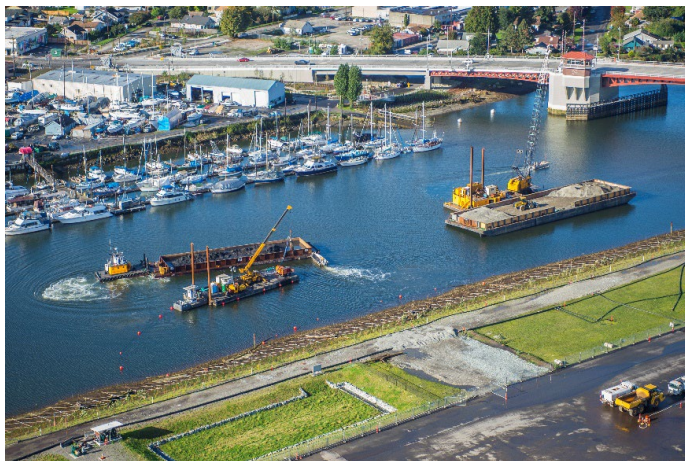


# When the Rubber Meets the Road, 6PPD-q What Ports Can Do

Patrick Hsieh, P.E.  
Dalton, Olmsted, and Fuglevand

Washington Public Ports Association  
Environmental Seminar  
September 19, 2024



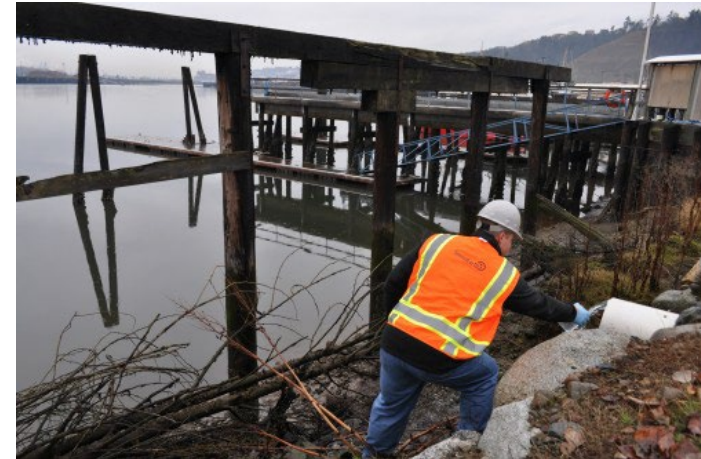
**DOF** DALTON  
OLMSTED  
FUGLEVAND



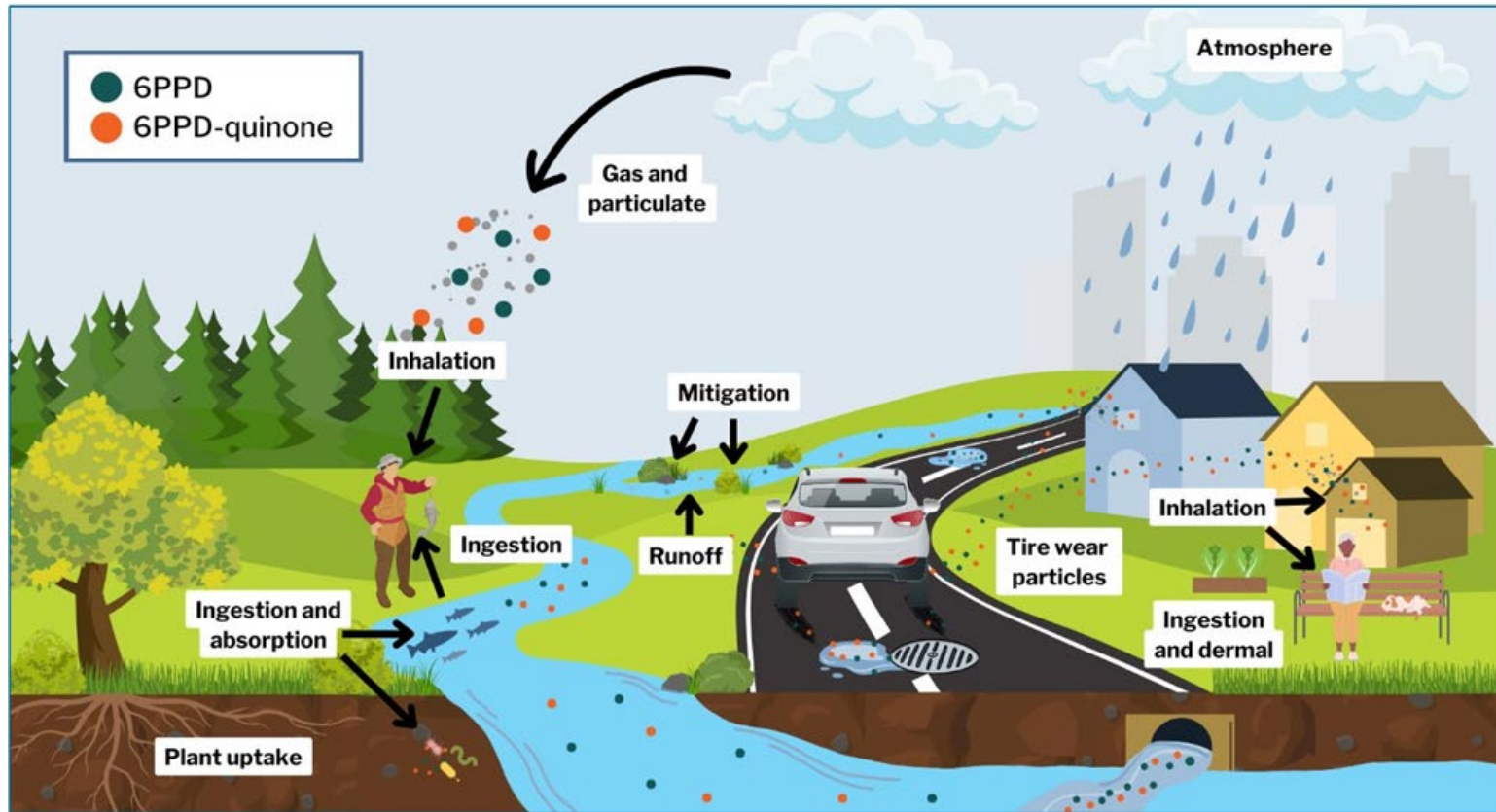
- Typical Challenges for Ports
- Source Control Options
- Key Treatment Characteristics
- Treatment BMP Options
- Current Resources Available
  - Ecology Resources
  - ITRC 6PPD Team
  - ITRC Stormwater BMPs
  - International SW Database
- Updates for Ongoing Research
- Recommendations
- Opportunity for questions

# Typical Challenges for Ports

- Large areas exposed to high levels of traffic
  - Changes to areas covered coming in 2025 ISGP
- Old Infrastructure
  - Many discharge points
  - Varying surfaces with significantly different traffic/tire wear
  - Substantially Identical?
- Limited Physical Options
  - Little to no vadose zone/high water tables
  - Flat sites with limited fall
- Balancing Treatment Costs with Future Revenue of Usable Footprint



# Source Control BMP Options



IITRC Focus Sheet- <https://6ppd.itrcweb.org/wp-content/uploads/2023/09/6PPD-Focus-Sheet-Web-Layout-9.pdf>

# 6PPD and 6PPD-q

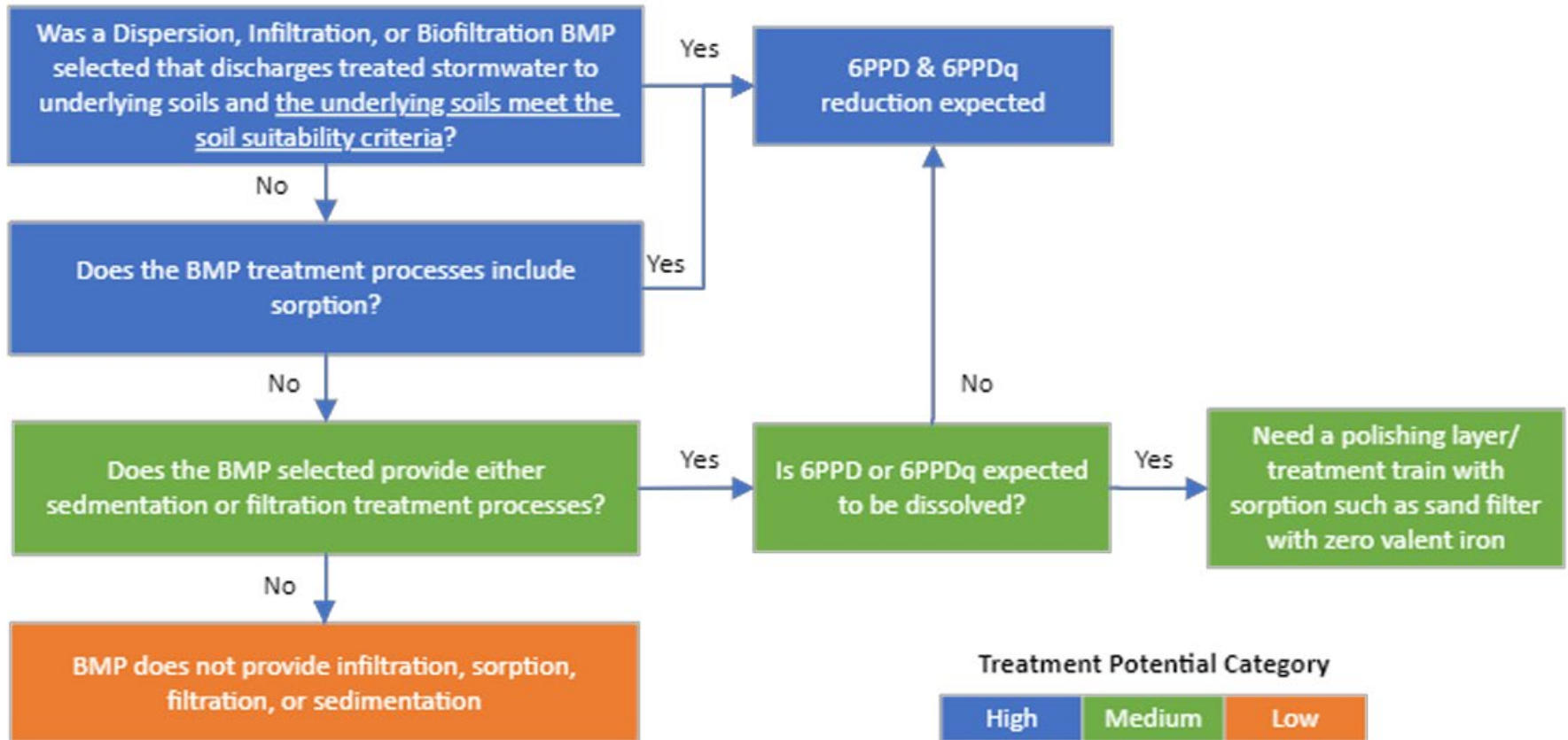
## Key Treatment Characteristics

### *Solubility*

- *6PPD is more soluble than 6PPD-q in water (mg/L vs ug/L)*
- *6PPD-q preferentially binds to organic matter and can sorb to containers, so it has some hydrophobic properties.*
- *Conversely, 6PPD-q is sufficiently soluble to be transported by water until it is captured by an organic media.*

Clay	< 3.9 $\mu\text{m}$
Silt	3.9 to 62.5 $\mu\text{m}$
Very Fine Sand to Medium Sand	62.5 to 500 $\mu\text{m}$
Coarse Sand to Fine Pebbles	500 to 4750 $\mu\text{m}$
Pebbles to Cobbles, Floatables, & Debris	> 4750 $\mu\text{m}$

# Treatment BMP Options



**Figure 4.2 Flow and Treatment BMP Evaluation Process**

<https://apps.ecology.wa.gov/publications/documents/2203020.pdf>



## 6PPD in Road Runoff Assessment and Mitigation Strategies

Prepared for

Model Toxics Control Act Legislative Program  
Washington State Legislature

By the

Environmental Assessment and Water Quality Programs  
Washington State Department of Ecology  
Olympia, Washington

October 2022

Publication 22-03-020



Water Quality Program



## Focus on: Best Management Practices for 6PPD-q



### The 6PPD-q stormwater problem

In 2020, scientists at the University of Washington-Tacoma, Washington State University, and other collaborators [identified the transformation product 6PPD-quinone](#), or 6PPD-q, as the chemical culprit causing acute Coho salmon death in small streams after rain events. 6PPD-q comes from 6PPD, a chemical preservative found in tires used to increase tire lifespan. Currently, 6PPD is used in all tires, is found in recycled tire products, and can contaminate stormwater anywhere tires are used.

Rain falls on tires and roads, washing tire particulates, which includes 6PPD and 6PPD-q, into the stormwater system. Without stormwater management, the chemicals may flow into waterbodies where contact with Coho salmon has proven to be fatal at very low concentrations. Runoff that travels from paved surfaces unmanaged into the water is currently considered to be the main source of tire wear debris and 6PPD-q contamination. Stormwater management is achieved using best management practices (BMPs) to control sources of contaminants, control flows and volumes of stormwater, and to treat stormwater prior to release in the stormwater system.

While manufacturers work to find alternative rubber preservatives, stormwater managers in Washington state are seeking solutions to prevent 6PPD-q contamination in runoff and to determine the best options to reduce concentrations for existing and future infrastructure.

### 2022 Stormwater BMP Evaluation

In June 2022, with legislative funds, Ecology procured engineering consultants to provide best professional judgment, reported in [Stormwater Treatment of Tire Contaminants - Best Management Practices Effectiveness](#), on existing BMP options and their likelihood to manage particulate tire wear, 6PPD, and 6PPD-quinone. The report explores all categories of stormwater BMPs in Ecology's manuals, including:

**Stormwater source control BMPs:** prevent stormwater contamination with methods such as roof or street sweeping to control runoff from tires, tire products, and tire wear particulates.

**Flow control BMPs:** slow runoff down and reduce runoff volumes by holding water back via infiltration methods such as ponds, infiltration basins, and bioretention.

**Runoff treatment BMPs:** reduce concentrations of the targeted pollutants, typically through physical filtration or chemical sorption media like biofiltration swales, bioretention, and manufactured treatment devices.

## ■ STORMWATER TREATMENT OF TIRE CONTAMINANTS BEST MANAGEMENT PRACTICES (BMP) EFFECTIVENESS

**Table 4.4 Examples of Flow and Treatment BMPs by Treatment Potential Category**

Treatment Potential Category	Examples of Flow and Treatment BMPs
High	Bioretention, Infiltration Basins, Media Filter Drain, Dispersion
Medium	Sand Filter, Detention Ponds, Permeable Pavements
Low	Perforated Stub-Out Connection, Vegetated Roofs, Tree Retention and Tree Planting

**Table 4.5 Examples of Source Control BMPs with Different Treatment Potential Categories**

Prevention Potential Category	Examples of Source Control BMPs
High	BMPs for Streets and Highways, BMPs for Maintenance of Roadside Ditches
Medium	E&O Programs Related to 6PPD or 6PPD-q, Construction Wheel Wash
Low	BMPs for Temporary Fruit Storage, BMPs for Railroad Yards



# Ecology Guidance- Infiltration/Filtration

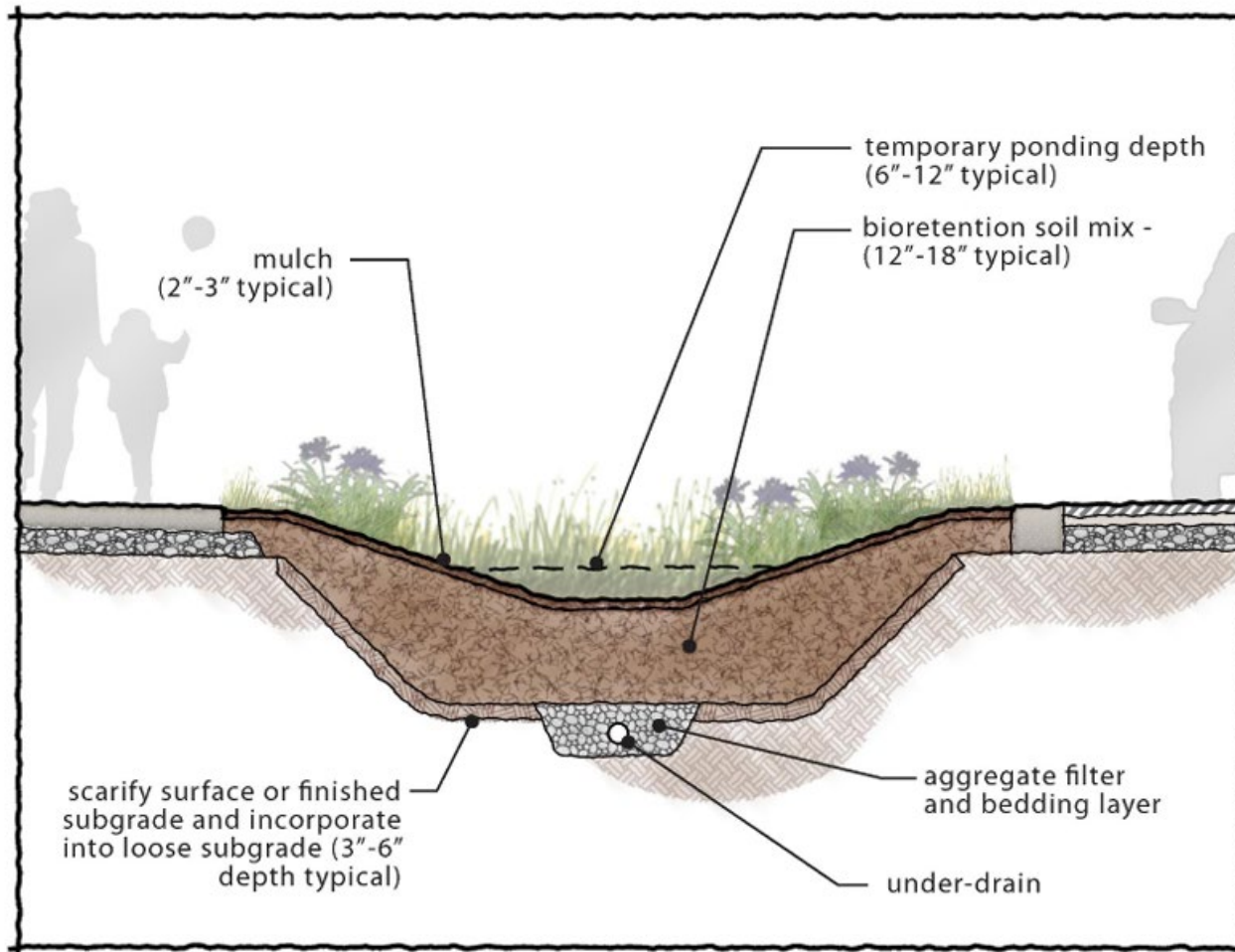


Figure 3. Typical bioretention system with design features. Current research is focused on optimizing the depth and composition of the bioretention soil mix. Courtesy of AHBL, Inc.

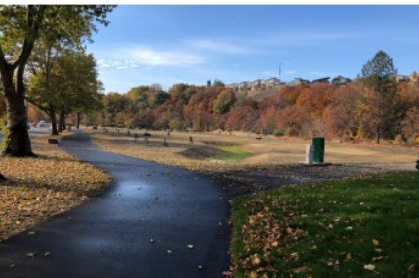


- Focus Sheet Available Now
  - <https://6ppd.itrcweb.org/wp-content/uploads/2023/09/6PPD-Focus-Sheet-Web-Layout-9.pdf>
- Full Guidance Document Coming September 24, 2024!
  - <https://itrcweb.org/itrcwebsite/teams/active/6ppd-q>
  - <https://6ppd.itrcweb.org/>

# Ecology Guidance Documents

- Stormwater Management Manuals for both Eastern and Western Washington

**Stormwater Management Manual  
for Eastern Washington**



February 2019



Publication Number 18-10-044

Printed on recycled paper

**Stormwater Management Manual  
for Western Washington**



July 2019



Publication Number 19-10-021

# ITRC's Online Stormwater BMP Guidance Document

**Stormwater Best Management Practices Performance Evaluation** HOM

**INTERSTATE TECHNOLOGY COUNCIL ITRC REGULATORY**

Search this website

Home

Navigating this Website

- 1 Introduction
- 2 Data Applicability
- 3 BMP Screening Tool and Considerations
- 4 Installation
- 5 Operational Strategies
- Additional Information

# Welcome

## Stormwater Best Management Practices Performance Evaluation (Stormwater-1)

**Overview Video Welcome to the Guidance**

**Introducing Chapter 1 Guidance Document Content**

**Introducing Chapter 2 Data Resources and Intro to Screening Tool**

**Introducing Chapter 3 How to Use the Screening Tool**

This guidance offers the user details on post construction BMP lifecycle processes including contracting, cost considerations, installation factors including construction

**ITRC** Stormwater BMPs: Welcome to t...

# ITRC's Online Stormwater BMP Guidance Document

## Centralized resource for information on stormwater BMP effectiveness and how to use and implement that information

INTERSTATE TECHNOLOGY COUNCIL **ITRC** REGULATORY

Search this website

- Home
- Navigating this Website
- 1 Introduction
- 2 Data Applicability
- 3 BMP Screening Tool and Considerations
- 4 Installation
- 5 Operational Strategies

This guidance offers the user details on post construction BMP lifecycle processes including contracting, cost considerations, installation factors including construction challenges, inspection checklists, quality control and record drawings. It goes on to address long-term technology- and performance-based operational strategies, including aspects such as routine and non-routine maintenance. Data and information from existing publicly available BMP performance programs has been incorporated into an online [BMP Screening Tool](#). Using site-specific pollutant treatment requirements and installation considerations, the Tool can assist the user by identifying a list of BMPs that may be appropriate for a given site. The Tool also provides users summarized information on the treatment efficiency, installation requirements and maintenance issues regarding the identified BMPs, with links to access more detailed information.

Publication Date: November 2018

 [Print this page/s...](#)

Stormwater BMPs: Welcome to t...

Overview Video

Welcome to the Guidance



**Stormwater-1**  
web document



**Stormwater-1**  
Glossary



**Stormwater-1**  
References



**Stormwater-1**  
Acronyms

ITRC  
Contact Us  
About ITRC  
Visit ITRC



ITRC on Social Media

# ITRC's Online Stormwater BMP Guidance Document

- Home
- Navigating this Website
- ▼ 1 Introduction
- ▼ 2 Data Applicability
- ▼ 3 BMP Screening Tool and Considerations
- ▼ 4 Installation
- ▼ 5 Operational Strategies
- ▼ Additional Information

- 2 Data Applicability
- 3 BMP Screening Tool and Considerations
- 4 Installation
- Additional Information
  - Appendix A. State and Local Survey results
  - Appendix B. BMP Installation Checklist
  - Appendix F. BMP Information Sheets
  - Acronyms
  - Glossary
  - Acknowledgments
  - Team Contacts
  - Document Feedback

# Step 1: Choose Pollutants

ITRC Stormwater Post-Construction BMP Evaluation Tool

Pollutant Removal Determinations

## Pollutant Screening

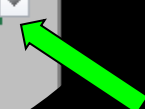
Select pollutant(s):

Sediments	Y/N
Total Suspended Solids	N
Suspended Solid Concentration	N
Turbidity	N
Total Solids	N
Dissolved Arsenic	N
Nutrients	Y/N
Total Nitrogen	N
Kjeldahl Nitrogen	N
Nitrate/ Nitrite	N
Ammonia	N
Phosphorous	Y
Ortho-phosphorous	N
Other	Y/N
Radionuclides	N

ITRC Stormwater Post-Construction B

RESET

## Related Practices (BMP)



# Step 2: Secondary Screening

Pollutant Removal Determinations

Related Practices (BMP)

**Pollutant**

Select pollutant(s)

**Sediments**

Total Suspended Solids

Suspended Solids

Turbidity

Total Solids

Total Dissolved Solids

**Metals**

Total Dissolved Metals

Total Copper

Dissolved Copper

Total Zinc

Dissolved Zinc

Total Lead

Dissolved Lead

Total Cadmium

Dissolved Arsenic

Dissolved

**Nutrients**

Total Nitrogen

Kjeldahl Nitrogen

Nitrate/ Nitrite

Ammonia

Phosphorous

Ortho-phosphorous

**Other**

Radionuclides

## Secondary Screening Criteria

**Select applicable installation condition(s):**

Installation Conditions	Y/N
Will the BMPs experience freezing conditions?	N
Will the BMPs experience arid conditions?	N
Is there limited space in which to install BMPs?	N
Are contaminated soils potentially present in the installation area?	<div style="border: 1px solid #0056b3; padding: 2px; display: inline-block;">Y</div> <div style="border: 1px solid #0056b3; padding: 2px; display: inline-block;">N</div>
Will the BMPs be installed in an area with high groundwater?	N
Will the BMPs experience high TSS loads?	N

Information

Wet Pond / Wet Basin
Media Filters
Permeable Pavement
Infiltration Devices
Chemical Treatment



# Step 3: Review Related Practices

**Pollutant Removal Determinations**

**Pollutant Screening**

Select pollutant(s):

**Sediments**

Total Suspended Solids

Suspended Solid Concentration

Turbidity

Total Solids

Total Dissolved Solids

**Metals**

Total Dissolved Metals

Total Copper

Dissolved Copper

Total Zinc

Dissolved Zinc

Total Lead

Dissolved Lead

Total Cadmium

Dissolved Arsenic

**Nutrients**

	Y/N
Total Nitrogen	N
Kjeldahl Nitrogen	N
Nitrate/ Nitrite	N
Ammonia	N
Phosphorous	Y
Ortho-phosphorous	N

**Other**

Radionuclides

**Secondary Screening**

Select applicable installation condition(s)

**Installation Conditions**

Will the BMPs experience freezing conditions?

Will the BMPs experience arid conditions?

Is there limited space in which to install BMPs?

Are contaminated soils potentially present in the area?

Will the BMPs be installed in an area with high TSS loads?

Will the BMPs experience high TSS loads?

**Related Practices (BMP)**

Soil Management and Soil Amendments

Tanks and Vaults

Media Filters

Permeable Pavement

Infiltration

Chemical

<https://stormwater-1.itrcweb.org/appendix-f-bmp-information-sheets/> - f10 - Click once to follow. Click and hold to select this cell.

[28] Certifications more commonly apply to products, or proprietary BMPs, which generally follow the demonstrative approach and must demonstrate they are effective. Most practices, or public domain BMPs such as permeable pavement, follow the presumptive approach and are presumed to be effective as long as they are built following the design criteria of the regulatory agency. Users should refer to their local regulatory agency for information on approved permeable pavement BMPs.

## **Structural Design**

- The subgrade is the layer below the paving and the subbase. Where traditional pavement tries to reduce water from entering the subgrade, permeable pavement allows for water to enter the subgrade.
- The subbase is below the paving and provides vertical support, storage capacity and filtering ability.
- Pavement strength (i.e., concrete, paver, asphalt, etc.) is based on the material used and the design specifications for the area.
- Structural thickness can vary based on the local conditions, experience of using permeable pavements, and pavement mixture design.

## **Stormwater Management Design**

- Determine permeable pavement type (i.e., porous concrete, pervious pavers, non-pervious interlocking pavers, etc.).
- Consider three specific design features: 1) reduced runoff volume, 2) reduced treatment volume, and 3) reduced impervious area.
- Determine if there is a stormwater treatment option considered and its effectiveness for the design considerations.

# ITRC BMP Information Sheets- Data

## International Stormwater BMP Database Performance Summary, 2016 – Media Filters

Prepared for City and County of Denver and Urban Drainage and Flood Control District, February 2017. Prepared by Wright Water Engineers and Geosyntec Consultants. (Wright Water Engineers and Geosyntec ([Consultants 2016](#)))

	BMPs <sup>[17]</sup>		EMCs <sup>[18]</sup>		25th		Median Concentration <sup>[19]</sup>		Difference <sup>[20]</sup>	75th	
	In	Out	In	Out	In	Out	In	Out		In	Out
Fecal Coliform (MPN/100 mL)	15	15	184	169	120	33	900 (400, 1,500)	400 (200, 800)	◇◆◆	10,000	5,600
Kjeldahl nitrogen (TKN) (mg/L)	21	20	323	312	0.56	0.29	0.94 (0.83, 1.02)	0.50 (0.43, 0.55)	◆◆◆	1.78	1.00
Nitrogen, NO <sub>x</sub> as N (mg/L)	22	21	346	328	0.21	0.34	0.34 (0.31, 0.37)	0.57 (0.49, 0.63)	◆◆◆	0.58	0.94
Nitrogen, Nitrate (NO <sub>3</sub> ) as N (mg/L)	12	12	178	174	0.20	0.30	0.32 (0.28, 0.35)	0.56 (0.46, 0.63)	◆◆◆	0.59	0.94
Nitrogen, Nitrite (NO <sub>2</sub> ) + Nitrate (NO <sub>3</sub> ) as N (mg/L)	10	9	168	154	0.24	0.38	0.35 (0.31, 0.40)	0.57 (0.48, 0.68)	◆◆◆	0.58	0.94
Copper, Total (µg/L)	20	20	345	330	4.97	2.46	9.98 (8.60, 10.00)	5.53 (4.58, 6.30)	◆◆◆	16.87	10.00

# Ongoing Research

## List of Research Projects

To learn about research projects, click on the project below or scroll down this page.

- [City of Redmond](#) - Redmond Paired Watershed Study
- [City of Tacoma](#) - Monitoring for Stormwater Contaminants of Emerging Concern in Western Washington
- [City of Tacoma](#) - Sediment Method Development
- [EA Engineering, Science, and Technology Inc., PBC](#) - The Use of Unamended Soils for Treatment of 6PPDQ in Stormwater: Persistence, Soil Types, and Influence of Vegetation
- [Herrera Environmental Consultants](#) - 6PPDQ in Highway Runoff, BMP Effectiveness, and Field Protocol Development
- [King County](#) - King County Multi-Criterion Decision Tool to Address 6PPDQ and Tire Wear Particles
- [King County](#) - Testing Removal of 6PPDQ and Coho Salmon Lethality by High Performance Bioretention Media Blends
- [King County](#) - Treatment effectiveness of a Full-scale Stormwater Facility using High Performance Bioretention Soil Media for 6PPD-quinone and other Toxic Chemicals
- [King County Environmental Lab](#) - Characterizing Stormwater Pollutant Concentrations in Mixed Residential and Highway Runoff in Seattle
- [The Nature Conservancy](#) - Puget Sound Stormwater Heatmap Version 2.0
- [NV5](#) - Verification of BMP Effectiveness, Crumb Rubber Investigation, and Street Sweeping and Traffic Density Characterization
- [Osborn Consulting Inc & Evergreen StormH2O](#) - Stormwater Treatment of Tire Contaminants Report
- [Pierce County](#) - 6PPD-quinone Removal in Decant Facility
- [Snoqualmie Indian Tribe](#) - Testing 6PPD-quinone on the Snoqualmie Reservation
- [University of Washington - Tacoma](#) - Development of Chemical Indicators to Detect, Track, and Assess Pollutants
- [University of Washington - Tacoma](#) - Enhanced Watershed Monitoring & Toxicological Analysis of CECs
- [University of Washington - Tacoma](#) - Evaluation of 6PPDQ Treatment using Soils and Sorbent Media
- [University of Washington - Tacoma](#) - Sampling, Occurrence, and Toxicity of 6PPD-quinone and Related Chemicals
- [Washington Stormwater Center](#) - Synthesis of Street Sweeping Research & Practices: Guiding Program Development & Implementation
- [Washington State University - Puyallup](#) - Longevity of Bioretention Depths for Preventing Acute Toxicity from Urban Stormwater Runoff

[https://www.ezview.wa.gov/site/alias\\_\\_1962/40944/6ppd\\_stormwater\\_best\\_management\\_practices\\_research.aspx](https://www.ezview.wa.gov/site/alias__1962/40944/6ppd_stormwater_best_management_practices_research.aspx)

# Washington Public Ports Association Environmental Seminar September 19, 2024



**Patrick Hsieh**

**Senior Chemical Engineer**

**Dalton, Olmsted, & Fuglevand**

**Seattle, WA**

**206-731-7550**

[phsieh@dofnw.com](mailto:phsieh@dofnw.com)

<https://www.dofnw.com/>

- ▶ Remediation Design
- ▶ Water Treatment  
(wastewater, stormwater,  
dredge return water)
- ▶ TSD Operations Support
- ▶ Environmental Compliance

## Links to Free ITRC Resources that might be helpful to Ports

Sediment Capping-

<https://sd-1.itrcweb.org/>

PFAS-

<https://pfas-1.itrcweb.org/>

Stormwater-

<https://stormwater-1.itrcweb.org/>