

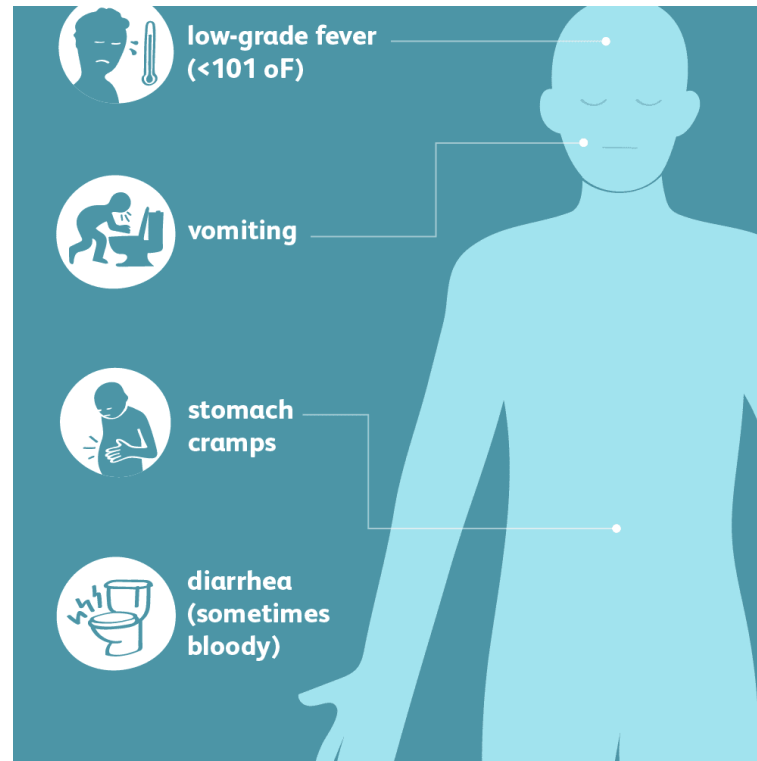
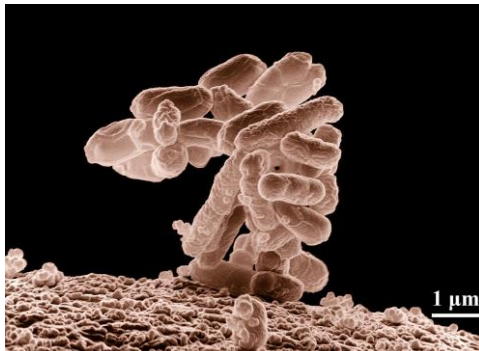
# Removing *E. coli* bacteria from stormwater using biochar filter BMPs

Justine Dauphinais, CCWD  
Sarah Nalven, Wenck



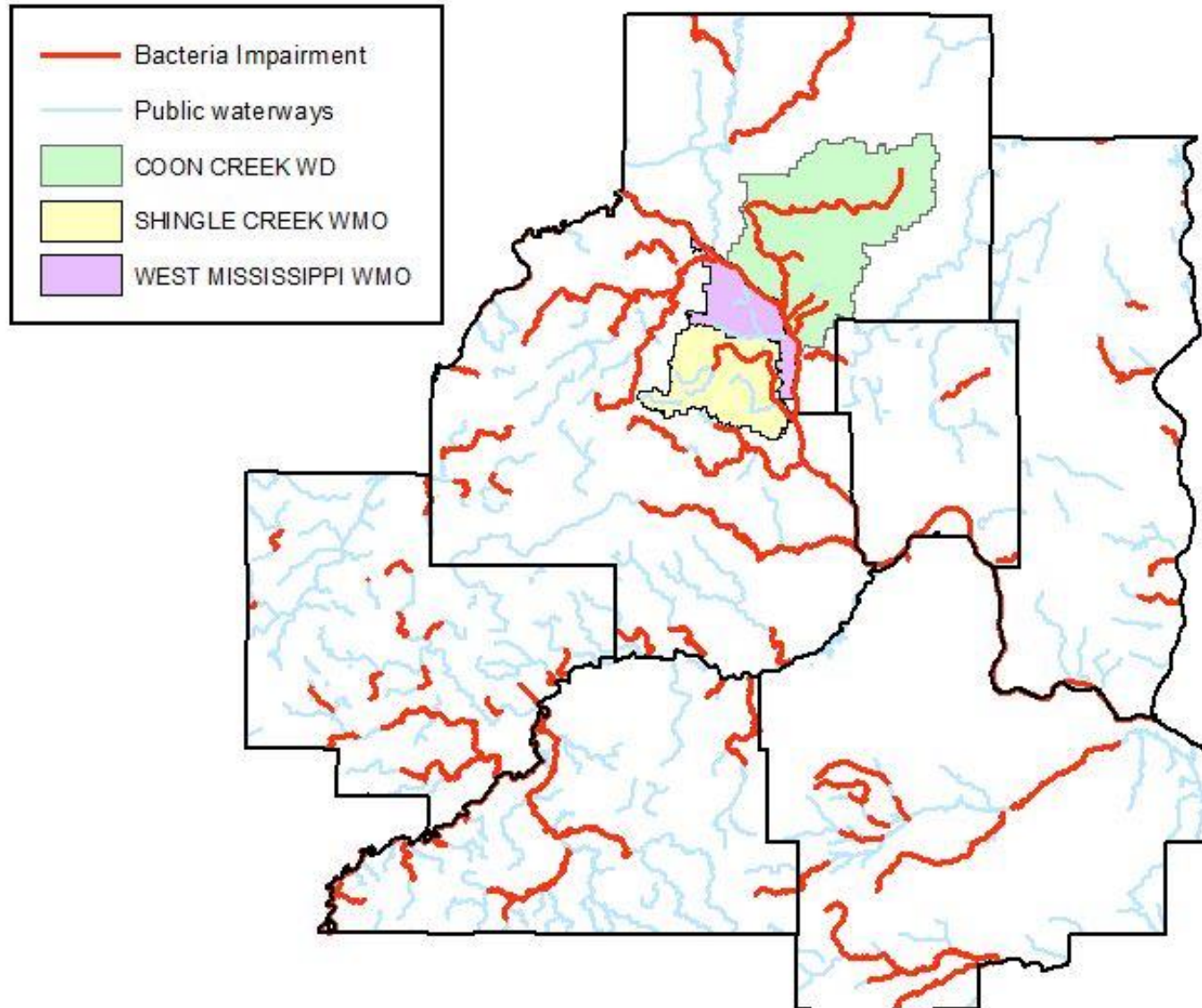
# *E. coli* can cause disease

Some strains of *E. coli* produce toxins and cause disease



<https://www.verywellhealth.com/e-coli-symptoms-diagnosis-treatment-4174407>

# Too much *E. coli* in Twin Cities waters



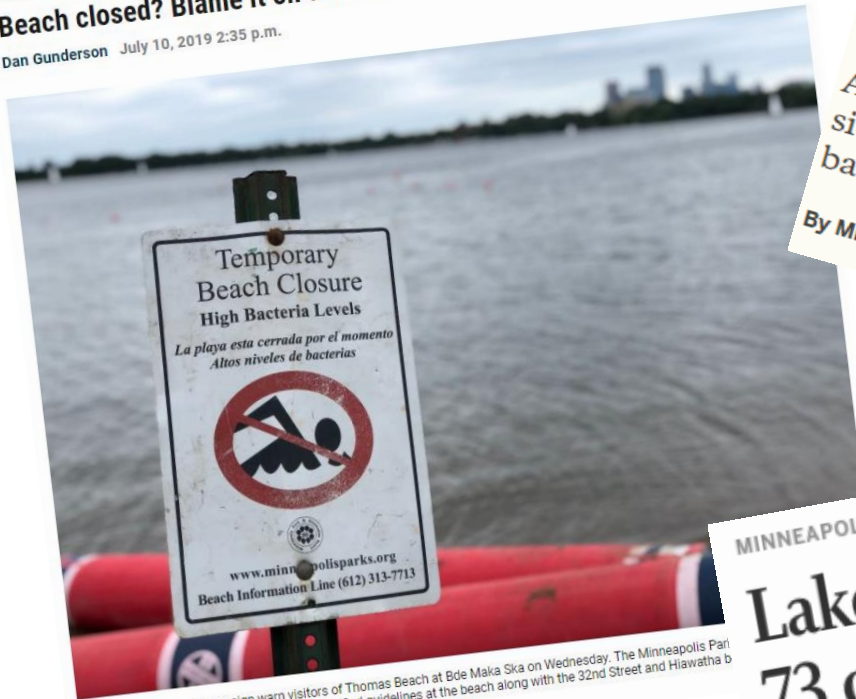
# *E. coli* made the headlines this summer

Many people got sick/ many beaches closed

Outside in MN

**Beach closed? Blame it on the rain**

Dan Gunderson July 10, 2019 2:35 p.m.



A temporary beach closure sign warn visitors of Thomas Beach at Bde Maka Ska on Wednesday. The Minneapolis Park found that *E. coli* bacteria exceeded state specified guidelines at the beach along with the 32nd Street and Hiawatha b  
John Nguyen | MPR News

MINNEAPOLIS

## *E. coli* leads to record number of beach closures in Minneapolis

An overwhelming amount of rain — and one potentially sick swimmer — has led to a summer ruined by the bacteria.

By Miguel Otárola Star Tribune

AUGUST 14, 2019 — 10:11PM

MINNEAPOLIS

## Lake Nokomis beaches reopen after 73 confirmed cases of *E. coli* illness

A park commissioner says action should be taken to avoid similar closures next year.

By Miguel Otárola Star Tribune

SEPTEMBER 6, 2019 — 10:13PM



# Where does *E. coli* come from?

- Pet waste
- Wildlife waste
- Failing septic systems
- Sanitary sewer overflows/leakages
- Source is diffuse, making upstream prevention difficult



# Biochar

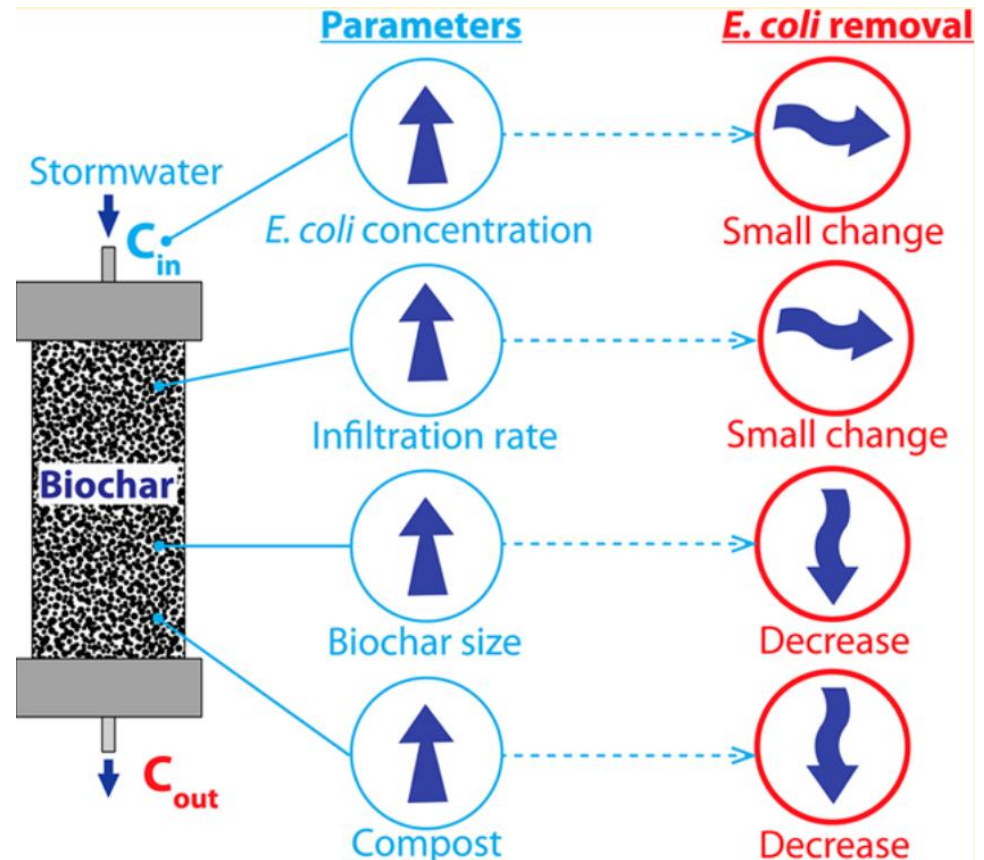
- A special type of charcoal
- Made by burning organic material in the absence of oxygen
- Has been used as a soil amendment
- Immense surface area/ complex pore structure
- Shown to remove E. coli from stormwater



<https://lewisbamboo.com/product/biochar/>

# Biochar removes *E. coli* from stormwater

- Demonstrated in the lab (not in field)
- Mechanism poorly understood, but thought to be due to van der Waals forces and/or hydrophobic attraction



Sanjay Mohanty et al. 2014

# Research Question

Can biochar filters be used in the field to remove *E. coli* from stormwater?





# FIELD APPLICATIONS & RESULTS

## 1. Catch basin inserts



## 2. Creek diversion filter box



## 3. Flow-through weir filter



## 4. Pond filter benches



# Catch Basin Inserts: What Are They?



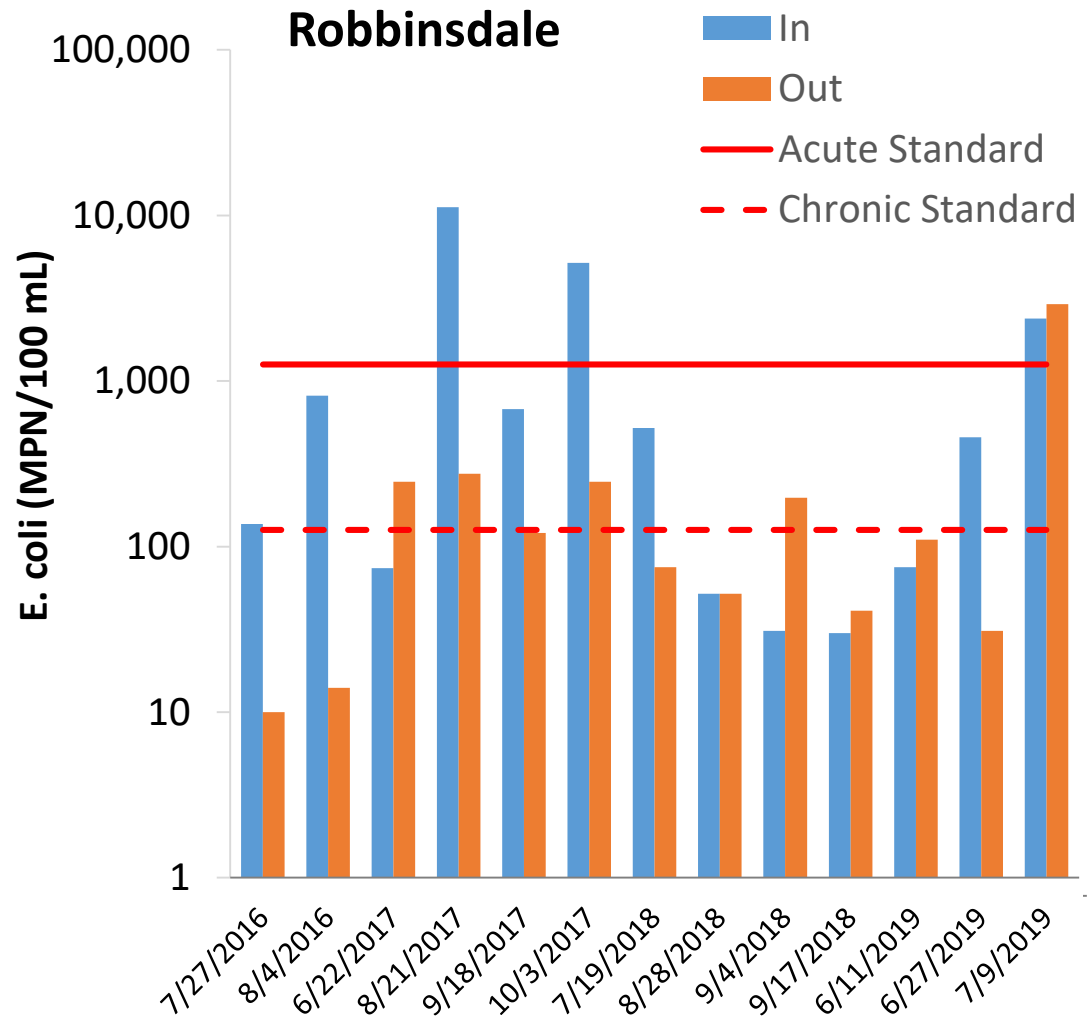
**IRON-ENHANCED SAND**

**BIOCHAR**

**IRON-ENHANCED SAND**

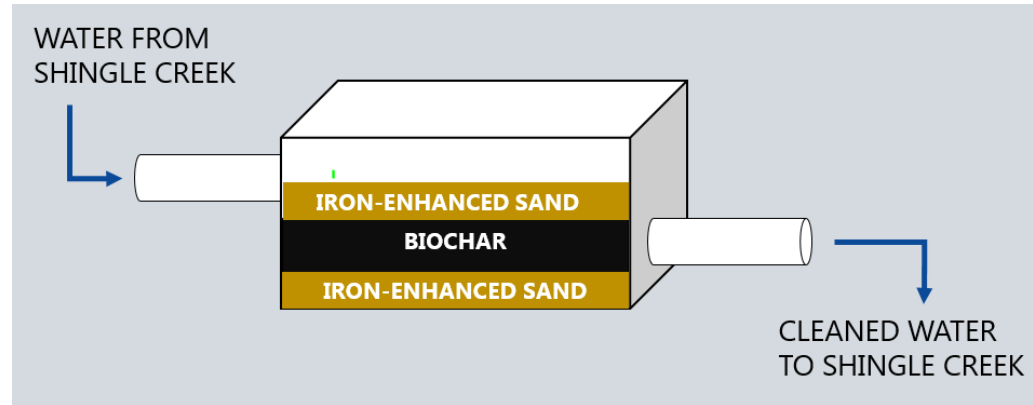
# Catch Basin Insert: Results

- 2 sites
- Inconsistent performance
- Removal in 11 of 21 events
- 0-98% range in removal
- 49% overall removal



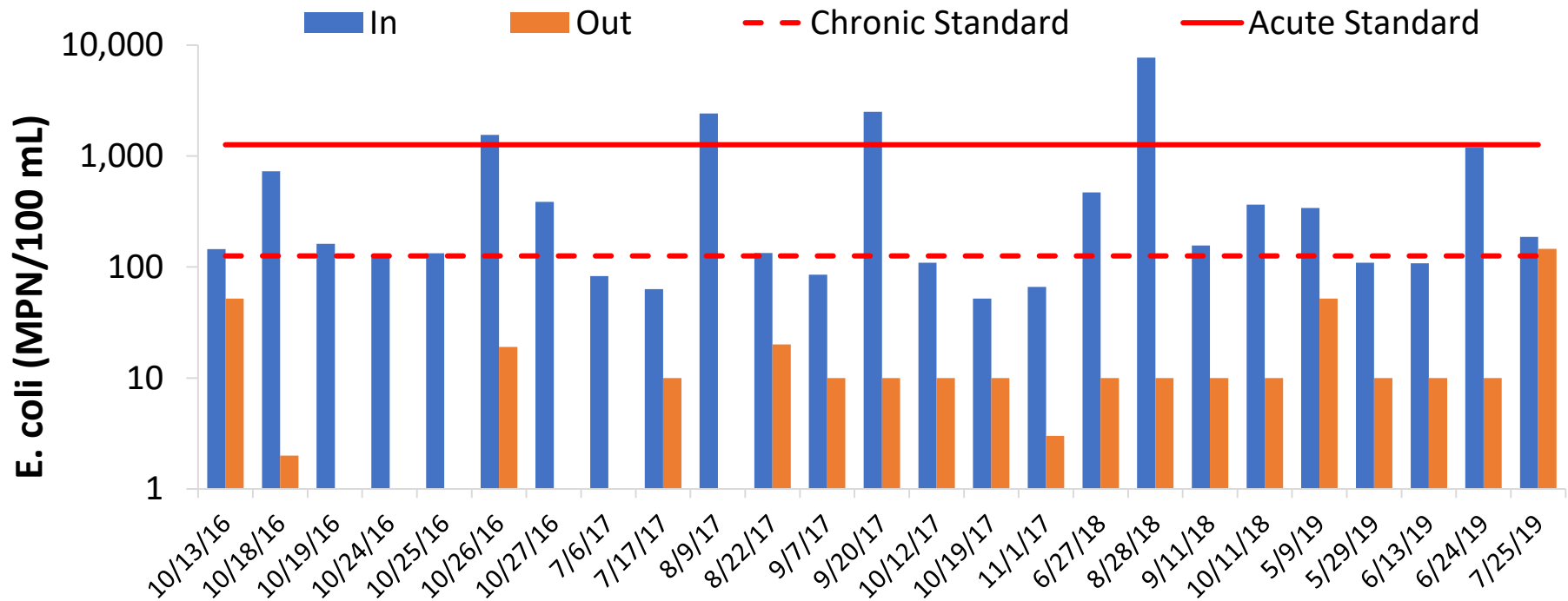


# Creek Diversion Filter Box: What Is It?





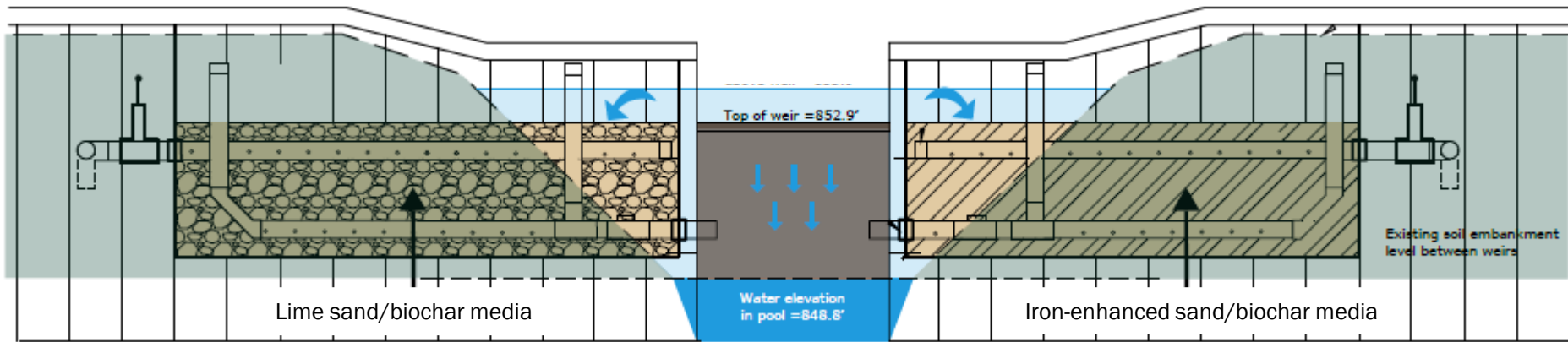
# Creek Diversion Filter Box: Results



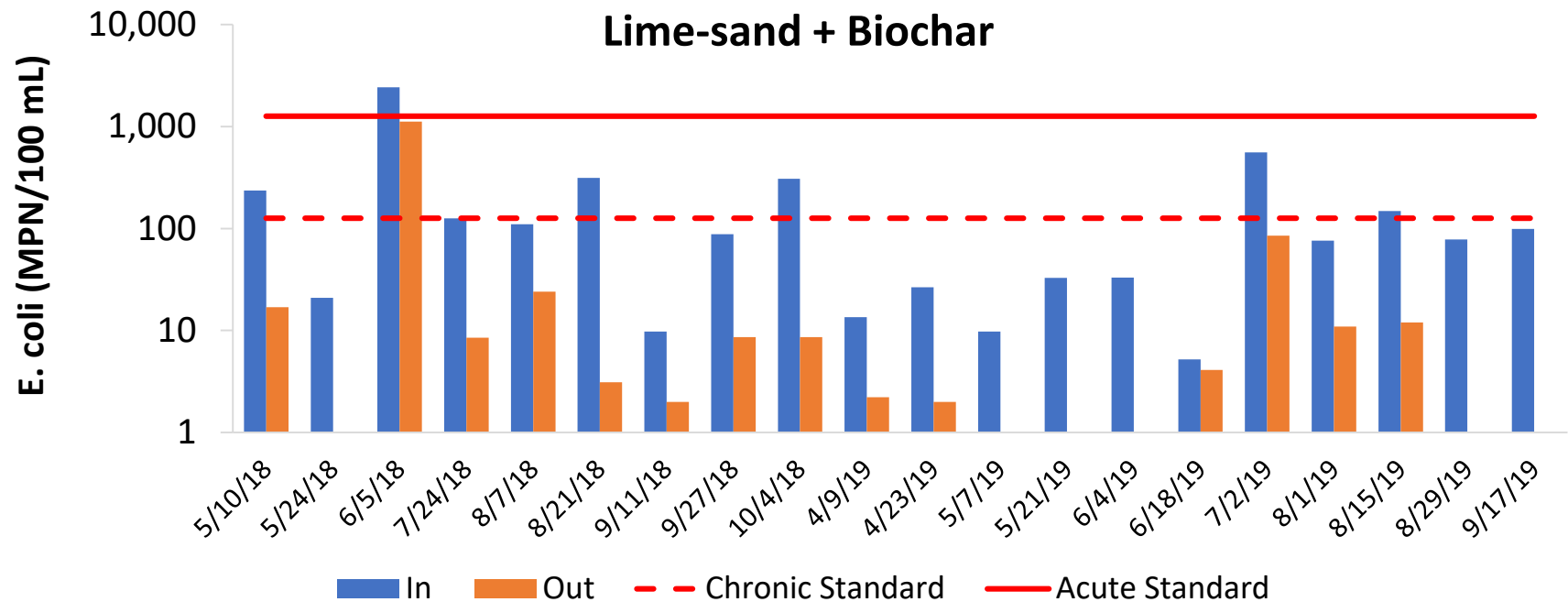
- Consistent, successful performance
- Removal in 25 of 25 events
- 97% overall removal
- 22-100% removal
- High influent *E. coli* (geomean=266 MPN/100ml)

# Flow-through Weir Filter: What Is it?

- Half iron-enhanced sand (IES)+ biochar
- Half lime-sand + biochar
- Continuous flow

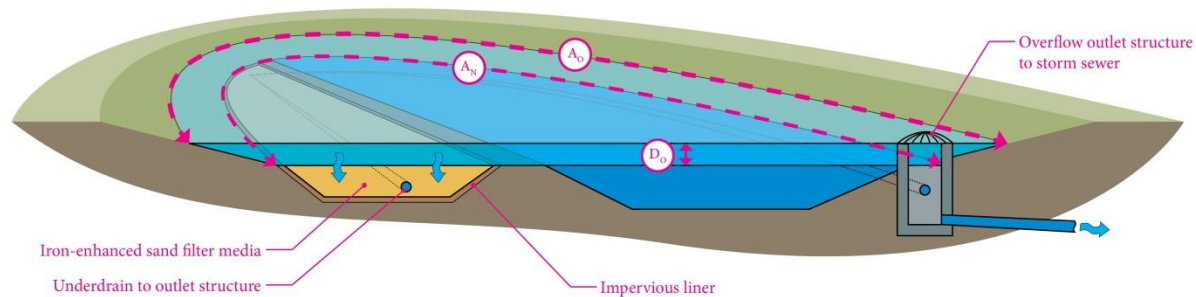


# Flow-through Weir Filter: Results



- Consistent, successful performance
- Removal in 39 of 39 events
- 89% overall removal
- 19-99% removal
- Relatively low influent *E. coli* (geomean=61 MPN/100ml)

# Pond Filter Benches: What Are They?

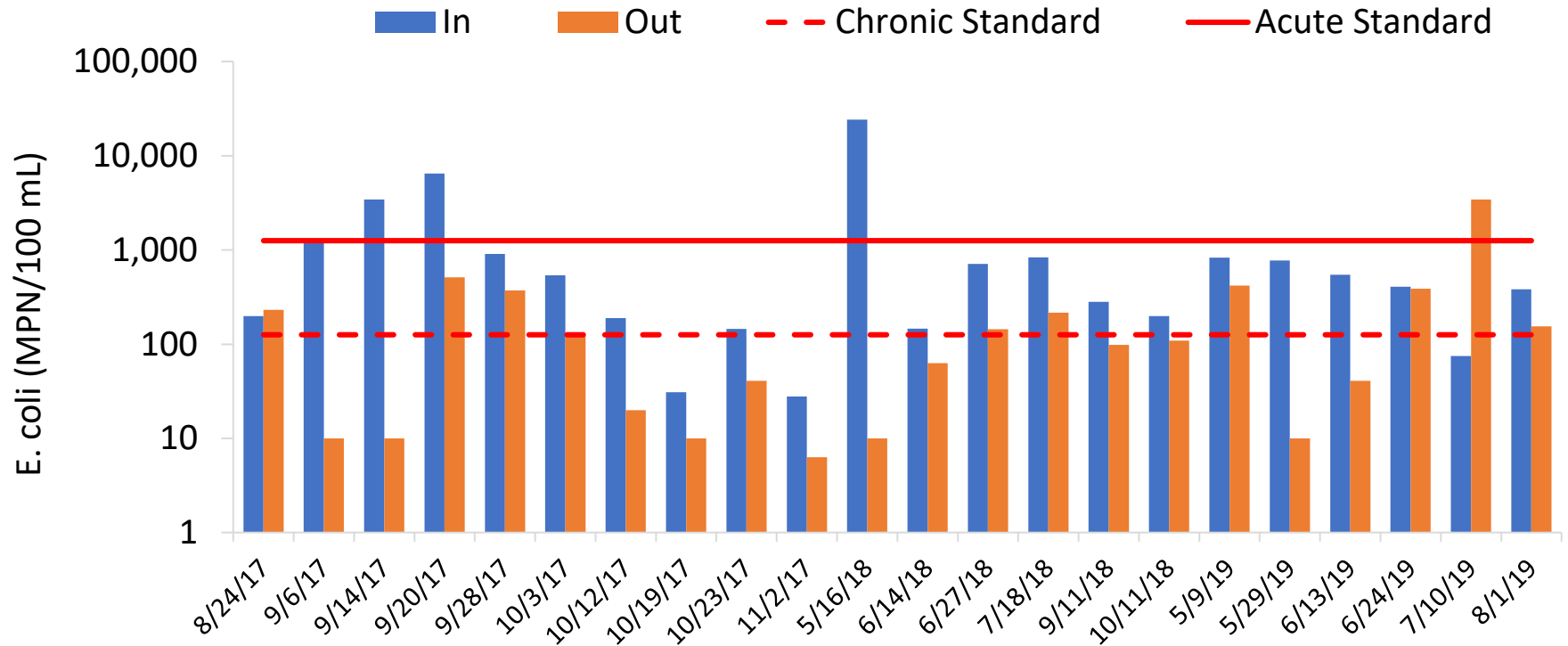


Iron Enhanced Sand Filter Bench in Wet Pond

Source: Minnesota Stormwater Manual

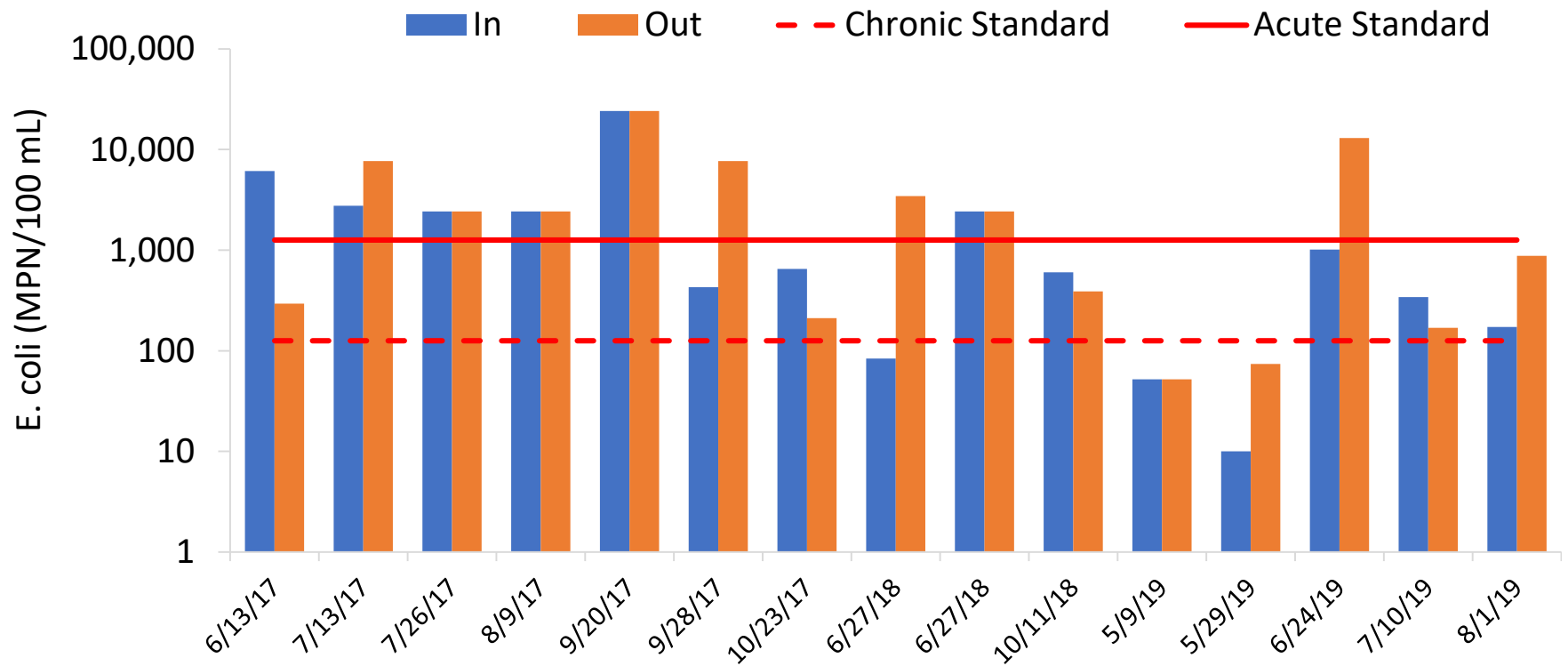


# Pond Filter Bench: Results



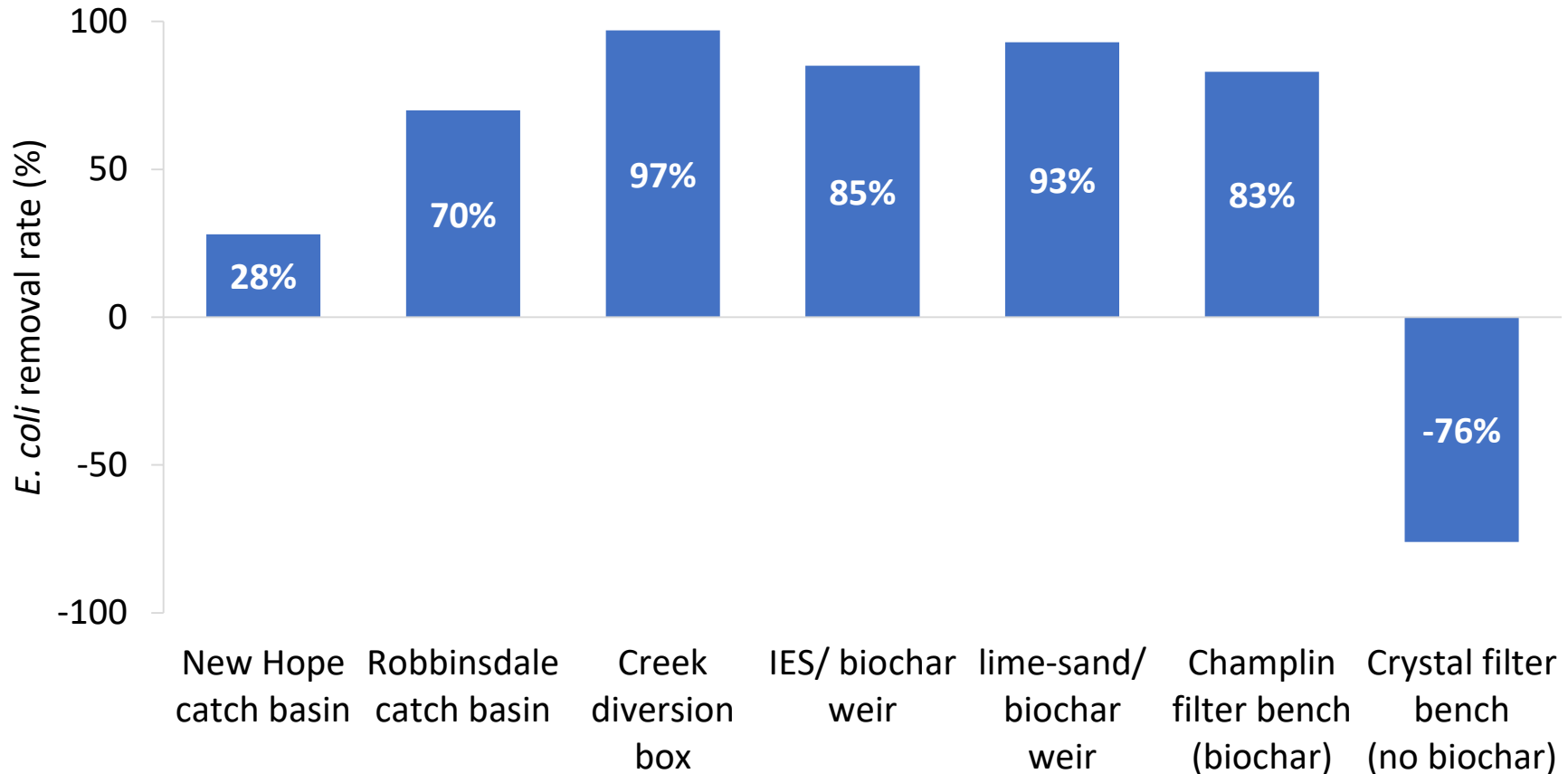
- Consistent, successful performance
- Removal in 20/22 events
- 83% overall removal
- 0-100% removal efficiency
- High influent *E. coli* (geomean=457 MPN/100ml)

# Control Pond Filter Bench: Results



- Poor performance
- -76% overall removal
- Removal in 5/15 events

# Overall Removal Efficiencies



- With biochar, 28 to 97% overall *E. coli* removal (influent vs. effluent geomean)
- Without biochar, more *E. coli* observed in filtered effluent than influent
- Stream & pond filters performed better than catch basin filters: 90% vs. 49%

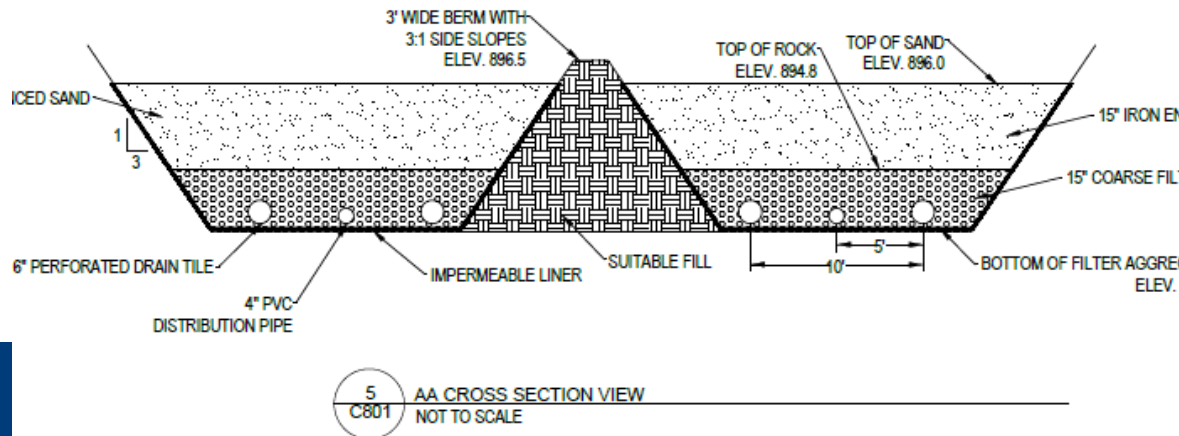
# CONCLUSIONS

- Incorporating biochar into filter-based BMPs is a promising new tool for *E. coli* removal from stormwater
- Removal efficiency varies by filter type
  - pond benches/stream diversions work best
  - catch basins should be used on case by case basis
- No relationship between influent concentrations of *E. coli* and filter performance
- Continued monitoring necessary to determine if biochar performance is maintained over time



# FUTURE WORK

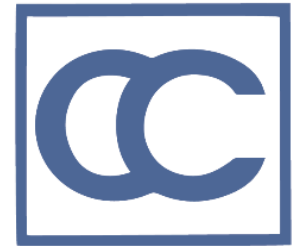
- Measure flow to quantify *E. coli* load reductions
- Employ true negative controls, adjacent to test filters
- Quantify removal of other pollutants
- Test “designer” chars



# Acknowledgements



- ❖ Cities of Crystal, Robbinsdale, Minneapolis, Champlin & Fridley, MN
- ❖ Minneapolis Park and Recreation Board
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  - Coon Creek Watershed District



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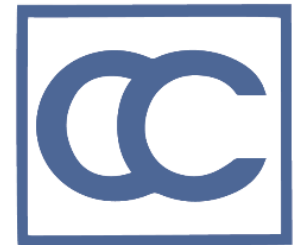
Coon Creek Watershed District

[jdauphinais@cooncreekwd.com](mailto:jdauphinais@cooncreekwd.com)

763-258-4021



Responsive partner.  
Exceptional outcomes.



# DESIGN SPECS

- ❖ 5-30% biochar by volume
- ❖ Layered biochar in between sand due to biochar's buoyancy
- ❖ Layered with iron-enhanced sand/ lime to add phosphorus removal
- ❖ Biochar was hardwood pyrolyzed @ 500-700 °C
- ❖ Potential Suppliers:
  - National Carbon Technologies (MN)
  - American Biochar Company (MI)
- ❖ Estimated cost: \$215-\$500 per CY

# TROUBLESHOOTING & LESSONS LEARNED

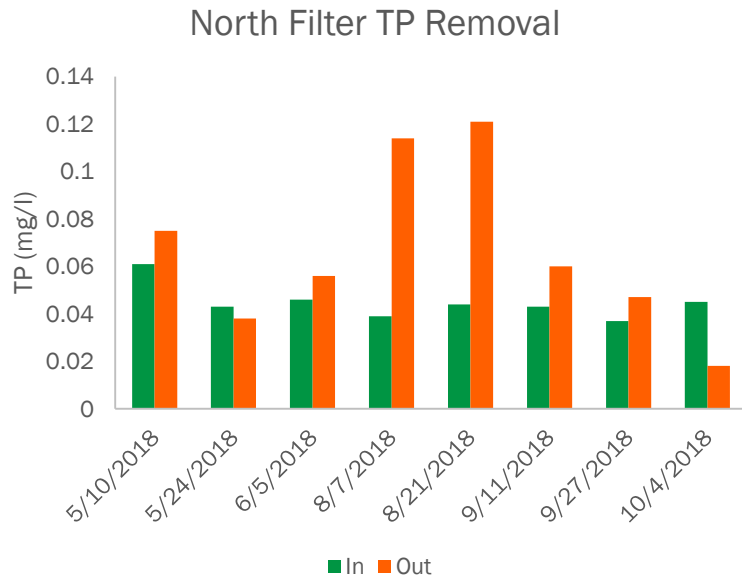
- Pre-treatment of TSS important
- Do not use socked pipe
- Include air vent for effluent pipes
- Design with sampling & maintenance in mind  
(e.g. tailwater impacts, shut-off valves)



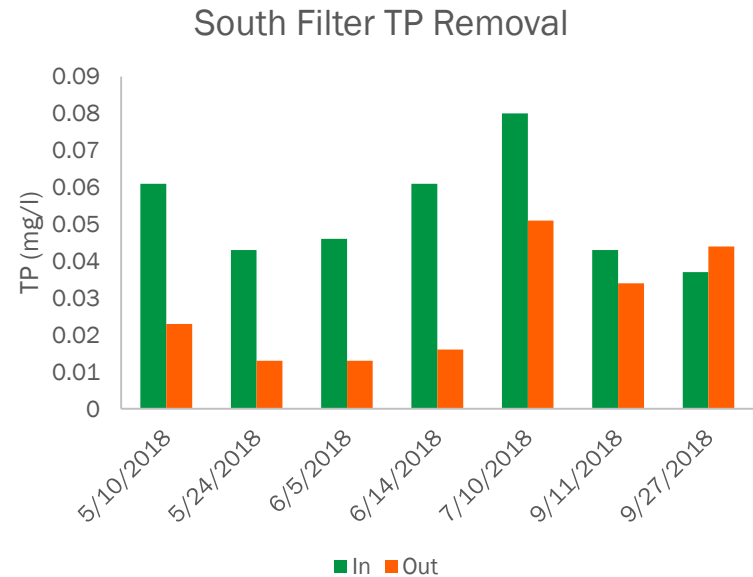


# SPRINGBROOK CREEK FILTER TP REMOVAL

North Filter: Lime-biochar

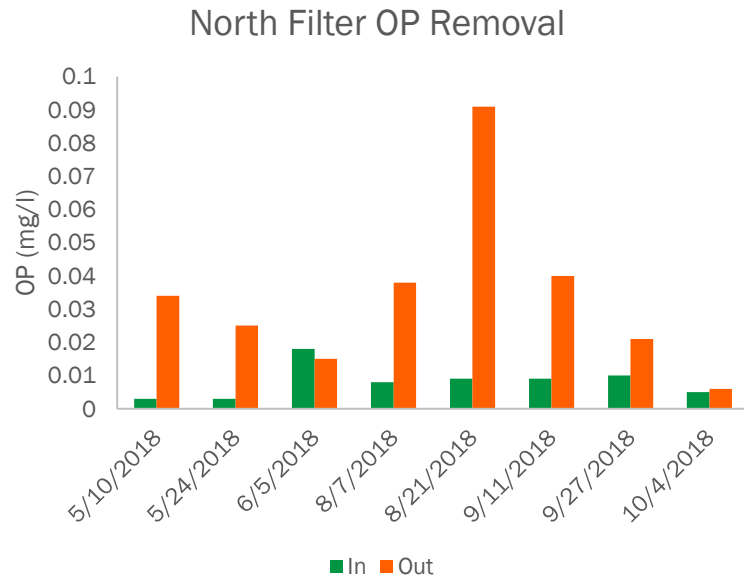


South Filter: IES-biochar



# SPRINGBROOK CREEK FILTER DISSOLVED-P REMOVAL

North Filter: Lime-biochar



South Filter: IES-biochar

