

## Ranked List of Effectiveness Study Topics and Potential Questions

This table summarizes the findings of the draft literature review synthesis papers completed in February 2013 (download them at <https://sites.google.com/site/pugetsoundstormwaterworkgroup/home/selection-of-effectiveness-studies/synthesis-papers>).

*Note that the draft synthesis papers are available for comment through March 22, 2013 and should be finalized in mid-April.*

RANK	Stormwater Management Program Element	Effectiveness Study Topic Null Hypothesis (H <sub>0</sub> )	Potential Questions for RSMP Request for Proposals - Submitted by the SWG to Ecology in September 2011	Questions/Needs Posed for Consideration Based on the Initial Findings in February 2013
1	Source Control	Construction site inspections are not effective at controlling sediments and turbidity from permitted construction sites. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>• Are the temporary erosion and sediment control (TESC) Best Management Practices (BMPs) required during development or redevelopment adequate to control erosion and sediment from construction sites? <b>Answered. Yes, but depends on proper BMP selection, O&amp;M, and site conditions.</b></li> <li>• Are the TESC BMPs used at construction sites effective at reducing turbidity/TSS for compliance with water quality standards (WQS)? <b>Partially answered. High levels of sediment removal may still not meet WQS.</b></li> <li>• What frequency of construction erosion and sediment control inspections are most effective for achieving compliance with codes/ordinance requirements at new development and redevelopment project sites? <b>Not answered. Recommend consistent schedule and special inspections following significant rainfall.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Which of the TESC BMPs in the SWMMWW are most effective at controlling erosion and sediment at construction sites in W WA?</li> <li>• Study use of anionic polyacrylamide (PAM) to control erosion from Puget Sound area soils.</li> <li>• Study BMPs performance in meeting WQS under field conditions in W WA.</li> <li>• Review SWMMWW sediment pond design and try other approaches to estimating sediment loading.</li> </ul>

## Ranked List of Effectiveness Study Topics and Potential Questions

2	Source Control	Education and inspection of private stormwater facilities does not affect water quality. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>• Do more frequent site visits and contact with private facility owners improve compliance with operation and maintenance (O&amp;M) requirements? <b>Answered. Generally yes.</b></li> <li>• What is the optimum frequency of inspections to maintain the functionality of private stormwater facilities? <b>Not answered. Depends on activities and relationships. Recommend annual visits at minimum.</b></li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>
3	Public Education	Permit-required public education programs do not result in decreased levels of pollutants in stormwater.	<ul style="list-style-type: none"> <li>• Are fecal coliform levels in stormwater reduced after an extensive pet waste education program? <b>Partially answered. More people are picking up pet waste.</b></li> <li>• Are nutrient levels in stormwater reduced following an extensive natural yard care education program? <b>Partially answered. Fewer people report fertilizer use.</b></li> <li>• Are pesticide concentrations and number of hits reduced in an urban stream following general awareness? <b>Not answered. Fewer people report pesticide use.</b></li> <li>• Does establishing a spill hotline result in reduced stormwater pollutants? <b>Not answered. Hotlines do bring illicit discharges to local jurisdictions' attention.</b></li> <li>• Does a fundraiser car washing education program result in reduced surfactants in stormwater? <b>Not answered. Mixed findings.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Apply findings to new public education and outreach initiatives.             <ul style="list-style-type: none"> <li>○ People are aware; need to focus on barriers to behavior change.</li> </ul> </li> <li>• If effectiveness studies are done, measure intermediate outcomes, i.e., behavior change, not stormwater pollutant levels or receiving water conditions.</li> <li>• Need to prioritize behaviors to target to reduce the most important pollutants.</li> </ul>

## Ranked List of Effectiveness Study Topics and Potential Questions

4	Illicit Discharge Detection and Elimination (IDDE)	IDDE program components are not effective at reducing pollutants. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>• Which combination of methods; smoke testing, dye testing, CCTV, flow monitoring and outfall screening (wet and dry season) work best for detection of illicit connections? <b>Partially answered. Many methods work well. Depends on local conditions and needs.</b></li> <li>• How effective is wet weather screening as a tool to detect illicit connections? <b>Partially answered. Can be effective as part of a comprehensive program.</b></li> <li>• Which parameters should be measured during dry weather screening to improve the ability to detect illicit connections? <b>Partially answered. Screening parameters should match foreknowledge of illicit discharges.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Need more information on how IDDE methods work across a range of conditions.</li> <li>• Need a regional chemical indicators database.</li> </ul>
5	O&M- Pollution Prevention	Frequency of inspecting and cleaning catch basins is not dependent on land use or road size. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>• Do catch basins on arterial streets require more frequent cleaning vs. non-arterial streets? <b>Answered. Yes, high AADT streets accumulate more sediment.</b></li> <li>• Can land use or road size/type be used to set an optimal frequency for inspection and cleaning catch basins? <b>Answered. Yes. Map road size/type with land use to help predict accumulation rates and cleaning needs.</b></li> <li>• Does the land use surrounding a catch basin influence the rate of sediment accumulation in catch basins? <b>Answered. Yes. Industrial accumulates more sediment than commercial accumulates more sediment than residential.</b></li> <li>• Can catch basin maintenance frequency be determined by land use surrounding the catch basin? <b>Answered, see above. Attention is needed for curbless areas, construction, and following snowmelt where sand is applied.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Investigate feasibility of increasing catch basin sump sizes.</li> </ul>

## Ranked List of Effectiveness Study Topics and Potential Questions

6	<p>Low Impact Development (LID)</p>	<p>LID measures are not effective at reducing storm flows in retrofits and new development. <b>This null hypothesis is rejected.</b></p>	<ul style="list-style-type: none"> <li>• Which LID measures are most effective at reducing flow from developed areas? <b>Answered. All are effective, sizing is key. Infiltration is more effective than green roof.</b></li> <li>• Will installing porous pavement in alleys and road rights-of-way with rain gardens substantially reduce runoff? <b>Answered. Yes if subsurface conditions are appropriate.</b></li> <li>• Does amending landscapes with compost significantly reduce flows during small and medium storms? <b>Answered. No, attenuation only until saturated.</b></li> <li>• Is LID more effective than traditional BMPs for improving hydrology at the basin scale? <b>Answered. Yes. LID provides volume reduction, traditional BMPs focus on peak reduction, so recommend combination.</b></li> <li>• Will a developed basin with a high density of LID measures have measurable differences in hydrology and pollutant loads compared to a similar basin with a low density of LID measures? <b>Answered. Yes for small storms. Size-dependent for large storms.</b></li> <li>• How well can a calibrated and verified stormwater model (<i>e.g.</i>, SUSTAIN and EPA SWMM5) function as a replacement for a control in a paired watershed study design? <b>Answered. Most reliable results if collect very good pre-treatment data.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Need information at BMP, site, basin, and organizational levels.</li> <li>• Need better sizing information to avoid facility bypass.</li> <li>• Do basin-scale performance studies match field results with modeling? Conduct watershed-scale flow reduction study.</li> <li>• How is long-term performance affected by maintenance practices?</li> <li>• Measure flow reduction and study role of under-drains at bioretention sites. Evaluate meteorology and exfiltration.</li> <li>• Evaluate permeable pavement infiltration performance over time.</li> <li>• Assess administrative approaches to overseeing design, installation, and maintenance of LIDs.</li> </ul>
---	-------------------------------------	--	---	---

## Ranked List of Effectiveness Study Topics and Potential Questions

7	LID	<p>LID measures are not effective at reducing pollutant loads in retrofits and new development. <b>This null hypothesis is rejected.</b></p>	<ul style="list-style-type: none"> <li>• Does the installation of bioretention, bioinfiltration, biofiltration, rain gardens, and other LID measures have a measurable effect on water quality? <b>Not answered for receiving waters. Most parameter concentrations are reduced, and loads are substantially reduced as a consequence of flow reductions.</b></li> <li>• Which LID measures are most effective at improving water quality from developed areas? <b>Answered. Permeable pavements and bioretention facilities best except for nutrient (and sometimes copper) concentrations. Loading is reduced through flow reduction.</b></li> <li>• Can compost mixes and plant species be tailored to enhance removal of specific pollutants (<i>i.e.</i>, phosphorus, metals, bacteria)? <b>Answered. Yes.</b></li> <li>• Is LID more effective than traditional BMPs for improving water quality at the basin scale? <b>Not answered, though improvement in receiving waters likely results from fewer small to medium size storms.</b></li> <li>• Will a developed basin with a high density of LID measures have measurable differences in pollutant loads compared to a similar basin with a low density of LID measures? <b>Not answered.</b></li> <li>• Does bioretention treat runoff sufficiently to allow for infiltration without violating groundwater quality standards? <b>Answered. Yes, with possible exception for nitrate in some settings.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Need information at BMP, site, basin, and organizational levels.</li> <li>• Model various densities/types of LID and conduct a watershed-scale water quality study to verify model results.</li> <li>• Conduct soil amendment leaching studies combined with plant selection studies for optimum removal of nutrients, bacteria, and metals.</li> <li>• Identify long-term media fertility to support plant growth.</li> <li>• How is long-term performance affected by maintenance practices?</li> <li>• Need better sizing information to avoid facility bypass.</li> <li>• Study long-term infiltration rates.</li> <li>• Study long-term adsorption capacity.</li> <li>• Where and when are nutrient outputs of ecological concern?</li> <li>• Is reduced frequency of untreated stormwater flows from small and medium storms the mechanism of water quality benefit to receiving waters?</li> </ul>
---	-----	--	--	--

## Ranked List of Effectiveness Study Topics and Potential Questions

			<ul style="list-style-type: none"> <li>• What type and frequency of maintenance is needed to ensure the long-term performance of bioretention facilities? <b>Not answered.</b></li> </ul>	
8	Source Control	<p>Business inspection and outreach are not effective source control techniques. <b>This null hypothesis is rejected.</b></p>	<ul style="list-style-type: none"> <li>• Are businesses that receive an in-person visit/inspection more likely to implement source control BMPs? <b>Answered. Generally yes. Refer to public education findings.</b></li> <li>• What frequency of business inspections is most effective for implementing and maintaining source control requirements/BMPs at businesses? <b>Partially answered. Depends on activities and relationships.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Address the connection between in-person visits and source control BMPs.</li> <li>• How do business inspections and outreach activities relate to the implementation and maintenance of stormwater source control BMPs?</li> </ul>
9	Public Education	<p>Permit-required public education programs promoting behavior change do not result in increased awareness and behavior change. <b>This null hypothesis is rejected.</b></p>	<ul style="list-style-type: none"> <li>• What is the increase or decrease over time of various target audiences willing to make a simple change in their daily lives to help Puget Sound? <b>Not answered.</b></li> <li>• What is the increase or decrease over time of various target audiences willing to invest over \$1,000 to make a change in their property to help Puget Sound? <b>Partially answered. Farmers are generally more willing to invest in changes than some small business owners.</b></li> <li>• What is the increase or decrease over time of car owners to fix leaks? <b>Not answered.</b></li> <li>• What is the increase or decrease in stormwater drain awareness of various business sectors involved in commercial property maintenance inspections? <b>Not answered.</b></li> <li>• Does a fundraiser car wash education program decrease the number of fundraiser car wash events? <b>Partially answered.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Continue investments in regional education efforts.</li> <li>• Sound Behavior Index and Social Capital Index are useful indicators. Need to focus on specific behaviors. <ul style="list-style-type: none"> <li>○ Leak question is a good example.</li> </ul> </li> <li>• Need to tell people what to do.</li> </ul>

## Ranked List of Effectiveness Study Topics and Potential Questions

10	Traditional BMPs	Retrofitting using water quality treatment devices does not reduce pollutant loads. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>• Which combinations of retrofit BMPs in a basin are most effective at reducing pollutants to receiving waters? <b>Not answered.</b></li> <li>• To what extent does retrofitting using water quality treatment devices reduce urban stormwater pollution to receiving water bodies? <b>Partially answered. Limited studies for TSS, metals, nutrients.</b></li> <li>• Once installed, do model predicted quantities of stormwater controls in a basin reduce stormwater impacts enough to support the receiving water's designated beneficial uses? <b>Partially answered.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Perform field studies of existing urban retrofitted BMPs in WWA to assess effectiveness at pollutant removal.               <ul style="list-style-type: none"> <li>○ Conduct a more extensive literature review.</li> <li>○ Compare model predictions to field data.</li> <li>○ Compare BMPs and combinations for specific pollutants.</li> <li>○ Develop urban-specific models.</li> </ul> </li> <li>• Investigate retrofit feasibility and landowner incentives.</li> </ul>
11	LID	LID measures are not feasible in areas with tight soils or shallow groundwater. <b>These two null hypotheses are: rejected, and accepted.</b>	<ul style="list-style-type: none"> <li>• What, if any, LID measures are feasible in areas with tight soils? <b>Answered. Tight soils allow more infiltration than expected, so bioretention is feasible in almost all areas. Concern about preferential pathways to building foundations in densely developed areas.</b></li> <li>• What, if any, LID measures feasible in areas with shallow groundwater? <b>Answered. Shallow groundwater will interfere with LID performance.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Perform local field study of exfiltration conditions and affect on sizing around bioretention facilities especially where low infiltration sub-grades exist.</li> </ul>
12	Traditional BMPs	Reducing the size of a filter strip does not alter its effectiveness at reducing pollutant concentrations.	<ul style="list-style-type: none"> <li>• Are existing sizing criteria for vegetative filter strips (based on bioswales) overly conservative? <b>Not answered.</b></li> <li>• Which combinations of length, width, slope, soil types and vegetation types result in greatest removal of sediment by vegetative filter strips? <b>Not answered.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Conduct studies to determine optimal combination of design variables under light to moderate rainfall intensities.</li> </ul>

## Ranked List of Effectiveness Study Topics and Potential Questions

13	LID	Permeable pavement will fail on high-speed roads. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>Is permeable pavement feasible over the long-term for applications on high-speed roads? <b>Answered. Yes. Asphalt has worked on freeways, but pavers are only appropriate for low velocity, low AADT roads.</b></li> </ul>	<ul style="list-style-type: none"> <li>Conduct a long-term study of permeable asphalt on high-speed and high-use road in W WA.</li> </ul>
14	LID	Recycled concrete cannot be used to provide storage under permeable pavement. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>Can recycled concrete be used as storage under permeable pavement? <b>Answered. Yes, if increased pH is not a water quality concern.</b></li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>
15	O&M-Pollution Prevention	Catch basins do not contribute sufficient fecal coliform bacteria to exceed water quality standards. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>Are catch basins a significant source of fecal coliform or other pollutants? <b>Answered. Yes.</b></li> <li>What frequency of catch basin maintenance is needed to reduce the level of fecal coliform to meet Total Maximum Daily Load (TMDL) requirements? <b>Partially answered. Fast regrowth of bacteria throughout system, including curbs, prevents success.</b></li> </ul>	<ul style="list-style-type: none"> <li>Need to address the likelihood that fecal coliform bacteria in biofilms are no longer indicating presence of pathogens.</li> <li>Focus future study on other BMPs, biofilm accumulation and influence, and other O&amp;M practices.</li> </ul>
16	Public Education	Public Education of lake property owners about residential pollutants will not reduce summer algae blooms.	<ul style="list-style-type: none"> <li>Are summer algae blooms due to excess runoff or recycling of nutrients? <b>Answered (though outside scope of public education). Most likely due to phosphorus.</b></li> <li>Can education and prevention of phosphorus loads from runoff influence the frequency and duration of lake algae blooms? <b>Partially answered.</b></li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>

## Ranked List of Effectiveness Study Topics and Potential Questions

17	Public Education	Storm drain stenciling does not raise awareness about where stormwater goes or that it is not treated. <b>This null hypothesis is rejected.</b>	<ul style="list-style-type: none"> <li>• What is the level of awareness of adjacent land owners to storm drain stencils compared to landowners with no storm drain stencils? <b>Answered. There is a high level of awareness. However there is an unintended consequence: some folks think stormwater runoff that goes to un-stenciled drains is treated.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Do people living near stenciled storm drains put fewer chemicals in them?</li> <li>• Are fewer chemicals found in stenciled storm drains?</li> <li>• Are nearby water bodies healthier?</li> </ul>
18	Traditional BMPs	There are no differences in ecological or intrinsic human benefits derived from maintained versus unmaintained stormwater ponds.	<ul style="list-style-type: none"> <li>• Are water quality benefits increased by letting ponds take a more natural, successional path rather than continual maintenance?</li> <li>• Do humans value the unmaintained pond for the “wildness” it can introduce to their neighborhood (trees, shrubs, wildlife, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>
19	Source Control	Nutrient and Integrated Pest Management (IPM) programs do not improve water quality in receiving water bodies.	<ul style="list-style-type: none"> <li>• Does implementation of nutrient management result in the reduction of nutrients in stormwater?</li> <li>• Does implementation of IPM result in the reduction of pesticides in stormwater?</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>
20	Traditional BMPs	Toxics are not transferred to the nearshore from uplands by stormwater infrastructure.	<ul style="list-style-type: none"> <li>• Will installation of devices to restrict tidal influence on stormwater systems reduce the transfer of toxics to Puget Sound?</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>

## Ranked List of Effectiveness Study Topics and Potential Questions

---

21	Traditional BMPs	Oil/water separators are not effective in driveway applications.	<ul style="list-style-type: none"> <li>• What is the lowest threshold of paved surface that makes it cost/treatment effective to install an oil/water separator?</li> <li>• Are there other methods (<i>i.e.</i>, LID) that would be as effective in improving water quality as oil/water separators?</li> </ul>	•
22	IDDE	Receiving water body sampling does not confirm removal of an illicit connection or successful IDDE program.	<ul style="list-style-type: none"> <li>• How well does receiving water body sampling confirm the elimination of illicit connections?</li> <li>• Are there measurable differences in the concentration of fecal coliform in a receiving water body when illicit connections are removed?</li> </ul>	•