Pervious Pavements and the Toxicity of Urban Stormwater

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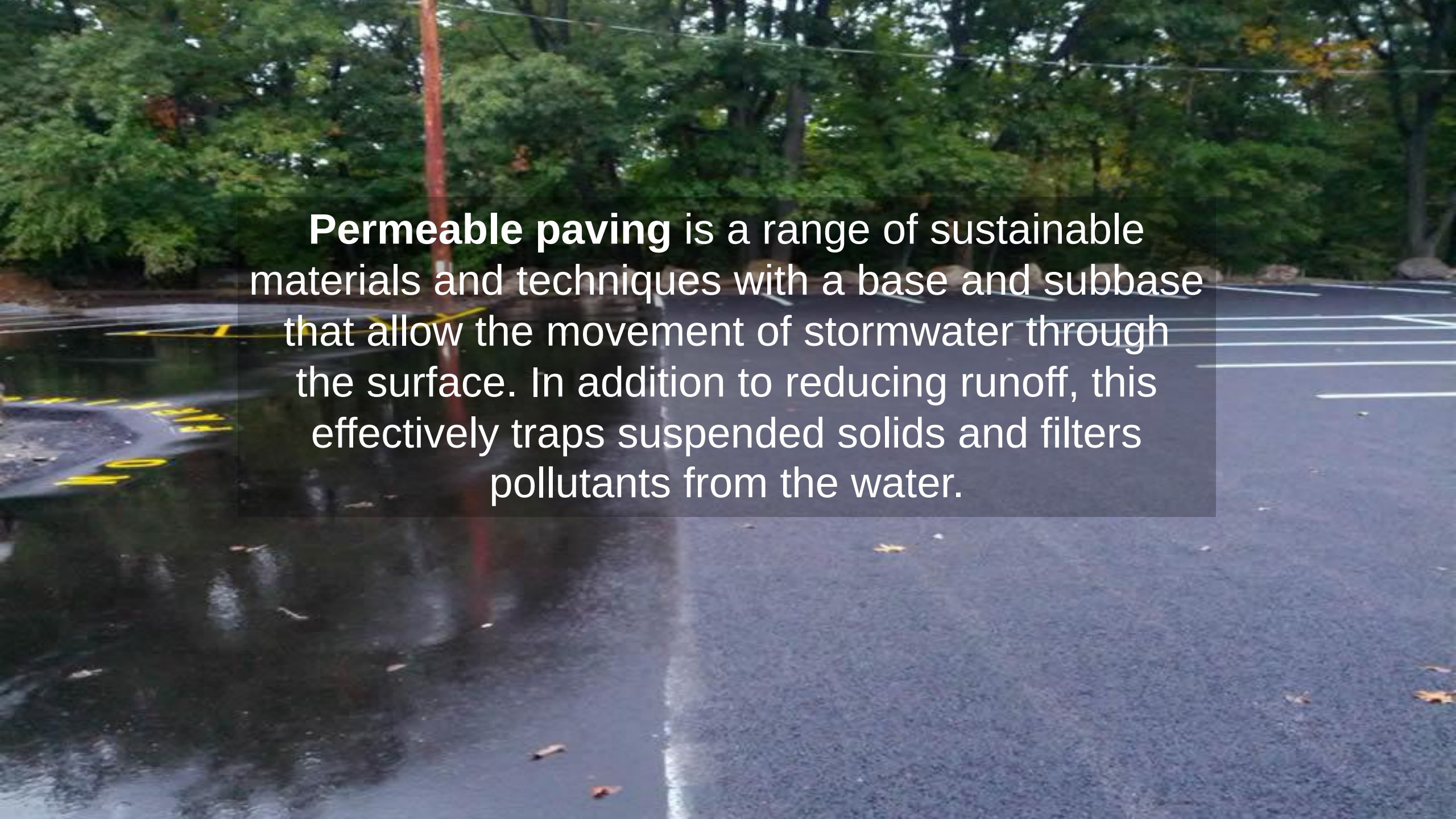


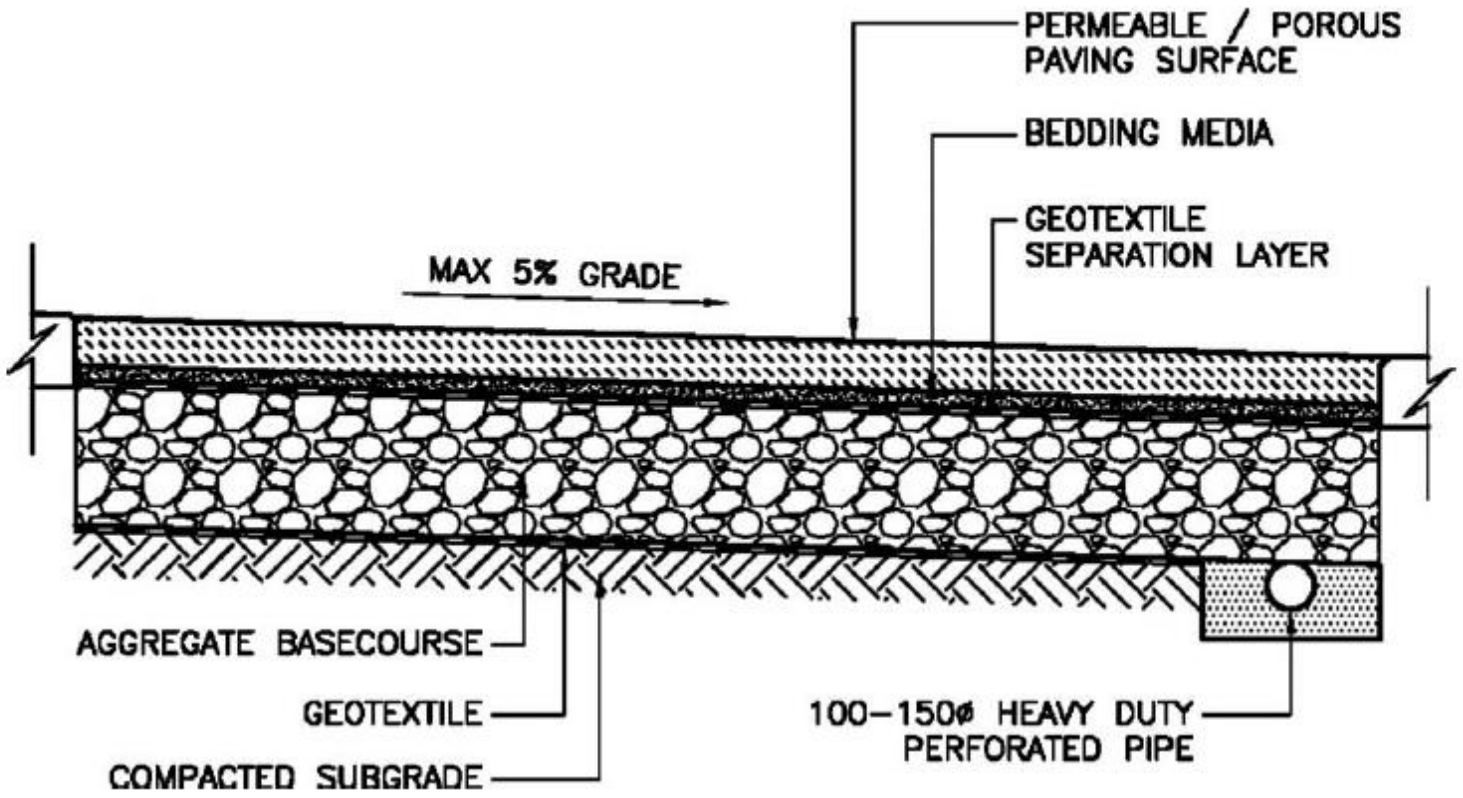
Permeable paving is a range of sustainable materials and techniques with a base and subbase that allow the movement of stormwater through the surface. In addition to reducing runoff, this effectively traps suspended solids and filters pollutants from the water.

Permeable pavements - a great idea but there are problems

- **Do not have the tensile and compressive strength of regular pavements**
- **Can clog over time if not maintained properly**

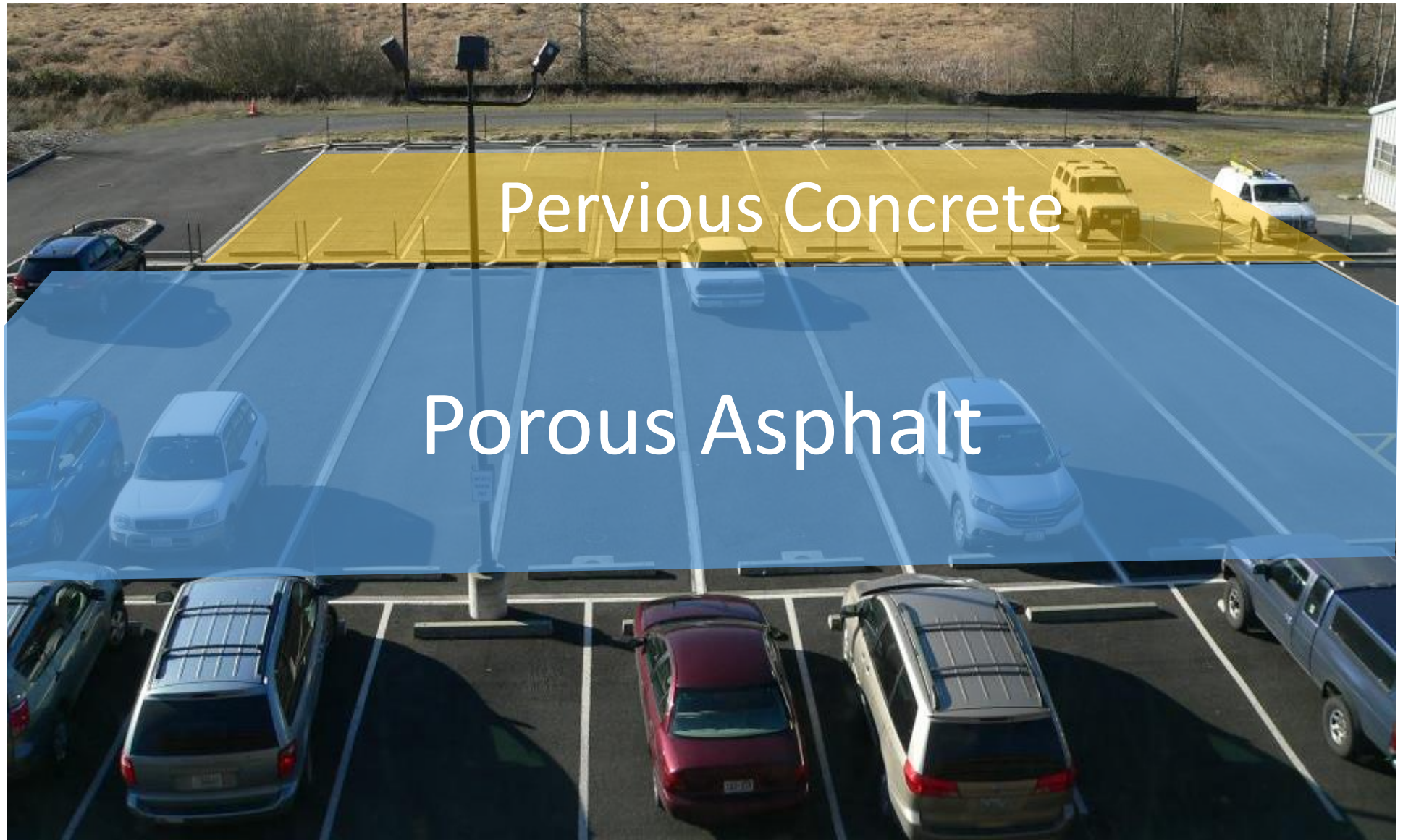
WSU Puyallup Green Stormwater Infrastructure Program

Permeable pavement study



Fassman, Elizabeth A., and Samuel Blackbourn. "Urban runoff mitigation by a permeable pavement system over impermeable soils." *Journal of Hydrologic Engineering* 15.6 (2010): 475-485.

Permeable Pavements



Porous asphalt outflow

Hypotheses: Porous asphalt

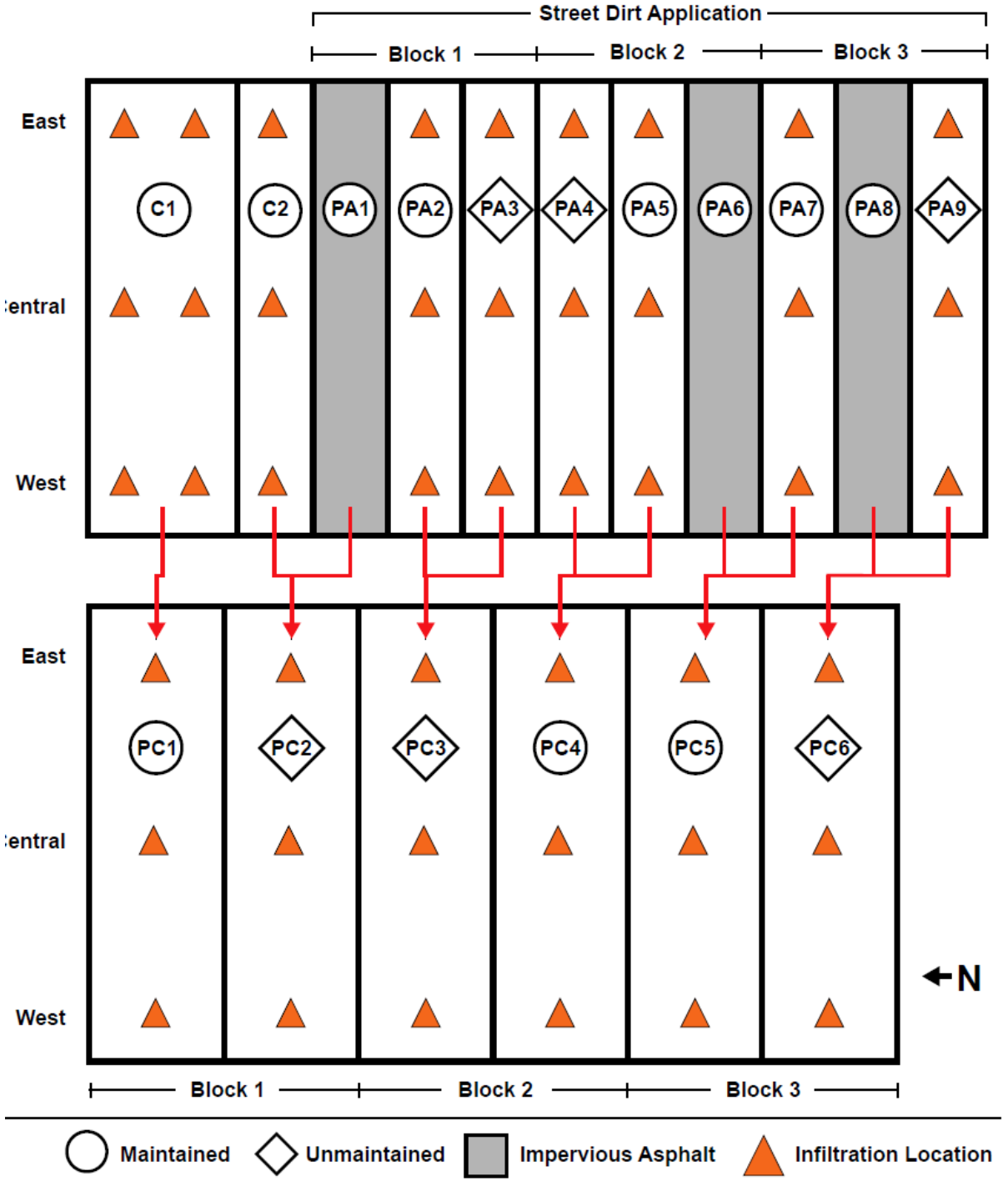
1) Porous asphalt attenuates stormwater flow.

2) Street dirt clogs porous asphalt and reduces infiltration rate with time

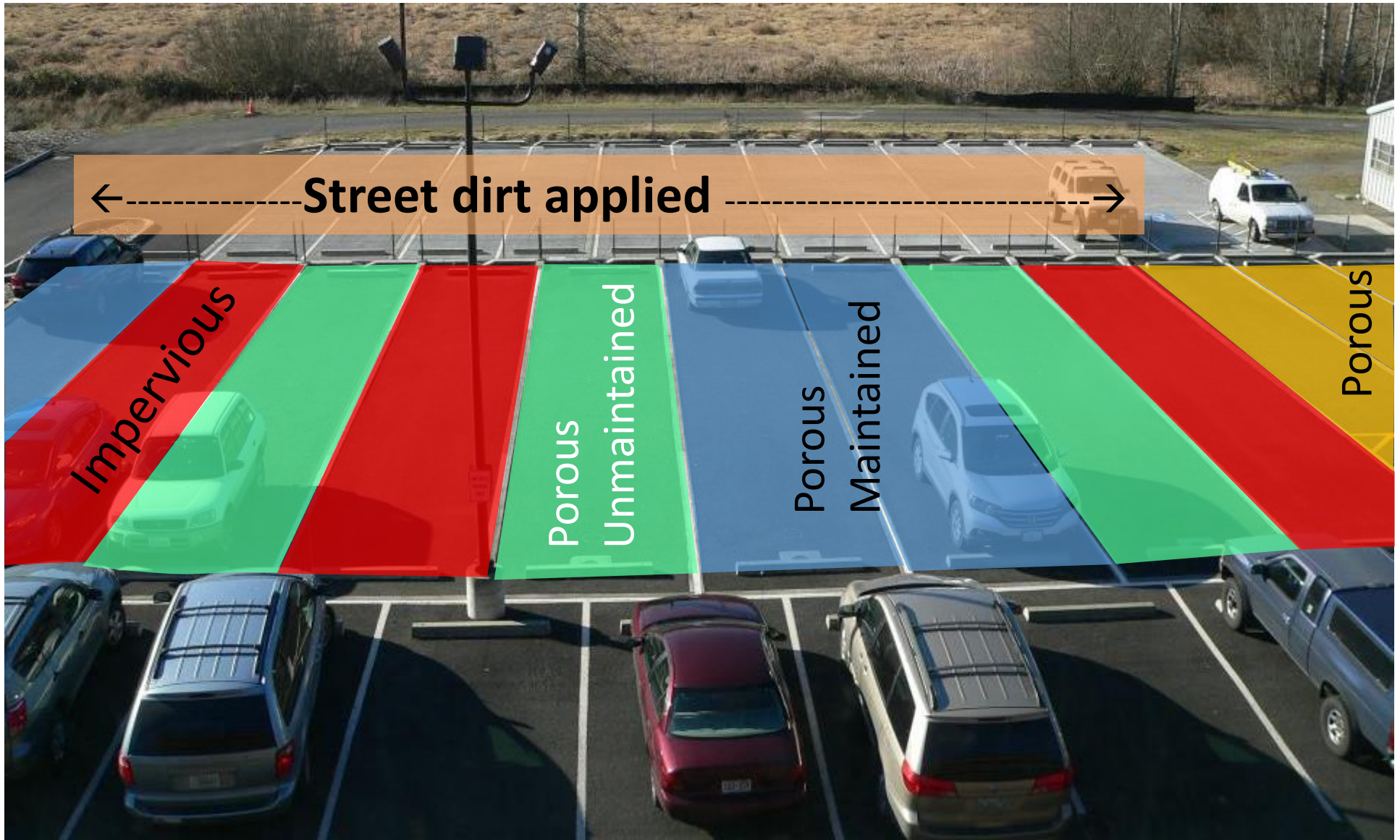
3) Maintenance preserves initial infiltration rates

Porous Asphalt

Pervious Concrete



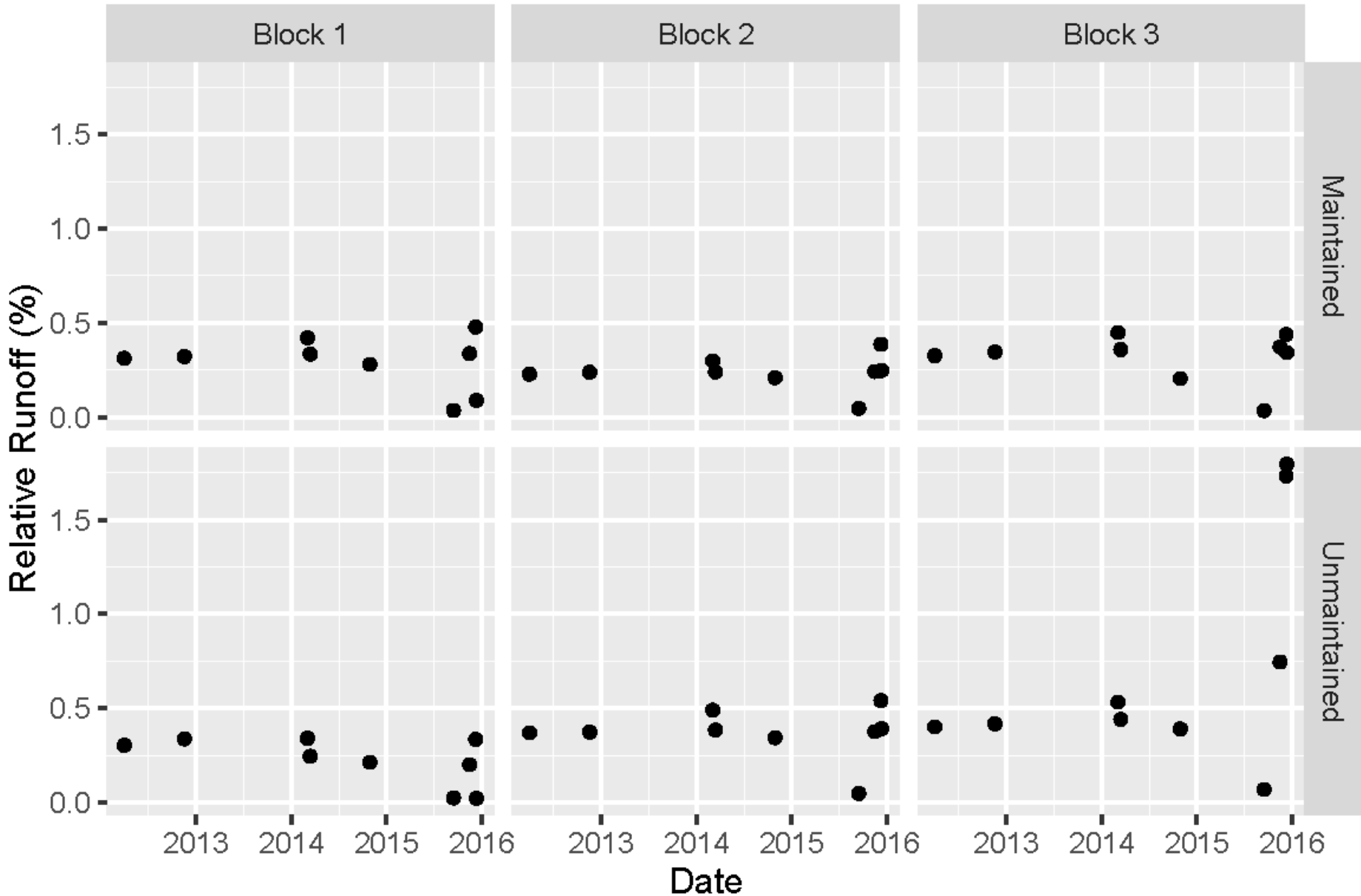
Porous Asphalt Experiment




GMC


MCV

Porous Asphalt Surface Runoff

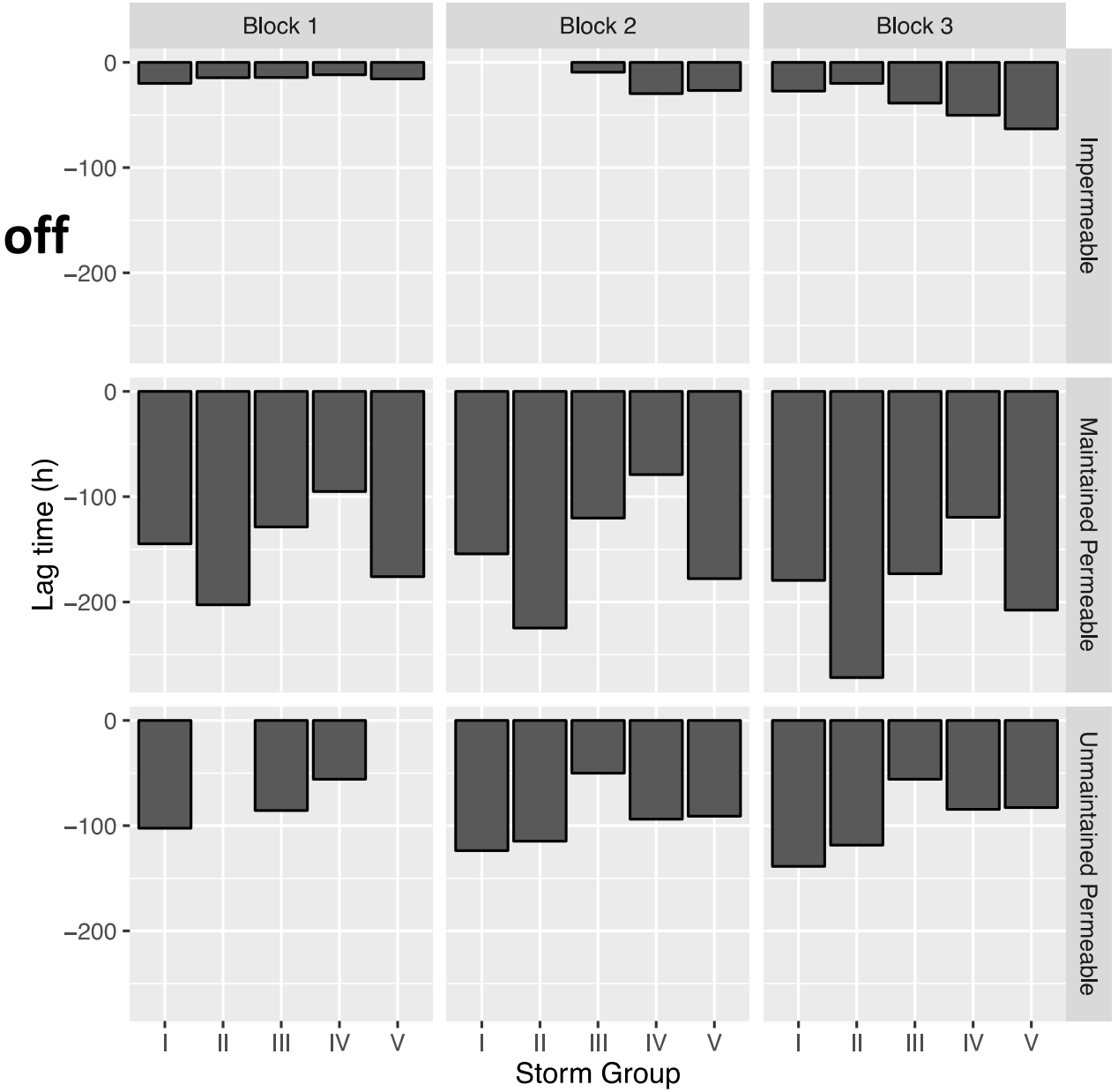


Porous Asphalt Lag Time - subsurface

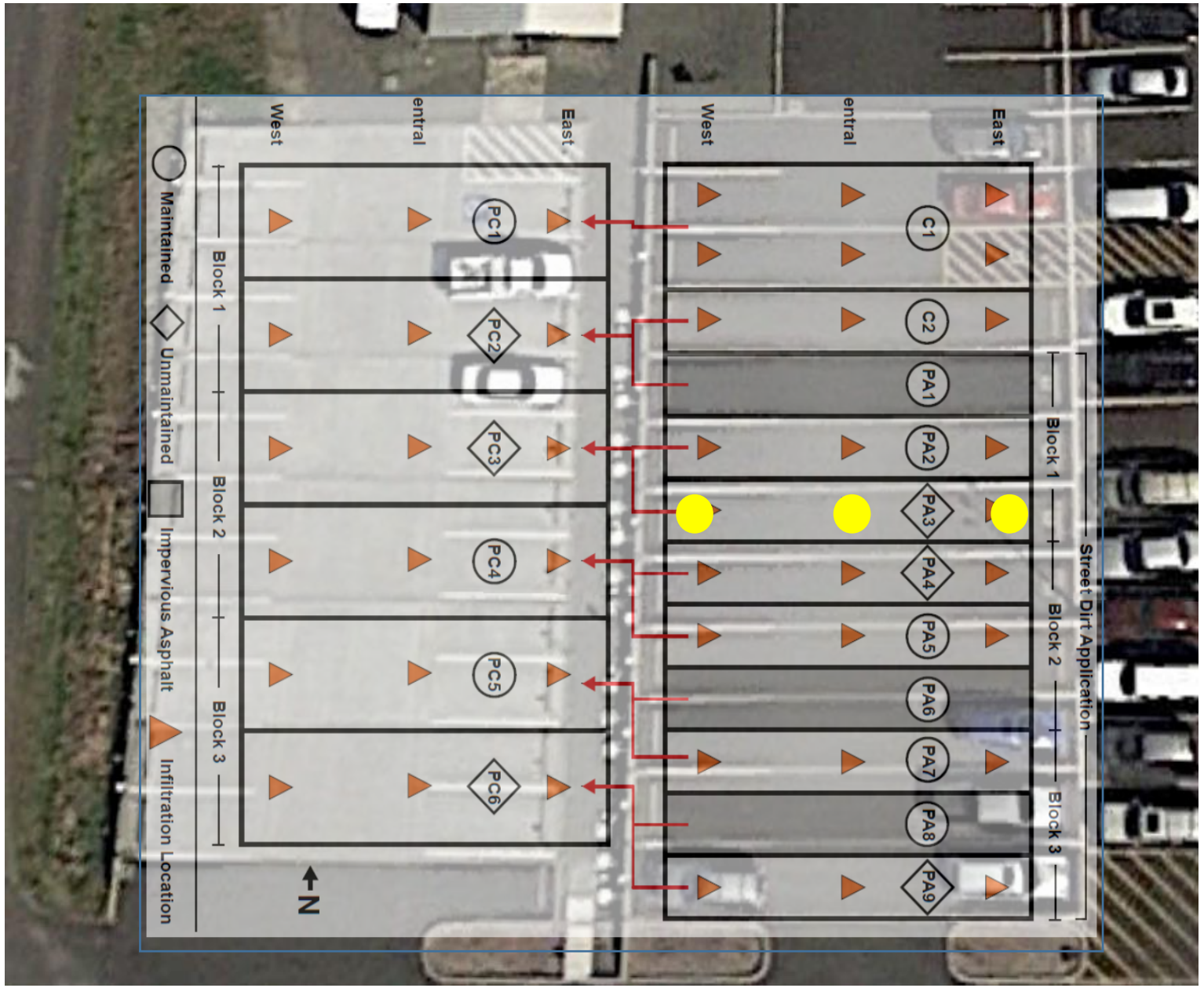
Average lag = 26 min
Rainfall –> surface runoff

Average lag = 164 min
Rainfall –> subsurface runoff

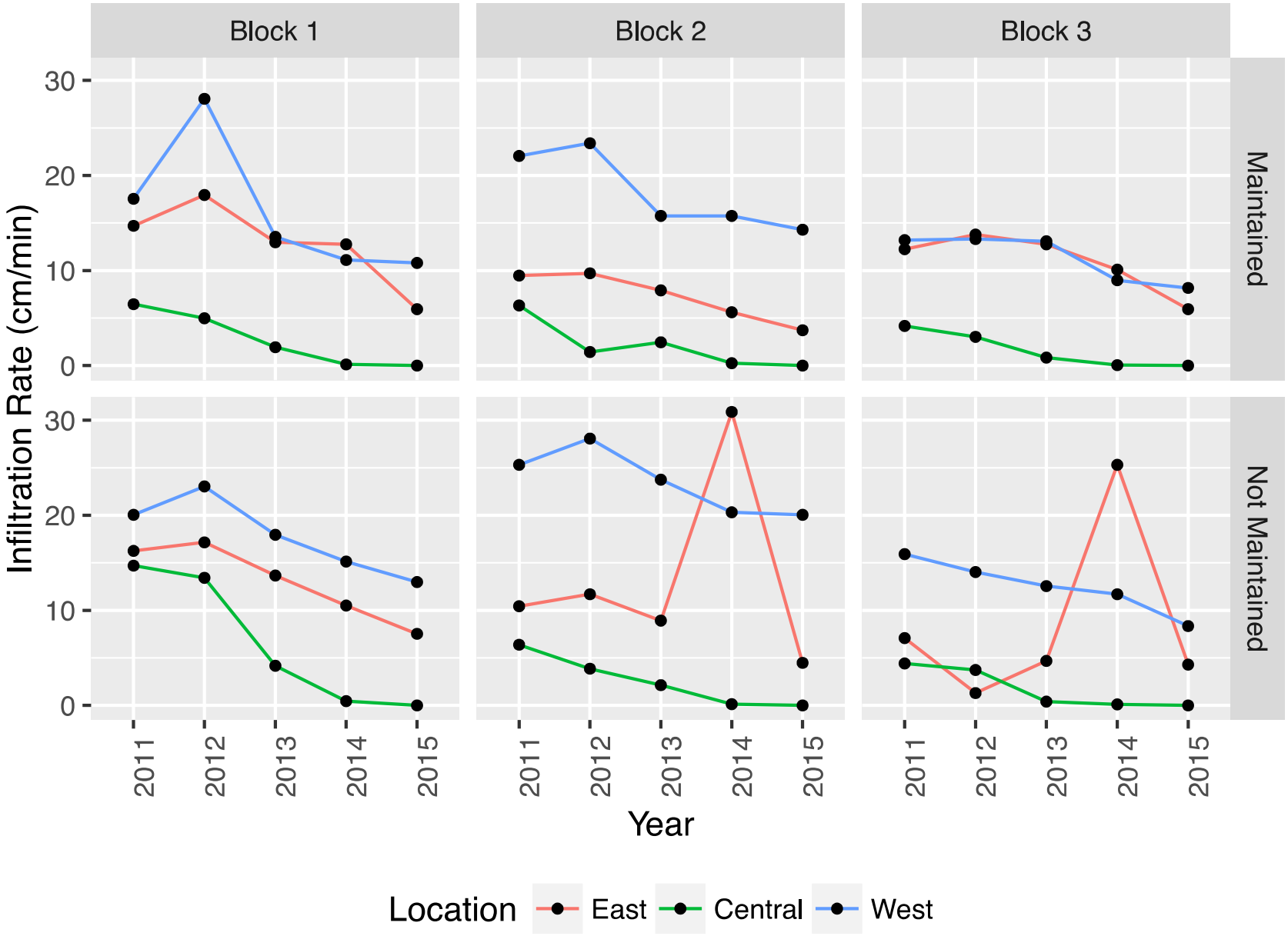
Average lag = 92 min
Rainfall –> subsurface runoff



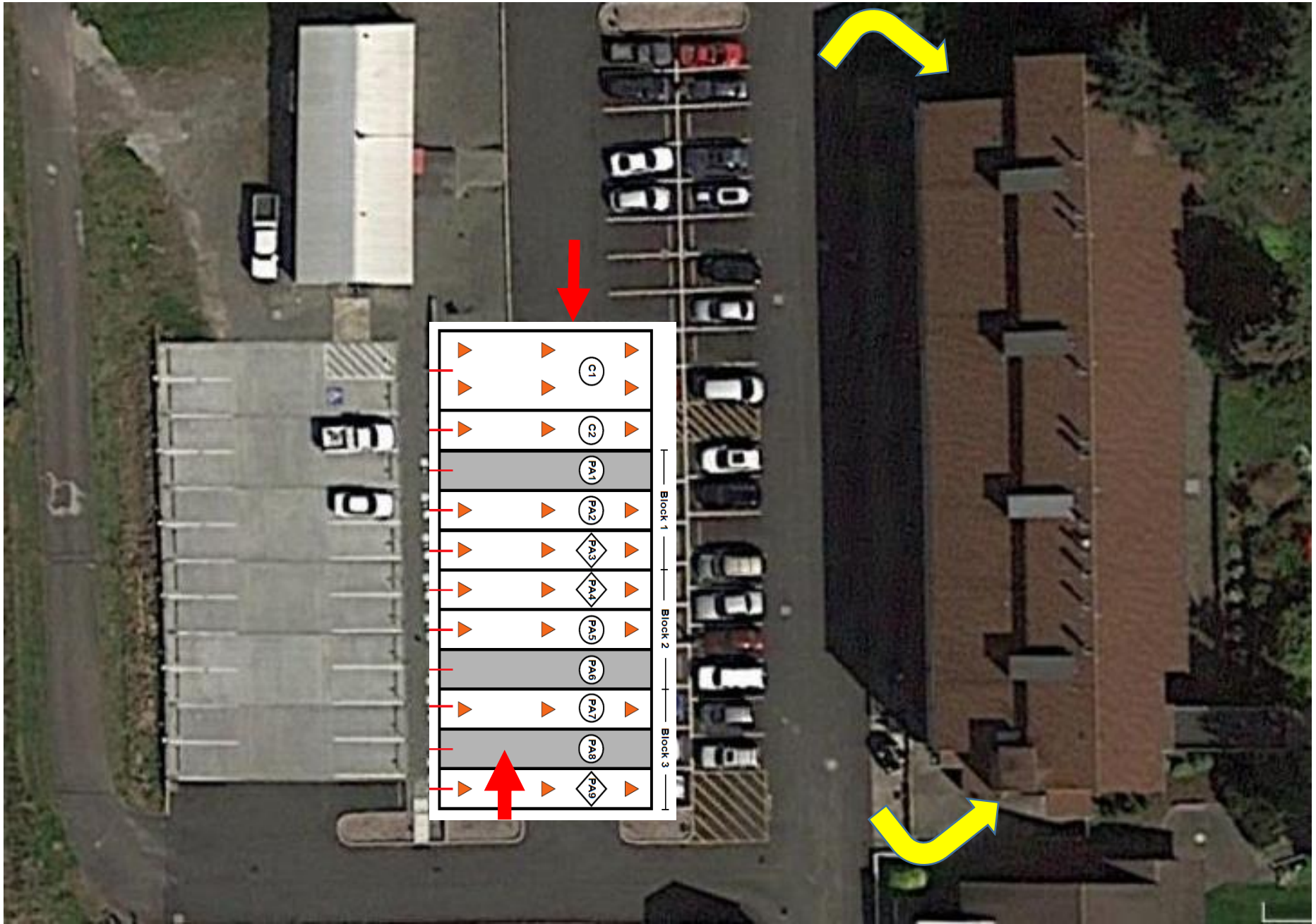
Porous Asphalt Infiltration Testing



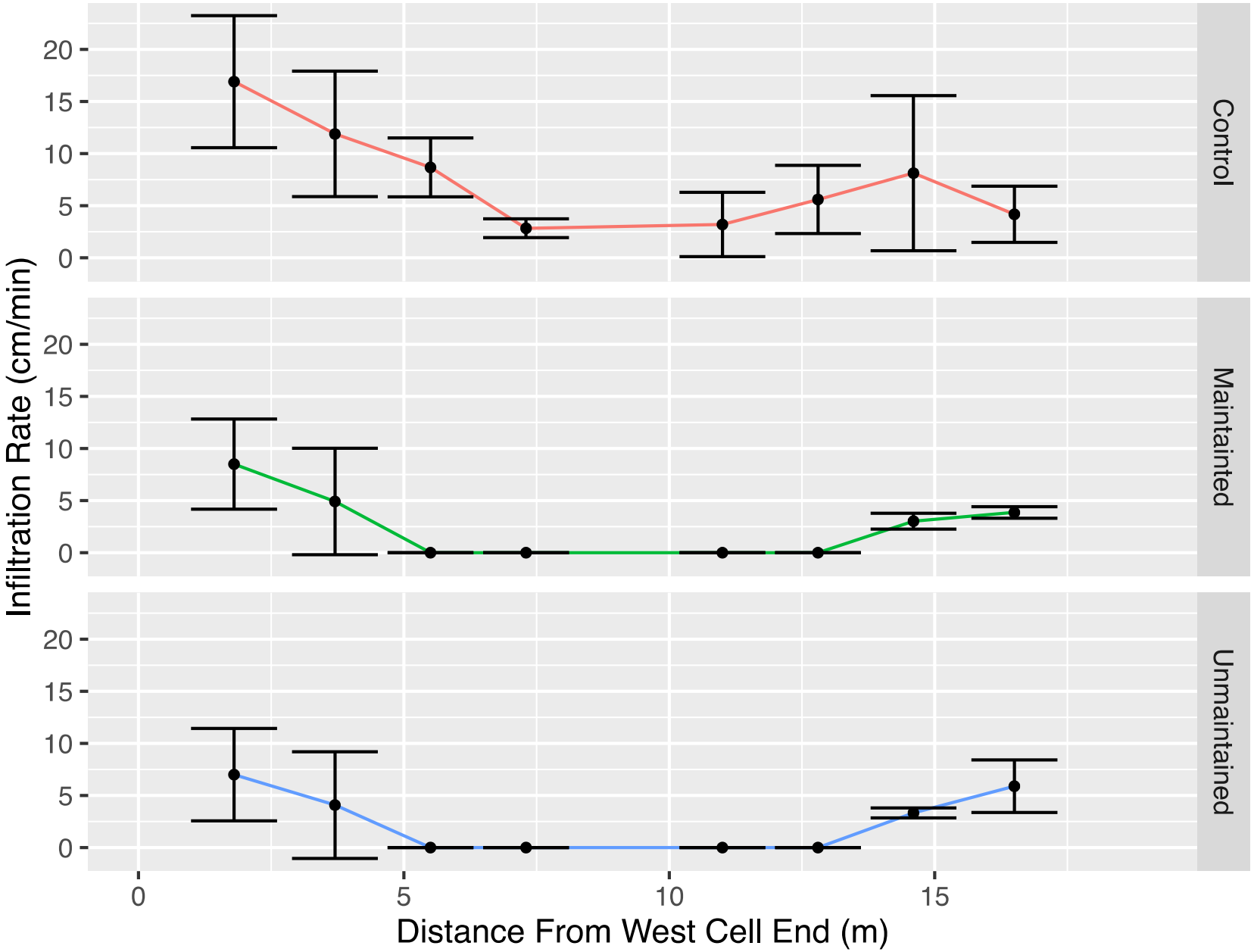
Porous Asphalt: infiltration testing



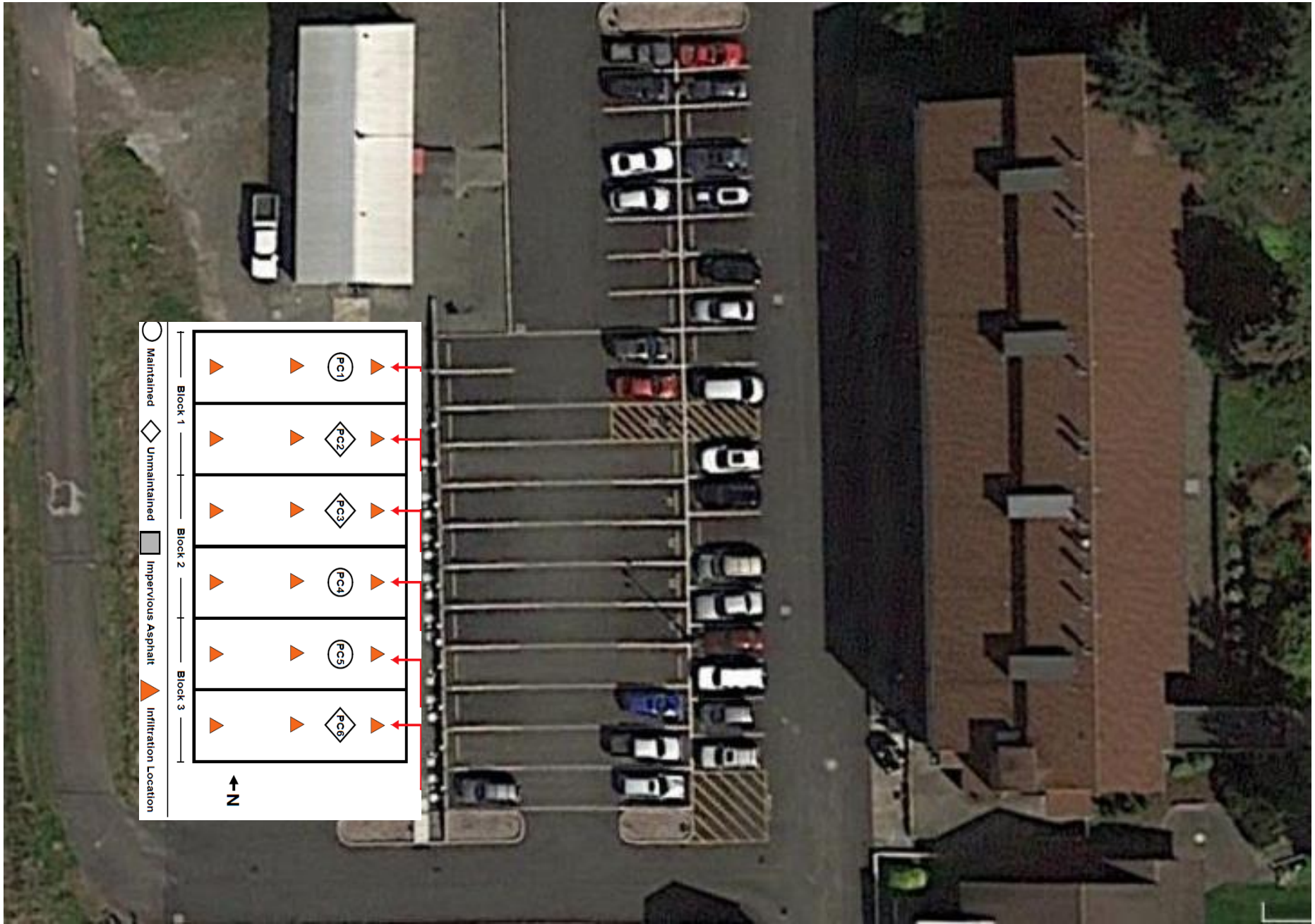
Traffic patterns



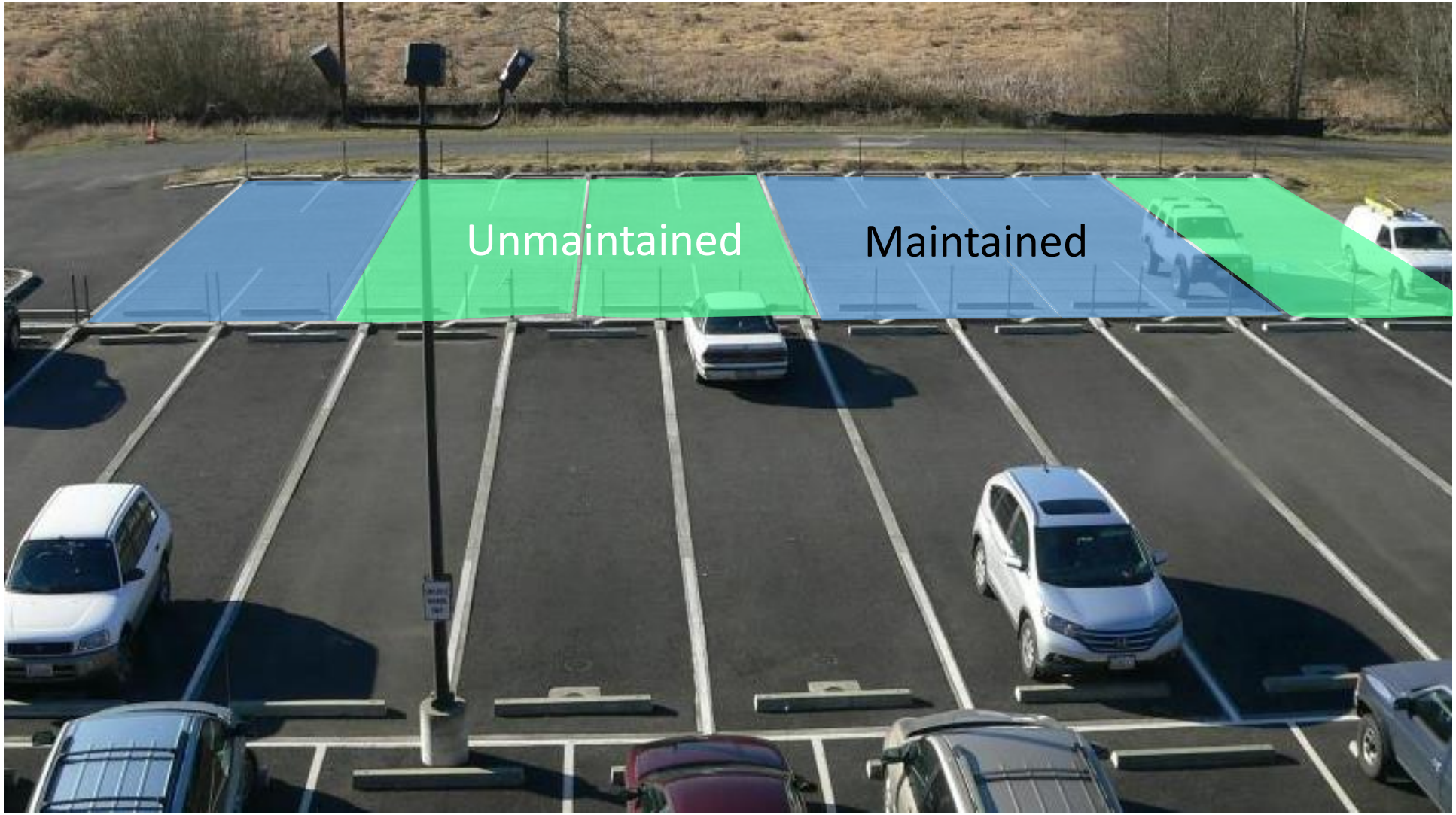
Porous Asphalt: infiltration by location



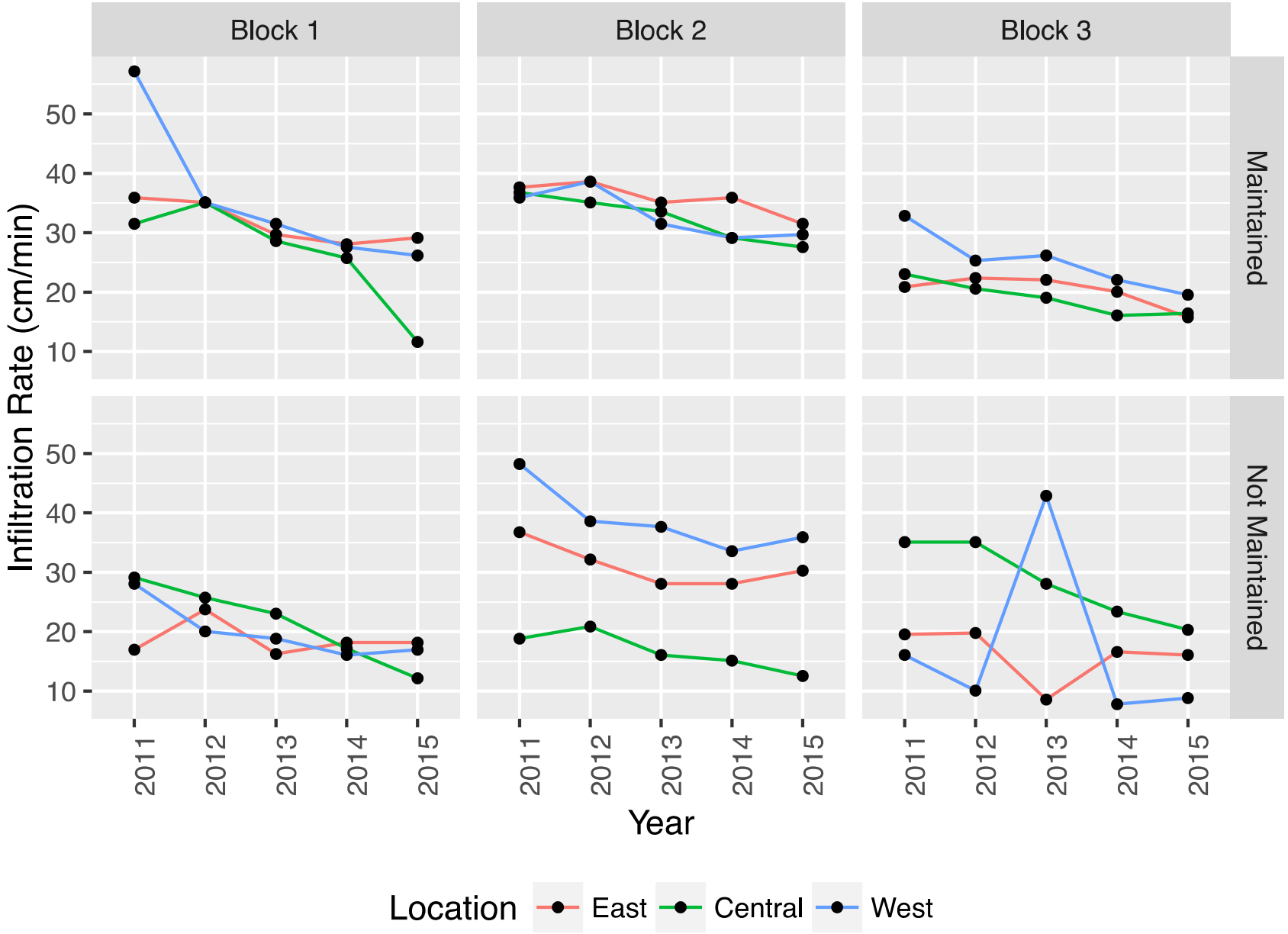
Pervious Concrete Results



Pervious Concrete Test



Pervious concrete: all data

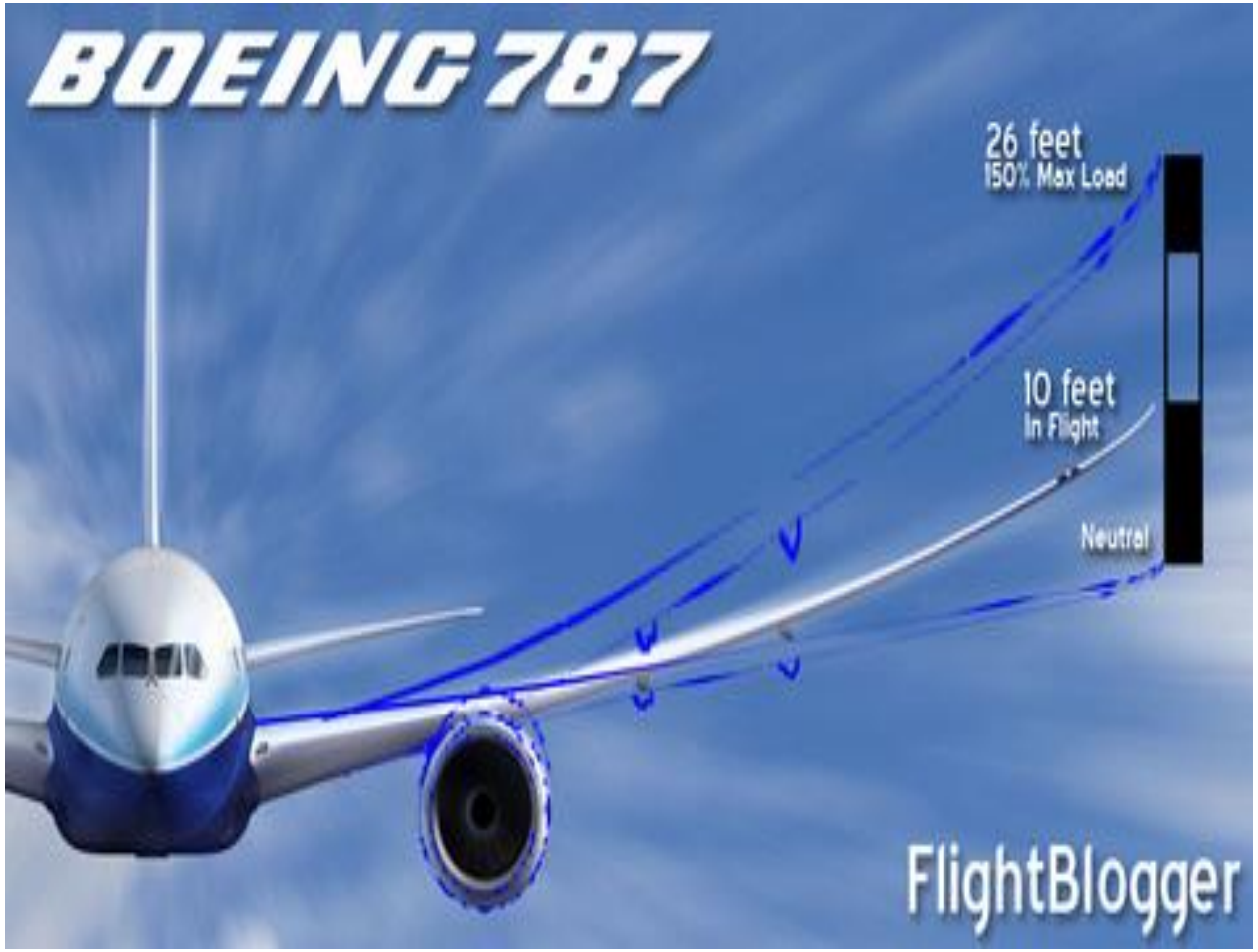


Early Conclusions

- Porous asphalt infiltrates stormwater.
- Street dirt application did not reduce the functionality of porous asphalt.
- Annual regenerative air sweeping did not improve infiltration rates on porous asphalt but did for porous concrete.
- Traffic impacts functioning of porous asphalt

Boeing Carbon Fiber Project

WSU received a grant from Boeing to evaluate a carbon fiber product that they developed for aircraft wings as a potential means to increase the durability of permeable pavements



This project was funded by the Boeing Foundation

Partners/Personnel

WSU Civil and Environmental Engineering

Karl Englund, Liv Hasselbach, Li Hui,
Sommayeh Nassiri,

WSU Puyallup

Tanyalee Erwin

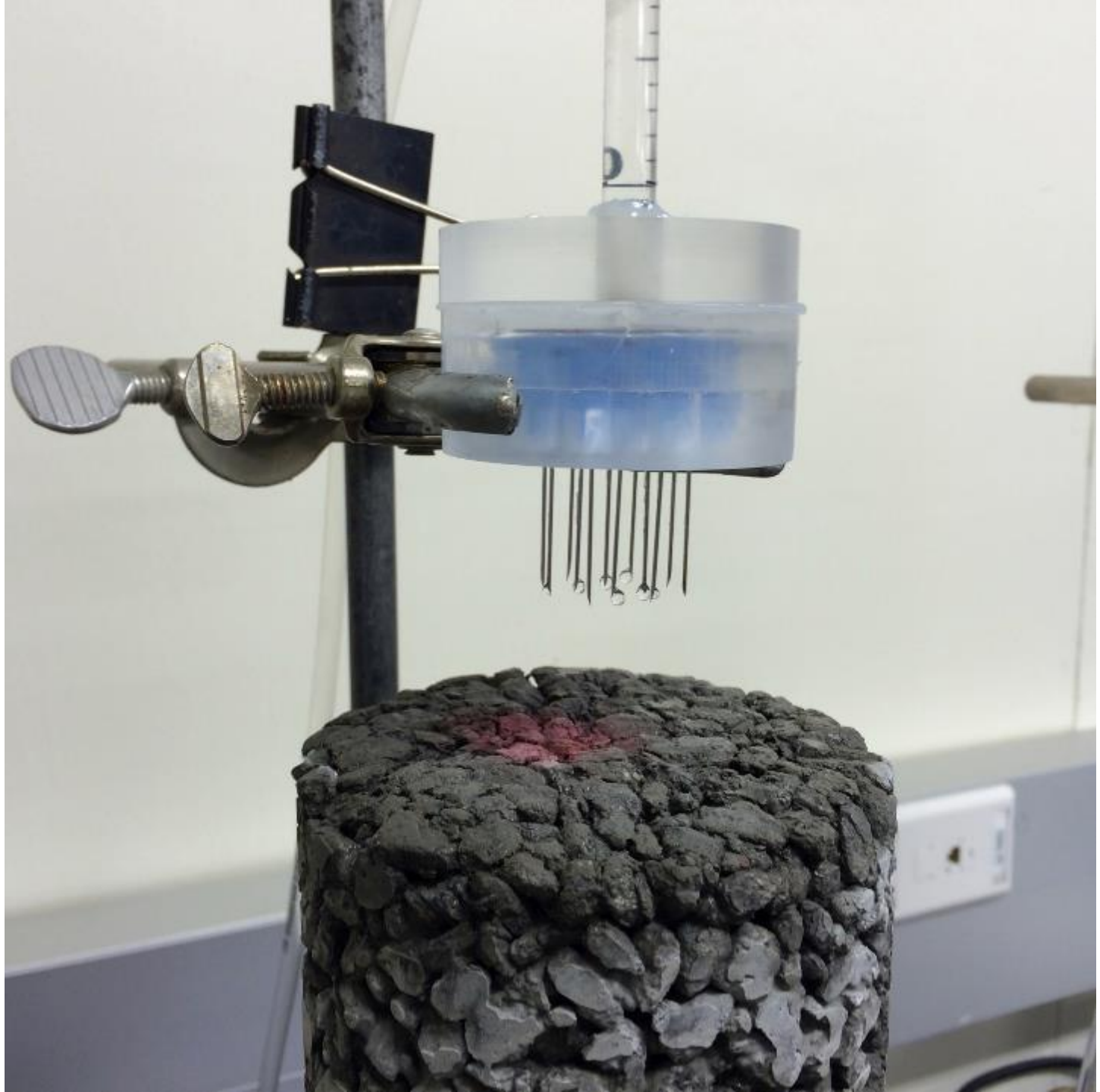
- The WSU engineering team developed the process to incorporate carbon fiber into permeable asphalt and concrete

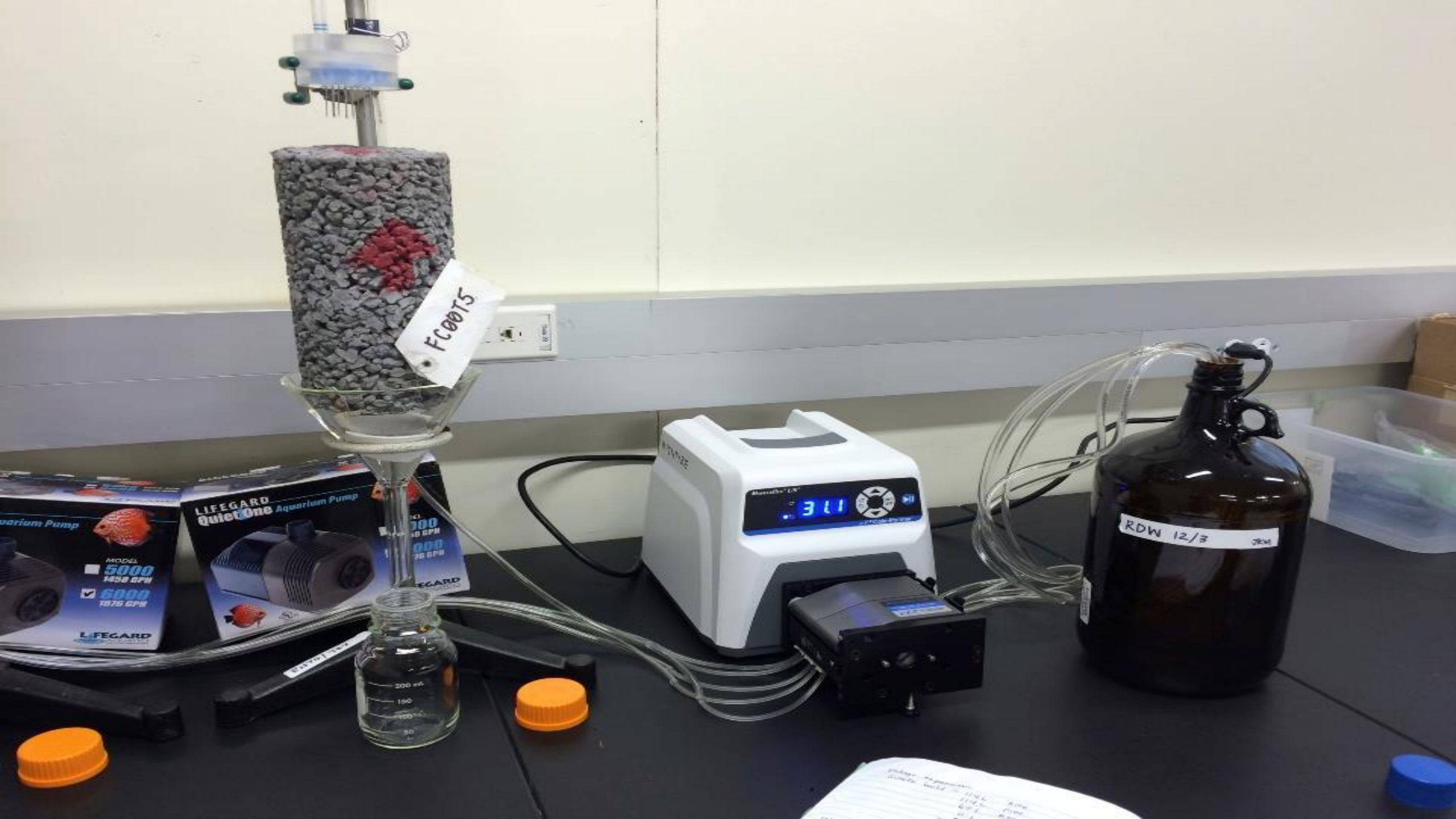
- WSU Puyallup developed the toxicity data

Toxicity studies

- Exposed *Ceriodaphnia dubia* to lab water and lab water run through traditional permeable asphalt and concrete and carbon-fiber modified permeable pavements
- Exposed *C. dubia* to urban stormwater run through traditional permeable asphalt and concrete and carbon-fiber modified permeable pavements

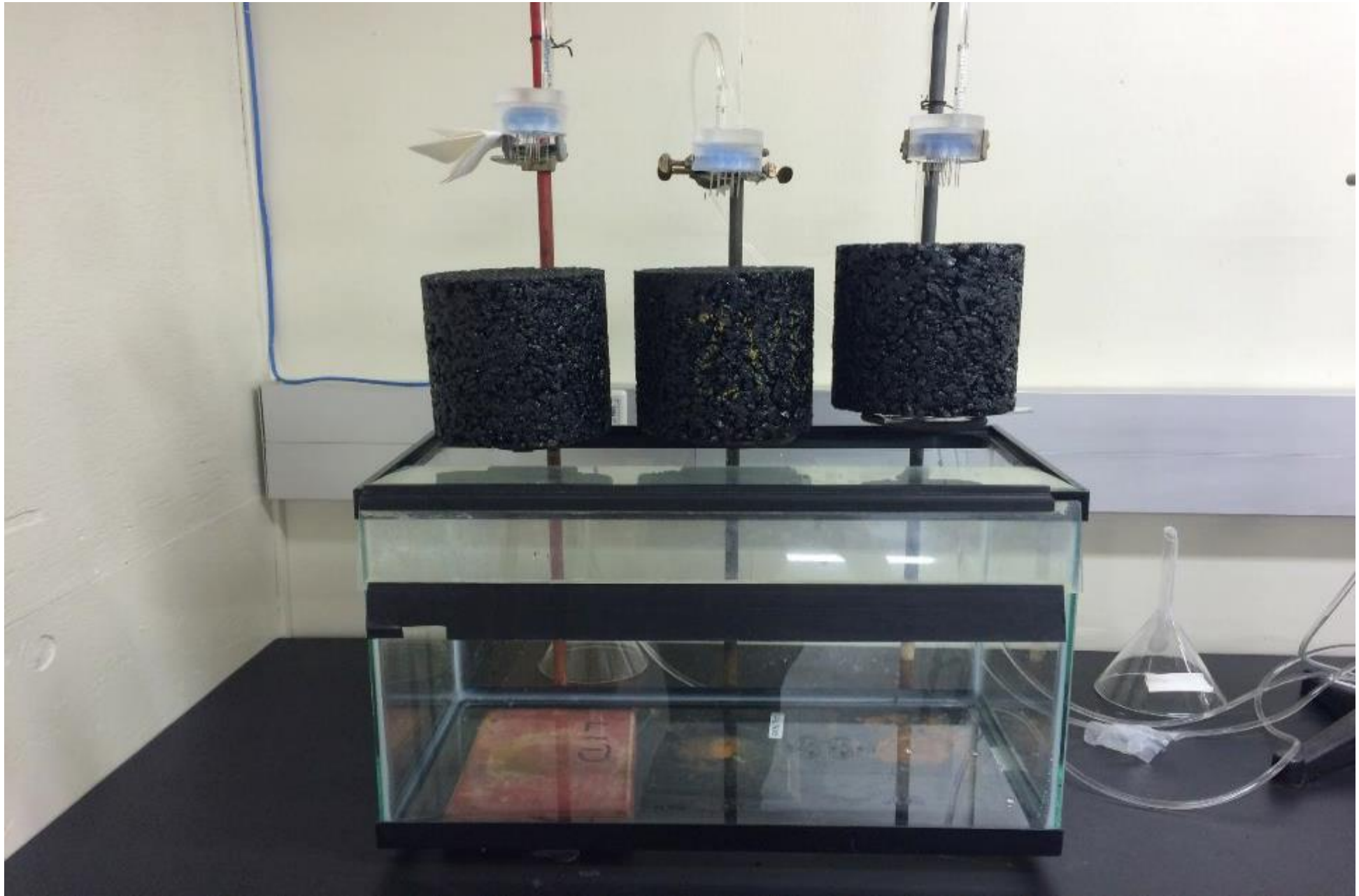
Concrete Columns




FC00TS
LIFEGARD
Quiet One Aquarium Pump
MODEL
5000
1450 GPH
6000
1875 GPH
LIFEGARD
RDW 12/3

Flocculate in lab leach water from concrete cores

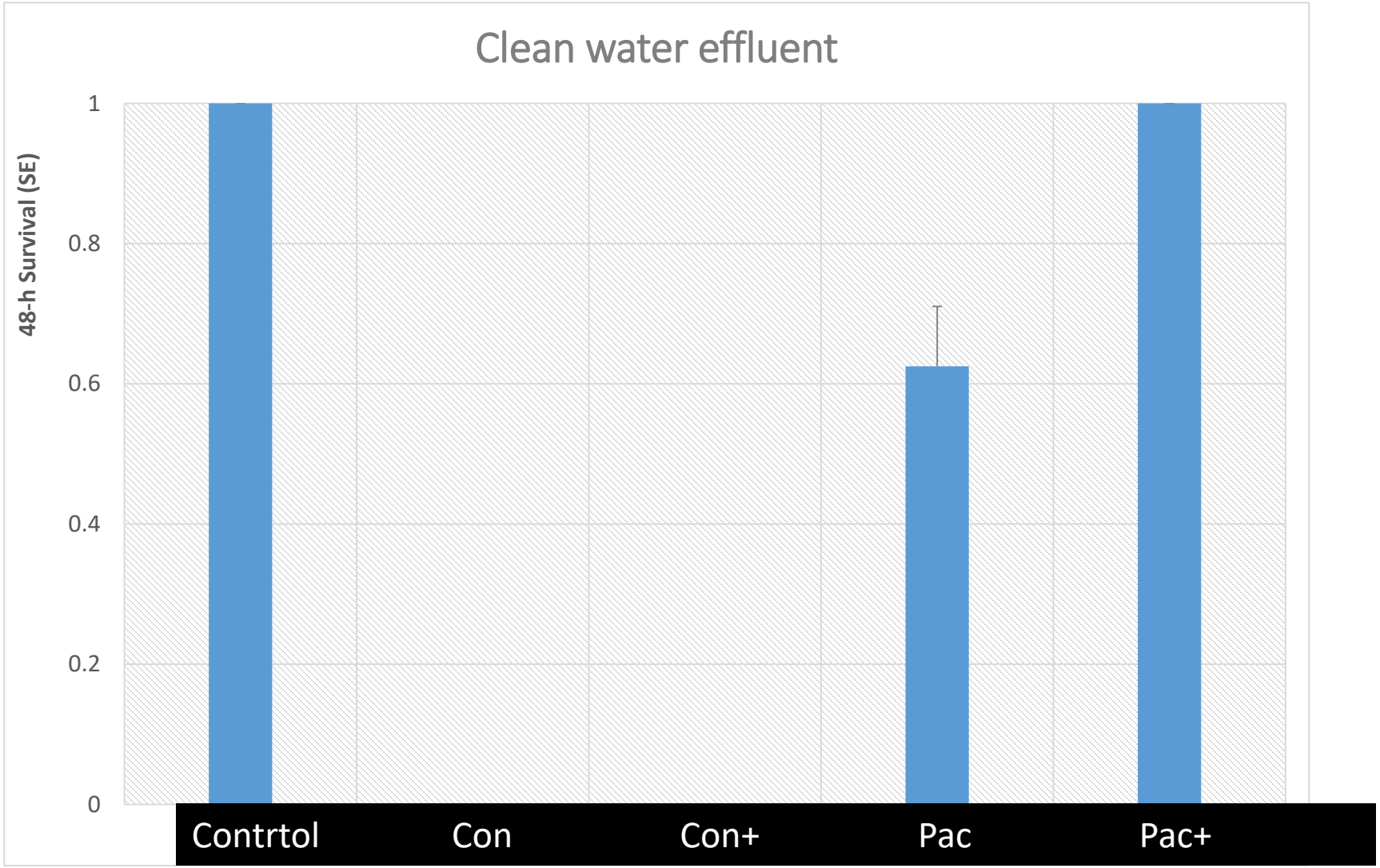
Asphalt columns



Results

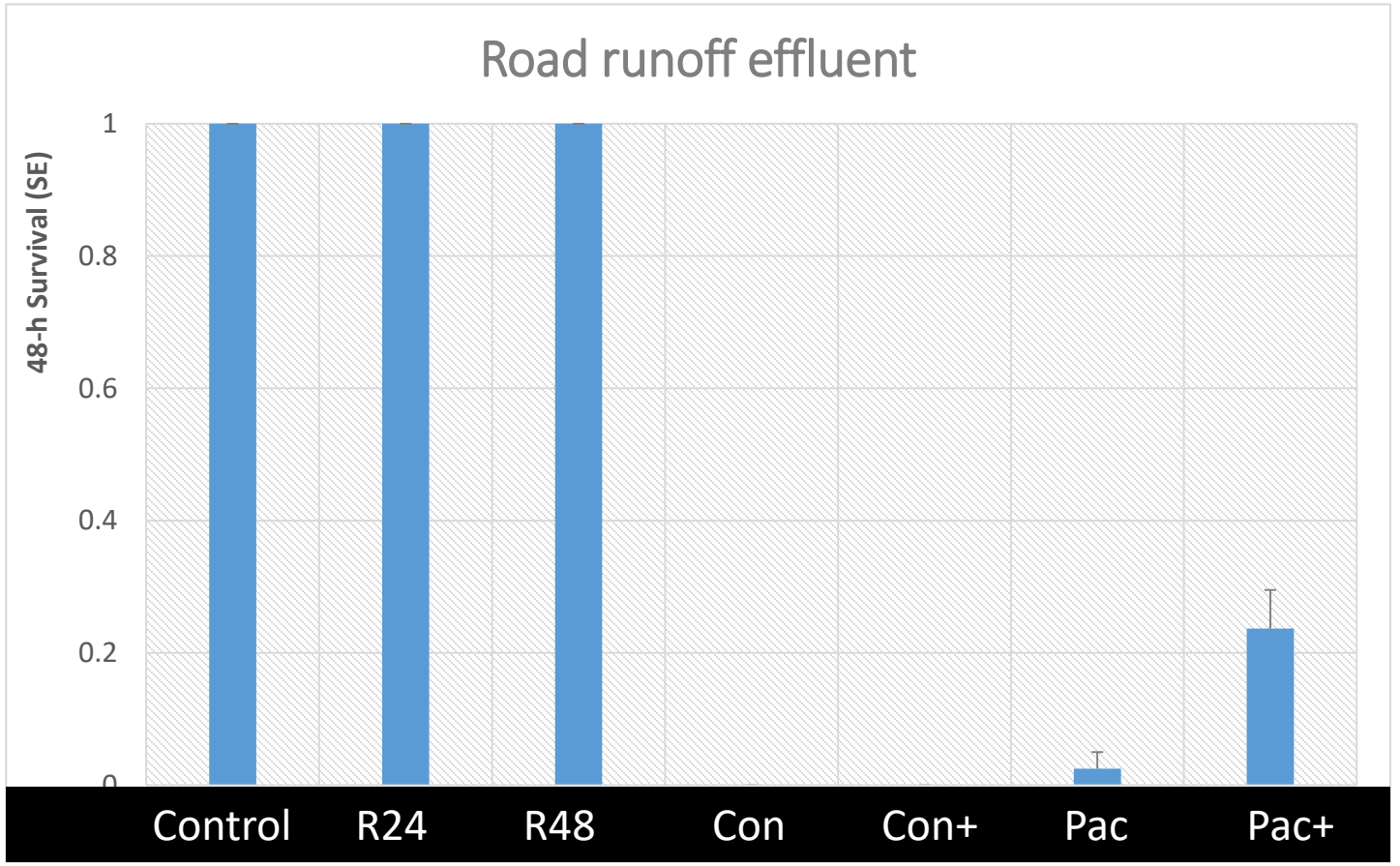
Addition of Boeing's carbon fiber to both pervious concrete and porous asphalt increased tensile and compressive strength

Survival of *C. dubia* to lab water



Seattle Freeway runoff

Survival of *C. dubia* exposed to urban runoff



Conclusions

- Addition of Boeing's carbon fiber to pervious concrete and porous asphalt resulted in increased tensile and compressive properties and improved infiltration
- Lab water that leached through pervious concrete was toxic to *C. dubia*. This was due to a large increase in pH. In future studies, pH adjustment needs to be considered as well.
- Lab water leaching through porous asphalt was also toxic to *C. dubia*.
- Addition of carbon fiber to porous asphalt reduced toxicity to *C. dubia*.

Conclusions continued

- Stormwater collected from a Seattle freeway was not toxic to *C. dubia* due to frequent rain events.
- But when stormwater was run through the asphalt columns, it was more toxic than lab water perhaps pulling out more toxic compounds. The addition of carbon fiber reduced this toxicity.

Next steps

- Work on pH issues with toxicity to Daphniids
- Evaluate toxicity to salmon and other fish species
- Evaluate stormwater from a series of rain events
- Evaluate leachate toxicity over time – multiple water samples run through the columns