



Concrete Rainforests: Protecting Salmon from Toxic Stormwater Using Green Infrastructure

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Research PARTNERS & SUPPORTERS



WASHINGTON STATE
UNIVERSITY



THE
SUQUAMISH
TRIBE



W



THE
PUYALLUP TRIBE
OF INDIANS



King County



DEPARTMENT OF
ECOLOGY
State of Washington

Seattle
Public
Utilities



Urban stormwater runoff causes high prespawn mortality rates



Symptoms

- Surfacing & gaping
- Loss of equilibrium
- Death within hours of symptoms

Ruled out potential causes

Physical Water Quality

- DO, Temp., pH normal

Parasites/pathogens

- No organ damage
- No infections specific to stricken fish

Pesticides

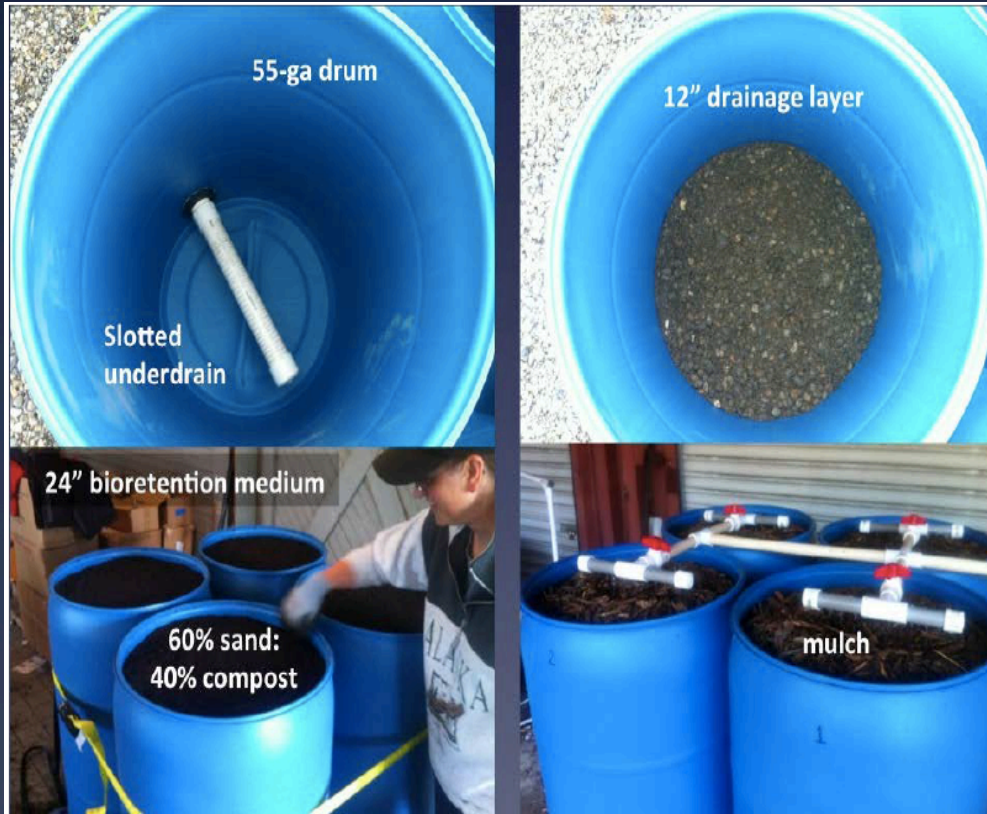
- No acetylcholinesterase inhibition

Metals and polyaromatic hydrocarbons

- Exposed in urban streams,
but do not alone elicit symptoms



Bioretention removes stormwater toxicity

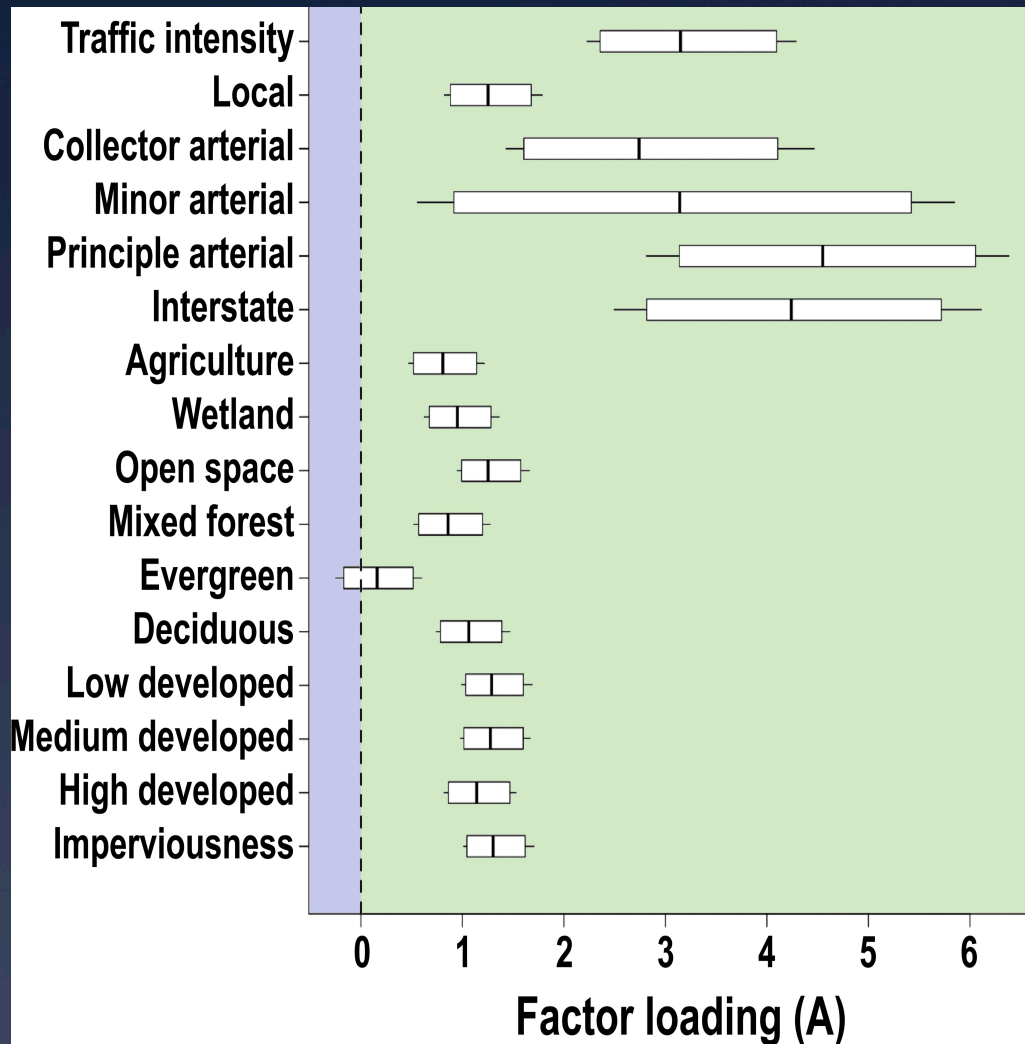


Unknown mixture of chemicals in stormwater to blame

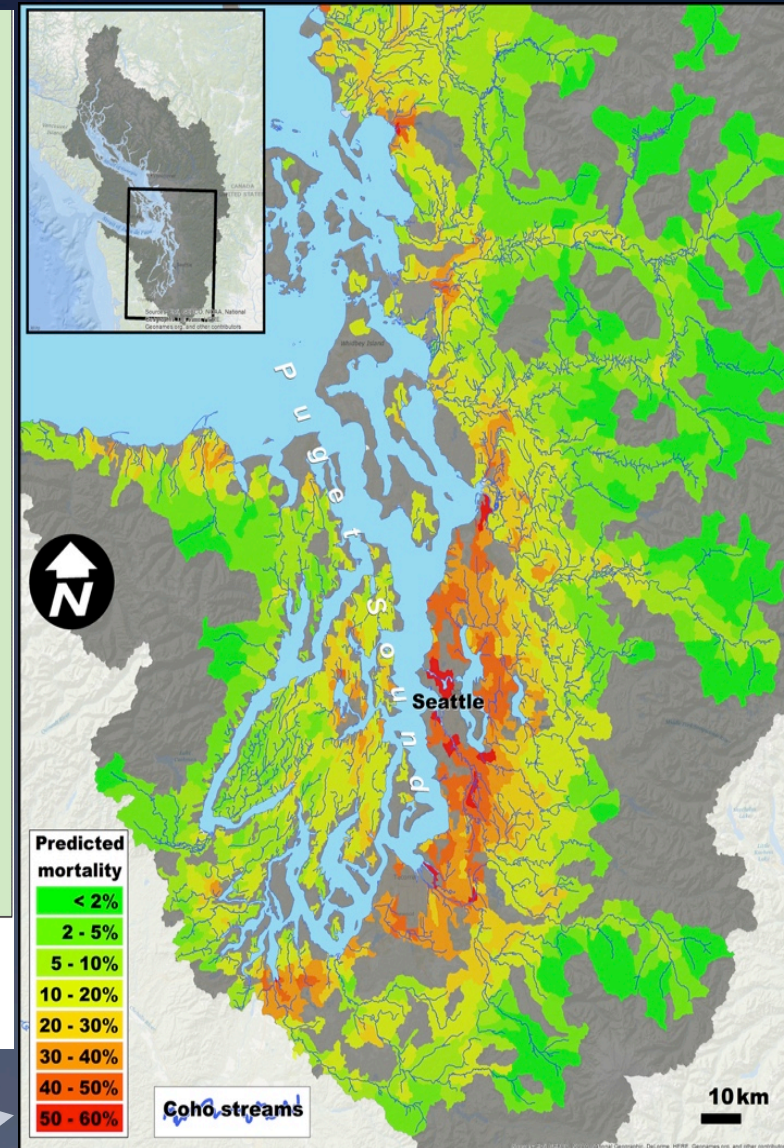
- What are the toxicants and sources?
- How do they impact salmon?
- How can we remediate stormwater using green infrastructure?

Coho prespawn mortality landscape features

Contributing Factors



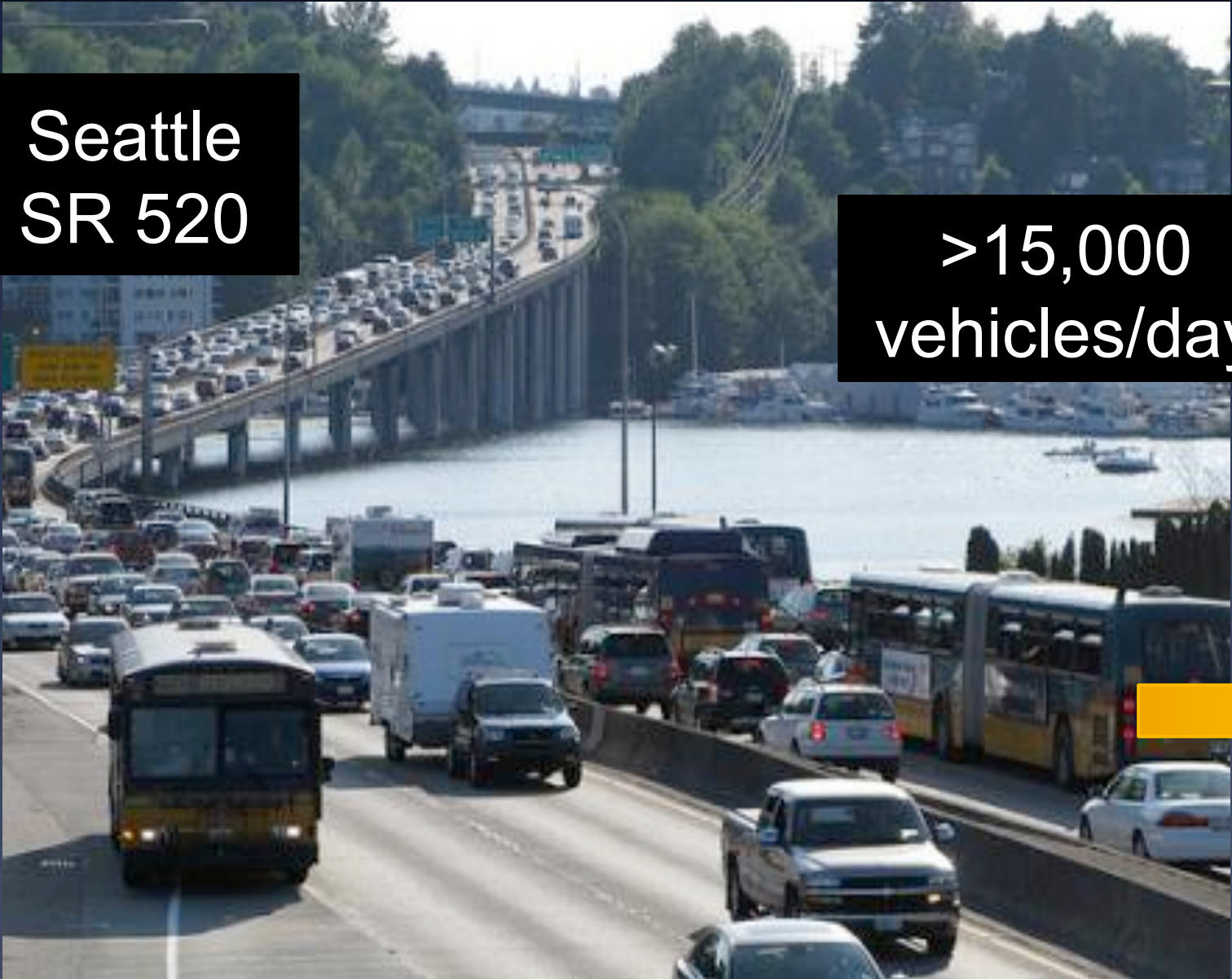
Major roads and heavy traffic predictors of PSM



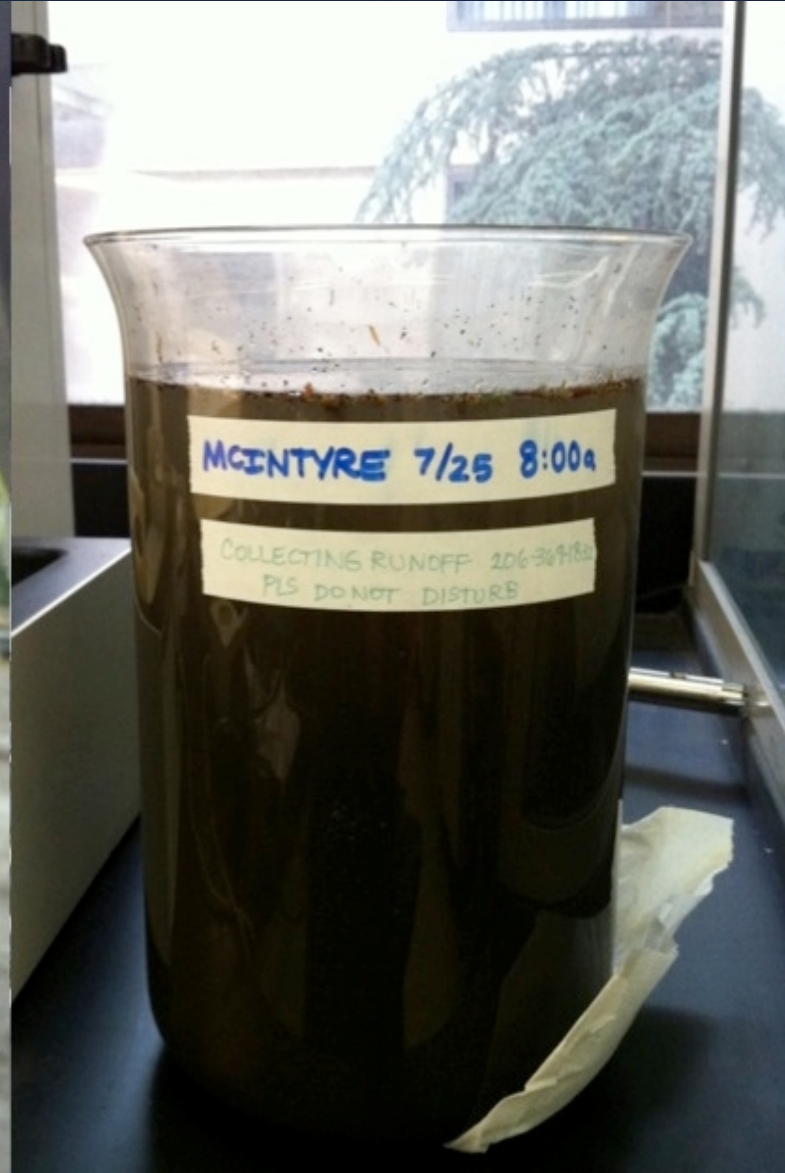
Road Runoff

Seattle
SR 520

>15,000
vehicles/day



Collecting Road Runoff



Coho life history phases: Acute lethal response

Adult

Juvenile

Alevin

Toxicity of urban stormwater runoff

Zebrafish

Pacific Herring

Coho

Fish embryos: Growth impairment, cardiotoxicity, neurotoxicity

Experimentally exposing coho spawners to road runoff



clean well water

A photograph of a white rectangular tank containing clear, light-colored water. Four vertical white cylinders are positioned in the tank, each with a green arrow pointing downwards. A black tube is connected to the bottom of the cylinders, leading to a small pump or filter unit at the bottom of the tank. The background shows some outdoor equipment and a person's legs.



road runoff

A photograph of a white rectangular tank containing dark, murky water. A single vertical white cylinder is positioned in the tank, with a red arrow pointing downwards. A black tube is connected to the bottom of the cylinder, leading to a small pump or filter unit at the bottom of the tank. The background shows some outdoor equipment and a person's legs.

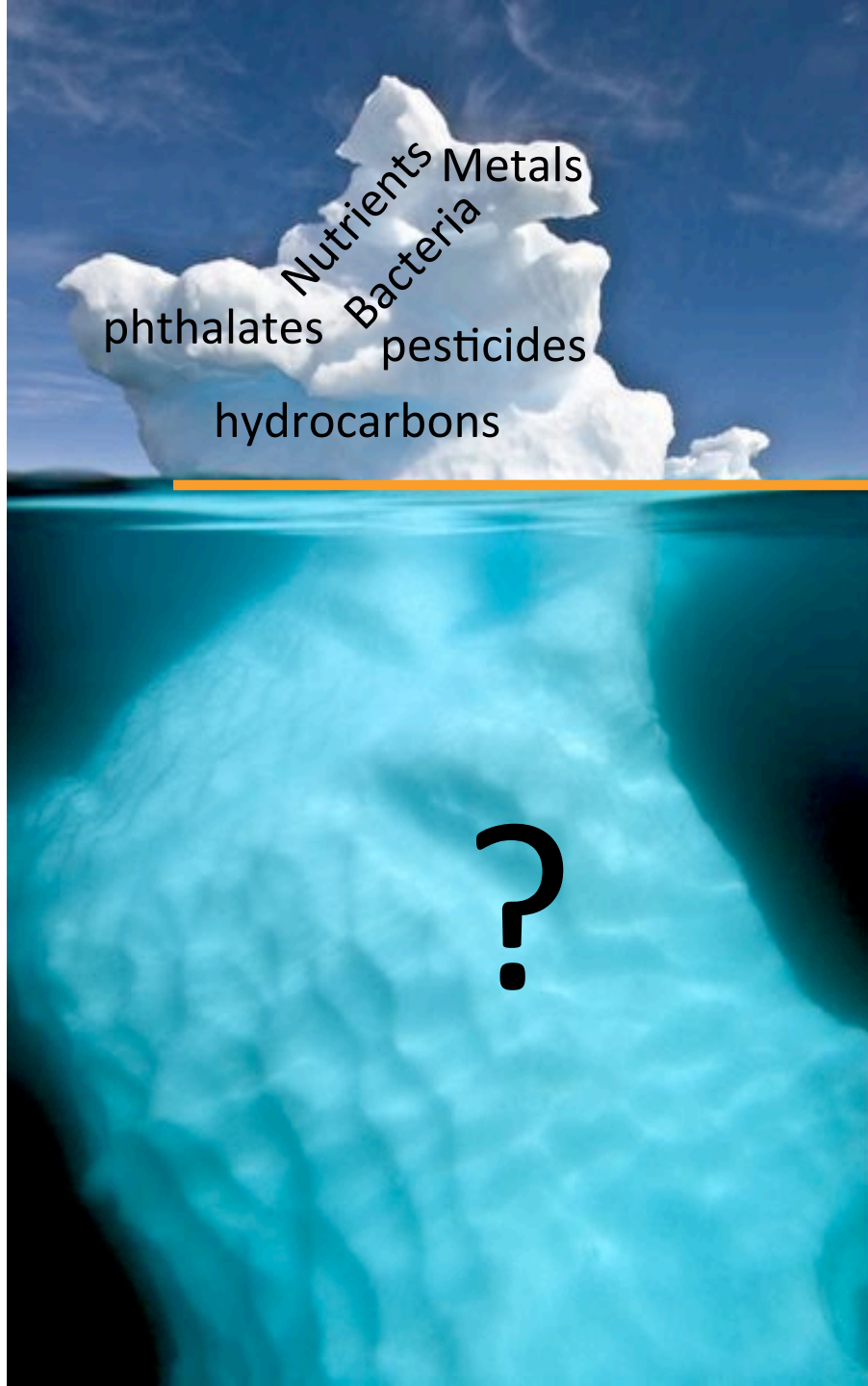
...induces pre-spawn mortality

Unexposed (3.5 h)



Stormwater-exposed
(3.5 h)





The chemistry of stormwater runoff

Thousands of unique
chemicals are present in
urban road runoff

Du et al. 2017. Env. Sci. Processes and Impacts

Relatively few of them are
identified

Peter et al. 2018. ES&T

Priority pollutants not causing
observed toxicity

Spromberg et al. 2016. J. Appl. Ecol.

What are vehicle sources of chemicals in road runoff?



Tire Wear



Exhaust



Brakes



Washer Fluid



Leaks

Automobile Leaks:

- Fuel
- Engine Oil
- Brake Fluid
- Engine Coolant
- Transmission Fluid

Which are most toxic?

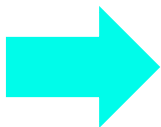
Hierarchical cluster analysis of chemical signatures

W

Vehicle
sources

Coho-
killing
runoff

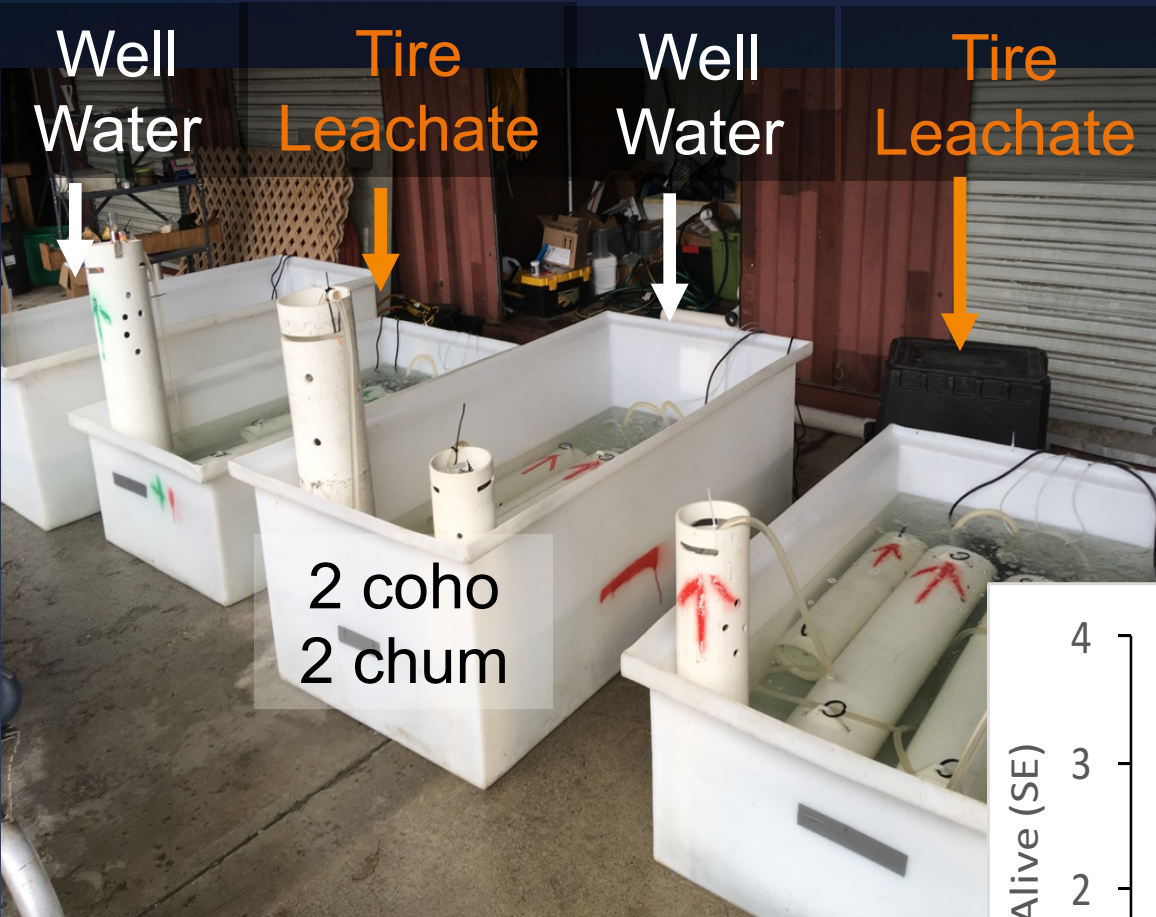
PSM
Streams



Absent → Highly Abundant

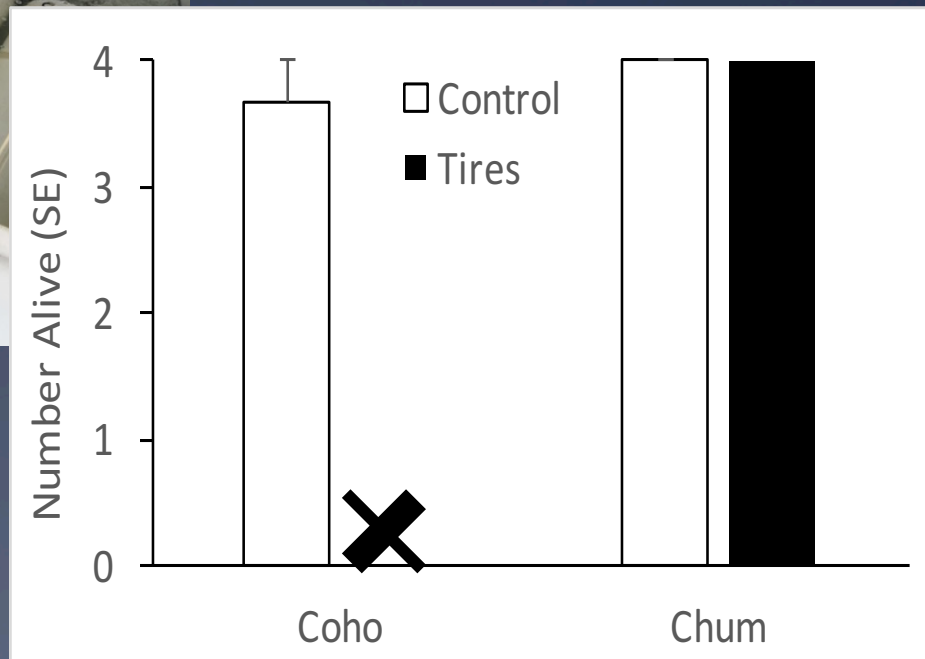


Tire chemicals kill coho but not chum

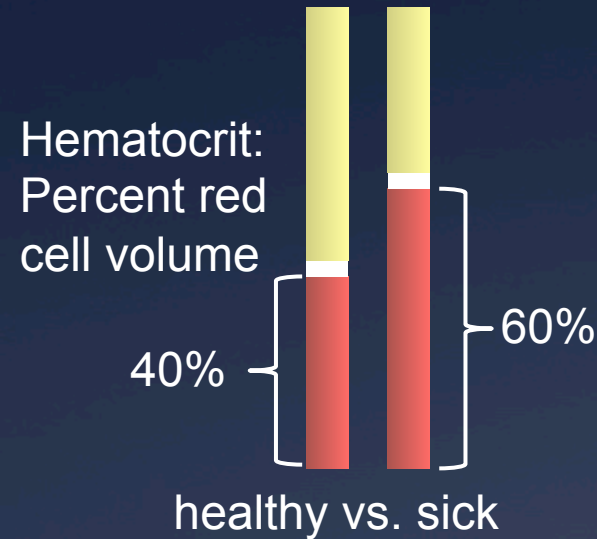


Similar to runoff,
adult chum were
not affected

- Tire Leachate = 0.32 g/L (nominal)
- 24 h exposure
- Expect 100% mortality in coho



Urban stormwater runoff affects coho blood



Osmoregulatory imbalance & hemoconcentration

- Increased hematocrit
- Loss of Na^+ and Cl^-

Behavior: respiratory impairment

- Surfacing & gaping
- Loss of equilibrium

Death typically 2-4 hours after exposure to runoff





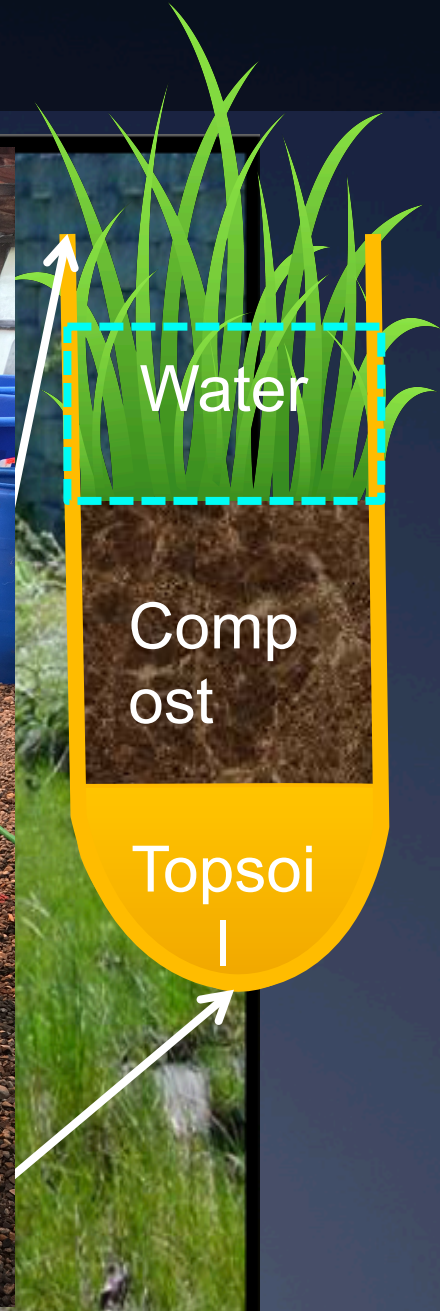
Solutions: Green Stormwater Infrastructure



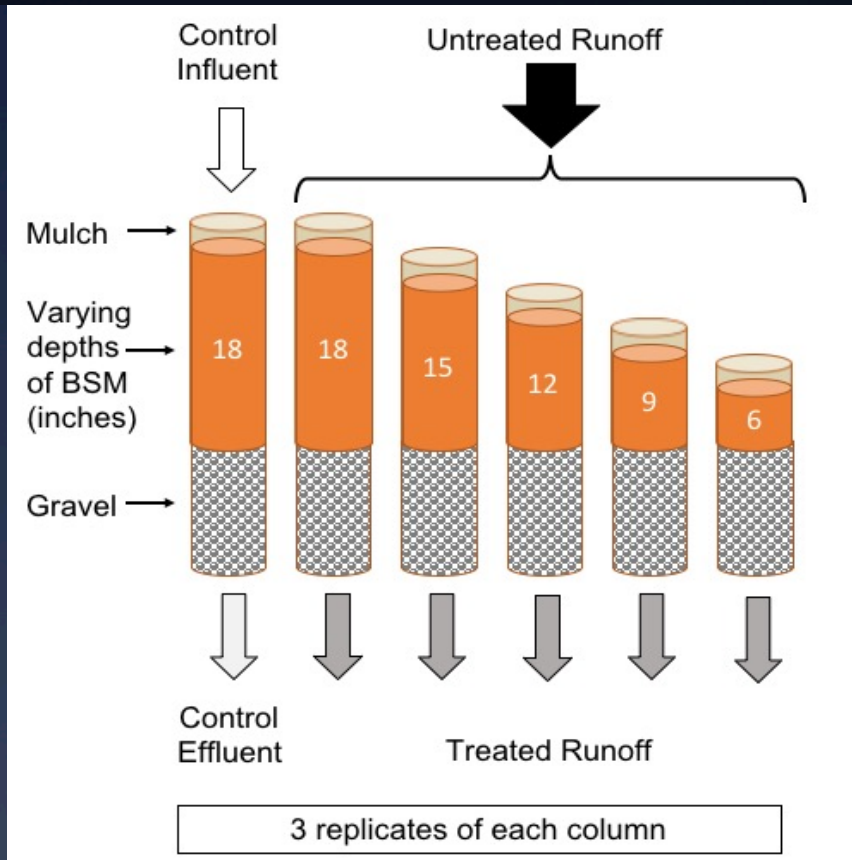
Bioretention Performance: Roadside Treatments

WSU

Ben Leonard
Ph.D. student
SOE



Bioretention Performance: Longevity



Research questions:

- What depths of bioretention are necessary to treat runoff?
- For how long are they effective?

Accelerated aging:

- 10 water years into 2 year study



Lane Maguire
M.S. Student
SOE
Fall 2018

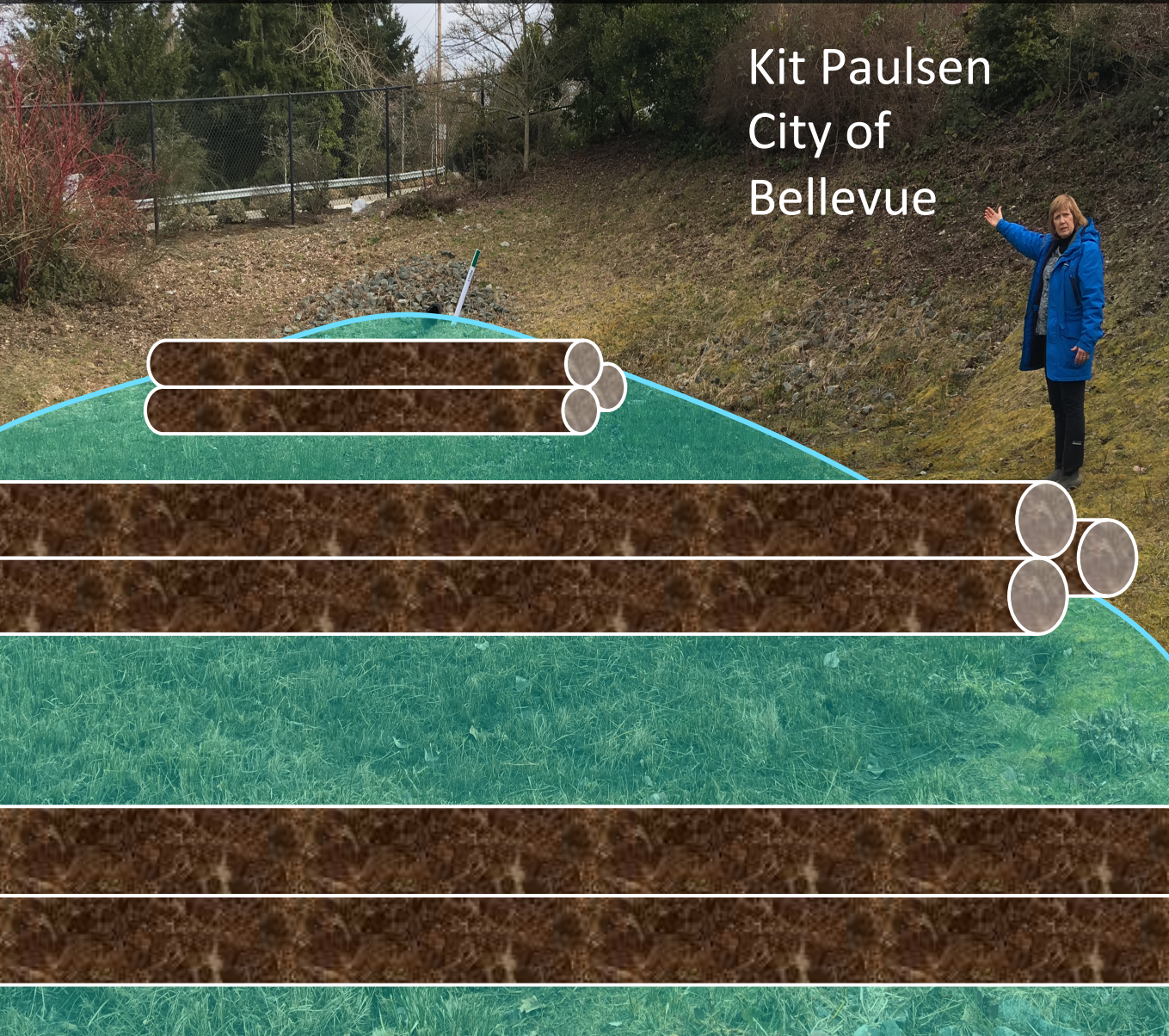


Bioretention Performance: BURitos

Kit Paulsen
City of
Bellevue

Bioretention
Urban Retrofit
of stormwater
detention
ponds

Compost-filled
berms to treat
road runoff
before enters
urban streams



Questions?

