

**Supporting Information for:**

**Field evaluation of a biochar-amended stormwater filtration system  
for retention of nutrients, metals, and *Escherichia coli***

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**Table S1.** Dry and wet biochar yields for custom biochar production.

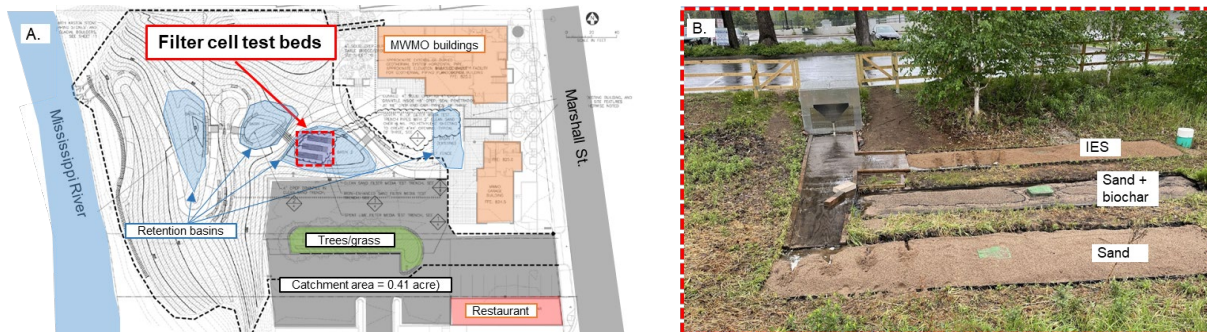
|                    | Wet Yield at ~ 3% Moisture | Dry Yield |
|--------------------|----------------------------|-----------|
| >3.36 mm           | 7.71                       | 7.48      |
| 0.500 mm – 3.36 mm | 131.99                     | 128.03    |
| < 0.500 mm         | 39.01                      | 37.84     |

**Table S2.** Technical specifications for commercial biochar. The biochar was obtained from American Biochar Company (ABC-biochar, technical specifications obtained from ambiochar.com).

| General Information |                                      | TYPICAL ANALYSIS            |            |
|---------------------|--------------------------------------|-----------------------------|------------|
| Composition         | 100% Wood BioChar                    | pH                          | 7.5-9.0    |
| Feedstock           | Southern Yellow Pine Species         | Hydrogen:Carbon Ratio (H:C) | 1:3 (.37)  |
| Production Method   | Pyrolysis, temp. range of 550-900° C | Nitrogen (N)                | .40% tdm   |
| Pore Surface Area   | 557 acres/cf (225 hectares/cf)       | Phosphorous (P)             | 837 mg/kg  |
| Carbon Content      | 77.6% (USDA 95%)                     | Potassium (K)               | 1215 mg/kg |
| Particle Size       | .5mm – 2.0mm                         | Iron (Fe)                   | 1014 mg/kg |
| Bulk Density        | 15.1 lbs/cu ft                       | Manganese (Mn)              | 457 mg/kg  |
| Moisture Content    | 25 – 46%                             | Sodium (Na)                 | nd         |
|                     |                                      | Magnesium (Mg)              | .36% dwt   |
|                     |                                      | Calcium (Ca)                | 2.22% dwt  |
|                     |                                      | Zinc (Zn)                   | 14.1 mg/kg |

**Table S3.** Biochar characterization results. Results for elemental analysis (Ultimate and Proximate analysis), dual adsorption gas analysis (reported as cumulative pore volumes), and pH results for the custom-produced RP-550 biochar and commercial biochar.

| Parameter                                 | ASTM Method | RP-550 | ABC-biochar |
|---|-------------|--------|-------------|
| Moisture total (wt%)                      | ASTM E871   | 3.03   | 8.75        |
| Ash (wt%)                                 | ASTM D1102  | 1.52   | 12.00       |
| Volatile matter (wt%)                     | ASTM D3175  | 18.33  | 8.5         |
| Fixed carbon by difference (wt%)          | ASTM D3172  | 80.15  | 79.51       |
| Sulfur (wt%)                              | ASTM D4239  | 0.012  | 0.029       |
| SO <sub>2</sub> (lb/mmbtu)                | Calculated  | 0.016  | 0.049       |
| Carbon (C) (wt%)                          | ASTM D5373  | 77.86  | 80.59       |
| Hydrogen (H) (wt%)                        | ASTM D5373  | 3.12   | 0.65        |
| Nitrogen (N) (wt%)                        | ASTM D5373  | 0.84   | 0.75        |
| O (O) (wt%)                               | ASTM D3176  | 16.66  | 5.99        |
| H/C                                       | NA          | 0.040  | 0.008       |
| O/C                                       | NA          | 0.214  | 0.074       |
| (O+N)/C                                   | NA          | 0.225  | 0.084       |
| pH in DI water (biochar/water)            | NA          | 8.64   | 9.67        |
| Cumulative pore vol. (cm <sup>3</sup> /g) | NA          | 0.369  | 0.443       |
| Micropore vol. (cm <sup>3</sup> /g)       | NA          | 0.111  | 0.214       |
| Mesopore vol. (cm <sup>3</sup> /g)        | NA          | 0.238  | 0.222       |



**Figure S1.** Depictions of the field site and testbed. (A) Schematic of the field site at the MWMO Stormwater Park and Learning Center. (B) Filter cell testbed system treating runoff discharged from parking lot. Bricks were placed on the apron directing flow to the filter testbeds as a means of controlling the flow distribution between filters.

**Table S4.** Particle size distribution of concrete sand installed in testbed. Particle size distribution information was provided by Plaisted Companies.

| Sieve Size            | Passing (%) |
|-----------------------|-------------|
| 9.5 mm (3/8 inch)     | 100         |
| 4.75 mm (No. 4)       | 100         |
| 2.36 mm (No. 8)       | 96          |
| 1.18 mm (No. 16)      | 83          |
| 600 $\mu$ m (No. 30)  | 60          |
| 300 $\mu$ m (No. 50)  | 23          |
| 150 $\mu$ m (No. 100) | 4           |
| 75 $\mu$ m (No. 200)  | 0.7         |

**Table S5.** Mineral composition of concrete sand determined by X-ray diffraction (includes illite, mica, kaolinite, and chlorite). Data were provided by Plaisted Companies.

| Mineral             | Weight percent |
|---------------------|----------------|
| Quartz              | 65.7           |
| K-feldspar          | 9.8            |
| Plagioclase         | 17.6           |
| Calcite             | 1.3            |
| Dolomite            | 1.1            |
| Pyrite              | 0.2            |
| Total Clay Minerals | 4.3            |

**Table S6.** Water quality analyses performed by Metropolitan Council Environmental Services.

| Analyte (units)                  | Method Reference          | Method Detection Limit |
|----------------------------------|---------------------------|------------------------|
| Chloride ion (mg/L)              | SM 4500-CL- E-2011        | 5                      |
| <i>E. coli</i> (MPN/100 ml)      | SM 9223 B (Colilert-18 w/ | 1                      |
| Copper (ug/L)                    | EPA 200.8, Rev. 5.4       | 0.3                    |
| Lead (ug/L)                      | EPA 200.8, Rev. 5.4       | 0.5                    |
| Nickel (ug/L)                    | EPA 200.8, Rev. 5.4       | 0.5                    |
| Zinc (ug/L)                      | EPA 200.8, Rev. 5.4       | 5                      |
| Ammonia Nitrogen (mg/L)          | EPA 350.1, Rev. 2.0       | 0.06                   |
| Nitrate N (mg/L)                 | SM 4500-NO3- F-2011       | 0.2                    |
| Nitrite N (mg/L)                 | SM 4500-NO3- F-2011       | 0.007                  |
| Nitrite Plus Nitrate (mg/L)      | SM 4500-NO3- F-2011       | 0.2                    |
| Total Kjeldahl Nitrogen (mg/L)   | EPA 351.2, Rev. 2.0       | 0.03                   |
| Total Phosphorus (mg/L)          | EPA 365.4                 | 0.02                   |
| Ortho Phosphate as P (mg/L)      | SM 4500 P-F-2011          | 0.02                   |
| Total Organic Carbon (mg/L)      | SM 5310 C-2011            | 0.05                   |
| Total suspended solids (mg/L)    | SM 2540 E-2011            | 3                      |
| Volatile suspended solids (mg/L) | SM 2540 E-2011            | 3                      |

**Table S7.** Bulk filter media properties. Bulk density, porosity, moisture content, and saturated hydraulic conductivity ( $K_{sat}$ ) are reported by season and filter. Bulk density and porosity measurements are the mean of five measurements (2 shallow cores and 3 deep cores) with the standard deviation as error. Note that the moisture content and  $K_{sat}$  are reported as the mean  $\pm$  95% confidence interval for two measurements for 2021, and the mean  $\pm$  95% confidence interval for three measurements for 2022, so the higher error values from 2021 do not necessarily reflect a higher variability in hydraulic conductivity.

| Property          | 2021            |                 |                 | 2022            |                 |                 |
|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                   | Sand            | Biochar         | IES             | Sand            | Biochar         | IES             |
| Bulk Density      | 1.63 $\pm$ 0.03 | 1.41 $\pm$ 0.06 | 1.63 $\pm$ 0.02 | 1.53 $\pm$ 0.07 | 1.23 $\pm$ 0.15 | 1.60 $\pm$ 0.08 |
| Porosity          | 0.34 $\pm$ 0.04 | 0.39 $\pm$ 0.01 | 0.34 $\pm$ 0.02 | 0.37 $\pm$ 0.07 | 0.43 $\pm$ 0.13 | 0.38 $\pm$ 0.06 |
| Moisture          | 5.6% $\pm$ 0.1  | 15.0% $\pm$ 0.1 | 4.6% $\pm$ 0.1  | 2.7% $\pm$ 0.1  | 9.8% $\pm$ 0.1  | 3.5% $\pm$ 0.1  |
| $K_{sat}$ (mm/hr) | 898 $\pm$ 180   | 1016 $\pm$ 226  | 1418 $\pm$ 142  | 718 $\pm$ 101   | 1002 $\pm$ 165  | 969 $\pm$ 43    |

**Calculation S1.** Runoff coefficient. The runoff coefficient (R) was calculated according to the annual cumulative total discharge volumes and precipitation depths for each field season as described below:

$$R = V_{Discharge,PL} / (A_{Catchment} D_{Precip}) \quad \text{Equation S1.}$$

where  $V_{Discharge,PL}$  is the net discharge volume from the influent weir over each field season ( $m^3$ ),  $A_{Catchment}$  is the catchment area ( $m^2$ ), and  $D_{Precip}$  is the total precipitation depth for each field season (m). As the testbed would overflow during high intensity rain events, the total volume of water discharged into the conveyance channel ( $V_{Discharge,PL}$ ) exceeded the total combined volume of water discharged from the three filter cells at the end of both field seasons.

**Calculation S2.** Filter-specific apparent cumulative contaminant loads. To account for variations in flow distribution across filters, filter performance was compared on the basis of the apparent cumulative contaminant retention (or the difference between the cumulative contaminant loads entering and exiting each filter) over the duration of the experiment. The apparent cumulative load of contaminant entering each

filter ( $M_{in}$ , g; or most probable number, MPN, for *E. coli*) and apparent cumulative load of contaminant released from each filter ( $M_{out}$ ) were calculated for each contaminant as described below:

$$M_{in}(t) = \sum_{t=t_0}^t m_{in}(t) \quad \text{Equation S2A.}$$

$$M_{out}(t) = \sum_{t=t_0}^t m_{out}(t) \quad \text{Equation S2B.}$$

where  $m_{in}$  and  $m_{out}$  are the estimated incremental contaminant loads received and released between sampling events, respectively. These values were calculated for each contaminant and each filter between all sampling events as follows:

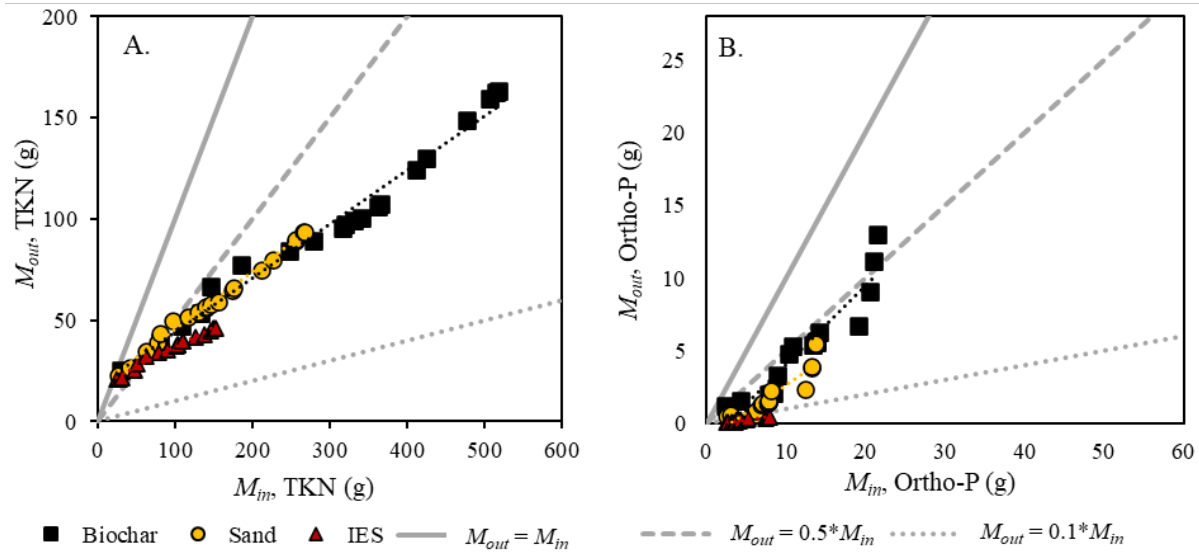
$$m_{in}(t) = C_{in}(t)[V_{out}(t) - V_{out}(t - 1)] \quad \text{Equation S3A.}$$

$$m_{out}(t) = C_{out}[V_{out}(t) - V_{out}(t - 1)] \quad \text{Equation S3B.}$$

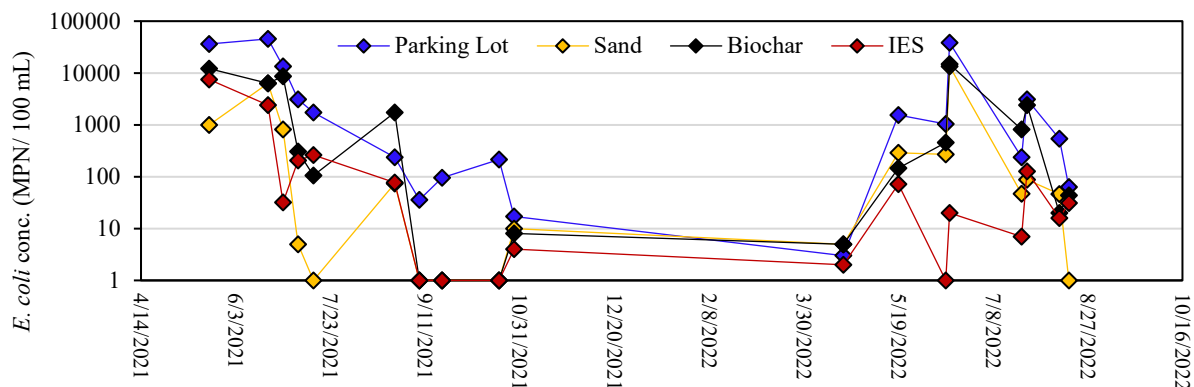
where  $C_{in}$  is the concentration of a given contaminant in the influent weir at time  $t$ , and  $C_{out}$  is the concentration of a given contaminant from effluent of a given filter cell at time  $t$ . Concentrations for instances where contaminant levels were below detection limits were approximated as half of the associated detection limit. The cumulative mass of contaminant retained within the filter was therefore estimated as:

$$M_{retained}(t) = M_{in}(t) - M_{out}(t) \quad \text{Equation S4.}$$

$$\text{Percent mass retained} = M_{retained}(t) / M_{in}(t) \quad \text{Equation S5.}$$



**Figure S2.** Apparent cumulative contaminant released ( $M_{out}$ ) versus load received ( $M_{in}$ ) by filter for (A) total Kjeldahl nitrogen (TKN), and (B) ortho-phosphorous (Ortho-P).



**Figure S3.** *E. coli* levels in influent and the effluents from the three filters over 2021 and 2022.

**Table S8.** Influent and effluent contaminant concentrations by date and filter for N constituents (DL = detection limit, BDL = below detection limit)

| Date       | Nitrate-N (mg/L, DL = 0.2 mg/L)  |      |         |      | Nitrate + Nitrite N (mg/L, DL = 0.2) |      |         |      |
|------------|----------------------------------|------|---------|------|--------------------------------------|------|---------|------|
|            | Inflow                           | Sand | Biochar | IES  | Inflow                               | Sand | Biochar | IES  |
| 5/20/2021  | BDL                              | 0.52 | BDL     | 0.38 | BDL                                  | 0.52 | BDL     | 0.44 |
| 6/20/2021  | 0.74                             | 1.5  | 0.66    | 0.72 | 0.74                                 | 1.46 | 0.66    | 0.78 |
| 6/28/2021  | 0.20                             | 0.81 | BDL     | BDL  | 0.4                                  | 0.81 | BDL     | BDL  |
| 7/6/2021   | 0.58                             | BDL  | 0.51    | 0.38 | 0.69                                 | 0.1  | 0.51    | 0.38 |
| 7/14/2021  | BDL                              | BDL  | 0.45    | 0.64 | 0.25                                 | 0.1  | 0.45    | 0.64 |
| 8/7/2021   | 0.23                             | 0.43 | 0.31    | 0.33 | 0.23                                 | 0.5  | 0.38    | 0.39 |
| 8/26/2021  | 0.69                             | 1.31 | 0.34    | 0.67 | 0.69                                 | 1.31 | 0.34    | 0.67 |
| 9/8/2021   | 0.47                             | BDL  | BDL     | 0.31 | 0.47                                 | BDL  | BDL     | 0.31 |
| 9/20/2021  | 0.58                             | 0.21 | BDL     | BDL  | 0.65                                 | 0.21 | BDL     | BDL  |
| 10/20/2021 | 1.3                              | 0.82 | 0.26    | BDL  | 1.3                                  | 0.82 | 0.26    | BDL  |
| 10/28/2021 | BDL                              | BDL  | BDL     | BDL  | BDL                                  | BDL  | BDL     | BDL  |
| 4/20/2022  | 2.2                              | 1.3  | 0.72    | 0.24 | 2.29                                 | 1.3  | 0.79    | 0.24 |
| 4/30/2022  | 0.48                             | 0.32 | 0.41    | 0.21 | 0.48                                 | 0.32 | 0.41    | 0.21 |
| 5/19/2022  | 0.6                              | 2.2  | BDL     | 0.58 | 0.59                                 | 2.2  | BDL     | 0.88 |
| 5/25/2022  | BDL                              | 0.72 | 0.35    | 0.5  | BDL                                  | 0.72 | 0.35    | 0.5  |
| 6/13/2022  | 0.32                             | 3.9  | 1.3     | 0.39 | 0.43                                 | 3.9  | 1.4     | 0.39 |
| 6/15/2022  | BDL                              | 2.9  | 0.28    | 0.52 | 0.39                                 | 3.0  | 2.1     | 0.72 |
| 7/23/2022  | 0.89                             | 6.5  | 3.1     | 4.3  | 0.97                                 | 6.6  | 3.2     | 4.3  |
| 7/26/2022  | 0.8                              | 2.02 | 2.0     | 2.7  | 0.8                                  | 2.0  | 2.0     | 2.7  |
| 8/12/2022  | BDL                              | 0.25 | 0.74    | 0.32 | BDL                                  | 0.25 | 0.74    | 0.32 |
| 8/17/2022  | 0.52                             | 0.65 | 2.3     | 1.7  | 0.62                                 | 0.65 | 2.3     | 1.7  |
| Date       | Ammonia-N (mg/L, DL = 0.06 mg/L) |      |         |      | TKN (mg/L, DL = 0.03 mg/L)           |      |         |      |
|            | Inflow                           | Sand | Biochar | IES  | Inflow                               | Sand | Biochar | IES  |
| 5/20/2021  | BDL                              | BDL  | BDL     | BDL  | 1.8                                  | 1.1  | 1.1     | 0.96 |
| 6/20/2021  | 0.44                             | BDL  | 0.07    | 1.01 | 4.4                                  | 4.0  | 4.2     | 3.8  |
| 6/28/2021  | 1.1                              | BDL  | BDL     | BDL  | 9.7                                  | 2.3  | 2.6     | 1.3  |
| 7/6/2021   | 4.2                              | BDL  | 0.51    | 0.15 | 9.2                                  | 3.8  | 2.6     | 1.7  |
| 7/14/2021  | 1.6                              | 0.07 | 0.24    | 0.08 | 5.2                                  | 1.5  | 1.4     | 1.2  |
| 8/7/2021   | BDL                              | BDL  | BDL     | 0.13 | 0.72                                 | 0.73 | 0.75    | 0.68 |
| 8/26/2021  | 0.7                              | BDL  | BDL     | BDL  | 1.6                                  | 0.65 | 0.43    | 0.55 |
| 9/8/2021   | 0.83                             | BDL  | BDL     | BDL  | 3.9                                  | 0.40 | 0.44    | 0.43 |
| 9/20/2021  | 0.35                             | BDL  | BDL     | BDL  | 3.4                                  | 0.61 | 0.55    | 0.5  |
| 10/20/2021 | 1                                | BDL  | BDL     | BDL  | 5.5                                  | 1.0  | 0.86    | 0.85 |

|            |      |      |      |      |      |      |      |      |
|------------|------|------|------|------|------|------|------|------|
| 10/28/2021 | 0.09 | BDL  | BDL  | BDL  | 0.47 | 0.25 | 0.27 | 0.26 |
| 4/20/2022  | 3.0  | 0.07 | 0.13 | 0.4  | 6.4  | 1.3  | 1.2  | 0.97 |
| 4/30/2022  | 0.62 | 0.06 | BDL  | 0.56 | 2    | 0.32 | 0.22 | 0.82 |
| 5/19/2022  | 1.2  | BDL  | 0.14 | 0.35 | 2.6  | 0.84 | 0.7  | 0.83 |
| 5/25/2022  | 0.14 | 0.1  | 0.08 | 0.16 | 0.61 | 0.4  | 0.3  | 0.37 |
| 6/13/2022  | 1.8  | 0.45 | 0.33 | 0.03 | 7.3  | 1.8  | 2.6  | 0.68 |
| 6/15/2022  | 1.8  | BDL  | BDL  | BDL  | 7.2  | 2.3  | 3.3  | 0.87 |
| 7/23/2022  | 0.65 | 0.09 | 0.52 | BDL  | 3.9  | 1.3  | 1.4  | 0.75 |
| 7/26/2022  | 0.74 | 0.14 | 0.25 | 0.25 | 3.0  | 1.2  | 1.1  | 1.0  |
| 8/12/2022  | 0.31 | BDL  | BDL  | 0.08 | 0.66 | 0.26 | 0.21 | 0.23 |
| 8/17/2022  | 0.83 | 0.09 | 0.14 | 0.1  | 3.7  | 0.32 | 1.2  | 0.49 |

**Table S9.** Influent and effluent contaminant concentrations by date and filter for P-containing nutrients, TOC, and *E. coli* (DL = detection limit, BDL = below detection limit). Dates for which data were not collected are indicated with a “-“.

| Date       | TP (mg/L, DL = 0.02 mg/L)  |      |         |      | Ortho-P (mg/L, DL = 0.02 mg/L)               |      |         |      |
|------------|----------------------------|------|---------|------|--|------|---------|------|
|            | Inflow                     | Sand | Biochar | IES  | Inflow                                       | Sand | Biochar | IES  |
| 5/20/2021  | 0.15                       | 0.10 | 0.08    | 0.03 | BDL  | BDL  | BDL     | BDL  |
| 6/20/2021  | 0.90                       | 0.47 | 0.73    | 0.05 | 0.50   | 0.11 | 0.25    | BDL  |
| 6/28/2021  | 1.02                       | 0.10 | 0.28    | 0.05 | 0.35   | 0.01 | 0.06    | BDL  |
| 7/6/2021   | 1.41                       | 0.30 | 0.39    | 0.09 | 1.19   | 0.01 | 0.15    | BDL  |
| 7/14/2021  | 0.56                       | 0.07 | 0.15    | BDL  | 0.12   | 0.01 | 0.02    | BDL  |
| 8/7/2021   | 0.06                       | 0.10 | 0.11    | BDL  | 0.03   | 0.05 | 0.07    | BDL  |
| 8/26/2021  | 0.14                       | 0.09 | 0.10    | 0.03 | 0.06   | 0.04 | 0.06    | BDL  |
| 9/8/2021   | 0.31                       | 0.04 | 0.04    | BDL  | -  | -    | -       | -    |
| 9/20/2021  | 0.17                       | BDL  | 0.03    | BDL  | 0.02   | BDL  | 0.02    | BDL  |
| 10/20/2021 | 0.72                       | 0.06 | 0.13    | 0.05 | 0.35   | BDL  | BDL     | BDL  |
| 10/28/2021 | 0.08                       | 0.05 | 0.05    | 0.03 | 0.06   | 0.03 | 0.03    | BDL  |
| 4/20/2022  | 0.14                       | 0.05 | 0.03    | 0.04 | 0.04   | 0.01 | BDL     | BDL  |
| 4/30/2022  | 0.09                       | 0.04 | 0.04    | BDL  | BDL  | 0.03 | 0.02    | BDL  |
| 5/19/2022  | 0.18                       | 0.07 | 0.06    | BDL  | -  | -    | -       | -    |
| 5/25/2022  | 0.07                       | 0.07 | 0.05    | BDL  | 0.03   | 0.07 | 0.05    | BDL  |
| 6/13/2022  | 1.08                       | 0.13 | 0.31    | 0.03 | -  | -    | -       | -    |
| 6/15/2022  | 1.11                       | 0.26 | 0.29    | 0.07 | 0.61   | 0.02 | 0.06    | BDL  |
| 7/23/2022  | 0.33                       | 0.25 | 0.23    | 0.03 | 0.11   | 0.20 | 0.18    | BDL  |
| 7/26/2022  | 0.24                       | 0.25 | 0.33    | 0.07 | 0.04   | 0.17 | 0.21    | BDL  |
| 8/12/2022  | 0.05                       | 0.14 | 0.15    | BDL  | -  | -    | -       | -    |
| 8/17/2022  | 0.28                       | 0.12 | 0.18    | 0.04 | 0.04   | 0.11 | 0.13    | BDL  |
| Date       | TOC (mg/L, DL = 0.05 mg/L) |      |         |      | <i>E. coli</i> (MPN/ 100 mL, DL = 1/ 100 mL) |      |         |      |
|            | Inflow                     | Sand | Biochar | IES  | Inflow                                       | Sand | Biochar | IES  |
| 5/20/2021  | 20.5                       | 17.0 | 20.9    | 23.2 | 36400  | 1000 | 12200   | 7500 |
| 6/20/2021  | 32.0                       | 76.4 | 86.4    | 77.6 | 45500  | 6300 | 6300    | 2420 |
| 6/28/2021  | 106.0                      | 43.2 | 66.8    | 32.4 | 13500  | 816  | 8600    | 32   |
| 7/6/2021   | 149.0                      | 39.6 | 41.6    | 33.3 | 3100   | 5    | 308     | 205  |
| 7/14/2021  | 66.3                       | 41.4 | 30.6    | 28.8 | 1733   | 1    | 105     | 261  |
| 8/7/2021   | 10.6                       | 12.4 | 12.2    | 10.1 | -  | -    | -       | -    |
| 8/26/2021  | 12.8                       | 11.0 | 8.3     | 9.7  | 238  | 74   | 1733    | 77   |
| 9/8/2021   | 47.2                       | 3.4  | 4.4     | 4.3  | 36   | 0    | 1       | 0    |
| 9/20/2021  | 31.1                       | 7.7  | 6.3     | 5.5  | 96   | 0    | 1       | 1    |
| 10/20/2021 | 95.1                       | 10.6 | 13.2    | 10.0 | 214  | 1    | 1       | 0    |
| 10/28/2021 | 17.2                       | 7.6  | 11.2    | 9.7  | 17   | 10   | 8       | 4    |



|           |       |      |      |      |       |       |       |     |
|-----------|-------|------|------|------|-------|-------|-------|-----|
| 4/20/2022 | 41.9  | 14.0 | 13.3 | 5.6  | 3     | 5     | 5     | 2   |
| 4/30/2022 | 11.7  | 2.7  | 2.4  | 2.4  | -     | -     | -     | -   |
| 5/19/2022 | 10.4  | 14.3 | 12.6 | 10.4 | 1553  | 291   | 147   | 72  |
| 5/25/2022 | 10.3  | 7.0  | 7.2  | 5.0  | -     | -     | -     | -   |
| 6/13/2022 | 101.0 | 18.5 | 51.3 | 9.2  | 1046  | 270   | 457   | 0   |
| 6/15/2022 | 74.4  | 34.6 | 38.4 | 14.2 | 38300 | 13500 | 14800 | 20  |
| 7/23/2022 | 29.6  | 10.0 | 9.3  | 6.0  | 238   | 47    | 816   | 7   |
| 7/26/2022 | 29.2  | 14.2 | 13.1 | 8.4  | 3100  | 88    | 2420  | 127 |
| 8/12/2022 | -     | -    | -    | -    | 539   | 46    | 20    | 16  |
| 8/17/2022 | 27.2  | 2.9  | 12.2 | 4.1  | 63    | 1     | 44    | 31  |

**Table S10.** Influent and effluent water quality measurements by date and filter for TSS, VSS, specific conductivity, and salinity (DL = detection limit, BDL = below detection limit). Dates for which data were not collected are indicated with a “-“.

| Date       | TSS (mg/L, DL = 3 mg/L)       |      |         |     | VSS (mg/L, DL = 3 mg/L) |      |         |      |
|------------|-------------------------------|------|---------|-----|-------------------------|------|---------|------|
|            | Inflow                        | Sand | Biochar | IES | Inflow                  | Sand | Biochar | IES  |
| 5/20/2021  | 16                            | 28   | 12      | 6   | 15                      | 13   | 6       | 5    |
| 6/20/2021  | 26                            | 30   | 41      | 5   | 24                      | 19   | 22      | 4    |
| 6/28/2021  | 57                            | 18   | 24      | 6   | 29                      | 17   | 12      | 6    |
| 7/6/2021   | 57                            | 34   | 11      | 14  | 30                      | 28   | 5       | 8    |
| 7/14/2021  | 50                            | 4    | 6       | 6   | 30                      | 5    | 5       | BDL  |
| 8/7/2021   | 11                            | 15   | 11      | 3   | 7                       | BDL  | BDL     | BDL  |
| 8/26/2021  | 28                            | 5    | BDL     | 3   | 16                      | 3    | BDL     | BDL  |
| 9/8/2021   | 37                            | 8    | 7       | 6   | 23                      | 4    | 6       | 6    |
| 9/20/2021  | 59                            | 5    | 3       | 4   | 32                      | 5    | BDL     | 4    |
| 10/20/2021 | 124                           | 10   | 7       | 12  | 65                      | 7    | 5       | 11   |
| 10/28/2021 | 4                             | BDL  | BDL     | BDL | 3                       | BDL  | BDL     | BDL  |
| 4/20/2022  | 31                            | 4    | 4       | 9   | 14                      | BDL  | BDL     | BDL  |
| 4/30/2022  | 28                            | 9    | BDL     | BDL | 17                      | BDL  | BDL     | BDL  |
| 5/19/2022  | 80                            | 5    | 4       | 4   | 28                      | BDL  | BDL     | BDL  |
| 5/25/2022  | 10                            | 3    | BDL     | BDL | 7                       | BDL  | BDL     | BDL  |
| 6/13/2022  | 24                            | 8    | 8       | BDL | 21                      | 5    | 8       | BDL  |
| 6/15/2022  | 179                           | 15   | 13      | 4   | 75                      | 12   | 12      | BDL  |
| 7/23/2022  | 134                           | BDL  | 4       | 4   | -                       | -    | -       | -    |
| 7/26/2022  | 35                            | BDL  | BDL     | BDL | 17                      | BDL  | BDL     | BDL  |
| 8/12/2022  | 6                             | BDL  | BDL     | BDL | 4                       | BDL  | BDL     | BDL  |
| 8/17/2022  | 19                            | BDL  | BDL     | BDL | 13                      | BDL  | BDL     | BDL  |
| Date       | Specific conductivity (uS/cm) |      |         |     | Salinity (ppt)          |      |         |      |
|            | Inflow                        | Sand | Biochar | IES | Inflow                  | Sand | Biochar | IES  |
| 5/20/2021  | 63                            | 166  | 142     | 109 | 0.03                    | 0.08 | 0.07    | 0.05 |
| 6/20/2021  | 143                           | 189  | 213     | 194 | 0.07                    | 0.09 | 0.10    | 0.09 |
| 6/28/2021  | 220                           | 315  | 366     | 202 | 0.10                    | 0.15 | 0.17    | 0.10 |
| 7/6/2021   | 349                           | 359  | 354     | 223 | 0.17                    | 0.17 | 0.17    | 0.11 |
| 7/14/2021  | 261                           | 299  | 279     | 210 | 0.12                    | 0.14 | 0.13    | 0.10 |
| 8/7/2021   | 37                            | 83   | 95      | 81  | 0.02                    | 0.04 | 0.04    | 0.04 |
| 8/26/2021  | 39                            | 147  | 158     | 106 | 0.02                    | 0.07 | 0.07    | 0.05 |
| 9/8/2021   | 112                           | 81   | 71      | 84  | 0.05                    | 0.04 | 0.03    | 0.04 |
| 9/20/2021  | 97                            | 110  | 99      | 82  | 0.04                    | 0.05 | 0.05    | 0.04 |
| 10/20/2021 | 175                           | 209  | 196     | 168 | 0.08                    | 0.10 | 0.09    | 0.08 |
| 10/28/2021 | 58                            | 101  | 85      | 92  | 0.03                    | 0.05 | 0.04    | 0.04 |
| 4/20/2022  | 249                           | 174  | 245     | 246 | 0.12                    | 0.08 | 0.12    | 0.12 |
| 4/30/2022  | 65                            | 114  | 96      | 75  | 0.03                    | 0.05 | 0.04    | 0.03 |
| 5/19/2022  | 33                            | 370  | 119     | 440 | 0.01                    | 0.18 | 0.22    | 0.21 |
| 5/25/2022  | 38                            | 98   | 94      | 96  | 0.02                    | 0.05 | 0.04    | 0.04 |
| 6/13/2022  | 237                           | 183  | 239     | 255 | 0.11                    | 0.09 | 0.11    | 0.23 |
| 6/15/2022  | 198                           | 246  | 353     | 335 | 0.09                    | 0.12 | 0.17    | 0.16 |
| 7/23/2022  | 80                            | 235  | 296     | 266 | 0.04                    | 0.11 | 0.14    | 0.13 |
| 7/26/2022  | 100                           | 225  | 217     | 218 | 0.05                    | 0.11 | 0.10    | 0.10 |
| 8/12/2022  | -                             | -    | -       | -   | 0.01                    | 0.04 | 0.02    | 0.00 |
| 8/17/2022  | -                             | -    | -       | -   | -                       | -    | -       | -    |

**Table S11.** Influent and effluent contaminant concentrations by date and filter for heavy metals (DL = detection limit, BDL = below detection limit). Dates for which data were not collected are indicated with a “-”.

| Date       | Copper (µg/L, DL = 0.3 µg/L) |      |         |      | Lead (µg/L, DL = 0.5 µg/L) |      |         |     |
|------------|------------------------------|------|---------|------|----------------------------|------|---------|-----|
|            | Inflow                       | Sand | Biochar | IES  | Inflow                     | Sand | Biochar | IES |
| 5/20/2021  | 7.5                          | 14.0 | 13.4    | 5.2  | 1.2                        | 1.1  | 0.6     | 1.3 |
| 6/20/2021  | 15.2                         | 45.0 | 50.9    | 23.2 | 1.5                        | 0.6  | 1.4     | BDL |
| 6/28/2021  | 18.5                         | 19.4 | 14.7    | 12.6 | 2.2                        | 0.3  | 1.6     | BDL |
| 7/6/2021   | 25.2                         | 13.8 | 12.4    | 6.3  | 3.6                        | 2.3  | 1.4     | 0.7 |
| 7/14/2021  | 12.4                         | 6.6  | 6.0     | 3.4  | 2.6                        | BDL  | 0.9     | BDL |
| 8/7/2021   | 4.0                          | 10.6 | 8.2     | 2.1  | 1.1                        | 0.8  | 0.6     | 0.6 |
| 8/26/2021  | 7.2                          | 5.6  | 3.6     | 2.0  | 2.1                        | BDL  | BDL     | BDL |
| 9/8/2021   | 9.0                          | 4.9  | 4.8     | 1.2  | 8.5                        | BDL  | BDL     | BDL |
| 9/20/2021  | 12.4                         | 5.2  | 4.6     | 1.1  | 4.8                        | BDL  | BDL     | BDL |
| 10/20/2021 | 34.7                         | 6.4  | 6.4     | 2.2  | 12.8                       | BDL  | BDL     | 0.6 |
| 10/28/2021 | 2.5                          | 4.1  | 3.8     | 1.6  | 0.6                        | BDL  | BDL     | BDL |
| 4/20/2022  | 12.5                         | 7.4  | 6.2     | 3.5  | 3.5                        | BDL  | BDL     | 1.0 |
| 4/30/2022  | 7.9                          | 4.8  | 3.3     | 0.7  | 3.0                        | 0.7  | BDL     | 0.7 |
| 5/19/2022  | 11.8                         | 7.8  | 4.6     | 1.7  | 15.2                       | BDL  | BDL     | BDL |
| 5/25/2022  | 3.5                          | 4.1  | 7.3     | 1.4  | 1.0                        | BDL  | BDL     | BDL |
| 6/13/2022  | 27.4                         | 8.8  | 21.1    | 2.3  | 1.3                        | BDL  | BDL     | BDL |
| 6/15/2022  | 41.0                         | 15.4 | 12.6    | 7.8  | 15.3                       | 0.5  | BDL     | BDL |
| 7/23/2022  | 20.0                         | 8.9  | 3.9     | 3.3  | 14.6                       | BDL  | BDL     | BDL |
| 7/26/2022  | 11.5                         | 6.1  | 4.6     | 2.5  | 4.0                        | BDL  | BDL     | BDL |
| 8/12/2022  | 2.5                          | 2.5  | 3.2     | 0.8  | 0.7                        | BDL  | BDL     | BDL |
| 8/17/2022  | 10.5                         | 2.6  | 3.3     | 1.2  | 1.5                        | BDL  | BDL     | BDL |
| Date       | Nickel (µg/L, DL = 0.5 µg/L) |      |         |      | Zinc (µg/L, DL = 5 µg/L)   |      |         |     |
|            | Inflow                       | Sand | Biochar | IES  | Inflow                     | Sand | Biochar | IES |
| 5/20/2021  | 1.7                          | 3.9  | 4.3     | 5.6  | 52                         | 202  | 29      | 36  |
| 6/20/2021  | 2.8                          | 9.2  | 9.9     | 19.0 | 223                        | 55   | 53      | 53  |
| 6/28/2021  | 5.5                          | 11.3 | 10.7    | 16.1 | 106                        | 134  | 51      | 159 |
| 7/6/2021   | 8.4                          | 9.8  | 8.0     | 6.3  | 218                        | 229  | 90      | 111 |
| 7/14/2021  | 5.4                          | 6.0  | 5.7     | 5.2  | 113                        | 118  | 38      | 41  |
| 8/7/2021   | 0.9                          | 2.7  | 2.1     | 3.2  | 35                         | 14   | 13      | 8   |
| 8/26/2021  | 1.1                          | 1.4  | 1.2     | 2.4  | 53                         | 13   | 9       | 27  |
| 9/8/2021   | 3.2                          | 1.0  | 0.7     | 1.1  | 218                        | 93   | 30      | 42  |
| 9/20/2021  | 3.0                          | 1.1  | 0.8     | 1.1  | 121                        | 148  | 27      | 34  |
| 10/20/2021 | 7.0                          | 1.7  | 1.8     | 2.5  | 340                        | 87   | 45      | 58  |
| 10/28/2021 | 0.6                          | 0.7  | 0.6     | 3.1  | 77                         | 10   | 6       | BDL |
| 4/20/2022  | 3.7                          | 1.3  | 1.1     | 2.3  | 101                        | 16   | 35      | 154 |
| 4/30/2022  | 1.7                          | 1.0  | 0.6     | 0.9  | 66                         | 19   | 7       | 10  |
| 5/19/2022  | 2.3                          | 3.2  | 4.1     | 4.7  | 129                        | 95   | 74      | 51  |
| 5/25/2022  | 0.8                          | 0.8  | 1.1     | 1.2  | 37                         | 6    | 7       | BDL |
| 6/13/2022  | 6.4                          | 2.9  | 4.9     | 2.3  | 240                        | 83   | 135     | 87  |
| 6/15/2022  | 9.6                          | 6.4  | 1.2     | 5.7  | -                          | -    | -       | -   |
| 7/23/2022  | 4.5                          | 1.9  | 2.3     | 2.7  | 193                        | 70   | 76      | 137 |
| 7/26/2022  | 2.9                          | 1.8  | 1.5     | 2.3  | 92                         | 48   | 22      | 34  |
| 8/12/2022  | BDL                          | BDL  | BDL     | 0.6  | 25                         | 6    | BDL     | 6   |
| 8/17/2022  | 2.2                          | 0.5  | 0.8     | 1.3  | 65                         | 42   | 22      | 44  |

**Table S12.** Influent and effluent water quality measurements by date and filter for pH, temperature, dissolved oxygen, and chloride (DL = detection limit, BDL = below detection limit). Dates for which data were not collected are indicated with a “-”.

| Date       | pH                      |      |         |      | Temperature (°C)             |      |         |      |
|------------|-------------------------|------|---------|------|------------------------------|------|---------|------|
|            | Inflow                  | Sand | Biochar | IES  | Inflow                       | Sand | Biochar | IES  |
| 5/20/2021  | 8.30                    | 7.70 | 7.40    | 7.70 | 14.8                         | 15.4 | 30.3    | 14.6 |
| 6/20/2021  | 7.70                    | 8.00 | 8.30    | 8.00 | 21.6                         | 22.9 | 22.7    | 22.6 |
| 6/28/2021  | 6.50                    | 6.40 | 6.40    | 6.40 | 24.0                         | 23.3 | 23.7    | 23.6 |
| 7/6/2021   | 6.00                    | 6.20 | 6.40    | 6.60 | 21.8                         | 22.0 | 23.0    | 22.4 |
| 7/14/2021  | 6.90                    | 7.30 | 7.40    | 7.00 | 22.3                         | 23.1 | 23.5    | 23.8 |
| 8/7/2021   | 7.80                    | 7.60 | 8.10    | 8.60 | 21.7                         | 22.3 | 21.9    | 22.3 |
| 8/26/2021  | 8.50                    | 7.80 | 7.50    | 7.90 | 20.5                         | 21.9 | 21.4    | 21.5 |
| 9/8/2021   | 7.60                    | 7.70 | 7.70    | 8.10 | 21.4                         | 20.8 | 20.9    | 21.4 |
| 9/20/2021  | 6.60                    | 6.70 | 6.90    | 6.50 | 21.8                         | 21.4 | 21.4    | 21.6 |
| 10/20/2021 | 7.56                    | 8.09 | 7.73    | 7.37 | 14.2                         | 12.9 | 12.4    | 12.6 |
| 10/28/2021 | 7.91                    | 7.77 | 8.05    | 8.53 | 9.3                          | 9.5  | 9.0     | 9.4  |
| 4/20/2022  | 8.60                    | 9.58 | 8.86    | 8.73 | 6.9                          | 5.6  | 5.5     | 6.4  |
| 4/30/2022  | 8.96                    | 9.14 | 8.56    | 8.73 | 10.5                         | 9.9  | 10.0    | 9.6  |
| 5/19/2022  | 8.16                    | 7.71 | 7.49    | 7.56 | 16.9                         | 18.1 | 17.1    | 17.3 |
| 5/25/2022  | 9.00                    | 8.33 | 8.20    | 8.14 | 13.1                         | 14.0 | 14.2    | 13.9 |
| 6/13/2022  | 6.54                    | 6.66 | 6.51    | 7.48 | 19.9                         | 20.9 | 20.2    | 20.5 |
| 6/15/2022  | 7.84                    | 7.92 | 8.04    | 7.74 | 21.5                         | 21.9 | 21.9    | 21.3 |
| 7/23/2022  | 9.13                    | 8.15 | 8.12    | 8.36 | 24.1                         | 24.0 | 26.2    | 24.6 |
| 7/26/2022  | 7.54                    | 7.15 | 7.14    | 7.05 | 22.9                         | 23.3 | 24.1    | 23.7 |
| 8/12/2022  | 8.81                    | 9.17 | 8.85    | -    | 19.0                         | 19.5 | 19.0    | -    |
| 8/17/2022  | -                       | -    | -       | -    | -                            | -    | -       | -    |
| Date       | Dissolved oxygen (mg/L) |      |         |      | Chloride (mg/L, DL = 5 mg/L) |      |         |      |
|            | Inflow                  | Sand | Biochar | IES  | Inflow                       | Sand | Biochar | IES  |
| 5/20/2021  | 1.5                     | 7.1  | 3.0     | 4.9  | BDL                          | BDL  | BDL     | BDL  |
| 6/20/2021  | 7.1                     | 6.3  | 5.9     | 4.1  | BDL                          | BDL  | BDL     | BDL  |
| 6/28/2021  | 4.1                     | 4.4  | 3.3     | 6.2  | 9                            | 6    | 10      | BDL  |
| 7/6/2021   | 3.5                     | 4.9  | 4.4     | 4.4  | 12                           | 9    | 7       | 6    |
| 7/14/2021  | 3.1                     | 4.9  | 5.3     | 4.2  | 7                            | 6    | 5       | 5    |
| 8/7/2021   | 7.6                     | 6.2  | 5.6     | 3.1  | BDL                          | BDL  | BDL     | BDL  |
| 8/26/2021  | 8.6                     | 5.7  | 5.5     | 4.1  | BDL                          | BDL  | BDL     | BDL  |
| 9/8/2021   | 6.8                     | 8.8  | 8.8     | 9.5  | 10                           | BDL  | BDL     | BDL  |
| 9/20/2021  | 6.4                     | 7.8  | 7.6     | 8.5  | BDL                          | BDL  | BDL     | BDL  |
| 10/20/2021 | 9.2                     | 9.6  | 8.8     | 10.7 | 11                           | BDL  | BDL     | BDL  |
| 10/28/2021 | 10.4                    | 8.0  | 8.2     | 5.8  | BDL                          | BDL  | BDL     | BDL  |
| 4/20/2022  | 9.3                     | 9.5  | 9.0     | 8.6  | 23                           | 11   | 13      | 10   |
| 4/30/2022  | 9.7                     | 6.0  | 8.6     | 9.0  | 6                            | BDL  | BDL     | BDL  |
| 5/19/2022  | 8.8                     | 5.0  | 4.3     | 5.0  | BDL                          | 13   | 16      | 13   |
| 5/25/2022  | 9.5                     | 4.4  | 6.1     | 7.3  | BDL                          | BDL  | BDL     | BDL  |
| 6/13/2022  | 2.8                     | 6.8  | 5.0     | 6.1  | 7                            | BDL  | 7       | BDL  |
| 6/15/2022  | 5.9                     | 4.6  | 3.1     | 4.9  | 6                            | 8    | 13      | BDL  |
| 7/23/2022  | 8.0                     | 4.9  | 4.1     | 5.1  | BDL                          | BDL  | BDL     | BDL  |
| 7/26/2022  | 6.1                     | 5.1  | 4.3     | 5.1  | BDL                          | BDL  | BDL     | BDL  |
| 8/12/2022  | 9.0                     | 5.5  | 7.7     | -    | BDL                          | BDL  | BDL     | BDL  |
| 8/17/2022  | -                       | -    | -       | -    | BDL                          | BDL  | BDL     | BDL  |