewers of this draft technical memorandum, and not co-authors of this technical memorandum.

3. Results

Overview:
Runoff from the built environment, or “urban runoff”, if not adequately managed, is generally viewed as creating two primary problems: Those related to altered surface flows and those related to delivering pollutants to receiving waters.

Regarding altered surface flows, during wetter months, urban runoff, if not adequately managed, can cause flooding, property and infrastructure damage, alteration and harm to stream channels and fish and wildlife habitat, and indirect and direct harm to aquatic species. Conversely, because development leads to increased impervious surfaces, rainfall cannot infiltrate to the ground as it did under natural conditions, leading to lower in-stream flows in streams and rivers during the dry season. Both the higher flows during wet weather conditions and the lower flows during the dryer months can cause severe problems for aquatic resources, including salmonids. Rapidly changing hydroperiods due to development and urban runoff can also severely harm wetland ecosystems as well.

Untreated urban runoff can carry an assortment of pollutants over impervious surfaces and through natural and human-made conveyances to streams, rivers and eventually Puget Sound. Types and concentrations of pollutants carried by urban runoff are highly variable due to land use, intensity and duration of storm, seasonality, and other factors. Pollutants can include sediment, bacteria, nutrients, metals, petroleum products, and other toxicants. Surface runoff is the main pathway for toxic chemicals getting into Puget Sound (Ecology, 2010).

Unmitigated urban runoff affects smaller receiving waters, such as streams, creeks and wetlands, differently than it does larger rivers and marine waters. In the former, flow is often the primary agent of alteration and harm whereas in larger rivers and marine waters pollutants are often the leading agent of alteration and harm.
Unmitigated urban runoff affects and harms ecological components (such as salmonids), can pose risks to human health (e.g., fish consumption, contact recreation, or groundwater contamination), and can affect local businesses and traditions (such as shellfish harvest). In addition, there are key management strategies or actions that must take place in order to reduce impacts to receiving waters from the above-described harms.

In recognition of these complexities, the Team’s candidate objectives fall into three categories, discussed in detail below: Subtopic 1: Objectives related to Ecological Components; Subtopic 2: Objectives related to Human Health/Well Being; and Subtopic 3: Objectives related to Management Activities.

Recommended objectives and indicators for Subtopic 1: Ecological Components

Objective 1: Restore flows in small streams. By 2020 20%, or 35%, or 50% of 2nd and 3rd order (wadeable) streams within urban growth areas (UGAs) that are monitored exhibit flows closer to natural conditions.

a. Description: Of all 2nd and 3rd order wadeable streams within UGAs being monitored, some percentage target (20%, 35% or 50%) would, by 2020, exhibit flows closer to natural conditions. A series of metrics could be selected that, when combined, result in an overall numeric score (e.g., high pulse count, high pulse range, TQ Mean, and/or other key metrics).

b. Rationale: Urban runoff, if not adequately managed, results in higher wet season flows in smaller streams and creeks. Larger rivers are not as affected due to higher base flows. Due to reduced infiltration, urbanization, if not adequately mitigated, results in lower stream flows in dryer months. Current stormwater flow control standards require that new development controls flow so that downstream receiving waters, especially smaller creeks and streams, are not adversely affected from high flow scouring. Existing stormwater infrastructure is retrofitted, and upgraded, for many reasons, one of which is the improved protection and/or restoration of smaller urban creeks and streams, many of which support salmon runs. Monitoring smaller, wadeable streams (2nd and 3rd order) to assess the extent to which the streams are, over time, exhibiting flows closer to conditions that existed prior to development will evaluate the effectiveness of our stormwater management flow controls for new development and redevelopment, and if we are addressing (and upgrading) existing development to restore already-degraded streams.

c. Evaluation: Currently, numerous local governments and the U.S. Geologic Service (USGS) maintain stream flow gauges, and there is significant data. However, current data is not necessarily compatible, and most of it has not been amassed, synthesized and interpreted. Most of USGS’s stations are on large rivers. A new mechanism and additional effort would be needed to pull together and synthesize this data. King County reports the results of “stream flashiness” in 20 streams as an environmental indicator on an annual basis (King County, 2011). Regional research has identified several flow metrics (i.e., hydrologic indicators) that correlate well with level of urbanization and biological health in small streams, as measured by BIBI (DeGasperi et al, 2009). The Stormwater Work Group (SWG), charged with developing a coordinated stormwater monitoring program for Puget Sound, recommends monitoring flow in small streams (Puget Sound Stormwater Work Group, 2010). While valuable as a candidate objective,
and while work has been done with this indicator, further work would be required before we could begin tracking and reporting on this objective.

d. Program and policy relevance: Overall, there should be little effect on our regional policy for new development. Currently, new development in most urban areas of western Washington is required to control flow durations to natural land cover conditions for a wide range of storm events. (This is true for all new development in areas under National Pollutant Discharge Elimination System (NPDES) stormwater permits, which cover most urban areas around Puget Sound.) This flow control standard, coupled with proposed new requirements to use low impact development (LID) where feasible (which is expected to be in the next round of municipal permits in 2012), is intended to protect wadeable streams (Ecology, 2011). However, not all of the region’s land area and urban growth areas are covered by permit; therefore, it is unknown whether new development in those unpermitted areas would adversely affect 2nd and 3rd order streams monitored.

There is significant policy relevance for existing development. Most development in the region occurred prior to the use of our current flow control standard; therefore, a significant new effort to upgrade this existing development would need to occur in tandem with adopting this as an objective and target, especially the higher range of the numeric target (35% or 50%). Infrastructure upgrades would likely need to occur through redevelopment policies (enacted when an existing development is significantly added to or changed) and through stand-alone retrofits. In addition to technical considerations, such an effort could be extremely expensive and resource intensive – a recent assessment estimated the cost to retrofit development in the basin prior to 1992 (through stand-alone retrofits) at $3 – $15 billion (Parametrix, 2010). (Note: This assessment accounted for treatment only – not flow control, which would be needed for this objective and can result in higher implementation costs – and did not account for additional land acquisition costs to locate the stormwater facilities. It also did not take into account the albeit limited retrofits that have already occurred over the last 5-10 years.)

There are significant implications for stormwater maintenance activities. One of the largest costs for municipalities is regular inspection and maintenance of stormwater facilities. Maintenance preserves the ability of the facilities to normalize flows. Changes in these activities (increase or decrease) should translate into changes in streamflows.

**Objective 2: Restore biological health of small streams.** By 2020, 20%, or 35%, or 50% of all 2nd and 3rd order (wadeable) streams monitored within UGAs show improved BIBI scores to the point where they are rated in a higher (healthier) category.

a. Description: Of all 2nd and 3rd order wadeable streams within UGAs being monitored, the BIBI score for (20%, or 35% or 50%) of these streams would, by 2020, improve to a point where the score progresses to a higher category. For example, if 20% were chosen, then by 2020 20% of all 2nd and 3rd order streams monitored within UGAs would have improved BIBI scores sufficient that they are moved into a higher category (e.g., Poor to fair; or fair to good; or good to excellent). BIBI refers to the Benthic Index of Biotic Integrity. BIBI measures the abundance and types of benthic macroinvertebrates found in streams. The target would be a net increase in score “upgrades,” similar to the target adopted recently by the Leadership Council for commercial shellfish bed upgrades.
b. Rationale: Originally developed by James Karr and others in the 1980s, the Puget Sound Lowland BIBI was developed from data on stream benthic macroinvertebrates that were calibrated to conditions of our region. Benthic macroinvertebrates are viewed as valuable indicators of watershed health due to their limited mobility, use of streambeds for habitat, ease of collection, and response to changes in stormwater flows, water quality and habitat. Various metrics can be used to represent benthic macroinvertebrate health in streams. The Puget Sound lowland BIBI integrates 10 different metrics to derive a score between 10 and 50 that represents the general health of the stream (King County, 2009). By measuring the BIBI of smaller streams in the region, one can relatively quickly and accurately identify the level with which development and urban runoff (flow and water quality) is affecting and harming the biological health of those streams.

c. Evaluation: Data is available for this objective and target. King County is leading an effort to assemble BIBI data into a single database. Currently, 21 agencies from around the Puget Sound basin, including the Department of Ecology, are participating. The approach uses 10 metrics to compile scores across 3 categories, then the scores are combined to create one score for the stream being assessed. A score of 10-16 is considered very poor; 18-26 is considered poor; 28-36 is considered fair; 38-44 is considered good; and 46-50 is considered excellent (Puget Sound Stream Benthos, 2011). The database holds results from 2,486 stream benthos samples (Simmonds, 2011). The SWG recommends monitoring macroinvertebrates in small streams (Puget Sound Stormwater Work Group, 2010). There is significant citizen monitoring of BIBI in many counties around Puget Sound, resulting in good potential for increasing data sets in the future and use of this objective as a readily available public education and involvement tool.

Program and policy relevance: Overall, there should be little effect on our regional policy for new development. Currently, new development in most urban areas of western Washington is required to control flow durations to natural conditions for a wide range of storm events. (This is true for all new development in areas under federally mandated, state-issued National Pollutant Discharge Elimination System (NPDES) stormwater permits, which cover most urban areas around Puget Sound.) This flow control standard, coupled with current treatment standards and new proposed requirements to use LID where feasible (which is expected to be in the next round of municipal permits in 2012) is intended to protect smaller streams and biota using the streams (Ecology, 2011). However, not all of the region’s land area and urban growth areas are covered by permit; therefore, it is unknown whether new development in those unpermitted areas would adversely affect macro-invertebrate populations in 2nd and 3rd order streams monitored.

There is significant policy relevance for existing development. Most development in the region occurred prior to the use of our current flow control and treatment standards; therefore, a significant new effort to upgrade this existing development would need to occur in tandem with adopting this as an objective and target, especially the higher numeric ranges of the objective (35% or 50%). Infrastructure upgrades would likely need to occur through redevelopment policies (enacted when an existing development is significantly added to or changed) and through stand-alone retrofits. In addition to technical considerations, such an effort could be extremely expensive and resource intensive – a recent assessment estimated the cost to retrofit development in the basin prior to 1992 (through stand-alone retrofits) at $3 – $15 billion (Parametrix, 2010). (Note: This assessment accounted for treatment only – not flow control, which would be needed for this target and can result in higher implementation costs – and did
not account for additional land acquisition costs to site the stormwater facilities. It also did not take into account the albeit limited retrofits that have already occurred over the last 5-10 years.)

There are significant implications for stormwater maintenance and source control activities. One of the largest costs for municipalities is regular inspection and maintenance as well as source control activities to minimize the discharge of pollutants into systems. Maintenance preserves the ability of the current flow control and treatment facilities to normalize flows and reduce pollutant discharges into the receiving waters. Changes in these programs (increase or decrease) should translate into changes in macroinvertebrate populations. Source control programs result in a reduction of pollutants carried to receiving waters and changes in these programs (increase or decrease) should translate into changes in macroinvertebrate populations.

**Objective 3: Prevent salmon pre-spawn mortality. By 2020, there is a 50%, or 75%, or 100% reduction in pre-spawn mortality above natural levels in streams or creeks in urban growth areas.**

a. Description: For urban streams monitored, by 2020 there will be a 50%, or 75%, or 100% reduction in the incidences of pre-spawn mortality of salmon in the streams above estimated natural levels. Pre-spawn mortality refers to the urban stormwater-related premature death of otherwise healthy female Coho salmon in urban creeks and streams prior to their digging redds and depositing eggs.

b. Rationale: In the late 1990s the National Ocean and Atmospheric Administration (NOAA) researchers discovered dead female salmonids in Seattle-area urban streams that still had eggs in their bellies. These urban streams had undergone restoration to revive salmonid runs and habitat had been restored. NOAA then began tracking this phenomenon in 2002 and has several years of data for 5 Seattle-area urban streams and 1 rural control stream. Researchers have observed a variety of erratic behavior in the salmonids (Coho and chum) such as disorientation, lethargy, fin-splaying, and gaping, followed within hours of death. The dying salmon appear otherwise healthy. Pre-spawn mortality rates are extremely high in urban streams (67-100%) vs. the rural stream (<1%) (McCarthy et al, 2008). Urban runoff is strongly implicated by NOAA researchers yet it is not yet known what in the stormwater is causing the die-offs. NOAA is tracking pre-spawn mortality in relation to the timing and intensity of rain events (NOAA, 2011).

c. Evaluation: There is strong evidence that in central Puget Sound urban streams studied there are very high rates of pre-spawn mortality whereas in the rural control stream there is very little pre-spawn mortality (McCarthy et al, 2008). The urban streams have been restored and fish barriers have been removed, in-stream improvements have occurred, and riparian habitat has been planted. Because the surrounding land use is densely developed residential and commercial, the connection to urban runoff appears very clear. The number of urban streams studied thus far appears limited (5). NOAA, along with area partners, continues to study this phenomenon and has several years of data. NOAA is trying to determine exactly what in the stormwater is causing the die-offs. NOAA is also trying to draw better connections to land use so our region can begin to forecast the potential for pre-spawn mortality across urbanized and urbanizing basins around Puget Sound.

Program and policy relevance: Overall, there should be little effect on our regional policy for new development. Currently, new development in most urban areas of western Washington is
required to control flow durations to natural conditions for a wide range of storm events. (This is true for all new development in areas under National Pollutant Discharge Elimination System (NPDES) stormwater permits, which cover most urban areas around Puget Sound.) This flow control standard, coupled with current treatment standards and proposed new requirements to use LID where feasible (which is expected to be in the next round of municipal permits in 2012) is intended to protect salmon-bearing streams (Ecology, 2011). However, not all of the region’s land area and urban growth areas are covered by permit; therefore, it is unknown whether new development in those unpermitted areas would adversely affect returning salmon.

There is significant policy relevance for existing development. Most development in the region occurred prior to the use of our current flow control and treatment standards; therefore, a significant new effort to upgrade this existing development would need to occur in tandem with adopting this as a target. Infrastructure upgrades would likely need to occur through redevelopment policies (enacted when an existing development is significantly added to or changed) and through stand-alone retrofits. In addition to technical considerations, such an effort could be extremely expensive and resource intensive – a recent assessment estimated the cost to retrofit development in the basin prior to 1992 (through stand-alone retrofits) at $3 – $15 billion (Parametric, 2010). (Note: This assessment accounted for treatment only – not flow control, which would likely be needed to meet this objective and can result in higher implementation costs – and did not account for additional land acquisition costs to site the stormwater facilities. It also did not take into account the albeit limited retrofits that have already occurred over the last 5-10 years.) Where structural upgrades are not made (either due to technical limitations, lack of funding, lack of redevelopment activity or another factor), significant new source control would likely be needed to reduce discharges of toxicants to the salmon-bearing streams.

There are significant implications for stormwater maintenance and source control activities. One of the largest costs for municipalities is regular inspection and maintenance as well as source control activities to minimize the discharge of pollutants into systems. Maintenance preserves the ability of the current flow control and treatment facilities to normalize flows and reduce pollutant discharges into the receiving waters. Changes in these programs (increase or decrease) should translate into changes in greater or lower level of protection for salmonids in urban streams. Source control programs result in a reduction of pollutants carried to receiving waters and changes in these programs (increase or decrease) should translate into similar changes in level of protection.

Recommended objective and indicator for subtopic 2: Human Health/Well Being

Objective 4: Prevent contact recreational advisories and shellfish restrictions. By 2020 there are no contact recreational advisories or shellfish restrictions within UGAs caused by urban stormwater runoff.

a. Description: Local governments post advisories for contact recreation in freshwater and marine waters due to monitoring results showing high counts of fecal coliform bacteria. The state Department of Health (DOH) classifies commercial and recreational shellfish growing areas according to monitoring that tracks counts of fecal coliform bacteria. This objective would mean that for both of these beneficial uses, by 2020 there would be no contact recreation advisories
or shellfish restrictions within UGAs caused by urban runoff.

b. Rationale: Both of the restrictions on the above-listed beneficial uses are caused by the presence of human and/or animal waste in the water (as measured by the indicator, fecal coliform bacteria). Unmitigated urban runoff, while highly variable, can carry high numbers of fecal coliform bacteria (Glaseo and Christy, 2005). High fecal counts in urban runoff have closed shellfish harvest beaches and led to health advisories for contact recreation in our region. To meet this objective urban runoff would need to be adequately treated for bacteria prior to discharge to fresh and marine waters.

c. Evaluation: There is strong evidence that urban runoff, though variable, can carry sufficiently high concentrations of bacteria to lead to contact advisories and shellfish bed closures. Increasingly, DOH states that urban runoff (rather than other sources) restricts harvest at many areas, especially as the Puget Sound region develops more land under population pressures (Woolrich, 2011). There is therefore a strong connection between urban runoff and this objective. There is ample monitoring data showing when and where contact advisories occur as well as data and staff analysis showing where and when shellfish harvest restrictions occur due to urban runoff. DOH has for several years now listed the 5-6 shellfish growing areas that they believe are primarily degraded due to urban runoff (vs. other sources). However, this objective is not entirely consistent with the target already adopted by the Leadership Council for shellfish harvest, which calls for a net increase in commercial shellfish acreage available for harvest.

d. Program and policy relevance: Because our region’s treatment standard is for total suspended solids removal and not for bacteria removal, there could be significant implications for our region’s policy for new and existing development. Other than source control measures, few Ecology-approved BMPs exist to remove bacteria in urban runoff. Where areas are covered by NPDES stormwater permits, there should be less significant effect on our regional policy for new development. New development in areas covered by permits will need to require LID where feasible (proposed for the 2012 municipal permits) (Ecology, 2011). Using the LID approach and techniques should help significantly reduce storm volumes released, which will help reduce pollutant volumes released, including bacteria. Areas covered by stormwater permits are also required to implement programs (e.g., maintenance, illicit discharge elimination) that should contribute to the reduction of bacteria loadings to surface waters. However, while these permits cover most urban areas around Puget Sound, they do not cover all urban areas and urban growth areas. For urban areas not covered by permit, it is unknown whether new development would hinder our region’s ability to meet this objective. Further, federal and state policy and rules regarding safe shellfish harvest are extremely strict – it may prove very difficult to meet this objective that there be NO shellfish harvest restrictions in urban areas, especially as population (and impervious surfaces) are expected to increase in designated urban growth areas.

There is significant policy relevance for existing development. Most development in the region occurred prior to the use of our current flow control and treatment standards; therefore, a significant new effort to upgrade this existing development would need to occur in tandem with adopting this as an objective and target. Infrastructure upgrades would likely need to occur through redevelopment policies (enacted when an existing development is significantly added to or changed) and through stand-alone retrofits. In addition to technical considerations (e.g., the lack of BMPs approved for treatment of bacteria), such an effort could be extremely
expensive and resource intensive – a recent assessment estimated the cost to retrofit development in the basin prior to 1992 (through stand-alone retrofits) at $3 – $15 billion (Parametrix, 2010). (Note: This assessment did not account for additional land acquisition costs to site stormwater facilities. It also did not take into account the albeit limited retrofits that have already occurred over the last 5-10 years.)

Recommended objectives and indicators for subtopic 3: Management Activities

**Objective 5: Upgrade inadequate infrastructure. By 2020, high priority sites equaling 5%, or 10%, or 20%, of acres of impervious area built prior to 1992 are retrofitted or redeveloped with current level stormwater controls for treatment, and flow control where applicable.**

a. **Description:** Satellite imagery would be used to depict and map urban development and impervious surfaces existing prior to 1992. These acres of impervious area are presumed to need retrofitting, as they would have been developed prior to the advent of today’s generation of flow control and treatment standards. Some percentage (5%, 10% or 20%) of those total acres of impervious surface would be prioritized for upgrade and strategically retrofitted for treatment, and flow control where applicable. Large rivers and Puget Sound are exempt from flow control requirements. Also, basins that are 40% impervious or greater for at least 20 years are exempt from the native land cover flow control standard, and instead use existing land condition (Ecology, 2011.) By 2020, 5%, or 10%, or 20%, of that total area of impervious surface area would be retrofitted to today’s standards for treatment, and flow control where applicable.

b. **Rationale:** Current treatment standards aim to remove 80% total suspended solids from stormwater before discharging. Many pollutants of concern adhere to sediment; therefore, capturing the sediment (or suspended solids) removes those pollutants. Enhanced treatment (i.e., additional treatment to remove dissolved metals) is required where runoff drains from a land use that is suspected of discharging more dissolved metals (e.g., roads above a certain annual average daily traffic, multi-family homes, commercial development, and industrial sites) to fish-bearing streams or lakes (Ecology, 2005). These treatment standards are designed to protect water and sediment quality, environmental resources and other beneficial uses. Development prior to the early 1990s did not have this level of control; therefore, unless it’s been already retrofit, it is presumed to be discharging untreated or undertreated urban runoff to Puget Sound. This untreated or undertreated runoff is a leading factor behind the Puget Sound Action Agenda, U.S. EPA and many other sources calling urban runoff the biggest threat to the health of the nation’s waters, including Puget Sound (Puget Sound Partnership, 2008).

Current flow control standards require that the flow duration be controlled over a wide range of storms to meet historical land cover conditions. This flow control standard is designed to protect fish-bearing streams and wetlands from high, frequent, long-lasting wet weather storm flows. Development prior to the early 1990s was often built with flood control techniques designed to minimize flooding and property damage. The older development, unless already retrofitted, is likely discharging unmanaged, or undermanaged flows that continue to degrade fish-bearing stream channels and wetlands, and harm aquatic species, including salmonids.

c. **Evaluation:** A strategic retrofitting of outdated stormwater infrastructure is likely needed to meet several recovery goals for Puget Sound, including the Ecological and Human Health...
objectives listed here (objectives 1 - 4). Stormwater, if not properly treated, typically contains a variety of pollutants that harm Puget Sound’s resources, lower our quality of life, and cost jobs. Some infrastructure need only be retrofitted to provide treatment; other infrastructure, whose flows are adversely affecting receiving waters, would also need to be retrofit for flow control as well. The impervious surface area built prior to 1992 has already been mapped and documented (Parametrix, 2010). Choosing 1992 is not precise in that some development through the 1990s was built to older standards due to vesting laws and the speed with which updated, current stormwater controls were adopted and used by local governments (Tucker, 2011).

d. Program and policy relevance: There is significant policy relevance for existing development. The issue becomes one of funding and prioritization, as the estimated total cost to retrofit the impervious surfaces of Puget Sound built prior to 1992 (through stand-alone retrofits) at $3 – $15 billion (Parametrix, 2010). The range reflects how much impervious surface area is retrofitted. (Note: This estimate was to provide treatment only – not flow control – and land acquisition costs to site stormwater facilities were not included. Therefore, the total cost is likely higher.) If the 10% target for this objective were chosen, then the estimated cost to meet this target would be approximately $300 million - $1.5 billion (plus land acquisition costs, where applicable). The region is also in the process of developing a more strategic method to prioritize funding for upgrading stormwater infrastructure. Projects such as King County’s Stormwater Retrofit Planning Project for the Green River Watershed, the Department of Ecology’s Watershed Characterization Study, and the Department of Transportation’s (WSDOT) retrofit prioritization efforts are three examples of such projects designed to improve our ability to prioritize retrofit projects across the region and make strategic investments. The NPDES municipal stormwater phase I permit currently requires retrofit planning but no level of effort is stipulated in the permit. The NPDES municipal stormwater phase II permit contains no requirement for retrofitting. In order to meet this objective, some increased level of retrofitting requirements in the stormwater permits is likely necessary in concert with significant new financial assistance for permittees and other local governments not covered by permit. In addition to stand-alone retrofits, significant upgrading of existing stormwater infrastructure could occur through redevelopment policies (enacted when an existing development is significantly changed or added to). A regional system to track implementation of stormwater retrofits currently does not exist and would need to be established in order to track progress on this objective.

**Objective 6: Maintain infrastructure.** By 2020, 90%, or 100%, of public and private stormwater facilities are regularly maintained to function to engineering design standards.

a. Description: Of all stormwater facilities built and in use, a certain percentage (90% or 100%) would be regularly maintained, as defined by annually inspected and corrected as needed, so that the facility functions and performs as designed.

b. Rationale: Stormwater facilities for flow control and treatment are designed to function and perform to a certain performance level. According to the U.S. EPA, the effectiveness of post-construction stormwater control best management practices depends upon regular maintenance of the control measures (U.S. EPA, 2011). Failure to regularly inspect and maintain stormwater facilities can lead to the facility underperforming or outright failing, which can cause a host of problems, including: a decrease in pollutant removal efficiency, an actual increase in pollutants generated and exported, flooding of downstream property, adverse effects on jobs
and local economies, costly cleanup efforts, and lost recreational access. For these factors, the NPDES stormwater permits for municipalities and WSDOT currently require permittees to regularly inspect and maintain their public stormwater systems.

c. Evaluation: The connection between inspecting and maintaining stormwater facilities and reducing harms from urban runoff is well established. Existing permits require activities of inspecting and maintaining, tracking these activities, and reporting on them to the Department of Ecology. Setting an objective of a high percentage of facilities being regularly inspected and maintained appears to be an effective action that should be attainable provided there are sufficient resources available.

d. Program and policy relevance: Municipal permittees and WSDOT have found that inspection and maintenance activities are very resource intensive, and they struggle for adequate resources to meet this permit condition. One reason is the sheer number of facilities and catch basins under their jurisdiction. For example, WSDOT estimates that there are approximately 30,000 catch basins and 1,893 other stormwater control devices within its permit coverage area. Retaining sufficient resources and staff to inspect and maintain those on an annual basis is very difficult. WSDOT recently requested approximately $21 million from the state legislature – 71% of that additional increase is for inspection and maintenance (JLARC, 2011). Much of that is due to increased maintenance requirements in the permit and increased scope of permit coverage area --- in its current stormwater permit WSDOT has a lot more area under permit than before and therefore a lot more stormwater facilities to maintain. Municipal permittees recently reported that on average approximately 35% of their stormwater permit-related budgets are directed to inspection and maintenance activities (Parametrix, 2010). Regular inspections and maintenance of stormwater facilities is, in sum, essential yet costly. Because of these factors, if this objective were adopted as a target there would likely need to be an examination of additional resources needed and options for meeting this need.

4. Discussion

Prioritization of recommended objectives:
The Team struggled with several aspects of this work. One aspect related to which types of objectives to recommend: Ecological (those relating to the receiving environment); human health/well being; or management-related. Stormwater managers in the region have shown increasing interest in tracking the effects of urban runoff on biological communities in receiving waters (Puget Sound Stormwater Work Group, 2010). By tracking the response of environmental indicators whose health is tied to the effects of stormwater runoff, stormwater managers and other decision makers can receive more direct feedback on their management actions than through other means, such as sampling chemistry of stormwater discharges.

For this primary reason, the Team prioritizes the first 3 objectives (flows in 2nd and 3rd order streams, BIBI in 2nd and 3rd order streams, and pre-spawn mortality). Each of these ecological objectives would, in the opinion of the Team, serve as good indicators reflecting our region’s relative success in reducing the harms from runoff from the built environment. For each, an objective could be adopted as a target that would serve as a desired future state by 2020. For each, there is current and planned monitoring, available data, and transferability across the region. Public understand of each varies, with perhaps the
most understandable being pre-spawn mortality, followed by BIBI (due to the amount of citizen monitoring around BIBI).

At the same time, the Team recognizes the importance of carrying out and tracking implementation of key strategies and actions necessary to reduce threats posed by urban stormwater discharges and meet ecologically-based objectives. Therefore, in some form (perhaps through the Open Standards Process), the Team hopes that the two objectives related to management actions (retrofitting a percentage of existing development and regularly maintaining a percentage of all stormwater facilities) are embraced and tracked.

Additional objectives considered:
The Team also wrestled with ideas for an additional objective related to new development; specifically, that all new development will occur while still protecting the site’s natural hydrology, and that the watershed’s natural hydrology would be protected as well. This is a very timely and critical discussion, as it relates directly to our region’s (and the nation’s) growing understanding of the limitations of conventional development and stormwater management controls in adequately mitigating for the full range of effects of development, the region’s transition to the LID approach and techniques; recent rulings by the Pollution Control Hearings Board that direct the Department of Ecology to add LID requirements (where feasible) to municipal stormwater NPDES permits; near-term actions in the Puget Sound Action Agenda calling for LID requirements to be added to local codes and standards; and the Department of Ecology’s process to develop LID standards and add them to the next round of permits. There are several reasons why this additional objective was not moved forward: First, the Team, at the urging of the author of this memorandum, tried hard to limit the number of objectives recommended. Second, unlike the other objectives it’s unclear exactly how this would be monitored and tracked. Third, participants, faced with limited time and focused on developing the other objectives, ran short of time.

The Team also discussed in detail several other objectives but ultimately decided to remove them from this “short list,” as they appear to be covered by dashboard of indicators already developed. These include freshwater quality and toxics in sediment. However, the Team wishes to stress to the freshwater quality indicator champion the importance of tracking freshwater quality in 2nd and 3rd order (wadeable) streams, as these receiving waters are more sensitive to inputs from urban runoff than larger streams and rivers. The Team also wishes to stress the importance of tracking the performance of receiving waters in meeting water quality standards. Last, the Team wishes to stress to the indicator champion for toxics in sediment the importance of tracking toxicity in sediments appropriately sited near stormwater outfalls, as these sites are more sensitive to inputs from urban runoff.

Implications, caveats & cautions for policy making:
Selection of any of these candidate objectives, including the prioritized ecological ones, has significant implications for policy, as described above. While the implications for new development are much less significant, they are highly significant for our policy towards existing development, maintenance and source control. Simply put, if we are to reach the objectives suggested in this draft memorandum, there will need to be concurrent, new, significant investments in addressing existing development. Municipal permittees have stressed that short-term the greatest investment should be made in fully implementing NPDES municipal permit programs, especially fully maintaining all stormwater facilities to remove legacy loads (Parametrix, 2010). In conjunction with permit implementation, as stated earlier, several key steps will be needed regarding retrofitting: Development of a new, significant funding source, development of a new stormwater prioritization process for retrofits (as we lack funding to meet the total need), and
likely increased requirements for municipalities in future permits. As stated earlier, the estimate for total need is, at a minimum, $3 - $15 billion.

**Scientific uncertainties:**

**Objective 1:** Flows in 2\(^{nd}\) and 3\(^{rd}\) order streams – We currently do not know all the locations of the stream gauges throughout Puget Sound. The SWG recognizes this, and is in the process of working with USGS to assess their and local government gauges. In addition, if this objective were selected, additional work would be needed to a) characterize the present condition of these streams (i.e., what percentage of these streams are at or approaching “natural conditions?” Our knowledge of the baseline condition is currently lacking; b) make data compatible; c) synthesize and interpret the data; d) define better what is meant by “closer to natural conditions.”

**Objective 2:** BIBI in 2\(^{nd}\) and 3\(^{rd}\) order streams – We have limited data trends for many streams in the region; this may make it difficult to “forecast” the effort needed to improve BIBI scores sufficiently so they move to a healthier category. Further, macroinvertebrates in streams may be slow to respond to management actions.

**Objective 3:** Pre-spawn mortality in 2\(^{nd}\) and 3\(^{rd}\) order streams – We have limited information regarding what specifically is causing this high mortality in salmon. Is it a single contaminant? A synergistic mix? We also have limited technical solutions to completely eliminate urban runoff inputs to these urban streams. How much runoff is allowable? And which management actions will prevent this mortality so we can meet the objective?

**Objective 4:** Contact recreational advisories/shellfish restrictions—The primary sources of fecal coliform bacteria in urban areas include pet waste, failing on-site sewage systems, leaking sewer lines, and wildlife. It is often challenging to separate urban runoff from these other sources. Second, there are limited stormwater treatment technologies for fecal coliform bacteria, once in the system.

**Implications for monitoring:**

Monitoring is occurring for 5 of the 6 objectives included in this memorandum. Monitoring is not currently occurring for Objective 5: Retrofit, and would need to be established. Improvements and additional monitoring would be needed for Objective 1: Flow; Objective 2: BIBI; and Objective 6: Maintenance. It is not known whether additional improvements and/or additional monitoring would be needed for Objective 3: Pre-spawn mortality.

The SWG, in their June 2010 report, recommends several parameters for monitoring in small streams and the marine nearshore. Their recommendations for monitoring flow and macro-invertebrates in small streams have direct relevance to objectives 1 and 2 in this technical memorandum. The SWG, in its October 2010 recommendations to Ecology for monitoring in the reissuance of the municipal stormwater NPDES permits recommends monitoring macroinvertebrates in small streams as part of the status and trends sampling (Puget Sound SWG, 2010). This would provide significant new data starting in years 4 and 5 of the permit (2016-17 if the permit is reissued in 2012), and if this is added to the next round of permits. Flow monitoring in small streams may not occur, depending on the results of an assessment of current streamflow gauges and monitoring.
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