PHASE 1: DEVELOPMENT OF EFFECTIVENESS STUDY QUESTIONS FOR EASTERN WASHINGTON PERMITTEES

Prepared for
City of Spokane Valley
and
Eastern Washington Stormwater Group

Prepared by
Herrera Environmental Consultants, Inc.
Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will copy correctly when duplexed.
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INTRODUCTION

The National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater Permit for Eastern Washington requires that the 18 cities and 6 counties covered under the permit collaborate to “select, propose, develop and conduct” Washington State Department of Ecology (Ecology) approved studies to assess the effectiveness of permit required stormwater management activities. The Eastern Washington Stormwater Group (EWSG) has until June 30, 2016 to develop a ranked list of 12 to 15 effectiveness study ideas. It then have another year to develop detailed study design proposals for 8 to 12 of the top-ranked ideas. As a first step, the permittees agreed to apply for grant funding to provide support for the planning and facilitation associated with preliminary development of up to 15 effectiveness study proposals. The City of Spokane Valley led the grant application and was awarded a Grant of Regional or Statewide Significance (GROSS) from Ecology (Grant #G1400503) to carry out this first study phase (Phase 1). Herrera Environmental Consultants, Inc. (Herrera) was selected to assist the EWSG through this first phase of the process.

As described in more detail below, through a series of meetings and workshops, the EWSG identified, discussed, and defined over 30 study ideas that were eventually pared down to a list of 24. Through a final series of smaller regional meetings, initial preferences were tested and used to informally rank the questions as high, medium, or low. This ranking was very informal and is not final, but does provide an idea of where the EWSG is leaning at this time. There is still work to be done over the next 6 to 9 months before final decisions will be made about which study questions will be carried forward.

This report describes the process followed to identify the effectiveness study questions and develop them into the research proposals. Because there was much discussion during the course of the project about why Eastern Washington in general is dissimilar to many other places where stormwater research is occurring, including Western Washington, the report begins with a summary of some of these differences. The discussion on regional characteristics is followed by a description of the study question development process, then a description of the criteria developed for rating the study questions, and last some information on cost...
allocation models is provided for use in the next phase of the project. The study questions are included in Appendix A. Appendix B contains the more detailed “research proposals” developed for each question. Appendix C contains workshop agendas, sign-in sheets, and workshop summaries. Appendix D contains more detailed research proposals that were prepared for two of the study questions. More in-depth proposals were prepared for these questions due to uncertainty about the level of effort that would be required to complete them and as a means of improving the cost estimates. Appendix E provides a summary of the many collaboration efforts between the Eastern Washington permittees. Although the summary is not directly relevant to the selection of study questions, it is provided as a means of documenting the many efforts of this group.
REGIONAL CHARACTERISTICS

Eastern Washington has a generally semi-arid climate with comparatively cold winters and hot summers. With the relative exception of the Spokane and Tri-Cities areas, it has a very low population density and the small population centers are largely surrounded by ultra-low density rural areas. While these conditions are not unique to the western United States, they are not typical of the characteristics of the areas where most of the stormwater research has focused. Therefore, it follows that stormwater programs and identification of study questions related to the effectiveness of those programs may be different in Eastern Washington.

There is also a wide range in variability within the region. In the Stormwater Management Manual for Eastern Washington (SWMMEW; Ecology 2004), Eastern Washington is subdivided into four climatic regions based almost solely on precipitation patterns (Figure 1), as summarized below.

Region 1 – East Slopes of the Cascade Mountains: This region is composed of mountain areas on the east slopes of the Cascade Mountains. It is bounded to the west by the Cascade crest and to the east by a generalized contour line of 16 inches mean annual precipitation. Region 1 experiences the variability in rain and snowfall typical of mountain slopes. Annual precipitation varies from 92 inches at Stampede Pass to 22 inches in Cle Elum, with a similar range in average winter snowfall of approximately 400 inches near the summit to 75 inches at 2,000 feet. Of the Eastern Washington permittees, only rural parts of Yakima and Chelan counties lie within this region. None of the area covered under the NPDES permit in these two counties lies within Region 1.

Region 2 – Central Basin: The Central Basin region comprises the Columbia Basin and adjacent low-elevation areas in central Washington. It is bounded to the west by the generalized contour line of 16 inches mean annual precipitation that forms the eastern slopes of the Cascade Mountains, and bounded to the north and east by the contour line of 14 inches mean annual precipitation. The average annual precipitation for the entire Central Basin is approximately 8 inches per year. Twelve of the eighteen cities covered by the Eastern Washington permit are located in Region 2, and four of the six counties have some area within this region.
Figure 1. Eastern Washington Climate Regions and the NPDES Municipal Stormwater Permit Areas.

Legend
- Climate region
- Highway
- NPDES city
- NPDES County

Coordinates: NAD 1983 HARN Washington State Plane FIPS South 4402 Feet
K:\Projects\Y2014\14-05823-000\Project\npdes_areas_alt.mxd (6/5/2015)
Region 3 – Okanogan, Spokane, Palouse: This region lies within an inter-mountain area and includes areas near Okanogan, Spokane, and the Palouse. It is bounded to the west by the eastern slopes of the Cascade Mountains and the Central Basin, to the northeast by the Kettle River Range and Selkirk Mountains, and to the southeast by the Blue Mountains. Annual precipitation ranges from approximately 14 to 22 inches in Region 3. Six of the cities covered by the Eastern Washington permit are located in this region and parts of three counties.

Region 4 – Northeastern and Blue Mountains: This region comprises mountain areas in the easternmost part of Washington State. It includes portions of the Kettle River Range and Selkirk Mountains in the northeast, and the Blue Mountains in the southeast corner of Eastern Washington. Mean annual precipitation ranges from a minimum of 22 inches to over 60 inches. The western boundary of Region 4 is a generalized contour line of 22 inches mean annual precipitation. Parts of Asotin County and to a lesser extent Spokane County lie within this region.

Precipitation patterns tell only a small part of the story of differences within the region. During development of the effectiveness study questions, it became apparent that the different jurisdictions face widely different conditions. Therefore, before describing the process used to develop the study questions, it is valuable to first detail some of the underlying conditions and program characteristics that form the framework for stormwater management in Eastern Washington.

Precipitation: While annual precipitation is low throughout Eastern Washington, it varies widely throughout the region and can vary extensively even within just a few miles. What is similar throughout the region is that rain primarily falls during the winter months and that larger rain events are more often short-duration, high-intensity storms that occur during the late spring and summer months. They may create localized flooding; but typically, the flooding lasts only a few hours. While all the communities have some snow most winters, in general it does not last long; days or weeks rather than months. However, frozen ground is a common condition. Therefore, larger runoff events are the high intensity summer time storms and the rain on snow or frozen ground events that occur in the winter.

Groundwater: Groundwater conditions are also variable; in terms of depth and vulnerability to contamination. There are a number of areas in Eastern Washington where seasonal high groundwater occurs during summer and is driven by irrigation rather than being driven by normal patterns of groundwater recharge such as rain and snow.

Soils: In general, Eastern Washington has soils that drain quickly; infiltration rates of 18 inches per hour are not uncommon, but much higher rates also occur. For example, Spokane Valley has infiltration rates as high as 200 inches per hour (A. Jenkins, City of Spokane Valley, personal communication). Under these conditions, natural dispersion of stormwater occurs quickly and easily. Of course, there are pockets where well-drained soils are not the case; this condition is often found near region boundaries, close to side slopes of hills and mountains. Pullman in particular has very poorly drained soils with an infiltration rates of 0.5 to 0.10 inch per hour in the native silt/clay on which most new development is occurring (R. Buchert, City of Pullman, personal communication). The Wenatchee Valley area also has many areas or pockets of poorly drained soils.
Wind: While Eastern Washington in general can be windy, the Tri-Cities area and Ellensburg are known to be particularly windy, albeit for different reasons. What is interesting from a stormwater perspective is that the wind in these two places moves different material. In Ellensburg, it moves very small (dust-size) particles and hay chaff, while in the Tri-Cities, it moves sand-sized particles. Because it is often windy, air deposition of material can be quite high. This affects activities such as street sweeping and catch basin cleaning, the efficacy of permeable pavement, and maintenance needs associated with trash and tumbleweed build up in stormwater facilities.

Stormwater Systems: In some places, such as Spokane, Pullman, and parts of the Wenatchee Valley area, piped conveyance systems convey stormwater to central locations and/or outfalls. Generally, however, natural dispersion and infiltration are the norm. This is especially true in more rural areas. There are also places where springs and perched groundwater are a concern and a few places where many streams course through the urban environment. For example, Ellensburg has 7 streams as well as 5 irrigation systems that flow through the city and Walla Walla has 17 streams. This is unusual in the Central Basin. Comingling of irrigation water with stormwater is also an issue in some jurisdictions.

Other jurisdictions may contend more with drainage ditches and their associated outfalls. For example, the small city of Sunnyside has an estimated 100 outfalls that are essentially drainage ditch discharges. Many Eastern Washington jurisdictions are working toward entirely eliminating outfalls.

Underground injection control (UIC) facilities are commonly used for stormwater control in Eastern Washington, but, again, the extent to which they are used varies widely. The city of Spokane Valley is at the high end of the spectrum with an estimated 7,000 UICs, but even the small cities of Sunnyside, Union Gap, and Selah have as many as 50 UICs each.
Stormwater Programs: Overall, the stormwater programs in Eastern Washington are small with a few full-time equivalent (FTE) staff divided between different city or county departments. Thus, stormwater operations and maintenance staff are often affiliated with the roads department or the wastewater department. This creates its own set of issues related to control and responsibilities. Most of the jurisdictions have an established stormwater utility. A number of jurisdictions have partnered to share stormwater functions.

All this variability within the region equates to significant differences on issues of primary concern to each jurisdiction. Studies of permeable pavement may be of more interest in more urban areas and where air deposition of windblown materials is not as high. Similarly, interest in bioretention is not high in areas where simple infiltration is the most common stormwater treatment technique. Other variables include whether Total Maximum Daily Loads (TMDLs) are in play, whether there is an aquifer to protect, or whether species protected by the Endangered Species Act exist in the area; all are issues that affect the driving issues for individual jurisdictions. These many differences may make it more difficult for the EWSG to coalesce around one group of study questions.
The following section summarizes the process used for developing effectiveness study questions. Essentially, the process included a series of online and in-person meetings as well as three 2-day workshops. These meetings and workshops were well attended, and the level of participation was high for the participants. (Appendix C contains workshop summaries and attendance sheets.)

The process of identifying potential effectiveness study questions began as a requirement in the previous NPDES permit that each permittee list potential effectiveness study questions as part of its annual report. Approximately 32 different questions were identified in the annual reports. In addition, in December 2013, the EWSG held a workshop to begin the process of prioritizing questions listed in the permittees’ annual reports and identifying other topics of interest. In May 2014, a facilitated process of study question development was begun via a 1-day workshop. This workshop began by discussing the proposed approach to the project including the schedule, products, and communications. Other workshop objectives included agreeing on topics of interest for upcoming work sessions and agreeing on five to six study questions each related to street sweeping and public education and outreach to allow the consultant team to move forward with literature reviews associated with those topic areas. A summary of the May 2014 workshop is provided in Appendix C.

A 2-day workshop was held in October 2014. At this workshop, the questions developed at the December 2013 workshop, in addition to those listed in the annual reports, were used to form the initial list of potential questions. Next, each section of the permit was reviewed and discussed as a means of soliciting study ideas related to the specific permit section and to identify other possible topics of interest. Study questions were identified to correspond to the following permit sections:

- Public Education and Outreach
- Illicit Discharge Detection and Elimination
• Construction Site Stormwater Management
• Post Construction Stormwater Management
• Operations and Maintenance
• Monitoring and Assessment
• Record Keeping and Reporting

As a result of this workshop, a series of 16 topics of interest were identified. In the following months, each of the topics were written as effectiveness study questions; these were then refined through literature searches and conversations with subject experts to lay out a conceptual study approach for answering the questions. Conceptual level studies were reviewed and refined with the EWSG through a series of conference calls and meetings. As conceptual level studies were approved by the EWSG, they were provided to Ecology for initial review and comment. Some questions were eliminated based on feedback from Ecology, but in most cases, the questions were modified to better meet the test objectives. If significant modifications were made to questions, these changes were reviewed again with the EWSG to ensure they still met the group’s needs and original intent.

As study questions advanced beyond the conceptual approach level, they were moved into the final “Research Proposal” format. Generally, while these research proposals are still fairly conceptual, they have been outlined to a degree that budget assumptions could be applied and budget estimates could be created.

A third 2-day workshop was held in March 2015. At this workshop, all research proposals that had been through the multi-phase review and refinement process were again shared with the EWSG and discussed by permit category. Although it was not the intent or objective of the workshop to prioritize or rank questions, some initial ranking tools were tested to demonstrate different techniques for evaluating and comparing study questions. For example, a “vote by hand” was used for some categories to simply select participants’ first, second, and third favorites; this was an easy way to eliminate study questions that did not have general support from the EWSG. A second tool that was tested was use of a “strengths, weaknesses,
opportunities, threats” (SWOT) type of analysis that used “cost” and “value” to compare study questions within specific categories. While the purpose of these exercises was to demonstrate a few simple tools that might eventually be used to aid the prioritization process, and it did not serve as a “vote,” the exercises did provide information as to which study questions had the broadest support within each permit category. At this workshop, six additional questions were identified and refined through the same iterative process as described previously.

By the end of the March 2015 workshop and during the weeks immediately following, 27 research questions were considered. A few questions were eliminated after discussions with Ecology, resulting in a final tally of 24 effectiveness study questions.

In early May 2015, a series of meetings were held at subregional hubs (i.e., Tri-Cities, Pullman, Spokane, Wenatchee, and Yakima) to further solicit opinions as to which questions were preferred and which were disliked. These meetings were also used to gather information on the unique characteristics of each of the jurisdictions. Some of the information gained during these meetings is summarized in the Regional Characteristics section above. It was an enlightening discussion, providing important insight into why there are differences in needs and interests between permittees.

Although it is not the purpose of this report to describe all of the study questions nor to explain why the EWSG was interested in them, a few topics merit additional description because of the level of interest they generated. These topics were bioretention, LID, and inspection of private facilities. The following provides a brief summary of some of the concerns that were raised related to these topics. These concerns are not shared by all of the Eastern Washington permittees. Regional differences described above, as well as differences between urbanized and more rural areas and differences between city(s) and county(s), all affect the level of interest in these topics by individual permittees.

**Bioretention:** These facilities are used in much of Eastern Washington, so many permittees had a high level of interest in improving their effectiveness. As many in the EWSG commented, building a facility that requires addition of organic matter and then water to keep plants alive in an area naturally devoid of both, is a recipe for weed invasion. Even the physical depressions in the ground formed by bioretention facilities can be problematic in windy areas, since they collect trash and tumbleweeds. Because of these concerns, many study questions were identified related to improving the design of bioretention facilities or verifying the importance of different components (e.g., media composition, media depth, irrigation needs, and planting options [including an option of not using plants]).
**Low Impact Development:** Although the requirements of the current permit related to low impact development (LID) are not of high concern, there is some concern that the next permit may have more requirements and use a more stringent definition of LID. If LID is defined as a development philosophy for reducing contributing impervious surface (e.g., narrower streets, smaller lots, roof gardens and permeable pavement), then a number of jurisdictions in Eastern Washington may be reluctant to fully embrace LID. In most of Eastern Washington, stormwater runoff volume can typically be easily controlled through less-expensive options. When other practical issues, such as emergency vehicle access or creating deterrents to development, are considered, support for LID-based developments is minimal. However, if LID is interpreted as intentional use of natural dispersion or infiltration facilities (e.g., bioretention, bio-infiltration swales, and UICs), then most of Eastern Washington has been using those techniques for years and supports the concept.

**Inspection of Private Facilities:** This is an area of the current permit that generates concern by a number of permittees. As described previously, most Eastern Washington jurisdictions have shoestring budgets and only a few part-time staff; therefore, inspection of private facilities would require significant new funding sources. The City of Ellensburg has estimated that its utility cost would need to increase from $7.88 to $19.00 per equivalent residential unit (ERU) to support additional maintenance needs related to this activity. This would be an unacceptable increase, especially since in most cases and specifically in newer developments, private facilities do not directly connect to the Municipal Separate Storm Sewer System (MS4). Thus, from the permittees’ perspective, this permit requirement represents a large additional expenditure with low potential for water quality improvement. Also important are legal concerns related to right of access and assignment of costs for any required maintenance. These problems aside, a few jurisdictions (for example, City of Richland, Asotin County, and City of Wenatchee) already accept ownership of private facilities and, therefore, would not have the same legal concerns.
It was not an objective of this first phase of the study question selection process to prioritize and select questions; however, it was an objective to begin establishing criteria that could be used in the future as a tool to help evaluate between the study questions. An initial brainstorming session was conducted during the March 2015 workshop to develop criteria for prioritizing the effectiveness study questions. Ultimately, criteria were developed for the following three categories:

- Value
- Risk/Reliability
- Cost

The criteria included in each of the four categories are summarized in Table 1. A spreadsheet-based matrix of the criteria was also developed to allow for tracking scores and was provided to the EWSG for its future use.

During the subregional meetings held in May 2015, participants were asked to identify their preferred questions as well as questions they disliked. This was not intended to be a formal or rigorous voting process, and there was no formal vote. Although the process was purposely informal, there was some value in the information obtained. The results provide an indication as to which study questions had broad support from the EWSG as well as those few that had little support and could be eliminated from future discussions. The results are summarized in Table 2 as “high,” “medium,” and “low” based on the casual straw votes.

There were a few things worth noting about the ranking process that may have adversely affected how some of the questions were ranked. There were two topics of interest for which three individual, but somewhat related, questions were identified; these included the general topics of “improvements to bioretention facilities” and “studies of permeable pavements.” Because there were three questions, the voting for these may have been “diluted.” Further, for each of these topics of interest there was at least one study question (No. 14 and No. 27) that represented a currently ongoing study. Since it was unclear whether these ongoing studies would be considered by Ecology as one of the effectiveness studies that could be put forward, they were not necessarily treated the same by the group. This, too, likely adversely biased the
initial ranking. Now that it is clear that Ecology would accept these study questions, the group may want to revisit these general topic areas and the specific questions.

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>Applicability of local conditions</td>
<td>The study may be more applicable to another region of Eastern Washington than in your region.</td>
</tr>
<tr>
<td></td>
<td>Potential to provide clear recommendations for your stormwater program</td>
<td>Outcome of study is anticipated to provide clear recommendations for the future direction of your stormwater program.</td>
</tr>
<tr>
<td></td>
<td>Potential to save your program money</td>
<td>Outcome of study is anticipated to refine or improve a portion of your stormwater program that is currently a large percentage of your overall stormwater program budget.</td>
</tr>
<tr>
<td></td>
<td>Addresses known water quality issues</td>
<td>The study addresses a water quality issue that is also an issue in your City/County or in your region.</td>
</tr>
<tr>
<td></td>
<td>Timing of the study</td>
<td>The timing of the study is appropriate.</td>
</tr>
<tr>
<td>Risk/Reliability</td>
<td>Impact to your stormwater program budget</td>
<td>The study may potentially have an impact on the stormwater program budget (e.g., if more sweeping is needed than is currently being implemented, the cost of implementing an effective public education program is higher than budgeted).</td>
</tr>
<tr>
<td></td>
<td>Measurability</td>
<td>The study approach targets a specific metric or multiple metrics that are easily measurable.</td>
</tr>
<tr>
<td></td>
<td>Accuracy</td>
<td>The proposed study approach is expected to result in an accurate answer.</td>
</tr>
<tr>
<td></td>
<td>Consistency with Permit</td>
<td>The study focuses on a well-defined requirement in the NPDES Phase II Municipal Stormwater Permit for Eastern Washington.</td>
</tr>
<tr>
<td>Cost</td>
<td>Reasonable cost</td>
<td>The cost to fund the study seems reasonable for the potential benefits that will be provided.</td>
</tr>
<tr>
<td></td>
<td>Staff responsibilities</td>
<td>The study will require additional staff support from the sponsoring jurisdiction.</td>
</tr>
<tr>
<td></td>
<td>Likelihood of outside funding</td>
<td>Grant funding will potentially be available to support this type of study.</td>
</tr>
<tr>
<td>Study Question Identification</td>
<td>Study Title</td>
<td>Initial Ranking</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Study 1</td>
<td>Modernizing Education and Outreach Strategies</td>
<td>High</td>
</tr>
<tr>
<td>Study 2</td>
<td>Mobile Contractor Illicit Discharge Education</td>
<td>High</td>
</tr>
<tr>
<td>Study 11</td>
<td>Comparison of Conventional and LID BMPs</td>
<td>High</td>
</tr>
<tr>
<td>Study 15</td>
<td>Street Sweeping and Catch Basin Cleaning Comparison</td>
<td>High</td>
</tr>
<tr>
<td>Study 18</td>
<td>Catch Basin Retrofit Device Placement</td>
<td>High</td>
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<tr>
<td>Study 20</td>
<td>Planting Options for Bioretention BMPs</td>
<td>High</td>
</tr>
<tr>
<td>Study 3</td>
<td>Illicit Discharge Detection Methods</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 5</td>
<td>Business Inspection Program Strategies</td>
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</tr>
<tr>
<td>Study 7</td>
<td>Stormwater BMP Owner Awareness</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 9</td>
<td>BMP Inspection and Maintenance Responsibilities</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 10</td>
<td>Impact of Privately Owned BMPs on MS4s</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 12</td>
<td>Long-term Permeable Pavement Sidewalk Infiltration Performance</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 13</td>
<td>Permeable Pavement Parking Lot Maintenance</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 14</td>
<td>Sharp Avenue Porous Pavement Study</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 16</td>
<td>Seasonal Differences in Street Sweeping Material Removal</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 17</td>
<td>Catch Basin Insert Monitoring Protocol</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 19</td>
<td>Seeding and Irrigation for Vegetated BMPs</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 21</td>
<td>Media Component Study</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 27</td>
<td>Media Thickness Study</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 6</td>
<td>Soil Amendments for Erosion Control and Revegetation</td>
<td>Low</td>
</tr>
<tr>
<td>Study 8</td>
<td>Long-Term Maintenance of Privately Owned BMPs</td>
<td>Low</td>
</tr>
<tr>
<td>Study 22</td>
<td>Treatment for Commingled Stormwater and Agricultural Discharges</td>
<td>Low</td>
</tr>
<tr>
<td>Study 24</td>
<td>Biochar Media Stormwater Treatment Study</td>
<td>Low</td>
</tr>
</tbody>
</table>

BMPs = best management practices

Note: A number of study questions (i.e., 4, 23, 25, and 26) were eliminated as part of the review process; therefore, some numbers are missing in the sequence.
Cost Allocation

Decisions have yet to be made about which studies will be prioritized and, therefore, what the total cost for completing the studies might be. Also, there has been only very limited discussion during this phase of the work related to how costs for these studies might be shared across the different jurisdictions. Final selection of questions still needs to be made, lead agencies need to be selected to champion each question, and different structures for organizing the work are still being discussed. However, cost allocation will be one of the next important discussion items; therefore, this section has been included to provide some of the framework that might be used to begin discussions of how to share costs. The different cost allocation methods are provided as a means of providing some perspective; none of these have been discussed or proposed by the EWSG.

A variety of approaches could be used for allocating costs among the permittees for the effectiveness studies they eventually select. The following approaches are briefly summarized, and related cost allocation tables are provided:

- Allocating costs based solely on city or county population Applying a base and equal investment for all permittees
- Considering per capita income
- Allocating costs based on the quantity and/or quality of stormwater generated (impervious surface or effective impervious surface, drainage basin area, number of outfalls, pollutant loads)
- Allocating costs based on the number of housing units within the permitted area (similar to how the NPDES permit fees are calculated)

Other allocation methods, as well as methods that reflect a blend of these approaches, are likely available.

Although the allocation approach used by Western Washington is not directly relevant to Eastern Washington, there is some merit in providing it as an example to
assist in understanding some of the specifics of the approach. The selected approach in Western Washington was to allocate costs based solely on population. This approach was selected because it was considered the most equitable, since it is based on the number of ratepayers in each jurisdiction. County populations were based on unincorporated populations associated with Urban Growth Areas (UGAs) in the permit coverage areas. It was acknowledged that these population estimates slightly underestimate the populations inside permit coverage areas because some census-defined urban areas lie outside UGA boundaries; this same situation exists in Eastern Washington. If the total unincorporated populations of these counties had been used, it would have greatly overestimated the covered populations. Future annexations could also potentially affect the proportional allocation of costs. Secondary permittees and new permittees were not included in the cost allocation for Western Washington.

Eight to twelve effectiveness studies will eventually be selected for implementation by the EWSG. The total cost of implementing these studies is unknown, since the studies have not yet been selected. An approximate cost for implementing all 24 of the remaining effectiveness study questions is $2.65 million. For purposes of the cost allocation evaluation presented in Tables 4, 5, 6, and 7 below, an assumed total cost of $1,000,000 was selected as a means of providing a basis for comparison.

Assuming $1,000,000 in implementation costs for the study questions and that costs are shared based solely on population, the costs range from $1,387 (City of Asotin) to $231,549 (City of Spokane) (Table 3). The total city populations were used for this analysis; however, county populations were adjusted based on the NPDES permit coverage area. (Using total county populations would have introduced large errors due to double counting of the population within the cities.) The adjusted county populations ranged from 11 to 77 percent lower (for Asotin County and Chelan County, respectively) than the unincorporated county populations.

The tables below represent total estimated cost. It is expected that the costs would be spread out over a span of years; for example, they might be spread over the 5-year term of the permit. Since the time span is unknown, no attempt has been made to estimate potential annual costs.
Table 3. Projected Allocation of Costs Based Solely on Population and Assuming a Total Cost of $1,000,000.

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Population (2010 estimate)(^a)</th>
<th>Percent of Population</th>
<th>Allocation by Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asotin</td>
<td>1,251</td>
<td>0.14</td>
<td>$1,387</td>
</tr>
<tr>
<td>Clarkston</td>
<td>7,229</td>
<td>0.80</td>
<td>$8,012</td>
</tr>
<tr>
<td>East Wenatchee</td>
<td>13,190</td>
<td>1.46</td>
<td>$14,619</td>
</tr>
<tr>
<td>Ellensburg</td>
<td>18,174</td>
<td>2.01</td>
<td>$20,143</td>
</tr>
<tr>
<td>Kennewick</td>
<td>73,917</td>
<td>8.19</td>
<td>$81,925</td>
</tr>
<tr>
<td>Moses Lake</td>
<td>20,366</td>
<td>2.26</td>
<td>$22,572</td>
</tr>
<tr>
<td>Pasco</td>
<td>59,781</td>
<td>6.63</td>
<td>$66,257</td>
</tr>
<tr>
<td>Pullman</td>
<td>29,799</td>
<td>3.30</td>
<td>$33,027</td>
</tr>
<tr>
<td>Richland</td>
<td>48,058</td>
<td>5.33</td>
<td>$53,264</td>
</tr>
<tr>
<td>Selah</td>
<td>7,147</td>
<td>0.79</td>
<td>$7,921</td>
</tr>
<tr>
<td>Spokane</td>
<td>208,916</td>
<td>23.15</td>
<td>$231,549</td>
</tr>
<tr>
<td>Spokane Valley</td>
<td>89,755</td>
<td>9.95</td>
<td>$99,479</td>
</tr>
<tr>
<td>Sunnyside</td>
<td>15,858</td>
<td>1.76</td>
<td>$17,576</td>
</tr>
<tr>
<td>Union Gap</td>
<td>6,047</td>
<td>0.67</td>
<td>$6,702</td>
</tr>
<tr>
<td>Walla Walla</td>
<td>31,731</td>
<td>3.52</td>
<td>$35,169</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>31,925</td>
<td>3.54</td>
<td>$35,384</td>
</tr>
<tr>
<td>West Richland</td>
<td>11,811</td>
<td>1.31</td>
<td>$13,091</td>
</tr>
<tr>
<td>Yakima</td>
<td>91,067</td>
<td>10.09</td>
<td>$100,933</td>
</tr>
<tr>
<td>Asotin County</td>
<td>11,738</td>
<td>1.30</td>
<td>$13,009</td>
</tr>
<tr>
<td>Chelan County</td>
<td>7,030</td>
<td>0.78</td>
<td>$7,791</td>
</tr>
<tr>
<td>Douglas County</td>
<td>14,744</td>
<td>1.63</td>
<td>$16,341</td>
</tr>
<tr>
<td>Spokane County</td>
<td>68,670</td>
<td>7.61</td>
<td>$76,110</td>
</tr>
<tr>
<td>Walla Walla County</td>
<td>8,972</td>
<td>0.99</td>
<td>$9,944</td>
</tr>
<tr>
<td>Yakima County</td>
<td>25,077</td>
<td>2.78</td>
<td>$27,794</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>902,253</strong></td>
<td><strong>100%</strong></td>
<td><strong>$1,000,000</strong></td>
</tr>
</tbody>
</table>

\(^a\) Source: OFM 2010 Census data. City populations are based on total city populations as per the 2010 census. County population data has been adjusted based on the NPDES permit coverage area. The population totals for the counties have been adjusted per census block based on the percentage of the total census block within the jurisdiction boundary. For example, a census block with 47 percent of its total area in a jurisdiction and a 2010 population of 100 people would be assigned a population of 47 in this analysis.
Assuming $1,000,000 in total implementation costs and costs that are allocated based on one equal investment from each of the 24 permittees, the total cost per jurisdiction would be $41,667. Assuming $1,000,000 in total implementation costs and costs that are allocated based on per capita income, the costs range from $26,537 (City of Union Gap) to $65,802 (City of Richland) (Table 4).

Table 4. Projected Allocation of Costs Based on Per Capita Income and Assuming a Total Cost of $1,000,000.

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Per Capita Income(^a)</th>
<th>Percent of Total Eastern WA Per Capita Income</th>
<th>Allocation by Per Capita Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asotin</td>
<td>$19,819</td>
<td>3.71</td>
<td>$37,135</td>
</tr>
<tr>
<td>Clarkston</td>
<td>$18,059</td>
<td>3.38</td>
<td>$33,837</td>
</tr>
<tr>
<td>East Wenatchee</td>
<td>$23,462</td>
<td>4.40</td>
<td>$43,960</td>
</tr>
<tr>
<td>Ellensburg</td>
<td>$16,367</td>
<td>3.07</td>
<td>$30,667</td>
</tr>
<tr>
<td>Kennewick</td>
<td>$24,088</td>
<td>4.51</td>
<td>$45,133</td>
</tr>
<tr>
<td>Moses Lake</td>
<td>$23,142</td>
<td>4.34</td>
<td>$43,361</td>
</tr>
<tr>
<td>Pasco</td>
<td>$17,353</td>
<td>3.25</td>
<td>$32,514</td>
</tr>
<tr>
<td>Pullman</td>
<td>$17,351</td>
<td>3.25</td>
<td>$32,510</td>
</tr>
<tr>
<td>Richland</td>
<td>$35,119</td>
<td>6.58</td>
<td>$65,802</td>
</tr>
<tr>
<td>Selah</td>
<td>$23,013</td>
<td>4.31</td>
<td>$43,119</td>
</tr>
<tr>
<td>Spokane</td>
<td>$24,034</td>
<td>4.50</td>
<td>$45,032</td>
</tr>
<tr>
<td>Spokane Valley</td>
<td>$23,769</td>
<td>4.45</td>
<td>$44,536</td>
</tr>
<tr>
<td>Sunnyside</td>
<td>$14,702</td>
<td>2.75</td>
<td>$27,547</td>
</tr>
<tr>
<td>Union Gap</td>
<td>$14,163</td>
<td>2.65</td>
<td>$26,537</td>
</tr>
<tr>
<td>Walla Walla</td>
<td>$21,430</td>
<td>4.02</td>
<td>$40,153</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>$23,842</td>
<td>4.47</td>
<td>$44,672</td>
</tr>
<tr>
<td>West Richland</td>
<td>$31,310</td>
<td>5.87</td>
<td>$58,665</td>
</tr>
<tr>
<td>Yakima</td>
<td>$20,516</td>
<td>3.84</td>
<td>$38,440</td>
</tr>
<tr>
<td>Asotin County</td>
<td>$24,353</td>
<td>4.56</td>
<td>$45,630</td>
</tr>
<tr>
<td>Chelan County</td>
<td>$25,747</td>
<td>4.82</td>
<td>$48,242</td>
</tr>
<tr>
<td>Douglas County</td>
<td>$22,870</td>
<td>4.29</td>
<td>$42,851</td>
</tr>
<tr>
<td>Spokane County</td>
<td>$25,891</td>
<td>4.85</td>
<td>$48,512</td>
</tr>
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<td>Walla Walla County</td>
<td>$23,698</td>
<td>4.44</td>
<td>$44,403</td>
</tr>
<tr>
<td>Yakima County</td>
<td>$19,610</td>
<td>3.67</td>
<td>$36,743</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>100%</td>
<td><strong>$1,000,000</strong></td>
</tr>
</tbody>
</table>

Assuming $1,000,000 in total implementation costs for the study questions and costs that are allocated based on the impervious surface area coverage, the costs range from $1,391 (City of Asotin) to $204,878 (City of Spokane) (Table 5). Note that these impervious surface estimates might also be modified to reflect the impervious surface within the permitting area of each city and county.

Table 5. Projected Allocation of Costs Based on Impervious Surface Area Coverage and Assuming a Total Cost of $1,000,000.

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Impervious Area (acres)⁹</th>
<th>Percent of Impervious²</th>
<th>Percent of Total Eastern WA Impervious</th>
<th>Allocation by Impervious Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asotin</td>
<td>110</td>
<td>17</td>
<td>0.14</td>
<td>$1,391</td>
</tr>
<tr>
<td>Clarkston</td>
<td>569</td>
<td>46</td>
<td>0.72</td>
<td>$7,224</td>
</tr>
<tr>
<td>East Wenatchee</td>
<td>958</td>
<td>39</td>
<td>1.21</td>
<td>$12,150</td>
</tr>
<tr>
<td>Ellensburg</td>
<td>1,208</td>
<td>27</td>
<td>1.53</td>
<td>$15,329</td>
</tr>
<tr>
<td>Kennewick</td>
<td>5,766</td>
<td>33</td>
<td>7.32</td>
<td>$73,163</td>
</tr>
<tr>
<td>Moses Lake</td>
<td>2,680</td>
<td>24</td>
<td>3.40</td>
<td>$34,013</td>
</tr>
<tr>
<td>Pasco</td>
<td>5,989</td>
<td>29</td>
<td>7.60</td>
<td>$75,998</td>
</tr>
<tr>
<td>Pullman</td>
<td>1,528</td>
<td>25</td>
<td>1.94</td>
<td>$19,383</td>
</tr>
<tr>
<td>Richland</td>
<td>5,640</td>
<td>22</td>
<td>7.16</td>
<td>$71,570</td>
</tr>
<tr>
<td>Selah</td>
<td>540</td>
<td>18</td>
<td>0.68</td>
<td>$6,850</td>
</tr>
<tr>
<td>Spokane</td>
<td>16,146</td>
<td>36</td>
<td>20.49</td>
<td>$204,878</td>
</tr>
<tr>
<td>Spokane Valley</td>
<td>9,941</td>
<td>41</td>
<td>12.61</td>
<td>$126,137</td>
</tr>
<tr>
<td>Sunnyside</td>
<td>1,046</td>
<td>22</td>
<td>1.33</td>
<td>$13,269</td>
</tr>
<tr>
<td>Union Gap</td>
<td>923</td>
<td>29</td>
<td>1.17</td>
<td>$11,707</td>
</tr>
<tr>
<td>Walla Walla</td>
<td>2,111</td>
<td>26</td>
<td>2.68</td>
<td>$26,789</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>2,102</td>
<td>42</td>
<td>2.67</td>
<td>$26,672</td>
</tr>
<tr>
<td>West Richland</td>
<td>1,088</td>
<td>7</td>
<td>1.38</td>
<td>$13,801</td>
</tr>
<tr>
<td>Yakima</td>
<td>6,073</td>
<td>34</td>
<td>7.71</td>
<td>$77,059</td>
</tr>
<tr>
<td>Asotin County</td>
<td>1,060</td>
<td>19</td>
<td>1.35</td>
<td>$13,457</td>
</tr>
<tr>
<td>Chelan County</td>
<td>1,145</td>
<td>18</td>
<td>1.45</td>
<td>$14,530</td>
</tr>
<tr>
<td>Douglas County</td>
<td>1,408</td>
<td>14</td>
<td>1.79</td>
<td>$17,867</td>
</tr>
<tr>
<td>Spokane County</td>
<td>7,690</td>
<td>21</td>
<td>9.76</td>
<td>$97,582</td>
</tr>
<tr>
<td>Walla Walla County</td>
<td>1,050</td>
<td>10</td>
<td>1.33</td>
<td>$13,324</td>
</tr>
<tr>
<td>Yakima County</td>
<td>2,038</td>
<td>8</td>
<td>2.59</td>
<td>$25,856</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>78,808</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>$1,000,000</strong></td>
</tr>
</tbody>
</table>

⁹ Impervious acreages represent the total estimated in the city or county. Estimates were derived from National Land Cover Database (Xian et al. 2011).
Assuming $1,000,000 in total implementation costs for the study questions and costs that are allocated based on the number of housing units (similar to how the NPDES permit fees are calculated), the costs range from $0 (cities of Selah, Sunnyside, and Union Gap) to $206,122 (City of Spokane) (Table 6). The number of housing units for the cities of Selah, Sunnyside, and Union Gap are included in the Yakima County total because these cities are co-permittees; therefore, a separate cost is not provided in Table 6 for these permittees.

Table 6. Projected Allocation of Costs Based on the Number of Housing Units and Assuming a Total Cost of $1,000,000.

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Number of Housing Units&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Percent of Total Eastern WA Housing Units</th>
<th>Allocation by Housing Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asotin</td>
<td>433</td>
<td>0.13</td>
<td>$1,267</td>
</tr>
<tr>
<td>Clarkston</td>
<td>3,355</td>
<td>0.98</td>
<td>$9,815</td>
</tr>
<tr>
<td>East Wenatchee</td>
<td>5,318</td>
<td>1.56</td>
<td>$15,558</td>
</tr>
<tr>
<td>Ellensburg</td>
<td>8,786</td>
<td>2.57</td>
<td>$25,704</td>
</tr>
<tr>
<td>Kennewick</td>
<td>30,635</td>
<td>8.96</td>
<td>$89,624</td>
</tr>
<tr>
<td>Moses Lake</td>
<td>8,824</td>
<td>2.58</td>
<td>$25,815</td>
</tr>
<tr>
<td>Pasco</td>
<td>20,884</td>
<td>6.11</td>
<td>$61,097</td>
</tr>
<tr>
<td>Pullman</td>
<td>11,945</td>
<td>3.49</td>
<td>$34,946</td>
</tr>
<tr>
<td>Richland</td>
<td>22,012</td>
<td>6.44</td>
<td>$64,397</td>
</tr>
<tr>
<td>Selah</td>
<td>NA&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>Spokane</td>
<td>70,456&lt;sup&gt;c&lt;/sup&gt;</td>
<td>20.61</td>
<td>$206,122</td>
</tr>
<tr>
<td>Spokane Valley</td>
<td>39,693</td>
<td>11.61</td>
<td>$116,124</td>
</tr>
<tr>
<td>Sunnyside</td>
<td>NA&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>Union Gap</td>
<td>NA&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>Walla Walla</td>
<td>12,727</td>
<td>3.72</td>
<td>$37,233</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>13,374</td>
<td>3.91</td>
<td>$39,126</td>
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<tr>
<td>West Richland</td>
<td>4,750</td>
<td>1.39</td>
<td>$13,896</td>
</tr>
<tr>
<td>Yakima</td>
<td>38,286</td>
<td>11.20</td>
<td>$112,007</td>
</tr>
<tr>
<td>Asotin County</td>
<td>4,277</td>
<td>1.25</td>
<td>$12,513</td>
</tr>
<tr>
<td>Chelan County</td>
<td>2,768</td>
<td>0.81</td>
<td>$8,098</td>
</tr>
<tr>
<td>Douglas County</td>
<td>5,840</td>
<td>1.71</td>
<td>$17,085</td>
</tr>
<tr>
<td>Spokane County</td>
<td>23,785</td>
<td>6.96</td>
<td>$69,584</td>
</tr>
<tr>
<td>Walla Walla County</td>
<td>2,066</td>
<td>0.60</td>
<td>$6,044</td>
</tr>
<tr>
<td>Yakima County</td>
<td>11,603&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.39</td>
<td>$33,945</td>
</tr>
<tr>
<td>Total</td>
<td>341,817</td>
<td>100%</td>
<td>$1,000,000</td>
</tr>
</tbody>
</table>

<sup>a</sup> Source: Personal communication. Abbey Stockwell, Washington State Department of Ecology

<sup>b</sup> Yakima County includes the cities of Selah, Sunnyside, Union Gap as co-permittees.

<sup>c</sup> The City of Spokane estimate was extrapolated from the permit fee and based on the "not to exceed" permit fee allowed under WAC 173-224(5b) of $50,024.
In Table 7, minimum to maximum costs (based on the four allocation models presented in Tables 3 through 6) for each jurisdiction are presented using assumed total costs of $1,000,000, $1,500,000, and $2,000,000. This table is provided to better reflect what might be the total range in potential study implementation costs. For example, with the City of Asotin using the allocation approach most favorable to it (i.e., based on housing units) at the lowest potential total cost (i.e., $1,000,000), the City’s cost would be $1,267. At the other end of the range, if the City used the allocation approach that was least favorable to it (i.e., an equal fee for all permittees) and the highest potential total cost was assumed (i.e., $2,000,000), the City’s cost would be $83,333. Because permittees need to start planning now for the eventual costs associated with this program, this table provides permittees with a basic tool for initial planning.

### Table 7. Range of Projected Allocation of Costs.

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>$1,000,000 Basis</th>
<th></th>
<th>$1,500,000 Basis</th>
<th></th>
<th>$2,000,000 Basis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Asotin</td>
<td>$1,267</td>
<td>$41,667</td>
<td>$1,900</td>
<td>$62,500</td>
<td>$2,534</td>
<td>$83,333</td>
</tr>
<tr>
<td>Clarkston</td>
<td>$7,224</td>
<td>$41,667</td>
<td>$10,836</td>
<td>$62,500</td>
<td>$14,447</td>
<td>$83,333</td>
</tr>
<tr>
<td>East Wenatchee</td>
<td>$12,150</td>
<td>$43,960</td>
<td>$18,225</td>
<td>$65,941</td>
<td>$24,300</td>
<td>$87,921</td>
</tr>
<tr>
<td>Kennewick</td>
<td>$41,667</td>
<td>$81,925</td>
<td>$62,500</td>
<td>$122,887</td>
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*a The ranges shown display the range between the most favorable allocation method (low) for the individual permittees to the least favorable method (high). The projections include the allocation method of a base and equal pay that was described but not shown in a table and which ranged from $41,667 for all permittees (at $1,000,000) to $83,333 for all permittees (at $2,000,000).

*b Yakima County includes the cities of Selah, Sunnyside, Union Gap as co-permittees.
CONCLUSIONS AND RECOMMENDATIONS

As a result of this project, a group of 24 effectiveness study questions and related research proposals were developed, refined, and approved through an iterative process that involved the EWSG and review and comment by Ecology staff. Some initial “testing of the waters” was performed to assess which research proposals had the most and least support, and this was used to develop an initial ranking. This was the first phase (Phase 1) in the effectiveness study question selection process. In the following year(s), the process of formally selecting questions for study, assigning responsibilities for the individual studies, and agreeing on an appropriate cost allocation model will need to occur.

This process was successful in a number of ways. It produced a list of effectiveness studies/research proposals that the EWSG could support, and it provided more opportunities for the EWSG to share experiences and ideas and to discuss the future direction of the NPDES permit. Although the EWSG has yet to complete a formal process of selecting and prioritizing the study questions, there appears to be support for a core group of study questions. However, there are important subregional differences in concerns and needs that may make consensus on 8 to 12 final effectiveness studies less straightforward. Permeable pavement represents a good example; while there was interest in evaluating permeable pavement projects from a broad part of the EWSG, some subregions were not at all interested in these studies. While some jurisdictions may be able to approve funding for a study question that they have limited interest in, by justifying that other questions identified by the EWSG are of interest, other jurisdictions may not agree. The EWSG may need to consider more complex cost-sharing models that ensure each jurisdiction contributes a “fair” share while also being able to choose the projects to which it contributes.
REFERENCES


<table>
<thead>
<tr>
<th>Study No.</th>
<th>Study Title</th>
<th>Permit Category</th>
<th>Study Summary</th>
<th>Approximate Cost</th>
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<tbody>
<tr>
<td>1</td>
<td>Modernizing Education and Outreach Strategies</td>
<td>Public Education and Outreach</td>
<td>A marketing firm would be hired to develop an education and outreach program utilizing modern communication tools (apps, social media, would be developed for one stormwater permit related topic (e.g., reporting illicit discharges). Public awareness and behaviors about the topic would be assessed via survey before and after deliver of the educational campaign to assess results.</td>
<td>$150,000</td>
</tr>
<tr>
<td>2</td>
<td>Mobile Contractor Illicit Discharge Education</td>
<td>Public Education and Outreach</td>
<td>This study will involve the development and testing of a new educational programs for educating contractors that move on a daily basis about illicit discharge prevention. The study will focus, in particular, on ways of reaching mobile contractors and delivering the material.</td>
<td>$100,000</td>
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<td>3</td>
<td>Illicit Discharge Detection Methods</td>
<td>IDDE</td>
<td>The study will survey stormwater managers to gather information regarding illicit discharges detected by various IDDE methods. The purpose is to identify which methods result in the highest detection rate.</td>
<td>$30,000</td>
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<tr>
<td>5</td>
<td>Business Inspection Program Strategies</td>
<td>IDDE</td>
<td>This survey study will query Phase II Western Washington Jurisdictions with business inspection programs. The purpose of the survey will be to qualitatively assess the effectiveness of business inspection programs in Western Washington, and to learn effective strategies that can be adopted into the developing business inspection programs of Eastern Washington jurisdictions.</td>
<td>$30,000</td>
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<tr>
<td>6</td>
<td>Soil Amendments for Erosion Control and Revegetation</td>
<td>Construction Site Stormwater Runoff Control</td>
<td>This study will test commercially available soil amendments claiming to improve plant growth by enhancing soil structure and water holding capacity. The study will be conducted at a plot scale using typical erosion control seed grass mixes.</td>
<td>$90,000</td>
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<td>7</td>
<td>Stormwater BMP Owner Awareness</td>
<td>Post-Construction Stormwater Management</td>
<td>This simple, survey study will be delivered to homeowners, homeowners associations, and businesses that have structural stormwater BMPs installed on their properties. The survey will assess their general knowledge about the stormwater BMPs on their land, the maintenance requirements of the BMP, and their responsibility to continually maintain the BMP.</td>
<td>$30,000</td>
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<tr>
<td>8</td>
<td>Long-Term Maintenance of Privately Owned BMPs</td>
<td>Post-Construction Stormwater Management</td>
<td>This two-part study will review existing inspection and maintenance records to evaluate the effectiveness of each Eastern Washington Jurisdiction's inspection and maintenance program, and survey permittees to learn about the most significant impediments to conducting BMP inspections</td>
<td>$50,000</td>
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<tr>
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<td>9</td>
<td>BMP Inspection and Maintenance Responsibilities</td>
<td>Post-Construction Stormwater Management</td>
<td>A survey will be used to gather information from Washington Jurisdictions to learn novel and effective ways that municipalities are meeting the challenge of ensuring ongoing maintenance of structural BMPs on private property. In particular the survey will question permittees about different models of BMP ownership and responsibility for continued maintenance of BMPs.</td>
<td>$30,000</td>
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<td>10</td>
<td>Impact of Privately Owned BMPs on MS4s</td>
<td>Post-Construction Stormwater Management</td>
<td>This study will evaluate the percentage of privately owned BMPs that would drain to the MS4 in the event of failure. The study will use GIS analysis at the subbasin scale.</td>
<td>$80,000</td>
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<tr>
<td>11</td>
<td>Comparison of Conventional and LID BMPs</td>
<td>Post-Construction Stormwater Management</td>
<td>This study will evaluate flow control benefits through sizing and modeling various BMPs (both common infiltration BMPs and LID BMPs) for typical residential and commercial development in Eastern Washington. The study would also include a cost comparison among various BMPs and compile an Eastern Washington Stormwater BMP cost database.</td>
<td>$90,000</td>
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<td>12</td>
<td>Long-term Permeable Pavement Sidewalk Infiltration Performance</td>
<td>Municipal Operations and Maintenance</td>
<td>Test strips of permeable pavement sidewalks will be constructed in four Eastern Washington communities. Infiltration measurements will occur twice yearly for a 10-year study period. No maintenance will take place, so the infiltration measurements will document decreases in infiltration performance over time as the pavement becomes clogged with sediment.</td>
<td>$110,000</td>
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<td>13</td>
<td>Permeable Pavement Parking Lot Maintenance</td>
<td>Municipal Operations and Maintenance</td>
<td>Test segments will be designated within the traveling lanes of a newly constructed permeable pavement parking lot. Each test segment will be subjected to different maintenance regimes ranging from no-maintenance to monthly vacuuming. The infiltration rate of the pavement will be measured on a quarterly basis and the infiltration performance of each test segment will be tracked over time.</td>
<td>$150,000</td>
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<td>14</td>
<td>Sharp Avenue Porous Pavement Study</td>
<td>Municipal Operations and Maintenance</td>
<td>A porous pavement &quot;laboratory&quot; will be constructed in the traveling and parking lanes of a City arterial street near Gonzaga University. A porous concrete intersection, full-width pervious asphalt, pervious asphalt in the parking lanes only, and a control section will be installed. Gonzaga University students will monitor water quality, pavement condition over time (especially with respect to studded tire use) and operation and maintenance impacts.</td>
<td>$350,000</td>
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Table A-1 (continued). Proposed Effectiveness Study Questions.

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<td>15</td>
<td>Street Sweeping and Catch Basin Cleaning Comparison</td>
<td>Municipal Operations and Maintenance</td>
<td>This study will use a small-scale, &quot;paired&quot; basin approach for evaluating differences in the amount of material removal by street sweeping and catch basin cleaning compared to only catch basin sweeping. One of the basins will be swept regularly, and the other will not. The total amount of material removed will be calculated for both basins and compared. All Eastern Washington jurisdictions will also be surveyed about their street sweeping and catch basin cleaning procedures.</td>
<td>$150,000</td>
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<td>16</td>
<td>Seasonal Differences in Street Sweeping Material Removal</td>
<td>Municipal Operations and Maintenance</td>
<td>All the roadways within four or five communities will be swept on a monthly basis. The amount of material and pollutants removed during each sweeping event will be totaled. Statistical analysis will be used to identify whether there are significant factors (timing, region) affecting the amount of material removed by each sweeping event (a surrogate for sediment deposition rate).</td>
<td>$200,000</td>
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<td>17</td>
<td>Catch Basin Insert Monitoring Protocol</td>
<td>Municipal Operations and Maintenance</td>
<td>The objective of this study is to develop a protocol (QAPP) for evaluating the effectiveness of commercially available catch basin inserts at bench and field scales. Having this procedure in place will streamline testing and evaluation, and will ensure uniformity of methods allowing for objective performance comparisons. This protocol would be developed with input from Ecology and interested vendors. Vendors who chose to have their product tested would provide the funding for the testing.</td>
<td>$30,000</td>
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<tr>
<td>18</td>
<td>Catch Basin Retrofit Device Placement</td>
<td>Municipal Operations and Maintenance</td>
<td>The objective of this research is to evaluate gross solids removal differences between two, similarly sized and located catchments; one in which a downturned elbow type retrofit is only installed at the most downstream catch basin and one in which retrofits are installed at multiple locations within the catchment.</td>
<td>$60,000</td>
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<td>19</td>
<td>Seeding and Irrigation for Vegetated BMPs</td>
<td>Monitoring and Assessment</td>
<td>Test plots simulating conditions in vegetated BMPs (e.g., bioretention, bioinfiltration, dispersion) will be constructed. Different seeding densities of seed mixes typically used in Eastern Washington, and irrigation regimes will be applied to each test plot. Beneficial plant and weed growth will be monitored. Jurisdictions will be able to use this information to help with plants establishment in vegetated BMPs, resulting in better performance, reduced maintenance needs, and cost savings.</td>
<td>$80,000</td>
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<tr>
<td>Study No.</td>
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<td>20</td>
<td>Planting Options for Bioretention BMPs</td>
<td>Monitoring and Assessment</td>
<td>A plant list of climate-appropriate plants will be developed based on literature sources. Test plots simulating conditions in bioretention BMPs will be constructed. Combinations of seed mixes and substrates, as well as at least one option that has no plants will be applied to the test plots. Infiltration and soil cation exchange capacity will be measured throughout the study.</td>
<td>$70,000</td>
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<td>21</td>
<td>Media Component Study</td>
<td>Monitoring and Assessment</td>
<td>This project would mimic the Western Washington study conducted at the Washington Stormwater Center that evaluated media mixes used in bioretention facilities. The purpose of this study would be to develop bioretention media better suited for Eastern Washington conditions, and if possible maximize usage of locally sourced materials.</td>
<td>$250,000</td>
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<td>22</td>
<td>Treatment for Comingled Stormwater and Agricultural Discharges</td>
<td>Monitoring and Assessment</td>
<td>Synthetic water blends with nutrient, metal, bacteria, and pesticide concentrations typical of those found in agricultural runoff in eastern Washington will be run through test columns with different media and native soil combinations found in Eastern Washington infiltration and UIC stormwater treatment devices. The purpose of this experiment is to determine if existing stormwater treatment is capable of treating agricultural water that is comingled with stormwater to a level that is safe and protective of water quality so that decision makers can make more informed decisions.</td>
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<td>24</td>
<td>Biochar Media Stormwater Treatment Study</td>
<td>Monitoring and Assessment</td>
<td>Two types of biochar are being studied for their stormwater treatment capacity (Kentucky bluegrass and wood-based biochars). A bench-scale laboratory study was completed in 2015. A field scale pilot study began construction in 2014 and will be implemented in 2015. The field portion of the study includes construction and water quality monitoring of storm gardens with biochar-supplemented treatment media along Garland Avenue in Spokane.</td>
<td>$65,000</td>
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<td>27</td>
<td>Media Thickness Study</td>
<td>Monitoring and Assessment</td>
<td>This study will help to determine optimal media depths for maximizing performance and cost-effectiveness bioinfiltration BMPs in Eastern Washington. A bioinfiltration pond with two treatment cells (12- and 18-inch media depth) was constructed adjacent to the parking area at Gonzaga University’s Rudolph Fitness Center. Influent and effluent concentrations for each of the treatment cells will be compared to determine treatment efficiency of each of the cells. From this analysis, differences in treatment efficiency and performance attributable to the different media depths of each of the cells should be determined.</td>
<td>$150,000</td>
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TOTAL ESTIMATED COST $2,595,000
APPENDIX B

Research Proposals
1. **RESEARCH PROPOSAL TITLE**
Modernizing Education and Outreach Strategies

2. **RESEARCH PROBLEM DESCRIPTION**
The way people receive, process, and interact with educational materials is changing as technology evolves. As a result, strategies for disseminating information that were effective in the past (i.e., brochures or posters), may not be as effective now. New, more interactive media tools are becoming available, and, consequently, more interactive media is needed to capture people’s attention.

There are a growing number of examples of how interactive apps, games and media can be used for disseminating environmental messages. These examples may be used as a templates, but it can be daunting to figure out how to adapt your own educational messages to new technology platforms, and creating the new materials might require a specialized skillset that may not be available in-house.

3. **RESEARCH OBJECTIVE**
A new public education technique would be developed for one stormwater topic (e.g., understanding and identifying illicit discharges) that uses new communication technologies and more interactive, educational materials, and addresses cultural differences present in Eastern Washington. The effectiveness of the new materials at eliciting behavioral and attitude changes among target groups will be measured.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**
Environmental interpretation, or more directly, environmental marketing, is a strategy for eliciting behavioral changes among a target audience. While it was practiced long before, the tenants of environmental interpretation were first described by Freeman Tilden, in his book “Interpreting our Heritage,” which was first published in 1957. The tenants of environmental interpretation have remained largely the same, but the delivery methods have evolved as new information dissemination technologies and strategies have been developed. Social media is drastically changing the way people interact, and offers exciting new possibilities for disseminating environmental messages. Social media has been successfully used by environmental groups to get large corporations to change certain environmental policies; however, there is not much research available on how effective social media is at getting the general public to change behavior. There are, however, a number of resources for published (web information), and even college courses taught at a number of well-known institutions such as the Duke Nicholas School of the Environment, regarding using social media for communicating environmental concepts.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

   How broadly will the results of this research apply?
   
   _X_ Nationally  ____Pacific Northwest  ____WA Only  ____Eastern WA
   ____Western WA  ____Puget Sound Basin  ____Interior PNW

   How quickly will you need the results of this research?
   ____ASAP  ____Within 6 months  ____Within 1 year  _x_ ____Within 2 years
   ____Within 5 years  ____Ongoing
6. CONCEPTUAL RESEARCH APPROACH

The first step in this project would be to identify Phase I jurisdictions that may already have begun incorporating more modern and interactive dissemination techniques into their public education programs. If an example is identified that incorporates interactive educational material, social media and other modern communication technologies for a stormwater topic that could adapted for Eastern Washington, it may be selected for evaluation. Otherwise, a research and marketing firm would be hired to develop a new education campaign for one stormwater permit related topic that takes advantage of interactive educational tools, social media and other communication technologies to educate the target audience.

The campaign would be implemented in three different communities in Eastern Washington, which would be selected to ensure that multiple cultures are represented. A survey would be prepared to test the target audience’s understanding of the issue. The survey would be implemented in the three test communities as well as three communities where the campaign was not implemented, but where typical public education materials and strategies were implemented. The survey would be conducted before and after the education strategies were implemented to normalize for existing differences in environmental awareness and to detect behavioral changes among the target groups.

A cost comparison would also be conducted comparing the relative development and distribution cost between the traditional and modernized education campaign with the respective results in the test communities.

Depending on the perceived reception of the new message and distribution strategies, other aspects of public education and outreach programs could be similarly updated.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Modernizing outreach strategies to incorporate social media and other more exciting dissemination techniques, may help to make jurisdiction’s outreach programs more culturally relevant, meaningful, and reach a wider audience.

8. ESTIMATED COST AND TIMING

This study would take between 1 to 2 years and is estimated to cost $100,000. This estimate includes contacting Phase I jurisdictions, development of an educational campaign, baseline assessment of the target audience and other communities, a cost comparison, reassessment of the target audience, a final report, and a 10% project management budget for the lead jurisdiction.
1. RESEARCH PROPOSAL TITLE
Mobile Contractor Illicit Discharge Education

2. RESEARCH PROBLEM DESCRIPTION
Eastern Washington permittees suspect that many illicit discharges are caused by mobile contractors and service providers (e.g., painters, builders, landscapers, concrete companies) who wash waste materials into the street or directly into storm drains. Since this appears to be a widespread and recurring problem, it seems that current education strategies, or inadequate fines and enforcement, are failing to compel mobile contractors and service providers to handle and dispose of wastes properly. Because the mobile nature of these businesses involves working in different locations on a daily basis, traditional outreach strategies that focus on a specific geographic area (e.g., business inspections and outreach at a specific commercial area) are unlikely to reach the mobile contractors. Additionally, because the service providers change locations frequently, illicit discharge detection is more challenging, since a discharge is unlikely to recur in the same location.

3. RESEARCH OBJECTIVE
The objective of this study is to develop and test the effectiveness of new outreach strategies aimed at reaching contractors and service providers about illicit discharges, their responsibilities for proper waste material disposal, and consequences for non-compliance. Developing and testing strategies for ensuring that the mobile service providers are receiving training and outreach materials will also be an integral component of the study.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
Community based social marketing is a common tool for raising people’s awareness of environmental issues (Ecology 2003). There are a number of resources and examples to follow in developing targeted outreach programs. A recent example of such a program is the Puget Sound Spill Kit Program Developed by the Environmental Coalition of South Seattle, (ECOSS 2015) which educated restaurant owners and other businesses about illicit discharges and spill prevention. This program used ‘before and after’ surveys to assess the impact of the education program, similar to what is proposed for this study. There are a number of examples, both local and national which may offer ideas for program development and evaluation of the effectiveness of the program. Literature developed by public health educators and medical professionals also offers analogous examples of successful social marketing, and effectiveness analysis strategies.

5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH
How broadly will the results of this research apply?

___X__Nationally  ____Pacific Northwest  ____WA Only  ____Eastern WA
____Western WA  ____Puget Sound Basin  ____Interior PNW

How quickly will you need the results of this research?

____ASAP  ____Within 6 months  ____Within 1 year  __x__Within 2 years
____Within 5 years  ____Ongoing
6. CONCEPTUAL RESEARCH APPROACH

A specific target service provider (e.g., painters) will be selected through interviews with the permittees. Once a target audience is identified, a social marketing approach will be developed that addresses different messages and delivery mechanisms that could be applied. The approach developed will specifically address outreach to specific ethnicities and cultures common to the construction and landscaping industries in Eastern Washington.

The study approach will likely have the following general steps:

- Baseline assessment of target audience’s awareness and practices pertaining to illicit discharges in test and non-test locations
- Delivery of new education program to target audiences in test locations
- Reassessment of target audience’s awareness relating to illicit discharges at specific time intervals following the educational campaign in test and non-test locations.

Where possible, the new education strategies will incorporate modern educational tools including mobile phone apps, games, etc.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Current education and outreach programs aimed at informing contractors and service providers about their responsibility in avoiding illicit discharges could be updated to incorporate effective elements identified through this research.

8. ESTIMATED COST AND TIMING

This study would take 2 to 3 years to complete and cost approximately $100,000. This estimate includes interviews with permittees, development of a social marketing approach, baseline assessment of the target audience, delivery of the educational materials, reassessment of the target audience, a final report, and a 10% project management budget for the lead jurisdiction.

References


1. RESEARCH PROPOSAL TITLE
Illicit Discharge Detection Methods

2. RESEARCH PROBLEM DESCRIPTION
Permittees are currently required to perform field assessment on at least 40 percent of their municipal separate storm sewer system (MS4) by December 2018, and on average 12 percent each year thereafter. As a result of this requirement most of the resources spent on IDDE are related to meeting this permit requirement. Permittees would like to know if it would be more effective to put the time and money spent on field assessment toward focused outreach, an illicit discharge hotline, and/or additional crew training.

3. RESEARCH OBJECTIVE
The objective of this study is to determine if the routine dry weather field screening is the most appropriate approach for locating illicit discharges. If limited or no illicit discharges are being found through routine field assessment, then it may make sense to propose a modification to the permit during the next permit cycle to help permittees focus these resources on methods that will be more effective in locating illicit discharges.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
An initial survey regarding effectiveness of various illicit discharge field screening methods was conducted during the development of the Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual (Herrera 2012); however, the results of this survey were qualitative and were intended to help with selecting the field screening methodologies that were included in the guidance manual. This survey will focus on quantitative as well as qualitative results.

5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH
How broadly will the results of this research apply?

- [x] Nationally
- [ ] Pacific Northwest
- [ ] WA Only
- [ ] Eastern WA
- [ ] Western WA
- [ ] Puget Sound Basin
- [ ] Interior PNW

How quickly will you need the results of this research?

- [ ] ASAP
- [ ] Within 6 months
- [ ] Within 1 year
- [ ] Within 2 years
- [x] Within 5 years
- [ ] Ongoing
6. CONCEPTUAL RESEARCH APPROACH

This study will be conducted via a survey of stormwater managers. The intent is to for this survey to be statewide and to include both Eastern WA and Western WA jurisdictions.

The survey will gather information from stormwater managers regarding:

- Number of illicit discharges reported through the illicit discharge hotline (currently an annual report question)
- Number of illicit discharges reported by field crews
- Number of illicit discharges found through routine field assessment (will request the methodology used [outfall inspections, catch basin/manhole inspections, etc.])
- Effectiveness of focused business outreach (if this method is being implemented)

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Stormwater managers may shift focus from routine dry-weather screenings to other, more effective, illicit discharge detection methods.

8. ESTIMATED COST AND TIMING

This survey study would take less than a year to complete and cost approximately $30,000. This estimate includes development of the survey questions, coordination with the review team and potential survey participants, Survey Monkey (or similar software), a final report, and a 10% project management budget for the lead jurisdiction.

References

1. **RESEARCH PROPOSAL TITLE**
   Business Inspection Program Strategies

2. **RESEARCH PROBLEM DESCRIPTION**
   Business inspections are not specified in the Eastern Washington permit, but they have been identified as both a field screening and source tracing methodology in the Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual (May 2013). General business inspections focus on material storage and site activities which aim to prevent and control pollutants related to business operations before they reach the storm drainage system or a receiving water.

3. **RESEARCH OBJECTIVE**
   The objective of this study is to determine if business inspections are an effective methodology for illicit connection and illicit discharge field screening. If business inspection programs are shown to be an effective methodology for illicit connection and illicit discharge field screening, then it will help Eastern Washington permittees focus resources currently used for dry weather field assessment on a methodology and educational approach to prevent and control pollutants related to business operations.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**
   An initial survey regarding effectiveness of various illicit discharge field screening methods was conducted during the development of the Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual (Herrera 2012); however, the results of this survey were qualitative and were intended to help with selecting the field screening methodologies that were included in the guidance manual. Business inspections were one of the methodologies included in this survey. A total of 24 out of 35 survey respondents reported using business inspections for illicit discharge field screening. Approximately half of the respondents found business inspections to be very effective and the remaining 50 percent reported that it was moderately effective. A larger study, aimed specifically at jurisdictions that are currently implementing business inspection programs would be useful for jurisdictions who are currently contemplating implementing a business inspection program, but would like to quantify the benefits in terms of illicit discharge reduction.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**
   **How broadly will the results of this research apply?**
   - [x] Nationally  [ ] Pacific Northwest  [ ] WA Only  [ ] Eastern WA  
   - [ ] Western WA  [ ] Puget Sound Basin  [ ] Interior PNW
   **How quickly will you need the results of this research?**
   - [ ] ASAP  [ ] Within 6 months  [ ] Within 1 year  [x] Within 2 years  
   - [ ] Within 5 years  [ ] Ongoing
6. CONCEPTUAL RESEARCH APPROACH

This study will be conducted via a survey of Western Washington stormwater managers with business inspection programs. The survey will gather information from stormwater managers regarding:

- Whether they prioritize business types or areas, and if so how they do so.
- Whether they consider their programs to be effective/cost effective.
- Specifics about how their programs are organized; notification procedures (letter and/or call to business owner), follow-up needs, forms used during business inspections.
- Issues related to private property access for business inspections?
- Is dye testing of floor drains and other indoor plumbing connections performed as part of a routine business inspection or only if an illicit connection is suspected?
- How many illicit connections have been found through their business inspection program?
- How many potential illicit discharges have been corrected through their business inspection program?
- What are the most common problems and corrective actions encountered?

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Results from this question will help stormwater managers prioritize the different components of their illicit discharge and detection program allocate resources and effort where it will have the greatest impact.

8. ESTIMATED COST AND TIMING

This survey study would take less than a year to complete and cost approximately $30,000. This estimate includes development of the survey questions, coordination with the review team and potential survey participants, Survey Monkey (or similar software), a final report, and a 10% project management budget for the lead jurisdiction.

References


1. RESEARCH PROPOSAL TITLE
Soil Amendments for Erosion Control and Revegetation

2. RESEARCH PROBLEM DESCRIPTION
Establishing erosion control vegetation in Eastern Washington can be challenging due to soil conditions and the region’s arid climate. The Stormwater Management Manual for Eastern Washington (Ecology 2004), provides seed mix suggestions and application methods (hydroseeding and mulching). Although there are a number of products and materials available that are meant to enhance establishment of the vegetation, it is unknown how effective they are. Yet, based on some of the available materials from vendors, these products may pose a real advantage to erosion control particularly in problem prone areas. Soil amendments, both proprietary (e.g., Soil2O, Permatamrix, etc.) and widely available additives (e.g., compost) may help boost plant productivity by enhancing soil structure and water retention. There is little comparative information regarding the effectiveness of soil amendments, in Eastern Washington climates.

3. RESEARCH OBJECTIVE
The objective of this study is to test the effectiveness of soil additives for enhancing grass establishment for erosion control in Eastern Washington climates.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
There are a number of studies which evaluate the effectiveness and appropriateness of erosion control plant species. Ecology (2004) also provides specific guidelines for grass species and seeding rates and used for erosion control for Eastern Washington based on rainfall. However, there is no or limited comparative effectiveness information for the different amendment types, especially in relation to plant growth for erosion control in arid and semi-arid climates. A number of academic papers, and method manuals provide guidance on how soil sampling and moisture monitoring should be conducted.

5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH
How broadly will the results of this research apply?

___ Nationally  ___ Pacific Northwest  ___ WA Only  ___ Eastern WA
___ Western WA  ___ Puget Sound Basin  ___ Interior PNW

How quickly will you need the results of this research?

___ ASAP  ___ Within 6 months  ___ Within 1 year  ___ Within 2 years
___ Within 5 years  ___ Ongoing
6. CONCEPTUAL RESEARCH APPROACH

The study will be completed at the field plot scale. At three or more geographic regions in Eastern Washington, small plots would be constructed replicating the soil conditions of typical erosion control/re-vegetation sites. The slope would be kept constant for all test plots. Each plot would receive specific treatments of soil amendments and pre-defined erosion control seed mix based on Ecology (2004) recommendations. Each plot would receive the same establishment irrigation regime, followed by no irrigation, to better resemble field conditions. On a monthly basis for one year, a characterization of plant growth (e.g., height, percent cover) for the planted grasses, and any identified weed species would be conducted. On a quarterly basis, core samples from each plot would be collected for root density measurements. Soil water content will be measured, either continuously in-situ at two depths in each plot, or daily for a period of 2 weeks following rain events using a portable TDR moisture meter (e.g., FieldScout 300). At the onset of the experiment (before planting) and at the conclusion of the experiment, soil properties including: texture, bulk density, cation exchange capacity, nitrogen, potassium, phosphorus, carbon, calcium/magnesium, aluminum, manganese, iron, aluminum and zinc, pH and conductivity would be measured. Statistical analysis would be used to identify significant patterns in growth of the erosion control grasses and weed species attributable to the soil amendments. Statistical tests will also be used for detecting significant differences in soil properties before and after plant establishment, and differences in soil properties between plots and locations.

The results of this study would not identify or quantify the performance of specific products. Rather it would compare generally, whether commercially available soil amendments, as a group, offer any real benefits over non-amended or compost amended conditions. If there are significant performance differences among commercially available products the differences would be reported, but kept anonymous.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Soil amendments shown to improve the growth of grasses for erosion control, while limiting weed growth over native (or disturbed soil) conditions could be used for erosion control projects.

8. ESTIMATED COST AND TIMING

This study would be completed in under two years. The cost of the study as proposed is likely about $90,000. This cost estimate includes about $45,000 for labor QAPP development and reporting, $10,000 for analytical costs and $25,000 for special equipment and a 10% project management budget for the lead jurisdiction. The $25,000 equipment estimate is for in-situ soil moisture monitoring. The equipment cost would likely be about $10,000 - $15,000 less for periodic soil moisture measurements.

References

1. **RESEARCH PROPOSAL TITLE**

Stormwater BMP Owner Awareness

2. **RESEARCH PROBLEM DESCRIPTION**

The permit clearly specifies that the responsibility for upkeep and ensuring the continued function of structural stormwater BMPs falls on the property owner. However many property owners are unaware of these responsibilities, and when a property has changed hands many times, may not even know the BMP exists. Additionally, municipal staff sometimes have difficulty conducting permit specified inspections of structural BMPs because property owners are not aware that BMP inspections are required to take place and they do not want official inspectors on their property. Increasing property owner’s awareness of the obligation and need to routinely maintain structural BMPs to ensure their proper function, may help improve the condition and long-term performance of BMPs. This problem is nation-wide and is not limited to Eastern Washington, so the results of this study may have wide-reaching impacts.

3. **RESEARCH OBJECTIVE**

The objective of this study is to gauge the current level of property owner awareness of maintenance needs, and responsibilities to maintain structural BMPs. Additionally this study will also assess the effectiveness of public outreach for increasing awareness of BMP maintenance responsibility.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**

Difficulties with ensuring maintenance of BMPs located on private property have been documented in the literature. Rafter (2007) highlighted many impediments to maintenance of privately owned BMPs such as; owner awareness, access issues, and expense. These issues were also identified as problems by the Eastern Washington PAG. The same article (Rafter 2007) also identified possible models for allocating maintenance responsibilities. Many municipalities have some published information on their websites about BMPs and their maintenance (e.g., Metropolitan St. Louis Sewer District 2015), but no assessments of the effectiveness of these materials were identified.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

How broadly will the results of this research apply?

- X Nationally
- ___ Pacific Northwest
- ___ WA Only
- ___ Eastern WA
- ___ Western WA
- ___ Puget Sound Basin
- ___ Interior PNW

How quickly will you need the results of this research?

- ___ ASAP
- ___ Within 6 months
- ___ Within 1 year
- X ___ Within 2 years
- ___ Within 5 years
- ___ Ongoing
6. CONCEPTUAL RESEARCH APPROACH

This study is a two part project aimed at assessing BMP owner awareness of maintenance needs and responsibilities, and developing education materials for increasing BMP owner awareness.

As proposed, this study is designed solely as an information gathering effort, consist of survey of property owners with BMPs on their land. Responses will be solicited from owners of a range of BMP types (e.g., filters, detention ponds, vegetated filter strips, bioretention swales), and property types (residential, commercial, industrial). The survey will be designed to gauge the BMP owner’s awareness of the maintenance and inspection requirements of the BMPs on their property. The surveys will be conducted face to face so that the survey can verify the respondent’s answers on-site. A specific list of questions has not yet been developed. The following example questions illustrate the type and subject areas of the survey questions:

- Do you have any stormwater treatment or flow control (BMPs) on your property?
- Where is the BMP located?
- What is the purpose of the BMP?
- How did you obtain information about the BMP on your property?
- How frequently is the BMP maintained? What does that maintenance entail?
- Who maintains the BMP?
- Have municipal staff ever asked you if they may inspect the BMP? Did you let them?

Survey results will be evaluated to determine the level of awareness and where there may be information gaps in BMP owner awareness.

If it appears, based on the results of this of the first phase of this study, that lack of BMP owner awareness is a common reason for BMP failure or lack of maintenance, a follow-up education campaign will be initiated. A targeted education campaign could be developed to specifically address information gaps identified by this survey. The education campaign may incorporate the effective outreach practices through some of the other proposed effectiveness studies. The survey developed during the first phase of the study could be delivered to the BMP owners some length of time after an education campaign is delivered to assess the effectiveness of the education strategy.

If the first (survey) phase of the project does not indicate that BMP owner awareness is a problem, an educational campaign for increasing BMP owner awareness will not be developed.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Based on the results of this study, and others identifying effective outreach practices, a targeted education campaign could be developed to address, specifically, the awareness shortcomings of BMP owners identified by this survey.

8. ESTIMATED COST AND TIMING

This project could be completed in less than a year and would cost approximately $30,000. This estimate includes development of the survey questions, coordination with the review team and potential survey participants, a final report, and a 10% project management budget for the lead jurisdiction.

If an education campaign were developed following the survey, the time to complete and cost would be substantially higher depending on the type of material developed.
References


1. **RESEARCH PROPOSAL TITLE**

   Long-term Maintenance of Privately-Owned BMPs

2. **RESEARCH PROBLEM DESCRIPTION**

   BMPs need to be consistently maintained to ensure their long-term performance. When BMPs are constructed on private property, the property owner is responsible for BMP maintenance; and the permittee is responsible for making sure that necessary maintenance is occurring and that the BMP is in good working order. In Eastern Washington, the permit requires inspections at five year intervals.

   Regular inspections can be hindered by a number of factors. There may not be enough trained municipal staff to conduct the inspections, and ensure that corrective actions are being completed in a timely manner. Access to private facilities for inspection can also be problematic, because property owners don’t want inspectors visiting their properties. Also, in cases when a property with a BMP has changed hands several times, property owners may be unaware of the existence of the BMP.

3. **RESEARCH OBJECTIVE**

   The objective of this study is to determine:
   
   a) If privately owned structural BMPs are being inspected at the permit specified 5-year frequency, and that they are being properly maintained
   
   b) The most significant issues impeding effective long-term BMP maintenance on privately-owned or built facilities.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**

   There was not any literature identified specifically related to strategies or conducting BMP inspections on private property, or strategies for ensuring that BMP maintenance is occurring. However, even among Eastern Washington permittees, it is clear that there are a variety of strategies currently being used. Cataloging these strategies, and evaluating the strengths and weakness of each will help permittees modify and adapt their own programs to be more successful.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

   *How broadly will the results of this research apply?*
   
   X Nationally  Pacific Northwest  WA Only  Eastern WA  
   Western WA  Puget Sound Basin  Interior PNW

   *How quickly will you need the results of this research?*
   
   ASAP  Within 6 months  X Within 1 year  Within 2 years  
   Within 5 years  Ongoing
6. CONCEPTUAL RESEARCH APPROACH

This study will be addressed in two stages. The first stage will serve to provide a snapshot of the status of the inspections and maintenance, and the outcome of corrective actions for privately owned/built BMPs. If the results of this information gathering effort indicate that inspections are being conducted, BMPs are well maintained, and corrective actions are promptly enacted when problems are noted, then no further study is needed. If, however, during the first phase, it appears that current strategy for inspecting and overseeing the management of private BMPs is not working efficiently (i.e., BMPs are not functioning as designed, are poorly maintained, or their status is unknown due to a lack of inspection records), then a second study stage will be conducted to identify the underlying problems and potential solutions.

The first study phase would be to compile existing inspection and maintenance records that have been submitted in annual reports. These reports would be compared to an inventory of privately owned structural BMPs. Inventory records will be used to determine:

- Total number of privately-owned BMPs in each jurisdiction
- Apparent inspection frequency
- Number of BMPs that passed inspection
- Number of BMPs requiring corrective actions
  - if the corrective actions were enacted
  - if fines were issued
  - if a follow-up inspection took place

The second study phase will consist of a survey of Eastern WA permittees to determine what the policy/regulatory limitations are to inspection access or enforcement. The results of this second study phase will provide a framework for a follow-up study aimed at identifying more effective strategies for handling privately owned structural BMPs. All inventory surveys will be provided anonymously.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH Findings

By identifying the most significant issues impeding regular inspections of privately owned BMPs, and identifying the process that are most effective for ensuring that inspections are taking place when they should, policies and procedures can be adjusted to make inspections more efficient and worthwhile.

8. ESTIMATED COST AND TIMING

This project is project to take less than one year. The projected budget would be about $50,000. This estimate includes an initial record review, development of the survey questions, coordination with the review team and potential survey participants, Survey Monkey (or similar software), a final report, and a 10% project management budget for the lead jurisdiction.
1. RESEARCH PROPOSAL TITLE

BMP Inspection and Maintenance Responsibilities

2. RESEARCH PROBLEM DESCRIPTION

Privately-owned structural BMPs represent a unique problem for ensuring long-term maintenance. Complications can arise from access issues for inspection (e.g., an inspector may not have permission to enter private property), and failure to maintain structural BMPs may occur due to lack of interest, unclear and changing ownership, lack of incentive, or limited funding. Commonly, the private party that owns the BMP is responsible for all maintenance. However, there may be other strategies or models, such as public ownership and maintenance responsibility which could support better long-term performance of BMPs.

The following four general strategies were identified for evaluation:

- City/County performs inspection of structural BMPs but requires that the property owner hire a qualified contractor to conduct necessary maintenance and provides proof that the maintenance has been completed
- City/County requires structural BMP owners to contract with a third party inspector and provide an inspection certification letter to the City/County, as well as proof that any required maintenance has been completed
- City/County performs maintenance but the BMP remains under private ownership and the property owner pays the City/County for the service
- City/County assumes ownership, and responsibility for maintenance. Funding could be through existing stormwater fees and/or a onetime payment by the property owner or other means.

3. RESEARCH OBJECTIVE

The objective of this study is to gather information from Washington jurisdictions to learn novel and effective ways that municipalities are meeting the challenge of ensuring ongoing maintenance of structural BMPs on private property.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY

There was not any literature identified specifically related to designating responsibility for maintenance of privately owned BMPs. However, it is clear from discussions with Eastern Washington stormwater managers, as well as guidance documents published by municipalities in other states, that the challenge of long-term BMP maintenance is not unique to Eastern Washington, and that there are a variety of strategies for addressing this challenge. As part of the development of the Western Washington LID Operations and Maintenance (O&M) Guidance Document, an advisory committee on administrative issues was convened and maintenance of privately-owned BMPs was one of the topics discussed and summarized in the Western Washington LID O&M Guidance Document (Herrera 2013).
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

___X___ Nationally  ____ Pacific Northwest  ____ WA Only  ____ Eastern WA
____ Western WA  ____ Puget Sound Basin  ____ Interior PNW

How quickly will you need the results of this research?

___ ASAP  ____ Within 6 months  ____X____ Within 1 year  ____ Within 2 years
____ Within 5 years  ____ Ongoing

6. CONCEPTUAL RESEARCH APPROACH

A survey will be conducted of 10 to 15 municipalities in Washington State to determine how they address the long-term needs of privately-owned structural BMPs. The survey will cover:

- The strategy that the jurisdiction currently uses for inspection and maintenance responsibility
- Number of structural BMPs inspected each year
- Number of enforcement actions taken as a result of those inspections
- Funding mechanisms (e.g., cost share or fee programs for implementing the selected strategy (if applicable)
- Potential inspection or enforcement cost savings through implementation of the selected strategy
- Issues with access or other legalities
- Issues with enforcement or follow through by different agency programs

Stormwater managers from these municipalities will then be interviewed to further discuss their perceptions of the advantages and shortcoming of their programs.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

More effective models for ensuring that privately owned BMPs are maintained on a regular basis may be identified through the proposed research effort. These models may be adopted by jurisdictions where appropriate.

8. ESTIMATED COST AND TIMING

This survey study would take less than a year to complete and cost approximately $30,000. This estimate includes development of the survey questions, coordination with the review team and potential survey participants, Survey Monkey (or similar software), a final report, and a 10% project management budget for the lead jurisdiction.

References

1. **RESEARCH PROPOSAL TITLE**

Impact of Privately Owned BMPs on MS4s

2. **RESEARCH PROBLEM DESCRIPTION**

Many commercial and residential properties in Eastern Washington have privately owned BMPs to handle on-site stormwater. In most cases, it is the owner’s responsibility to maintain these BMPs. However, as per the NPDES permit, municipalities are responsible for inspecting these BMPs once every five years to ensure that they are regularly maintained and function properly. Because stormwater control in Eastern Washington is largely addressed through many individual BMPs (e.g., dry wells and infiltration trenches) rather than the larger BMPs of Western Washington (e.g., constructed wetlands that treat water from entire subbasins), this permit requirement may impose a more stringent requirement on Eastern Washington permittees than was expected. These inspections also pose a number of pragmatic difficulties for jurisdictions including access restrictions and budget limitations in combination with the difficulty of determining the functional status of BMPs when they are dry. This creates a serious set of problems for performing meaningful inspections. In addition, many privately owned BMPs are not designed to discharge to the MS4, even if they overflow, and therefore do not pose a risk to the MS4. If this is the case, the inspection requirement in the permit should be modified to better reflect the level of risk. This study will help assess whether the potential for discharge has increased or decreased following adoption of the Eastern Washington Stormwater Permit.

3. **RESEARCH OBJECTIVE**

The objective of this study is to evaluate whether the potential for discharge to the MS4 has changed as a result of permit implementation.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**

Difficulties with ensuring maintenance of BMPs located on private property have been documented in the literature. Rafter (2007) highlighted many impediments to maintenance of privately owned BMPs such as owner awareness, access issues, and expense that were identified as problems by the Eastern Washington permittees. No information has been identified related to stormwater BMP discharges to MS4s in typically dry areas.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

How broadly will the results of this research apply?

- [ ] Nationally  [ ] Pacific Northwest  [ ] WA Only  [x] Eastern WA  
- [ ] Western WA  [ ] Puget Sound Basin  [ ] Interior PNW  

How quickly will you need the results of this research?

- [ ] ASAP  [ ] Within 6 months  [ ] Within 1 year  [ ] Within 2 years  
- [ ] Within 5 years  [ ] Ongoing
6. CONCEPTUAL RESEARCH APPROACH

Three jurisdictions representing different areas in Eastern Washington would be selected for the study. In each jurisdiction, four different subbasins representing primarily residential land use would be selected for evaluation. Two of the subbasins will have been developed before adoption of the stormwater permit, and two will have been developed after adoption of the stormwater permit. In each of the subbasins, a detailed field assessment will be performed documenting the type and location of all BMPs, their discharge points, and expected discharge point under conditions of failure. Distance to the MS4 will also be estimated. The field assessment will also include a qualitative assessment of the condition of the BMP in terms of potential maintenance needs. If available, engineering reports or other design details associated with the BMPs will be reviewed. Ground truthing of the findings will occur during storm event surveys of the different subbasins. Data collected will be used to calculate the percentage of BMPs that can be expected to contribute to the entire MS4 during typical and large storm events.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Determining if the potential for discharge has increased or decreased since implementation of the permit may help inform design requirements for BMPs in future permit cycles.

8. ESTIMATED COST AND TIMING

This study would take approximately one year to complete and cost approximately $80,000. This estimate includes QAPP development, site selection, field assessment, GIS evaluation, reviewing engineering reports and other design details, conducting storm event surveys, data evaluation, a final report, and a 10% project management budget for the lead jurisdiction.

References

1. RESEARCH PROPOSAL TITLE
Comparison of Costs and Benefits of LID Implementation for Eastern Washington

2. RESEARCH PROBLEM DESCRIPTION
Low impact development (LID) is increasingly being promoted as a viable and effective means of flow control in developed watersheds. There is a growing body of research demonstrating that LID provides substantial flow control benefits over conventional development. However, this research is often focused on specific LID BMPs (e.g., pervious pavement, rain gardens, etc) or LID development philosophies such as implementing the full suite of LID BMPs in a development. In Eastern Washington where there is little rain and generally soils with excellent infiltration capacity, natural dispersion and infiltration are commonly used to control stormwater. Since ‘designed’ low impact development is generally more costly, it is important for planners, developers, and stormwater managers to be able to evaluate whether LID provides a meaningful advantage over traditional development, justifying the higher cost.

This study is a two-part project that will evaluate both flow control benefits and cost effectiveness of conventional stormwater treatment strategies compared to LID.

Flow control benefits will be evaluated through modeling three development approaches: 1) conventional stormwater infrastructure (defined as conveyance pipes, catchbasins as is typical in Western Washington and some parts of Eastern Washington), 2) fully designed’ LID (similar to what is promoted in Western Washington) and 3) a typical Eastern Washington development. Cost estimates will also be developed for each of the three approaches. The model will evaluate two scenarios; one for a subbasin in Eastern Washington and one for a subbasin in Western Washington. This will allow a comparison of the total volume of runoff that could be controlled through the different development approaches which will allow a practical assessment of the differences in costs and benefits.

3. RESEARCH OBJECTIVE
The objective of this study is to compare the runoff volume control benefits achieved through different development approaches and to evaluate their cost-effectiveness when construction and O&M costs are considered. This information will be used by permittees to decide whether and when the different BMP types may be most appropriate for different conditions.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
A number of recent studies use a paired basin approach to compare the relative effectiveness of LID to conventional development. For example, (Line et. al. 2012, Selbig et. al. 2008, Dietz et. al. 2004) compare runoff volumes from watersheds developed with LID to conventional watersheds using both modeling and monitoring. A Cost benefit study was recently performed in Western Washington that evaluated the BMP sizing and cost of implementing stormwater treatment and flow control best management practices (BMPs) in the 2012 Stormwater Management Manual for Western Washington (SWMMWW) vs. the 2005 SWMMWW (Herrera 2013). The study included costs for construction and operations and maintenance (O&M) of Low Impact Development (LID) BMPs as well as conventional stormwater BMPs. Another recent effort compiled construction and O&M costs for LID BMPs and traditional stormwater BMPs for the Puget Sound region (Herrera 2012). Outside of Washington, numerous studies have been completed that evaluate the cost of LID BMPs versus conventional BMPs (ECONorthwest 2007, EPA 2007, EPA 2013, Shaver 2009, and University of New Hampshire 2011). A BMP and LID Whole Life Cost Model was also developed by the Water Environment Research
Foundation (WERF) in 2009 (WERF 2009); however, it does not include the full suite of BMPs that Eastern Washington may be interested in evaluating.

5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

___ Nationally  ___ Pacific Northwest  ____ WA Only  ____ Eastern WA
___ Western WA  ____ Puget Sound Basin  ____ Interior PNW

How quickly will you need the results of this research?

___ ASAP  ____ Within 6 months  ____ Within 1 year  ____ Within 2 years
___ Within 5 years  ____ Ongoing

6. CONCEPTUAL RESEARCH APPROACH

The flow control benefit and cost analysis evaluation would include an Eastern Washington and Western Washington subbasin and the following development scenarios:

- 10-acre single family residential development
- 1-acre commercial development
- 10-acre commercial development

Under each scenario the three different development approaches (conventional, LID, and typical Eastern Washington) will be modeled.

A survey of Eastern Washington permittees would also be conducted to gather bid tabulations from recent projects (e.g., past 5 years) that included structural BMP elements. This information will be used to compile an Eastern Washington Stormwater BMP cost database.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

The information obtained as a result of this study could be used by permittees to evaluate when LID should be implemented and the extent to which they may want to promote LID. It will also support future cost estimating (construction and O&M), benefit evaluation, and selecting the most appropriate BMP design for future stormwater projects.

8 ESTIMATED COST AND TIMING

This study would take 12 to 18 months to complete and cost approximately $90,000. This estimate includes development of the scenarios, coordination with project partners and outreach, modeling and sizing BMPs, a survey and compilation of Eastern WA BMP costs, preparation of a final report, and a 10% project management budget for the lead jurisdiction.
References


1. RESEARCH PROPOSAL TITLE
   Long-term Permeable Pavement Sidewalk Infiltration Rate

2. RESEARCH PROBLEM DESCRIPTION
   Permeable pavement is more expensive than conventional paving materials if material availability and skilled contractors are not readily available; so its function as a stormwater BMP in addition to being a viable and long-lasting surface is critical for its cost justification. Permeable pavement usage for sidewalks is becoming more common in Eastern Washington. However, there are concerns that the infiltration performance and durability of the pavement may be reduced because of Eastern Washington’s harsh climate. Specifically, there are concerns that large seasonal temperature variation resulting in frequent freeze-thaw cycling may shorten the durable lifespan of the surface, and that wind-blown deposition of fine sediments may cause clogging and reduction in infiltration rate of the pavement, limiting its effectiveness as a stormwater BMP.

3. RESEARCH OBJECTIVE
   This study is to determine the useful lifespan of permeable pavement as a sidewalk material, considering both durability and infiltration performance. Specifically, the study will examine the permeability performance over time of the pavement without any maintenance. The study will also evaluate deterioration in surface condition of permeable pavement over time compared to conventional pavement.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
   Numerous studies regarding infiltration performance and longevity of permeable pavement have been conducted in recent years. While these studies have been fairly rigorous, and conducted in a range of locations and climates, there are still questions about how permeable pavement would perform in Eastern Washington’s dry, windy environment with cold winters and hot summers. Several studies (e.g., Liebens et al. 2012, Schauss et al. 2009) address performance in cold climates where freeze thaw cycling is common, and have shown that when appropriate asphalt or cement mixes are used, the durability of the pavement can nearly equal that of conventional paving materials; and that infiltration performance does not suffer as a result of freeze thaw cycling. Sediment loading and clogging of permeable pavement is frequently studied at the pilot scale to simulate lifetime loading of permeable pavement.

   Not surprisingly, these studies have shown that higher sediment loading rates correlate with decreasing infiltration rates (Pezzaniti et al., 2009). No studies were identified that evaluated the infiltration performance of permeable pavement where wind inputs are a concern at the field scale.

   Several guidance documents (i.e., EPA 1999), specifically recommend against using permeable pavement where wind-blown inputs are a concern. Given the extent to which the performance and longevity of permeable pavement has been studied, there are good models to follow for experimental designs and procedures. The most appropriate for measuring infiltration rates of permeable pavement in Washington is ASTM C1701 “Standard Test Method for Infiltration Rate of in Place Pervious Concrete.”
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

___Nationally ___Pacific Northwest ___WA Only ___Eastern WA
___Western WA ___Puget Sound Basin ___Interior PNW

How quickly will you need the results of this research?

____ASAP ____Within 6 months ____Within 1 year ____Within 2 years
____X__Within 5 years ____Ongoing

6. CONCEPTUAL RESEARCH APPROACH

Block-long test segments of permeable pavement sidewalks will be constructed in at least four Eastern Washington communities in similar land use areas. The segment locations should be where there is a grass buffer strip between the roadway and the sidewalk, to ensure that snow and associated street debris is not deposited onto the sidewalk by plowing. No maintenance (i.e., sweeping, vacuuming, pressure washing) will occur even if a decrease in infiltration performance is observed.

Infiltration rate of each of the sidewalk segments will be measured twice yearly for a period of at least 10 years. Infiltration measurements will be taken at 10 locations to account for spatial variability in infiltration rate. Infiltration rate over time will be graphed to determine if, and how fast, a decrease in infiltration rate occurs. Observations of the condition of the pavement will be made on an annual basis. These evaluations will consist of qualitative visual assessments.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

If it is found that the infiltration performance of sidewalk applications of permeable pavement holds up over time, with little or no maintenance in Eastern Washington, permeable pavement may be adopted as a stormwater BMP in appropriate locations.

8. ESTIMATED COST AND TIMING

The study duration will be 10 years, with the option to extend the study indefinitely. The approximate cost over the planned 10 year study period will be $110,000. This cost estimate includes labor, equipment, QAPP development, a final report, and a 10% project management budget for the lead jurisdiction. The estimate does not include construction of the permeable pavement sidewalks.

References


June 2015
B-26 Phase 1: Development of Effectiveness Study Questions for Eastern Washington Permittees
1. **RESEARCH PROPOSAL TITLE**

Permeable Pavements Parking Lot Maintenance

2. **RESEARCH PROBLEM DESCRIPTION**

Permeable pavement can be more expensive than conventional paving materials if material availability and skilled contractors are not readily available; so its function as a stormwater BMP in addition to being a viable and long-lasting surface is critical for its cost justification. There are not yet many permeable pavement parking lots in Eastern Washington. Part of the reason for its slow adoption is due to concerns that the infiltration performance and durability of the pavement may be reduced because of Eastern Washington’s harsh climate. Specifically, there are concerns that large seasonal temperature variation resulting in frequent freeze-thaw cycling may shorten the durable lifespan of the surface, and that wind-blown deposition of fine sediments may cause clogging and reduction in infiltration rate of the pavement, limiting its effectiveness as a stormwater BMP.

3. **RESEARCH OBJECTIVE**

This study will help to address the feasibility of parking lot applications of permeable pavement in Eastern Washington. The study will examine the permeability performance over time of permeable pavement without any maintenance, and will also attempt to identify maintenance practices and restoration procedures to prolong the infiltration capacity of the pavement. The study will also evaluate deterioration in surface condition of permeable pavement over time compared to conventional pavement.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**

Numerous studies regarding infiltration performance and longevity of permeable pavement have been conducted in recent years. While these studies have been fairly rigorous, and conducted in a range of locations and climates, there are still questions about how permeable pavement would perform in Eastern Washington’s dry, windy environment with cold winters and hot summers. Several studies (e.g., Liebens et al. 2012, Schauss et al. 2009) address performance in cold climates where freeze thaw cycling is common, and have shown that when appropriate asphalt or cement mixes are used, the durability of the pavement can nearly equal that of conventional paving materials; and that infiltration performance does not suffer as a result of freeze thaw cycling. Sediment loading and clogging of permeable pavement is frequently studied at the pilot scale to simulate lifetime loading of permeable pavement.

Not surprisingly, these studies have shown that higher sediment loading rates correlate with decreasing infiltration rates (Pezzaniti et al. 2009). No studies were identified that evaluated the infiltration performance of permeable pavement where wind inputs are a concern at the field scale.

Several guidance documents (i.e., EPA 1999), specifically recommend against using permeable pavement where wind-blown inputs are a concern. Given the extent to which the performance and longevity of permeable pavement has been studied, there are good models to follow for experimental designs and procedures. The most appropriate for measuring infiltration rates of permeable pavement in Washington is ASTM C1701 “Standard Test Method for Infiltration Rate of in Place Pervious Concrete.”
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

___ Nationally  ___ Pacific Northwest  ___ WA Only  ___ Eastern WA
___ Western WA  ___ Puget Sound Basin  ___x___ Interior PNW

How quickly will you need the results of this research?

___ ASAP  ___ Within 6 months  ___ Within 1 year  ___ Within 2 years
___x___ Within 5 years  ___ Ongoing

6. CONCEPTUAL RESEARCH APPROACH

Test segments would be designated within the traveling lanes of a newly constructed parking lot. The lanes will be chosen based on sweeper maneuverability limitations and to try to ensure similar loading environments (e.g., avoiding sites in the lee of a building). A specific maintenance treatment will be applied to each segment. The proposed maintenance scenarios would be:

- No routine maintenance, followed by rejuvenation pressure washing and vacuuming on a biennial basis
- Spring time vacuuming only
- Spring time vacuuming followed by quarterly vacuuming
- Spring vacuuming followed by monthly vacuuming

Normal snow removal (i.e., plowing, snow-blowing, and non-sand deicer applications) will continue on all of the test segments. Infiltration rate will be measured for all of the maintenance scenarios on at least a quarterly basis. Over time, these data points will be used to develop curves which will relate infiltration rate over time for each maintenance scenario and thereby predict when failure might occur. Regression statistics will be used to determine if there are significant trends in permeability over time; and if there are differences in the rate of change among the different maintenance scenarios.

Infiltration rate will also be measured before and after cleaning events. These measurements will help determine if there is an immediate effect on infiltration rate attributable to cleaning. Rapid clogging and decrease in permeability is expected under the no routine maintenance scenario, thus the before and after cleaning measurements will also help to determine the extent to which permeability performance can be restored following significant clogging.

Observations of the condition of the pavement will be made on an annual basis. These evaluations will include qualitative visual observations, and may involve quantitative distress surveys involving core samples, density testing, roughness, and failing weight measurements.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

If it is shown in Eastern Washington, that the performance of permeable pavement can be preserved through maintenance practices that are not unreasonably burdensome, permeable pavement may be considered as a viable alternative to conventional stormwater BMPs.
8. ESTIMATED COST AND TIMING
The study duration will be 5 years, with the option to extend the study indefinitely. The approximate cost over the planned 5-year study period will be **$150,000**. This cost estimate includes labor, infiltration testing equipment, QAPP development, coordination, evaluation, a final report, and a 10% project management budget for the lead jurisdiction. The estimate does not include construction of the permeable pavement parking lot, the cost to purchase street sweeping equipment, or the labor for the sweeper operator.

References


1. **RESEARCH PROPOSAL TITLE**

   Sharp Avenue Permeable Pavement Study

2. **RESEARCH PROBLEM DESCRIPTION**
   Permeable pavements have the potential to provide a cost-effective LID solution to stormwater management if they are properly designed, installed, and maintained. While permeable pavement has been installed around the country, and even around the world, research data is limited. The Sharp Avenue Permeable Pavement Feasibility Study (Gonzaga University, August 29, 2014) found long-term monitoring of hydrologic and water quality performance, durability, and maintenance requirements is limited in technical literature especially for high traffic loading and studded tire usage. Before permeable pavement can be considered as an effective stormwater management tool in eastern Washington, the durability (especially during winter conditions), water quality treatment, and long term infiltration performance will need to be assessed.

3. **RESEARCH OBJECTIVE**
   The objective of this study is to assess the effectiveness of three different pervious pavement configurations on an urban arterial with respect to durability, water quality, and long term infiltration performance. Full width pervious concrete, full width porous asphalt, and porous asphalt in parking lanes only will be assessed in comparison to a standard asphalt control section. The project will be installed on Sharp Avenue between Ruby and Hamilton.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**
   The City of Spokane has been working with the Gonzaga University Center for Engineering Design and Entrepreneurship to research the feasibility of construction permeable pavements on Sharp Avenue. The feasibility evaluation required examining existing data sources and scientiﬁc journal papers, along with interviewing professionals who have conducted studies or dealt with porous asphalt (PA) and/or pervious concrete (PC) in other locations. The evaluation found that little data exists for long-term hydrologic and water quality performance and durability. However, the Sharp Avenue site is well suited for such a study with respect to geology, topography, and traffic loading.

   The Sharp Avenue project will be the first of its kind for the City of Spokane. To test the constructability, porous asphalt specification, and monitoring setup, a porous asphalt test strip will be constructed in 2015. A final report for the CEDE 2014 project class (Gonzaga University, April 24, 2015) describes the proposed design and location of the test strip and monitoring, as well as a suggested monitoring framework for the full scale study.

   Design reports for construction of the full scale Sharp Avenue project were prepared by the City of Spokane and submitted to Ecology.
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

_x__Nationally  ____Pacific Northwest  ____WA Only  __ __Eastern WA  ____Western WA  -
____Puget Sound Basin  ____Interior PNW

How quickly will you need the results of this research?

____ASAP  ____Within 6 months  ____Within 1 year  ____Within 2 years  _x__Within 5 years
 ____Ongoing

6. CONCEPTUAL RESEARCH APPROACH

The porous asphalt test strip will be monitored for baseline conditions, including construction
inspection, an as-built conditions evaluation, infiltration monitoring, and possibly water quality
monitoring for about one year. The test strip will be removed for construction of the full scale project.

Three types of permeable pavement sections will be installed on Sharp Avenue: a full width pervious
concrete intersection, several blocks of full width porous asphalt, and several blocks of porous asphalt
bike lanes and parking lanes with standard asphalt travel lanes. Water quality monitoring equipment
will be installed at two different depths for each of the three test sections, below the permeable
pavement section and below the base course, and monitored for water quality. Control samples will be
collected from a nearby control section with standard asphalt. Permanent ring infiltrometers will be
installed in several locations to test infiltration rates over time. Cores will also be collected at intervals
for the first several years after construction to assess infiltration over time.

Durability monitoring will be done by performing traffic counts, observation and rating of surface
stresses, and studded tire detection devices. It will be performed for the same sections as the water
quality and quantity monitoring.

7. ESTIMATED COST AND TIMING

The estimated monitoring budget is $350,000. The test strip will be monitored from summer 2015 to
summer 2016. The full scale project will be monitored after construction in 2016 for several years.

8. CONTACT INFORMATION

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lschmidt@spokanecity.org
509-625-7908
1. **RESEARCH PROPOSAL TITLE**

Street Sweeping and Catch Basin Cleaning Comparison

2. **RESEARCH PROBLEM DESCRIPTION**

Catch basin cleaning and street sweeping are both documented effective strategies for reducing sediment and associated pollutant loads from stormwater runoff. As such, it seems that both strategies are a means to the same end; and therefore one may be substituted for the other, or that there may be an efficient balance to be reached between the two. However, the material removed by each may not be equivalent. For example, street sweeping may be more effective at removing finer particles and catch basins may be more effective at trapping larger particles (Sutherland et. al. 2002). This study aims to compare the amount, size and type of pollutants removed by street sweeping and catch basin cleaning in relation to each other to help evaluate the relative merits of both stormwater protection methods.

3. **RESEARCH OBJECTIVE**

The objective of this study is to compare the type and quantity of material and pollutants removed by both catch basin cleaning and street sweeping. This will help document the relative value of each strategy for protecting stormwater quality, and will help stormwater managers find a cost effective balance of street sweeping and catch basin cleaning.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**

Despite being nearly ubiquitous practices, there are relatively few studies which provide sufficient data for quantifying the pollutant removal rate for street sweeping and catch basin cleaning. For both methods, wide ranges of pollutant removal rates are reported (Law et al. 2008). The wide range of pollutant removal rates reported for street sweeping, vary based on sweeping frequency, sweeper technology and operation, street conditions, and the chemical and physical characteristics of street dirt on catchment conditions, cleaning frequency and type of pollutant (Sutherland et. al 2002, Sutherland et al. 1997, Law et al. 2008). Variability in catch basin pollutant removal rates are largely attributable to site and regional dynamics. Because street sweeping and catch basin cleaning are seemingly complimentary practices, many studies have evaluated the effectiveness of each strategy together. However, there is little information on how the effectiveness of street sweeping and catch basin cleaning pollutant removal is affected by the interaction between the two practices.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

*How broadly will the results of this research apply?*

<table>
<thead>
<tr>
<th>Nationally</th>
<th>Pacific Northwest</th>
<th>WA Only</th>
<th>Eastern WA</th>
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<td>Puget Sound Basin</td>
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*How quickly will you need the results of this research?*

| ASAP | Within 6 months | Within 1 year | x | Within 2 years | Within 5 years | Ongoing |
| _____ | _____ | _____ | x | _____ | _____ | _____ |

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June 2015  
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6. CONCEPTUAL RESEARCH APPROACH

This study will be conducted using a paired watershed approach. Two small watersheds (possibly different sides or segments of the same roadway) will be selected for monitoring. In one of the watersheds, street sweeping will be conducted at regular, monthly intervals, and in the other watershed, street sweeping will not take place. All debris collected during sweeping events will be weighed, analyzed for mass and particle size. Subsequently the amount and size fractions of material removed by street sweeping will be calculated. Catch basins within both watersheds will be cleaned twice per year and the debris collected in catch basins will be analyzed similar to the street sweeping debris. These three reference points will allow for determining how much more material removal was realized in the watershed where both street sweeping and catch basin cleaning were applied as compared to the watershed that only experienced catch basin cleaning.

To normalize between potential differences in pollutant loading between each test segment, the treatments will be switched midway through the study.

Additionally, all Eastern Washington jurisdictions will be requested to report details of their street sweeping and catch basin cleaning programs.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Street sweeping and catch basin cleaning schedules may be adjusted to maximize effectiveness, in terms of material removed and cost efficiency.

8. ESTIMATED COST AND TIMING

The projected project duration will be two years. The approximate project cost will be $150,000. This estimate includes QAPP development, protocols and written guidance, staff coordination, data analysis, a final report, and a 10% project management budget for the lead jurisdiction.

References


Sutherland, R.C. and S.L. Jelen. 1997. Contrary to conventional wisdom, street sweeping can be an effective BMP. Advances in Modeling the Management of Stormwater Impacts. 5: 179-190.

1. RESEARCH PROPOSAL TITLE
Seasonal Differences in Street Sweeping Material Removal

2. RESEARCH PROBLEM DESCRIPTION
Street sweeping is a proven technique for removing solids and associated pollutants from roadways. There have been a number of street sweeping studies that correlate higher pollutant removal with greater sweeping frequency. However, these studies were largely performed in more urbanized areas and focused on evaluation of the effectiveness of street sweeping at regular sweeping intervals (e.g., twice monthly, monthly, and semi-annual). No studies were identified that address the climate conditions and considerations such as seasonal wind-borne inputs faced by Eastern Washington permittees.

While routine sweeping may be a reasonable strategy in areas with consistent pollutant accumulations, it may not be the most cost-effective strategy in areas with large seasonal fluxes. There may be strategies for maximizing the effectiveness of street sweeping that are driven more by region and time of year rather than by routine time intervals (e.g., monthly). A targeted study for Eastern Washington could help stormwater managers make more informed decisions about where and when to focus their efforts to optimize street sweeping effectiveness.

3. RESEARCH OBJECTIVE
The objective of this study is to evaluate seasonal and regional differences in sediment and pollutant accumulations (using pollutant removal through sweeping as a surrogate measure). The information collected will be used by permittees to optimize the cost-effectiveness of their street sweeping programs.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
There is a large body of research that documents the effectiveness of street sweeping as a stormwater BMP for reducing sediment and pollutant loads. A wide range of sediment and pollutant removal rates attributable to street sweeping are reported (Law et al. 2008). The most important variables affecting pollutant removal rates appear to be sweeper type, and sweeping frequency (Sutherland et al. 1997, Law et al. 2008). The highest removal rates were consistently realized using high efficiency, regenerative air vacuums at a twice weekly frequency. At lower sweeping frequencies, or with less efficient equipment, much lower pollutant removal rates were reported.

Municipalities in Eastern Washington, and elsewhere, commonly target street sweeping to coincide with patterns in deposition (e.g., leaf accumulation, and winter sanding), in lieu of, or in addition to regular sweeping. No studies were identified that quantify pollutant removal associated with these seasonally timed sweeping events; nor were any studies identified that evaluated the effectiveness of seasonally adjusted street sweeping frequency based on climatic factors such as wind-blowed inputs.

5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH
How broadly will the results of this research apply?

- [ ] Nationally
- [ ] Pacific Northwest
- [ ] WA Only
- [x] Eastern WA
- [ ] Western WA
- [ ] Puget Sound Basin
- [ ] Interior PNW

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6. CONCEPTUAL RESEARCH APPROACH

Four or five communities representing different regions of Eastern Washington would be selected for monitoring. All the roadways in each community would be swept on a monthly basis (half the community every two weeks). The staggering of sweeping events allows for greater capture of variability in deposition (e.g., wind deposits) events. By sweeping entire communities rather than individual, specific roadway segments, possible factors that could affect loading such as land use, roadway surface type, and traffic volumes are accounted for, even though they wouldn’t be studied individually; and more representative data will be obtained.

For each sweeping event, the amount of material collected will be weighed and recorded (per mile of roadway). On a quarterly basis (four total samples collected during the course of the study), samples will be analyzed for particle size distribution (PSD) and for specific pollutants (e.g., copper and zinc). Statistical analysis will be used to identify whether there are significant factors (e.g., timing, region) affecting the amount of material removed by each sweeping event (a surrogate for sediment deposition rate). Graphical analysis will be used to depict the volume of material and associated pollutants removed with each sweeping event to identify patterns or differences between regions.

If possible, sweepers of the same type (e.g., high efficiency or regenerative air) should be used in each of the communities where the study would be conducted to allow for comparability of results among communities. However, because the study is looking at mass removed in individual communities, and not efficiency (percent of deposited load removed), the sweepers do not have to be the same.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

The timing of street sweeping events may be better focused on the time(s) of year when it will have the greatest effect on material removal. This may improve the effectiveness of street sweeping programs by increasing the amount of material removed, and may save jurisdictions money, because they can scale back street sweeping when it will have less impact.

8. ESTIMATED COST AND TIMING

Sampling for this study would be conducted over a 2-year period during the sweeping season (March-October). The approximate cost of the study would be about $200,000. This estimate includes development of a QAPP, coordination, laboratory analysis, labor associated with sample collection, data QA, a final report, and a 10% project management budget for the lead jurisdiction. This estimate does not account for equipment (sweeper) purchase and does not include the cost of sweeper operation, sweeper operator wages, or the purchase of scales for weighing loads.
References


Sutherland, R.C. and S.L. Jelen. 1997. Contrary to conventional wisdom, street sweeping can be an effective BMP. Advances in Modeling the Management of Stormwater Impacts. 5: 179-190.
1. RESEARCH PROPOSAL TITLE

Catch Basin Insert Monitoring Protocol

2. RESEARCH PROBLEM DESCRIPTION

Catch basin inserts (CBIs) are a simple to use technology that, if effective, may offer stormwater managers a viable solution for addressing small and large scale stormwater pollution problems. The Stormwater Management Manual for Eastern Washington currently suggests CBIs for inlet protection, but only in a limited capacity, and primarily for handling site-specific problems. However, a few studies have shown that widespread, targeted applications of CBIs can aid in achievement of total maximum daily loads (TMDLs) for certain water quality constituents.

There is some, albeit limited, performance data available for commercially available CBIs. However, the performance data comes from multiple sources with different interests (i.e., academic vs. vendor) and evaluation methods vary widely, so balanced comparisons for making decisions on appropriate applications is difficult. Where there are more rigorous comparison studies, the specific CBI type is often left unnamed. Additionally, removal efficiencies for different constituents appears to vary widely among brands and types, therefore different CBIs may be more appropriate for specific situations. Having a framework for evaluating CBI performance will help stormwater managers to objectively test specific brands and designs of CBIs to ascertain their applicability for meeting specific water quality goals.

3. RESEARCH OBJECTIVE

The objective of this study is to develop a protocol (Quality Assurance Project Plan [QAPP]) for evaluating the effectiveness of commercially available CBIs at bench and field scales. Having this procedure in place will streamline testing and evaluation, and will ensure uniformity of methods allowing for objective performance comparisons. This protocol would be developed with input from Ecology and interested vendors. Vendors who chose to have their product tested would provide the funding for the testing.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY

There are a number of published studies (e.g., Mullen 2003; Hipp et al. 2008) which quantify the performance of CBIs. However, the list is far from exhaustive with respect the number of commercially available CBIs. The majority of studies were conducted at the mesocosm scale with synthetic stormwater. This strategy was used by Hipp et al. (2008), University of Arkansas (2003) and others, and appears to be a relatively efficient and controlled way to evaluate performance. About half of the research identified was academic and the other half was published information provided by CBI vendors. Some academic studies provided reliable pollutant removal rates, but due to vendor requests did not identify by name the CBIs that were tested. In general, it appears that some CBIs may be helpful at reducing specific pollutant concentrations and, subsequently, pollutant loads, but more testing is needed to identify the best-suited CBI for various performance objectives.
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

- [X] Nationally  - [ ] Pacific Northwest  - [ ] WA Only  - [ ] Eastern WA  
- [ ] Western WA  - [ ] Puget Sound Basin  - [ ] Interior PNW  

How quickly will you need the results of this research?

- [ ] ASAP  - [ ] Within 6 months  - [ ] Within 1 year  - [X] Within 2 years  
- [ ] Within 5 years  - [X] Ongoing  

6. CONCEPTUAL RESEARCH APPROACH

The primary intent of this study is to develop a QAPP with input from affected parties. However, the following provides a general description of is the expected approach that would be used for testing.

The performance of each CBI will be evaluated at the laboratory scale using synthetic stormwater and flow rates within the manufacturer’s inflow specifications. Each CBI’s performance will be evaluated based upon removal efficiency of total suspended solids (TSS; analyzed by particle size class), nutrients, metals, hydrocarbons, and other selected organic compounds. The testing would be done in such a way to extrapolate life cycle (initial and routine operations and maintenance) costs for each CBI. The results would also indicate the extent to which treatment performance specific to individual pollutants differs between CBI types.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

This question will likely not affect any management changes immediately. However the testing protocol developed via this study will afford stormwater managers the tools to make informed decisions when choosing catch basin retrofits to address specific stormwater problems.

8. ESTIMATED COST AND TIMING

QAPP development would likely take less than six months and cost approximately $30,000. This estimate includes QAPP development, coordination, and a 10% project management budget for the lead jurisdiction.

References


1. **RESEARCH PROPOSAL TITLE**
Catch Basin Retrofit Device Placement

2. **RESEARCH PROBLEM DESCRIPTION**
There are several 'simple' catch basin retrofits such as hoods/snouts, downturned elbows, and tees that are thought to improve the effectiveness of catch basins for removing floatables and gross solids and the pollutants associated with them. Smith (2010) reported floatable and gross solid removal rates ranging from 27 to 52 percent for catch basins equipped with a snout, elbow or tee. Catch basins without these devices are thought to do little to remove floatables and oils, because the primary removal mechanism of a typical, deep sump catch basin is settling.

The presence of these retrofits, is reported to cause difficulties for routine maintenance and cleaning, especially in smaller catch basins. This is due to the lack of space for the vacuum hose to easily reach the bottom of the catch basin sump. As a result, the devices are sometimes removed and may not be reinstalled correctly, or at all. Given the access difficulties in smaller catch basins with these devices installed, a study would help determine how retrofits can be applied most effectively to maximize their benefit and minimize maintenance burdens.

3. **RESEARCH OBJECTIVE**
The objective of this research is to evaluate gross solids removal differences between two, similarly sized and located catchments; one in which a downturned elbow type retrofit is only installed at the most downstream catch basin and one in which retrofits are installed at multiple locations within the catchment. If targeted application (i.e., downstream installations) of downturned elbows is shown to be equally effective, identifying locations within the municipal separate storm sewer system (MS4) where these retrofits have the greatest benefit would help to prioritize where they are used, and inform catch basin design to facilitate compatibility and reasonable maintenance procedures.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**
A few recent studies (Mullen 2003; Smith 2010) have clearly documented the effectiveness of hoods, snouts and tees for improving the effectiveness of catch basins and removing floatable solids and oils. Documented removal rates vary widely, and range from about 30 to 85 percent (Smith 2010), depending on the material trapped. All of the studies identified performed a direct comparison between retrofitted and typical catch basins. However, none of these studies documented system-wide effectiveness where only selected catch basins are retrofitted. Also, none of the studies reviewed addressed the reported maintenance problems in small catch basins with retrofits installed.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

How broadly will the results of this research apply?

___X___ Nationally   ___Pacific Northwest   ___WA Only   ___Eastern WA
___Western WA   ___Puget Sound Basin ___Interior PNW

How quickly will you need the results of this research?

___ASAP ___Within 6 months ___Within 1 year  _X___Within 2 years
___Within 5 years ___Ongoing

June 2015

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6. CONCEPTUAL RESEARCH APPROACH

Small paired catchments (e.g., two sides of the same street or large parking lots) will be selected for monitoring. Catchments will be selected that contain a series of catch basins connected to the same endpoint. In one catchment, each catch basin would contain a retrofit device; in the other, only the final catch basin in the series would be retrofitted. At specific intervals (e.g., monthly) the quantity of oil and grease, solids, floatables, and other associated pollutants will be estimated in each of the catch basins in both test catchments. The total amount of material removed would be quantified for each system, with the area normalized to account for differences in drainage area between the watersheds, and compared.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

If it is shown that targeted, downstream installations of simple catch basin retrofits is as effective as installing catch basin retrofits in every catch basin, documented access and maintenance difficulties could be substantially reduced.

8. ESTIMATED COST AND TIMING

This study would take approximately 18 months to complete and cost around $60,000. This cost estimate includes QAPP development, field labor for sample collection, laboratory costs, data QA and preparation, coordination, preparation of a final report, and a 10% project management budget for the lead jurisdiction. This cost estimate does not include the cost of retrofit parts.

References


1. **RESEARCH Proposal Title**
Catch Basin Retrofit Device Placement

2. **RESEARCH PROBLEM DESCRIPTION**
There are several ‘simple’ catch basin retrofits such as hoods/snouts, downturned elbows, and tees that are thought to improve the effectiveness of catch basins for removing floatables and gross solids and the pollutants associated with them. Smith (2010) reported floatable and gross solid removal rates ranging from 27 to 52 percent for catch basins equipped with a snout, elbow or tee. Catch basins without these devices are thought to do little to remove floatables and oils, because the primary removal mechanism of a typical, deep sump catch basin is settle.

The presence of these retrofits, is reported to cause difficulties for routine maintenance and cleaning, especially in smaller catch basins. This is due to the lack of space for the vacuum hose to easily reach the bottom of the catch basin sump. As a result, the devices are sometimes removed and may not be reinserted correctly, or at all. Given the access difficulties in smaller catch basins with these devices installed, a study would help determine how retrofits can be applied most effectively to maximize their benefit and minimize maintenance burdens.

3. **RESEARCH OBJECTIVE**
The objective of this research is to evaluate gross solids removal differences between two, similarly sized and located catchments; one in which a downturned elbow type retrofit is only installed at the most downstream catch basin and one in which retrofits are installed at multiple locations within the catchment. If targeted application (i.e., downstream installations) of downturned elbows is shown to be equally effective, identifying locations within the municipal separate storm sewer system (MS4) where these retrofits have the greatest benefit would help to prioritize where they are used, and inform catch basin design to facilitate compatibility and reasonable maintenance procedures.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**
A few recent studies (Mullen 2003; Smith 2010) have clearly documented the effectiveness of hoods, snouts and tees for improving the effectiveness of catch basins and removing floatable solids and oils. Documented removal rates varied widely, and range from about 30 to 85 percent (Smith 2010), depending on the material trapped. All of the studies identified performed a direct comparison between retrofitted and typical catch basins. However, none of these studies documented system-wide effectiveness where only selected catch basins are retrofitted. Also, none of the studies reviewed addressed the reported maintenance problems in small catch basins with retrofits installed.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**
How broadly will the results of this research apply?

- [X] Nationally
- [ ] Pacific Northwest
- [ ] WA Only
- [ ] Eastern WA
- [ ] Western WA
- [ ] Puget Sound Basin
- [ ] Interior PNW

How quickly will you need the results of this research?

- [X] ASAP
- [ ] Within 6 months
- [ ] Within 1 year
- [ ] Within 2 years
- [ ] Within 5 years
- [ ] Ongoing

June 2015
6. CONCEPTUAL RESEARCH APPROACH

Small paired catchments (e.g., two sides of the same street or large parking lots) will be selected for monitoring. Catchments will be selected that contain a series of catch basins connected to the same endpoint. In one catchment, each catch basin would contain a retrofit device; in the other, only the final catch basin in the series would be retrofitted. At specific intervals (e.g., monthly) the quantity of oil and grease, solids, floatables, and other associated pollutants will be estimated in each of the catch basins in both test catchments. The total amount of material removed would be quantified for each system, with the area normalized to account for differences in drainage area between the watersheds, and compared.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

If it is shown that targeted, downstream installations of simple catch basin retrofits is as effective as installing catch basin retrofits in every catch basin, documented access and maintenance difficulties could be substantially reduced.

8. ESTIMATED COST AND TIMING

This study would take approximately 18 months to complete and cost around $60,000. This cost estimate includes QAPP development, field labor for sample collection, laboratory costs, data QA and preparation, coordination, preparation of a final report, and a 10% project management budget for the lead jurisdiction. This cost estimate does not include the cost of retrofit parts.

References


1. RESEARCH PROPOSAL TITLE
Seeding and Irrigation for Vegetated BMPs

2. RESEARCH PROBLEM DESCRIPTION
Beneficial plants can improve the treatment and hydrologic performance of vegetated BMPs (e.g., bioretention, bioinfiltration, dispersion) and also perform an important aesthetic function. However, the current media specified for these facilities is rich in carbon. This, coupled with irrigation practices intended to maintain plant growth, may promote the establishment of undesirable weed species. The Eastern Washington LID Guidance Manual (AHBL and HDR 2013) is a good starting point for guiding permittees in terms of selecting plants for vegetated BMPs. It provides an exhaustive plant list, and general guidance for selecting appropriate plants for different functions (e.g., dispersion and bioretention). However, since the Eastern Washington LID Guidance Manual applies to the whole of Eastern Washington, and covers many topics, its recommendations lack sufficient detail to guide planting procedures in specific locations.

It is possible the plant choices, seeding techniques, and irrigation practices commonly used and promoted in Eastern Washington facilitate weed growth instead of promoting establishment of desirable plants. For example, current planting and irrigation strategies may include high density seeding (upward of 200 seeds/square foot [sf]) and regular irrigation. This strategy can be effective in the short term, but over time, may benefit less desirable plants or monocultures. One of the causes may be that high germination rates result in increased competition for water, light and nutrients among the plants, giving a competitive advantage to the hardiest species, which may be weeds. Similarly, providing supplemental water may remove the competitive advantage native plants have for surviving in semi-arid environments. Proper selection of seed mixes, and careful sourcing of weed free media, can help reduce weed problems in BMPs. Ultimately though, the density at which the seeds are applied (seeds/sf), and the timing and volume of irrigation water (if any) applied may have an even bigger impact on whether a mix of desirable plants thrive, or whether one or two weedy species outcompete the rest.

3. RESEARCH OBJECTIVE
This study question will evaluate different combinations of seeding and irrigation strategies to develop a region-specific seeding and irrigation protocol.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
Seeding rate and irrigation guidelines are readily available for forage and erosion control grasses, and are available in a number of university extension documents. For example McLain et al., (2009) lists seeding rates for more than 10 grasses based on precipitation and soil type. Darseen (2009) recommends a seeding rate of about 40 seeds per square foot for the establishment of grasses in New Mexico, and the Natural Resources Conservation Service (NRCS) generally recommends seeding rates of 20-60 seeds per foot for grasses, citing nutrient and water competition as the reason for the seemingly low rates (NRCS 2009).

However, there is not the same volume of research on non-forage plants that are used in vegetated BMPs in dry climates. Seeding recommendations for non-grass are much scarcer, and there are even fewer recommendations for dry climates.
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

_____ Nationally   _____ Pacific Northwest   _____ WA Only   _____ Eastern WA
_____ Western WA   _____ Puget Sound Basin   _____ Interior PNW

How quickly will you need the results of this research?

_____ ASAP   _____ Within 6 months   _____ Within 1 year   _____ Within 2 years
_____ Within 5 years   _____ Ongoing

6. CONCEPTUAL RESEARCH APPROACH

The study will be completed at the field plot scale. At three or more geographic locations, 12 small plots would be constructed replicating the conditions of a vegetated BMP. Each plot would receive specific treatments of seeding density, irrigation timing and volume, and nutrient levels (see table below). As illustrated in the table, the treatments will test the effects of seeding density (using a commonly applied seed mix), typical irrigation strategies, and high and low nutrient level media mixes. At set time intervals (e.g., 1, 2, 3, and 5 years), the plants within each test plot would be identified and estimates would be developed of percent cover, percent cover by individual species, height and general plot and plant conditions. Statistical analysis would be used to identify significant patterns related to irrigation and seeding practices, media nutrient levels, and interactions between these factors.

<table>
<thead>
<tr>
<th>Example vegetated BMP seeding, irrigation, and media treatments</th>
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<tr>
<td><strong>Low Density Seeding</strong></td>
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<td>Low nutrients</td>
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<td>Traditional irrigation</td>
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<td>No irrigation</td>
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7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Better strategies for establishing beneficial plants in vegetated BMPs may be adopted resulting in better performance, reduced maintenance needs, and cost savings.

8. ESTIMATED COST AND TIMING

The duration of this study will be approximately 5 years; however, it could be longer depending on the value of continued plant community observations. For a 5-year study, the approximate cost would be about $80,000. This cost assumes that there is no land cost (i.e., the study is performed on existing publically owned property) and that municipal maintenance staff would prepare the test plots using public equipment. The $80,000 cost estimate also includes 10% for project management for the lead jurisdiction.
References


### 1. RESEARCH PROPOSAL TITLE
Planting Options for Bioretention BMPs

### 2. RESEARCH PROBLEM DESCRIPTION
A number of BMPs included in the Stormwater Management Manual for Eastern Washington (e.g., bioinfiltration swales and vegetated filter strips) include installation of plants as part of the design. In Eastern Washington, these facilities are typically planted with a dryland grass seed mix. While these plants or their root structure may enhance pollutant removal and/or infiltration capacity and aesthetics, they also create extra maintenance needs, including watering and mowing. The extra watering especially in combination with the nutrient-enriched planting soil media used in these facilities provides enhanced growth conditions for establishment of weedy species. It is possible that appropriate plant selection will minimize the need for supplemental watering and decrease the establishment of weed species and that the infiltration performance of these BMPs, which is the primary purpose in Eastern Washington, may be adequate without the presence of plants.

### 3. RESEARCH OBJECTIVE
The purpose of this study is to compare different planting options, focusing on plants that require less water to establish and maintain, with typical dryland grass in terms of plant community establishment, maintenance needs, and weed establishment. A secondary objective is to test the feasibility of a ‘no plants’ option for BMPs that are typically vegetated.

### 4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
There are a number of lists of plants suitable for bioretention in arid climates that are available through state agencies and university cooperative extensions such as Vanderhaar (2009) as well as the plant lists developed for the Eastern Washington Low Impact Development (LID) Guidance Manual (AHBL and HDR 2013) and the Yakima Regional LID Stormwater Design Manual (AHBL and URS 2011). There is relatively little research relating plant growth success with climate specific patterns and or media characteristics. One study was identified that was similar to the study proposed here. Houdeshel et al. (2010) conducted test bioretention swales and exposed them to different precipitation timing, while keeping the volume relatively constant. Their results showed the important role that precipitation timing has on the success of plant growth of specific species in arid climates. This gives credence to the idea that local factors should be considered in the design of vegetated BMPs in arid climates.

### 5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH
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6. CONCEPTUAL RESEARCH APPROACH

A list of native and climate appropriate plant species for use in non-irrigated environments, such as those used for restoration of mine sites or dryland riparian environments, will be developed. Their habitat needs (e.g., soil structure and water requirements), reproduction strategies, and other characteristics will be evaluated against the physical conditions that exist in a bioretention swale in Eastern Washington. Based on this background research, up to four plant/media combinations will be selected for testing at field sites; one of which will represent a dryland grass and soil media as commonly used in Eastern Washington, and one of which will include no plants and a media that minimizes nutrients. A minimum of three locations representing different ecoregions of Eastern Washington will be selected for testing. Four plots representing the four plant/media combinations will be installed in each of the three locations. One of the plant/media combinations tested will not include any vegetation. Supplemental watering and weeding will occur during the first year of establishment in all plots except the no plants plot. In subsequent years no supplemental watering or weeding will occur. Infiltration rate would be measured every six months. Plant species type, density and condition will be monitored each year for three years. No water quality sampling will occur. A follow-up study evaluating differences in pollutant removal may be merited, depending upon the results of this study and/or others that may be proposed.

7. POTENTIAL MANAGEMENT CHANGES resulting FROM RESEARCH FINDINGS

Stormwater managers will be able to make more informed decisions in selecting planting strategies for bioretention BMPs. The effectiveness of bioretention BMPs may be improved through these actions.

8. ESTIMATED COST AND TIMING

The duration of this study will be about 3 years, but it could be longer depending on the value of continued community observations. For a 3-year study, the approximate cost would be $70,000. This estimate includes development of a QAPP, labor costs and materials for planting and seeding, labor costs and equipment (3 infiltrometers) for evaluation for the 3-year duration of the study, data QA and preparation, a final report, and a 10% project management budget for the lead jurisdiction. This estimate does not include land cost (i.e., the study is done on existing property) and assumes that municipal maintenance staff will prepare the test plots using public equipment.

References


1. RESEARCH PROPOSAL TITLE
Media Component Study

2. RESEARCH PROBLEM DESCRIPTION
Current research results for improving performance of bioretention media have resulted in extensive information on characteristics of various potential bioretention media components. The general recommendations from this study will likely be a blend that consists of:

- Volcanic sand (or any coarse sand that does not export pollutants)
- A carbon source such as high carbon fly ash and/or granular activated carbon
- Organic material such as coco coir for plant support

The purpose of this study is to use the current research results as a starting point for evaluating whether modifications to the media mix may result in a blend that is more suitable to Eastern Washington. In Eastern Washington, different performance criteria may be appropriate. For example, it may not be as desirable to install plants in these BMPs when plants are used, their nutrient and water needs are different. Therefore, there may be differences in media components and/or the percent composition of these components that would create a media more suited to Eastern Washington. The study will be used to evaluate local sources of some of the media components (e.g., local sand to replace the sand component and local sandy loams to replace the sand/organic component) where appropriate. A media that maximizes use of locally sourced components and that does not contribute to excessive growth of less desirable plants or plants that require supplemental watering would reduce overall costs and possibly maintenance needs.

3. RESEARCH OBJECTIVE
Evaluate the potential for modifying the composition of the bioretention media blend specified for Western Washington to better suit the needs of Eastern Washington. This study would also contribute to the growing science of bioretention media and the functional attributes of various media components. Depending upon research results, a follow-up field study may be implemented to evaluate performance of the selected media under field conditions, most notably during periods of frozen ground or freeze/thaw conditions.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
In the past few years, the body of research related to bioretention media has expanded greatly. A current study has resulted in collection of extensive data on the characteristics of various components and recommendation on a high performing blend. This study has shown a high level of performance in terms of pollutant removals without the inclusion of plants. This and other research have also demonstrated that there are vastly different physical and performance characteristics associated with different sources of the same components (e.g., different sands). This study will expand those results to evaluate additional local sources of media components and look more closely at the value of a ‘no plants’ option for bioretention facilities in Eastern Washington.
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

___ Nationally  ___ Pacific Northwest  ____ WA Only  ___ Eastern WA

___ Western WA  ____ Puget Sound Basin  ___ Interior PNW

How quickly will you need the results of this research?

___ ASAP  ___ Within 6 months  ____ Within 1 year  ___ Within 2 years

___ Within 5 years  ___ Ongoing

6. CONCEPTUAL RESEARCH APPROACH

This bench scale study will take advantage of the same media column testing design that is being used in the current research in Western Washington. The study will be used to evaluate local sources of some of the media components (e.g., local sand to replace the sand component and local sandy loams to replace the sand/organic component). These media blends will be tested at application rates that typify the storm intensity and volumes experienced in Eastern Washington. These media blends will also be tested using locally sourced materials. No technical, political or institutional barriers have been identified for this study; it is an expansion and refinement of existing or ongoing work.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

Developing media mixes for bioretention BMPs that maintain or enhance water quality treatment benefits and utilize more local sources of materials, will improve the overall cost effectiveness and feasibility of bioretention BMPs for stormwater treatment in Eastern Washington.

8. ESTIMATED COST AND TIMING

This project would likely take 2 years to complete. The project, as proposed, would cost approximately $250,000. Design and set up of the test columns is the most significant expense variable. This estimate includes development of a QAPP, materials and labor for constructing test columns, laboratory analysis, data QA and preparation, a final report, and a 10% project management budget for the lead jurisdiction.
1. **RESEARCH PROPOSAL TITLE**

Treatment for Comingled Stormwater and Agricultural Discharges

2. **RESEARCH PROBLEM DESCRIPTION**

Many Eastern Washington municipal separate storm sewer systems (MS4s) serve as receiving waters for agricultural discharges, yet the pollutants of most concern in agricultural discharges, particularly nutrients, bacteria, pesticides, and metals, can be different than those associated with municipal stormwater, and may occur at substantially higher concentrations. The treatment technologies used to address pollutants associated with municipal stormwater may not necessarily address the pollutants generated in agricultural discharges. This can pose a problem for stormwater managers because when agricultural water is comingled with stormwater, it becomes the responsibility of the municipality to ensure that the discharge meets water quality standards. This is an especially pertinent concern in Eastern Washington because stormwater management strategies are increasingly moving towards infiltration and underground injection. Stormwater treatment technologies may not be capable of reducing the pollutants associated with agricultural discharges and therefore this poses a potential risk to drinking water sources.

3. **RESEARCH OBJECTIVE**

The objectives of this study are to identify typical water quality differences between agricultural discharges and stormwater; and to evaluate the capability of existing and commonly used stormwater treatment technologies, particularly those that rely on infiltration or underground injection, to treat these discharges to a safe level that is protective of water quality. The underlying intent is to provide this information to decision makers in order to educate them about the potential risk.

4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**

Numerous studies have characterized pollutant concentrations in agricultural discharges for irrigated agriculture in the western United States. A preliminary literature review did not result in many studies specific to Eastern Washington, although publications such as Johnson et. al. (2000) do provide some values. There was no literature identified that examined, specifically, the impacts of comingle agricultural discharges and stormwater, and only a few gray literature publications that mentioned comingle of agricultural discharges and stormwater; although the problem is believed to be fairly common at the urban/agricultural interface throughout the irrigated west.

5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

*How broadly will the results of this research apply?*

- X National
- Pacific Northwest
- WA Only
- Eastern WA
- Western WA
- Puget Sound Basin
- Interior PNW

*How quickly will you need the results of this research?*

- ASAP
- Within 6 months
- Within 1 year
- X Within 2 years
- Within 5 years
- Ongoing

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June 2015

Phase 1: Development of Effectiveness Study Questions for Eastern Washington Permittees
6. CONCEPTUAL RESEARCH APPROACH

Literature values of nutrient, metal, pesticide and bacteria concentrations associated with stormwater and agricultural wastewater will be obtained; focusing on information available from Eastern Washington.

Laboratory test columns will be constructed with substrates typical of infiltration stormwater treatment technologies (e.g., bioretention soil media), and with native soils that are relied upon for underground injection. Synthetic blends of water with pollutant concentrations approximating the literature values identified for agricultural discharge will be run through the test columns, and pollutant removal efficiency will be calculated. The concentration of pollutants flowing through the columns, which represents what could potentially be reaching surface and groundwater, will be compared to state water quality, groundwater, and drinking water standards.

7. POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS

There will likely be no immediate management changes resulting from this research study. Ultimately, jurisdictions might work towards keeping agricultural return flows separate, so that they can each be treated more effectively prior to discharge.

8. ESTIMATED COST AND TIMING

The expected project duration is 1 to 2 years. The expected budget is approximately $250,000. Design and set up of the test columns is the most significant expense variable. This estimate includes development of a QAPP, materials and labor for constructing test columns, laboratory analysis, data QA and preparation, a final report, and a 10% project management budget for the lead jurisdiction.

References

1. RESEARCH PROPOSAL TITLE
Biochar Media Stormwater Treatment Study

2. RESEARCH PROBLEM DESCRIPTION
Bioretention (also known as storm gardens in the Spokane region) is a form of LID that intercepts and treats stormwater through plants and engineered soil media before discharging the treated water through infiltration or underdrains. The standard soil mix for bioretention in the eastern and western Washington LID manuals is a mix of sandy soils and compost. However, recent research has indicated that phosphorus and nitrogen can be leached from the compost component of the soil mix. Because phosphorus is a critical concern in the Spokane River and aquifer, alternatives to this soil mix that leach less phosphorus, while still treating metals and other contaminants, are desired.

One potential alternative to compost that may be able to capture stormwater contaminants and nutrients is biochar. Biochar is a carbon-rich material produced from thermal decomposition of biomass at elevated temperatures with little or no oxygen. The biomass can come from a multitude of different feed stocks, such as wood or grass. It has a high surface area and porosity, which are desirable characteristics for capturing contaminants.

3. RESEARCH OBJECTIVE
The goal of this project is to sample stormwater pollutant concentrations entering and exiting a storm garden cell containing a specified mixture of wood biochar and soil, which was determined from laboratory column studies. Stormwater will be sampled for a suite of standard parameters relevant to best management practice (BMP) performance. The main objective is to determine pollutant removal efficiency through the storm garden amended with wood biochar.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY
Phase I of this study included bench scale laboratory testing to identify a soil mix for future analysis in a field application. The City worked in coordination with Gonzaga University, The Lands Council, AHBL, and other interested parties to complete this first phase of analysis. Column testing was performed at the Gonzaga University hydraulics laboratory. A series of columns were constructed containing various quantities of the two biochars, loamy sand, and other additives such as oyster shells, basalt containing iron, and limestone dolomite. A synthetic stormwater mixture was created to mimic City stormwater and dosed through the columns at a rate mimicking natural storms. Synthetic stormwater effluent was analyzed from each column for the removal of total suspended solids, total and dissolved lead, copper and zinc, total and dissolved phosphorus, ammonia, nitrate, nitrite, total kjeldahl nitrogen, hardness, and pH.

Results from the study determined that the wood biochar with loamy sand (and no other additives) removed the greatest amount of contaminants in the study, and was selected for use in the storm garden field sampling phase. A soil specification was developed, and is included in the QAPP for the field portion of the study.
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

___Nationally  ___x__Pacific Northwest  ____WA Only  ____Eastern WA  ____Western WA  -
____Puget Sound Basin  ____Interior PNW

How quickly will you need the results of this research?

___ASAP  ____Within 6 months  ____Within 1 year  ___x__Within 2 years  ____Within 5 years
___Ongoing

6. CONCEPTUAL RESEARCH APPROACH

The objective of this study will be achieved through collection of stormwater grab samples before and after treatment through the biochar media and analysis of sample data. A representative control sample will be collected in the sampling structure at the storm garden inlet. The treated stormwater sample will be collected from the sampling sump located in the storm garden, which collects treated stormwater than has passed through the soil/biochar media.

Analysis will be performed for total and dissolved phosphorus, total kjeldahl nitrogen, nitrate and nitrite, ammonia, total suspended solids, hardness, total petroleum hydrocarbons, and total and dissolved metals (arsenic, cadmium, chromium, lead, copper, and zinc). One of the samples will be analyzed for PCBs. A total of seven sample events are proposed in 2015, representing the spring and fall wet seasons as well as one summer thunderstorm event (subject to change per weather conditions).

7. ESTIMATED COST AND TIMING

Shared costs have been estimated at $65,000.

8. CONTACT INFORMATION

Lynn Schmidt, City of Spokane
lschmidt@spokanecity.org
509-625-7908
1. **RESEARCH PROPOSAL TITLE**

Bioinfiltration Swale Media Thickness Study

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2. **RESEARCH PROBLEM DESCRIPTION**

There are numerous studies on bioinfiltration bmp design and treatment media. However, there is no consensus on the appropriate depth of the media, or the appropriate mix of media materials for optimum treatment. This is especially true for semi-arid regions like Eastern Washington. The Stormwater Management Manual for Eastern Washington requires a minimum media depth of 6 inches for bioinfiltration swales and ponds. However, thicker depths of treatment media are often used based on the assumption that greater thickness provides. Media and excavation is costly, so if the same treatment performance can be realized with thinner media depths, bioinfiltration BMPs may be constructed more cost effectively.

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3. **RESEARCH OBJECTIVE**

This study will help to determine optimal media depths for maximizing performance and cost-effectiveness bioinfiltration BMPs in Eastern Washington.

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4. **LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY**

Gonzaga University in coordination with Spokane County has been working to develop a quality assurance project plan (QAPP) for a very similar, related study. This QAPP references other documents that characterize pollutant concentrations for Eastern Washington Storm Events, and several design manuals. No research beyond that which is referenced in the QAPP has been conducted for this study question.

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5. **GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

How broadly will the results of this research apply?

- [ ] Nationally
- [x] Pacific Northwest
- [ ] WA Only
- [ ] Eastern WA
- [ ] Western WA
- [ ] Puget Sound Basin
- [ ] Interior PNW

How quickly will you need the results of this research?

- [ ] ASAP
- [ ] Within 6 months
- [ ] Within 1 year
- [ ] Within 2 years
- [ ] Within 5 years
- [ ] Ongoing

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6. **CONCEPTUAL RESEARCH APPROACH**

A bioinfiltration pond was constructed adjacent to the parking area at Gonzaga University’s Rudolph Fitness Center. The pond was designed with two treatment cells. One of the treatment cells has a media depth of 12 inches, the other has a media depth of 18 inches. Influent and effluent from each of the treatment cells will be collected during qualifying storm events using both manual and automated sampling techniques. Samples will be analyzed for identified constituents of concern (TSS, metals, total nitrogen, total phosphorus, fecal coliform, total petroleum hydrocarbons). Influent and effluent concentrations for each of the treatment cells will be compared to determine treatment efficiency of each of the cells; and the treatment efficiencies of each cell will be compared to each other. From this analysis, differences in treatment efficiency and performance attributable to the different media depths.
of each of the cells should be determined. Though not specifically part of the project plan, the study could be extended, and the media in each of the cells could be replaced with different media to test the relative effectiveness of different media types at different thicknesses.

### 7. MANAGEMENT CHANGES THAT MAY RESULT FROM RESEARCH FINDINGS

Results from this study will help inform design the design of bioinfiltration BMPs to improve treatment performance and cost effectiveness.

### 8. ESTIMATED COST AND TIMING

Cost has been estimated at $150,000.
APPENDIX C

Workshop Documentation
(agendas, handouts, attendance lists, workshop summaries)
Meeting Objective:
The purpose of the May 29th meeting was to begin the process of selecting effectiveness studies to fulfill effectiveness monitoring component of Section S8.B of the Eastern Washington National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Stormwater Permit. The specific objectives of the meeting were to:

- Provide an overview of our project approach (schedule, products, communications)
- Agree on categories of interest for workshops
- Agree on 5 to 6 study questions related to street sweeping to move forward to literature review phase
- Agree on 5 to 6 study questions related to education and training to move forward to literature review phase

The meeting agenda also outlines these objectives, and is included as attachment B.1.

Meeting Overview:
Thursday, May 29, 2014 marked the first effectiveness monitoring study development workshop of the Eastern Washington Project Advisory Group (PAG). The meeting was held at the Moses Lake Civic Center in Moses Lake Washington. The meeting was co-facilitated by Art Jenkins from the City of Spokane Valley and Joy Michaud from Herrera Environmental Consultants (Herrera). The meeting was attended by fifteen regional stormwater program managers, four representatives from the Washington Department of Ecology (Ecology) and two staff members from Herrera, a third member of Herrera’s staff listened in by phone.

At the meeting, the PAG agreed on a project schedule, an approach for developing effectiveness studies, and developed study questions related to street sweeping and education and training. The study questions developed by the group will guide the literature review of those topics.

Discussion:

Project Schedule and Approach
The PAG will work with Herrera over the next 12 months to develop between 10 and 12 implementable effectiveness study plans for Eastern Washington. The project was initially planned to conclude after 9 months, in March of 2015. However, given the difficulty of coordinating meetings over the summer months, a lengthened schedule, with a conclusion date of June 30, 2015 was approved by Ecology and coincides with the end of the grant period. The consultant work will be scheduled to be concluded by May 31, to allow ample time for grant wrap-up.
The approach presented for developing effectiveness studies was a phased process. A flowchart outlining the process was provided to meeting participants and is provided in Attachment C.1. Generally, for each of the seven stormwater topics of interest (discussed in the following section) the PAG will work to develop and prioritize ‘effectiveness questions’ that ask whether certain components of stormwater programs are beneficial and worthwhile. These questions will be used to guide literature reviews and identify data gaps and this information will then be used to further refine the series of questions. Through group discussions, it will decided which questions will move forward to the initial concept/study proposal phase. Herrera will then construct study plans and provide general cost estimates that can then be used to develop a cost/benefit analysis. All of this information will eventually be used by the PAG to rank and prioritize study questions.

Topics of Interest

Eastern Washington permittees had identified study topics of interest as part of their NPDES reporting requirements. These had been summarized and provided as a complete list. Before the May 29 meeting, Herrera categorized the submitted questions, plus others that are generally considered of interest by stormwater program managers and arrived at six stormwater topics of interest. These were reviewed with the PAG and approved as study topics to address at workshops. The topics of interest identified were:

- Street sweeping
- Education and outreach
- Catch basin maintenance
- Construction program
- Stormwater treatment media
- Retrofits
- Other

Identification of Street Sweeping Questions

PAG members were divided into small groups and were asked to develop a list effectiveness questions for street sweeping subtopics. Each small group was provided with example effectiveness questions to help engage participants and generate discussion. Each group was asked to condense and prioritize their lists down to the two most pertinent questions; although in at least one case more than two questions were identified. The effectiveness questions from each small group were then presented to the whole group.

Group 1 was posed the question, “Is street sweeping effective as a stormwater BMP?” The questions the group selected were:

1. How, when, and where do we sweep for greatest effectiveness/efficiency?

2. Is there a measurable improvement in stormwater runoff quality attributable to street sweeping?

The group acknowledged that question 1 is a very broad question. Subsequently they made a list of variables that could be studied; during full group discussion a few additional variables were added. The list of identified variables included:

- Equipment
- Speed
- Brush (or no brush); type of brush
- Timing relative to rain events
- Timing relative to special events (parades, etc.)
- Impacts of leaf litter
- Roadway type and shoulder type
- Condition of the roadway
How soon after installing a new roadway/resurfacing should you sweep?
Type of stormwater facility
Depth to groundwater; distance to surface discharge

Group 2 was posed the question, “Is street sweeping cost effective?” The first two questions listed below were selected by the group and the third was added during full group discussion:

1. How much can you extend the life of downstream infiltration systems through street sweeping?
2. Is street sweeping cost effective compared to catch basin cleaning?
3. Is cost effectiveness changed by land-use or road surface type?

This question addresses two components of street sweeping cost effectiveness. First, whether street sweeping is more or less cost effective in areas of different land use (e.g. commercial vs. low density residential); and second, whether the actual substrate of the road (e.g. asphalt, chip seal, or cement) affects the performance of street sweeping.

The group also indicated that while not specifically a study question, cost effectiveness is closely tied to public perception. There is the sense that the public perceives the aesthetic benefit of street sweeping, such as cleaning leaves in the fall or removing wind deposited sand.

Group 3 was posed the question, “How can street sweeping be more cost effective?” The questions the group selected were:

1. What is the optimum street sweeping frequency? How does this change with land use and roadway type?
2. Is there a difference in sweeping performance between well maintained and poorly maintained sweeping equipment?

Similar to Group 1, this group also acknowledged that other aspects of question 1 could be studied in addition to frequency. Subsequently they made a list of variables that could be studied including:
- Equipment: what level of equipment maintenance is most effective
- Sweeper Speed: what speed is optimal for pollutant removal
- Timing/seasonality: is seasonally adjusted sweeping more effective than routine sweeping?

Identification of Public Education and Training Questions

The format for developing public education and training sessions was the same as for the street sweeping questions (i.e. divided into small groups; ideas presented to whole group). Although, in some cases the small groups had trouble narrowing down their lists of questions so up to six questions are listed for each group.

Group 1 was assigned the question, “Is the public responding positively to information about methods to reduce adverse effects of stormwater discharges?” The public in this case included the general public and businesses, not contractors, engineers, and planners, which were addressed by another group. The questions selected by the group were:

1. Is a broader geographic program more effective than local messaging?
2. How much per capita needs to be spent in order to make a positive impact?
Group 2 was assigned the question, “Are engineers, contractors, and developers adopting measures to mitigate site runoff pollution during and after construction?” The target audience for this question included engineers, contractors, developers, development review staff, and land use planners. The following questions were developed by the group.

1. Are the engineers and contractors aware of codes, manuals, and requirements specific to Eastern Washington and local jurisdictions?
2. Is the owner supporting and funding proper stormwater management during and post-construction (including long-term maintenance planning)?
3. Do they understand that it is not allowable to connect sanitary sewer pipe to stormwater pipe (and vice versa)?
4. Who should we be training (plumbers, owners, landscapers, aggregate suppliers, sawcutters, concrete companies, etc.)?

Group 2 intended question 1 to be presented in a survey format with the following list of tools identified in a bulleted list or checkboxes:

- Yakima Regional Low Impact Development Stormwater Design Manual (AHBL and URS 2011)
- Local illicit discharge regulations
- Other (to be added if this question is selected for further development)

Group 2 also suggested vetting the list of survey questions with a few members of the target audience before sending the survey out to a larger group in order to ensure that the questions made sense to the contractor and developer audience.

Group 3 was assigned the question, “Are education and outreach programs having a measurable effect on water quality.” The group decided that the assigned question was too narrow, and broadened the question by including measurable effects on behavior as well. The questions they identified were:

1. Are nationwide campaigns more effective? Cost effective?
2. Which public education and outreach programs have a measurable effect?
3. What makes some public education programs successful?
4. What is the relationship between the number of communications and effectiveness of the public outreach effort
5. As there are more reports on stormwater, is water quality improving?
6. Is less sediment entering the stormwater system and surface waters as a result of proper sediment control BMP implementation on construction sites?

Next Steps

Due to the likelihood of scheduling difficulties, it was agreed that the next workshop will take place in early September 2014. Occasional conference calls will be scheduled for those that can attend between
June and September. The schedule and content of these was not discussed. A meeting for June 25, 2014 has already been scheduled.

In the interim, effectiveness study development activities will continue. Herrera will begin a literature review and data gap analysis on street sweeping and public education and outreach related to the effectiveness questions developed in this workshop.

Herrera will also develop a Survey Monkey survey to gather information on street sweeping and public education and outreach programs from PAG members (and other Eastern Washington permittees not involved in the PAG) to further focus literature review efforts. Some of the Survey Monkey questions recommended by PAG members during the workshop included:

1. Average cost per mile swept
2. What do you use for snow and ice control in the winter
3. What is your sweeping approach for picking up snow and ice control materials in the spring?
4. Are there specific pollutants you are concerned with that you believe would benefit from a targeted education and outreach program?
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EASTERN WASHINGTON EFFECTIVENESS STUDY DEVELOPMENT
WORKSHOP #1

Moses Lake Civic Center Museum Classroom
May 29, 2014
9:30 am to 3:00 pm

Workshop Objectives:
• Provide an overview of our project approach (schedule, products, communications)
• Agree on categories of interest for workshops
• Agree on 5 to 6 study questions related to street sweeping to move forward to literature review phase
• Agree on 5 to 6 study questions related to public education and outreach to move forward to literature review phase

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<td>Overview of Project Approach</td>
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<td>10:00 – 12:00</td>
<td>Brainstorming Session: Street Sweeping Questions</td>
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<td>• Open Discussion: Q&amp;A about existing street sweeping programs</td>
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<td>• Break out Groups: Develop study ideas around a specific street sweeping question</td>
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<td>• Group Summaries</td>
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<td>12:00 – 1:00</td>
<td>Lunch (on your own or order as pizza or teriyaki as a group)</td>
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<td>1:00 – 2:30</td>
<td>Brainstorming Session: Public Education and Outreach Study Questions</td>
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<td></td>
<td>• Overview of Requirements and Previously Identified Questions</td>
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<td>• Break Out Groups: Develop study ideas around specific audiences</td>
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<td>• Group Summaries</td>
<td>30 min</td>
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<tr>
<td>2:30 – 3:00</td>
<td>Meeting Overview/Input for Next Workshop (September 2014)</td>
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Effectiveness Study Project Overview

- Identify Study Questions
  - Identify pertinent questions from 7 study categories:
    - Street Sweeping
    - Education
    - Catch Basin Cleaning
    - Construction Program
    - Media Studies
    - Retrifits
    - Other

- Literature Review and Gap Analysis
  - Review available literature regarding studies from the 7 study categories

- Refine and Prioritize
  - Refine study ideas and decide which should be further developed into study proposals

- Develop and Prioritize Studies
  - Create study outlines and proposals with rough budgets
  - Prioritize studies based on merit, feasibility, and budget considerations

- Reporting
  - Develop selected proposals into effectiveness study plans

Timeline:
- Today
- September (2014)
- May (2015)

June 2015
Phase 1: Development of Effectiveness Study Questions for Eastern Washington Permittees

Attachment C.1.
Study Development Process
Meeting Objective:
The purpose of the October, 2014 workshop was to have representatives from several Eastern Washington jurisdictions develop a list of 15-20 ‘effectiveness questions’ that will be further developed into study conceptual designs over following six to eight months. The conceptual study designs ultimately will be paired down to a list of 10-12 effectiveness studies to be implemented over the next few years.

Meeting Overview:
The October 20, and 21, workshop (Agenda Attached, Attachment B.2) was the second in a series of effectiveness monitoring study development workshops of the Eastern Washington Stormwater Group (EWSG). The meeting was held at the City of Richland Public Works Shop. The meeting was co-facilitated by Art Jenkins from the City of Spokane Valley and Joy Michaud from Herrera Environmental Consultants (Herrera). The meeting was attended by 16 regional stormwater program managers and three staff members from Herrera. Dylan Ahearn from Herrera presented up to date results of the bioretention media testing currently under way at Washington State University Puyallup. A list of the Attendees is contained in Attachment A.2.

At the meeting Herrera presented the results of a literature review and data gap analysis in the form of ‘topic briefs’ that generally outlined the status of knowledge pertaining to the topics of interest identified at the May, 2014 workshop. The topics discussed loosely mirrored the Eastern Washington Stormwater Permit categories. Specifically; operations and maintenance, construction site maintenance, illicit discharge detection and elimination (IDDE), post construction stormwater management, monitoring and assessment, and education and outreach were discussed. Effectiveness study ideas were suggested and discussed by the group for each of the topic areas.

By the end of the meeting the group proposed 32 effectiveness questions. After a discussion and prioritization exercise the list was narrowed to 15. Herrera and the PAG will work over the next several months to develop these 15 effectiveness question into conceptual study designs, and eventually research proposals.

Discussion:

General Status Overview
During the five months between the May workshop and the October workshop, Herrera performed a basic literature review for the study topic categories identified at the May workshop (identified above). Herrera also developed example study questions and conceptual study designs for one to three questions from each topic category. The purpose of developing these conceptual study designs, was to demonstrate to the PAG, a process for taking loosely formed study ideas into a coherent study design.
Over the next few months Herrera and The EWSG will work to develop the 15 study ideas identified at this workshop into conceptual study designs, perform a limited, but targeted literature review for each study question, and develop more studies as new questions arise.

**Municipal Operations and Maintenance**

Several topics related to municipal operations and maintenance were discussed. The topics specifically discussed were; catch basin cleaning, street sweeping, and the application of catch basin retrofits. Although the topics were varied, a common thread among all of the O&M questions was trying to identify ways of maximizing the cost efficiency of O&M programs, and specifically tailoring O&M activities for Eastern Washington. The following questions were developed. Questions in italics were those selected for further development.

1. How does catch basin design (e.g. size, sump depth, pipe diameter), and the use of simple (non-filtering) catch basin retrofits (e.g. elbows and tees) affect performance, sedimentation and maintenance? (O&M: Catch Basins)

2. How effective are catch basin inserts (CBIs), what are their maintenance requirements and therefore under what conditions are they likely to be cost-effective? (O&M: Catch Basins)

3. What is the most cost-effective blend of street sweeping and catch basin cleaning operations? Develop a process/model for evaluating this that can be modified for other communities in Eastern Washington. (O&M: Catch Basins / Street Sweeping)

4. How should maintenance practices and frequency change when using permeable pavements? What are the impacts of their use on water quality? (O&M: No Specific Permit Nexus)

5. Data mining of catch basin maintenance needs to determine appropriate inspection and cleaning frequency. (Piggyback on propose WW study)

**Post Construction stormwater management**

Most of the discussion about post construction stormwater management focused on common issues experienced with inspection and maintenance of stormwater BMPs located on private property. The primary issues identified, were difficulty accessing properties for inspection, owner awareness, and lack of resources to conduct inspections. Also, several group members question the necessity of inspections, especially dry weather inspections, since it may be difficult to tell whether the BMP needs maintenance or not. The following post construction stormwater management questions were developed. Questions in italics were those selected for further development.

1. Are there successful strategies for handling privately built facilities (site access, funding/fines, bonds, who)? Are structural BMPs being maintained long-term? What are the policy/regulatory limitations to inspection if privately owned? (Post-Construction)

2. Is it more effective for municipalities to take ownership and be responsible for the maintenance of BMPs constructed by private entities (businesses, developers etc.); or is it better left in private hands? (Post- Construction)

3. Comparison of dispersed private facilities vs. regional facilities (e.g. HOAs) for long term success).
4. Is [improper] installation or [lack of] maintenance the bigger contributor to BMP Failure?

5. Does annual inspection and maintenance of publicly owned structural BMPs result in improved water quality?

Monitoring and Assessment

Several wide-ranging topics were discussed under the heading of monitoring and assessment. Questions ranged from specifics about the maintenance of permeable pavement; planting techniques for vegetated BMPs, and ways of handling comingled agricultural and stormwater discharges. The following monitoring and assessment questions were developed. Questions in italics were those selected for further development.

1. Evaluate different planting options and materials that are appropriate for Eastern Washington for BMPs that are traditionally vegetated. Include a no-plants option in the evaluation. (Monitoring and Assessment)

2. Evaluate treatment performance of different media components (for bio-infiltration based BMPs) that are appropriate for Eastern Washington and locally available, including testing of amendments/inoculants that might kickstart media performance. (Monitoring and Assessment)

3. Estimate the contribution of pollutants from different land uses to water bodies in Eastern Washington; including evaluation of differences in sediment (e.g., catchbasin sediments) quality. (Monitoring and Assessment)

4. Does sediment quality (trapped in catch basins) vary with land use?

5. What are the best biological indicators for healthy topsoil?

6. Evaluate rainfall records in various regions of Eastern Washington to develop reasonable qualifying storm event criteria.

7. Are there amendments/inoculants that can kick start BMP performance? (bioretention)

8. What is the capacity of native materials for water quality treatment?

9. Are Phase II requirements changing development patterns (i.e. pushing development outside jurisdictional boundaries) and therefore resulting in water quality that is, overall, worse?

10. How do you create the most effective and cost-effective local source of soil based media for bioretention? Can you “design” compost to meet WQ criteria?

Public Education and Outreach

Everyone acknowledged the importance of education and outreach. However, many of the people present at the meeting thought there may be ways of making their respective education and outreach programs more efficient and effective through the adoption of modern technologies, better targeted messages, and potentially combining resources from multiple jurisdictions for the development of educational materials. There was also significant overlap in discussions of public education and outreach with IDDE as there is overlap in the requirements of these two permit components. The following public education and outreach questions were developed. Questions in italics were those selected for further development.
1. Would a regional public education program be more effective or cost-effective than individual programs? How effective are current public education program(s) (websites, brochures etc.) at reaching different target audiences? (Public Education and Outreach)

2. Poll Permittees on successful public education efforts

Record Keeping and Reporting / Organizational Structures.

Record keeping and reporting is challenging for many jurisdictions. Lack of standardization and transparent interpretation among permit requirements leaves stormwater program managers uncertain of reporting requirements. This is especially problematic during audits when the permittee and auditor may have interpreted permit language differently. Most of the discussions and the resulting questions about record keeping focused on ways to increase standardization and make audits more predictable. The following record keeping and reporting questions were developed. Questions in italics were those selected for further development.

3. Would a standardized checklist result in a better reporting program? (Record Keeping and Reporting)

4. What tools are different entities using to track information; which are successful? (Include with construction site question)

IDDE

Several group members were critical of the current permit requirements for IDDE. Many felt that IDDE is important, but the permit requirements, particularly routine dry weather screenings are ineffective at identifying illicit connections, yet require the most staff time and resources. Most of the time devoted to IDDE was spent brainstorming effective alternatives for finding illicit connections and discharges. The following IDDE questions were developed. Questions in italics were those selected for further development.

1. Evaluate which IDDE techniques net the most benefit. How does routine dry weather field screening (at 12%/year) compare with focused outreach to known problem areas or business types? How does field screening compare to a hotline or crew reporting? (IDDE)

2. What is the impact of upstream agricultural discharges (return flows) on the water quality (i.e., bacteria and nitrates) of the MS4 discharge? (IDDE)

3. Evaluate Western Washington’s Business Inspection Programs (IDDE)

4. What groups (e.g. postal carriers, firefighters etc.) are the best to train for IDDE?

5. Are specific business targeted brochures effective for IDDE education?

Construction Site Maintenance

Construction site maintenance was discussed only briefly. However aspects of construction site maintenance were frequently discussed during other topic discussions. None of the proposed
construction site maintenance questions were selected for further development. The following questions were proposed though:

1. Does the implementation of construction site best management practices reduce O&M expenses for local jurisdictions?

2. What tools are different entities using to track information; which are successful? (Include with construction site question)

Other Topics (Permeable Pavement)

Some of the discussions that took place, and some of the questions proposed did not necessarily fit under one of the permit topics. For example, several people were interested in permeable pavement, but there is no permit nexus that covers permeable pavement. Permeable pavement was discussed primarily in terms of its appropriateness for Eastern Washington, and whether there are special maintenance needs in light of Eastern Washington’s harsh climate. In an unrelated discussion the question The following questions, which did not fit a specific permit category were developed. Questions in italics were those selected for further development.

1. How should maintenance practices and frequency change when using permeable pavements? What are the impacts of their use on water quality? (O&M: No Specific Permit Nexus)

Current or Planned Studies

Some permittees already have planned or current studies that may be eligible effectiveness studies. These studies and respective jurisdictions are:

Spokane County: Biofiltration Swale/Media configuration study
City of Spokane: Porous Asphalt Study (Sharp Avenue Study)
City of Spokane: BioChar Amendment BMP research
WSU Puyallup: Biofiltration media impacts on fish mortality

Herrera and Art Jenkins will discuss the possibility of these studies being included as some of the 10-12 required effectiveness studies at an upcoming meeting.
Attachment A.2.
October 20-21, 2014, Workshop Attendance Sheet
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<th>Representing</th>
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<th>Alternate Contact(s)</th>
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<tr>
<td>City of Ellensburg</td>
<td>Jon Morrow</td>
<td><a href="mailto:morrow@ci.ellensburg.wa.us">morrow@ci.ellensburg.wa.us</a></td>
<td></td>
<td>509-929-3844</td>
<td>By Phone</td>
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<tr>
<td>City of West Richland</td>
<td>Brian Woodard</td>
<td><a href="mailto:bwoodard@westrichland.org">bwoodard@westrichland.org</a></td>
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<td></td>
<td>Drew Woodruff</td>
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<td>City of Richland</td>
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<td>509-942-7508</td>
<td>Nancy Aldrich</td>
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<td>Nancy Aldrich</td>
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<td>City of Kennewick</td>
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<td>Nancy Read-Jennings</td>
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<td>City of Pasco</td>
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<td>City of East Wenatchee</td>
<td>Greg Pezolet</td>
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<td>City of Wenatchee</td>
<td>Jessica Shaw</td>
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<td>Chelan County</td>
<td>Jason Detamore</td>
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<td>Douglas County</td>
<td>Jennifer Lange</td>
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<td>Ruby Irving-Hewey</td>
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<td>David Haws</td>
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<td>Joe Henne</td>
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<td></td>
<td>Ted Pooler</td>
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<td>City of Clarkston</td>
<td>Matt Carlson</td>
<td><a href="mailto:mcarlson@co.asotin.wa.us">mcarlson@co.asotin.wa.us</a></td>
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<td>509-243-2071</td>
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<td>City of Moses Lake</td>
<td>Bill Aukett</td>
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<td><a href="mailto:baukett@cityofml.com">baukett@cityofml.com</a></td>
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<td>Shawn O'Brien</td>
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<td>City of Pullman</td>
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<td>Marcia Davis</td>
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<td>City of Spokane Valley</td>
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<td>City of Walla Walla</td>
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<td>509-524-4669</td>
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<tr>
<td>Walla Walla County</td>
<td>Tony Garcia Morales</td>
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<td><a href="mailto:tsparcia@wwcountyrcads.com">tsparcia@wwcountyrcads.com</a></td>
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10/21/14

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10/16/2014
Page 2/2
Attachment B.2.
October 20-21, 2014, Workshop Agenda
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<td>10:00 – 10:15</td>
<td>Workshop Overview and Goals</td>
<td>Art</td>
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<td>10:15 – 11:15</td>
<td>Planned Effectiveness Studies</td>
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<td>11:15 – 12:15</td>
<td>Construction Site Stormwater Runoff Control</td>
<td>Rebecca</td>
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<td>Post-Construction Stormwater Management</td>
<td>Rebecca</td>
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<td>Municipal O&amp;M: Street Sweeping, Question/Study Development</td>
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<td>Break</td>
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<td>3:30 – 4:30</td>
<td>Municipal O&amp;M: Catch Basin Maintenance</td>
<td>Neil</td>
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<td>4:30 – 5:00</td>
<td>Tuesdays Agenda Development and Wrap Up</td>
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<td><strong>Day 2 – 21 OCT 2014 (Tentative)</strong></td>
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<td>7:30 – 8:30</td>
<td>Breakfast Speaker-Bioretention Media Study</td>
<td>Curtis Hinman</td>
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<td>Recap of Day 1</td>
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<td>Structural BMP Effectiveness</td>
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<td>Monitoring and Assessment +/- Structural BMP Effectiveness</td>
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<td>Potential Topics: Irrigation &amp; MS4, IDDE, Pub Ed., etc. or clean up of previous topics</td>
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<td>Prioritization of Study Topics</td>
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**Eastern Washington Effectiveness Studies Meeting Summary**

**Date:** March 23 and 24, 2015  
**Location:** City of Richland Public Works Shop

**Attendees:**  
See Attachment A.

**Meeting Objective:**  
The purpose of the March 2015 meeting was to review the research proposals developed based on the study concepts proposed at the October, 2014 workshop, in addition to developing new effectiveness study concepts from the following topic areas:

- Municipal Operations and Maintenance  
- Monitoring and Assessment  
- Construction Site Maintenance and Post Construction BMPs  
- Public Education and Outreach  
- Organizational Structures and Record Keeping

A second objective was to begin the process of prioritizing study questions through brainstorming a list of criteria for rating them and to do some initial testing of ‘preferences’ to assess level of interest in specific questions or topic areas.

**Meeting Overview:**  
The workshop on March 23 and 24, 2015 marked the third in a series of effectiveness monitoring study development workshops of the Eastern Washington Stormwater Group (EWSG) The meeting was held at the City of Richland Public Works Shop. The meeting was co-facilitated by Joy Michaud from Herrera Environmental Consultants (Herrera) and Art Jenkins from the City of Spokane Valley. The meeting was attended by 15 regional stormwater program managers and two additional staff members from Herrera. A list of the attendants for each day of the workshop is contained in Attachment A.3.

At the workshop, the EWSG discussed, and further refined the 18 study proposals developed following the October, 2014 workshop. As has been the case during development, the questions were segregated by topic category, based on the related stormwater permit sections. (See attached agenda, Attachment B.3.) The first day, Operations and Maintenance, and Monitoring and Assessment permit areas were discussed. The second day, Construction Stormwater Management, Post Construction Stormwater Management, and Public Education and Outreach permit areas were discussed. New study concepts were also proposed during each topic area discussion to round out the list of study questions, and ensure that all EWSG member’s interests were represented. Following each topic discussion, initial preferences were tested through a simple vote by hand of favorites.

Both days of the workshop included short sessions aimed at developing study prioritization tools. The first day, the EWSG worked as a whole to brainstorm rating criteria for study ideas. The second day, the EWSG divided into small groups applied SWOT analysis to specific study questions. Additionally, on the first day of the meeting, there was a short discussion about updating the Eastern Washington Stormwater Manual, and its development process.
Discussion:

**General Status Overview**
Over the past 6 months, the list of study topics/questions developed at the October workshop, were refined through a reiterative review process into effectiveness study designs. At the time of this meeting 18 studies (for a list of studies see attachment C.3.) were generated and put into a research proposal template. For each of these studies, a research problem description (i.e. a justification for the study) a basic experimental design, rough cost estimate, potential timeline, and a brief literature review summary were developed. The attached ‘question status matrix’ has a summary and status of each of the studies (Attachment C.3.)

**Municipal Operations and Maintenance Study Question Review.**
The group reviewed the list of 7 operations and maintenance questions. Comments and modifications of these questions were minimal. However, a fair amount of time was spent discussing and refining some of the assumptions that went into developing the rough cost estimates. While the group at times expressed concern over the costs of the studies, it was clearly stated that the concern was more over return on investment rather than absolute cost (i.e. a higher cost study should produce more valuable results than a lower cost study). It was also agreed that cost estimates should be conservative (high at this point), so that when and if funding is sought for a particular study it is adequate. Lessons learned from the western Washington stormwater group related to underestimating administrative costs and site selection costs were also discussed.

The majority of time during this meeting session was spent proposing and discussing new ideas for developing into effectiveness studies.

The new study ideas were:

- How cost effective are traditional infiltration methods compared to LID when taking into account lifetime maintenance costs of both technologies? The assertion was that in Eastern Washington traditional infiltration (e.g. drywells) is highly effective, has basically the same end result as LID (infiltration) and is many times cheaper to maintain.
- Although not a ‘new’ study idea, the Sharp Avenue permeable pavement study conducted by the City of Spokane and Gonzaga will be written into the proposal template.

At the conclusion of the Municipal Operations and Maintenance session of the meeting the group members did informal voting for their initial preferences. The street sweeping questions and the catchbasin retrofit question had the most support among the group. Again, the informal nature of the voting and the fact that the questions were not ranked against the entire list of study questions means that while informative the results are not a valid representation of actual prioritization or ranking. The results are in the table below.

<table>
<thead>
<tr>
<th>Study Title</th>
<th>Permit category</th>
<th>Favorite</th>
<th>2nd Favorite</th>
<th>3rd Favorite</th>
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<td>Infiltration Rate and Lifespan</td>
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<td>Pavement Study</td>
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<tr>
<td>---------------------------------------------------</td>
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<td>Catch Basin Retrofit Study</td>
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</tbody>
</table>

11 14 12

Favorite studies based on initial voting results

**Eastern Washington Stormwater Management Manual (EWSWMM)**

The purpose of this agenda item was to discuss whether the group was in support of revising and updating the EWSWMM. The group was in agreement that the manual should be updated and they agreed to send a letter of support to Ecology.

**Group Work on Rating Criteria**

Development of rating criteria was done through a brainstorming session based on specific topic areas. These included; Value, Risk, Reliability, and Cost. For each topic area the group identified subcategories or attributes that should be considered when thinking about each of the ranking topics. For example, to rank a study questions ‘value’ considerations such as whether it addressed a known water quality problem or whether it could drive an effective change in stormwater programs were considered important attributes. The results from this session are not summarized here but have been included in the criteria rating matrix provided in the final report for the study.

**Monitoring and Assessment**

Six monitoring and assessment studies were discussed. Four of the studies were developed by the EWSG, the other two (the Biochar and Lincoln SURGE study) are current or proposed studies that were developed outside the EWSG process.

Of the existing questions, most of the discussion regarded the proposed study ‘Evaluating Treatment Adequacy for Commingled Stormwater and Agricultural Discharges’. Since the previous discussion of the question, the study was changed from a large, field-scale monitoring study to a smaller bench scale study. Areas where agricultural discharges into the MS4 are problematic were identified as Wenatchee, Kennewick, Ellensburg, and Yakima. There was discussion but no decision to move forward in evaluating what it might involve to separate agricultural water from stormwater in the areas where it is an issue.

A new question that would evaluate the effectiveness of proprietary commercial soil amendments at aiding plant growth on disturbed soils. The question will be phrased similar to the CBI study where vendors would pay for the monitoring. This question will be developed for discussion at the April 23, 2015 meeting.
At the conclusion of the Monitoring and Assessment session of the meeting the group members voted on their initial preferences. As with the previous topic area, these are very informal results, but informative nonetheless. The results are in the table below.

<table>
<thead>
<tr>
<th>Study Title</th>
<th>Permit category</th>
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<th>2nd Favorite</th>
<th>3rd Favorite</th>
</tr>
</thead>
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<td>Evaluating Planting Options for Bioretention BMPs</td>
<td>Monitoring and Assessment</td>
<td>6</td>
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<td>Media Component Study</td>
<td>Monitoring and Assessment</td>
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<td>Biochar media stormwater treatment study</td>
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<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Evaluating Treatment Adequacy for Comingled Stormwater and Agricultural Discharges</td>
<td>Monitoring and Assessment</td>
<td>2</td>
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<td>0</td>
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<td>Lincoln SURGE storm garden monitoring</td>
<td>Monitoring and Assessment</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</table>

Favorite studies based on initial voting results

**Record Keeping and Reporting/Organizational Structures.**

There was one question related to record keeping and reporting and one question related to organizational structures discussed. The question ‘Evaluating organizational structures’ did not have much support, and was not discussed at length. It was suggested that the study could be simplified by dividing it into multiple, separate studies, but ultimately the group decided that it would be better kept as one study. The record keeping question ‘Standardized Checklists for Trouble Free Audits’ spurred a lengthy conversation about available software and other tools used by Eastern Washington Jurisdictions for record keeping.

**Post Construction Stormwater Management.**

Although there were four studies developed related to Post Construction Stormwater Management, most of the time allocated to this permit area was spent constructively brainstorming ways that the permit requirements for inspections could be improved. There is still the overarching impression that site inspections are not necessary at permit specified intervals. It was proposed that BMPs could be ranked by relative risk of failure, and only those in the higher risk categories would require inspections. This would alleviate stresses on municipal staff responsible for inspections. It was also suggested that drive-by inspections might be sufficient in most cases. The most significant item that came to light is that it is suspected that most private BMPs would not drain into the MS4 even in the event of failure, and there is almost never enough rain to cause an overflow. So, this raises the question, if the BMPs don’t, and can’t discharge to the MS4 why would a jurisdiction expend so much of its available resources on inspection and possible enforcement when they pose a very low potential risk to water quality? A new study idea will be developed to address this issue.
IDDE

The EWSG felt the two studies developed since the October meeting were good. However, many group members surmise that an important source of illicit discharges are mobile contractors (i.e. painters, concrete companies, landscapers etc.). These groups may not be reached by standard education and outreach methods, and violations are difficult to enforce due to the mobile nature of their businesses. It was agreed that a new study question would be developed to investigate ways to improve outreach to mobile contractors.

Public Education

The one Education and Outreach question ‘Modernizing Education and Outreach Strategies’. It was suggested that Todd Norton (a communications professor) and Graham Dixon at WSU might be interested in this study. It was also suggested that mobile contractors, mentioned during the IDDE discussion might serve as a target test group for the new outreach strategy. It was also discussed whether positive or negative messaging is more effective, although no studies to evaluate this were proposed.

New Study Questions

In addition to the new study questions described above there were questions identified during other parts of the two day workshop. In all seven new study questions were identified at this meeting. Each question contains notes about the party responsible for developing the question into a study idea and formatting it to the study template.

1. How cost-effective are traditional infiltration methods compared to LID?
2. How do partnerships and regional solutions on common permit tasks make permit implementation more or less effective than each permittee developing these materials on their own? (There was legthty discussion and questions about the purpose of this question and Art Jenkins agreed to develop it further and bring it back to the group.)
3. How effective are soil additives for erosion and sediment control?
4. Is there a meaningful level of imperviousness in Eastern WA? (This question relates to concerns originally expressed by Brian C. and Art Jenkins was to follow up with him.)
5. How effective are the various methods of data collection being used by permittees?
6. What is the potential for impact from private stormwater facilities in Eastern WA to the MS4?
7. What are the most effective ways of reaching mobile contractors or service providers regarding stormwater education?
Attachment A.3.
March 23-24, 2015, Workshop Attendance Sheet
<table>
<thead>
<tr>
<th>Representing</th>
<th>Primary Contact</th>
<th>Alternate Contact(s)</th>
<th>email</th>
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<tr>
<td>1 City of Ellensburg</td>
<td>Jon Morrow</td>
<td></td>
<td><a href="mailto:morrowjl@ci.ellenburg.wa.us">morrowjl@ci.ellenburg.wa.us</a></td>
<td>509-929-3844</td>
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<tr>
<td>2 City of West Richland</td>
<td>Bryan Woodard</td>
<td>Drew Woodruff</td>
<td><a href="mailto:bwoodard@westrichland.org">bwoodard@westrichland.org</a></td>
<td>509-967-5434</td>
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<tr>
<td></td>
<td></td>
<td>Roscoe Slade</td>
<td><a href="mailto:roscoe@westrichland.org">roscoe@westrichland.org</a></td>
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</tr>
<tr>
<td>3 City of Richland</td>
<td>John Bykonen</td>
<td></td>
<td><a href="mailto:ibykonen@ci.richland.wa.us">ibykonen@ci.richland.wa.us</a></td>
<td>509-942-7508</td>
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<tr>
<td></td>
<td></td>
<td>Nancy Aldrich</td>
<td><a href="mailto:NAldrich@CI.RICHLAND.WA.US">NAldrich@CI.RICHLAND.WA.US</a></td>
<td></td>
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<tr>
<td>4 City of Kennewick</td>
<td>Martin Nelson</td>
<td></td>
<td><a href="mailto:Martian@ci.kennewick.wa.us">Martian@ci.kennewick.wa.us</a></td>
<td>509-585-4306</td>
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<tr>
<td>5 City of Pasco</td>
<td>Teresa Reed-Jennings</td>
<td></td>
<td><a href="mailto:reed-jenningsct@pasco-wa.gov">reed-jenningsct@pasco-wa.gov</a></td>
<td>509-545-3444</td>
</tr>
<tr>
<td>6 City of East Wenatchee</td>
<td>Greg Pezoldt</td>
<td></td>
<td><a href="mailto:Gpezoldt@east-wenatchee.com">Gpezoldt@east-wenatchee.com</a></td>
<td>509-884-1829</td>
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<tr>
<td>7 City of Wenatchee</td>
<td>Jessica Shaw</td>
<td></td>
<td><a href="mailto:Jshaw@WenatcheeWA.Gov">Jshaw@WenatcheeWA.Gov</a></td>
<td>509-888-3225</td>
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<tr>
<td>8 Chelan County</td>
<td>Jason Detamore</td>
<td></td>
<td><a href="mailto:Jason.Detamore@co.chelan.wa.gov">Jason.Detamore@co.chelan.wa.gov</a></td>
<td>509-667-6415</td>
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<tr>
<td>9 Douglas County</td>
<td>Jennifer Lange</td>
<td></td>
<td><a href="mailto:Jlange@co.douglas.wa.us">Jlange@co.douglas.wa.us</a></td>
<td>509-886-3728</td>
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<td>Ruby Irving-Hewey</td>
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<td>11 City of Union Gap</td>
<td>Dennis Henne</td>
<td></td>
<td><a href="mailto:uppwdirector@cityofuniongap.com">uppwdirector@cityofuniongap.com</a></td>
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<tr>
<td>12 City of Sunnyside</td>
<td>Shane Fisher</td>
<td></td>
<td><a href="mailto:sfisher@ci.sunnyside.wa.us">sfisher@ci.sunnyside.wa.us</a></td>
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<tr>
<td>13 Yakima County</td>
<td>David Haws</td>
<td>Terry Keenan</td>
<td><a href="mailto:David.Haws@co.yakima.wa.us">David.Haws@co.yakima.wa.us</a></td>
<td>509-574-2277</td>
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<tr>
<td></td>
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<td>Don Gatchalian</td>
<td><a href="mailto:Terry.Keenan@co.yakima.wa.us">Terry.Keenan@co.yakima.wa.us</a></td>
<td>509-574-2300</td>
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<td></td>
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<td><a href="mailto:donald.patchalian@co.yakima.wa.us">donald.patchalian@co.yakima.wa.us</a></td>
<td>509-574-2300</td>
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<tr>
<td>14 City of Selah</td>
<td>Joe Henne</td>
<td></td>
<td><a href="mailto:jhenna@fairpoint.net">jhenna@fairpoint.net</a></td>
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3/18/2015
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<td>Project and Workshop Overview</td>
<td>Art/Joy</td>
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<td>Municipal O&amp;M Study Question Review</td>
<td>Rebecca</td>
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<td>• Review Existing Questions</td>
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<td>• Initial Test of Preferences</td>
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<td>Lunch (On Your Own)</td>
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<td>1:00-2:00</td>
<td>Group Work on Rating Criteria</td>
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<td>Eastern WA Stormwater Manual</td>
<td>Nancy</td>
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<td>10:30 – 10:45</td>
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<td>Public Education and Outreach</td>
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<td>11:45-12:45</td>
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<td>12:45 – 1:45</td>
<td>Group Work SWOT Tool</td>
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<td>2:00 – 3:00</td>
<td>Other (Organizational Structure &amp; Recordkeeping and others)</td>
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<td>3:00 – 3:30</td>
<td>Next Steps-Phase 1 and 2</td>
<td>Art</td>
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Attachment C.3.
Study Question Summary List
Phase 1: Development of Effectiveness Study Questions for Eastern Washington Permittees

C-37

June 2015

Biochar media stormwater discharges

Discharges and Agricultural Adequacy for Comingled Evaluating Treatment Media Component Study for Bioretention BMPs

Evaluating Planting Options Seeding and Irrigation Structures

Business Inspection Program Survey

IDDE

IDDE

IDDE

Monitoring and Assessment

Monitoring and Assessment

Monitoring and Assessment

Monitoring and Assessment

Study Title

Modernizing Education and Outreach Strategies

Illicit Discharge Detection Methods

Evaluating Organizational Structures

Seeding and Irrigation Strategies for Vegetated BMPs

Evaluating Planting Options for Bioretention BMPs

Media Component Study

Evaluating Treatment Adequacy for Commingled Stormwater and Agricultural Discharges

Biochar media stormwater treatment study

Study Summary

A marketing firm would be hired to develop an education and outreach program utilizing modern communication tools (apps, social media, would be developed for one stormwater permit related topic (e.g. reporting illicit discharges). Public awareness and behaviors about the topic would be assessed via survey before and after deliver of the educational campaign to assess results.

The study will survey stormwater managers to gather information regarding illicit discharges detected by various IDDE methods. The purpose is to identify which methods result in the highest detection rate.

This survey study would collect a number of examples of different organizational structures used by Washington municipalities as they pertain to their respective IDDE, construction site management, and post-construction program, and identify some of the advantages and disadvantages of each. Jurisdictions would then be able to use successful structures as guidance for strategizing and streamlining the long-term development of their own programs.

This study survey will query Phase II Western Washington Jurisdictions with business inspection programs. The purpose of the survey will be to qualitatively assess the effectiveness of business inspection programs in Western Washington, and to learn effective strategies that can be adopted into the developing business inspection programs of Eastern Washington Jurisdictions.

Test plots simulating conditions in vegetated BMPs (e.g. bio swales) will be constructed. Different seeding densities of seed mixes typically used in Eastern Washington, and irrigation regimes will be applied to each test plot. Beneficial plant and weed growth will be monitored to determine the most.

A plant list of climate appropriate plants will be developed based on literature sources. Test plots simulating conditions in bio retention BMPs will be constructed. Combinations of seed mixes and substrates, as well as at least one option that has no plants will be applied to the test plots. Infiltration and soil cation exchange capacity will be measured throughout the study.

This project would mimic the Western Washington study conducted at the Washington Stormwater Center that evaluated media mixes used in bioretention facilities. The purpose of this study would be to develop bio-retention media better suited for Eastern Washington conditions, and if possible maximize usage of locally sourced materials.

Synthetic water blends with nutrient, metal, bacteria, and pesticide concentrations typical of those found in agricultural runoff in eastern Washington will be run through test columns with different media and native soil combinations found in Eastern Washington infiltration and UIC stormwater treatment devices. The purpose of this experiment is to determine if existing stormwater treatment is capable of treating agricultural water that is comimgled with stormwater to a level that is safe and protective of water quality so that decision makers can make more informed decisions.

Biochar are being studied for their stormwater treatment capacity (kentucky bluegrass and wood based biochars). A bench-scale laboratory study was completed in 2015. A field scale pilot study began construction in 2014 and will be implemented in 2015. The field portion of the study includes construction and water quality monitoring of storm gardens with biochar-supplemented treatment media along Garland Avenue in Spokane.

Approved Cost

$100,000 3/5/2015

$25,000 2/5/2015

$25,000 3/5/2012

$60,000 1/29/2015

$80,000 1/29/2015

$250,000 1/22/2015

$225,000 2/5/2015

$75,000

$225,000 2/5/2015

$80,000 1/29/2015

$60,000 1/29/2015

$250,000 1/22/2015

$225,000 2/5/2015

The question reviewed by the EWSG was a large, field scale monitoring project. However as it was written it likely duplicated studies that have quantified pollutant loads in agricultural wastewaters. The current question is more related to stormwater treatment and ground/drinking water quality protection and will be a more valuable tool for informing decision makers about the issue of comimgling agricultural return flows with stormwater.

$250,000 1/22/2015

This question is largely unchanged since the last review by the EWSG. EWSG comments suggesting addition of CEC and infiltration testing have been addressed and added to the study.

This question was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review.

Following Ecology Review this question was limited to evaluating organizational structures pertaining only to IDDE, construction site management, and post construction, permit elements. The original question reviewed by the EWSG was intended to evaluate all permit elements.

This study was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review.

This study was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review.

The City of Spokane is implementing this project in the 2014-2015+ time frame regardless of effectiveness study status. The project is already underway.

Study Question Summary List.

<table>
<thead>
<tr>
<th>Study Title</th>
<th>Permit Category</th>
<th>Study Summary</th>
<th>Approved Cost</th>
<th>Reviewed/Discussed by EWSG</th>
<th>Substantial Changes Since Last EWSG Review</th>
</tr>
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<tbody>
<tr>
<td>Modernizing Education and Outreach Strategies</td>
<td>Education and Outreach</td>
<td>A marketing firm would be hired to develop an education and outreach program utilizing modern communication tools (apps, social media, would be developed for one stormwater permit related topic (e.g. reporting illicit discharges). Public awareness and behaviors about the topic would be assessed via survey before and after deliver of the educational campaign to assess results.</td>
<td>$100,000</td>
<td>3/5/2015</td>
<td>This study was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review</td>
</tr>
<tr>
<td>Illicit Discharge Detection Methods</td>
<td>IDDE</td>
<td>The study will survey stormwater managers to gather information regarding illicit discharges detected by various IDDE methods. The purpose is to identify which methods result in the highest detection rate.</td>
<td>$25,000</td>
<td>2/5/2015</td>
<td>This study was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review</td>
</tr>
<tr>
<td>Evaluating Organizational Structures</td>
<td>IDDE</td>
<td>This survey study would collect a number of examples of different organizational structures used by Washington municipalities as they pertain to their respective IDDE, construction site management, and post-construction program, and identify some of the advantages and disadvantages of each. Jurisdictions would then be able to use successful structures as guidance for strategizing and streamlining the long-term development of their own programs.</td>
<td>$25,000</td>
<td>3/5/2012</td>
<td>Following Ecology Review this question was limited to evaluating organizational structures pertaining only to IDDE, construction site management, and post construction, permit elements. The original question reviewed by the EWSG was intended to evaluate all permit elements.</td>
</tr>
<tr>
<td>Business Inspection Program Survey</td>
<td>IDDE</td>
<td>This study survey will query Phase II Western Washington Jurisdictions with business inspection programs. The purpose of the survey will be to qualitatively assess the effectiveness of business inspection programs in Western Washington, and to learn effective strategies that can be adopted into the developing business inspection programs of Eastern Washington Jurisdictions.</td>
<td>$25,000</td>
<td>2/5/2015</td>
<td>This study was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review</td>
</tr>
<tr>
<td>Seeding and Irrigation Strategies for Vegetated BMPs</td>
<td>Monitoring and Assessment</td>
<td>Test plots simulating conditions in vegetated BMPs (e.g. bio swales) will be constructed. Different seeding densities of seed mixes typically used in Eastern Washington, and irrigation regimes will be applied to each test plot. Beneficial plant and weed growth will be monitored to determine the most.</td>
<td>$60,000</td>
<td>1/29/2015</td>
<td>This study was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review</td>
</tr>
<tr>
<td>Evaluating Planting Options for Bioretention BMPs</td>
<td>Monitoring and Assessment</td>
<td>A plant list of climate appropriate plants will be developed based on literature sources. Test plots simulating conditions in bio retention BMPs will be constructed. Combinations of seed mixes and substrates, as well as at least one option that has no plants will be applied to the test plots. Infiltration and soil cation exchange capacity will be measured throughout the study.</td>
<td>$80,000</td>
<td>1/29/2015</td>
<td>This question is largely unchanged since the last review by the EWSG. EWSG comments suggesting addition of CEC and infiltration testing have been addressed and added to the study.</td>
</tr>
<tr>
<td>Media Component Study</td>
<td>Monitoring and Assessment</td>
<td>This project would mimic the Western Washington study conducted at the Washington Stormwater Center that evaluated media mixes used in bioretention facilities. The purpose of this study would be to develop bio-retention media better suited for Eastern Washington conditions, and if possible maximize usage of locally sourced materials.</td>
<td>$250,000</td>
<td>1/22/2015</td>
<td>This question is largely unchanged since the last EWSG review</td>
</tr>
<tr>
<td>Evaluating Treatment Adequacy for Commingled Stormwater and Agricultural Discharges</td>
<td>Monitoring and Assessment</td>
<td>Synthetic water blends with nutrient, metal, bacteria, and pesticide concentrations typical of those found in agricultural runoff in eastern Washington will be run through test columns with different media and native soil combinations found in Eastern Washington infiltration and UIC stormwater treatment devices. The purpose of this experiment is to determine if existing stormwater treatment is capable of treating agricultural water that is comimgled with stormwater to a level that is safe and protective of water quality so that decision makers can make more informed decisions.</td>
<td>$225,000</td>
<td>2/5/2015</td>
<td>The question originally reviewed by the EWSG was a large, field scale monitoring project. However as it was written it likely duplicated studies that have quantified pollutant loads in agricultural wastewaters. The current question is more related to stormwater treatment and ground/drinking water quality protection and will be a more valuable tool for informing decision makers about the issue of comimgling agricultural return flows with stormwater.</td>
</tr>
<tr>
<td>Biochar media stormwater treatment study</td>
<td>Monitoring and Assessment</td>
<td>Biochar are being studied for their stormwater treatment capacity (kentucky bluegrass and wood based biochars). A bench-scale laboratory study was completed in 2015. A field scale pilot study began construction in 2014 and will be implemented in 2015. The field portion of the study includes construction and water quality monitoring of storm gardens with biochar-supplemented treatment media along Garland Avenue in Spokane.</td>
<td>$75,000</td>
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</tr>
<tr>
<td>Study Title</td>
<td>Permit Category</td>
<td>Study Summary</td>
<td>Approximate Cost Estimate</td>
<td>Reviewed/Discussed by EWSG</td>
<td>Substantial Changes Since Last EWSG Review</td>
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<tr>
<td>Lincoln SURGE storm garden monitoring</td>
<td>Monitoring and Assessment</td>
<td>Storm garden bump-outs were installed along Lincoln Street in Spokane in 2011. Because of shallow bedrock, the storm gardens contain underdrains that drain to a single point at Cannon Hill Park Pond. This presents a unique opportunity for monitoring.</td>
<td>$4,000</td>
<td></td>
<td>The City of Spokane began monitoring the storm gardens in 2014 and will continue through at least spring 2015. Flow monitors have been operating continuously for several years. Information from this study can be used to supplement others if it is not a stand-alone project.</td>
</tr>
<tr>
<td>Sidewalk Permeable Pavement Infiltration Rate and Lifespan</td>
<td>Operations and Maintenance</td>
<td>Test strips of permeable pavement sidewalks will be constructed in 4 Eastern Washington communities. Infiltration measurements will occur twice yearly for a 10-year study period. No maintenance will take place, so the infiltration measurements will document decreases in infiltration performance over time as the pavement becomes clogged with sediment.</td>
<td>$100,000</td>
<td></td>
<td>This question was suggested by Ecology in addition to the Parking Lot Permeable Pavement Study. The EWSG has not reviewed this question.</td>
</tr>
<tr>
<td>Parking Lot Permeable Pavement Study</td>
<td>Operations and Maintenance</td>
<td>Test segments will be designated within the traveling lanes of a newly constructed permeable pavement parking lot. Each test segment will be subjected to different maintenance regimes ranging from no-maintenance to monthly vacuuming. The infiltration rate of the pavement will be measured on a quarterly basis and the infiltration performance of each test segment will be tracked over time.</td>
<td>$145,000</td>
<td>2/19/2015</td>
<td>The question reviewed by EWSG was modified to be conducted on permeable pavements in parking lots, rather than sidewalks, which the original question specified. This change was in response to Ecology's concern that sidewalks may not be suitable for testing due to high sediment loading rates that cause differences in infiltrating performance over the study period. A qualitative assessment of the long-term durability of the pavement surface was also added to the study design.</td>
</tr>
<tr>
<td>Sharp Avenue Porous Pavement Study</td>
<td>Operations and Maintenance</td>
<td>A porous pavement &quot;laboratory&quot; will be constructed in the traveling and parking lanes of a City arterial street near Gonzaga University. A porous concrete intersection, full-width pervious asphalt, pervious asphalt in the parking lanes only, and a control section will be installed. Gonzaga University students will monitor water quality, pavement condition over time (esp. with respect to studded tire use) and O&amp;M impacts.</td>
<td>$1,500,000</td>
<td>10/22/2014</td>
<td>This question was discussed informally at the October 2014 EWSG meeting. The City of Spokane is implementing this project in the 2015-2018 timeframe regardless of effectiveness study status. (pending official grant award in June 2015).</td>
</tr>
<tr>
<td>Street Sweeping and Catch Basin Cleaning Comparison</td>
<td>Operations and Maintenance</td>
<td>This study will use a small scale 'paired' basin approach for evaluating differences in the amount of material removal by street sweeping and catch basin cleaning compared to only catch basin sweeping. One of the basins will be swept regularly and the other wont. The total amount of material removed will be calculated for both basins and compared. All Eastern Washington jurisdictions will also be surveyed about their street sweeping and catch basin cleaning procedures.</td>
<td>$150,000</td>
<td>3/5/2015</td>
<td>This question unchanged since the last EWSG review. Ecology requested the addition of a survey for all Eastern Washington jurisdictions about equipment used protocols, frequency, gross estimate of materials, but these changes have not been added to the study.</td>
</tr>
<tr>
<td>Evaluating Seasonal Differences in the Amount of Material Removed By Street Sweeping</td>
<td>Operations and Maintenance</td>
<td>All the roadways within four or five communities will be swept on a monthly basis. The amount of material and pollutants removed during each sweeping event will be totaled. Statistical analysis will be used to identify whether there are significant factors (timing, region) affecting the amount of material removed by each sweeping event (a surrogate for sediment deposition rate).</td>
<td>$175,000</td>
<td>12/11/2014</td>
<td>This question was modified substantially since the last EWSG review. Herrera experts on street sweeping were concerned that sweeping and analyzing material from only the short roadway segments specified in the original question would not provide very representative results. They suggested sweeping the entire community and totaling results to account for the likely high spatial variability in street dirt loading rates, and this suggestion was incorporated</td>
</tr>
<tr>
<td>Catch basin Insert Monitoring Protocols</td>
<td>Operations and Maintenance</td>
<td>The objective of this study is to develop a protocol (QAPP) for evaluating the effectiveness of commercially available CBIs at bench and field scales. Having this procedure in place will streamline testing and evaluation, and will ensure uniformity of methods allowing for objective performance comparisons. This protocol would be developed with input from Ecology and interested vendors. Vendors who chose to have their product tested would provide the funding for the testing.</td>
<td>$25,000</td>
<td>12/11/2014</td>
<td>This study, as originally written and reviewed by the EWSG intended to test a number of commercial available CBIs. Following Ecology’s review, the question was modified only to develop a uniform process for effectiveness testing of the CBIs.</td>
</tr>
<tr>
<td>Study Title</td>
<td>Permit Category</td>
<td>Study Summary</td>
<td>Approximate Cost Estimate</td>
<td>Reviewed/Discussed by EWSG</td>
<td>Substantial Changes Since Last EWSG Review</td>
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<tr>
<td>Catch Basin Retrofit Study</td>
<td>Operations and Maintenance</td>
<td>The objective of this research is to evaluate gross solids removal differences between two, similarly sized and located catchments; one in which a downturned elbow type retrofit is only installed at the most downstream catch basin and one in which retrofits are installed at multiple locations within the catchment.</td>
<td>$60,000</td>
<td>12/11/2014</td>
<td>This study was originally written to evaluate differences in solids removal between catch basins with and without retrofits. Given the fairly well established benefits of retrofits, Ecology suggested modifying the study to look at the potential use of targeted application of retrofits. The current study adopted Ecology’s Approach</td>
</tr>
<tr>
<td>Assessing Awareness of Maintenance Responsibilities of Privately Owned Stormwater BMPs</td>
<td>Post-Construction Stormwater Management</td>
<td>This simple, survey study will be delivered to homeowners, homeowners associations, and businesses that have structural stormwater BMPs installed on their properties. The survey will assess their general knowledge about the stormwater BMPs on their land, the maintenance requirements of the BMP, and their responsibility to continually maintain the BMP.</td>
<td>$25,000</td>
<td></td>
<td>This question was developed in response to Ecology's comments on the question 'BMP Inspection and Maintenance Responsibility Allocation' and the EWSG has not reviewed this question to date.</td>
</tr>
<tr>
<td>Ensuring Long-Term Maintenance of Privately Owned BMPs</td>
<td>Post-Construction Stormwater Management</td>
<td>This two part study will review existing inspection and maintenance records to evaluate the effectiveness of each Eastern Washington Jurisdiction's inspection and maintenance program, and survey permittees to learn about the most significant impediments to conducting BMP inspections.</td>
<td>$40,000</td>
<td>1/8/2015</td>
<td>This study was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review</td>
</tr>
<tr>
<td>BMP Inspection and Maintenance Responsibility Allocation</td>
<td>Post-Construction Stormwater Management</td>
<td>A survey will be used to gather information from Washington Jurisdictions to learn novel and effective ways that municipalities are meeting the challenge of ensuring ongoing maintenance of structural BMPs on private property. In particular the survey will question permittees about different models of BMP ownership and responsibility for continued maintenance of BMPs.</td>
<td>$25,000</td>
<td>1/8/2015</td>
<td>This study was modified to fit the 'research proposal template' format, but the substance of the study is unchanged since the last EWSG review</td>
</tr>
<tr>
<td>Standardized Checklists for Trouble-Free Audits</td>
<td>Reporting and Record Keeping</td>
<td>Permittees will work with Ecology auditors to interpret each permit element, and clearly identify required actions of the permittee. Each of these required actions would become a checklist item on a standardized checklist for each permit component.</td>
<td>$75,000</td>
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APPENDIX D

Two Detailed Research Proposals
Research Proposal

Eastern Washington Effectiveness Study Group

Educating Mobile Contractors and Service Providers to Prevent Illicit Discharges

1. RESEARCH PROPOSAL TITLE

Improving Methods for Educating Mobile Contractors and Service Providers to Prevent Illicit Discharges

2. RESEARCH PROBLEM DESCRIPTION

Eastern Washington permittees suspect that an important source of illicit discharges may be mobile contractors and service providers (e.g., painters, builders, landscapers, concrete companies) who wash waste materials into the street or directly into storm drains. Because the mobile nature of these businesses involves working in different locations on a daily basis, traditional outreach strategies that focus on a specific geographic area (e.g., business inspections and outreach at a specific commercial area) or that rely on mailed brochures to commercial areas are unlikely to reach the mobile contractors. Additionally, because the service providers change locations frequently, discharge is unlikely to reoccur in the same location, making illicit discharge detection more challenging.

3. RESEARCH OBJECTIVE

The objective of this study is to develop and test the effectiveness of new outreach strategies aimed at reaching contractors and service providers about illicit discharges, their responsibilities for proper waste material disposal, and consequences for non-compliance. Developing and testing strategies for ensuring that the mobile service providers are receiving training and outreach materials will also be an integral component of the study.

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY

Traditional E&O methods and strategies typically consist of disseminating information to the public through the distribution of written materials or face to face interactions including hosting workshops (EPA, 2005). While these approaches can increase public awareness and understanding of stormwater issues, studies indicate education alone generally does not result in sustainable behavior changes (B. D. Keller, 2011; Giacalone et al., 2010; S. Grooner Associates Inc., 2012). An alternative approach utilizes social marketing strategies to develop and deliver targeted E&O programs. These programs address a specific community water quality issue and are tailored for a target audience with the goal of encouraging sustainable behavioral changes that will reduce pollution. Social marketing strategies rely heavily on an iterative research process and input from the target audience, which typically includes (D. McKenzie-Mohr, 2000):

1) Identify the community issue and determine barriers that may prevent the target audience from changing their behavior

2) Design a program that will overcome barriers and encourage sustainable behavior changes
3) Pilot test the program

4) Evaluate and refine the piloted program before broad implementation

A number of existing E&O programs have been developed using community based social marketing strategies and these programs provide examples to follow in the development of targeted E&O programs. Based on post surveys from some regional programs, the impact of these targeted programs appears promising, including an increase in awareness of stormwater pollution and sustained changes in behavior that can reduce pollution. One of those programs is the Puget Sound Spill Kit Program Developed by the Environmental Coalition of South Seattle, which focused on distributing 2,860 spill kits as well as providing onsite training and educational resources to businesses managers about illicit discharges and spill prevention. This program surveyed business owners using ‘before and after’ surveys to assess the impact of the education program after two years of implementation. The results indicated a 50% increase in understanding where stormwater runoff goes and a 28% increase in businesses who provided staff with spill training. In addition, over a 2 year period 11% (111) businesses used the spill kits (ECOSS, 2015). Seattle Public Resource Venture Program reported similar results for their program which included distributing over 900 free spill kits, spill response plans, and training to mostly automotive businesses and some grocery stores. Four years after implementing the program, fewer businesses washed spills away with a hose and half of the kits that had been used were replace (Cunningham Environmental Consulting, 2011).

Kitsap County Public Works conducted a study in 2011 using social marketing strategies to develop recommendations for designing and implementing E&O programs targeted at different business sectors including mobile contractors. The study approach focused on collecting information through surveys, interview, and focus groups from different businesses sectors with daily practices that may contribute to stormwater pollution. The goal of the study was to recommend E&O strategies for each sector by identifying the following: general awareness, current behaviors, desired behaviors, barriers, motivators, and recommended messages for future E&O efforts. Results from the study found that the mobile contractors had “…a limited understanding of surface water issues and were not aware that runoff to storm drains finds its way to water bodies.” Many contractors were also unlicensed and removed any business advertising from their vehicles to maintain anonymity which also reduces the likelihood of identifying the contractor if the public observes and reports an illicit discharge. Barriers identified from complying with illicit discharge regulations included; difficult to understand regulations, language barriers, cost, mistrust of government, and no existing groups (industry or trade) who disseminate educational information. Motivations contractors provided for changing behavior included “doing the right thing”, interest in environmental protection, and wanting to meet the needs of customers for green products and practices. Strategies recommended for future E&O efforts included finding an industry association, that works in cooperation with Ecology, to provide E&O for mobile contractors (Cunningham Environmental Consulting, 2011).

The Kitsap County Public Works study also reviewed and evaluated existing outreach strategies among all business sectors. Recommended strategies from this study included; spill kits, posters, on-site staff training or technical assistance, spill plan templates, and storm drain markers or stencils. Strategies which received mixed reviews included; training videos and public recognition for environmentally responsible businesses (specifically long term requirements for certification). Strategies not recommended included; written materials, direct mailers, off site training or workshops, and financial incentives to make structural changes (Cunningham Environmental Consulting, 2011).
5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH

How broadly will the results of this research apply?

X Nationally _____ Pacific Northwest _____ WA Only _____ Eastern WA _____ Western WA - _____ Puget Sound Basin _____ Interior PNW

How quickly will you need the results of this research?

ASAP _____ Within 6 months _____ Within 1 year _x__ Within 2 years _____ Within 5 years _____ Ongoing

6. CONCEPTUAL RESEARCH APPROACH

The proposed approach follows the social marketing process recommended in the literature search. This includes dividing the project up into four tasks; 1) identify program, 2) design program, 3) pilot program, and 4) evaluate program and recommendations. An overview of this process is illustrated in Figure 1 and summarized in the following sections.

Task 1
Identify Program
- Identify Pilot Location & Target service provided
- Design & Administer Survey
- Interviews or Focus Groups
- Evaluate Survey
- Program Design Recommendations

Task 2
Design Program
This may include:
- Core message, Slogan, Create Training Materials or spill plans
- Print materials, assembling kits

Task 3
Pilot Program
This may include:
- Disseminate Materials
- Provide Training
- Deliver Kits

Task 4
Evaluate Program & Recommend
- Design Post Surveys & Interview questions
- Administer Survey
- Conduct Interviews
- Evaluate Responses
- Recommend for Refining Program & Future Efforts

Figure 1. Overview of Proposed Approach

Task 1 Identify Program: The objective of this task is to assess the service provider’s baseline knowledge of illicit discharge and identify barriers/motivators for changing their behavior. This will be achieved by collecting and analyzing information about the target audience through surveys, interviews, and/or focus groups. Findings from this task will be used in task 2 to design a targeted E&O program. The proposed approach includes:

1. Identify Locations & Audience: A pilot test location and target service provider (e.g., painters) will be selected through interviews with the permittees. Then an inventory of contact
information will be developed from business license records and through the yellow pages. The contact information be will be used to administer the survey.

2. **Design & Administer Survey:** This task will focus on designing a survey with the goal of collecting baseline knowledge from the service providers including; general awareness, current behaviors, desired behaviors, barriers to changing behavior, and motivators for changing behavior. In addition, questions will also address ethnicity and preferred methods for receiving information. For ease of evaluation, the options for responses will only include multiple choice or yes/no questions. The surveys will be sent out using the contact information provided (e.g. emails and letters) and include a link to an electronic version of the survey. The duration of the survey period is 1 to 2 months. Depending on response, phone calls or a follow up letter may be used as a reminder about the survey.

3. **Evaluate Survey:** survey responses will be combined into a table format and converted to a Likert-type scale using numerical values (i.e., 0, 1, 2, 3, 4). This will allow for statistical analysis of the responses. The results will be presented in tables and graphs.

4. **Interviews of Focus Groups:** Follow up interviews with some respondents or a focus group will be set up to target specific issues identified in the survey and clarify responses before designing the program, for example asking respondent to expand on their motivations for changing behavior or barriers. This will include developing open ended questions prior to the interview of focus group. The responses will be analyzed as follows; code the responses, identifying common themes, combine response based on similar themes, and summarize results into a table. As motivation for participating in the study, incentives may be considered such as gas cards.

5. **Recommendations for Program:** Using the information from both the surveys and interviews, recommendations for designing the targeted E&O program (task 2) will be developed including; goals and an outline of the required elements. This may include; preferences for delivering information, identifying who will provide E&O, types of educational strategies (e.g. training onsite), handing out spill kits, etc.

**Task 2 Design Program:** The objective of this task is to design a program that will overcome barriers and encourage sustainable behavior changes. The results of this task will be an E&O program targeted at the service provided which will be pilot tested in task 3.

1. **Design the Program:** Using the goals and recommendations from task 1, design and develop the E&O program. This may include; developing a slogan and a core message, creating brochures, training materials or spill plans, assembling kits (similar to spill prevention kits), and providing the materials in different languages, etc.

**Task 3 Pilot Program:** the objective of this task is to pilot test the program in the targeted locations for approximately 6 months to one year. This will include disseminating the materials (using the preferred methods identified in the survey), offering onsite training, delivering kits, etc.

**Task 4 Evaluate Program and Recommendations:** The objective of this task is to evaluate the pilot program and recommend ways to refine the program before broad implementation. This will include conducting before and after surveys and interviews to assess the effectiveness of the program and develop recommendations.
2. **Design Surveys & Interview Questions:** This task will focus on designing a survey (and interview questions) similar to the pre-survey with the goal of collecting post pilot program knowledge from the service providers.

3. **Administer Survey & Conduct Interviews:** The survey information will be sent to the service provider using the preferred method identified in the pre-survey. The duration of the survey period is 1-2 months. Depending on response, phone calls or follow up letters may be used as a reminder. In addition, interviews will be conducted to expand on details in the responses.

4. **Evaluate Survey:** The evaluation will be the same methods as described in task 1. Additional analysis will include hypothesis testing to determine if pre and post responses are statistically different. Then determine the percent change in responses for each community.

5. **Recommendations for Program:** Using the survey/interview evaluation recommendations will be developed; for refining the program and for future efforts to expand the program. Recommendations should include; changes to the current program, and locations and audience for expanding the program.

7. **POTENTIAL MANAGEMENT CHANGES RESULTING FROM RESEARCH FINDINGS**

Current education and outreach programs aimed at informing mobile contractors and service providers about their responsibility in avoiding illicit discharges could be updated to incorporate effective elements identified through this research.

8. **ESTIMATED COST AND TIMING (Optional)**

This study would take between 12 to 18 months and is estimated to cost $75,000-$100,000.

**References**


Research Proposal
Eastern Washington Effectiveness Study Group
Modernizing Education and Outreach Strategies

1. RESEARCH PROPOSAL TITLE
Modernizing Stormwater Education and Outreach (E&O) Strategies to Incorporate New Communication Technology (NCT) Tools

2. RESEARCH PROBLEM DESCRIPTION
Stormwater Education and Outreach (E&O) programs strive to inform the public about the impacts of polluted stormwater discharges on local water bodies and encourage the public to modify behaviors that contribute to water quality problems (EPA, 2005a, 2005b). Considering the target audience for these programs may include all of the general public living in a community or region, achieving these requirements presents some challenges. The key challenges include developing program materials that are appropriate for a diverse audience as well as the logistics of disseminating information (B. D. Keller, 2011).

In addition, the way people receive, process, and interact with educational materials is also changing as technology evolves. As a result, traditional strategies alone for disseminating E&O information (e.g. distributing written material or hosting workshops), may not be as effective (E. T. Schultz, 2014). The development of new communication technology (NCT) tools (e.g. websites, email, social media, and interactive apps) has expanded E&O dissemination options and increased opportunities for capturing the public’s attention. However, integrating NCT tools into E&O programs present additional challenges with identifying the audiences preferred method(s) for receiving information and adapting E&O programs to the NCT tool platforms.

3. RESEARCH OBJECTIVE
The goal of the proposed study is to Modernize a Stormwater Education and Outreach (E&O) Program using Strategies that incorporates new communication technology (NCT) Tools. The program will focus on one topic for a target audience that includes the general public living in the NPDES Phase II jurisdictional areas of Eastern Washington. The specific objectives for this study include:

1. Define the program; measureable goals, core message, and NCT tools
2. Develop the program; adapt an existing program to integrate NCT tools and develop the NCT tools to disseminate the message
3. Implement and Evaluate the program; launch the program and evaluate the effectiveness of the program based on; changes in the public’s understanding and awareness, audience usage of the new technology tool, differences in program impacts among ethnic groups, and cost benefit analysis (assessment of program costs vs. program effectiveness).

The findings from the evaluation will be used to make recommendations to; refine the modernized program, assess whether the program should continue (based on cost benefit analysis), and identify lessons learned. In addition, the findings from this study may benefit other stormwater organizations.
by identifying important factors and lessons learned in the development of a regional stormwater E&O program that incorporates modernized strategies (NCT tools).

4. LITERATURE SEARCH AND RESEARCH IN PROGRESS SUMMARY

Developing E&O Programs: The National Pollutant Discharge Elimination System (NPDES) stormwater permit requirements prompted the development and implementation of E&O programs. Requirements for these programs include; informing the public about the impacts of stormwater pollution, encouraging changes in the public’s behavior that could reduce pollution, developing measureable goals for E&O programs, and evaluating the program effectiveness based on achieving progress toward those goals (EPA, 2005b).

Recommendations for developing successful E&O programs generally include developing a program around a water quality issue that is specific to the community and relevant to the target audience (Cunningham Environmental Consulting, 2011; D. McKenzie-Mohr, 2000; EPA, 2010; Giacalone, Mobley, Sawyer, Witte, & Eidson, 2010). Social Marketing strategies are a common approach for developing these programs, which focus community input (in the form of surveys or focus groups) to understanding the audience, which then guides the development of an E&O program that is tailored for a specific community issue and target audience (D. McKenzie-Mohr, 2000). A region wide E&O strategic plan was developed in South Carolina using a similar approach. The survey used to collect community input can be found at the following link which may provide serve as an example for this study; http://www.clemson.edu/public/carolinaclear/surveys2013.html

Modernized Dissemination Strategies for E&O Programs: As technology has evolved, strategies for disseminating E&O messages and materials have expanded to include NCT tools. However with more options comes more choices for permittees, specifically identifying effective strategies for reaching a large audience. A 2014 national survey of stormwater organizations explored this question and found the most common strategy for disseminating information to a large audience focused on NCT tools specifically internet advertising, websites, social media (Facebook and Twitter), emails, as well as online webinars and videos. Additional noted benefits of these approaches included; simple and inexpensive implementation and easy methods for measuring the effectiveness of the NCT tool for reaching the public including using built in features to track how often the tool is accessed (E. T. Schultz, 2014). The study also found that when the target audience is small, traditional methods for disseminating E&O were most successful including sending letters and face-to-face interactions.

Examples of NCT Tools: There are a growing number of examples where E&O programs use NCT tools to disseminate environmental messages. An internet search for examples include some of the NCT tools summarized in the Table below, which could serve as templates for the proposed E&O program.

<table>
<thead>
<tr>
<th>NCT Tool</th>
<th>Overview</th>
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<tbody>
<tr>
<td>Websites</td>
<td>Stormwater organizations use websites to promote their organization and to provide a clearinghouse of information and resources. Carolina Clear is a regional stormwater organization focuses on educating and involving the public in protecting waterways and preventing pollution. <a href="http://www.clemson.edu/public/carolinaclear/water_quality/idde/">http://www.clemson.edu/public/carolinaclear/water_quality/idde/</a></td>
</tr>
<tr>
<td>Social Media</td>
<td>Stormwater organizations incorporate their slogan into social media including; What’s up Stormwater?, Stormwater Matters, and Stormwater Steve.</td>
</tr>
<tr>
<td>Email Listserve</td>
<td>Many organizations, such as Ecology, use listserves to distribute information via email to the public. <a href="http://www.ecy.wa.gov/maillist.html">http://www.ecy.wa.gov/maillist.html</a></td>
</tr>
</tbody>
</table>
An

<table>
<thead>
<tr>
<th>Apps</th>
<th>Rain Garden is an apps that provides the public with guidance for installing rain gardens. <a href="http://nemo.uconn.edu/tools/app/raingarden.htm">http://nemo.uconn.edu/tools/app/raingarden.htm</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Games</td>
<td>Stormwater Sentries and Runoff are two game apps that focus on educating the public about the impacts of stormwater runoff. <a href="https://appsto.re/us/9xwnN.i">https://appsto.re/us/9xwnN.i</a> and <a href="http://www.timmonsgis.com/projects/stormwater-sentries">http://www.timmonsgis.com/projects/stormwater-sentries</a></td>
</tr>
</tbody>
</table>

**5. GEOGRAPHIC SCOPE AND URGENCY OF RESEARCH**

*How broadly will the results of this research apply?*

- **X** Nationally  
- ____ Pacific Northwest  
- ____ WA Only  
- ____ Eastern WA  
- ____ Western WA  
- ____ Puget Sound Basin  
- ____ Interior PNW

*How quickly will you need the results of this research?*

- ____ ASAP  
- ____ Within 6 months  
- ____ Within 1 year  
- _x_ ____ Within 2 years  
- ____ Within 5 years  
- ____ Ongoing

**6. CONCEPTUAL RESEARCH APPROACH**

The proposed research approach includes dividing the project into three tasks based on the objectives including: 1) Define the Program, 2) Develop the Program, and 3) Implement and Evaluate the Program. An overview of the approach is shown in Figure 1 and summarized in the following sections. In addition, this study integrates several significant elements into the modernized E&O program including; the core message, NCT tools, and addressing a diverse audience. In support of the study goal, which focuses on NCT tools, investigation of the other elements has been kept simple. The proposed approach includes identifying and integrating NCT tools into an existing E&O program or message (rather than developing a new program or message). The impact of the program among different ethnic groups will also be assessed in this study for two primary reasons; 1) determine if the E&O materials for this study should be produced in more than one language and 2) determine if there are any differences in the program impact. If there are observed difference in the impact, it is recommended that the results of this study be used to provide the basis for another study focused on developing strategies for an ethnically diverse audience.
Task 1: Define Program

The objective of Task 1 is to define the primary elements of the program including develop measureable goals, select an existing E&O program, (and identify changes needed to adapt the core message for the target audience), select NCT tools, develop baseline information about the target audience, and select strategies for integrating the NCT tool into the modernized program.

Task 1.1: Define Goals & Programs: This task will focus on working with the EWSCG to define the items below which will be used to guide decisions for the remaining task 1 items. The proposed approach includes collecting and organizing information using a combination of methods including surveys, brainstorming meetings, decision rubrics, and summarizing information into a table format.

1. Identify existing E&O programs. Since the EWSCG is composed of members from different permittees who have already developed E&O programs for the targeted audience, these programs will likely provide an ideal template for the modernized program. To determine which program to select, an inventory of existing programs will be developed including goals and estimated costs. The EWSCG will then select one program that will serve as the template for this project.

2. Develop goals for the Modernized E&O program. The EWSCG group will decide if the goals for the selected template are appropriate for the proposed study or if group should develop new goals. Either approach should incorporate the existing NPDES phase II permit requirements for E&O. These goals will then be used to design the pre-survey (task 1.2).

3. Identify potential methods for announcing public survey. Develop an inventory of existing methods for disseminating information, which will be used to announce the pre-survey to the public. This may include; posting a link to the survey on other organizations websites or social media accounts, announcing the survey the news on radio or tv, including information about the survey in utility bills, etc.

Task 1.2: Define Target Audience and Areas: This subtask will focus on designing and administering a pre-survey to collect information about the general public living in the phase II jurisdictions. This information will be used to; modify the existing program (selected in task 1.1) core message for the target audience and to evaluate the effectiveness of the program by comparing the pre-survey results with the post survey (task 3.3). The proposed approach is as follows:

1. Define Areas: Use census records to define ethnic groups, population, and zip codes

2. Pre-Survey: Use the goals defined in task 1.1 to develop a pre-survey for the general public including; baseline knowledge of the topic including their perceptions, understanding, and identify existing behaviors as well as awareness of how their behavior may contribute to pollution. Questions will also be included to determine the preferred NCT tools, which will be, determine based on responses to questions regarding how they heard about the survey or how they typically receive information (e.g. watching news, reading new websites, etc.). Additionally, questions will be included to determine the respondent gender, ethnicity, and language preference of the respondent. For ease of evaluation, the survey responses will only include multiple choice or yes/no response options.

3. Administer Survey: The survey will be setup on a website for a period of 1-2 months.

4. Evaluate Responses: The responses will be converted from multiple choice or yes/no to a Likert-type scale that uses numerical values (i.e. 0, 1, 2, 3, 4). This will allow responses to be statistically analyzed including determining the significance of the responses between pre and
post surveys (task 3.3). In addition, for comparing between locations with a different population, it may be necessary to use a weighted average based on population. For example, divide the number of people included in the survey by the population in a target location (zip code). The same can be done with categories of respondents, i.e. gender, ethnic group, age, income, gender, and education (Giacalone et al., 2010, p. 94).

**Task 1.3: Case Studies of Existing E&O Programs:** The focus of this subtask is identifying and summarizing examples of existing E&O programs that incorporated NCT tools in the form of case studies. This information will then be used to help define the elements of the modernized program (task 1.4), specifically; select NCT tools, identify strategies for integrating NCT tools, and consider costs of different NCT tools. The proposed approach includes:

1. **Case Study Requirements:** An investigation will be conducted (literature search, interviews, etc.) to identify and select existing E&O programs that incorporate NCT tools (and preferably with a core message focused on the same topic of interest as the modernized program).

2. **Case Study Summary:** A total of ten case study summaries will be developed. Each summary will provide an overview of the program as well as; the project title, lead agency, NCT tool, the E&O goals, core message, tag line or slogan including a picture of any visual graphic, program goals, the target audience demographics, total cost (broken down by development, implementation, and annual maintenance), length of time in use, current status of program, and methods for measuring public usage and effectiveness of program.

**Task 1.4: Define Modernized Program and Decision:** The goal of this subtask is to fully define the elements of the program, specifically; select a NCT tool and identify any revisions needed the core message to help focus the developed of the program and NCT tools (task 2). If the existing E&O program core message does not require any changes or an existing NCT tool can be used for the program (without developing a new tool) then Task 2 would be skipped. The approach includes:

1. **NCT tool Selection:** based on an evaluating of the case studies (task 1.3), pre-survey responses (task 1.2), and estimated costs to select a NCT tool.

2. **Core Message Revisions:** Use the Task 1.2 survey responses to identify core message revisions or add a slogan, with the intent of tailoring the program to be more relevant to the audience. Specific changes may include promoting different behaviors or developing the materials in different languages, adding visual graphics, or printing the materials in a traditional format.

3. **Decision:** If needed, a rubric could be developed to prioritize and select options.

**Task 2: Develop the Program**

The objective of task 2 is to refine the modernized program core message and develop a NCT tool to disseminate core message.

**Task 2.1: Modify Core Message:** This task will focus on modifying the core message. If a slogan or visual graphics are needed, consideration should be given to hiring a social marketing firm to develop these items. Another option for generating the slogan/graphic that would also engage the community, is to hold a contest through the schools in the targeted areas. This could include having students develop a slogan/graphic and using the winning items for the program. This option may also require some professional modification to be suitable for the program.
**Task 2.2: Develop/Modify Program NCT Tool:** Hire Information-Communication Technology Developer (ICTD) to develop/modify NCT tool (app, game, social media, etc.) that aligns with preferred tools selected in Task 1.4 and that integrates the program message (Task 2.1). The developed tool should include options for tracking public usage (for evaluation).

**Task 3: Implement & Evaluate the Program**

This task includes launching the modernized program for a period of 6 months to one year and then evaluate the effectiveness of the program based on the measureable goals defined by the EWSCG. The findings from the evaluation will help determine if the program was effective, or needs to be refined or if the program was not effective recommendations may include stopping the program.

**Task 3.1: Implement Program:** Launch program using selected NCT tools. The proposed approach includes implementing program at task 1.2 selection locations for 6 months to a year. Actual implementation will depend on the tools selected.

**Task 3.2: Measure Program Impact:** The purpose of this task is to collect the information needed to determine if the program was effective or needs refinement and to determine if the NCT tool works properly. Results will be evaluated in Task 3.3. The proposed approach includes:

1. **Post Survey:** Design a survey that will measure the impact of the program following the approach and methods described in task 1.2. Questions will focus on identifying; changes in the public’s understanding and awareness regarding their own behavior, audience usage of the new technology tool, and differences in program impacts among ethnic groups.

2. **Administer Post-Survey:** Follow the same approach as task 1.2

3. **Evaluate Responses:** Evaluation will follow the same approach as defined in task 1.2. Additional analysis will include hypothesis testing to determine if pre and post responses are statistically different overall and between ethnic groups. Then determine the percent change in responses for each community using an $\alpha=0.05$.

**Task 3.3: Evaluate Program Effectiveness and Decision:** The goal of this task is to evaluate the effectiveness of the program and make recommendations for future use of, modifications to the program which may include recommendations for future studies focused on developing relevant materials for specific ethnic groups. The proposed approach includes:

1. **Evaluate Program Effectiveness:** Use the results from task 3.2, cost of the program (assessment of program costs vs. program effectiveness), and usage of NCT tool to determine if measureable progress was made. This may include developing graphs and summarizing data in a table including measureable goals.

2. **Decision:** Meet with EWSCG to review evaluation results and decide on the program future.

3. **Recommendations for Future Efforts:** using the survey data and feedback from the EWSCG, develop recommendations for based on progress toward measureable goals as well as; lesson learned, costs, suggestions from improving program impact among different ethnic groups.
7. ESTIMATED COST AND TIMING (Optional)

This study would take between one and two years and is estimated to cost $100,000-$150,000.

References


APPENDIX E

History of Collaboration among Eastern Washington Permittees
History of Collaboration among Eastern Washington Permittees

Members of the Eastern Washington Stormwater Group (EWSG) have worked together for many years on different aspects related to management of stormwater in their respective jurisdictions. The following is a list of the key collaborative activities the group has worked on. It is provided as a means of documenting this successful history of collaboration as the EWSG moves into the second phase of this effort.


- Public Education and Outreach: The Asotin County Regional Stormwater Program took the lead for developing some public education and outreach tools with wide support from the EWSG. This effort was supported by a grant from Ecology.

- **Eastern Washington Low Impact Development (LID) Manual**: Technical support was provided (through an Ecology grant) for review and development of this manual. Spokane County received and managed the grant. All of the Eastern Washington permittees weighed in on the manual.

- Five subregional groups have formed (Yakima area, Wenatchee Valley area, Walla Walla area, Tri-Cities, and Asotin area) that share information and tasks related to implementing the NPDES permit. Some of these areas have formalized agreements (ILAs) to share funding in permit implementation.

- GIS Application: One of the subregional groups used Ecology funding to build a “Stormwater Facility Inspection Tool” that helps with tracking maintenance inspections and needs for all of their stormwater infrastructure. This tool has since been implemented by several other permitted cities in Eastern Washington outside of the subregional group that originally had the tool created. With other agencies using the tool, it has been updated and improved over the years for everyone’s benefit and use.

- Operations and Maintenance (O&M) Plan for Phase 2: Several permittees worked on and shared O&M plans with one another and a template was developed for preparing these plans. With the new permit, discussion has started to possibly collaborate to help one another improve O&M plans.

- Erosion and Sediment Control Field Guide: Members of the EWSG worked together to modify several existing guides from other areas of the country and make their own field guide for construction contractors and inspectors.

- Water Quality Standards Rule Update: The EWSG has participated and discussed updates to the rule from the perspective of impacts to municipal stormwater programs.
- Funding and Grants: Several individuals from the EWSG serve as invited advisors to Ecology in the development and management of funding and grant programs for permitted municipal stormwater cities or counties.

- Rule Making: The EWSG regularly discusses and provides input on various rule-making efforts affecting municipal stormwater management. This included the State’s UIC rule and more recently, rule making for recycling solid street waste and debris.

- IDDE Field Screening Input: Members of the EWSG provided input on an IDDE Field Screening guidance that was sponsored by Ecology and western Washington permittees.

- Washington Stormwater Center: Members of the EWSG participated in formation of the Washington Stormwater Center, including development of its business plan.