Stormwater Retrofits for Treating Highway Runoff

Annotated Presentation given at MuniCon on May 17, 2017.

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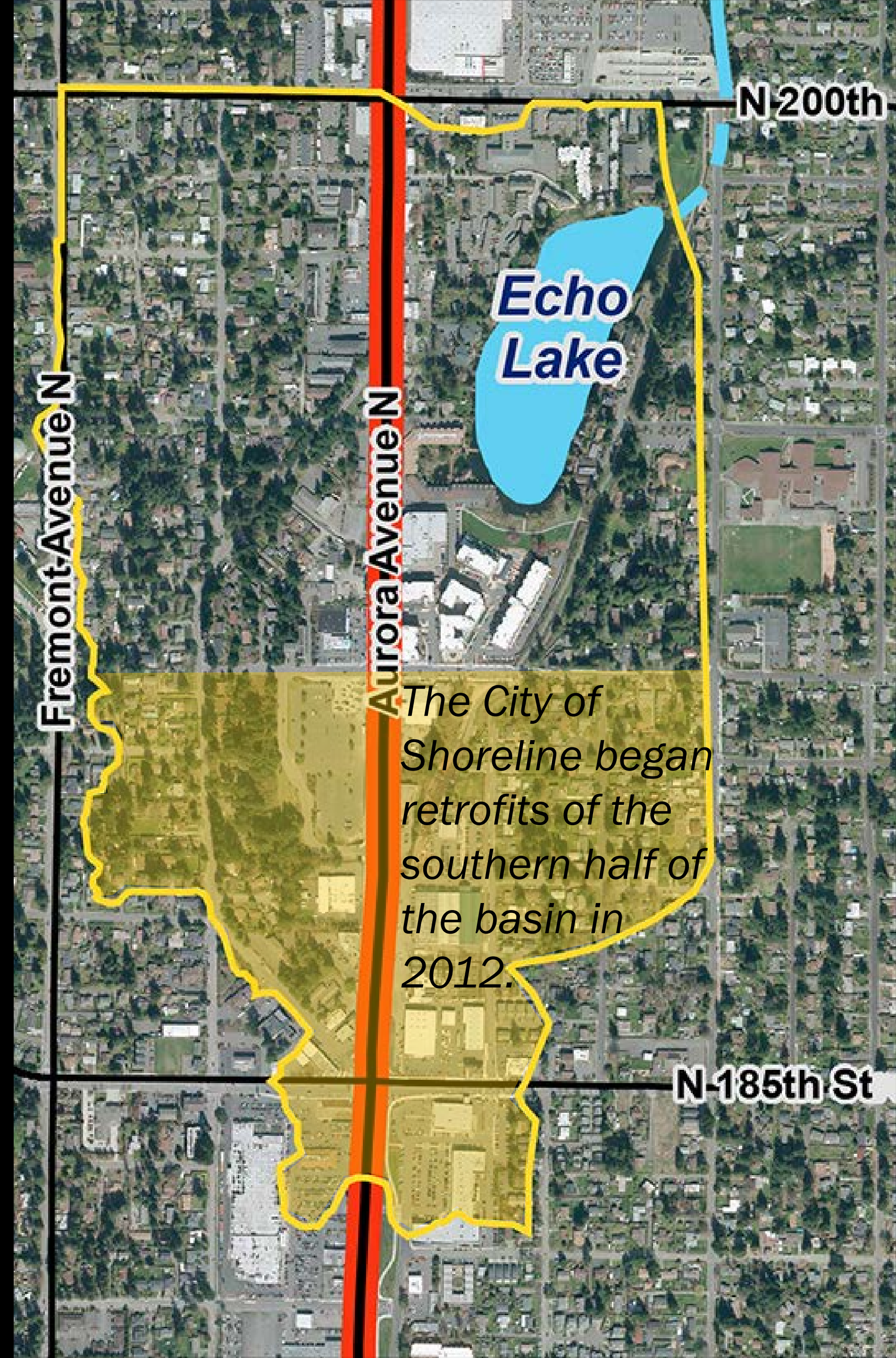
How well a retrofit improved water quality in a typical urban basin:

We looked for water quality improvements on three levels

1. **Individual BMPs**
2. **Larger stormwater system**
3. **Receiving water**

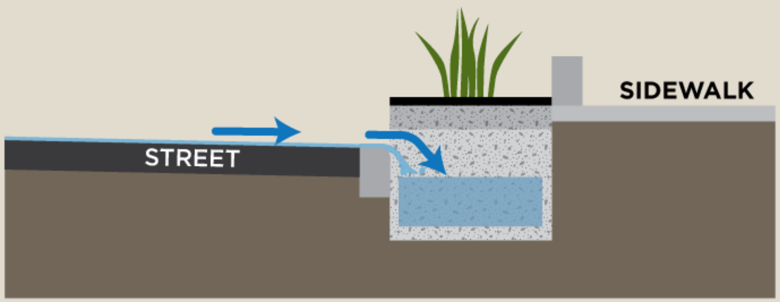

Study located in City of Shoreline
Lynnwood
Edmonds
Alderwood Manor
Woodway
Mountlake Terrace
Shoreline
Kenmore
LAKE CITY
NORTHGATE
GREENWOOD
BALLARD
FREMONT
QUEEN ANNE
CAPITOL HILL
Elliott Bay
Lake Washington
Seattle
ALKI
WEST SEATTLE
COLUMBIA CITY


N 200th
Echo Lake
Fremont Avenue N
Aurora Avenue N
The City of Shoreline began retrofits of the southern half of the basin in 2012.
N 185th St

The retrofit included Bioretention Planter Boxes

Bioretention Planter Boxes:

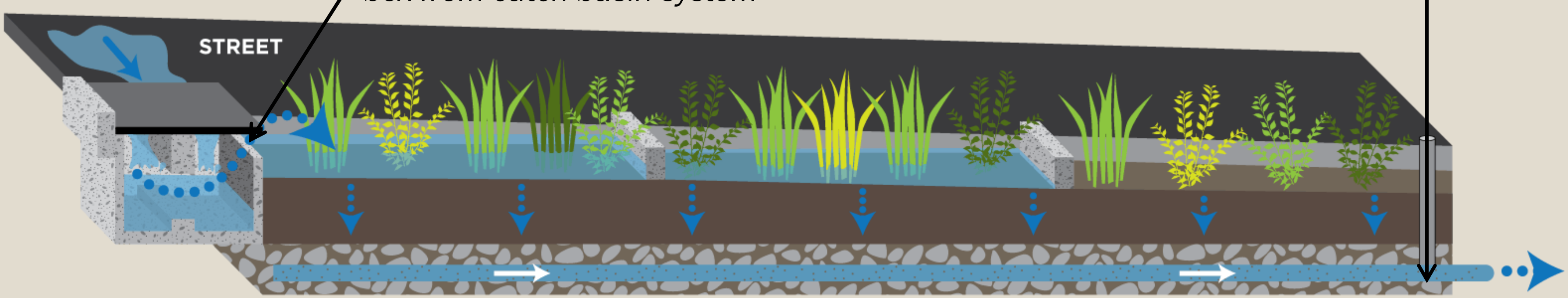
- 60/40 sand/compost mix
- Designed for enhanced treatment
- Runoff from roadway enters catch basin system before entering main planter box
- Concrete lined = no infiltration
- Perforated PVC pipe underdrain



END VIEW

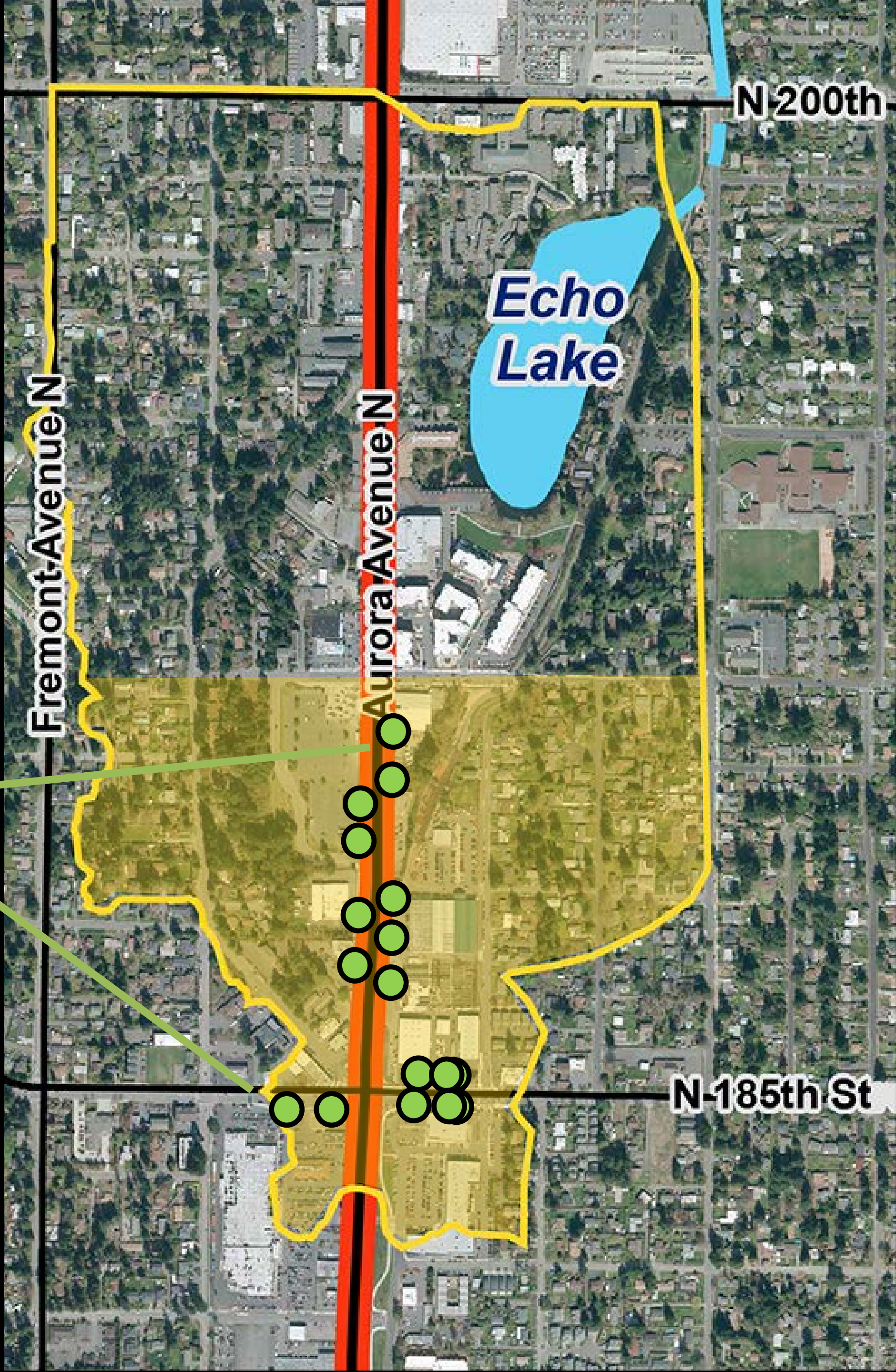
Influent samples collected from water just entering the main planter box from catch basin system

Effluent samples collected from underdrain through cleanout or overflow pipe



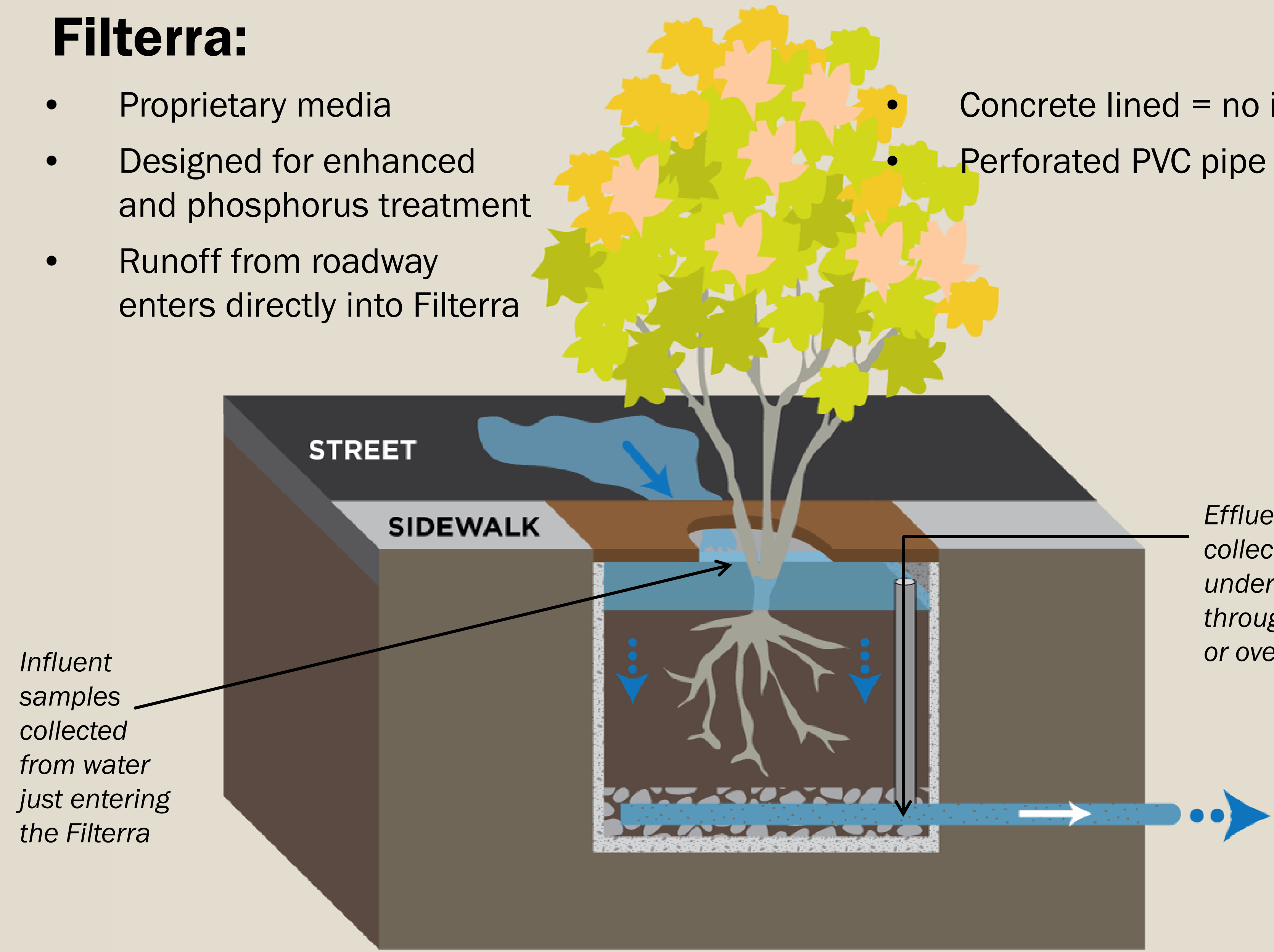
SIDE VIEW

The retrofit also included Filterra



Filterra:

- Proprietary media
- Designed for enhanced and phosphorus treatment
- Runoff from roadway enters directly into Filterra
- Concrete lined = no infiltration
- Perforated PVC pipe underdrain



New bioretention planter box installed in 2016, later than planned, not included in presentation

Included in presentation:

3 Bioretention Planter Boxes

1 Filterra

Basic study design:

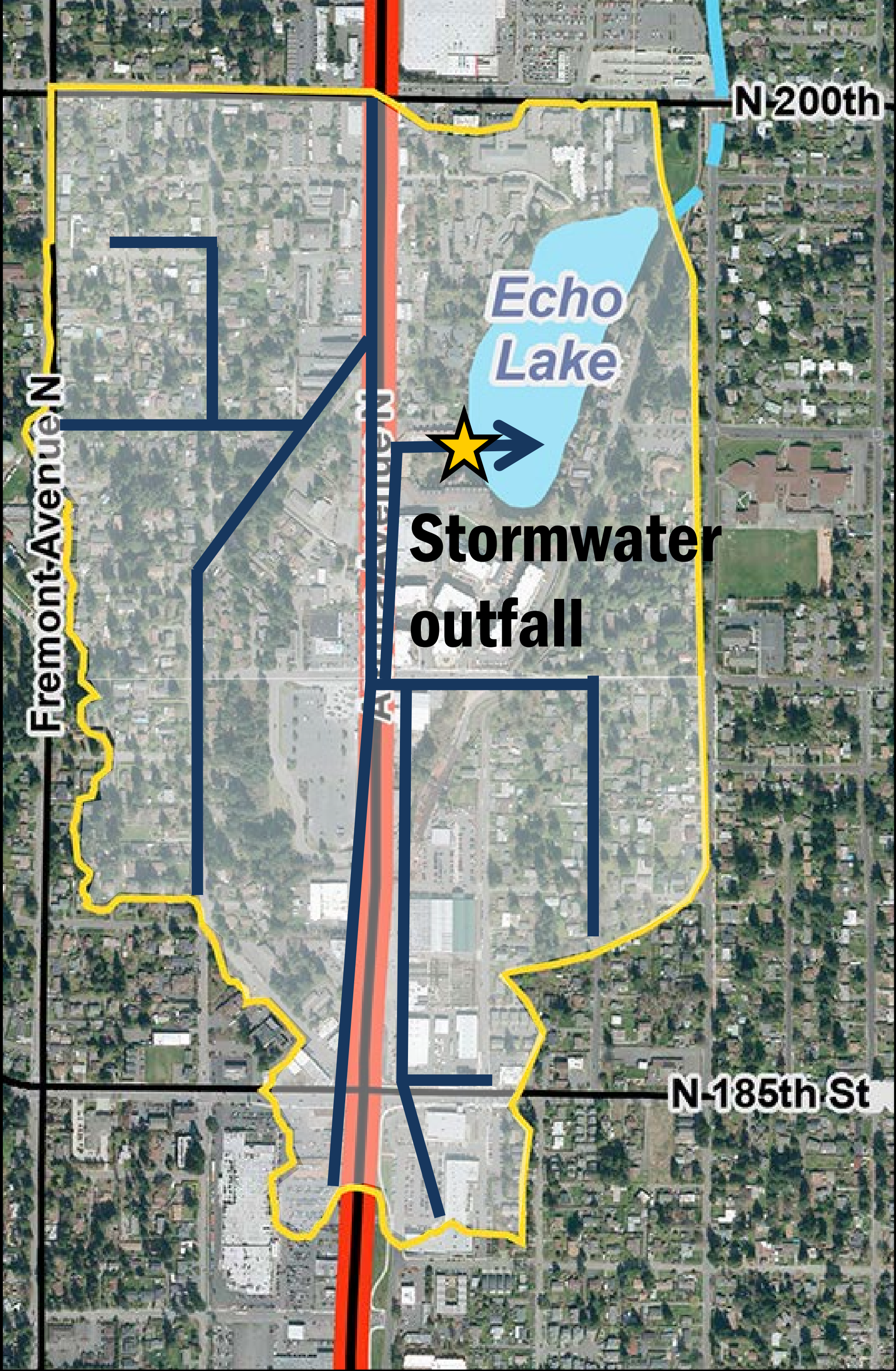
samples at the inlet and outlet

2015 - 2017

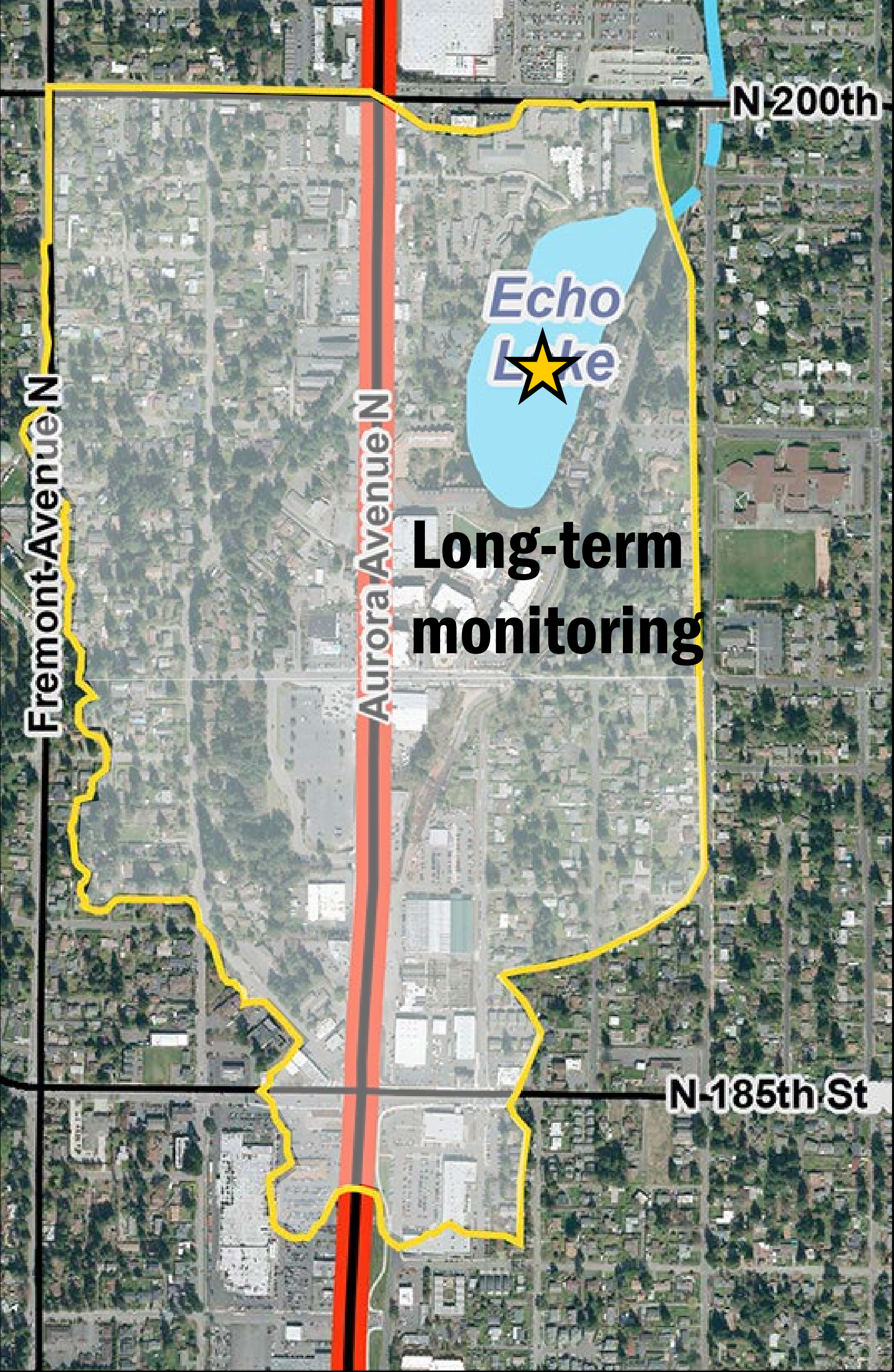
5 to 8 storms

We can also consider basin-wide effects at this site.

Samples had been collected at the stormwater outfall prior to retrofit, so these data were leveraged to compare with samples collected for this study (after the retrofit).



Echo Lake is part of a long-term monitoring program, and so these data were leveraged to compare water quality trends with retrofitting in the basin.



There are two additional things that make this study unique and valuable.

One is these treatment features have been around awhile. Many bioretention studies focus on brand new installations, but these bioretention planter boxes, as well as the Filterra, were online for three years before we started sampling. This is valuable because we need to understand the long-term effectiveness of our installations.

PCBS

Two, this study looked at some chemicals that are infrequently included in stormwater studies.

PCBs are a group of chemicals developed in the 30s that had a range of uses including additives for construction materials, like paints and caulk. The US banned PCB production in the 70s, but they are so persistent that they are a continuing environmental and human health issue. Several local studies have found stormwater to be a major pathway for these chemicals into our waterways...


...which means they get into our fish, which means they end up in our bodies. Some PCBs are known carcinogens and can cause endocrine/hormone disruption.

PAHs

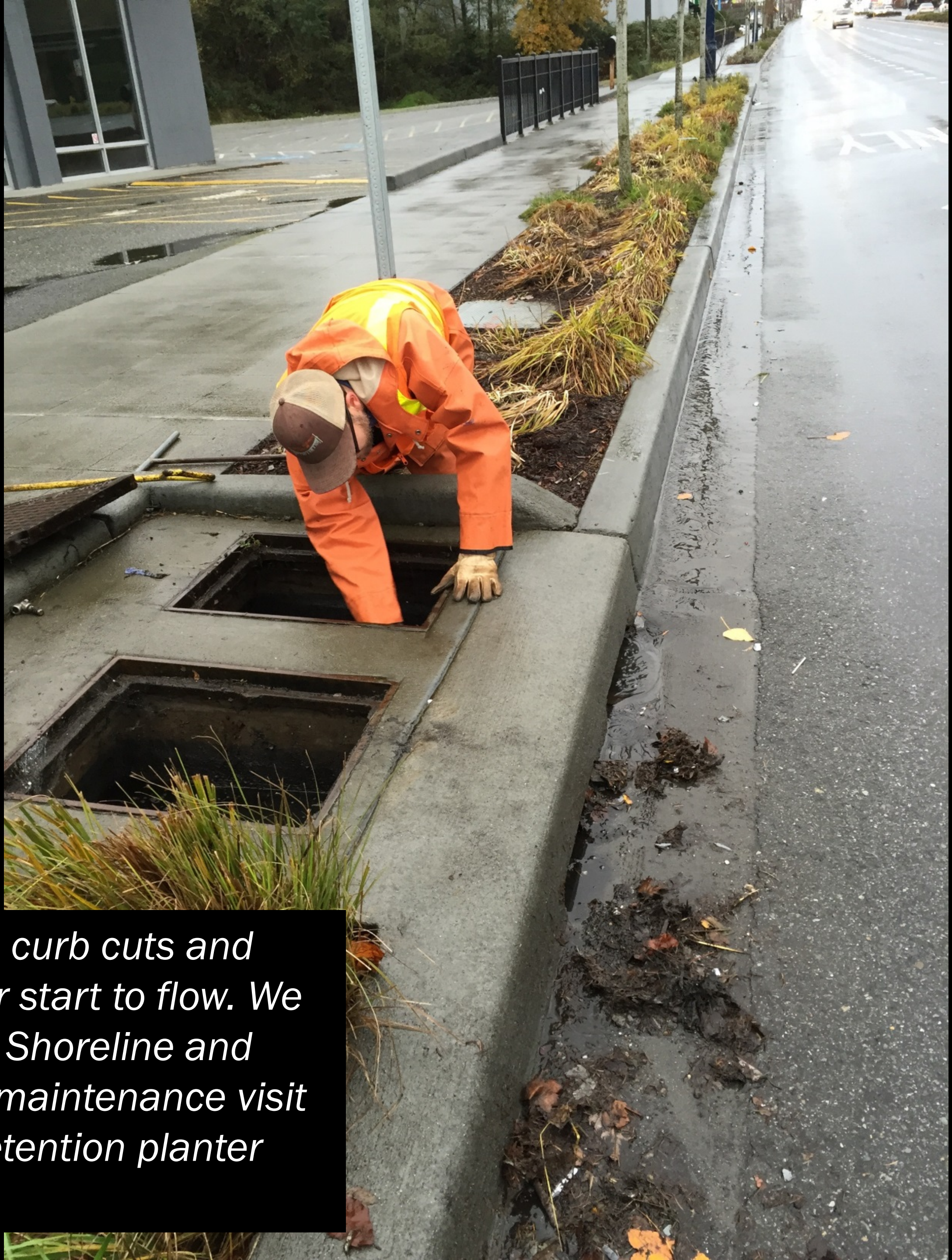
PAHs are a group of chemicals that can be produced through combustion of organic material. These are also associated with stormwater, and several are known carcinogens.

While PAHs and PCBs are not regulated with stormwater permits, many environmental professionals are looking for ways to reduce these contaminants in our waterways. Knowing how well common BMPs are removing PCBs and PAHs from the stormwater is valuable information for our community.

So in February 2015, my field lead (Christopher) and I planned a site visit to prepare for the study. It had been raining all week and we wanted to see how the installations had responded.

The first bioretention planter box looked pretty dry…

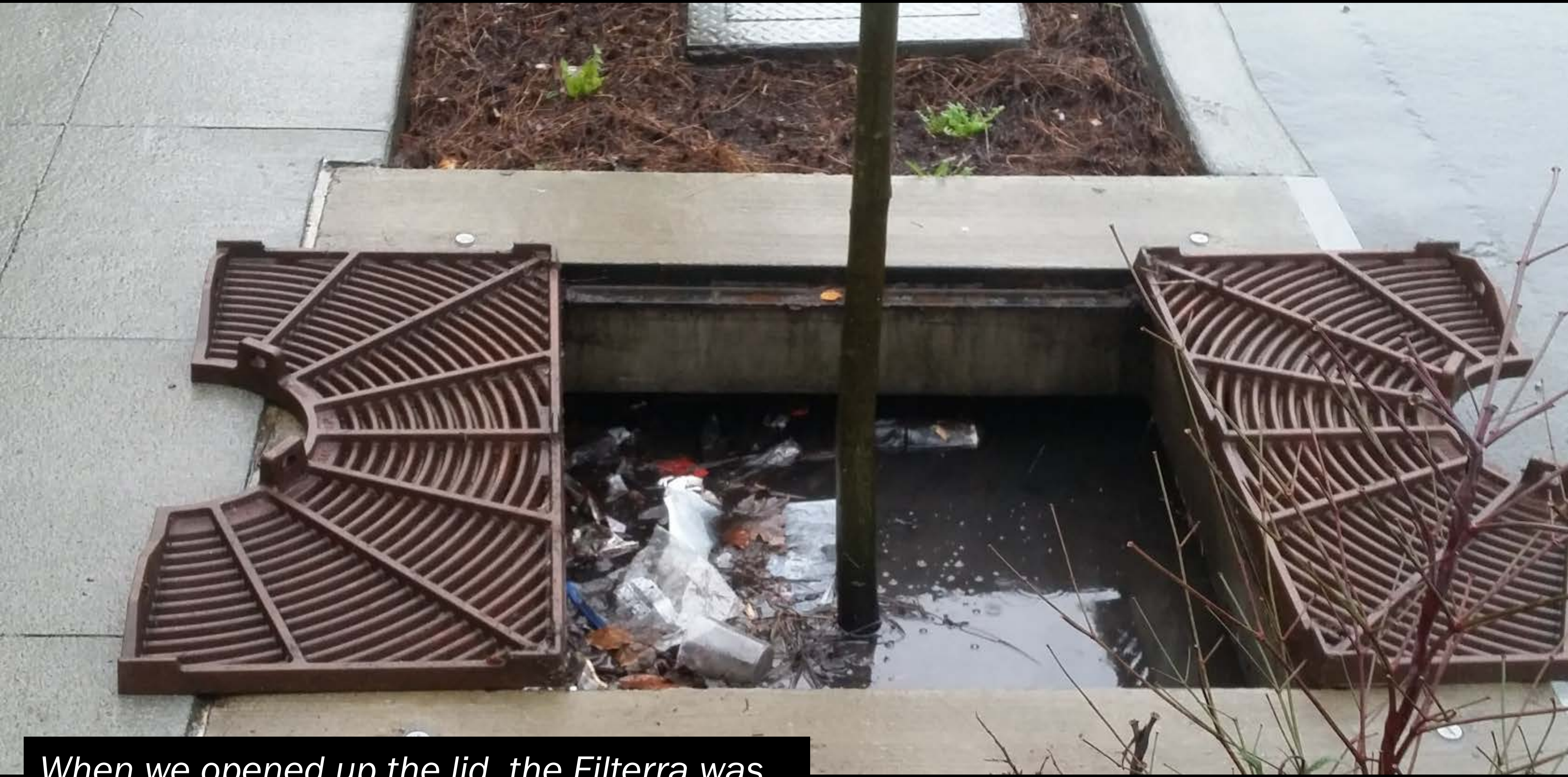
We looked in from the street, and saw dirt and debris had plugged the small curb cut, completely blocking the runoff from the highway. The other bioretention planter boxes were in a similar state.



We cleared all the curb cuts and watched the water start to flow. We talked with City of Shoreline and they scheduled a maintenance visit for the other bioretention planter boxes in the area.

Christopher visited the site a few weeks later to find a small amount of debris in the curb cuts, which had again completely blocked the stormwater from entering. We decided to visit the site every other week at a minimum to keep the curb cuts clear.

Now the Filterra curb cuts were bigger and were clear, but



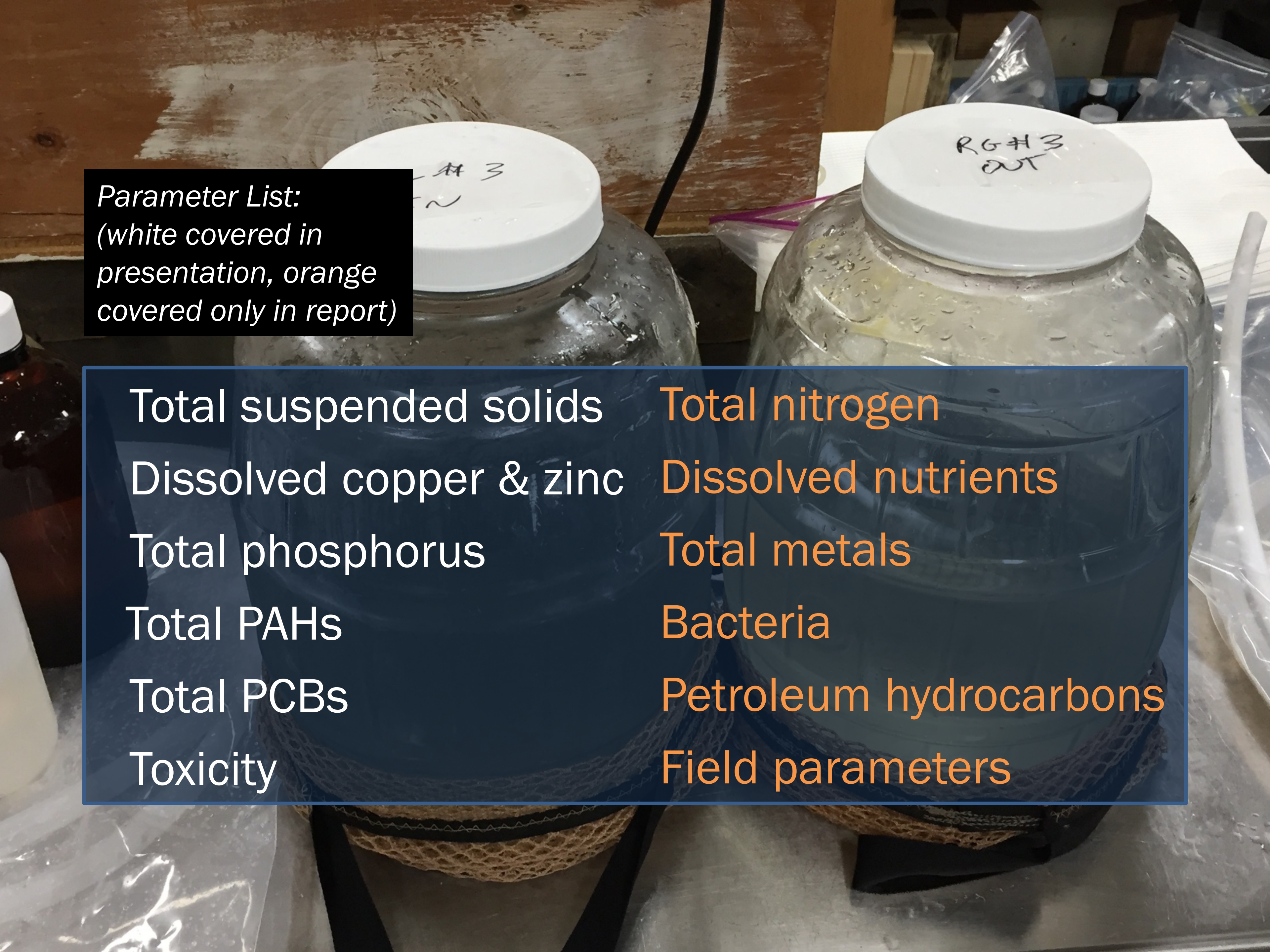
When we opened up the lid, the Filterra was flooded. It was still flooded during our site visit a few weeks later, and so the City of Shoreline replaced the media that summer.

A big storm hit in December and everything was up and running, so our sampling season began.

Influent sampling
(bioretention planter box)

Effluent sampling through cleanout/overflow pipe (bioretention planter box)

The lab then analyzed the concentration of contaminants in each sample. Between December 2015 and February 2017 we repeated this process for a total of five to eight storms at each site.



Parameter List: (white covered in presentation, orange covered only in report)

Total suspended solids	Total nitrogen
Dissolved copper & zinc	Dissolved nutrients
Total phosphorus	Total metals
Total PAHs	Bacteria
Total PCBs	Petroleum hydrocarbons
Toxicity	Field parameters

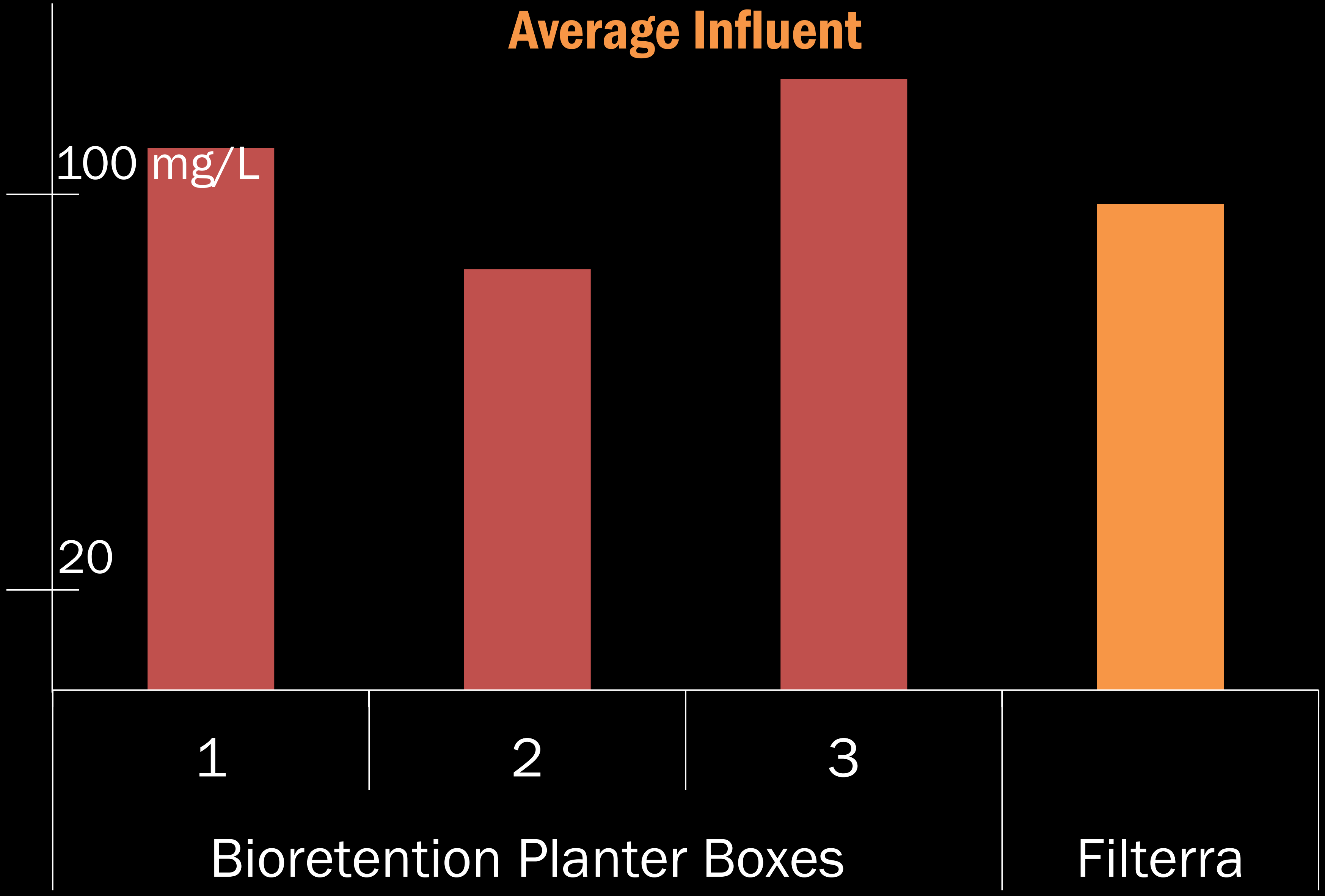
Walking through relevant TAPE performance goals to highlight sample results:

Basic Treatment

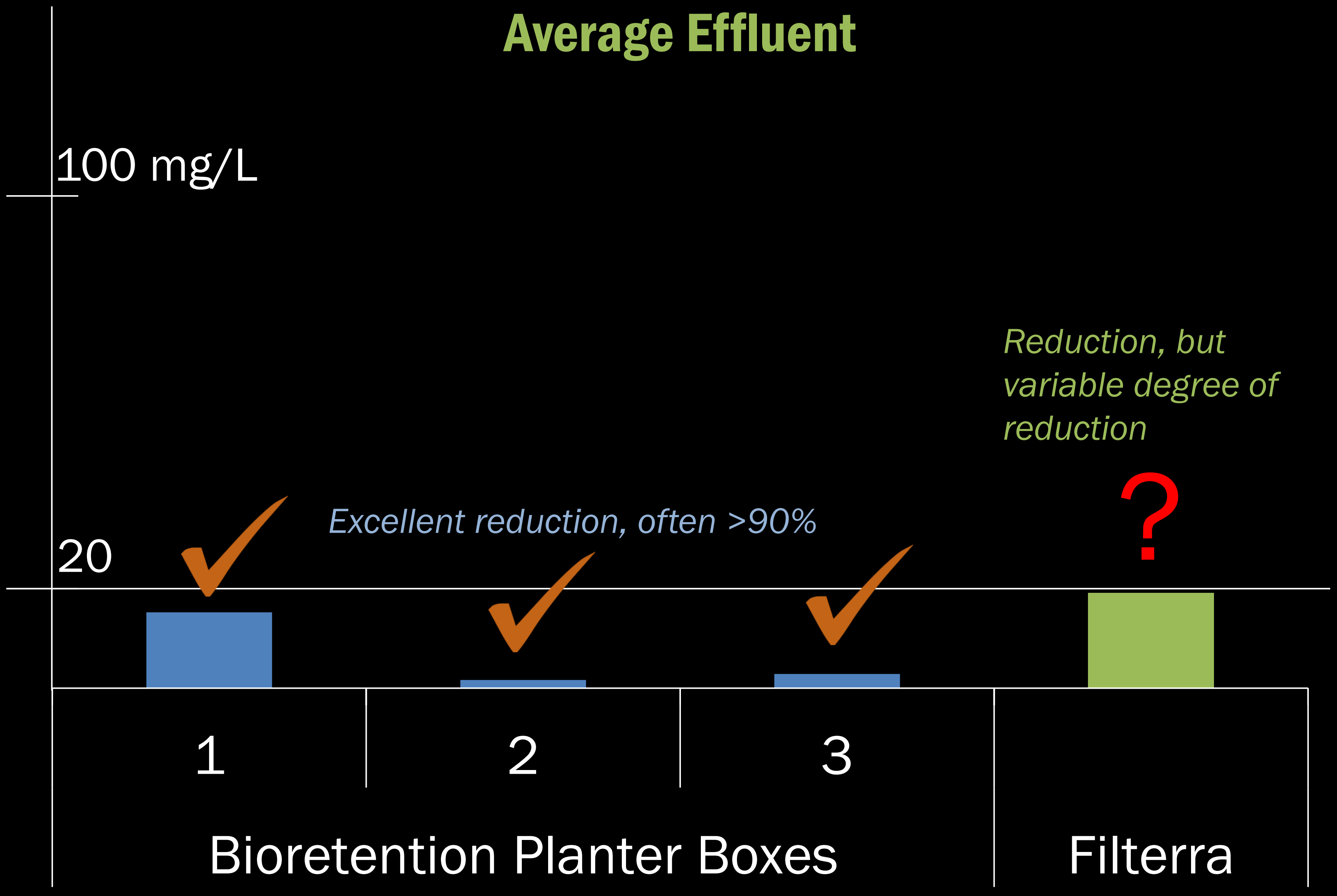
>80% total suspended solids removal

<20 mg/L total suspended solids effluent

Total Suspended Solids – Average Influent

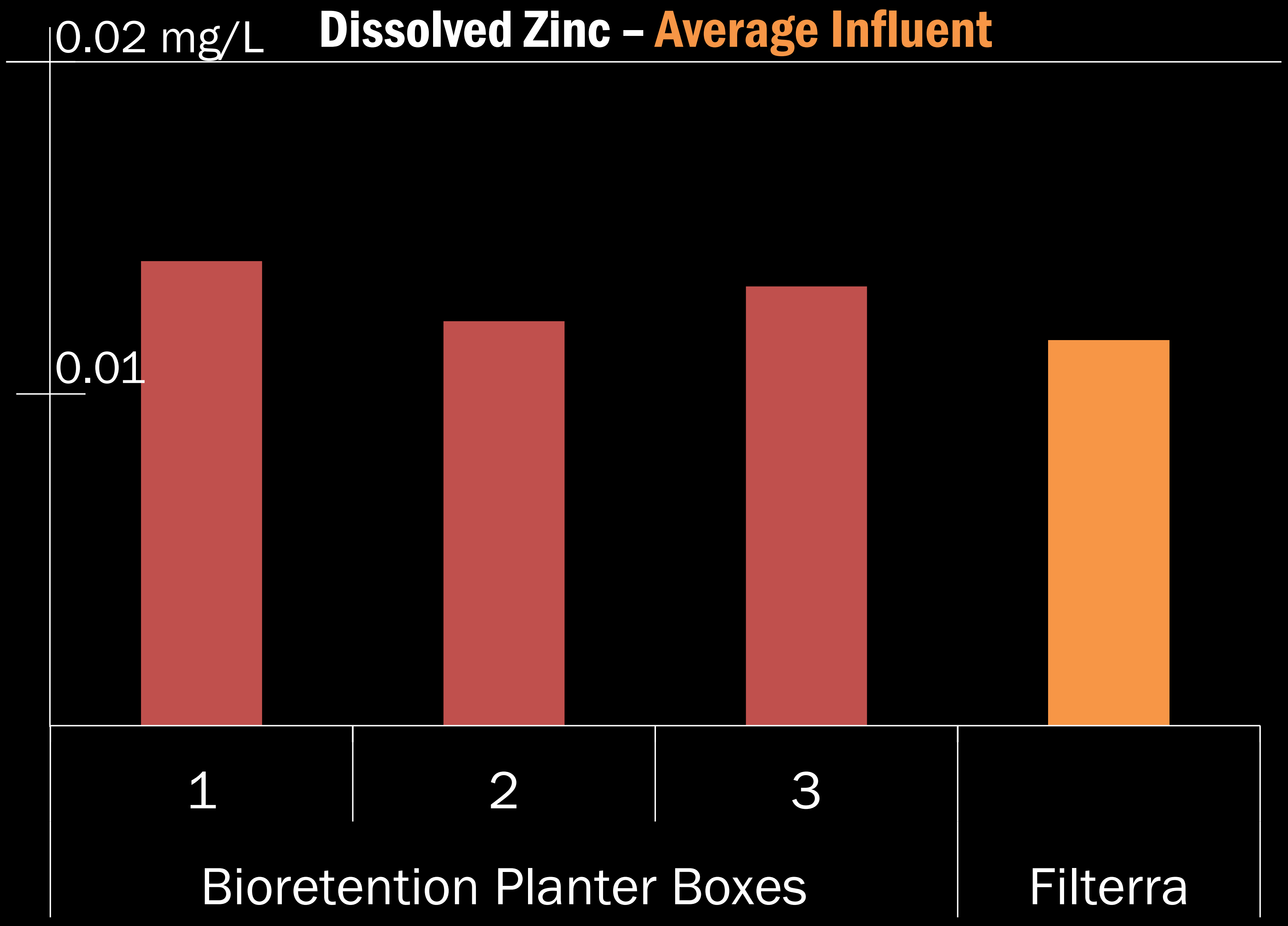


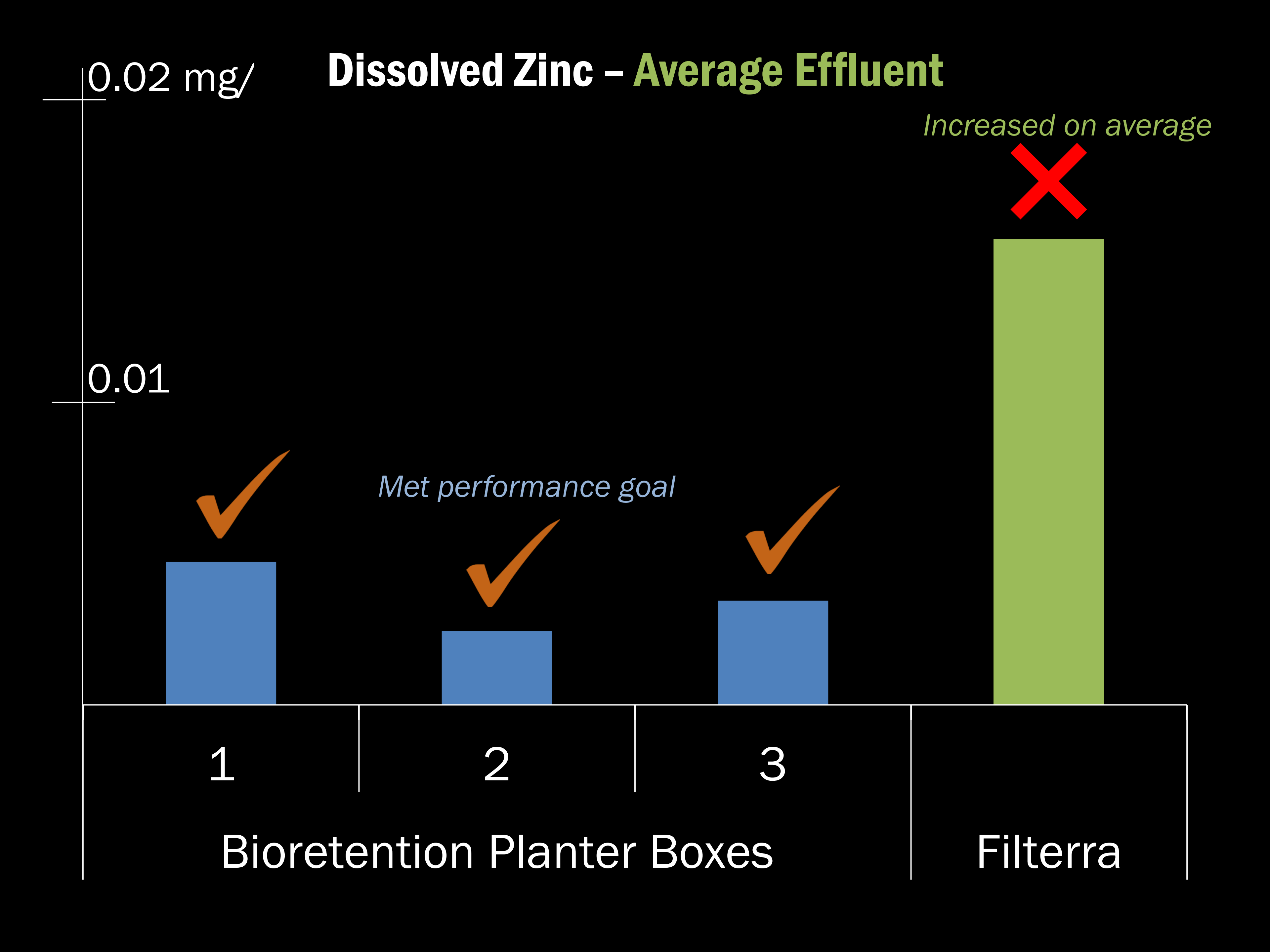
Total Suspended Solids – Average Effluent



Dissolved Metals Treatment

>60% dissolved zinc removal


Dissolved Zinc – Average Influent
0.02 mg/L
0.01
1
2
3
Bioretention Planter Boxes
Filterra

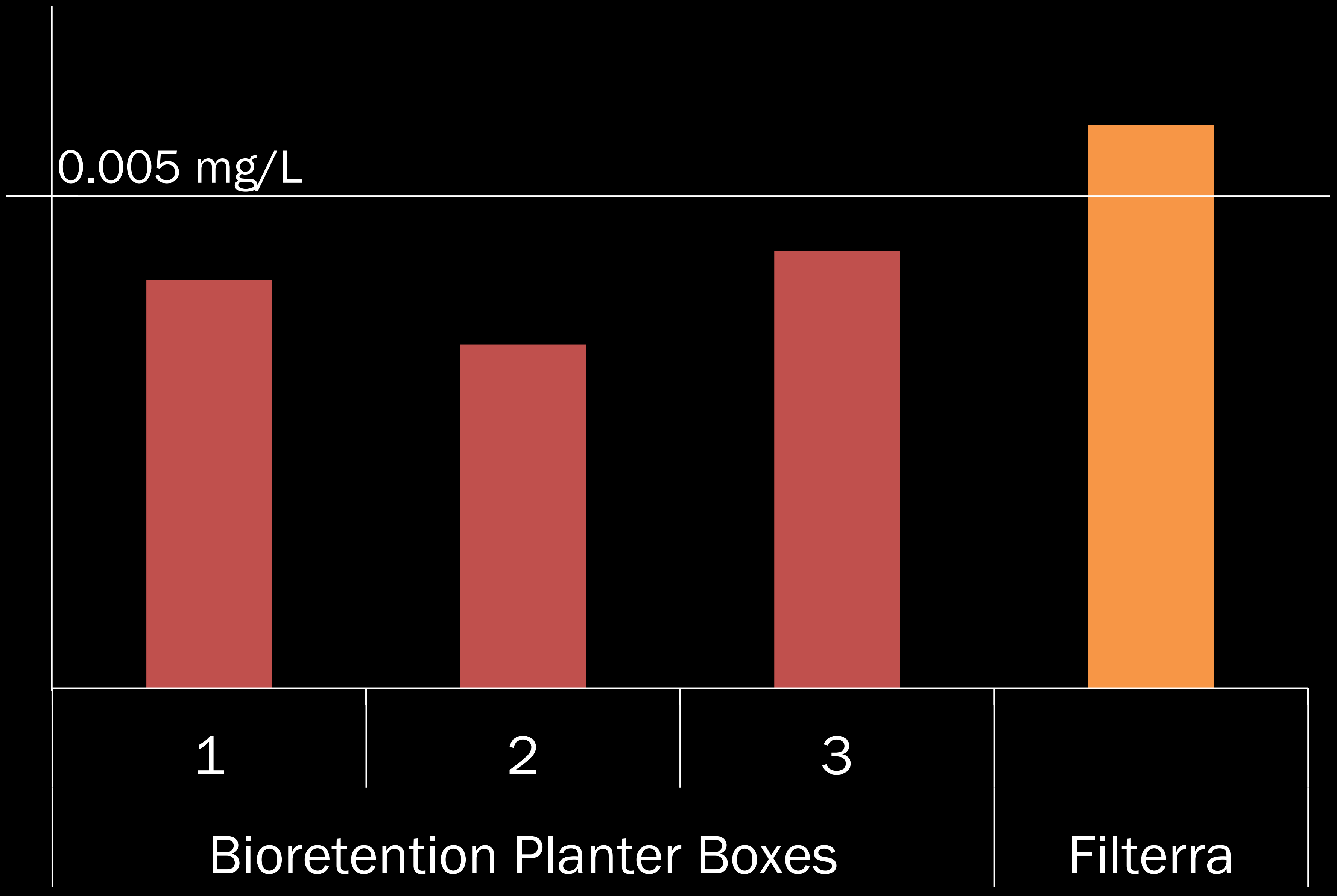


Dissolved Zinc – Average Effluent
0.02 mg/
0.01
Increased on average
Met performance goal
1
2
3
Bioretention Planter Boxes
Filterra

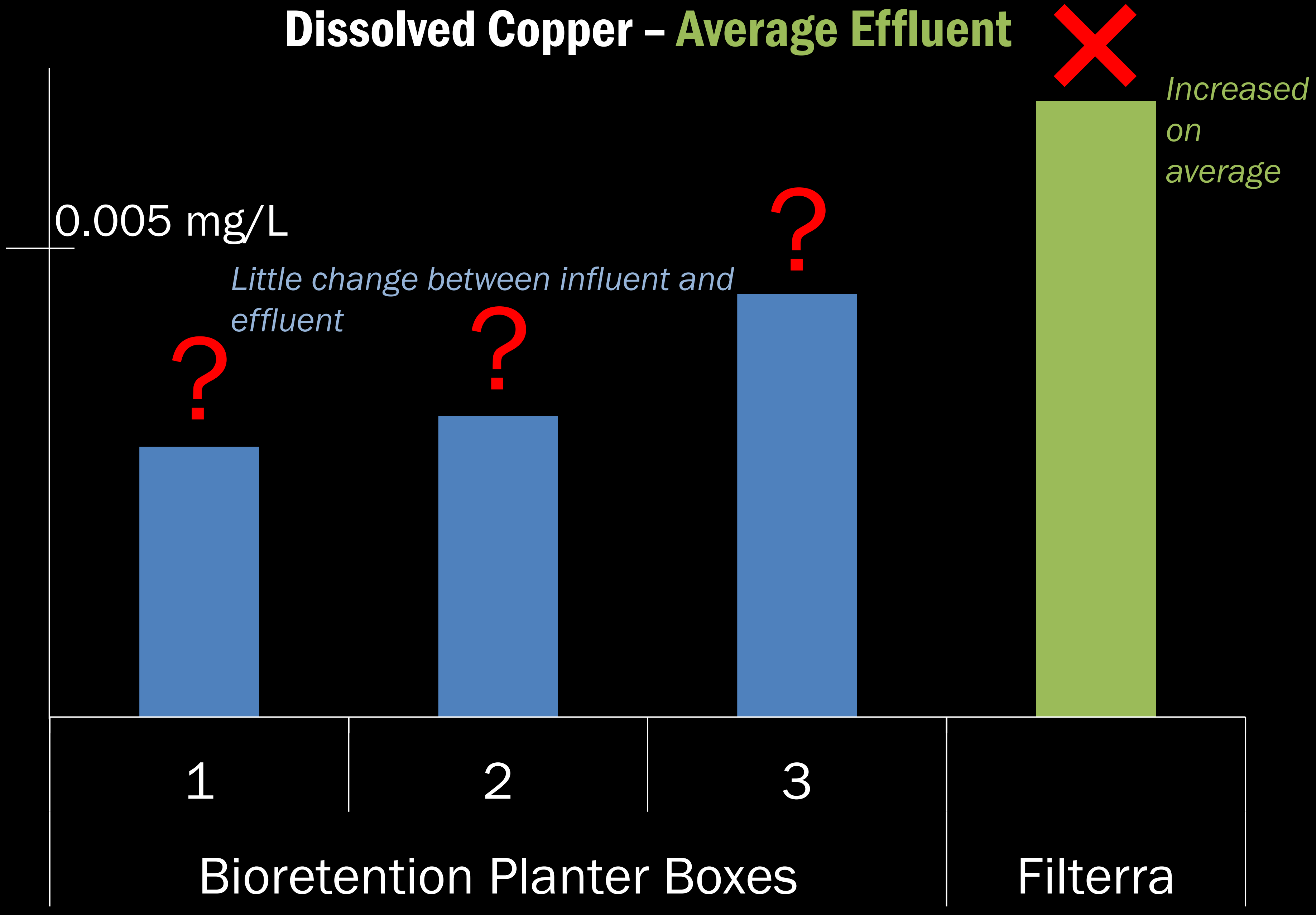
Dissolved Metals Treatment

>30% dissolved copper removal

Dissolved Copper – Average Influent

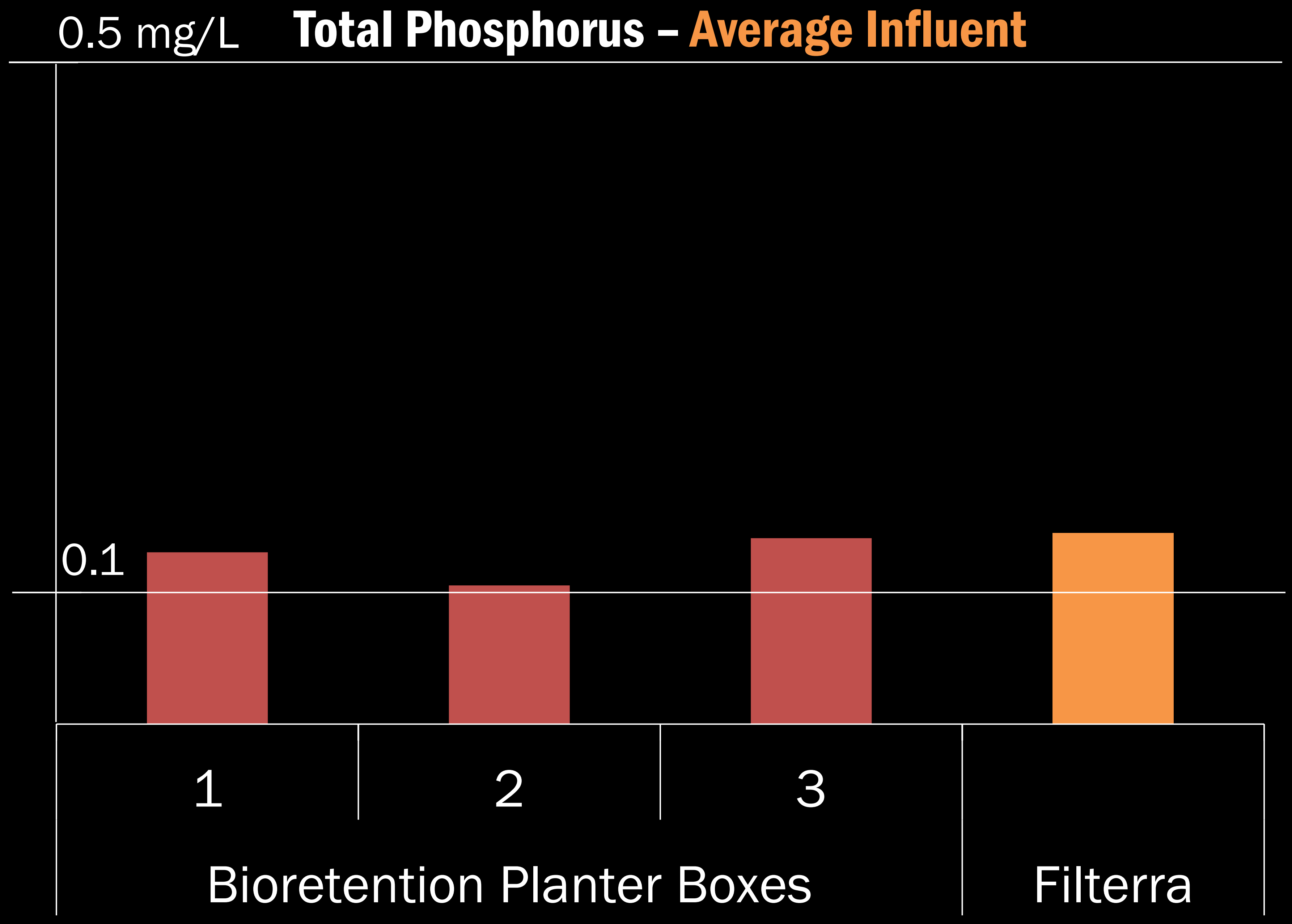


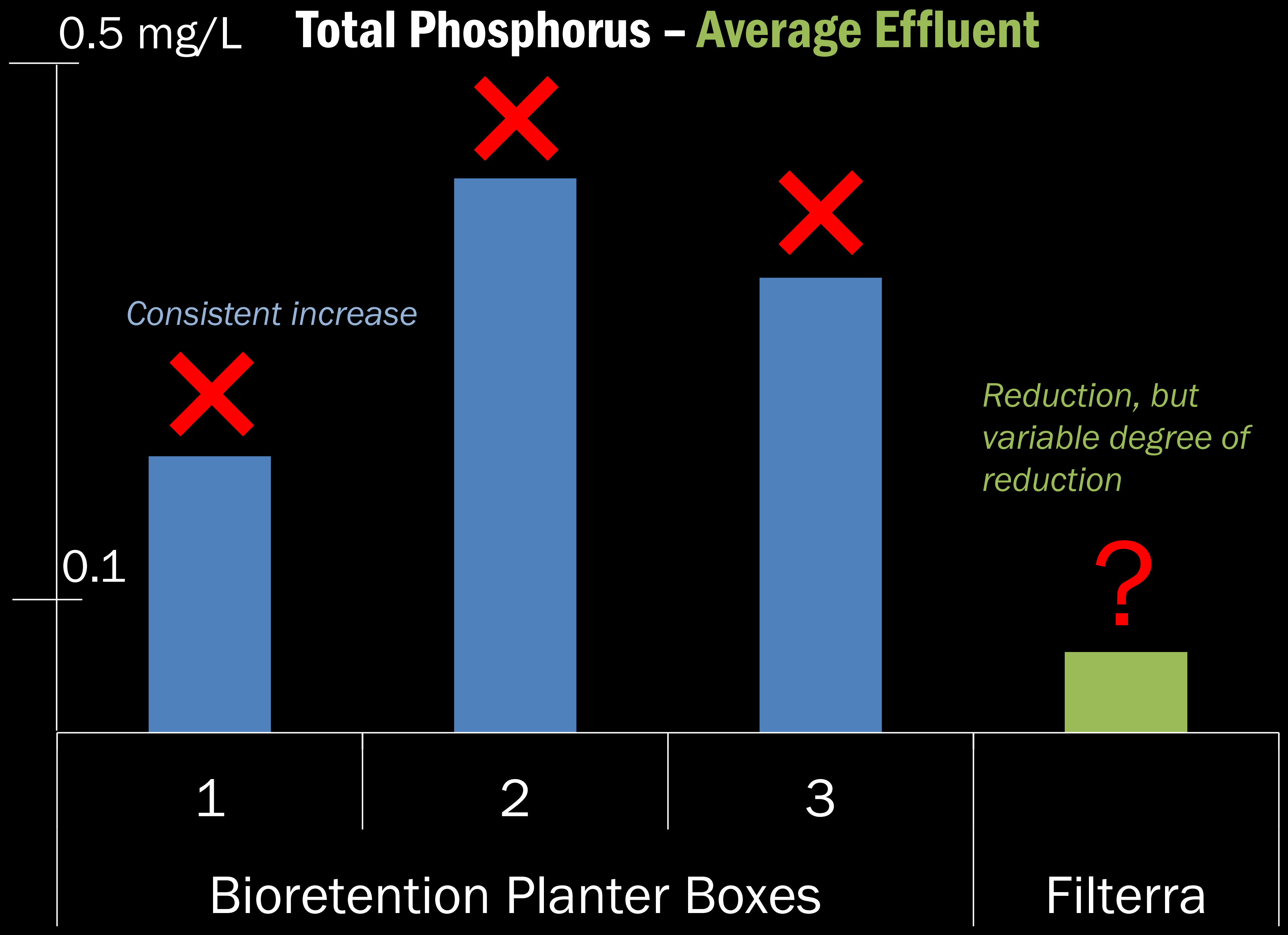
Dissolved Copper – Average Effluent



Phosphorus Treatment

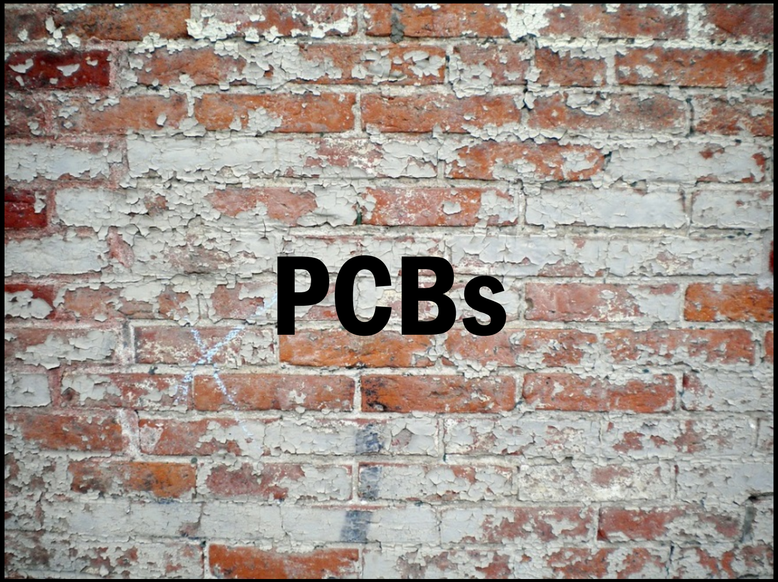
>50% total phosphorus removal


0.5 mg/L
Total Phosphorus – Average Influent
0.1
1
2
3
Bioretention Planter Boxes
Filterra

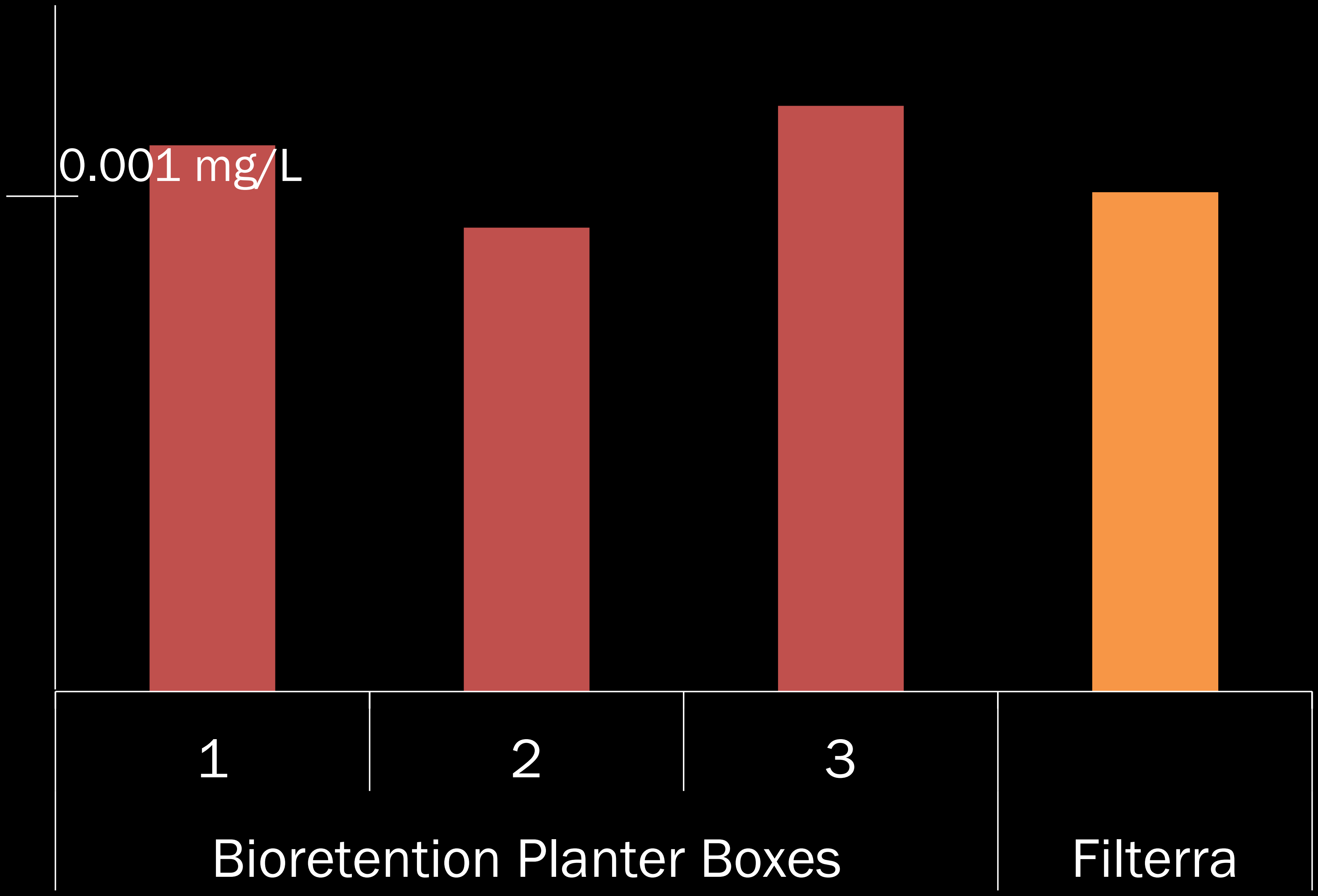


Total Phosphorus – Average Effluent
0.5 mg/L
0.1
Consistent increase
Reduction, but variable degree of reduction
?
1
2
3
Bioretention Planter Boxes
Filterra

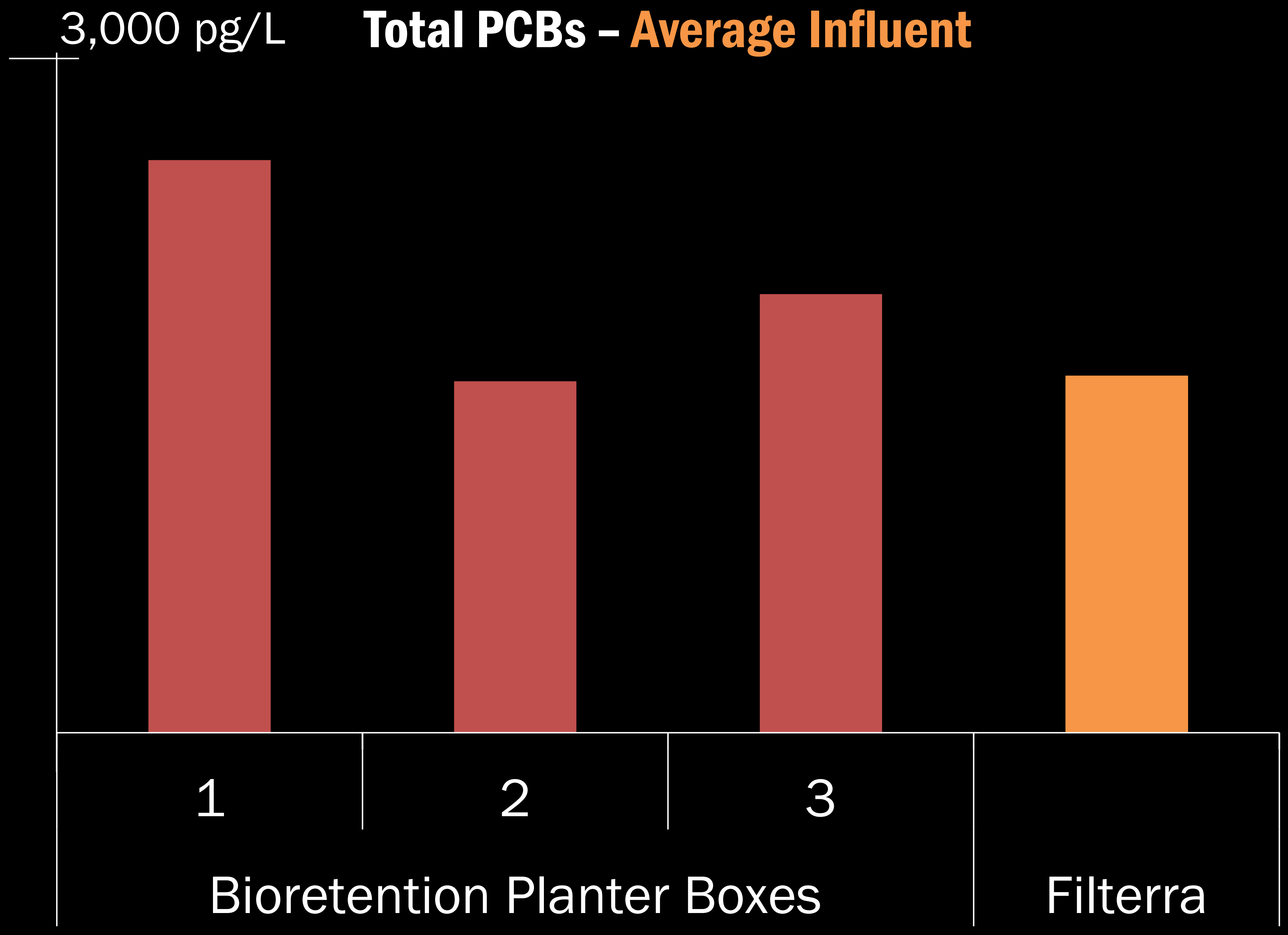
What about the other chemicals?



Total PAHs – Average Influent

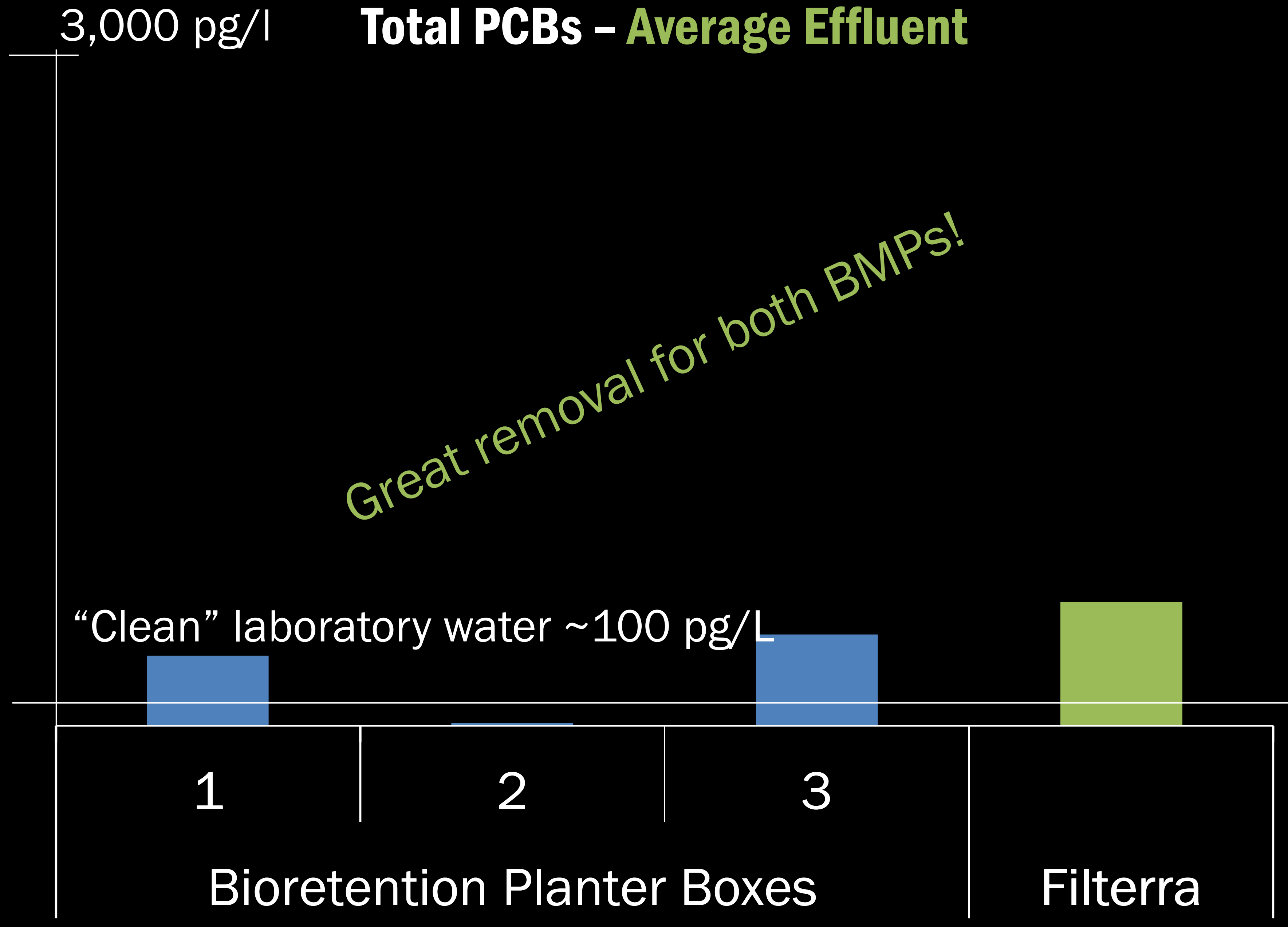


Total PAHs – Average Effluent



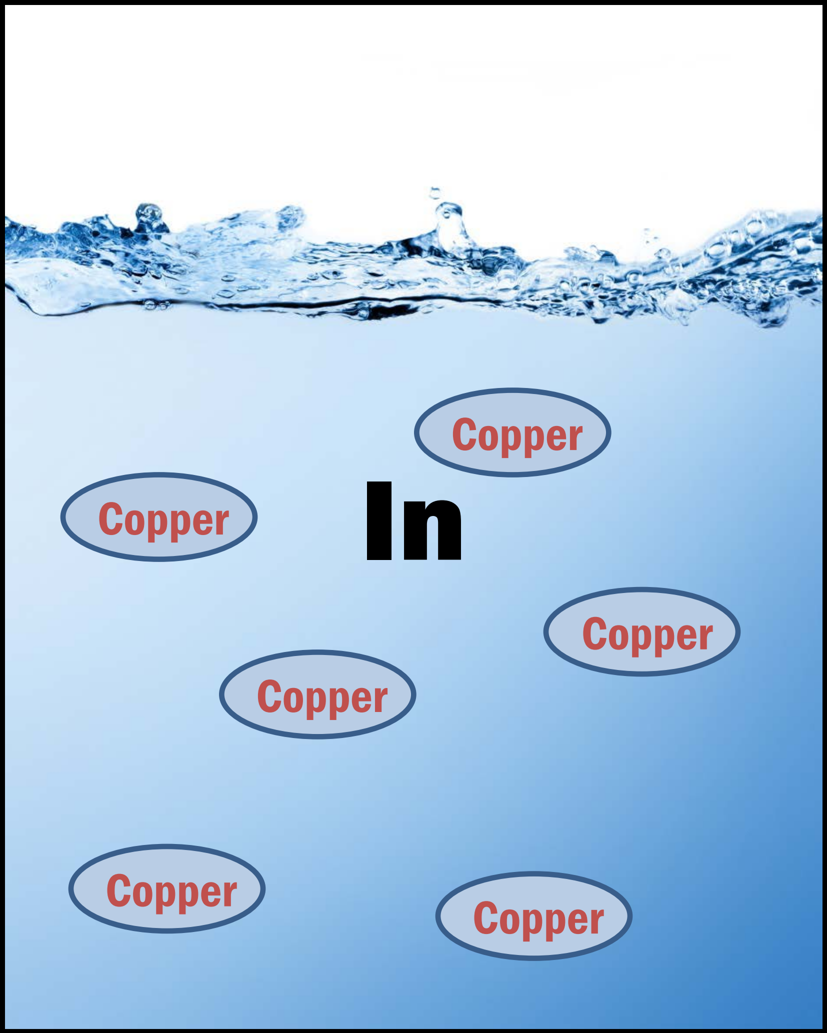
3,000 pg/L
Total PCBs – Average Influent
1
2
3
Bioretention Planter Boxes
Filterra

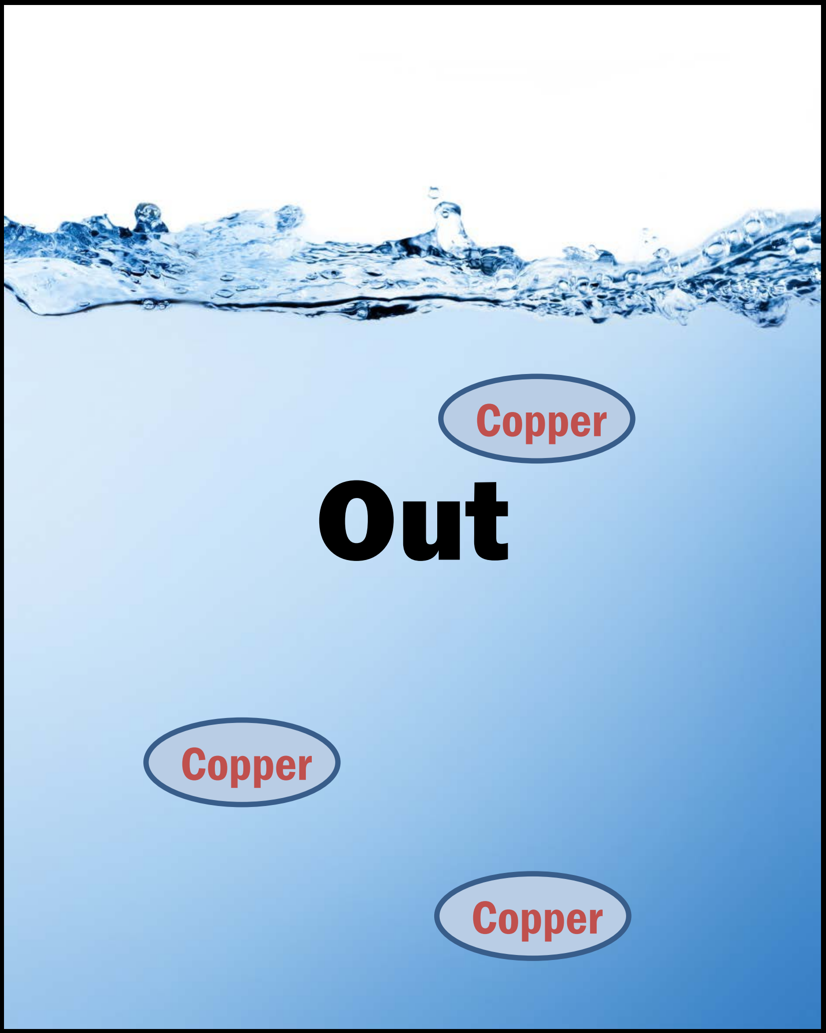
Total PCBs – Average Effluent



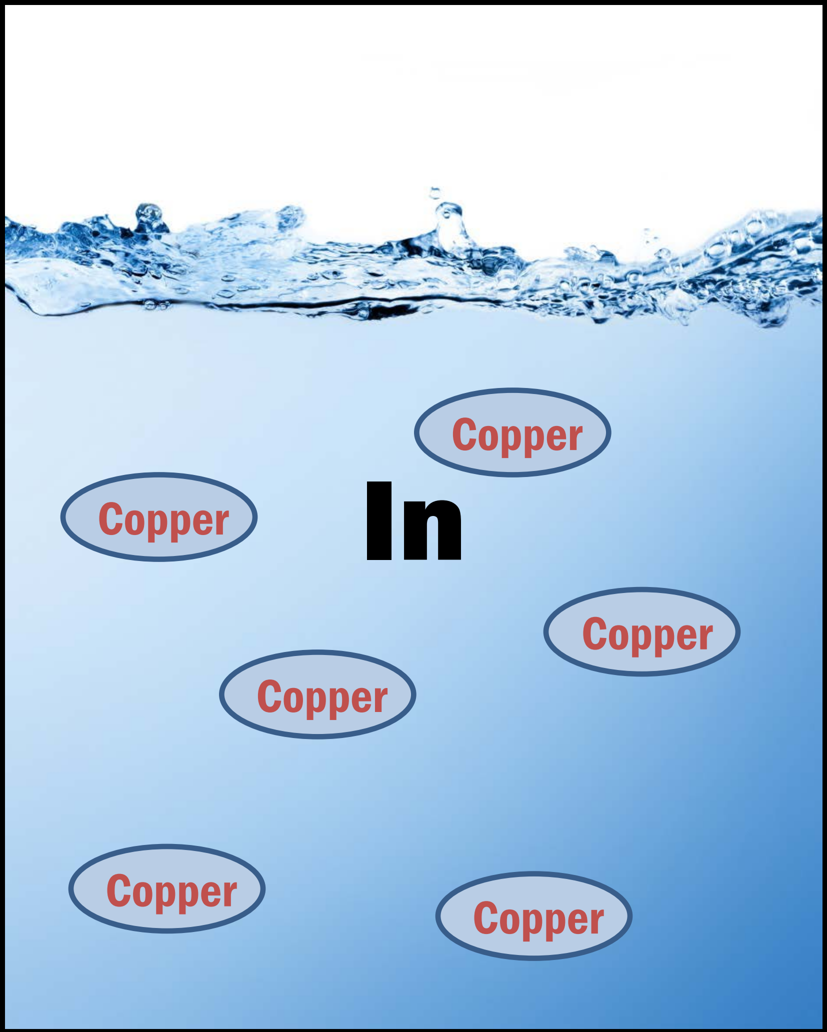
How is flow reduction is related to pollutant reduction?

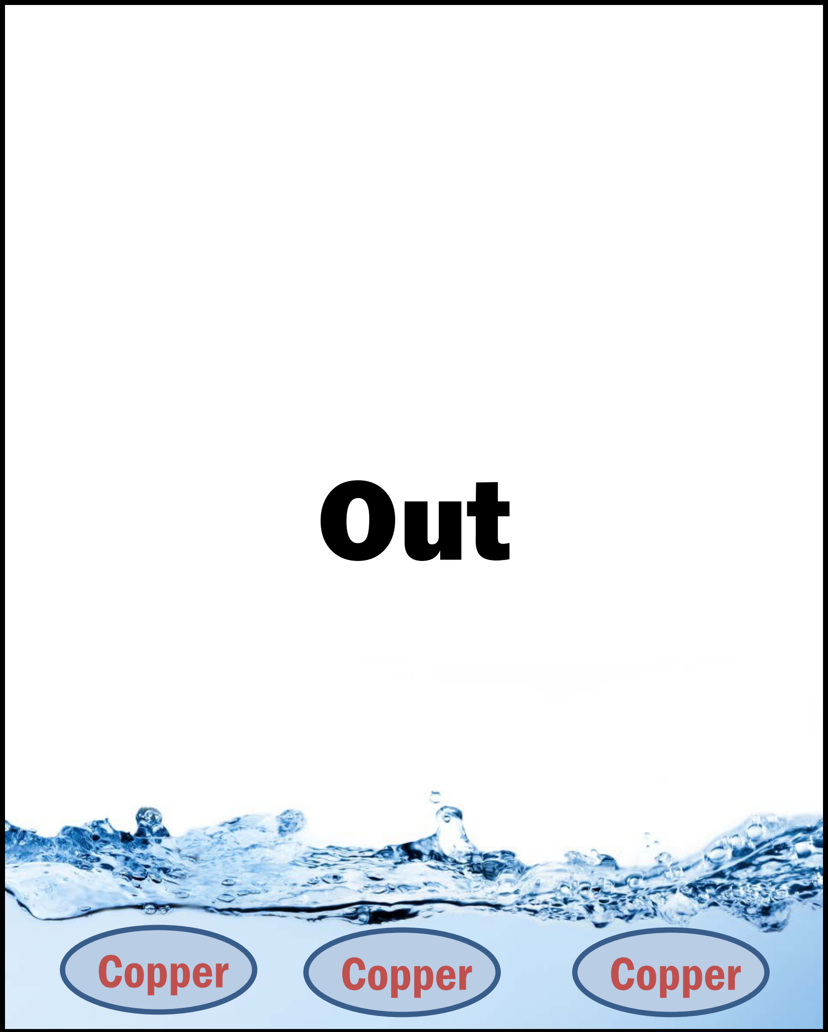
Let's imagine a BMP that doesn't change flow. If 6 copper ions come in and 3 go out that means the concentration is lower because there is less copper in the water



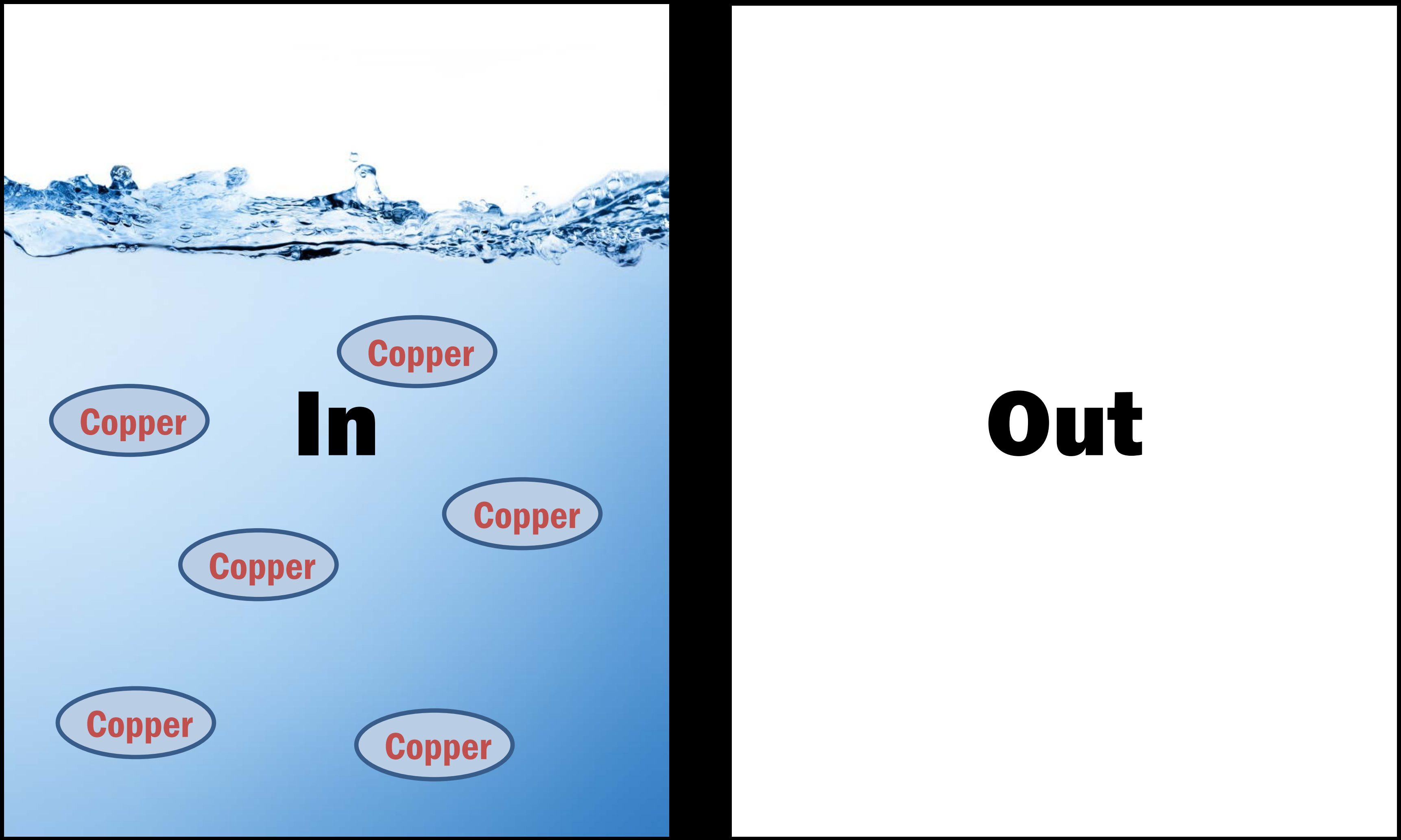


But what if that BMP also reduced flow? Now there is still less copper in the water but the concentration is higher.

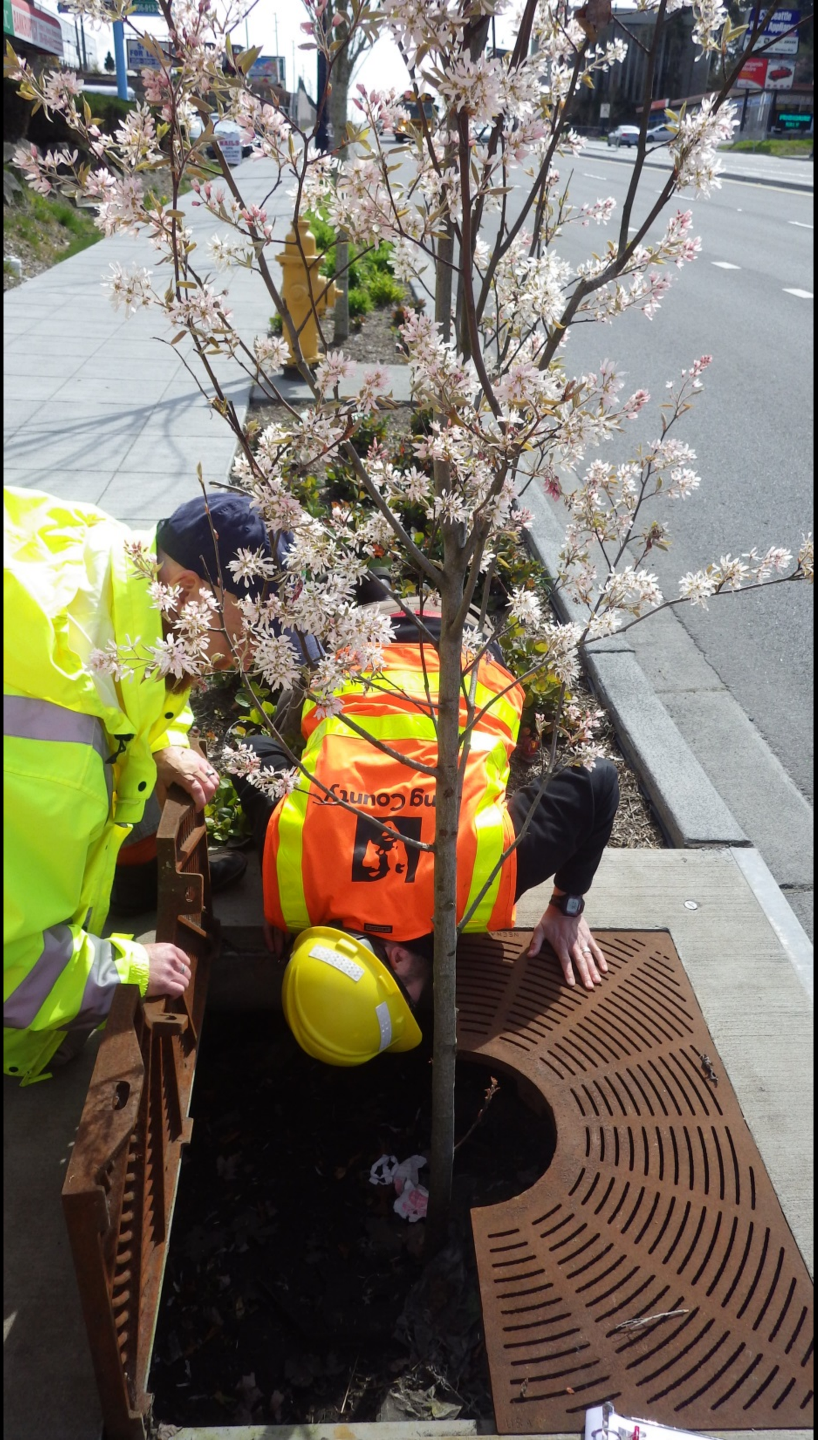




This could be happening at the bioretention planter boxes where we saw major reductions in flow. In fact, effluent was only present during periods of intense rainfall.



We don't know how much volume reduction was provided by the Filterra, because the design prevented us from visually observing the effluent. We would guess that the Filterra provided less volume reduction compared to the planter boxes, because the installation was smaller, providing less media for absorption.

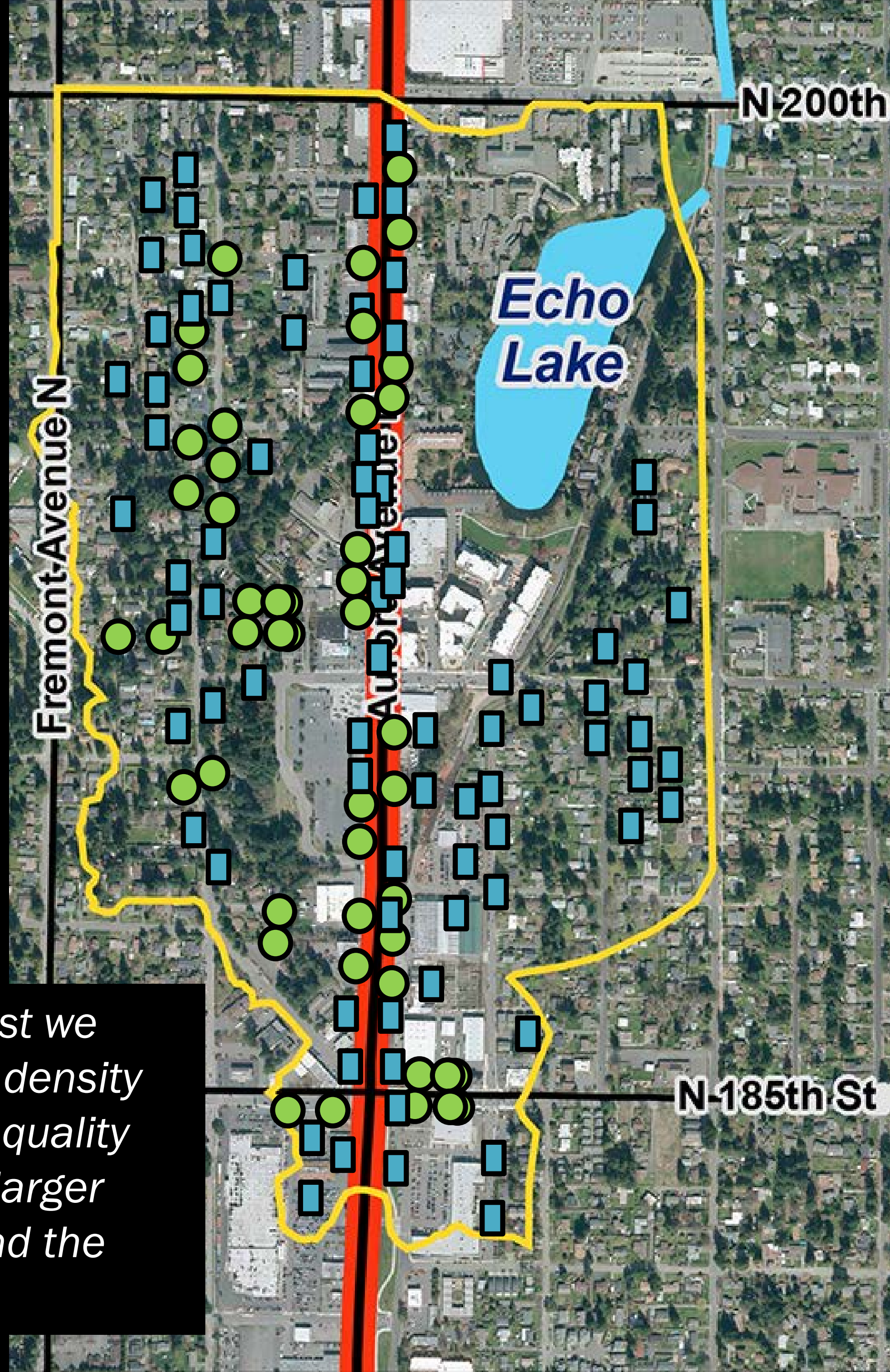


Toxicity tests conducted on daphnia for four storms at one bioretention planter box.

©Hajime Watanabe

Toxicity did not often occur at this site, but when it did, the bioretention planter box was able to successfully reduce toxicity

So how does this translate to basin-wide effects? We compared the samples collected at the stormwater outfall to the lake in 2010-11 (pre-retrofit) with samples collected just upstream of the outfall in 2016 (post-retrofit). Overall pretty similar – further analysis, including lake data, will be available in the final report.



So far the data suggest we would need a greater density of BMPs to see water quality improvements in the larger stormwater system and the lake.

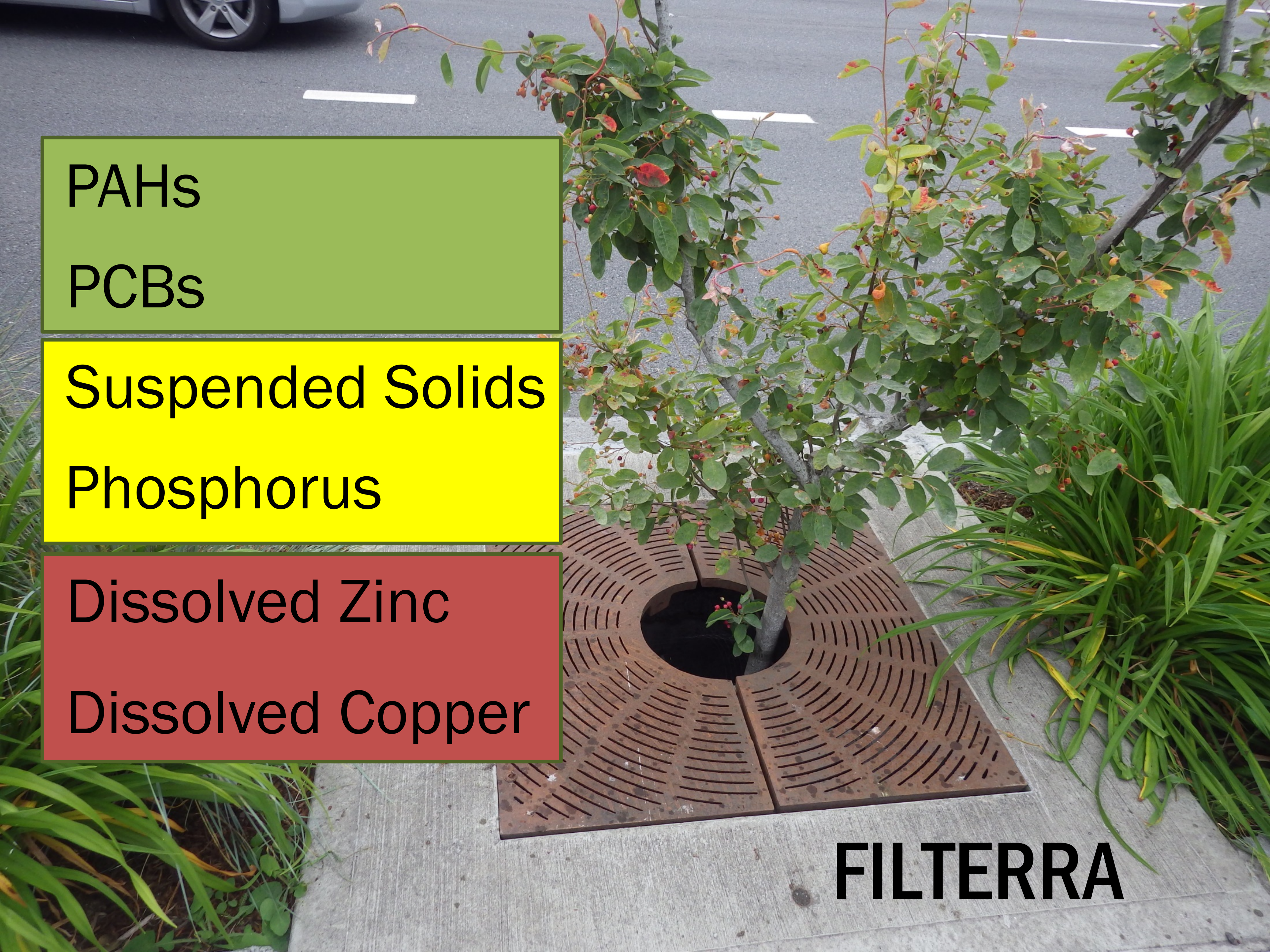
This would be a big investment, so we need to make sure we get our money's worth. This site required a lot of maintenance to keep the bioretention planter boxes online.

We need to better understand how to facilitate flow into these installations in order to utilize their capacity and maximize the amount of stormwater we can treat.

Larger curb cuts (like the Filterra here) don't get blocked as easily and require less maintenance.

But the Filterra had their own issues. The Filterra were clogged again during the last few sampling attempts. This means media replacements have been needed every 2 to 3 years at this site.

Regular inspections are needed to verify whether the anticipated maintenance schedule will really work at a given site. And we want to make sure these are flowing because they treat stormwater pretty well…


PAHs
PCBs
Suspended Solids
Phosphorus
Dissolved Zinc
Dissolved Copper
FILTERRA

Suspended Solids

Dissolved Zinc

PAHs

PCBs

Toxicity

Flow

Dissolved Copper

Phosphorus

Bioretention can treat your stormwater...


...but only if the
stormwater can get in.