

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY  
WATER RESOURCES DIVISION  
JULY 2019

STAFF REPORT

## Bacterial Monitoring Results for Michigan Rivers and Streams: 2018

### 1 Introduction

Staff from the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division (WRD), and its contractors collected samples from 74 sites on rivers and streams throughout the Lower Peninsula of Michigan and 15 sites in the Upper Peninsula (Figure 1; site locations are described in Appendix 1). Samples from these sites were analyzed for *E. coli* on a weekly basis, for 5 weeks, and results are shown in Appendix 2. Monitoring objectives were to:

1. Assess the current status and condition of individual waters of the state and determine whether the Total Body Contact (TBC) and Partial Body Contact (PBC) designated uses are being met. Michigan is committed to assessing the waters of the state to determine the attainment status of the designated uses. All data were considered in the upcoming 2020 Clean Water Act Sections 303(d) and 305(b) list.
2. Conduct microbial source tracking in impaired priority waters.
3. Obtain screening level dissolved oxygen (D.O.) measurements.

### 2 Water Quality Standards (WQS)

#### 2.1 *E. coli*

Michigan's designated use rule states that all water bodies shall be protected for TBC recreation from May 1 through October 31 and PBC recreation year-round (Rule 100 [R 323.1100] of the Part 4 Rules, WQS, promulgated pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended). To maintain these designated uses, Michigan has established ambient *E. coli* WQS in Rule 62 of the Part 4 Rules.

*E. coli* is a type of bacteria (single cell organism) that is used as an indicator of the presence of fecal contamination in surface water, such as lakes, streams, and wetlands. Ensuring that waters meet the *E. coli* WQS also ensures that other disease-causing microorganisms (pathogens) are kept below harmful levels. Pathogens in a stream or lake can infect humans through ingestion or skin contact, resulting in diseases such as gastroenteritis, giardia, hepatitis, or cholera.

The WQS of 130 *E. coli* per 100 milliliters (mL) as a 30-day geometric mean, and 300 *E. coli* per 100 mL as a daily maximum are established to protect the TBC use from May 1 through October 31. To protect the PBC use (year-round), 1,000 *E. coli* per 100 mL as a daily maximum is used.

#### 2.2 D.O.

D.O. minimum WQS are described in R 323.1064 of the Part 4 Rules and rely upon the coldwater and warmwater fishery designations set forth in the 1997 Michigan Department of Natural Resources Directors Order DFI-101.97 (MDNR, 1997). In surface waters of the state

designated to protect coldwater fish, the D.O. shall not fall below a minimum of 7 mg/L. In the remainder of streams, the WQS is a minimum of 5 mg/L, to protect warmwater fish species. D.O. results (with violations of the minimum WQS highlighted) and the coldwater or warmwater designations are found in Appendix 3. D.O. is lowest before sunrise because plants and microorganisms respire (and do not photosynthesize) throughout the night using up oxygen. Photosynthesis begins at sunrise releasing and replenishing oxygen.

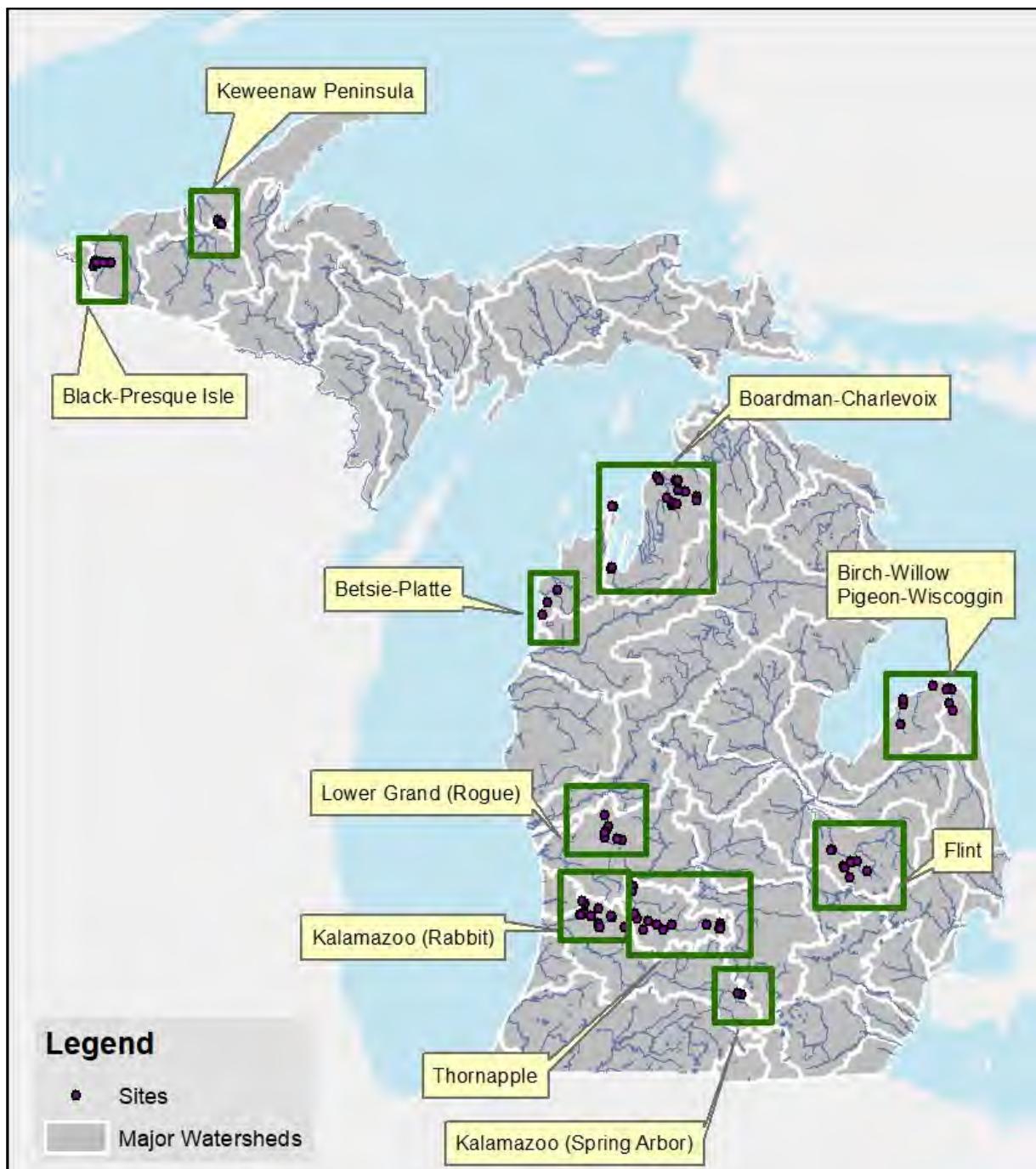


Figure 1. Project and site locations for *E. coli* and D.O. monitoring in 2018.

### 3 Interpretation of *E. coli* Results

Many environmental factors may affect the concentrations of *E. coli* in surface water, including precipitation, flow, settling of *E. coli* through the water column (particularly in a lake or impoundment), and the mortality of *E. coli* due to the passage of time or exposure to sunlight, proximity to sources, etc. In trying to determine sources of *E. coli* to a sampling site, it is helpful to look at results in the context of precipitation prior to sampling (shown in Appendix 2). When *E. coli* concentrations are high regardless of the weather conditions, the sources may be different from a location where *E. coli* is only high following rainfall. The results in Appendix 2 are color-coded to indicate TBC and PBC WQS exceedances, as described in Section 2.1.

Dry weather exceedances, or exceedances during low flows, indicate a constant source of *E. coli* is impacting the site, such as failing septic systems, illicit sanitary connections, livestock or wildlife congregating in the water, or shallow groundwater contamination.

Wet weather exceedances, or exceedances during high flows, indicate that the source is flushed into water bodies during precipitation events or inundated during flooding. Examples of wet weather sources include urban or rural storm water, runoff from agricultural fields or pastures, illicit sanitary connections to storm drains or field tiles, accumulated waste (animal or human) in storm drains or on the ground surface, or pet or wildlife waste on lawns or parks.

### 4 Sampling Methods

#### 4.1 *E. coli*

Each *E. coli* sampling event consisted of 3 samples taken at representative locations within a defined sampling area. In a flowing water body, these locations are referred to as left, center, and right. The center sample was collected in the spatial center of the stream, the right sample was collected midway between the center and the right bank, and the left sample was collected midway between the center location and the left bank. Care was taken to ensure that all samples were collected in the moving portion of the stream, avoiding stagnant areas near the banks, debris dams, or pilings. Samples were collected directly from the stream, just below the surface, into sterile wide-mouthed polypropylene bottles. Collection occurred using a sampler lowered from the bridge by a rope or by wading in and sampling upstream of the body. Care was exercised to avoid the surface microlayer of water and bottom sediment layer, both of which may be enriched in bacteria and not representative of the water column. Clean latex gloves were worn and replaced after sample collection at each site.

Field blanks were collected at a rate of 5 percent, by filling a sample bottle with deionized water. Duplicates were taken by collecting a larger volume of sample and pouring alternately between the sample bottle and the duplicate bottle at a rate of 10 percent of events. At randomly selected events and sites, duplicates were collected for the left, center, and right samples at the same sampling event (date and location). For example, the first sampling event at Site 1 was randomly selected for quality control sampling, and duplicates were collected for left, center, and right samples resulting in 6 samples (L, C, R, L<sup>dup</sup>, C<sup>dup</sup>, and R<sup>dup</sup>). These sample results were used to calculate a daily geometric mean (DGM) to be used in comparison with the daily TBC WQS, and the duplicate results were used to calculate a geometric mean for quality assurance (DGM<sup>dup</sup>). Samples were submitted to the EGLE Drinking Water Laboratory within the 6-hour bacterial hold time and chain-of-custody was maintained at all times.

Precipitation data for the 24-hours and 48-hours prior to each sampling event are recorded in Appendix 2, and graphed in Appendix 4, and were obtained from nearby weather stations (Michigan State University (MSU) Extension, 2018; Weather Underground, 2018). Where

possible, the relative water level was determined at each sampling event by measuring the distance in centimeters from a set point on the bridge or culvert to the surface of the river using a weighted metal tape (Appendices 4 and 5) (Figure 2).



Figure 2. Mark on culvert for determining the relative water level. Measurements are from this point to the water's surface and were recorded on each sampling visit.

#### 4.2 Microbial Source Tracking

For the source tracking study, a large sample volume (250-500 mL) was collected from the center portion of the stream, and 100 mL was sent to the EGLE Drinking Water Laboratory. The remaining volume was filtered and frozen according to the laboratory's standard operating procedures, then shipped to the MSU laboratory on dry ice. Chain-of-custody was maintained at all times.

#### 4.3 D.O.

Instantaneous D.O. and temperature measurements were recorded weekly during *E. coli* sample collection using a YSI EXO Multiparameter Water Quality Sonde. The sonde was calibrated weekly following the manufacturer's instructions. When violations of the D.O. WQS were recorded in the field, or the D.O. seemed abnormally high (above 10 mg/L), the sonde was recalibrated on site and the measurement was verified. This verification was completed no more than once per day. The D.O. measurements collected during this study were collected between 8:00 a.m. and 12:00 p.m., thereby missing the most critical time for D.O. depletion (just prior to sunrise). Results are contained in Appendix 3.

### 5 Quality Control

#### 5.1 Goals

The goals for quality assurance and quality control sampling were:

- Blanks – Field blanks should not contain detectable levels of *E. coli*. The detection level for *E. coli* in surface water is <10 *E. coli* per 100 mL.
- Duplicates - If both the DGM and the DGM<sup>dup</sup> for a randomly selected event fall within 0-299 *E. coli* per 100 mL (attainment with the TBC WQS), or conversely, both are more than 300 *E. coli* per 100 mL (nonattainment with the TBC WQS), then the data are considered acceptable. When the DGM and DGM<sup>dup</sup> would result in a different attainment decision, then the results of duplicate analyses should be used to calculate a

relative percent difference between the DGM and DGM<sup>dup</sup>. The target for the relative percent difference is ≤50 percent.

## 5.2 Quality Control Results

The results for quality assurance and quality control in this study were as follows:

- Blanks – All field blanks contained less than 10 *E. coli* per 100 ml (reporting level).
- Duplicates - Of the 445 sampling events (89 sites visited 5 times each), 48 sampling events (10.7 percent) were randomly selected for duplicate sample collection. The DGM and DGM<sup>dup</sup> were not in agreement on TBC attainment status at 2 selected events. The Relative Percent Differences for these events were 18 percent and 31 percent; therefore, the quality control goal was met.

## 6 Conclusions

### 6.1 Monitoring Objective 1 and 2

#### 6.1.1 General Information

Water levels relative to a fixed point (relative water levels) were measured at most sites. Measurements are listed in Appendix 2 and graphed in Appendices 4 and 5. The lowest water level recorded at each site was the baseline measurement (represented as 0) in the Appendices and relative water level change is calculated as the difference between baseline and the event measurement for the sampling event (e.g., for the Planter Creek site, on August 7, 2018, the water levels were 2 centimeters above baseline, which occurred the previous week). As water levels at some sites were very stable during the study, water level relationships could not be discerned (these are not shown in Appendix 5).

*E. coli* concentrations had a positive relationship with increased water levels (increased as the water level increased) at most of the sites in this study although the strength of the relationship varied. This indicates that high flow issues are impacting these sites, such as urban storm water or tiles and ditches flowing during times of high water table. High flow events were not captured in all of the 5-week studies. Conversely, increasing *E. coli* concentrations with decreasing water levels were less common in this study, and reveal impacts from dry weather and low flow sources such as illicit connections, failing septic systems, or livestock with direct access to the water body.

To assist in determining the sources of *E. coli* to water bodies, Microbial Source Tracking analysis was conducted for selected sites and projects (Table 1). The presence of a host-specific genetic source tracking marker (either human or bovine) indicates the presence of a potential source of that type in the sample. *Bacteroides thetaiotaomicron* (*B. theta*) was used as a human marker (Yampara-Iquise et al., 2008) and CowM2 as the bovine marker (Shanks et al., 2008). *B. theta* dies almost immediately on exposure to the environment and degrades quickly at surface water temperatures. Studies have shown that only 10 percent is detectable using qPCR after about 3 days in riverine conditions (Balleste and Blanch, 2010), and its presence therefore indicates recent contamination by treated or untreated human sewage.

There are a few considerations when interpreting Microbial Source Tracking data:

- Deoxyribonucleic acid (DNA), used in Microbial Source Tracking, does survive wastewater treatment and composting processes. DNA may appear in the sample, while the source bacteria are dead. It is important to consider the presence of wastewater treatment facilities

upstream of sites, which would not contribute significantly to live *E. coli* (if in compliance with their permit) but could contribute human Microbial Source Tracking markers.

- The Microbial Source Tracking genetic targets are based on host-specific *Bacteroides* bacteria, which are very different from *E. coli*. As an example, *E. coli* may live many months in soil, whereas the longevity of *B. theta* is significantly shorter.
- DNA degrades over time, once the host cell is dead. The decay occurs at variable rates due to many factors, including the taxa of the Microbial Source Tracking target; sunlight; substrate where the bacteria are residing (water vs. sediment); and ambient temperature (Murphy, 2018). The detection of a marker with a short persistence time indicates more recent pollution by the host animal. The absence of a marker may indicate that it has decomposed to the point of non-detection.
- A non-detect result does not rule out the host animal as a source in the upstream areas. Microbial Source Tracking markers may not be detected due to decomposition, dilution below detection levels, the presence of compounds in the sample, which inhibit the detection using qPCR techniques (known as ‘inhibition’), or the complete absence of the target marker in the sample.
- Weather at the time the sample was collected and location of known sources (such as National Pollutant Discharge Elimination System discharges) are important considerations in determining potential sources.
- Knowledge of the *E. coli* concentration at the time of sampling assists in interpreting results. Higher bacterial concentrations would be more likely to yield a positive detection, while low bacterial densities would be more likely to result in a non-detect. Additionally, if *E. coli* levels were below the daily maximum TBC WQS, EGLE typically chose not to analyze the source tracking samples.
- A false negative occurs when the target marker is not found in the sample (the result is non-detect), but the marker is present. It is not possible to know if a negative result indicates the source is absent from the sample, or if the marker is not detectable due to inhibition, decomposition, or other reason.

Table 1. Selected sites and dates analyzed for bovine and human markers. Microbial source tracking results are in gene copies per 100 mL (average of 2-3 detectable results) and are presented alongside the *E. coli* DGM. Results are the average (in gene copies/100 mL) of 2-3 detectable results. Results lower than the method detection limit (354 copies/100 mL) are non-detect (ND).

| Site ID | Site Description                               | Date      | <i>E. coli</i> DGM | Human<br>(B. theta) | Bovine<br>(CowM2) |
|---------|--|-----------|--------------------|---------------------|-------------------|
| 150104  | Strover Creek - Ferry Ave                      | 7/9/2018  | 352                | ND                  | ND                |
| 150104  | Strover Creek - Ferry Ave                      | 7/16/2018 | 308                | ND                  | 479.87            |
| 150104  | Strover Creek - Ferry Ave                      | 7/20/2018 | 257                | ND                  | ND                |
| 150104  | Strover Creek - Ferry Ave                      | 7/26/2018 | 366                | ND                  | ND                |
| 150105  | Loeb Creek - M 66                              | 7/9/2018  | 352                | ND                  | ND                |
| 150105  | Loeb Creek - M 66                              | 7/16/2018 | 419                | ND                  | ND                |
| 150105  | Loeb Creek - M 66                              | 7/26/2018 | 869                | ND                  | ND                |
| 150105  | Loeb Creek - M 66                              | 8/2/2018  | 285                | ND                  | ND                |
| 150191  | Brown S Creek - McKay St                       | 7/9/2018  | 448                | ND                  | ND                |
| 150191  | Brown S Creek - McKay St                       | 7/16/2018 | 687                | ND                  | ND                |
| 150191  | Brown S Creek - McKay St                       | 7/20/2018 | 315                | ND                  | ND                |
| 150191  | Brown S Creek - McKay St                       | 7/26/2018 | 479                | ND                  | 432.67            |
| 150254  | Trib to Lake Charlevoix - Champerret Dr W      | 7/16/2018 | 257                | ND                  | ND                |
| 150254  | Trib to Lake Charlevoix - Champerret Dr W      | 8/2/2018  | 273                | ND                  | ND                |
| 280316  | Kids Creek - 11th St                           | 7/10/2018 | 366                | ND                  | ND                |
| 280316  | Kids Creek - 11th St                           | 7/17/2018 | 316                | ND                  | ND                |
| 280316  | Kids Creek - 11th St                           | 7/23/2018 | 517                | ND                  | ND                |
| 280316  | Kids Creek - 11th St                           | 7/27/2018 | 537                | ND                  | ND                |
| 280418  | Kids Creek (Trib A) - Elmwood Ave              | 7/10/2018 | 498                | ND                  | ND                |
| 280418  | Kids Creek (Trib A) - Elmwood Ave              | 7/17/2018 | 299                | ND                  | ND                |
| 280418  | Kids Creek (Trib A) - Elmwood Ave              | 7/20/2018 | 403                | ND                  | ND                |
| 280418  | Kids Creek (Trib A) - Elmwood Ave              | 7/27/2018 | 785                | ND                  | ND                |
| 280418  | Kids Creek (Trib A) - Elmwood Ave              | 8/3/2018  | 583                | ND                  | ND                |
| 280426  | Kids Creek - Front St                          | 7/10/2018 | 625                | ND                  | ND                |
| 280426  | Kids Creek - Front St                          | 7/17/2018 | 470                | ND                  | ND                |
| 280426  | Kids Creek - Front St                          | 7/23/2018 | 470                | 401.2               | ND                |
| 280426  | Kids Creek - Front St                          | 7/27/2018 | 642                | ND                  | ND                |
| 280426  | Kids Creek - Front St                          | 8/3/2018  | 308                | ND                  | ND                |
| 100226  | Cold Creek (S Br) - d/s Michigan Ave (south)   | 7/17/2018 | 320                | ND                  | ND                |
| 100226  | Cold Creek (S Br) - d/s Michigan Ave (south)   | 7/23/2018 | 262                | ND                  | ND                |
| 100226  | Cold Creek (S Br) - d/s Michigan Ave (south)   | 7/27/2018 | 269                | ND                  | ND                |
| 100261  | Cold Creek (N Br) - off Michigan Ave (north)   | 7/17/2018 | 820                | ND                  | ND                |
| 100261  | Cold Creek (N Br) - off Michigan Ave (north)   | 7/20/2018 | 342                | ND                  | ND                |
| 100262  | Cold Creek (Mid Br) - Narrow Gauge Rd (N side) | 7/10/2018 | 402                | ND                  | ND                |
| 100262  | Cold Creek (Mid Br) - Narrow Gauge Rd (N side) | 7/17/2018 | 496                | ND                  | ND                |
| 100262  | Cold Creek (Mid Br) - Narrow Gauge Rd (N side) | 7/23/2018 | 982                | ND                  | ND                |
| 100262  | Cold Creek (Mid Br) - Narrow Gauge Rd (N side) | 7/27/2018 | 326                | ND                  | ND                |
| 270223  | Planter Creek - Thomaston Rd. (PC-4)           | 8/3/2018  | 2,033              | ND                  | ND                |
| 270223  | Planter Creek - Thomaston Rd. (PC-4)           | 8/7/2018  | 200                | ND                  | 416.9             |
| 270223  | Planter Creek - Thomaston Rd. (PC-4)           | 8/16/2018 | 235                | ND                  | 472               |
| 270223  | Planter Creek - Thomaston Rd. (PC-4)           | 8/23/2018 | 270                | ND                  | ND                |
| 270223  | Planter Creek - Thomaston Rd. (PC-4)           | 8/27/2018 | 2,684              | 424.8               | 424.8             |

### 6.1.2 Watershed Summaries:

The following are summaries by watershed, accompanied by a table of results color coded to indicate value relative to other events (Tables 2-11). Cells with warmer colors (red and orange) indicate *E. coli* results above the median of all data (yellow cells). Cooler colors (blues) indicate results below the median. Data are summarized by weekly averages and the 30-day geometric mean to allow spatial and temporal visualization of results. The relationship between flow and *E. coli* concentrations, weather information, and microbial source tracking results are also summarized in each of the watershed summaries below.

#### a. Black-Presque Isle (7 sites) and Keweenaw Peninsula (4 sites) –

In the Keweenaw watershed, all sites exceeded the daily TBC WQS; of these, the tributary to West Branch Firesteel River at Old M-35 exceeded the PBC during dry weather (although flows were relatively high at that time) (Table 2). Three sites in the Black-Presque-Isle watershed exceeded the TBC: Powder Mill Creek at US-2, Kallander Creek, and Planter Creek (Table 3). Of these, the Planter Creek site exceeded the PBC WQS in both wet and dry weather. The remaining sites in this watershed met all applicable *E. coli* WQS. Both human and bovine *Bacteroides* were found in Planter Creek samples. Planter Creek is the receiving water for the Wakefield Wastewater Stabilization Lagoon (WWSL); however, the most recent discharge from the WWSL prior to our August sampling occurred in late May. The WWSL isolated its lagoon from receiving new sewage on May 11, 2018, and discharged from approximately May 25-31, 2018, with nondetect fecal coliform levels prior to discharge (MiWaters, Permit Number-MI0021440, accessed February 25, 2019). Since *B. theta* degrades after only a few days in the environment, the *B. theta* detected in Planter Creek likely did not originate from the seasonal WWSL discharge.

*Table 2. E. coli DGM, 30-day geometric means, and weekly averages at Keweenaw Peninsula sites.*

| Site Description                         | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | 30-Day Geometric Mean |
|--|--------|--------|--------|--------|--------|-----------------------|
| Firesteel R - M-26                       | 191    | 379    | 70     | 88     | 229    | 159                   |
| Trib to W Br Firesteel R - M-26          | 31     | 103    | 32     | 63     | 307    | 72                    |
| Trib to W Br Firesteel R (SW) - Old M-35 | 2      | 1,132  | 31     | 9      | 534    | 52                    |
| W Br Firesteel R - Old M 35              | 54     | 324    | 134    | 88     | 252    | 139                   |
| Weekly Average                           | 70     | 485    | 67     | 62     | 330    |                       |

Table 3. *E. coli* DGM, 30-day geometric means, and weekly averages at Black-Presque-Isle sites.

| Site Description                            | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | 30-Day Geometric Mean |
|---|--------|--------|--------|--------|--------|-----------------------|
| Black River - Black Jack Rd                 | 32     | 9      | 49     | 18     | 196    | 35                    |
| Black River - Moore Rd                      | 48     | 49     | 74     | 101    | 213    | 82                    |
| Kallander Creek - Stone Rd.                 | 198    | 184    | 192    | 190    | 621    | 242                   |
| Planter Creek - Thomaston Rd. (PC-4)        | 2,033  | 200    | 235    | 270    | 2,684  | 586                   |
| Powder Mill Creek - Black River Rd          | 16     | 33     | 22     | 69     | 209    | 44                    |
| Powder Mill Creek – US-2                    | 57     | 203    | 102    | 188    | 273    | 143                   |
| Trib To Powder Mill Creek - Black River Rd. | 10     | 76     | 23     | 18     | 73     | 30                    |
| Weekly Average                              | 342    | 108    | 100    | 122    | 610    |                       |

### b. Kalamazoo (16 sites)

All sites exceeded the daily TBC WQS multiple times. During sampling in the Rabbit River (Table 4) a large rain event caused very high flows on the last sampling event (October 1-2, 2018). At several of the sites the flows were up by more than a meter and were close to exceeding the capacity of the bridges and culverts (Figure 3), resulting in *E. coli* concentrations as high as 473,240 *E. coli*/100mL. Evidence of sediment deposited on roadways and high on the banks noted during low flows indicates that these high flows are not uncommon in the Rabbit River watershed. All the sites in the Rabbit River watershed showed a strong positive relationship between *E. coli* and flow (Appendix 5). Dry weather exceedances of the PBC were also common in the Rabbit River. Sampling in the Spring Arbor/Concord Drain (upper Kalamazoo watershed) occurred in May-June, and no major rain events preceded sampling. Neither of the 2 Spring Arbor/Concord Drain sites exceeded the PBC WQS during dry weather (Table 5); additionally, results showed that *E. coli* levels generally decreased as the flows got higher, indicating constant sources of *E. coli* during this study (Appendix 4). Livestock (sheep) with direct and unrestricted access to a tributary of Arbor/Concord Drain were a known source during the 2018 monitoring.



Figure 3. Tributary to Black Creek at 40<sup>th</sup> Avenue. Image on left was taken during low flows on September 5, 2018; water levels were 2.3 meters higher on October 2, 2018 (on right).

*Table 4. E. coli DGM, 30-day geometric means, and weekly averages at Lower Kalamazoo sites.*

| Site Description              | Week 1 | Week 2 | Week 3 | Week 4 | Week 5  | 30-Day Geometric Mean |
|-------------------------------|--------|--------|--------|--------|---------|-----------------------|
| Bear Creek - 130th Ave        | 583    | 693    | 1,925  | 868    | 119,348 | 2,405                 |
| Black Creek - 139th Ave       | 1,547  | 641    | 699    | 1,066  | 142,801 | 2,539                 |
| Black Creek - 32nd St         | 1,574  | 777    | 1,461  | 1,786  | 78,150  | 3,015                 |
| Cuddy Drain - Patterson Rd    | 519    | 800    | 838    | 492    | 15,810  | 1,221                 |
| Dorr And Byron Dr - 21st St   | 1,710  | 339    | 994    | 323    | 65,327  | 1,648                 |
| Haney Drain - 138th Ave       | 1,134  | 607    | 1,102  | 865    | 41,146  | 1,933                 |
| Little Rabbit River - 32nd St | 1,428  | 723    | 1,334  | 584    | 123,201 | 2,508                 |
| Miller Creek - 128th Ave      | 548    | 472    | 946    | 556    | 44,554  | 1,434                 |
| Pigeon Creek - 138th Ave      | 2,807  | 646    | 1,351  | 1,309  | 55,544  | 2,819                 |
| Rabbit River - 10th St        | 437    | 463    | 522    | 680    | 11,548  | 963                   |
| Rabbit River - 132nd Ave      | 1,725  | 390    | 1,160  | 571    | 36,241  | 1,745                 |
| Rabbit River - 36th St        | 380    | 465    | 708    | 427    | 79,594  | 1,335                 |
| Red Run Dr - 21st St          | 1,862  | 557    | 495    | 413    | 473,240 | 2,513                 |
| Trib To Black Creek - 40th    | 1,423  | 1,063  | 973    | 1,059  | 70,637  | 2,561                 |
| Weekly Average                | 1,263  | 617    | 1,036  | 786    | 96,939  |                       |

*Table 5. E. coli DGM, 30-day geometric means, and weekly averages at Upper Kalamazoo sites.*

| Site Description                          | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | 30-Day Geometric Mean |
|---|--------|--------|--------|--------|--------|-----------------------|
| Spring Arbor/Concord Drain - King Rd      | 54     | 159    | 403    | 750    | 507    | 266                   |
| Spring Arbor/Concord Drain - N Concord Rd | 98     | 283    | 280    | 548    | 747    | 317                   |
| Weekly Average                            | 76     | 221    | 341    | 649    | 627    |                       |

### c. Lower Grand (7 sites)

All sites in the Lower Grand (Rogue River) watershed exceeded the daily TBC WQS, except for the Rogue River at 22 Mile Road; however, this site did exceed the 30-day geometric mean TBC WQS (Table 6). Rogue River at 22 Mile Road was also the only site in this watershed where *E. coli* appeared to have a negative relationship with relative water level (higher water level events had lower *E. coli*, despite the lack of daily exceedances); the rest had a positive relationship (Appendix 5). Four of the sites exceeded the PBC WQS one or more times, with Ball Creek having 3 exceedances. Apart from Ball Creek, which exceeded multiple times, the PBC WQS exceedances occurred on the final sampling event (July 2, 2018). A heavy rainfall (1.69 inches on June 27, 2018) raised water levels dramatically 5 days prior to that sampling event. During this time the mainstem Rogue River had a noticeable sewage odor (personal observation). The water level had largely receded by the July 2, 2018, sampling date but remained elevated at some sites. Inundation of septic systems adjacent to the rivers and increased flow from field tiles may be the reason for the high *E. coli* on July 2, 2018.

*Table 6. E. coli DGM, 30-day geometric means, and weekly averages at Lower Grand (Rogue River) sites.*

| <b>Site Description</b>          | <b>Week</b> | <b>Week</b> | <b>Week</b> | <b>Week</b> | <b>Week</b> | <b>30-Day Geometric Mean</b> |
|----------------------------------|-------------|-------------|-------------|-------------|-------------|------------------------------|
|                                  | 1           | 2           | 3           | 4           | 5           |                              |
| Ball Creek - Stebbins Ave NW     | 1,197       | 518         | 1,042       | 636         | 1,141       | 860                          |
| Cedar Creek - Friske Dr NE       | 243         | 349         | 543         | 385         | 7,608       | 670                          |
| Duke Creek - N Division Ave      | 353         | 304         | 465         | 519         | 2,219       | 565                          |
| Nash Creek - E Division St       | 478         | 236         | 486         | 450         | 358         | 388                          |
| Rogue River - 12 Mile Rd         | 227         | 278         | 308         | 283         | 2,282       | 417                          |
| Rogue River - 22 Mile Rd NW      | 159         | 115         | 209         | 142         | 138         | 150                          |
| Rogue River - Indian Lakes Rd NW | 347         | 284         | 421         | 361         | 348         | 350                          |
| Weekly Average                   | 348         | 275         | 445         | 363         | 961         |                              |

#### d. Thornapple (14 sites)

Two sites in the Thornapple watershed met all applicable *E. coli* WQS (Thornapple River at North Airport Road, and upper Glass Creek at Goodwill Road), with an additional site (Thornapple River at East Main Street [Middleville]) meeting the daily TBC WQS but exceeding the 30-Day geometric TBC WQS. Generally, sites in the Middle and Upper Thornapple had more exceedances of the TBC and PBC WQS (top portion of Table 7). In the upper Thornapple (HUC 0405000701), all sites exceeded the daily TBC WQS continually (in both dry weather/low flow exceedances, and wet weather/high flow [Appendices 4 and 5]). Within the Thornapple, *E. coli* had a negative relationship with flow (higher flows had lower *E. coli*) at 3 sites: Fall Creek, Mud Creek, and the Thornapple River at East Main Street in Middleville (Appendix 5). The remainder of the Thornapple watershed sites showed the opposite general relationship of increasing *E. coli* with increasing flows (Appendix 5).

*Table 7. E. coli DGM, 30-day geometric means, and weekly averages at Thornapple sites.*

| Site Description                           | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | 30-Day Geometric Mean |
|--|--------|--------|--------|--------|--------|-----------------------|
| Butternut Creek - Mcconnel Rd              | 1,395  | 1,309  | 464    | 452    | 1,887  | 937                   |
| Church Drain - Stewart Rd                  | 601    | 1,080  | 650    | 973    | 913    | 822                   |
| Little Thornapple River - Gresham Hwy      | 966    | 866    | 570    | 1,712  | 1,072  | 974                   |
| Thornapple River - N Stewart Rd            | 768    | 1,960  | 805    | 1,405  | 1,423  | 1,193                 |
| Thornapple River - Gresham Hwy             | 628    | 902    | 572    | 1,019  | 1,382  | 855                   |
| Mud Creek - Barger Rd                      | 446    | 266    | 287    | 635    | 571    | 415                   |
| Cedar Creek - Mckeown Rd                   | 276    | 669    | 425    | 3,177  | 590    | 681                   |
| Fall Creek - Shriner St                    | 415    | 282    | 524    | 554    | 1,493  | 551                   |
| Glass Creek - N M 37                       | 445    | 368    | 446    | 185    | 546    | 375                   |
| Glass Creek - Goodwill Rd                  | 87     | 58     | 256    | 70     | 166    | 109                   |
| Thornapple River - 68th St SE              | 52     | 70     | 472    | 174    | 52     | 110                   |
| Thornapple River - E Main St - Middleville | 165    | 276    | 292    | 232    | 281    | 244                   |
| Thornapple River - N Airport Rd            | 92     | 103    | 153    | 105    | 79     | 104                   |
| McCords Creek - Buttrick Ave SE            | 267    | 234    | 466    | 232    | 416    | 309                   |
| Weekly Average                             | 472    | 603    | 456    | 780    | 776    |                       |

### e. Betsie-Platte (6 sites)

All the sites in the Betsie-Platte exceeded the daily TBC and 30-day TBC WQS, but none exceeded the PBC WQS. Herring Creek and Cold Creek (Middle Branch) had the most exceedances in this watershed, with the Cold Creek site coming close to exceeding the PBC WQS (Table 8). Within the Betsie-Platte watershed, only samples from the 3 Cold Creek sites were sent for microbial source tracking, and neither bovine or human bacteroides were detected.

*Table 8. E. coli DGM, 30-day geometric means, and weekly averages at Betsie-Platte sites.*

| Site Description                               | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | 30-Day Geometric Mean |
|--|--------|--------|--------|--------|--------|-----------------------|
| Cold Creek (Mid Br) - Narrow Gauge Rd (N Side) | 402    | 496    | 982    | 326    | 205    | 420                   |
| Cold Creek (N Br) - Off Michigan Ave (North)   | 121    | 820    | 342    | 163    | 111    | 228                   |
| Cold Creek (S Br) - D/S Michigan Ave (South)   | 150    | 320    | 262    | 269    | 127    | 212                   |
| Herring Creek (Trib To) - Gorivan Rd           | 649    | 547    | 498    | 332    | 260    | 433                   |
| Raymond Ditch - Mick Rd                        | 367    | 152    | 199    | 228    | 66     | 175                   |
| Richley Creek - Saint Pierre Rd                | 150    | 189    | 120    | 313    | 146    | 173                   |
| Weekly Average                                 | 307    | 421    | 400    | 272    | 153    |                       |

## f. Boardman-Charlevoix (17 sites)

The majority of the sites in the tributaries to Lake Charlevoix (including the Boyne and Jordan Rivers) met all applicable *E. coli* WQS (Table 9). The exceptions were the unnamed tributary at Champerret Drive and Brown S, Strover, and Loeb Creeks. Microbial source tracking for bovine and human sources indicated bovine sources were present at Strover Creek on July 16 (dry weather) and at Brown S Creek on July 26 (minor wet weather event). In Kids Creek, located in Traverse City, the PBC was not exceeded; however, the daily and 30-day TBC WQS were exceeded. Human bacteroides was detected at Kids Creek - Front Street on 1 occasion (July 23, 2018) following a rainfall event of about 0.9 inches in the previous 48-hours. Two sites were located on Northport Creek (Leelanau County); the site above the town of Northport (Melkild/3rd Street) met all applicable *E. coli* WQS, while the downstream site (Rose Road) exceeded the daily TBC once during dry weather, as well as the 30-day geometric mean. A likely source of contamination is the impoundment located upstream of the Rose Road site, which is popular with waterfowl.

*Table 9. E. coli DGM, 30-day geometric means, and weekly averages at Boardman-Charlevoix sites.*

| Site Description                          | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | 30-Day Geometric Mean |
|---|--------|--------|--------|--------|--------|-----------------------|
| Boyne River - Lake Rd Bridge - Boyne City | 47     | 76     | 91     | 96     | 57     | 71                    |
| Brown S Creek - Mckay St                  | 448    | 687    | 315    | 479    | 239    | 407                   |
| Deer Creek - Pearsall Rd                  | 82     | 136    | 96     | 119    | 101    | 105                   |
| Horton Creek - Mouth                      | 60     | 87     | 59     | 145    | 52     | 75                    |
| Jordan River - Rogers Rd                  | 55     | 66     | 40     | 70     | 150    | 68                    |
| Loeb Creek - M 66                         | 352    | 419    | 147    | 869    | 285    | 351                   |
| Monroe Creek - M 66                       | 100    | 181    | 67     | 66     | 83     | 92                    |
| North Branch Boyne River - US 131         | 45     | 54     | 42     | 89     | 54     | 55                    |
| Porter Creek - Lake Shore Rd              | 134    | 155    | 92     | 151    | 98     | 123                   |
| S Br Boyne River - Boyne Mountain Rd      | 27     | 64     | 36     | 63     | 132    | 55                    |
| Strover Creek - Ferry Ave                 | 352    | 308    | 257    | 366    | 228    | 297                   |
| Trib To Lake Charlevoix - Champerret Dr W | 92     | 257    | 228    | 241    | 273    | 204                   |
| Kids Creek - 11th St                      | 366    | 316    | 517    | 537    | 207    | 367                   |
| Kids Creek - Front St                     | 625    | 470    | 470    | 642    | 308    | 487                   |
| Kids Creek (Trib A) - Elmwood Ave         | 498    | 299    | 403    | 785    | 583    | 487                   |
| Northport Creek - Melkild/3rd             | 35     | 175    | 87     | 132    | 48     | 80                    |
| Northport Creek - Rose Rd                 | 153    | 395    | 187    | 180    | 66     | 168                   |
| Weekly Average                            | 204    | 244    | 184    | 296    | 174    |                       |

### g. Pigeon-Wiscoggin (5 sites) and Birch-Willow (4 sites)

In interpreting *E. coli* data from these watersheds, it should be noted that many of the streams in the Pigeon-Wiscoggin and Birch-Willow became stagnant between rainfall events. Extremely low flows can lead to increased mortality of *E. coli* by lengthening the time they are exposed to the ambient temperatures and sunlight. All sites in the Pigeon-Wiscoggin exceeded the daily and 30-day TBC WQS, with the Pigeon River at Geiger Road exceeding most often (all 5 events) (Table 10). Bird Creek and the New River also exceeded the PBC WQS, which occurred during relatively high flows but with little to no recent prior precipitation. Analysis of the Bird Creek results showed the trend of decreasing *E. coli* concentration with higher flows, indicating that dry weather (constant) sources of *E. coli* are likely being diluted (Appendix 5). All Birch-Willow sites exceeded the daily TBC WQS and only Willow Creek at Dobson did not exceed the PBC WQS. Due to a missing sample, a 30-day geometric mean was not available for Willow Creek at Stoddard Road; however, the remaining sites exceeded that standard. Results from the Tributary to Willow at Huron City Road showed decreasing *E. coli* concentration with higher flows, indicating that dry weather (constant) sources of *E. coli* are likely being diluted (Appendix 5). The remaining sites showed increasing *E. coli* with increasing water levels, although the strength of this relationship varied widely.

*Table 10. E. coli DGM, 30-day geometric means, and weekly averages at Pigeon-Wiscoggin and Birch-Willow sites.*

| Site Description                               | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | 30-Day Geometric Mean |
|--|--------|--------|--------|--------|--------|--------|-----------------------|
| Bird Creek - Knoblock/Hunter Rd                |        | 1,917  | 443    | 142    | 786    | 404    | 521                   |
| Fisher Drain - Griggs Rd                       | 360    | 944    | 73     | 398    | 209    |        | 290                   |
| New River - Stoddard Rd                        | 1,028  | 72     | 107    | 108    | 31     |        | 122                   |
| Pigeon River - Geiger Rd.                      | 602    | 308    | 304    | 410    | 873    |        | 458                   |
| Pigeon River - Limerick Rd                     | 197    | 786    | 156    | 228    | 231    |        | 264                   |
| East Branch Willow Creek - Upstream Minnick Rd | 85     | 2,420  | 1,095  | 1,954  | 339    |        | 683                   |
| Trib To Willow Creek - Huron City Rd           | 169    | 1,303  | 954    | 479    | 2,266  |        | 744                   |
| Willow Creek - Dobson Rd                       | 700    | 395    | 144    | 228    | 292    |        | 305                   |
| Willow Creek - Stoddard Rd                     | 262    | 193    |        | 174    | 140    | 2,420  |                       |
| Weekly Average                                 | 425    | 926    | 409    | 458    | 574    | 1,412  |                       |

## **h. Flint (9 sites)**

All sites exceeded the daily and 30-day TBC WQS, with 5 of the sites exceeding the daily TBC WQS during all events. While most sites exceeded the PBC WQS more than once, Carman Drain exceeded the PBC WQS for all 5 events. *E. coli* in Carman Drain was extremely high regardless of flow or weather, indicating a persistent and severe contamination issue (Appendix 4). No microbial source tracking was conducted in the Flint watershed; however, illicit discharges are the most probable source given the highly urban and residential nature of upstream areas. All sites showed increasing *E. coli* with increasing water levels, although the strength of this relationship varied widely. High water levels and a rain event likely caused the week 2 sampling event *E. coli* to be the overall highest (Table 11).

*Table 11. E. coli DGM, 30-day geometric means, and weekly averages at Flint sites.*

| <b>Site Description</b>           | <b>Week 1</b> | <b>Week 2</b> | <b>Week 3</b> | <b>Week 4</b> | <b>Week 5</b> | <b>30-Day Geometric Mean</b> |
|-----------------------------------|---------------|---------------|---------------|---------------|---------------|------------------------------|
| Carman Drain - 12th St            | 2,429         | 8,393         | 1,674         | 3,830         | 1,339         | 2,809                        |
| Cole Creek - Seymour Rd (North)   | 520           | 2,065         | 991           | 849           | 1,046         | 989                          |
| Flint River - Main St             | 130           | 1,429         | 24            | 115           | 606           | 200                          |
| Indian Creek - Cook Rd            | 1,528         | 3,503         | 584           | 743           | 1,029         | 1,190                        |
| Swartz Creek - Hammerberg Rd      | 1,602         | 5,331         | 492           | 820           | 1,396         | 1,369                        |
| Swartz Creek - Maple Rd           | 785           | 998           | 357           | 169           | 370           | 445                          |
| Thread Creek - Dort Hwy           | 2,438         | 3,213         | 521           | 863           | 1,066         | 1,303                        |
| Thread Creek - Perry Rd           | 399           | 950           | 270           | 281           | 605           | 445                          |
| W Branch Swartz Creek - Linden Rd | 821           | 2,572         | 220           | 715           | 2,000         | 921                          |
| <b>Weekly Average</b>             | <b>1,184</b>  | <b>3,161</b>  | <b>570</b>    | <b>932</b>    | <b>1,051</b>  |                              |

## **6.2 Monitoring Objective 3**

D.O. met the applicable minimum WQS at most monitored sites at the time of sampling (Appendix 3); however, because these events were instantaneous readings, it cannot be determined if the designated use is being met. Because these measurements were not collected prior to sunrise, during the time that is generally critical for low D.O., it is recommended that continuous D.O. studies be conducted at these sites, as resources allow.

Warmwater designated sites that had readings below the minimum D.O. WQS include (by watershed):

- Planter Creek (270223) in the Black-Presque Isle.
- Butternut Creek (230207), Little Thornapple River (230209), and Mud Creek (080211) in the Thornapple.
- Fisher Drain (320361), Bird Creek (320362), and New River (320335 ) in the Pigeon-Wiscoggin.
- East Branch Willow Creek (320279), Willow Creek (320240), and Tributary to Willow (320358) in the Birch-Willow watershed.
- Indian Creek (250460) in the Flint.

Coldwater designated streams (by watershed) that had readings below the D.O. WQS were:

- Tributary to West Branch Firesteel River (660090) in the Keweenaw Peninsula.
- Rogue River (620314 and 410644) and Nash Creek (410831) in the Lower Grand.
- Glass Creek (080230) in the Thornapple.
- North Branch Cold Creek (100261), Richley Creek (440260), and Tributary to Herring Creek (100263) in the Betsie-Platte.

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Amasa, Michigan 49903

## 8 References

- Balleste, E. and A. R. Blanch (2010). "Persistence of Bacteroides species populations in a river as measured by molecular and culture techniques." Appl Environ Microbiol **76**(22): 7608-7616.
- MDNR (1997). "Designated Trout Streams for the State of Michigan. Director's Order #DFI-101.97."
- MSU Extension. (2018). "Michigan Enviro-Weather." Retrieved Januare, 2018, 2018, from <http://www.enviro-weather.msu.edu/>.
- Murphy, H. (2018). Persistence of Pathogens in Sewage and Other Water Types. Part 4: Management of Risk from Excreta and Wastewater, Global Water Protection Project.
- Shanks, O. C., E. Atikovic, et al. (2008). "Quantitative PCR for detection and enumeration of genetic markers of bovine fecal pollution." Appl Environ Microbiol **74**(3): 745-752.
- Weather Underground. (2018). "<http://www.wunderground.com>. KMIIIRONW3 Ironwood MI US." Retrieved January, 2018, 2018.
- Yampara-Iquise, H., G. Zheng, et al. (2008). "Use of a Bacteroides thetaiotaomicron-specific alpha-1-6, mannanase quantitative PCR to detect human faecal pollution in water." J Appl Microbiol **105**(5): 1686-1693.



Appendix 1. Site location information including watershed name, 12-digit hydrologic unit code (HUC), description, site ID (WQX/Storet). All weather stations are from Michigan State University weather network (<https://mawn.geo.msu.edu/>), except the Ewen station ([www.weatherunderground.com](http://www.weatherunderground.com)).

| Watershed          | 12-Digit HUC | Site ID | Site Description                            | Latitude | Longitude | Weather Station |
|--------------------|--------------|---------|---|----------|-----------|-----------------|
| Black-Presque Isle | 040201010204 | 270223  | Planter Creek - Thomaston Rd. (PC-4)        | 46.50740 | -89.93480 | Ewen            |
|                    | 040201010205 | 270023  | Powder Mill Creek - Black River Rd          | 46.51013 | -90.07299 | Ewen            |
|                    | 040201010205 | 270103  | Black River - Moore Rd                      | 46.51228 | -90.05284 | Ewen            |
|                    | 040201010205 | 270169  | Powder Mill Creek - US2                     | 46.48127 | -90.07916 | Ewen            |
|                    | 040201010205 | 270176  | Kallander Creek - Stone Rd.                 | 46.49923 | -90.05056 | Ewen            |
|                    | 040201010205 | 270238  | Black River - Black Jack Rd                 | 46.50532 | -89.99614 | Ewen            |
|                    | 040201010205 | 270239  | Trib To Powder Mill Creek - Black River Rd. | 46.50847 | -90.06477 | Ewen            |
| Keweenaw Peninsula | 040201030104 | 660090  | Trib to W Br Firesteel R - M-26             | 46.78530 | -89.03360 | Ewen            |
|                    | 040201030104 | 660174  | Firesteel R - M-26                          | 46.79083 | -89.02655 | Ewen            |
|                    | 040201030104 | 660184  | Trib to W Br Firesteel R (SW) - Old M-35    | 46.76900 | -89.00220 | Ewen            |
|                    | 040201030104 | 660185  | W Br Firesteel R - Old M 35                 | 46.77050 | -89.00140 | Ewen            |
| Kalamazoo          | 040500030102 | 380442  | Spring Arbor / Concord Drain - King Rd      | 42.21831 | -84.61447 | albion          |
|                    | 040500030102 | 380443  | Spring Arbor / Concord Drain - N Concord Rd | 42.22999 | -84.64045 | albion          |
|                    | 040500030701 | 030721  | Cuddy Drain - Patterson Rd                  | 42.62436 | -85.54495 | kalamazoo       |
|                    | 040500030801 | 030728  | Haney Drain - 138th Ave                     | 42.69563 | -85.65479 | hudsonville     |
|                    | 040500030802 | 030575  | Rabbit River - 10th St                      | 42.68568 | -85.64359 | hudsonville     |
|                    | 040500030803 | 030726  | Miller Creek - 128th Ave                    | 42.62399 | -85.74458 | hudsonville     |
|                    | 040500030804 | 030607  | Bear Creek - 130th Ave                      | 42.63854 | -85.75855 | hudsonville     |
|                    | 040500030806 | 030527  | Dorr And Byron Dr - 21st St                 | 42.74083 | -85.75139 | hudsonville     |
|                    | 040500030806 | 030531  | Red Run Dr - 21st St                        | 42.73610 | -85.75139 | hudsonville     |
|                    | 040500030807 | 030580  | Little Rabbit River - 32nd St               | 42.71080 | -85.85900 | hudsonville     |
|                    | 040500030808 | 030582  | Pigeon Creek - 138th Ave                    | 42.69577 | -85.81524 | hudsonville     |
|                    | 040500030808 | 030677  | Rabbit River - 132nd Ave                    | 42.65300 | -85.74999 | hudsonville     |
|                    | 040500030809 | 030600  | Black Creek - 139th Ave                     | 42.70247 | -85.90044 | hudsonville     |
|                    | 040500030809 | 700691  | Black Creek - 32nd St                       | 42.77186 | -85.86140 | hudsonville     |
|                    | 040500030809 | 700692  | Trib To Black Creek - 40th Ave              | 42.78580 | -85.88110 | hudsonville     |
|                    | 040500030810 | 030673  | Rabbit River - 36th St                      | 42.70068 | -85.89892 | hudsonville     |
| Lower Grand        | 040500060401 | 620314  | Rogue River - 22 Mile Rd NW                 | 43.29354 | -85.70236 | kentcity        |

| Watershed           | 12-Digit HUC | Site ID | Site Description                               | Latitude | Longitude | Weather Station |
|---------------------|--------------|---------|--|----------|-----------|-----------------|
| Lower Grand         | 040500060402 | 410614  | Duke Creek - N Division Ave                    | 43.22787 | -85.67187 | kentcity        |
|                     | 040500060404 | 410831  | Nash Creek - E Division St                     | 43.16070 | -85.70231 | kentcity        |
|                     | 040500060405 | 410644  | Rogue River - Indian Lakes Rd NW               | 43.19680 | -85.68729 | kentcity        |
|                     | 040500060405 | 410832  | Ball Creek - Stebbins Ave NW                   | 43.19246 | -85.70094 | kentcity        |
|                     | 040500060406 | 410615  | Cedar Creek - Friske Dr NE                     | 43.15618 | -85.60285 | kentcity        |
|                     | 040500060408 | 410415  | Rogue River - 12 Mile Rd                       | 43.14639 | -85.56445 | kentcity        |
| Thornapple          | 040500070101 | 230207  | Butternut Creek - Mcconnel Rd                  | 42.61137 | -84.78323 | charlotte       |
|                     | 040500070102 | 230242  | Thornapple River - N Stewart Rd                | 42.62048 | -84.76835 | charlotte       |
|                     | 040500070102 | 230246  | Church Drain - Stewart Rd                      | 42.61720 | -84.76840 | charlotte       |
|                     | 040500070104 | 230209  | Little Thornapple R - Gresham Hwy              | 42.64047 | -84.87985 | charlotte       |
|                     | 040500070105 | 230196  | Thornapple River - Gresham Hwy                 | 42.64067 | -84.77034 | charlotte       |
|                     | 040500070208 | 080211  | Mud Creek - Barger Rd                          | 42.63593 | -85.16010 | charlotte       |
|                     | 040500070210 | 080223  | Cedar Creek - Mckeown Rd                       | 42.60816 | -85.23604 | charlotte       |
|                     | 040500070401 | 080270  | Fall Creek - Shriner St                        | 42.63758 | -85.28673 | hastings        |
|                     | 040500070402 | 080023  | Thornapple River - N Airport Rd                | 42.66338 | -85.35324 | hastings        |
|                     | 040500070403 | 080230  | Glass Creek - Goodwill Rd                      | 42.60970 | -85.39002 | hastings        |
|                     | 040500070403 | 080278  | Glass Creek - N M 37                           | 42.67492 | -85.43864 | hastings        |
|                     | 040500070406 | 080305  | Thornapple River - E Main St - Middleville     | 42.71116 | -85.46538 | hastings        |
|                     | 040500070407 | 410649  | Mccords Creek - Buttrick Ave SE                | 42.87398 | -85.46799 | hastings        |
|                     | 040500070407 | 410735  | Thornapple River - 68th St SE                  | 42.84005 | -85.47770 | hastings        |
| Betsie-Platte       | 040601040305 | 100226  | Cold Creek (S Br) - D/S Michigan Ave (South)   | 44.62997 | -86.09156 | benzonia        |
|                     | 040601040305 | 100261  | Cold Creek (N Br) - Off Michigan Ave (North)   | 44.63268 | -86.08970 | benzonia        |
|                     | 040601040305 | 100262  | Cold Creek (Mid Br) - Narrow Gauge Rd (N Side) | 44.63216 | -86.08909 | benzonia        |
|                     | 040601040404 | 440260  | Richley Creek - Saint Pierre Rd                | 44.48664 | -86.21457 | bearlake        |
|                     | 040601040406 | 100228  | Raymond Ditch - Mick Rd                        | 44.56085 | -86.16900 | bearlake        |
|                     | 040601040406 | 100263  | Herring Creek (Trib To) - Gorivan Rd           | 44.55910 | -86.17009 | bearlake        |
| Boardman Charlevoix | 040601050203 | 150011  | North Branch Boyne River - US 131              | 45.17982 | -84.91416 | gaylord         |
|                     | 040601050204 | 150010  | Jordan R - Rogers Rd                           | 45.13264 | -85.12377 | gaylord         |
|                     | 040601050204 | 150191  | Brown S Creek - Mckay St                       | 45.15045 | -85.11914 | gaylord         |
|                     | 040601050204 | 150204  | Deer Creek - Pearsall Rd                       | 45.13580 | -85.08079 | gaylord         |
|                     | 040601050205 | 150052  | Boyne R - Lake Rd Bridge - Boyne City          | 45.21420 | -85.01480 | gaylord         |

| Watershed           | 12-Digit HUC | Site ID | Site Description                          | Latitude | Longitude | Weather Station |
|---------------------|--------------|---------|---|----------|-----------|-----------------|
| Boardman Charlevoix | 040601050205 | 150187  | S Br Boyne River - Boyne Mountain Rd      | 45.15752 | -84.92135 | gaylord         |
|                     | 040601050206 | 150106  | Monroe Creek - M 66                       | 45.17964 | -85.16421 | gaylord         |
|                     | 040601050207 | 150104  | Strover Creek - Ferry Ave                 | 45.30082 | -85.24994 | gaylord         |
|                     | 040601050207 | 150105  | Loeb Creek - M 66                         | 45.27990 | -85.23237 | gaylord         |
|                     | 040601050207 | 150248  | Horton Creek - Mouth                      | 45.28080 | -85.08848 | gaylord         |
|                     | 040601050207 | 150252  | Porter Creek - Lake Shore Rd              | 45.22019 | -85.06858 | gaylord         |
|                     | 040601050207 | 150254  | Trib To Lake Charlevoix - Champerret Dr W | 45.27717 | -85.07257 | gaylord         |
|                     | 040601050507 | 280316  | Kids Creek - 11th St                      | 44.75566 | -85.63788 | kalkaska        |
|                     | 040601050507 | 280418  | Kids Creek (Trib A) - Elmwood Ave         | 44.75991 | -85.63985 | kalkaska        |
|                     | 040601050507 | 280426  | Kids Creek - Front St                     | 44.76421 | -85.63092 | kalkaska        |
|                     | 040601050708 | 450140  | Northport Creek - Rose Rd                 | 45.13032 | -85.61402 | elkrapids       |
|                     | 040601050708 | 450155  | Northport Creek - Melkild/3rd             | 45.13122 | -85.62316 | elkrapids       |
| Pigeon-Wiscoggan    | 040801030203 | 320316  | Pigeon River - Geiger Rd - PGN06          | 43.80132 | -83.26250 | pigeon          |
|                     | 040801030204 | 320317  | Pigeon River - Limerick Rd                | 43.91734 | -83.24322 | pigeon          |
|                     | 040801030204 | 320361  | Fisher Drain - Griggs Rd                  | 43.94673 | -83.23437 | pigeon          |
|                     | 040801030405 | 320362  | Bird Creek - Knoblock/Hunter Rd           | 44.02639 | -82.98936 | pigeon          |
|                     | 040801030407 | 320335  | New River - Stoddard Rd                   | 43.99933 | -82.87464 | pigeon          |
| Birch-Willow        | 040801040101 | 320279  | E Br Willow Creek - Minnick Rd            | 43.87126 | -82.83543 | verona          |
|                     | 040801040102 | 320240  | Willow Creek - Dobson Rd                  | 43.91410 | -82.85986 | verona          |
|                     | 040801040103 | 320324  | Willow Creek - Stoddard Rd                | 44.00137 | -82.85353 | verona          |
|                     | 040801040103 | 320358  | Trib to Willow Creek - Huron City Rd      | 43.99998 | -82.83464 | verona          |
| Flint               | 040802040304 | 250402  | W Branch Swartz Creek - Linden Rd         | 42.97125 | -83.77198 | flint           |
|                     | 040802040305 | 250460  | Indian Creek - Cook Rd                    | 42.90012 | -83.71828 | flint           |
|                     | 040802040305 | 250551  | Swartz Creek - Maple Rd                   | 42.95857 | -83.75362 | flint           |
|                     | 040802040306 | 250343  | Thread Creek - Dort Hwy                   | 42.99859 | -83.65396 | flint           |
|                     | 040802040306 | 250550  | Thread Creek - Perry Rd                   | 42.93274 | -83.57392 | flint           |
|                     | 040802040307 | 250335  | Swartz Creek - Hammerberg Rd              | 42.99958 | -83.70708 | flint           |
|                     | 040802040307 | 250339  | Carman Drain - 12th St                    | 42.99219 | -83.70971 | flint           |
|                     | 040802040501 | 250103  | Flint River - Main St                     | 43.06291 | -83.85681 | flint           |
|                     | 040802040501 | 250549  | Cole Creek - Seymour Rd (north)           | 43.06552 | -83.86531 | flint           |

Appendix 2. E. coli results by 10-digit Hydrologic Unit Code (HUC), including prior precipitation (in inches) and relative water level change (in cm). Relative water level change was calculated using the lowest levels recorded during the study as the zero baseline. Exceedances of the WQS are indicated in light red (TBC) and black (PBC).

|                 | L                  | C           | R                                    | Daily Geometric Mean | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|--------------------|-------------|--------------------------------------|----------------------|-----------------------|--------------------|--------------------|----------------------|
| Watershed:      | Black-Presque Isle |             |                                      | Black River          |                       |                    |                    |                      |
| 8-Digit HUC:    | 04020101           |             |                                      | 10-Digit HUC:        | 0402010102            |                    |                    |                      |
| Site ID/Storet: | 270223             | Description | Planter Creek - Thomaston Rd. (PC-4) |                      |                       |                    |                    |                      |
| 8/3/2018        | 1,700              | 1,900       | 2,600                                | 2,033                |                       | 0.01               | 0.02               | 0                    |
| 8/7/2018        | 200                | 200         | 200                                  | 200                  |                       | 0.00               | 0.00               | 2                    |
| 8/16/2018       | 210                | 270         | 230                                  | 235                  |                       | 0.00               | 0.00               | 0                    |
| 8/23/2018       | 250                | 280         | 280                                  | 270                  |                       | 1.73               | 1.73               | 0                    |
| 8/27/2018       | 2,400              | 3,100       | 2,600                                | 2,684                | 586                   | 0.66               | 0.93               | 2                    |
| Site ID/Storet: | 270023             | Description | Powder Mill Creek - Black River Rd   |                      |                       |                    |                    |                      |
| 8/3/2018        | 20                 | 10          | 20                                   | 16                   |                       | 0.01               | 0.17               | 0                    |
| 8/7/2018        | 30                 | 60          | 20                                   | 33                   |                       | 0.00               | 0.00               | 3                    |
| 8/16/2018       | 20                 | 50          | 10                                   | 22                   |                       | 0.00               | 0.00               | 3                    |
| 8/23/2018       | 74                 | 110         | 41                                   | 69                   |                       | 1.73               | 1.73               | 0                    |
| 8/27/2018       | 230                | 210         | 190                                  | 209                  | 44                    | 0.66               | 0.93               | 0                    |
| Site ID/Storet: | 270103             | Description | Black River - Moore Rd               |                      |                       |                    |                    |                      |
| 8/3/2018        | 41                 | 52          | 52                                   | 48                   |                       | 0.01               | 0.22               | 5                    |
| 8/7/2018        | 30                 | 80          | 50                                   | 49                   |                       | 0.00               | 0.00               | 10                   |
| 8/16/2018       | 90                 | 90          | 50                                   | 74                   |                       | 0.00               | 0.00               | 0                    |
| 8/23/2018       | 41                 | 120         | 210                                  | 101                  |                       | 1.73               | 1.73               | 0                    |
| 8/27/2018       | 220                | 200         | 220                                  | 213                  | 82                    | 0.66               | 0.93               | 10                   |
| Site ID/Storet: | 270169             | Description | Powder Mill Creek - US2              |                      |                       |                    |                    |                      |
| 8/3/2018        | 85                 | 52          | 41                                   | 57                   |                       | 0.01               | 0.04               | 0                    |
| 8/7/2018        | 260                | 200         | 160                                  | 203                  |                       | 0.00               | 0.00               | 8                    |
| 8/16/2018       | 80                 | 120         | 110                                  | 102                  |                       | 0.00               | 0.00               | 8                    |
| 8/23/2018       | 160                | 160         | 260                                  | 188                  |                       | 1.73               | 1.73               | 8                    |
| 8/27/2018       | 250                | 280         | 290                                  | 273                  | 143                   | 0.66               | 0.93               | 8                    |
| Site ID/Storet: | 270176             | Description | Kallander Creek - Stone Rd.          |                      |                       |                    |                    |                      |
| 8/3/2018        | 220                | 220         | 160                                  | 198                  |                       | 0.01               | 0.22               | 5                    |
| 8/7/2018        | 230                | 170         | 160                                  | 184                  |                       | 0.00               | 0.00               | 5                    |
| 8/16/2018       | 180                | 230         | 170                                  | 192                  |                       | 0.00               | 0.00               | 2                    |
| 8/23/2018       | 190                | 200         | 180                                  | 190                  |                       | 1.73               | 1.73               | 0                    |
| 8/27/2018       | 800                | 440         | 680                                  | 621                  | 242                   | 0.66               | 0.93               | 8                    |

| L               | C                  | R           | Daily Geometric Mean                        | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|--------------------|-------------|---|-----------------------|--------------------|--------------------|----------------------|
| Site ID/Storet: | 270238             | Description | Black River - Black Jack Rd                 |                       |                    |                    |                      |
| 8/3/2018        | 31                 | 52          | 20  | 32                    |                    | 0.01               | 0.02                 |
| 8/7/2018        | 1                  | 10          | 70  | 9                     |                    | 0.00               | 0.00                 |
| 8/16/2018       | 60                 | 50          | 40  | 49                    |                    | 0.00               | 0.00                 |
| 8/23/2018       | 20                 | 10          | 31  | 18                    |                    | 1.73               | 1.73                 |
| 8/27/2018       | 190                | 190         | 210   | 196                   | 35                 | 0.66               | 0.93                 |
| Site ID/Storet: | 270239             | Description | Trib To Powder Mill Creek - Black River Rd. |                       |                    |                    |                      |
| 8/3/2018        | 10                 | 10          | 10  | 10                    |                    | 0.01               | 0.11                 |
| 8/7/2018        | 60                 | 120         | 60  | 76                    |                    | 0.00               | 0.00                 |
| 8/16/2018       | 20                 | 30          | 20  | 23                    |                    | 0.00               | 0.00                 |
| 8/23/2018       | 31                 | 10          | 20  | 18                    |                    | 1.73               | 1.73                 |
| 8/27/2018       | 85                 | 63          | 73  | 73                    | 30                 | 0.66               | 0.93                 |
| Watershed:      | Keweenaw Peninsula |             | Firesteel River-Frontal Lake Superior       |                       |                    |                    |                      |
| 8-Digit HUC:    | 04020103           |             | 10-Digit HUC:                               | 0402010301            |                    |                    |                      |
| Site ID/Storet: | 660090             | Description | Trib to W Br Firesteel R - M-26             |                       |                    |                    |                      |
| 8/1/2018        | 20                 | 30          | 50  | 31                    |                    | 0.13               | 0.60                 |
| 8/9/2018        | 100                | 110         | 100   | 103                   |                    | 0.00               | 0.00                 |
| 8/14/2018       | 20                 | 31          | 52  | 32                    |                    | 0.00               | 0.00                 |
| 8/21/2018       | 97                 | 63          | 41  | 63                    |                    | 0.02               | 0.02                 |
| 8/30/2018       | 200                | 450         | 320   | 307                   | 72                 | 0.03               | 0.06                 |
| Site ID/Storet: | 660174             | Description | Firesteel R - M-26                          |                       |                    |                    |                      |
| 8/1/2018        | 150                | 310         | 150   | 191                   |                    | 0.20               | 0.62                 |
| 8/9/2018        | 420                | 370         | 350   | 379                   |                    | 0.00               | 0.00                 |
| 8/14/2018       | 63                 | 75          | 74  | 70                    |                    | 0.00               | 0.00                 |
| 8/21/2018       | 98                 | 110         | 63  | 88                    |                    | 0.02               | 0.02                 |
| 8/30/2018       | 230                | 200         | 260   | 229                   | 159                | 0.03               | 0.06                 |
| Site ID/Storet: | 660184             | Description | Trib to W Br Firesteel R (SW) - Old M-35    |                       |                    |                    |                      |
| 8/1/2018        | 1                  | 1           | 10  | 2                     |                    | 0.00               | 0.42                 |
| 8/9/2018        | 1,100              | 1,100       | 1,200                                       | 1,132                 |                    | 0.00               | 0.00                 |
| 8/14/2018       | 74                 | 41          | 10  | 31                    |                    | 0.00               | 0.00                 |
| 8/21/2018       | 41                 | 20          | 1   | 9                     |                    | 0.02               | 0.02                 |
| 8/30/2018       | 240                | 990         | 640   | 534                   | 52                 | 0.03               | 0.05                 |

| L               | C         | R           | Daily Geometric Mean                        | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|-----------|-------------|---|-----------------------|--------------------|--------------------|----------------------|
| Site ID/Storet: | 660185    | Description | W Br Firesteel R - Old M 35                 |                       |                    |                    |                      |
| 8/1/2018        | 40        | 50          | 80  | 54                    | 0.05               | 0.47               | 6                    |
| 8/9/2018        | 290       | 280         | 420   | 324                   | 0.00               | 0.00               | 6                    |
| 8/14/2018       | 110       | 130         | 170   | 134                   | 0.00               | 0.00               | 3                    |
| 8/21/2018       | 63        | 110         | 97  | 88                    | 0.02               | 0.02               | 0                    |
| 8/30/2018       | 220       | 260         | 280   | 252                   | 139                | 0.02               | 0.03                 |
| Watershed:      | Kalamazoo |             | North Branch Kalamazoo River                |                       |                    |                    |                      |
| 8-Digit HUC:    | 04050003  |             | 10-Digit HUC:                               | 0405000301            |                    |                    |                      |
| Site ID/Storet: | 380442    | Description | Spring Arbor / Concord Drain - King Rd      |                       |                    |                    |                      |
| 5/24/2018       | 80        | 50          | 40  | 54                    | 0.00               | 0.00               | 11                   |
| 5/29/2018       | 140       | 160         | 180   | 159                   | 0.00               | 0.00               | 1                    |
| 6/4/2018        | 290       | 450         | 500   | 403                   | 0.00               | 0.00               | 1                    |
| 6/11/2018       | 620       | 840         | 810   | 750                   | 0.01               | 0.54               | 2                    |
| 6/18/2018       | 500       | 500         | 520   | 507                   | 266                | 0.00               | 0.00                 |
| Site ID/Storet: | 380443    | Description | Spring Arbor / Concord Drain - N Concord Rd |                       |                    |                    |                      |
| 5/24/2018       | 140       | 170         | 40  | 98                    | 0.00               | 0.00               | 13                   |
| 5/29/2018       | 350       | 250         | 260   | 283                   | 0.00               | 0.00               | 3                    |
| 6/4/2018        | 290       | 270         | 280   | 280                   | 0.00               | 0.00               | 4                    |
| 6/11/2018       | 360       | 570         | 800   | 548                   | 0.01               | 0.54               | 4                    |
| 6/18/2018       | 730       | 750         | 760   | 747                   | 317                | 0.00               | 0.00                 |
| Watershed:      | Kalamazoo |             | Gun River                                   |                       |                    |                    |                      |
| 8-Digit HUC:    | 04050003  |             | 10-Digit HUC:                               | 0405000307            |                    |                    |                      |
| Site ID/Storet: | 030721    | Description | Cuddy Drain - Patterson Rd                  |                       |                    |                    |                      |
| 9/4/2018        | 420       | 710         | 470   | 519                   | 0.50               | 0.50               | 10                   |
| 9/11/2018       | 770       | 800         | 830   | 800                   | 0.00               | 0.01               | 3                    |
| 9/17/2018       | 770       | 860         | 890   | 838                   | 0.00               | 0.00               | 2                    |
| 9/24/2018       | 470       | 590         | 430   | 492                   | 0.00               | 0.00               | 0                    |
| 10/1/2018       | 13,000    | 16,000      | 19,000                                      | 15,810                | 1,221              | 0.26               | 0.30                 |

| L               | C         | R           | Daily Geometric Mean        | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |     |
|-----------------|-----------|-------------|-----------------------------|-----------------------|--------------------|--------------------|----------------------|-----|
| Watershed:      | Kalamazoo |             | Rabbit River                |                       |                    |                    |                      |     |
| 8-Digit HUC:    | 04050003  |             | 10-Digit HUC:               | 0405000308            |                    |                    |                      |     |
| Site ID/Storet: | 030728    | Description | Haney Drain - 138th Ave     |                       |                    |                    |                      |     |
| 9/5/2018        | 1,030     | 1,300       | 1,090                       | 1,134                 | 0.15               | 0.26               | 15                   |     |
| 9/10/2018       | 680       | 530         | 620                         | 607                   | 0.02               | 0.04               | 4                    |     |
| 9/18/2018       | 1,200     | 930         | 1,200                       | 1,102                 | 0.00               | 0.00               | 0                    |     |
| 9/25/2018       | 1,200     | 740         | 730                         | 865                   | 0.01               | 0.01               | 0                    |     |
| 10/2/2018       | 36,000    | 45,000      | 43,000                      | 41,146                | 1,933              | 0.99               | 1.53                 | 140 |
| Site ID/Storet: | 030575    | Description | Rabbit River - 10th St      |                       |                    |                    |                      |     |
| 9/5/2018        | 370       | 500         | 450                         | 437                   | 0.15               | 0.26               | 5                    |     |
| 9/10/2018       | 540       | 460         | 400                         | 463                   | 0.01               | 0.04               | 2                    |     |
| 9/18/2018       | 430       | 510         | 650                         | 522                   | 0.00               | 0.00               | 0                    |     |
| 9/25/2018       | 670       | 690         | 680                         | 680                   | 0.01               | 0.01               | 1                    |     |
| 10/2/2018       | 14,000    | 10,000      | 11,000                      | 11,548                | 963                | 0.99               | 1.50                 | 94  |
| Site ID/Storet: | 030726    | Description | Miller Creek - 128th Ave    |                       |                    |                    |                      |     |
| 9/4/2018        | 660       | 470         | 530                         | 548                   | 0.12               | 0.23               | 29                   |     |
| 9/11/2018       | 570       | 440         | 420                         | 472                   | 0.00               | 0.01               | 1                    |     |
| 9/17/2018       | 1,400     | 840         | 720                         | 946                   | 0.00               | 0.00               | 0                    |     |
| 9/24/2018       | 580       | 550         | 540                         | 556                   | 0.00               | 0.00               | 0                    |     |
| 10/1/2018       | 40,000    | 67,000      | 33,000                      | 44,554                | 1,434              | 0.46               | 0.58                 | 29  |
| Site ID/Storet: | 030607    | Description | Bear Creek - 130th Ave      |                       |                    |                    |                      |     |
| 9/4/2018        | 680       | 570         | 510                         | 583                   | 0.11               | 0.23               | 33                   |     |
| 9/11/2018       | 710       | 780         | 600                         | 693                   | 0.00               | 0.01               | 3                    |     |
| 9/17/2018       | 1,800     | 2,200       | 1,800                       | 1,925                 | 0.00               | 0.00               | 0                    |     |
| 9/24/2018       | 800       | 890         | 920                         | 868                   | 0.00               | 0.00               | 1                    |     |
| 10/1/2018       | 100,000   | 170,000     | 100,000                     | 119,348               | 2,405              | 0.42               | 0.54                 | 40  |
| Site ID/Storet: | 030527    | Description | Dorr And Byron Dr - 21st St |                       |                    |                    |                      |     |
| 9/4/2018        | 1,400     | 1,700       | 2,100                       | 1,710                 | 0.12               | 0.24               | 17                   |     |
| 9/11/2018       | 310       | 340         | 370                         | 339                   | 0.00               | 0.02               | 2                    |     |
| 9/17/2018       | 930       | 960         | 1,100                       | 994                   | 0.00               | 0.00               | 0                    |     |
| 9/24/2018       | 310       | 350         | 310                         | 323                   | 0.00               | 0.00               | 1                    |     |
| 10/1/2018       | 57,000    | 67,000      | 73,000                      | 65,327                | 1,648              | 0.33               | 0.42                 | 134 |

| L               | C       | R           | Daily Geometric Mean          | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |     |
|-----------------|---------|-------------|-------------------------------|-----------------------|--------------------|--------------------|----------------------|-----|
| Site ID/Storet: | 030531  | Description | Red Run Dr - 21st St          |                       |                    |                    |                      |     |
| 9/4/2018        | 2,000   | 1,700       | 1,900                         | 1,862                 | 0.12               | 0.24               | 16                   |     |
| 9/11/2018       | 610     | 450         | 630                           | 557                   | 0.00               | 0.02               | 7                    |     |
| 9/17/2018       | 530     | 440         | 520                           | 495                   | 0.00               | 0.00               | 0                    |     |
| 9/24/2018       | 420     | 440         | 380                           | 413                   | 0.00               | 0.00               | 4                    |     |
| 10/1/2018       | 410,000 | 550,000     | 470,000                       | 473,240               | 2,513              | 0.30               | 0.39                 | 105 |
| Site ID/Storet: | 030580  | Description | Little Rabbit River - 32nd St |                       |                    |                    |                      |     |
| 9/4/2018        | 1,300   | 1,600       | 1,400                         | 1,428                 | 0.13               | 0.25               | 32                   |     |
| 9/11/2018       | 790     | 630         | 760                           | 723                   | 0.00               | 0.01               | 6                    |     |
| 9/17/2018       | 1,800   | 1,200       | 1,100                         | 1,334                 | 0.00               | 0.00               | 0                    |     |
| 9/24/2018       | 590     | 650         | 520                           | 584                   | 0.00               | 0.00               | 0                    |     |
| 10/1/2018       | 100,000 | 110,000     | 170,000                       | 123,201               | 2,508              | 0.39               | 0.50                 | 42  |
| Site ID/Storet: | 030582  | Description | Pigeon Creek - 138th Ave      |                       |                    |                    |                      |     |
| 9/5/2018        | 2,300   | 2,600       | 3,700                         | 2,807                 | 0.15               | 0.26               | 3                    |     |
| 9/10/2018       | 720     | 720         | 520                           | 646                   | 0.02               | 0.05               | 2                    |     |
| 9/18/2018       | 1,600   | 1,100       | 1,400                         | 1,351                 | 0.00               | 0.00               | 0                    |     |
| 9/25/2018       | 1,200   | 1,100       | 1,700                         | 1,309                 | 0.01               | 0.01               | 0                    |     |
| 10/2/2018       | 60,000  | 51,000      | 56,000                        | 55,544                | 2,819              | 0.99               | 1.44                 | 33  |
| Site ID/Storet: | 030677  | Description | Rabbit River - 132nd Ave      |                       |                    |                    |                      |     |
| 9/4/2018        | 1,500   | 1,900       | 1,800                         | 1,725                 | 0.11               | 0.23               | 43                   |     |
| 9/11/2018       | 290     | 410         | 500                           | 390                   | 0.00               | 0.01               | 5                    |     |
| 9/17/2018       | 1,200   | 1,300       | 1,000                         | 1,160                 | 0.00               | 0.00               | 0                    |     |
| 9/24/2018       | 560     | 520         | 640                           | 571                   | 0.00               | 0.00               | 2                    |     |
| 10/1/2018       | 35,000  | 34,000      | 40,000                        | 36,241                | 1,745              | 0.36               | 0.46                 | 39  |
| Site ID/Storet: | 030600  | Description | Black Creek - 139th Ave       |                       |                    |                    |                      |     |
| 9/5/2018        | 1,210   | 1,700       | 1,800                         | 1,547                 | 0.16               | 0.27               | 52                   |     |
| 9/10/2018       | 700     | 580         | 650                           | 641                   | 0.02               | 0.05               | 11                   |     |
| 9/18/2018       | 730     | 650         | 720                           | 699                   | 0.00               | 0.00               | 0                    |     |
| 9/25/2018       | 1,100   | 1,100       | 1,000                         | 1,066                 | 0.01               | 0.01               | 3                    |     |
| 10/2/2018       | 130,000 | 140,000     | 160,000                       | 142,801               | 2,539              | 0.99               | 1.47                 | 121 |

| L               | C           | R           | Daily Geometric Mean           | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|-------------|-------------|--------------------------------|-----------------------|--------------------|--------------------|----------------------|
| Site ID/Storet: | 700691      | Description | Black Creek - 32nd St          |                       |                    |                    |                      |
| 9/5/2018        | 2,000       | 1,500       | 1,300                          | 1,574                 | 0.14               | 0.25               | 10                   |
| 9/10/2018       | 870         | 780         | 690                            | 777                   | 0.02               | 0.05               | 4                    |
| 9/18/2018       | 2,000       | 1,300       | 1,200                          | 1,461                 | 0.00               | 0.00               | 0                    |
| 9/25/2018       | 1,500       | 1,900       | 2,000                          | 1,786                 | 0.01               | 0.01               | 4                    |
| 10/2/2018       | 74,000      | 86,000      | 75,000                         | 78,150                | 3,015              | 0.99               | 1.34                 |
| Site ID/Storet: | 700692      | Description | Trib To Black Creek - 40th Ave |                       |                    |                    |                      |
| 9/5/2018        | 1,600       | 1,200       | 1,500                          | 1,423                 | 0.15               | 0.26               | 4                    |
| 9/10/2018       | 840         | 1,300       | 1,100                          | 1,063                 | 0.02               | 0.06               | 1                    |
| 9/18/2018       | 1,300       | 920         | 770                            | 973                   | 0.00               | 0.00               | 0                    |
| 9/25/2018       | 1,100       | 900         | 1,200                          | 1,059                 | 0.01               | 0.01               | 1                    |
| 10/2/2018       | 68,000      | 73,000      | 71,000                         | 70,637                | 2,561              | 0.99               | 1.37                 |
| Site ID/Storet: | 030673      | Description | Rabbit River - 36th St         |                       |                    |                    |                      |
| 9/5/2018        | 440         | 290         | 430                            | 380                   | 0.15               | 0.26               | 61                   |
| 9/10/2018       | 410         | 480         | 510                            | 465                   | 0.02               | 0.04               | 15                   |
| 9/18/2018       | 660         | 790         | 680                            | 708                   | 0.00               | 0.00               | 0                    |
| 9/25/2018       | 420         | 370         | 500                            | 427                   | 0.01               | 0.01               | 3                    |
| 10/2/2018       | 84,000      | 69,000      | 87,000                         | 79,594                | 1,335              | 0.99               | 1.41                 |
| Watershed:      | Lower Grand |             | Rogue River                    |                       |                    |                    |                      |
| 8-Digit HUC:    | 04050006    |             | 10-Digit HUC:                  | 0405000604            |                    |                    |                      |
| Site ID/Storet: | 620314      | Description | Rogue River - 22 Mile Rd NW    |                       |                    |                    |                      |
| 6/5/2018        | 180         | 140         | 160                            | 159                   | 0.23               | 0.23               | 14                   |
| 6/12/2018       | 110         | 140         | 100                            | 115                   | 0.00               | 0.00               | 9                    |
| 6/19/2018       | 220         | 230         | 180                            | 209                   | 0.26               | 0.26               | 0                    |
| 6/26/2018       | 150         | 160         | 120                            | 142                   | 0.00               | 0.46               | 0                    |
| 7/2/2018        | 130         | 120         | 170                            | 138                   | 150                | 0.00               | 0.00                 |
| Site ID/Storet: | 410614      | Description | Duke Creek - N Division Ave    |                       |                    |                    |                      |
| 6/5/2018        | 350         | 350         | 360                            | 353                   | 0.23               | 0.23               | 14                   |
| 6/12/2018       | 270         | 360         | 290                            | 304                   | 0.00               | 0.00               | 6                    |
| 6/19/2018       | 510         | 420         | 470                            | 465                   | 0.26               | 0.26               | 2                    |
| 6/26/2018       | 540         | 480         | 540                            | 519                   | 0.00               | 0.46               | 0                    |
| 7/2/2018        | 2,500       | 2,300       | 1,900                          | 2,219                 | 565                | 0.00               | 0.00                 |

|                 | L      | C           | R     | Daily Geometric Mean             | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|--------|-------------|-------|----------------------------------|-----------------------|--------------------|--------------------|----------------------|
| Site ID/Storet: | 410831 | Description |       | Nash Creek - E Division St       |                       |                    |                    |                      |
| 6/5/2018        | 330    | 660         | 500   | 478                              |                       | 0.23               | 0.23               |                      |
| 6/12/2018       | 240    | 250         | 220   | 236                              |                       | 0.00               | 0.00               |                      |
| 6/19/2018       | 490    | 510         | 460   | 486                              |                       | 0.35               | 0.35               |                      |
| 6/26/2018       | 450    | 460         | 440   | 450                              |                       | 0.00               | 0.01               |                      |
| 7/2/2018        | 340    | 330         | 410   | 358                              | 388                   | 0.00               | 0.00               |                      |
| Site ID/Storet: | 410644 | Description |       | Rogue River - Indian Lakes Rd NW |                       |                    |                    |                      |
| 6/5/2018        | 340    | 350         | 350   | 347                              |                       | 0.23               | 0.23               | 28                   |
| 6/12/2018       | 330    | 290         | 240   | 284                              |                       | 0.00               | 0.00               | 16                   |
| 6/19/2018       | 500    | 440         | 340   | 421                              |                       | 0.32               | 0.32               | 150                  |
| 6/26/2018       | 340    | 420         | 330   | 361                              |                       | 0.00               | 0.46               | 0                    |
| 7/2/2018        | 360    | 300         | 390   | 348                              | 350                   | 0.00               | 0.00               | 15                   |
| Site ID/Storet: | 410832 | Description |       | Ball Creek - Stebbins Ave NW     |                       |                    |                    |                      |
| 6/5/2018        | 1,300  | 1,200       | 1,100 | 1,197                            |                       | 0.23               | 0.23               | 5                    |
| 6/12/2018       | 430    | 540         | 600   | 518                              |                       | 0.00               | 0.00               | 2                    |
| 6/19/2018       | 870    | 1,300       | 1,000 | 1,042                            |                       | 0.38               | 0.38               | 1                    |
| 6/26/2018       | 670    | 600         | 640   | 636                              |                       | 0.00               | 0.07               | 0                    |
| 7/2/2018        | 1,500  | 900         | 1,100 | 1,141                            | 860                   | 0.00               | 0.00               | 1                    |
| Site ID/Storet: | 410615 | Description |       | Cedar Creek - Friske Dr NE       |                       |                    |                    |                      |
| 6/5/2018        | 240    | 250         | 240   | 243                              |                       | 0.23               | 0.23               | 4                    |
| 6/12/2018       | 380    | 360         | 310   | 349                              |                       | 0.00               | 0.00               | 3                    |
| 6/19/2018       | 410    | 550         | 710   | 543                              |                       | 0.29               | 0.29               | 2                    |
| 6/26/2018       | 460    | 310         | 400   | 385                              |                       | 0.00               | 0.46               | 0                    |
| 7/2/2018        | 6,200  | 9,600       | 7,400 | 7,608                            | 670                   | 0.00               | 0.00               | 6                    |
| Site ID/Storet: | 410415 | Description |       | Rogue River - 12 Mile Rd         |                       |                    |                    |                      |
| 6/5/2018        | 280    | 220         | 190   | 227                              |                       | 0.23               | 0.23               | 10                   |
| 6/12/2018       | 310    | 240         | 290   | 278                              |                       | 0.00               | 0.00               | 5                    |
| 6/19/2018       | 320    | 260         | 350   | 308                              |                       | 0.38               | 0.38               | 0                    |
| 6/26/2018       | 260    | 300         | 290   | 283                              |                       | 0.00               | 0.00               | 1                    |
| 7/2/2018        | 2,000  | 1,800       | 3,300 | 2,282                            | 417                   | 0.00               | 0.00               | 10                   |

| L               | C          | R           | Daily Geometric Mean              | 30-Day Geometric Mean  | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |   |
|-----------------|------------|-------------|-----------------------------------|------------------------|--------------------|--------------------|----------------------|---|
| Watershed:      | Thornapple |             |                                   | Upper Thornapple River |                    |                    |                      |   |
| 8-Digit HUC:    | 04050007   |             |                                   | 10-Digit HUC:          | 0405000701         |                    |                      |   |
| Site ID/Storet: | 230207     | Description | Butternut Creek - Mcconnel Rd     |                        |                    |                    |                      |   |
| 7/31/2018       | 1,100      | 1,900       | 1,300                             | <b>1,395</b>           |                    | 0.00               | 0.00                 | 0 |
| 8/7/2018        | 1,200      | 1,700       | 1,100                             | <b>1,309</b>           |                    | 0.27               | 0.47                 | 4 |
| 8/14/2018       | 390        | 610         | 420                               | <b>464</b>             |                    | 0.00               | 0.00                 | 2 |
| 8/21/2018       | 410        | 500         | 450                               | <b>452</b>             |                    | 0.22               | 0.26                 | 6 |
| 8/28/2018       | 780        | 2,100       | 4,100                             | <b>1,887</b>           | <b>937</b>         | 0.41               | 0.41                 | 4 |
| Site ID/Storet: | 230242     | Description | Thornapple River - N Stewart Rd   |                        |                    |                    |                      |   |
| 7/31/2018       | 700        | 760         | 850                               | <b>768</b>             |                    | 0.00               | 0.00                 | 1 |
| 8/7/2018        | 1,900      | 2,200       | 1,800                             | <b>1,960</b>           |                    | 0.27               | 0.47                 | 8 |
| 8/14/2018       | 880        | 750         | 790                               | <b>805</b>             |                    | 0.00               | 0.00                 | 0 |
| 8/21/2018       | 1,100      | 1,400       | 1,800                             | <b>1,405</b>           |                    | 0.22               | 0.26                 | 1 |
| 8/28/2018       | 1,500      | 1,200       | 1,600                             | <b>1,423</b>           | <b>1,193</b>       | 0.43               | 0.43                 | 1 |
| Site ID/Storet: | 230246     | Description | Church Drain - Stewart Rd         |                        |                    |                    |                      |   |
| 7/31/2018       | 540        | 650         | 620                               | <b>601</b>             |                    | 0.00               | 0.00                 | 0 |
| 8/7/2018        | 1,000      | 1,400       | 900                               | <b>1,080</b>           |                    | 0.27               | 0.47                 | 0 |
| 8/14/2018       | 670        | 640         | 640                               | <b>650</b>             |                    | 0.00               | 0.00                 | 1 |
| 8/21/2018       | 950        | 970         | 1,000                             | <b>973</b>             |                    | 0.22               | 0.26                 | 2 |
| 8/28/2018       | 900        | 880         | 960                               | <b>913</b>             | <b>822</b>         | 0.39               | 0.39                 | 2 |
| Site ID/Storet: | 230209     | Description | Little Thornapple R - Gresham Hwy |                        |                    |                    |                      |   |
| 7/31/2018       | 960        | 940         | 1,000                             | <b>966</b>             |                    | 0.00               | 0.00                 | 0 |
| 8/7/2018        | 890        | 900         | 810                               | <b>866</b>             |                    | 0.38               | 0.47                 | 2 |
| 8/14/2018       | 540        | 590         | 580                               | <b>570</b>             |                    | 0.00               | 0.00                 | 0 |
| 8/21/2018       | 1,900      | 2,200       | 1,200                             | <b>1,712</b>           |                    | 0.22               | 0.26                 | 1 |
| 8/28/2018       | 1,000      | 1,400       | 880                               | <b>1,072</b>           | <b>974</b>         | 0.25               | 0.25                 | 2 |
| Site ID/Storet: | 230196     | Description | Thornapple River - Gresham Hwy    |                        |                    |                    |                      |   |
| 7/31/2018       | 640        | 570         | 680                               | <b>628</b>             |                    | 0.00               | 0.00                 | 0 |
| 8/7/2018        | 1,100      | 750         | 890                               | <b>902</b>             |                    | 0.28               | 0.47                 | 7 |
| 8/14/2018       | 570        | 670         | 490                               | <b>572</b>             |                    | 0.00               | 0.00                 | 0 |
| 8/21/2018       | 970        | 910         | 1,200                             | <b>1,019</b>           |                    | 0.22               | 0.26                 | 2 |
| 8/28/2018       | 1,200      | 1,000       | 2,200                             | <b>1,382</b>           | <b>855</b>         | 0.37               | 0.37                 | 1 |

| L               | C          | R           | Daily Geometric Mean            | 30-Day Geometric Mean   | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|------------|-------------|---------------------------------|-------------------------|--------------------|--------------------|----------------------|
| Watershed:      | Thornapple |             |                                 | Middle Thornapple River |                    |                    |                      |
| 8-Digit HUC:    | 04050007   |             |                                 | 10-Digit HUC:           | 0405000702         |                    |                      |
| Site ID/Storet: | 080211     | Description | Mud Creek - Barger Rd           |                         |                    |                    |                      |
| 7/31/2018       | 410        | 460         | 470                             | 446                     |                    | 0.00               | 0.00                 |
| 8/7/2018        | 290        | 260         | 250                             | 266                     |                    | 0.47               | 0.47                 |
| 8/14/2018       | 310        | 330         | 230                             | 287                     |                    | 0.00               | 0.00                 |
| 8/21/2018       | 610        | 590         | 710                             | 635                     |                    | 0.22               | 0.26                 |
| 8/28/2018       | 920        | 430         | 470                             | 571                     | 415                | 0.31               | 0.31                 |
| Site ID/Storet: | 080223     | Description | Cedar Creek - McKeown Rd        |                         |                    |                    |                      |
| 7/31/2018       | 220        | 280         | 340                             | 276                     |                    | 0.00               | 0.00                 |
| 8/7/2018        | 650        | 640         | 720                             | 669                     |                    | 0.47               | 0.47                 |
| 8/14/2018       | 470        | 430         | 380                             | 425                     |                    | 0.00               | 0.00                 |
| 8/21/2018       | 2,700      | 3,600       | 3,300                           | 3,177                   |                    | 0.22               | 0.26                 |
| 8/28/2018       | 610        | 600         | 560                             | 590                     | 681                | 0.19               | 0.19                 |
| Watershed:      | Thornapple |             |                                 | Lower Thornapple River  |                    |                    |                      |
| 8-Digit HUC:    | 04050007   |             |                                 | 10-Digit HUC:           | 0405000704         |                    |                      |
| Site ID/Storet: | 080270     | Description | Fall Creek - Shriner St         |                         |                    |                    |                      |
| 7/9/2018        | 460        | 380         | 410                             | 415                     |                    | 0.00               | 0.00                 |
| 7/19/2018       | 110        | 370         | 550                             | 282                     |                    | 0.00               | 0.00                 |
| 7/23/2018       | 630        | 570         | 400                             | 524                     |                    | 0.02               | 0.04                 |
| 7/30/2018       | 470        | 670         | 540                             | 554                     |                    | 0.00               | 0.00                 |
| 8/6/2018        | 1,600      | 1,300       | 1,600                           | 1,493                   | 551                | 0.12               | 0.12                 |
| Site ID/Storet: | 080023     | Description | Thornapple River - N Airport Rd |                         |                    |                    |                      |
| 7/9/2018        | 100        | 70          | 110                             | 92                      |                    | 0.00               | 0.00                 |
| 7/19/2018       | 30         | 80          | 450                             | 103                     |                    | 0.00               | 0.00                 |
| 7/23/2018       | 110        | 180         | 180                             | 153                     |                    | 0.02               | 0.05                 |
| 7/30/2018       | 130        | 90          | 100                             | 105                     |                    | 0.00               | 0.00                 |
| 8/6/2018        | 100        | 70          | 70                              | 79                      | 104                | 0.06               | 0.06                 |
| Site ID/Storet: | 080230     | Description | Glass Creek - Goodwill Rd       |                         |                    |                    |                      |
| 7/9/2018        | 60         | 90          | 120                             | 87                      |                    | 0.00               | 0.00                 |
| 7/19/2018       | 50         | 100         | 40                              | 58                      |                    | 0.00               | 0.00                 |
| 7/23/2018       | 280        | 400         | 150                             | 256                     |                    | 0.02               | 0.05                 |
| 7/30/2018       | 100        | 50          | 70                              | 70                      |                    | 0.00               | 0.00                 |
| 8/6/2018        | 230        | 180         | 110                             | 166                     | 109                | 0.12               | 0.12                 |

|                 | L             | C           | R   | Daily Geometric Mean                         | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |  |  |
|-----------------|---------------|-------------|-----|--|-----------------------|--------------------|--------------------|----------------------|--|--|
| Site ID/Storet: | 080278        | Description |     | Glass Creek - N M 37                         |                       |                    |                    |                      |  |  |
| 7/9/2018        | 400           | 400         | 550 | 445  |                       | 0.00               | 0.00               | 3                    |  |  |
| 7/19/2018       | 380           | 410         | 320 | 368  |                       | 0.00               | 0.00               | 0                    |  |  |
| 7/23/2018       | 480           | 440         | 420 | 446  |                       | 0.02               | 0.05               | 10                   |  |  |
| 7/30/2018       | 180           | 220         | 160 | 185  |                       | 0.00               | 0.00               | 2                    |  |  |
| 8/6/2018        | 530           | 480         | 640 | 546  | 375                   | 0.00               | 0.00               | 2                    |  |  |
| Site ID/Storet: | 080305        | Description |     | Thornapple River - E Main St - Middleville   |                       |                    |                    |                      |  |  |
| 7/9/2018        | 270           | 110         | 150 | 165  |                       | 0.00               | 0.00               | 5                    |  |  |
| 7/19/2018       | 260           | 280         | 290 | 276  |                       | 0.00               | 0.00               | 3                    |  |  |
| 7/23/2018       | 400           | 240         | 260 | 292  |                       | 0.02               | 0.06               | 3                    |  |  |
| 7/30/2018       | 230           | 170         | 320 | 232  |                       | 0.00               | 0.00               | 1                    |  |  |
| 8/6/2018        | 300           | 230         | 320 | 281  | 244                   | 0.00               | 0.00               | 0                    |  |  |
| Site ID/Storet: | 410649        | Description |     | Mccords Creek - Buttrick Ave SE              |                       |                    |                    |                      |  |  |
| 7/9/2018        | 340           | 200         | 280 | 267  |                       | 0.00               | 0.00               | 1                    |  |  |
| 7/19/2018       | 340           | 210         | 180 | 234  |                       | 0.00               | 0.00               | 0                    |  |  |
| 7/23/2018       | 410           | 450         | 550 | 466  |                       | 0.02               | 0.06               | 2                    |  |  |
| 7/30/2018       | 260           | 210         | 230 | 232  |                       | 0.00               | 0.00               | 1                    |  |  |
| 8/6/2018        | 460           | 340         | 460 | 416  | 309                   | 0.00               | 0.00               | 0                    |  |  |
| Site ID/Storet: | 410735        | Description |     | Thornapple River - 68th St SE                |                       |                    |                    |                      |  |  |
| 7/9/2018        | 120           | 20          | 60  | 52   |                       | 0.00               | 0.00               | 1                    |  |  |
| 7/19/2018       | 100           | 50          | 70  | 70   |                       | 0.00               | 0.00               | 0                    |  |  |
| 7/23/2018       | 430           | 480         | 510 | 472  |                       | 0.02               | 0.05               | 7                    |  |  |
| 7/30/2018       | 170           | 220         | 140 | 174  |                       | 0.00               | 0.00               | 1                    |  |  |
| 8/6/2018        | 30            | 80          | 60  | 52   | 110                   | 0.00               | 0.00               | 2                    |  |  |
| Watershed:      | Betsie-Platte |             |     | Betsie River                                 |                       |                    |                    |                      |  |  |
| 8-Digit HUC:    | 04060104      |             |     | 10-Digit HUC:                                | 0406010403            |                    |                    |                      |  |  |
| Site ID/Storet: | 100226        | Description |     | Cold Creek (S Br) - D/S Michigan Ave (South) |                       |                    |                    |                      |  |  |
| 7/10/2018       | 115           | 153         | 192 | 150  |                       | 0.00               | 0.00               | 1                    |  |  |
| 7/17/2018       | 291           | 326         | 345 | 320  |                       | 0.00               | 0.07               | 0                    |  |  |
| 7/23/2018       | 248           | 249         | 291 | 262  |                       | 0.00               | 0.88               | 2                    |  |  |
| 7/27/2018       | 248           | 214         | 365 | 269  |                       | 0.09               | 0.43               | 3                    |  |  |
| 8/3/2018        | 140           | 114         | 130 | 127  | 212                   | 0.01               | 0.02               | 1                    |  |  |

| L               | C             | R           | Daily Geometric Mean                           | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|---------------|-------------|--|-----------------------|--------------------|--------------------|----------------------|
| Site ID/Storet: | 100261        | Description | Cold Creek (N Br) - Off Michigan Ave (North)   |                       |                    |                    |                      |
| 7/10/2018       | 121           | 108         | 137  | 121                   | 0.00               | 0.00               | 2                    |
| 7/17/2018       | 649           | 980         | 866  | 820                   | 0.00               | 0.07               | 2                    |
| 7/23/2018       | 649           | 248         | 248  | 342                   | 0.00               | 0.79               | 0                    |
| 7/27/2018       | 179           | 150         | 162  | 163                   | 0.09               | 0.43               | 5                    |
| 8/3/2018        | 110           | 116         | 108  | 111                   | 228                | 0.01               | 0.02                 |
| Site ID/Storet: | 100262        | Description | Cold Creek (Mid Br) - Narrow Gauge Rd (N Side) |                       |                    |                    |                      |
| 7/10/2018       | 308           | 326         | 649  | 402                   | 0.00               | 0.00               | 0                    |
| 7/17/2018       | 727           | 326         | 517  | 496                   | 0.00               | 0.07               | 1                    |
| 7/23/2018       | 866           | 1,046       | 1,046  | 982                   | 0.00               | 0.81               | 0                    |
| 7/27/2018       | 411           | 326         | 260  | 326                   | 0.09               | 0.43               | 3                    |
| 8/3/2018        | 178           | 231         | 210  | 205                   | 420                | 0.01               | 0.02                 |
| Watershed:      | Betsie-Platte |             | Glen Lake-Frontal Lake Michigan                |                       |                    |                    |                      |
| 8-Digit HUC:    | 04060104      |             | 10-Digit HUC:                                  | 0406010404            |                    |                    |                      |
| Site ID/Storet: | 440260        | Description | Richley Creek - Saint Pierre Rd                |                       |                    |                    |                      |
| 7/10/2018       | 173           | 147         | 133  | 150                   | 0.00               | 0.00               | 0                    |
| 7/17/2018       | 194           | 172         | 201  | 189                   | 0.00               | 0.00               | 4                    |
| 7/23/2018       | 126           | 135         | 102  | 120                   | 0.00               | 1.76               | 9                    |
| 7/27/2018       | 272           | 411         | 276  | 313                   | 0.10               | 0.46               | 13                   |
| 8/3/2018        | 152           | 147         | 140  | 146                   | 173                | 0.00               | 0.19                 |
| Site ID/Storet: | 100228        | Description | Raymond Ditch - Mick Rd                        |                       |                    |                    |                      |
| 7/10/2018       | 276           | 411         | 435  | 367                   | 0.00               | 0.00               | 0                    |
| 7/17/2018       | 118           | 147         | 201  | 152                   | 0.00               | 0.00               | 1                    |
| 7/20/2018       | 238           | 190         | 173  | 199                   | 0.07               | 0.07               | 1                    |
| 7/27/2018       | 214           | 161         | 345  | 228                   | 0.10               | 0.46               | 1                    |
| 8/3/2018        | 96            | 62          | 48   | 66                    | 175                | 0.00               | 0.19                 |
| Site ID/Storet: | 100263        | Description | Herring Creek (Trib To) - Gorivan Rd           |                       |                    |                    |                      |
| 7/10/2018       | 488           | 770         | 727  | 649                   | 0.00               | 0.00               |                      |
| 7/17/2018       | 517           | 649         | 488  | 547                   | 0.00               | 0.00               |                      |
| 7/23/2018       | 517           | 517         | 461  | 498                   | 0.00               | 1.76               |                      |
| 7/27/2018       | 308           | 365         | 326  | 332                   | 0.10               | 0.46               |                      |
| 8/3/2018        | 272           | 260         | 249  | 260                   | 433                | 0.00               | 0.19                 |

| L               | C                   | R           | Daily Geometric Mean                  | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |   |
|-----------------|---------------------|-------------|---------------------------------------|-----------------------|--------------------|--------------------|----------------------|---|
| Watershed:      | Boardman Charlevoix |             | Lake Charlevoix                       |                       |                    |                    |                      |   |
| 8-Digit HUC:    | 04060105            |             | 10-Digit HUC:                         | 0406010502            |                    |                    |                      |   |
| Site ID/Storet: | 150011              | Description | North Branch Boyne River - US 131     |                       |                    |                    |                      |   |
| 7/9/2018        | 43                  | 44          | 49                                    | 45                    |                    | 0.00               | 0.00                 | 0 |
| 7/16/2018       | 48                  | 58          | 56                                    | 54                    |                    | 0.00               | 0.05                 | 1 |
| 7/20/2018       | 40                  | 50          | 36                                    | 42                    |                    | 0.00               | 0.00                 | 1 |
| 7/26/2018       | 102                 | 88          | 79                                    | 89                    |                    | 0.11               | 0.11                 | 2 |
| 8/2/2018        | 52                  | 55          | 54                                    | 54                    | 55                 | 0.39               | 0.40                 | 1 |
| Site ID/Storet: | 150010              | Description | Jordan R - Rogers Rd                  |                       |                    |                    |                      |   |
| 7/9/2018        | 52                  | 54          | 59                                    | 55                    |                    | 0.00               | 0.00                 | 1 |
| 7/16/2018       | 65                  | 75          | 58                                    | 66                    |                    | 0.00               | 0.00                 | 3 |
| 7/20/2018       | 35                  | 36          | 50                                    | 40                    |                    | 0.00               | 0.00                 | 0 |
| 7/26/2018       | 79                  | 70          | 61                                    | 70                    |                    | 0.11               | 0.11                 | 5 |
| 8/2/2018        | 139                 | 157         | 155                                   | 150                   | 68                 | 0.40               | 0.41                 | 5 |
| Site ID/Storet: | 150191              | Description | Brown S Creek - Mckay St              |                       |                    |                    |                      |   |
| 7/9/2018        | 358                 | 613         | 411                                   | 448                   |                    | 0.00               | 0.00                 | 0 |
| 7/16/2018       | 649                 | 613         | 816                                   | 687                   |                    | 0.00               | 0.00                 | 2 |
| 7/20/2018       | 411                 | 308         | 248                                   | 315                   |                    | 0.00               | 0.00                 | 1 |
| 7/26/2018       | 488                 | 435         | 517                                   | 479                   |                    | 0.11               | 0.11                 | 2 |
| 8/2/2018        | 260                 | 260         | 201                                   | 239                   | 407                | 0.40               | 0.42                 | 1 |
| Site ID/Storet: | 150204              | Description | Deer Creek - Pearsall Rd              |                       |                    |                    |                      |   |
| 7/9/2018        | 73                  | 71          | 105                                   | 82                    |                    | 0.00               | 0.00                 | 0 |
| 7/16/2018       | 107                 | 172         | 135                                   | 136                   |                    | 0.00               | 0.00                 | 1 |
| 7/20/2018       | 117                 | 96          | 78                                    | 96                    |                    | 0.00               | 0.00                 | 0 |
| 7/26/2018       | 98                  | 135         | 127                                   | 119                   |                    | 0.11               | 0.11                 | 2 |
| 8/2/2018        | 83                  | 138         | 91                                    | 101                   | 105                | 0.41               | 0.42                 | 2 |
| Site ID/Storet: | 150052              | Description | Boyne R - Lake Rd Bridge - Boyne City |                       |                    |                    |                      |   |
| 7/9/2018        | 44                  | 56          | 44                                    | 47                    |                    | 0.00               | 0.00                 | 7 |
| 7/16/2018       | 76                  | 72          | 82                                    | 76                    |                    | 0.00               | 0.05                 | 3 |
| 7/20/2018       | 99                  | 101         | 76                                    | 91                    |                    | 0.00               | 0.00                 | 2 |
| 7/26/2018       | 89                  | 82          | 124                                   | 96                    |                    | 0.11               | 0.11                 | 3 |
| 8/2/2018        | 45                  | 55          | 76                                    | 57                    | 71                 | 0.38               | 0.39                 | 0 |

| L               | C      | R           | Daily Geometric Mean                 | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|--------|-------------|--------------------------------------|-----------------------|--------------------|--------------------|----------------------|
| Site ID/Storet: | 150187 | Description | S Br Boyne River - Boyne Mountain Rd |                       |                    |                    |                      |
| 7/9/2018        | 38     | 25          | 22                                   | 27                    | 0.00               | 0.00               | 1                    |
| 7/16/2018       | 57     | 74          | 61                                   | 64                    | 0.00               | 0.05               | 1                    |
| 7/20/2018       | 34     | 32          | 45                                   | 36                    | 0.00               | 0.00               | 0                    |
| 7/26/2018       | 62     | 63          | 64                                   | 63                    | 0.11               | 0.11               | 3                    |
| 8/2/2018        | 121    | 117         | 162                                  | 132                   | 55                 | 0.40               | 0.41                 |
| Site ID/Storet: | 150106 | Description | Monroe Creek - M 66                  |                       |                    |                    |                      |
| 7/9/2018        | 132    | 96          | 80                                   | 100                   | 0.00               | 0.00               | 0                    |
| 7/16/2018       | 238    | 144         | 172                                  | 181                   | 0.00               | 0.00               | 1                    |
| 7/20/2018       | 76     | 50          | 79                                   | 67                    | 0.00               | 0.00               | 1                    |
| 7/26/2018       | 58     | 80          | 63                                   | 66                    | 0.11               | 0.11               | 2                    |
| 8/2/2018        | 127    | 79          | 56                                   | 83                    | 92                 | 0.41               | 0.42                 |
| Site ID/Storet: | 150104 | Description | Strover Creek - Ferry Ave            |                       |                    |                    |                      |
| 7/9/2018        | 291    | 387         | 387                                  | 352                   | 0.00               | 0.00               | 1                    |
| 7/16/2018       | 291    | 365         | 276                                  | 308                   | 0.00               | 0.00               | 0                    |
| 7/20/2018       | 201    | 276         | 308                                  | 257                   | 0.00               | 0.00               | 0                    |
| 7/26/2018       | 308    | 365         | 435                                  | 366                   | 0.11               | 0.11               | 3                    |
| 8/2/2018        | 147    | 486         | 166                                  | 228                   | 297                | 0.41               | 0.42                 |
| Site ID/Storet: | 150105 | Description | Loeb Creek - M 66                    |                       |                    |                    |                      |
| 7/9/2018        | 387    | 308         | 365                                  | 352                   | 0.00               | 0.00               | 1                    |
| 7/16/2018       | 461    | 488         | 326                                  | 419                   | 0.00               | 0.00               | 1                    |
| 7/20/2018       | 160    | 153         | 129                                  | 147                   | 0.00               | 0.00               | 0                    |
| 7/26/2018       | 980    | 921         | 727                                  | 869                   | 0.11               | 0.11               | 4                    |
| 8/2/2018        | 308    | 172         | 435                                  | 285                   | 351                | 0.41               | 0.42                 |
| Site ID/Storet: | 150248 | Description | Horton Creek - Mouth                 |                       |                    |                    |                      |
| 7/9/2018        | 50     | 54          | 80                                   | 60                    | 0.00               | 0.00               | 1                    |
| 7/16/2018       | 94     | 72          | 99                                   | 87                    | 0.00               | 0.00               | 5                    |
| 7/20/2018       | 60     | 55          | 60                                   | 59                    | 0.00               | 0.00               | 0                    |
| 7/26/2018       | 148    | 132         | 155                                  | 145                   | 0.11               | 0.11               | 2                    |
| 8/2/2018        | 53     | 56          | 48                                   | 52                    | 75                 | 0.41               | 0.42                 |

| L               | C                   | R           | Daily Geometric Mean                      | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|---------------------|-------------|---|-----------------------|--------------------|--------------------|----------------------|
| Site ID/Storet: | 150252              | Description | Porter Creek - Lake Shore Rd              |                       |                    |                    |                      |
| 7/9/2018        | 140                 | 128         | 135                                       | 134                   |                    | 0.00               | 0.00                 |
| 7/16/2018       | 140                 | 161         | 166                                       | 155                   |                    | 0.00               | 0.00                 |
| 7/20/2018       | 93                  | 78          | 108                                       | 92                    |                    | 0.00               | 0.00                 |
| 7/26/2018       | 155                 | 138         | 162                                       | 151                   |                    | 0.11               | 0.11                 |
| 8/2/2018        | 98                  | 105         | 91  | 98                    | 123                | 0.41               | 0.42                 |
| Site ID/Storet: | 150254              | Description | Trib To Lake Charlevoix - Champerret Dr W |                       |                    |                    |                      |
| 7/9/2018        | 86                  | 96          | 93  | 92                    |                    | 0.00               | 0.00                 |
| 7/16/2018       | 291                 | 291         | 201                                       | 257                   |                    | 0.00               | 0.04                 |
| 7/20/2018       | 201                 | 291         | 201                                       | 228                   |                    | 0.00               | 0.00                 |
| 7/26/2018       | 248                 | 238         | 236                                       | 241                   |                    | 0.11               | 0.11                 |
| 8/2/2018        | 435                 | 161         | 291                                       | 273                   | 204                | 0.41               | 0.42                 |
| Watershed:      | Boardman Charlevoix |             | Boardman River                            |                       |                    |                    |                      |
| 8-Digit HUC:    | 04060105            |             | 10-Digit HUC:                             | 0406010505            |                    |                    |                      |
| Site ID/Storet: | 280316              | Description | Kids Creek - 11th St                      |                       |                    |                    |                      |
| 7/10/2018       | 326                 | 461         | 326                                       | 366                   |                    | 0.00               | 0.00                 |
| 7/17/2018       | 249                 | 308         | 411                                       | 316                   |                    | 0.00               | 0.00                 |
| 7/23/2018       | 547                 | 488         | 517                                       | 517                   |                    | 0.08               | 0.89                 |
| 7/27/2018       | 579                 | 461         | 579                                       | 537                   |                    | 0.07               | 0.20                 |
| 8/3/2018        | 201                 | 219         | 201                                       | 207                   | 367                | 0.00               | 0.17                 |
| Site ID/Storet: | 280418              | Description | Kids Creek (Trib A) - Elmwood Ave         |                       |                    |                    |                      |
| 7/10/2018       | 517                 | 548         | 435                                       | 498                   |                    | 0.00               | 0.00                 |
| 7/17/2018       | 435                 | 236         | 261                                       | 299                   |                    | 0.00               | 0.00                 |
| 7/23/2018       | 488                 | 461         | 291                                       | 403                   |                    | 0.08               | 0.89                 |
| 7/27/2018       | 727                 | 816         | 816                                       | 785                   |                    | 0.07               | 0.20                 |
| 8/3/2018        | 602                 | 501         | 659                                       | 583                   | 487                | 0.01               | 0.17                 |
| Site ID/Storet: | 280426              | Description | Kids Creek - Front St                     |                       |                    |                    |                      |
| 7/10/2018       | 579                 | 548         | 770                                       | 625                   |                    | 0.00               | 0.00                 |
| 7/17/2018       | 488                 | 488         | 435                                       | 470                   |                    | 0.00               | 0.00                 |
| 7/23/2018       | 411                 | 488         | 517                                       | 470                   |                    | 0.08               | 0.89                 |
| 7/27/2018       | 501                 | 687         | 770                                       | 642                   |                    | 0.07               | 0.20                 |
| 8/3/2018        | 285                 | 313         | 328                                       | 308                   | 487                | 0.01               | 0.17                 |

| L               | C                   | R           | Daily Geometric Mean             | 30-Day Geometric Mean                      | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |    |
|-----------------|---------------------|-------------|----------------------------------|--|--------------------|--------------------|----------------------|----|
| Watershed:      | Boardman Charlevoix |             |                                  | Threemile Creek-Frontal Grand Traverse Bay |                    |                    |                      |    |
| 8-Digit HUC:    | 04060105            |             |                                  | 10-Digit HUC: 0406010507                   |                    |                    |                      |    |
| Site ID/Storet: | 450140              | Description | Northport Creek - Rose Rd        |  |                    |                    |                      |    |
| 7/10/2018       | 153                 | 135         | 173                              | 153  |                    | 0.00               | 0.00                 | 1  |
| 7/17/2018       | 326                 | 461         | 411                              | 395  |                    | 0.00               | 0.00                 | 0  |
| 7/23/2018       | 236                 | 172         | 161                              | 187  |                    | 0.00               | 0.28                 | 3  |
| 7/27/2018       | 157                 | 210         | 179                              | 180  |                    | 0.01               | 0.08                 | 5  |
| 8/3/2018        | 73                  | 52          | 75                               | 66   | 168                | 0.01               | 0.23                 | 1  |
| Site ID/Storet: | 450155              | Description | Northport Creek - Melkild/3rd    |  |                    |                    |                      |    |
| 7/10/2018       | 35                  | 46          | 26                               | 35   |                    | 0.00               | 0.00                 | 0  |
| 7/17/2018       | 179                 | 142         | 210                              | 175  |                    | 0.00               | 0.00                 | 0  |
| 7/20/2018       | 91                  | 73          | 99                               | 87   |                    | 0.00               | 0.00                 | 2  |
| 7/27/2018       | 150                 | 127         | 120                              | 132  |                    | 0.01               | 0.08                 | 5  |
| 8/3/2018        | 49                  | 55          | 41                               | 48   | 80                 | 0.01               | 0.23                 | 0  |
| Watershed:      | Pigeon-Wiscoggin    |             |                                  | Pigeon River                               |                    |                    |                      |    |
| 8-Digit HUC:    | 04080103            |             |                                  | 10-Digit HUC: 0408010302                   |                    |                    |                      |    |
| Site ID/Storet: | 320316              | Description | Pigeon River - Geiger Rd - PGN06 |  |                    |                    |                      |    |
| 7/23/2018       | 579                 | 488         | 770                              | 602  |                    | 0.05               | 0.11                 | 0  |
| 7/30/2018       | 308                 | 365         | 260                              | 308  |                    | 0.00               | 0.01                 | 2  |
| 8/6/2018        | 236                 | 308         | 387                              | 304  |                    | 0.00               | 0.00                 | 2  |
| 8/13/2018       | 387                 | 345         | 517                              | 410  |                    | 0.00               | 0.00                 | 2  |
| 8/20/2018       | 727                 | 1,120       | 816                              | 873  | 458                | 0.00               | 0.00                 | 9  |
| Site ID/Storet: | 320317              | Description | Pigeon River - Limerick Rd       |  |                    |                    |                      |    |
| 7/23/2018       | 248                 | 179         | 173                              | 197  |                    | 0.09               | 0.11                 | 0  |
| 7/30/2018       | 572                 | 980         | 866                              | 786  |                    | 0.00               | 0.01                 | 9  |
| 8/6/2018        | 133                 | 194         | 148                              | 156  |                    | 0.00               | 0.00                 | 12 |
| 8/13/2018       | 276                 | 196         | 219                              | 228  |                    | 0.00               | 0.00                 | 13 |
| 8/20/2018       | 199                 | 291         | 214                              | 231  | 264                | 0.00               | 0.00                 | 0  |
| Site ID/Storet: | 320361              | Description | Fisher Drain - Griggs Rd         |  |                    |                    |                      |    |
| 7/23/2018       | 328                 | 461         | 308                              | 360  |                    | 0.09               | 0.11                 | 10 |
| 7/30/2018       | 1,120               | 921         | 816                              | 944  |                    | 0.00               | 0.01                 | 5  |
| 8/6/2018        | 127                 | 127         | 24                               | 73   |                    | 0.00               | 0.00                 | 8  |
| 8/13/2018       | 461                 | 250         | 548                              | 398  |                    | 0.00               | 0.00                 | 7  |
| 8/20/2018       | 115                 | 260         | 308                              | 209  | 290                | 0.00               | 0.00                 | 0  |

| L               | C                | R             | Daily Geometric Mean            | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |    |
|-----------------|------------------|---------------|---------------------------------|-----------------------|--------------------|--------------------|----------------------|----|
| Watershed:      | Pigeon-Wiscoggan |               | Bird Creek-Frontal Lake Huron   |                       |                    |                    |                      |    |
| 8-Digit HUC:    | 04080103         |               | 10-Digit HUC:                   | 0408010304            |                    |                    |                      |    |
| Site ID/Storet: | 320362           | Description   | Bird Creek - Knoblock/Hunter Rd |                       |                    |                    |                      |    |
| 7/30/2018       | 2,420            | 1,203         | 2,420                           | 1,917                 |                    | 0.00               | 0.01                 | 0  |
| 8/6/2018        | 613              | 461           | 308                             | 443                   |                    | 0.00               | 0.00                 | 4  |
| 8/13/2018       | 121              | 138           | 172                             | 142                   |                    | 0.00               | 0.00                 | 3  |
| 8/20/2018       | 866              | 816           | 687                             | 786                   |                    | 0.00               | 0.00                 | 4  |
| 8/28/2018       | 416              | 387           | 411                             | 404                   | 521                | 0.11               | 0.59                 | 7  |
| Site ID/Storet: | 320335           | Description   | New River - Stoddard Rd         |                       |                    |                    |                      |    |
| 7/23/2018       | 980              | 1,203         | 921                             | 1,028                 |                    | 0.09               | 0.11                 | 13 |
| 7/30/2018       | 77               | 62            | 79                              | 72                    |                    | 0.00               | 0.01                 | 18 |
| 8/6/2018        | 127              | 81            | 119                             | 107                   |                    | 0.00               | 0.00                 | 3  |
| 8/13/2018       | 119              | 96            | 112                             | 108                   |                    | 0.00               | 0.00                 | 5  |
| 8/20/2018       | 36               | 32            | 26                              | 31                    | 122                | 0.00               | 0.00                 | 0  |
| Watershed:      | Birch-Willow     |               | Elk Creek-Frontal Lake Huron    |                       |                    |                    |                      |    |
| 8-Digit HUC:    | 04080104         | 10-Digit HUC: | 0408010401                      |                       |                    |                    |                      |    |
| Site ID/Storet: | 320279           | Description   | E Br Willow Creek - Minnick Rd  |                       |                    |                    |                      |    |
| 7/23/2018       | 108              | 70            | 80                              | 85                    |                    | 0.13               | 0.41                 | 0  |
| 7/30/2018       | 2,420            | 2,420         | 2,420                           | 2,420                 |                    | 0.00               | 0.00                 | 3  |
| 8/6/2018        | 1,120            | 1,046         | 1,120                           | 1,095                 |                    | 0.00               | 0.00                 | 3  |
| 8/13/2018       | 1,986            | 2,420         | 1,553                           | 1,954                 |                    | 0.00               | 0.05                 | 6  |
| 8/20/2018       | 291              | 308           | 435                             | 339                   | 683                | 0.00               | 0.00                 | 2  |
| Site ID/Storet: | 320240           | Description   | Willow Creek - Dobson Rd        |                       |                    |                    |                      |    |
| 7/23/2018       | 687              | 687           | 727                             | 700                   |                    | 0.13               | 0.41                 | 5  |
| 7/30/2018       | 326              | 291           | 649                             | 395                   |                    | 0.00               | 0.00                 | 1  |
| 8/6/2018        | 291              | 28            | 365                             | 144                   |                    | 0.00               | 0.00                 | 0  |
| 8/13/2018       | 214              | 201           | 276                             | 228                   |                    | 0.00               | 0.05                 | 8  |
| 8/20/2018       | 345              | 248           | 291                             | 292                   | 305                | 0.00               | 0.00                 | 3  |
| Site ID/Storet: | 320324           | Description   | Willow Creek - Stoddard Rd      |                       |                    |                    |                      |    |
| 7/23/2018       | 308              | 261           | 225                             | 262                   |                    | 0.13               | 0.41                 | 1  |
| 7/30/2018       | 162              | 179           | 248                             | 193                   |                    | 0.00               | 0.00                 | 12 |
| 8/6/2018        | 192              | 272           |                                 |                       |                    | 0.00               | 0.00                 | 1  |
| 8/13/2018       | 142              | 172           | 214                             | 174                   |                    | 0.00               | 0.05                 | 5  |
| 8/20/2018       | 127              | 157           | 137                             | 140                   |                    | 0.00               | 0.00                 | 0  |
| 8/28/2018       | 2,420            | 2,420         | 2,420                           | 2,420                 |                    | 0.12               | 0.39                 | 11 |

| L               | C        | R           | Daily Geometric Mean                 | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |
|-----------------|----------|-------------|--------------------------------------|-----------------------|--------------------|--------------------|----------------------|
| Site ID/Storet: | 320358   | Description | Trib to Willow Creek - Huron City Rd |                       |                    |                    |                      |
| 7/23/2018       | 185      | 236         | 110                                  | 169                   | 0.13               | 0.41               | 4                    |
| 7/30/2018       | 1,300    | 1,414       | 1,203                                | 1,303                 | 0.00               | 0.00               | 3                    |
| 8/6/2018        | 866      | 1,300       | 770                                  | 954                   | 0.00               | 0.00               | 2                    |
| 8/13/2018       | 435      | 548         | 461                                  | 479                   | 0.00               | 0.05               | 2                    |
| 8/20/2018       | 2,420    | 1,986       | 2,420                                | 2,266                 | 744                | 0.00               | 0.00                 |
| Watershed:      | Flint    |             | Swartz Creek-Flint River             |                       |                    |                    |                      |
| 8-Digit HUC:    | 04080204 |             | 10-Digit HUC:                        | 0408020403            |                    |                    |                      |
| Site ID/Storet: | 250402   | Description | W Branch Swartz Creek - Linden Rd    |                       |                    |                    |                      |
| 8/2/2018        | 800      | 910         | 760                                  | 821                   | 0.02               | 0.41               | 1                    |
| 8/9/2018        | 2,700    | 2,100       | 3,000                                | 2,572                 | 0.01               | 1.44               | 0                    |
| 8/16/2018       | 140      | 210         | 360                                  | 220                   | 0.00               | 0.00               | 2                    |
| 8/23/2018       | 670      | 880         | 620                                  | 715                   | 0.00               | 0.59               | 0                    |
| 8/30/2018       | 2,000    | 1,600       | 2,500                                | 2,000                 | 921                | 0.05               | 0.92                 |
| Site ID/Storet: | 250460   | Description | Indian Creek - Cook Rd               |                       |                    |                    |                      |
| 8/2/2018        | 1,000    | 1,700       | 2,100                                | 1,528                 | 0.02               | 0.41               | 3                    |
| 8/9/2018        | 3,800    | 2,900       | 3,900                                | 3,503                 | 0.05               | 1.44               | 4                    |
| 8/16/2018       | 510      | 780         | 500                                  | 584                   | 0.00               | 0.00               | 0                    |
| 8/23/2018       | 690      | 640         | 930                                  | 743                   | 0.00               | 0.88               | 0                    |
| 8/30/2018       | 990      | 1,100       | 1,000                                | 1,029                 | 1,190              | 0.05               | 0.96                 |
| Site ID/Storet: | 250551   | Description | Swartz Creek - Maple Rd              |                       |                    |                    |                      |
| 8/2/2018        | 840      | 800         | 720                                  | 785                   | 0.02               | 0.41               | 7                    |
| 8/9/2018        | 980      | 1,140       | 890                                  | 998                   | 0.01               | 1.44               | 17                   |
| 8/16/2018       | 320      | 310         | 460                                  | 357                   | 0.00               | 0.00               | 3                    |
| 8/23/2018       | 150      | 200         | 160                                  | 169                   | 0.00               | 0.25               | 0                    |
| 8/30/2018       | 320      | 480         | 330                                  | 370                   | 445                | 0.05               | 0.92                 |
| Site ID/Storet: | 250343   | Description | Thread Creek - Dort Hwy              |                       |                    |                    |                      |
| 8/2/2018        | 2,500    | 2,900       | 2,000                                | 2,438                 | 0.02               | 0.41               | 2                    |
| 8/9/2018        | 2,600    | 5,800       | 2,200                                | 3,213                 | 0.02               | 1.44               | 8                    |
| 8/16/2018       | 540      | 460         | 570                                  | 521                   | 0.00               | 0.00               | 0                    |
| 8/23/2018       | 950      | 720         | 940                                  | 863                   | 0.00               | 0.59               | 5                    |
| 8/30/2018       | 1,000    | 1,100       | 1,100                                | 1,066                 | 1,303              | 0.05               | 0.95                 |

|                 | L        | C           | R                               | Daily Geometric Mean | 30-Day Geometric Mean | 24-Hour Prior Rain | 48-Hour Prior Rain | Relative Water Level |  |
|-----------------|----------|-------------|---------------------------------|----------------------|-----------------------|--------------------|--------------------|----------------------|--|
| Site ID/Storet: | 250550   | Description | Thread Creek - Perry Rd         |                      |                       |                    |                    |                      |  |
| 8/2/2018        | 370      | 390         | 440                             | <b>399</b>           |                       | 0.02               | 0.41               | 19                   |  |
| 8/9/2018        | 1,800    | 710         | 670                             | <b>950</b>           |                       | 0.01               | 1.44               | 22                   |  |
| 8/16/2018       | 340      | 170         | 340                             | 270                  |                       | 0.00               | 0.00               | 0                    |  |
| 8/23/2018       | 240      | 290         | 320                             | 281                  |                       | 0.00               | 0.87               | 4                    |  |
| 8/30/2018       | 570      | 590         | 660                             | <b>605</b>           | <b>445</b>            | 0.05               | 0.96               | 11                   |  |
| Site ID/Storet: | 250335   | Description | Swartz Creek - Hammerberg Rd    |                      |                       |                    |                    |                      |  |
| 8/2/2018        | 2,200    | 1,100       | 1,700                           | <b>1,602</b>         |                       | 0.02               | 0.41               | 4                    |  |
| 8/9/2018        | 4,700    | 5,200       | 6,200                           | <b>5,331</b>         |                       | 0.01               | 1.44               | 16                   |  |
| 8/16/2018       | 530      | 450         | 500                             | <b>492</b>           |                       | 0.00               | 0.00               | 0                    |  |
| 8/23/2018       | 660      | 860         | 970                             | <b>820</b>           |                       | 0.00               | 0.59               | 3                    |  |
| 8/30/2018       | 1,600    | 1,000       | 1,700                           | <b>1,396</b>         | <b>1,369</b>          | 0.05               | 0.96               | 18                   |  |
| Site ID/Storet: | 250339   | Description | Carman Drain - 12th St          |                      |                       |                    |                    |                      |  |
| 8/2/2018        | 2,900    | 2,600       | 1,900                           | <b>2,429</b>         |                       | 0.02               | 0.41               | 2                    |  |
| 8/9/2018        | 7,300    | 8,900       | 9,100                           | <b>8,393</b>         |                       | 0.01               | 1.44               | 17                   |  |
| 8/16/2018       | 1,700    | 2,300       | 1,200                           | <b>1,674</b>         |                       | 0.00               | 0.00               | 0                    |  |
| 8/23/2018       | 3,900    | 3,600       | 4,000                           | <b>3,830</b>         |                       | 0.00               | 0.15               | 7                    |  |
| 8/30/2018       | 1,600    | 1,000       | 1,500                           | <b>1,339</b>         | <b>2,809</b>          | 0.05               | 0.92               | 20                   |  |
| Watershed:      | Flint    |             |                                 | Flint River          |                       |                    |                    |                      |  |
| 8-Digit HUC:    | 04080204 |             |                                 | 10-Digit HUC:        | 0408020405            |                    |                    |                      |  |
| Site ID/Storet: | 250103   | Description | Flint River - Main St           |                      |                       |                    |                    |                      |  |
| 8/2/2018        | 120      | 140         | 130                             | 130                  |                       | 0.02               | 0.41               | 2                    |  |
| 8/9/2018        | 2,100    | 1,120       | 1,240                           | <b>1,429</b>         |                       | 0.01               | 1.44               | 18                   |  |
| 8/16/2018       | 30       | 20          | 1                               | 24                   |                       | 0.00               | 0.00               | 0                    |  |
| 8/23/2018       | 80       | 160         | 120                             | 115                  |                       | 0.00               | 0.15               | 3                    |  |
| 8/30/2018       | 690      | 520         | 620                             | <b>606</b>           | <b>232</b>            | 0.05               | 0.92               | 29                   |  |
| Site ID/Storet: | 250549   | Description | Cole Creek - Seymour Rd (north) |                      |                       |                    |                    |                      |  |
| 8/2/2018        | 610      | 490         | 470                             | <b>520</b>           |                       | 0.02               | 0.41               | 0                    |  |
| 8/9/2018        | 1,420    | 3,100       | 2,000                           | <b>2,065</b>         |                       | 0.01               | 1.44               | 6                    |  |
| 8/16/2018       | 960      | 1,300       | 780                             | <b>991</b>           |                       | 0.00               | 0.00               | 0                    |  |
| 8/23/2018       | 870      | 740         | 950                             | <b>849</b>           |                       | 0.00               | 0.15               | 2                    |  |
| 8/30/2018       | 1,050    | 1,070       | 1,020                           | <b>1,046</b>         | <b>989</b>            | 0.05               | 0.92               | 9                    |  |

Appendix 3. Dissolved oxygen and temperature results for selected sites and dates, by watershed. NOTE: Readings below the minimum D.O. standards (coldwater [CW] or warmwater [WW], as applicable) are shaded red. Daily average D.O. measurements are not available.

| Site ID   | Site Description                     | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|--------------------------------------|--------------|----------|----------------|-------------|----------------|
| Watershed | Black-Presque Isle                   | 040201010204 |          |                |             |                |
| 270223    | Planter Creek - Thomaston Rd. (PC-4) | 8/3/2018     | 2:40 PM  | 6.33           | 62.4        | WW             |
|           |                                      | 8/7/2018     | 1:50 PM  | 6.02           | 64.4        | WW             |
|           |                                      | 8/16/2018    | 9:30 AM  | 3.78           | 62.8        | WW             |
|           |                                      | 8/23/2018    | 9:50 AM  | 4.39           | 63.5        | WW             |
|           |                                      | 8/27/2018    | 12:20 PM | 7              | 67.6        | WW             |
| Watershed | Black-Presque Isle                   | 040201010205 |          |                |             |                |
| 270023    | Powder Mill Creek - Black River Rd   | 8/3/2018     | 12:10 PM | 9.4            | 57.9        | CW             |
|           |                                      | 8/7/2018     | 12:00 PM | 9.12           | 61.9        | CW             |
|           |                                      | 8/16/2018    | 11:40 AM | 8.71           | 65.8        | CW             |
|           |                                      | 8/23/2018    | 12:15 PM | 8.85           | 61.3        | CW             |
|           |                                      | 8/27/2018    | 10:12 AM | 8.25           | 61.5        | CW             |
| 270103    | Black River - Moore Rd               | 8/3/2018     | 11:25 AM | 9.84           | 61.9        | CW             |
|           |                                      | 8/7/2018     | 11:10 AM | 9.08           | 66          | CW             |
|           |                                      | 8/16/2018    | 11:00 AM | 8.09           | 70.2        | CW             |
|           |                                      | 8/23/2018    | 11:30 AM | 8.85           | 66          | CW             |
|           |                                      | 8/27/2018    | 11:15 AM | 7.81           | 62.4        | CW             |
| 270169    | Powder Mill Creek - US2              | 8/3/2018     | 1:15 PM  | 11.02          | 58.5        | CW             |
|           |                                      | 8/7/2018     | 10:40 AM | 9.01           | 59.2        | CW             |
|           |                                      | 8/16/2018    | 12:45 PM | 10.31          | 62.1        | CW             |
|           |                                      | 8/23/2018    | 1:00 PM  | 10.91          | 59.9        | CW             |
|           |                                      | 8/27/2018    | 9:35 AM  | 7.67           | 62.4        | CW             |
| 270176    | Kallander Creek - Stone Rd.          | 8/3/2018     | 11:00 AM | 9.9            | 57          | CW             |
|           |                                      | 8/7/2018     | 11:40 AM | 9.54           | 61.3        | CW             |
|           |                                      | 8/16/2018    | 10:45 AM | 10.03          | 65.1        | CW             |
|           |                                      | 8/23/2018    | 11:05 AM | 9.45           | 61          | CW             |
|           |                                      | 8/27/2018    | 10:55 AM | 7.89           | 66.4        | CW             |

| Site ID   | Site Description                            | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|---|--------------|----------|----------------|-------------|----------------|
| 270238    | Black River - Black Jack Rd                 | 8/3/2018     | 1:50 PM  | 8.7            | 65.7        | CW             |
|           |   | 8/7/2018     | 1:15 PM  | 8.53           | 66.6        | CW             |
|           |   | 8/16/2018    | 10:00 AM | 8.48           | 68.4        | CW             |
|           |   | 8/23/2018    | 10:40 AM | 9              | 62.4        | CW             |
|           |   | 8/27/2018    | 12:00 PM | 8.06           | 68.4        | CW             |
| 270239    | Trib To Powder Mill Creek - Black River Rd. | 8/3/2018     | 12:30 PM | 8.84           | 59.5        | CW             |
|           |   | 8/7/2018     | 12:25 PM | 8.57           | 60.4        | CW             |
|           |   | 8/16/2018    | 12:15 PM | 8.74           | 63.1        | CW             |
|           |   | 8/23/2018    | 12:35 PM | 8.96           | 61.2        | CW             |
|           |   | 8/27/2018    | 10:30 AM | 7.99           | 65.1        | CW             |
| Watershed | Keweenaw Peninsula                          | 040201030104 |          |                |             |                |
| 660090    | Trib to W Br Firesteel R - M-26             | 8/1/2018     | 12:35 PM | 6.71           | 64.4        | CW             |
|           |   | 8/9/2018     | 9:45 AM  | 6.69           | 64.2        | CW             |
|           |   | 8/14/2018    | 11:10 AM | 6.5            | 69.6        | CW             |
|           |   | 8/21/2018    | 9:50 AM  | 5.76           | 62.8        | CW             |
|           |   | 8/30/2018    | 11:00 AM | 8.52           | 57          | CW             |
| 660174    | Firesteel R - M-26                          | 8/1/2018     | 1:30 PM  | 8.57           | 61.9        | CW             |
|           |   | 8/9/2018     | 10:20 AM | 8.5            | 62.4        | CW             |
|           |   | 8/14/2018    | 10:32 AM | 8.77           | 66.2        | CW             |
|           |   | 8/21/2018    | 9:20 AM  | 8.39           | 61          | CW             |
|           |   | 8/30/2018    | 11:30 AM | 9.45           | 54.9        | CW             |
| 660184    | Trib to W Br Firesteel R (SW) - Old M-35    | 8/1/2018     | 11:22 AM | 7.45           | 61.7        | CW             |
|           |   | 8/9/2018     | 10:55 AM | 7.67           | 63.3        | CW             |
|           |   | 8/14/2018    | 11:50 AM | 7.41           | 67.5        | CW             |
|           |   | 8/21/2018    | 10:30 AM | 7.09           | 61.3        | CW             |
|           |   | 8/30/2018    | 10:30 AM | 8.76           | 54          | CW             |

| Site ID   | Site Description                            | Date      | Time         | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|---|-----------|--------------|----------------|-------------|----------------|
| 660185    | W Br Firesteel R - Old M 35                 | 8/1/2018  | 12:00 PM     | 8.85           | 59.5        | CW             |
|           |   | 8/9/2018  | 11:30 AM     | 8.79           | 60.4        | CW             |
|           |   | 8/14/2018 | 12:30 PM     | 8.7            | 64.9        | CW             |
|           |   | 8/21/2018 | 11:10 AM     | 8.95           | 58.8        | CW             |
|           |   | 8/30/2018 | 10:00 AM     | 9.59           | 52.3        | CW             |
| Watershed |   | Kalamazoo | 040500030102 |                |             |                |
| 380442    | Spring Arbor / Concord Drain - King Rd      | 5/24/2018 | 8:37 AM      | 6.43           | 54          | WW             |
|           |   | 5/29/2018 | 8:18 AM      | 6.25           | 58.6        | WW             |
|           |   | 6/4/2018  | 8:14 AM      | 6.45           | 56.3        | WW             |
|           |   | 6/11/2018 | 8:20 AM      | 7.06           | 56.5        | WW             |
|           |   | 6/18/2018 | 8:15 AM      | 6.17           | 66.9        | WW             |
| 380443    | Spring Arbor / Concord Drain - N Concord Rd | 5/24/2018 | 9:09 AM      | 6.37           | 56.5        | WW             |
|           |   | 5/29/2018 | 8:47 AM      | 5.85           | 63.7        | WW             |
|           |   | 6/4/2018  | 8:44 AM      | 6.67           | 58.7        | WW             |
|           |   | 6/11/2018 | 8:46 AM      | 7.3            | 58          | WW             |
|           |   | 6/18/2018 | 8:35 AM      | 6.17           | 71.4        | WW             |
| Watershed |   | Kalamazoo | 040500030701 |                |             |                |
| 030721    | Cuddy Drain - Patterson Rd                  | 9/4/2018  | 11:04 AM     | 7.34           | 71.2        | WW             |
|           |   | 9/11/2018 | 11:43 AM     | 8.68           | 60.6        | WW             |
|           |   | 9/17/2018 | 10:55 AM     | 8.44           | 65.8        | WW             |
|           |   | 9/24/2018 | 11:00 AM     | 8.75           | 58.6        | WW             |
|           |   | 10/1/2018 | 11:05 AM     | 9.4            | 52.9        | WW             |
| Watershed |   | Kalamazoo | 040500030801 |                |             |                |
| 030728    | Haney Drain - 138th Ave                     | 9/5/2018  | 10:37 AM     | 6.77           | 72.1        | WW             |
|           |   | 9/10/2018 | 10:30 AM     | 8.41           | 61.3        | WW             |
|           |   | 9/18/2018 | 10:43 AM     | 8.33           | 68.2        | WW             |
|           |   | 9/25/2018 | 10:18 AM     | 7.99           | 64.2        | WW             |
|           |   | 10/2/2018 | 11:05 AM     | 8              | 57          | WW             |

| Site ID   | Site Description            | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|-----------------------------|--------------|----------|----------------|-------------|----------------|
| Watershed | Kalamazoo                   | 040500030802 |          |                |             |                |
| 030575    | Rabbit River - 10th St      | 9/5/2018     | 10:53 AM | 7.33           | 69.1        | CW             |
|           |                             | 9/10/2018    | 10:50 AM | 8.5            | 58.6        | CW             |
|           |                             | 9/18/2018    | 10:55 AM | 8.33           | 64.1        | CW             |
|           |                             | 9/25/2018    | 10:35 AM | 8.08           | 61          | CW             |
|           |                             | 10/2/2018    | 10:52 AM | 7.4            | 57          | CW             |
| Watershed | Kalamazoo                   | 040500030803 |          |                |             |                |
| 030726    | Miller Creek - 128th Ave    | 9/4/2018     | 10:35 AM | 6.73           | 73.2        | WW             |
|           |                             | 9/11/2018    | 11:16 AM | 8.37           | 62.6        | WW             |
|           |                             | 9/17/2018    | 10:20 AM | 8.02           | 68          | WW             |
|           |                             | 9/24/2018    | 10:32 AM | 8.5            | 59.5        | WW             |
|           |                             | 10/1/2018    | 10:37 AM | 9.1            | 53.4        | WW             |
| Watershed | Kalamazoo                   | 040500030804 |          |                |             |                |
| 030607    | Bear Creek - 130th Ave      | 9/4/2018     | 10:21 AM | 6.89           | 67.1        | WW             |
|           |                             | 9/11/2018    | 11:03 AM | 8.79           | 60.3        | WW             |
|           |                             | 9/17/2018    | 10:03 AM | 7.91           | 63.1        | WW             |
|           |                             | 9/24/2018    | 10:15 AM | 8.9            | 55.4        | WW             |
|           |                             | 10/1/2018    | 10:14 AM | 9.15           | 52.7        | WW             |
| Watershed | Kalamazoo                   | 040500030806 |          |                |             |                |
| 030527    | Dorr And Byron Dr - 21st St | 9/4/2018     | 8:33 AM  | 5.45           | 65.8        | WW             |
|           |                             | 9/11/2018    | 8:45 AM  | 6.74           | 57.6        | WW             |
|           |                             | 9/17/2018    | 8:42 AM  | 6.27           | 60.1        | WW             |
|           |                             | 9/24/2018    | 8:51 AM  | 7              | 54.1        | WW             |
|           |                             | 10/1/2018    | 8:46 AM  | 9.08           | 51.4        | WW             |
| 030531    | Red Run Dr - 21st St        | 9/4/2018     | 8:50 AM  | 7              | 64.6        | WW             |
|           |                             | 9/11/2018    | 9:03 AM  | 8.24           | 56.5        | WW             |
|           |                             | 9/17/2018    | 9:00 AM  | 8.45           | 58.6        | WW             |
|           |                             | 9/24/2018    | 9:12 AM  | 8.68           | 54.1        | WW             |
|           |                             | 10/1/2018    | 9:02 AM  | 9.23           | 51.6        | WW             |

| Site ID   | Site Description              | Date      | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|-------------------------------|-----------|----------|----------------|-------------|----------------|
| Watershed | 040500030807                  |           |          |                |             |                |
| 030580    | Little Rabbit River - 32nd St | 9/4/2018  | 9:20 AM  | 6.98           | 65.7        | WW             |
|           |                               | 9/11/2018 | 10:03 AM | 8.4            | 58.1        | WW             |
|           |                               | 9/17/2018 | 9:25 AM  | 8.51           | 61.7        | WW             |
|           |                               | 9/24/2018 | 9:34 AM  | 8.76           | 55.6        | WW             |
|           |                               | 10/1/2018 | 9:30 AM  | 9.28           | 51.6        | WW             |
| Watershed | 040500030808                  |           |          |                |             |                |
| 030582    | Pigeon Creek - 138th Ave      | 9/5/2018  | 10:05 AM | 6.91           | 63.3        | WW             |
|           |                               | 9/10/2018 | 9:58 AM  | 7.75           | 57          | WW             |
|           |                               | 9/18/2018 | 9:57 AM  | 7.69           | 59.7        | WW             |
|           |                               | 9/25/2018 | 9:47 AM  | 7.24           | 59          | WW             |
|           |                               | 10/2/2018 | 10:14 AM | 8.09           | 58.3        | WW             |
| 030677    | Rabbit River - 132nd Ave      | 9/4/2018  | 10:00 AM | 9.36           | 71.4        | CW             |
|           |                               | 9/11/2018 | 10:40 AM | 8.11           | 61.3        | CW             |
|           |                               | 9/17/2018 | 9:46 AM  | 7.89           | 66.4        | CW             |
|           |                               | 9/24/2018 | 9:59 AM  | 8.47           | 58.5        | CW             |
|           |                               | 10/1/2018 | 9:45 AM  | 8.96           | 52.7        | CW             |
| Watershed | 040500030809                  |           |          |                |             |                |
| 030600    | Black Creek - 139th Ave       | 9/5/2018  | 9:20 AM  | 6.31           | 70.3        | WW             |
|           |                               | 9/10/2018 | 9:27 AM  | 8              | 59.2        | WW             |
|           |                               | 9/18/2018 | 9:21 AM  | 7.76           | 65.5        | WW             |
|           |                               | 9/25/2018 | 9:20 AM  | 7.64           | 61.7        | WW             |
|           |                               | 10/2/2018 | 9:39 AM  | 7.55           | 55.4        | WW             |
| 700691    | Black Creek - 32nd St         | 9/5/2018  | 8:58 AM  | 7.16           | 69.1        | WW             |
|           |                               | 9/10/2018 | 9:04 AM  | 8.67           | 57.9        | WW             |
|           |                               | 9/18/2018 | 8:43 AM  | 8.28           | 64.6        | WW             |
|           |                               | 9/25/2018 | 8:59 AM  | 7.94           | 61.5        | WW             |
|           |                               | 10/2/2018 | 9:15 AM  | 7.53           | 57.3        | WW             |

| Site ID   | Site Description               | Date        | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|--------------------------------|-------------|----------|----------------|-------------|----------------|
| 700692    | Trib To Black Creek - 40th Ave | 9/5/2018    | 8:38 AM  | 7.39           | 67.9        | WW             |
|           |                                | 9/10/2018   | 8:45 AM  | 76             | 57.7        | WW             |
|           |                                | 9/18/2018   | 8:43 AM  | 8.42           | 63.9        | WW             |
|           |                                | 9/25/2018   | 8:46 AM  | 7.92           | 61.5        | WW             |
|           |                                | 10/2/2018   | 8:53 AM  | 7.78           | 57.1        | WW             |
| Watershed |                                | Kalamazoo   |          | 040500030810   |             |                |
| 030673    | Rabbit River - 36th St         | 9/5/2018    | 9:46 AM  | 5.47           | 71.6        | CW             |
|           |                                | 9/10/2018   | 9:37 AM  | 7.98           | 59.7        | CW             |
|           |                                | 9/18/2018   | 9:34 AM  | 7.81           | 66          | CW             |
|           |                                | 9/25/2018   | 9:29 AM  | 7.91           | 60.8        | CW             |
|           |                                | 10/2/2018   | 9:51 AM  | 7.8            | 54.9        | CW             |
| Watershed |                                | Lower Grand |          | 040500060401   |             |                |
| 620314    | Rogue River - 22 Mile Rd NW    | 6/5/2018    | 8:39 AM  | 6.46           | 62.7        | CW             |
|           |                                | 6/12/2018   | 8:47 AM  | 5.6            | 65.7        | CW             |
|           |                                | 6/26/2018   | 8:43 AM  | 5.62           | 66          | CW             |
|           |                                | 7/2/2018    | 8:52 AM  | 4.79           | 75          | CW             |
| Watershed |                                | Lower Grand |          | 040500060402   |             |                |
| 410614    | Duke Creek - N Division Ave    | 6/5/2018    | 9:04 AM  | 8.61           | 59          | CW             |
|           |                                | 6/12/2018   | 9:25 AM  | 8.09           | 60.6        | CW             |
|           |                                | 6/26/2018   | 9:08 AM  | 8.61           | 59.9        | CW             |
|           |                                | 7/2/2018    | 9:18 AM  | 7.71           | 69.3        | CW             |
| Watershed |                                | Lower Grand |          | 040500060404   |             |                |
| 410831    | Nash Creek - E Division St     | 6/5/2018    | 10:02 AM | 6.61           | 61.1        | CW             |
|           |                                | 6/12/2018   | 10:29 AM | 6.19           | 65.1        | CW             |
|           |                                | 6/26/2018   | 9:49 AM  | 6.16           | 64          | CW             |
|           |                                | 7/2/2018    | 10:14 AM | 6.71           | 71.4        | CW             |

| Site ID   | Site Description                 | Date         | Time      | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|----------------------------------|--------------|-----------|----------------|-------------|----------------|
| Watershed | Lower Grand                      | 040500060405 |           |                |             |                |
| 410644    | Rogue River - Indian Lakes Rd NW |              | 6/5/2018  | 9:23 AM        | 7.71        | 62.2 CW        |
|           |                                  |              | 6/12/2018 | 9:44 AM        | 7.34        | 64.2 CW        |
|           |                                  |              | 6/26/2018 | 9:23 AM        | 7.96        | 64.2 CW        |
|           |                                  |              | 7/2/2018  | 9:46 AM        | 6.79        | 74.5 CW        |
| 410832    | Ball Creek - Stebbins Ave NW     |              | 6/5/2018  | 9:41 AM        | 8.55        | 56.1 CW        |
|           |                                  |              | 6/12/2018 | 10:10 AM       | 8.2         | 58.8 CW        |
|           |                                  |              | 6/26/2018 | 9:35 AM        | 8.87        | 58.4 CW        |
|           |                                  |              | 7/2/2018  | 10:04 AM       | 8.28        | 64.9 CW        |
| Watershed | Lower Grand                      | 040500060406 |           |                |             |                |
| 410615    | Cedar Creek - Friske Dr NE       |              | 6/5/2018  | 10:27 AM       | 9.51        | 58.9 CW        |
|           |                                  |              | 6/12/2018 | 11:00 AM       | 8.92        | 61.7 CW        |
|           |                                  |              | 6/26/2018 | 10:11 AM       | 9.37        | 60.9 CW        |
|           |                                  |              | 7/2/2018  | 10:43 AM       | 8.53        | 68.7 CW        |
| Watershed | Lower Grand                      | 040500060408 |           |                |             |                |
| 410415    | Rogue River - 12 Mile Rd         |              | 6/5/2018  | 11:03 AM       | 8.52        | 62.6 CW        |
|           |                                  |              | 6/12/2018 | 11:20 AM       | 8.33        | 64.6 CW        |
|           |                                  |              | 6/26/2018 | 10:32 AM       | 8.92        | 63.7 CW        |
|           |                                  |              | 7/2/2018  | 11:04 AM       | 7.43        | 73.6 CW        |
| Watershed | Thornapple                       | 040500070101 |           |                |             |                |
| 230207    | Butternut Creek - Mcconnel Rd    |              | 7/31/2018 | 10:34 AM       | 9.28        | 66.2 WW        |
|           |                                  |              | 8/7/2018  | 10:58 AM       | 7.37        | 72.6 WW        |
|           |                                  |              | 8/14/2018 | 10:28 AM       | 8.6         | 72.3 WW        |
|           |                                  |              | 8/21/2018 | 10:33 AM       | 8.63        | 70 WW          |
|           |                                  |              | 8/28/2018 | 10:22 AM       | 3.5         | 71.1 WW        |

| Site ID   | Site Description                  | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|-----------------------------------|--------------|----------|----------------|-------------|----------------|
| Watershed | Thornapple                        | 040500070102 |          |                |             |                |
| 230242    | Thornapple River - N Stewart Rd   | 7/31/2018    | 10:02 AM | 7.46           | 63.7        | WW             |
|           |                                   | 8/7/2018     | 10:12 AM | 6.64           | 69.3        | WW             |
|           |                                   | 8/14/2018    | 9:58 AM  | 6.8            | 66.9        | WW             |
|           |                                   | 8/21/2018    | 10:04 AM | 6.53           | 67.5        | WW             |
|           |                                   | 8/28/2018    | 9:37 AM  | 5.41           | 69.4        | WW             |
| 230246    | Church Drain - Stewart Rd         | 7/31/2018    | 10:16 AM | 9.91           | 54.9        | WW             |
|           |                                   | 8/7/2018     | 10:29 AM | 9.57           | 58.8        | WW             |
|           |                                   | 8/14/2018    | 10:11 AM | 9.38           | 57.6        | WW             |
|           |                                   | 8/21/2018    | 10:20 AM | 8.7            | 59.2        | WW             |
|           |                                   | 8/28/2018    | 10:08 AM | 6.83           | 62.2        | WW             |
| Watershed | Thornapple                        | 040500070104 |          |                |             |                |
| 230209    | Little Thornapple R - Gresham Hwy | 7/31/2018    | 9:16 AM  | 6.15           | 64.5        | WW             |
|           |                                   | 8/7/2018     | 9:22 AM  | 5.21           | 70          | WW             |
|           |                                   | 8/14/2018    | 9:14 AM  | 5.85           | 67.1        | WW             |
|           |                                   | 8/21/2018    | 9:32 AM  | 5.49           | 68.9        | WW             |
|           |                                   | 8/28/2018    | 8:46 AM  | 4.4            | 74.3        | WW             |
| Watershed | Thornapple                        | 040500070105 |          |                |             |                |
| 230196    | Thornapple River - Gresham Hwy    | 7/31/2018    | 9:41 AM  | 6.87           | 64.8        | WW             |
|           |                                   | 8/7/2018     | 9:46 AM  | 6.3            | 68.5        | WW             |
|           |                                   | 8/14/2018    | 9:36 AM  | 6.25           | 67.6        | WW             |
|           |                                   | 8/21/2018    | 9:53 AM  | 6.22           | 68          | WW             |
|           |                                   | 8/28/2018    | 9:18 AM  | 5.66           | 70.7        | WW             |
| Watershed | Thornapple                        | 040500070208 |          |                |             |                |
| 080211    | Mud Creek - Barger Rd             | 7/31/2018    | 8:37 AM  | 6.1            | 70          | WW             |
|           |                                   | 8/7/2018     | 8:42 AM  | 3.64           | 72.3        | WW             |
|           |                                   | 8/14/2018    | 8:36 AM  | 5.4            | 72.3        | WW             |
|           |                                   | 8/21/2018    | 8:50 AM  | 4.83           | 71.2        | WW             |
|           |                                   | 8/28/2018    | 8:46 AM  | 5.17           | 71.1        | WW             |

| Site ID   | Site Description                | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|---------------------------------|--------------|----------|----------------|-------------|----------------|
| Watershed |                                 | 040500070210 |          |                |             |                |
| 080223    | Cedar Creek - McKeown Rd        | 7/31/2018    | 8:12 AM  | 8.03           | 65.4        | CW             |
|           |                                 | 8/7/2018     | 8:11 AM  | 7.49           | 68.6        | CW             |
|           |                                 | 8/14/2018    | 8:15 AM  | 7.7            | 68.5        | CW             |
|           |                                 | 8/21/2018    | 8:36 AM  | 7.46           | 68          | CW             |
|           |                                 | 8/28/2018    | 8:25 AM  | 7.15           | 71.1        | CW             |
| Watershed | Thornapple                      | 040500070401 |          |                |             |                |
| 080270    | Fall Creek - Shriner St         | 7/9/2018     | 12:01 PM | 9.09           | 68.9        | WW             |
|           |                                 | 7/19/2018    | 11:00 PM | 9.44           | 66.4        | WW             |
|           |                                 | 7/23/2018    | 10:41 AM | 8.17           | 66.9        | WW             |
|           |                                 | 7/30/2018    | 10:31 AM | 9.1            | 64.6        | WW             |
|           |                                 | 8/6/2018     | 10:33 AM | 7.09           | 71.2        | WW             |
| Watershed | Thornapple                      | 040500070402 |          |                |             |                |
| 080023    | Thornapple River - N Airport Rd | 7/9/2018     | 11:21 AM | 9.39           | 75.4        | WW             |
|           |                                 | 7/19/2018    | 10:30 AM | 8.22           | 73.2        | WW             |
|           |                                 | 7/23/2018    | 10:18 AM | 7.56           | 70.2        | WW             |
|           |                                 | 7/30/2018    | 10:08 AM | 8.13           | 70.9        | WW             |
|           |                                 | 8/6/2018     | 10:11 AM | 5.92           | 75.8        | WW             |
| Watershed | Thornapple                      | 040500070403 |          |                |             |                |
| 080230    | Glass Creek - Goodwill Rd       | 7/9/2018     | 10:51 AM | 7.16           | 69.1        | CW             |
|           |                                 | 7/19/2018    | 10:07 AM | 7.24           | 66.2        | CW             |
|           |                                 | 7/23/2018    | 9:57 AM  | 4.86           | 67.5        | CW             |
|           |                                 | 7/30/2018    | 9:51 AM  | 7.01           | 65.5        | CW             |
|           |                                 | 8/6/2018     | 9:49 AM  | 5.38           | 71.9        | CW             |
| 080278    | Glass Creek - N M 37            | 7/9/2018     | 10:20 AM | 8.85           | 65.5        | CW             |
|           |                                 | 7/19/2018    | 9:32 AM  | 9.02           | 62.6        | CW             |
|           |                                 | 7/23/2018    | 9:28 AM  | 8.44           | 66          | CW             |
|           |                                 | 7/30/2018    | 9:22 AM  | 9.04           | 63.7        | CW             |
|           |                                 | 8/6/2018     | 9:22 AM  | 7.8            | 70.7        | CW             |

| Site ID   | Site Description                             | Date         | Time    | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|--|--------------|---------|----------------|-------------|----------------|
| Watershed | Thornapple                                   | 040500070406 |         |                |             |                |
| 080305    | Thornapple River - E Main St - Middleville   | 7/9/2018     | 9:33 AM | 7.05           | 71.4        | WW             |
|           |  | 7/19/2018    | 9:05 AM | 6.88           | 70.5        | WW             |
|           |  | 7/23/2018    | 9:09 AM | 6.92           | 68.5        | WW             |
|           |  | 7/30/2018    | 9:02 AM | 7.18           | 68.7        | WW             |
|           |  | 8/6/2018     | 8:59 AM | 6.43           | 74.7        | WW             |
| Watershed | Thornapple                                   | 040500070407 |         |                |             |                |
| 410649    | Mccords Creek - Buttrick Ave SE              | 7/9/2018     | 8:17 AM | 9.14           | 61.7        | WW             |
|           |  | 7/19/2018    | 8:13 AM | 9.21           | 60.1        | WW             |
|           |  | 7/23/2018    | 8:19 AM | 8.89           | 62.2        | WW             |
|           |  | 7/30/2018    | 8:08 AM | 9.28           | 59.7        | WW             |
|           |  | 8/6/2018     | 8:11 AM | 8.37           | 67.1        | WW             |
| 410735    | Thornapple River - 68th St SE                | 7/9/2018     | 8:55 AM | 8.04           | 72.3        | WW             |
|           |  | 7/19/2018    | 8:36 AM | 7.57           | 72.9        | WW             |
|           |  | 7/23/2018    | 8:37 AM | 7.13           | 69.6        | WW             |
|           |  | 7/30/2018    | 8:28 AM | 8.18           | 68.5        | WW             |
|           |  | 8/6/2018     | 8:30 AM | 7.6            | 74.5        | WW             |
| Watershed | Betsie-Platte                                | 040601040305 |         |                |             |                |
| 100226    | Cold Creek (S Br) - D/S Michigan Ave (South) | 7/10/2018    | 8:55 AM | 10.3           | 53.1        | CW             |
|           |  | 7/17/2018    | 9:05 AM | 10.21          | 52.9        | CW             |
|           |  | 7/23/2018    | 9:00 AM | 10.18          | 54.7        | CW             |
|           |  | 7/27/2018    | 9:15 AM | 10.25          | 53.6        | CW             |
|           |  | 8/3/2018     | 8:50 AM | 10.27          | 52.9        | CW             |
| 100261    | Cold Creek (N Br) - Off Michigan Ave (North) | 7/10/2018    | 9:30 AM | 5.09           | 64.4        | CW             |
|           |  | 7/17/2018    | 9:40 AM | 4.1            | 65.3        | CW             |
|           |  | 7/23/2018    | 9:30 AM | 4.43           | 67.5        | CW             |
|           |  | 7/27/2018    | 9:45 AM | 4.43           | 65.3        | CW             |
|           |  | 8/3/2018     | 9:15 AM | 4.59           | 64.8        | CW             |

| Site ID   | Site Description                               | Date                | Time    | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|--|---------------------|---------|----------------|-------------|----------------|
| 100262    | Cold Creek (Mid Br) - Narrow Gauge Rd (N Side) | 7/10/2018           | 9:20 AM | 9              | 60.3        | CW             |
|           |  | 7/17/2018           | 9:20 AM | 8.88           | 60.1        | CW             |
|           |  | 7/23/2018           | 9:15 AM | 8.69           | 61.9        | CW             |
|           |  | 7/27/2018           | 9:30 AM | 8.87           | 60.3        | CW             |
|           |  | 8/3/2018            | 9:05 AM | 8.03           | 60.4        | CW             |
| Watershed |  | Betsie-Platte       |         | 040601040404   |             |                |
| 440260    | Richley Creek - Saint Pierre Rd                | 7/10/2018           | 8:00 AM | 5.21           | 60.1        | CW             |
|           |  | 7/17/2018           | 7:55 AM | 4.57           | 59.7        | CW             |
|           |  | 7/23/2018           | 7:50 AM | 4              | 61.9        | CW             |
|           |  | 7/27/2018           | 7:45 AM | 3.5            | 59.5        | CW             |
|           |  | 8/3/2018            | 7:45 AM | 3.41           | 60.1        | CW             |
| Watershed |  | Betsie-Platte       |         | 040601040406   |             |                |
| 100228    | Raymond Ditch - Mick Rd                        | 7/10/2018           | 8:30 AM | 9.09           | 61.3        | CW             |
|           |  | 7/17/2018           | 8:40 AM | 9.14           | 60.3        | CW             |
|           |  | 7/20/2018           | 8:30 AM | 9.01           | 61.9        | CW             |
|           |  | 7/27/2018           | 8:30 AM | 9.15           | 60.3        | CW             |
|           |  | 8/3/2018            | 8:25 AM | 9.28           | 59.5        | CW             |
| 100263    | Herring Creek (Trib To) - Gorivan Rd           | 7/10/2018           | 8:20 AM | 7.6            | 59          | CW             |
|           |  | 7/17/2018           | 8:25 AM | 7.47           | 58.1        | CW             |
|           |  | 7/23/2018           | 8:20 AM | 6.72           | 61.2        | CW             |
|           |  | 7/27/2018           | 8:15 AM | 6.87           | 58.8        | CW             |
|           |  | 8/3/2018            | 8:15 AM | 7.34           | 58.3        | CW             |
| Watershed |  | Boardman Charlevoix |         | 040601050203   |             |                |
| 150011    | North Branch Boyne River - US 131              | 7/9/2018            | 8:20 AM | 9.69           | 57.6        | CW             |
|           |  | 7/16/2018           | 8:00 AM | 9.47           | 59.2        | CW             |
|           |  | 7/20/2018           | 7:35 AM | 9.69           | 57          | CW             |
|           |  | 7/26/2018           | 7:40 AM | 9.5            | 57.6        | CW             |
|           |  | 8/2/2018            | 7:45 AM | 9.64           | 57          | CW             |

| Site ID   | Site Description                      | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|---------------------------------------|--------------|----------|----------------|-------------|----------------|
| Watershed | Boardman Charlevoix                   | 040601050204 |          |                |             |                |
| 150010    | Jordan R - Rogers Rd                  | 7/9/2018     | 12:05 PM | 9.95           | 59.9        | CW             |
|           |                                       | 7/16/2018    | 12:20 PM | 9.71           | 61          | CW             |
|           |                                       | 7/20/2018    | 11:35 AM | 9.93           | 58.6        | CW             |
|           |                                       | 7/26/2018    | 11:25 AM | 9.54           | 59.2        | CW             |
|           |                                       | 8/2/2018     | 11:30 AM | 9.53           | 57.6        | CW             |
| 150191    | Brown S Creek - Mckay St              | 7/9/2018     | 11:30 AM | 9.61           | 64.4        | CW             |
|           |                                       | 7/16/2018    | 11:45 AM | 9.17           | 62.2        | CW             |
|           |                                       | 7/20/2018    | 11:00 AM | 9.28           | 61.9        | CW             |
|           |                                       | 7/26/2018    | 10:55 AM | 9.19           | 61          | CW             |
|           |                                       | 8/2/2018     | 11:00 AM | 9.4            | 60.1        | CW             |
| 150204    | Deer Creek - Pearsall Rd              | 7/9/2018     | 11:50 AM | 9.84           | 63          | CW             |
|           |                                       | 7/16/2018    | 12:05 PM | 9.5            | 64.4        | CW             |
|           |                                       | 7/20/2018    | 11:20 AM | 9.81           | 61.2        | CW             |
|           |                                       | 7/26/2018    | 11:15 AM | 9.52           | 62.2        | CW             |
|           |                                       | 8/2/2018     | 11:15 AM | 9.77           | 61.2        | CW             |
| Watershed | Boardman Charlevoix                   | 040601050205 |          |                |             |                |
| 150052    | Boyne R - Lake Rd Bridge - Boyne City | 7/9/2018     | 8:40 AM  | 8.18           | 65.3        | CW             |
|           |                                       | 7/16/2018    | 8:20 AM  | 7.75           | 68          | CW             |
|           |                                       | 7/20/2018    | 8:00 AM  | 7.81           | 63          | CW             |
|           |                                       | 7/26/2018    | 8:05 AM  | 7.42           | 65.5        | CW             |
|           |                                       | 8/2/2018     | 8:05 AM  | 7.65           | 65.3        | CW             |
| 150187    | S Br Boyne River - Boyne Mountain Rd  | 7/9/2018     | 8:00 AM  | 9.88           | 56.7        | CW             |
|           |                                       | 7/16/2018    | 7:45 AM  | 9.65           | 58.1        | CW             |
|           |                                       | 7/20/2018    | 7:20 AM  | 9.89           | 55.9        | CW             |
|           |                                       | 7/26/2018    | 7:30 AM  | 9.7            | 56.1        | CW             |
|           |                                       | 8/2/2018     | 7:30 AM  | 9.85           | 55.6        | CW             |

| Site ID   | Site Description             | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|------------------------------|--------------|----------|----------------|-------------|----------------|
| Watershed | Boardman Charlevoix          | 040601050206 |          |                |             |                |
| 150106    | Monroe Creek - M 66          | 7/9/2018     | 11:10 AM | 9.25           | 63.3        | CW             |
|           |                              | 7/16/2018    | 10:50 AM | 8.8            | 65.8        | CW             |
|           |                              | 7/20/2018    | 10:25 AM | 9.29           | 61.7        | CW             |
|           |                              | 7/26/2018    | 10:25 AM | 8.88           | 63.7        | CW             |
|           |                              | 8/2/2018     | 10:25 AM | 9.02           | 63          | CW             |
| Watershed | Boardman Charlevoix          | 040601050207 |          |                |             |                |
| 150104    | Strover Creek - Ferry Ave    | 7/9/2018     | 10:25 AM | 8.72           | 60.6        | CW             |
|           |                              | 7/16/2018    | 10:10 AM | 8.45           | 62.1        | CW             |
|           |                              | 7/20/2018    | 9:45 AM  | 8.66           | 59          | CW             |
|           |                              | 7/26/2018    | 9:45 AM  | 8.57           | 60.4        | CW             |
|           |                              | 8/2/2018     | 9:45 AM  | 8.56           | 60.3        | CW             |
| 150105    | Loeb Creek - M 66            | 7/9/2018     | 10:45 AM | 8.35           | 63.1        | CW             |
|           |                              | 7/16/2018    | 10:25 AM | 8              | 65.3        | CW             |
|           |                              | 7/20/2018    | 10:00 AM | 8.31           | 61.5        | CW             |
|           |                              | 7/26/2018    | 10:05 AM | 8.4            | 63.1        | CW             |
|           |                              | 8/2/2018     | 10:00 AM | 8.4            | 63.9        | CW             |
| 150248    | Horton Creek - Mouth         | 7/9/2018     | 9:50 AM  | 10             | 54.3        | CW             |
|           |                              | 7/16/2018    | 9:30 AM  | 9.7            | 55.9        | CW             |
|           |                              | 7/20/2018    | 9:10 AM  | 9.94           | 53.6        | CW             |
|           |                              | 7/26/2018    | 9:15 AM  | 9.38           | 55.6        | CW             |
|           |                              | 8/2/2018     | 9:10 AM  | 9.36           | 55.8        | CW             |
| 150252    | Porter Creek - Lake Shore Rd | 7/9/2018     | 9:00 AM  | 9.02           | 62.1        | CW             |
|           |                              | 7/16/2018    | 8:45 AM  | 8.66           | 64.8        | CW             |
|           |                              | 7/20/2018    | 8:20 AM  | 9.11           | 60.6        | CW             |
|           |                              | 7/26/2018    | 8:25 AM  | 7.49           | 62.2        | CW             |
|           |                              | 8/2/2018     | 8:25 AM  | 8.91           | 62.1        | CW             |

| Site ID   | Site Description                          | Date                | Time         | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|---|---------------------|--------------|----------------|-------------|----------------|
| 150254    | Trib To Lake Charlevoix - Champerret Dr W | 7/9/2018            | 9:30 AM      | 9.31           | 56.3        | WW             |
|           |   | 7/16/2018           | 9:15 AM      | 9.21           | 57.2        | WW             |
|           |   | 7/20/2018           | 8:50 AM      | 9.31           | 55.9        | WW             |
|           |   | 7/26/2018           | 8:55 AM      | 9.18           | 56.8        | WW             |
|           |   | 8/2/2018            | 8:50 AM      | 9.3            | 56.3        | WW             |
| Watershed |   | Boardman Charlevoix | 040601050507 |                |             |                |
| 280316    | Kids Creek - 11th St                      | 7/10/2018           | 12:45 PM     | 9.86           | 62.8        | CW             |
|           |   | 7/17/2018           | 12:40 PM     | 9.65           | 61.3        | CW             |
|           |   | 7/23/2018           | 12:35 PM     | 9.25           | 61.5        | CW             |
|           |   | 7/27/2018           | 12:40 PM     | 8.98           | 59.7        | CW             |
|           |   | 8/3/2018            | 12:15 PM     | 9.49           | 61.5        | CW             |
| 280418    | Kids Creek (Trib A) - Elmwood Ave         | 7/10/2018           | 12:25 PM     | 9.88           | 62.2        | CW             |
|           |   | 7/17/2018           | 12:25 PM     | 9.71           | 61.3        | CW             |
|           |   | 7/23/2018           | 12:20 PM     | 9.7            | 60.8        | CW             |
|           |   | 7/27/2018           | 12:20 PM     | 9.79           | 59.4        | CW             |
|           |   | 8/3/2018            | 12:05 PM     | 9.76           | 61.2        | CW             |
| 280426    | Kids Creek - Front St                     | 7/10/2018           | 12:05 PM     | 9.33           | 61          | CW             |
|           |   | 7/17/2018           | 12:05 PM     | 9.33           | 60.3        | CW             |
|           |   | 7/23/2018           | 12:05 PM     | 9.06           | 61.5        | CW             |
|           |   | 7/27/2018           | 12:05 PM     | 9.08           | 59.9        | CW             |
|           |   | 8/3/2018            | 11:35 AM     | 9.31           | 60.1        | CW             |
| Watershed |   | Boardman Charlevoix | 040601050708 |                |             |                |
| 450140    | Northport Creek - Rose Rd                 | 7/10/2018           | 11:05 AM     | 8.81           | 58.5        | CW             |
|           |   | 7/17/2018           | 11:00 AM     | 8.57           | 58.3        | CW             |
|           |   | 7/23/2018           | 10:55 AM     | 8.8            | 58.3        | CW             |
|           |   | 7/27/2018           | 11:10 AM     | 9.15           | 57.2        | CW             |
|           |   | 8/3/2018            | 10:45 AM     | 8.61           | 57.4        | CW             |

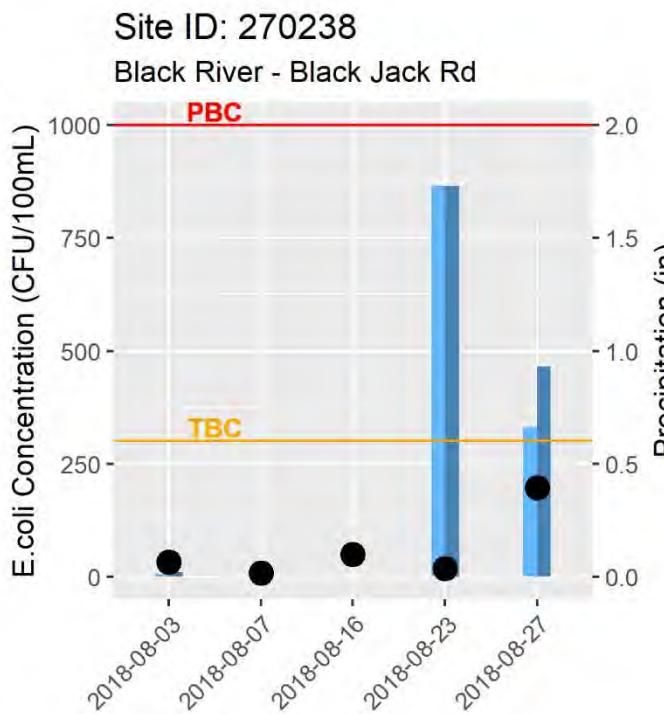
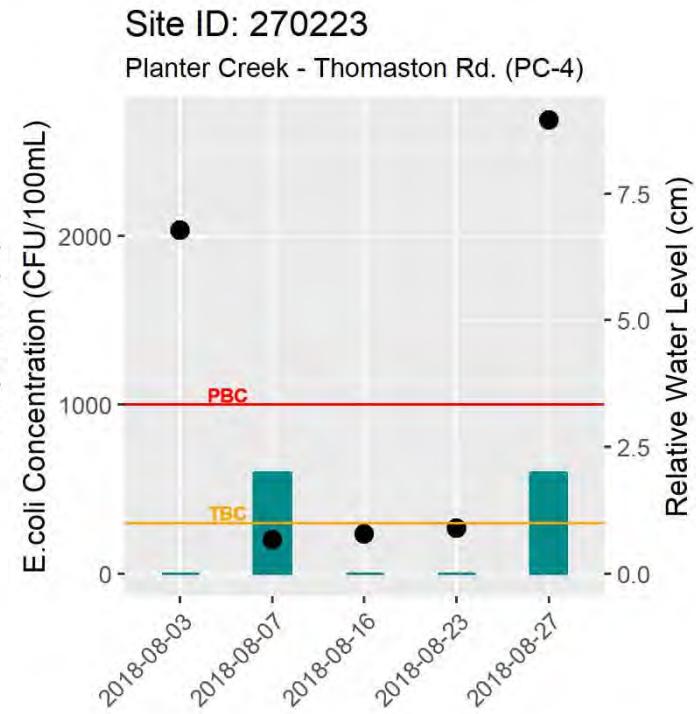
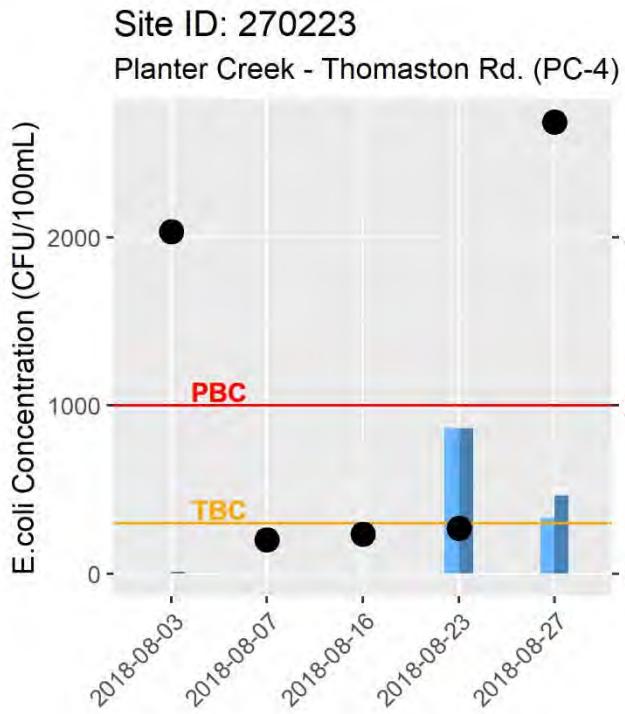
| Site ID   | Site Description                 | Date             | Time         | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|----------------------------------|------------------|--------------|----------------|-------------|----------------|
| 450155    | Northport Creek - Melkild/3rd    | 7/10/2018        | 10:50 AM     | 9.72           | 54          | CW             |
|           |                                  | 7/17/2018        | 10:45 AM     | 9.58           | 54.9        | CW             |
|           |                                  | 7/20/2018        | 10:40 AM     | 9.44           | 56.8        | CW             |
|           |                                  | 7/27/2018        | 10:55 AM     | 9.4            | 56.7        | CW             |
|           |                                  | 8/3/2018         | 10:35 AM     | 9.64           | 54.5        | CW             |
| Watershed |                                  | Pigeon-Wiscoggin | 040801030203 |                |             |                |
| 320316    | Pigeon River - Geiger Rd - PGN06 | 7/23/2018        | 10:52 AM     | 6.68           | 68.9        | WW             |
|           |                                  | 7/30/2018        | 12:15 PM     | 6.52           | 71.6        | WW             |
|           |                                  | 8/6/2018         | 12:15 PM     | 5.93           | 76.8        | WW             |
|           |                                  | 8/13/2018        | 11:05 AM     | 6.92           | 72.6        | WW             |
|           |                                  | 8/20/2018        | 11:12 AM     | 6.64           | 71.7        | WW             |
| Watershed |                                  | Pigeon-Wiscoggin | 040801030204 |                |             |                |
| 320317    | Pigeon River - Limerick Rd       | 7/23/2018        | 10:23 AM     | 5.38           | 67.2        | WW             |
|           |                                  | 7/30/2018        | 11:45 AM     | 7.34           | 72.4        | WW             |
|           |                                  | 8/6/2018         | 11:45 AM     | 5.68           | 75.4        | WW             |
|           |                                  | 8/13/2018        | 10:40 AM     | 8.5            | 71.7        | WW             |
|           |                                  | 8/20/2018        | 10:45 AM     | 6.33           | 71.5        | WW             |
| 320361    | Fisher Drain - Griggs Rd         | 7/23/2018        | 10:05 AM     | 6.16           | 68.1        | WW             |
|           |                                  | 7/30/2018        | 11:10 AM     | 7.76           | 70.9        | WW             |
|           |                                  | 8/6/2018         | 11:20 AM     | 4.49           | 74.8        | WW             |
|           |                                  | 8/13/2018        | 10:20 AM     | 4.25           | 70.5        | WW             |
|           |                                  | 8/20/2018        | 10:25 AM     | 1.63           | 69          | WW             |
| Watershed |                                  | Pigeon-Wiscoggin | 040801030405 |                |             |                |
| 320362    | Bird Creek - Knoblock/Hunter Rd  | 7/30/2018        | 10:35 AM     | 6.98           | 68.1        | WW             |
|           |                                  | 8/6/2018         | 10:40 AM     | 4.38           | 72.6        | WW             |
|           |                                  | 8/13/2018        | 9:50 AM      | 3.68           | 67.9        | WW             |
|           |                                  | 8/20/2018        | 9:45 AM      | 4.6            | 67.5        | WW             |
|           |                                  | 8/28/2018        | 9:50 AM      | 5.17           | 70.5        | WW             |

| Site ID   | Site Description                     | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|--------------------------------------|--------------|----------|----------------|-------------|----------------|
| Watershed | Pigeon-Wiscoggin                     | 040801030407 |          |                |             |                |
| 320335    | New River - Stoddard Rd              | 7/23/2018    | 8:55 AM  | 2.65           | 66          | WW             |
|           |                                      | 7/30/2018    | 9:55 AM  | 3.71           | 65.2        | WW             |
|           |                                      | 8/6/2018     | 10:15 AM | 4.72           | 72          | WW             |
|           |                                      | 8/13/2018    | 9:30 AM  | 3.41           | 67.5        | WW             |
|           |                                      | 8/20/2018    | 9:15 AM  | 4.33           | 67.4        | WW             |
| Watershed | Birch-Willow                         | 040801040101 |          |                |             |                |
| 320279    | E Br Willow Creek - Minnick Rd       | 7/23/2018    | 7:10 AM  | 10.1           | 67.4        | WW             |
|           |                                      | 7/30/2018    | 8:37 AM  | 5.97           | 66.6        | WW             |
|           |                                      | 8/6/2018     | 8:40 AM  | 8.36           | 74.7        | WW             |
|           |                                      | 8/13/2018    | 7:35 AM  | 5.2            | 68.8        | WW             |
|           |                                      | 8/20/2018    | 8:00 AM  | 3.88           | 68.5        | WW             |
| Watershed | Birch-Willow                         | 040801040102 |          |                |             |                |
| 320240    | Willow Creek - Dobson Rd             | 7/23/2018    | 7:33 AM  | 3.59           | 68.2        | WW             |
|           |                                      | 7/30/2018    | 9:00 AM  | 3.87           | 70.1        | WW             |
|           |                                      | 8/6/2018     | 9:15 AM  | 2.48           | 77.3        | WW             |
|           |                                      | 8/13/2018    | 8:55 AM  | 4.14           | 70.2        | WW             |
|           |                                      | 8/20/2018    | 8:20 AM  | 3.42           | 69.6        | WW             |
| Watershed | Birch-Willow                         | 040801040103 |          |                |             |                |
| 320324    | Willow Creek - Stoddard Rd           | 7/23/2018    | 8:43 AM  | 5.96           | 67.8        | WW             |
|           |                                      | 7/30/2018    | 9:35 AM  | 6.86           | 67.9        | WW             |
|           |                                      | 8/6/2018     | 10:00 AM | 6.24           | 75.7        | WW             |
|           |                                      | 8/13/2018    | 9:10 AM  | 8.24           | 70.5        | WW             |
|           |                                      | 8/20/2018    | 8:55 AM  | 6.89           | 69.1        | WW             |
|           |                                      | 8/28/2018    | 9:50 AM  | 7.46           | 71          | WW             |
| 320358    | Trib to Willow Creek - Huron City Rd | 7/23/2018    | 7:55 AM  | 2.71           | 61.8        | WW             |
|           |                                      | 7/30/2018    | 9:30 AM  | 4.52           | 64.3        | WW             |
|           |                                      | 8/6/2018     | 9:40 AM  | 2.72           | 70.8        | WW             |
|           |                                      | 8/13/2018    | 8:30 AM  | 3.6            | 68          | WW             |
|           |                                      | 8/20/2018    | 8:40 AM  | 3.41           | 68.7        | WW             |

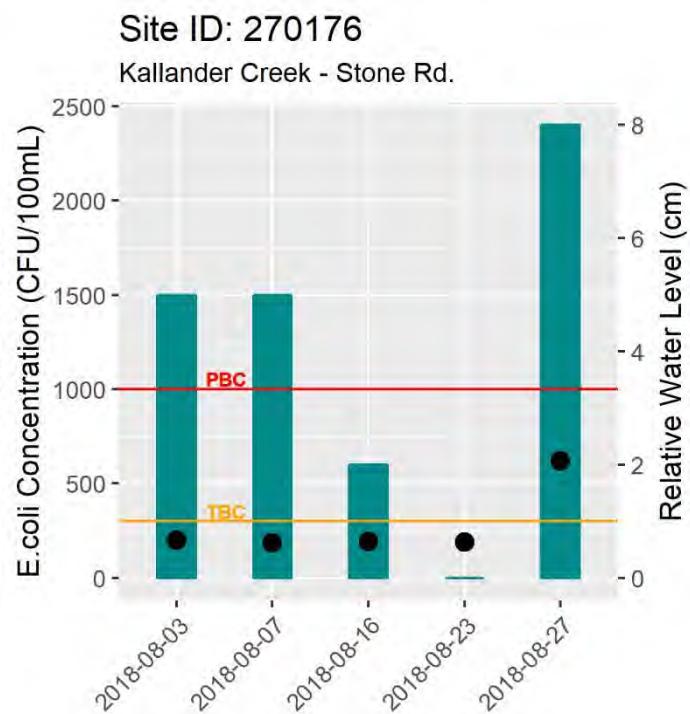
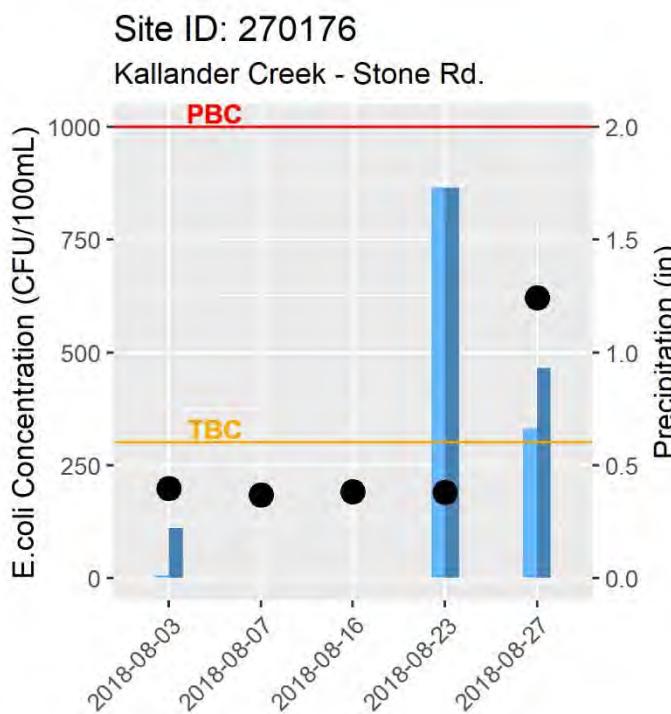
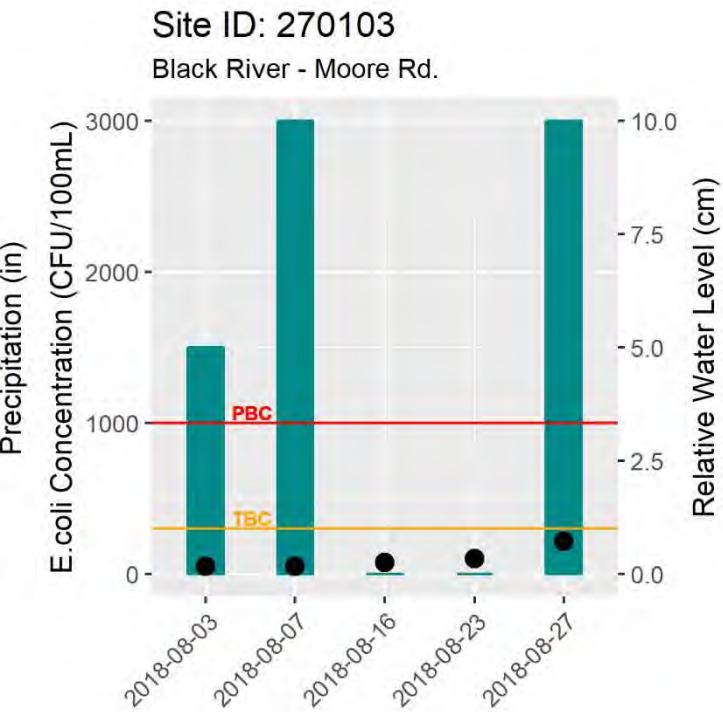
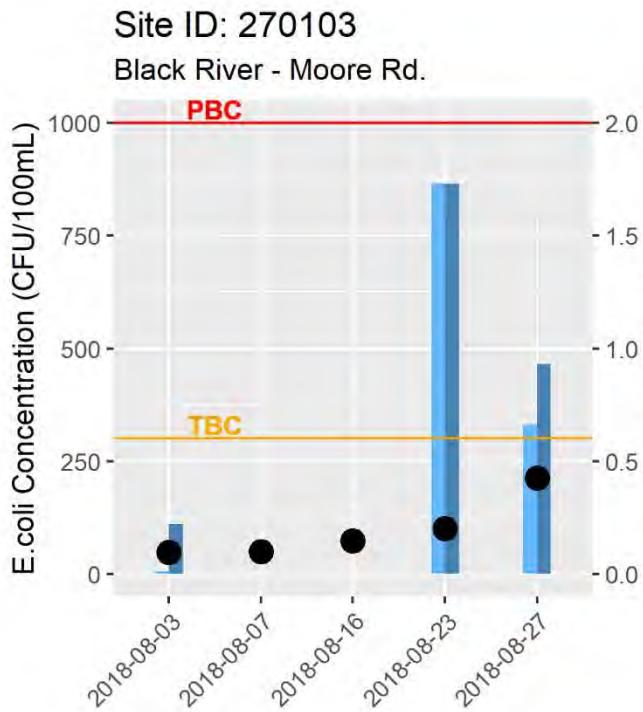
| Site ID   | Site Description                  | Date         | Time      | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|-----------------------------------|--------------|-----------|----------------|-------------|----------------|
| Watershed | Flint                             | 040802040304 |           |                |             |                |
| 250402    | W Branch Swartz Creek - Linden Rd |              | 8/2/2018  | 11:00 AM       | 7.85        | 70.1           |
|           |                                   |              | 8/9/2018  | 10:05 AM       | 6.43        | 71.5           |
|           |                                   |              | 8/16/2018 | 10:20 AM       | 5.02        | 73.1           |
|           |                                   |              | 8/23/2018 | 10:15 AM       | 5.59        | 66.8           |
|           |                                   |              | 8/30/2018 | 10:37 AM       | 7.21        | 68             |
| Watershed | Flint                             | 040802040305 |           |                |             |                |
| 250460    | Indian Creek - Cook Rd            |              | 8/2/2018  | 7:08 AM        | 4.78        | 61.8           |
|           |                                   |              | 8/9/2018  | 7:00 AM        | 9.01        | 66.2           |
|           |                                   |              | 8/16/2018 | 7:15 AM        | 3.72        | 62.3           |
|           |                                   |              | 8/23/2018 | 7:15 AM        | 4.03        | 57             |
|           |                                   |              | 8/30/2018 | 7:20 AM        | 4.82        | 61.8           |
| 250551    | Swartz Creek - Maple Rd           |              | 8/2/2018  | 10:45 AM       | 7.47        | 69.7           |
|           |                                   |              | 8/9/2018  | 9:45 AM        | 7.28        | 71.7           |
|           |                                   |              | 8/16/2018 | 10:00 AM       | 6.33        | 72.6           |
|           |                                   |              | 8/23/2018 | 9:55 AM        | 6.08        | 65             |
|           |                                   |              | 8/30/2018 | 10:12 AM       | 7.43        | 69             |
| Watershed | Flint                             | 040802040306 |           |                |             |                |
| 250343    | Thread Creek - Dort Hwy           |              | 8/2/2018  | 9:18 AM        | 6.12        | 67.5           |
|           |                                   |              | 8/9/2018  | 8:20 AM        | 6.64        | 71.2           |
|           |                                   |              | 8/16/2018 | 8:25 AM        | 5.33        | 72.4           |
|           |                                   |              | 8/23/2018 | 8:30 AM        | 6.59        | 65.3           |
|           |                                   |              | 8/30/2018 | 8:35 AM        | 7.42        | 68.6           |
| 250550    | Thread Creek - Perry Rd           |              | 8/2/2018  | 7:50 AM        | 6.91        | 67.1           |
|           |                                   |              | 8/9/2018  | 7:45 AM        | 6.77        | 70.3           |
|           |                                   |              | 8/16/2018 | 7:55 AM        | 6.03        | 72.6           |
|           |                                   |              | 8/23/2018 | 7:50 AM        | 7.63        | 64             |
|           |                                   |              | 8/30/2018 | 7:55 AM        | 7.48        | 67.4           |

| Site ID   | Site Description                | Date         | Time     | D.O.<br>(mg/L) | Temp<br>(F) | CW<br>or<br>WW |
|-----------|---------------------------------|--------------|----------|----------------|-------------|----------------|
| Watershed | Flint                           | 040802040307 |          |                |             |                |
| 250335    | Swartz Creek - Hammerberg Rd    | 8/2/2018     | 9:50 AM  | 6.71           | 68.2        | WW             |
|           |                                 | 8/9/2018     | 8:45 AM  | 6.77           | 71.7        | WW             |
|           |                                 | 8/16/2018    | 9:12 AM  | 6.54           | 73.6        | WW             |
|           |                                 | 8/23/2018    | 9:00 AM  | 7.29           | 65.6        | WW             |
|           |                                 | 8/30/2018    | 9:05 AM  | 7.71           | 68.1        | WW             |
| 250339    | Carman Drain - 12th St          | 8/2/2018     | 10:10 AM | 6.56           | 66.6        | WW             |
|           |                                 | 8/9/2018     | 9:15 AM  | 7.02           | 69.8        | WW             |
|           |                                 | 8/16/2018    | 9:27 AM  | 6.38           | 70.4        | WW             |
|           |                                 | 8/23/2018    | 9:30 AM  | 6.92           | 64.2        | WW             |
|           |                                 | 8/30/2018    | 9:30 AM  | 7.73           | 66.5        | WW             |
| Watershed | Flint                           | 040802040501 |          |                |             |                |
| 250103    | Flint River - Main St           | 8/2/2018     | 11:40 AM | 9.49           | 72.6        | WW             |
|           |                                 | 8/9/2018     | 11:00 AM | 7.38           | 75.2        | WW             |
|           |                                 | 8/16/2018    | 10:55 AM | 7.67           | 75.9        | WW             |
|           |                                 | 8/23/2018    | 10:55 AM | 9.47           | 70.4        | WW             |
|           |                                 | 8/30/2018    | 11:20 AM | 8.22           | 72.5        | WW             |
| 250549    | Cole Creek - Seymour Rd (north) | 8/2/2018     | 11:59 AM | 8.51           | 66.5        | WW             |
|           |                                 | 8/9/2018     | 11:15 AM | 8.47           | 70.1        | WW             |
|           |                                 | 8/16/2018    | 11:15 AM | 7.77           | 70.6        | WW             |
|           |                                 | 8/23/2018    | 11:15 AM | 8.97           | 65.6        | WW             |
|           |                                 | 8/30/2018    | 11:40 AM | 8.9            | 66          | WW             |

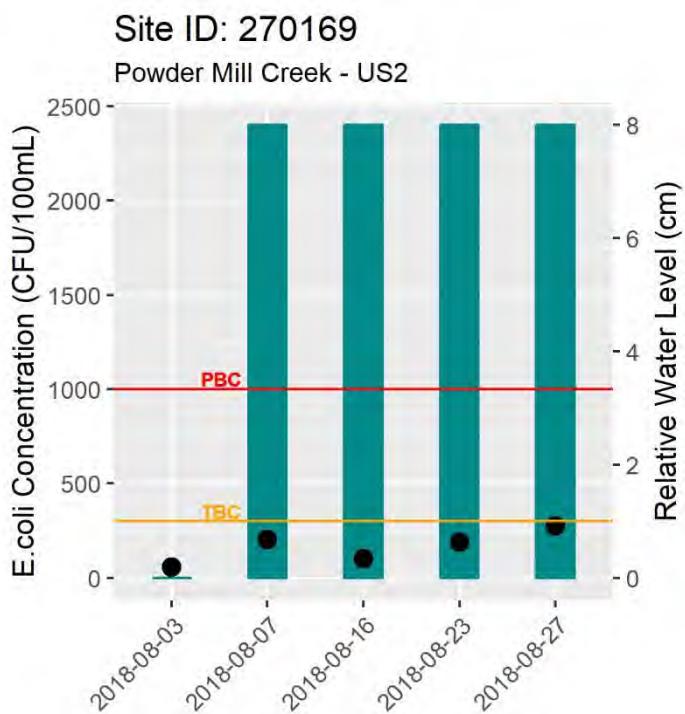
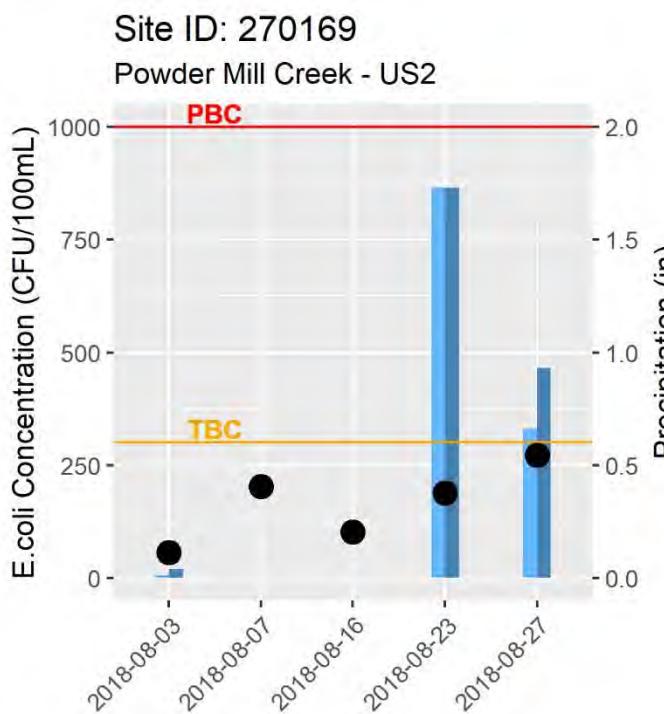
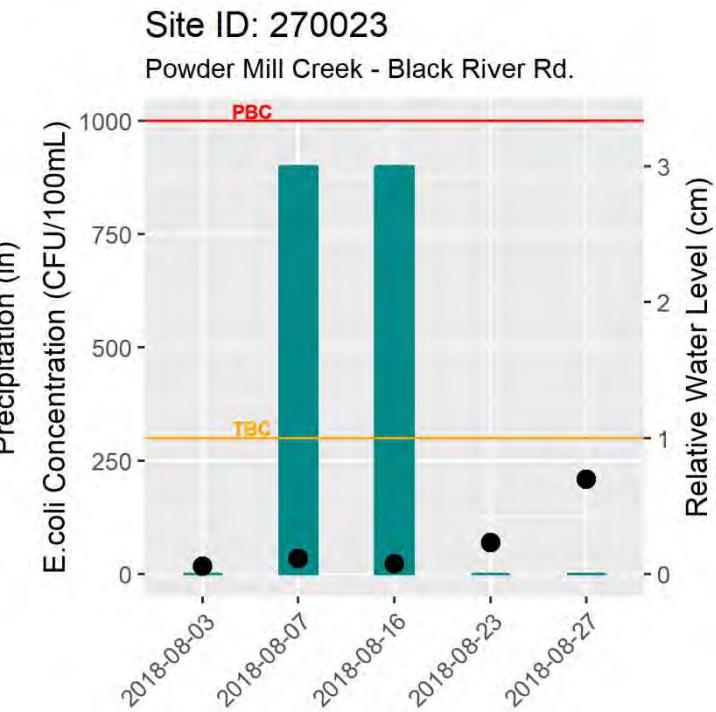
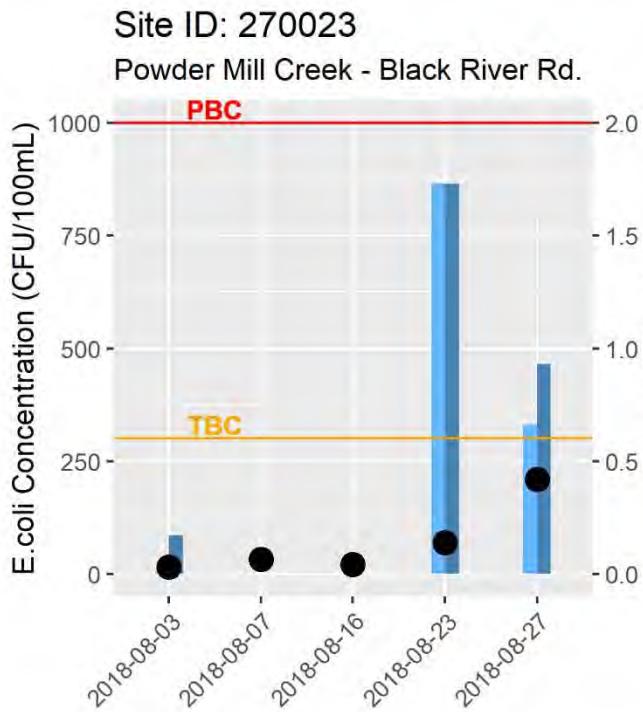
Appendix 4. *E. coli* concentrations for each site (organized by watershed) graphed with prior precipitation (left column) and relative water levels (right column). Relative water levels are the change in water level relative to the lowest measured during the 5-week study and are represented by bars on the secondary y-axis. Prior precipitation is represented by light (24-hour) and dark (48-hour) blue bars on the secondary axis. These graphs are a visual representation of Appendix 1.



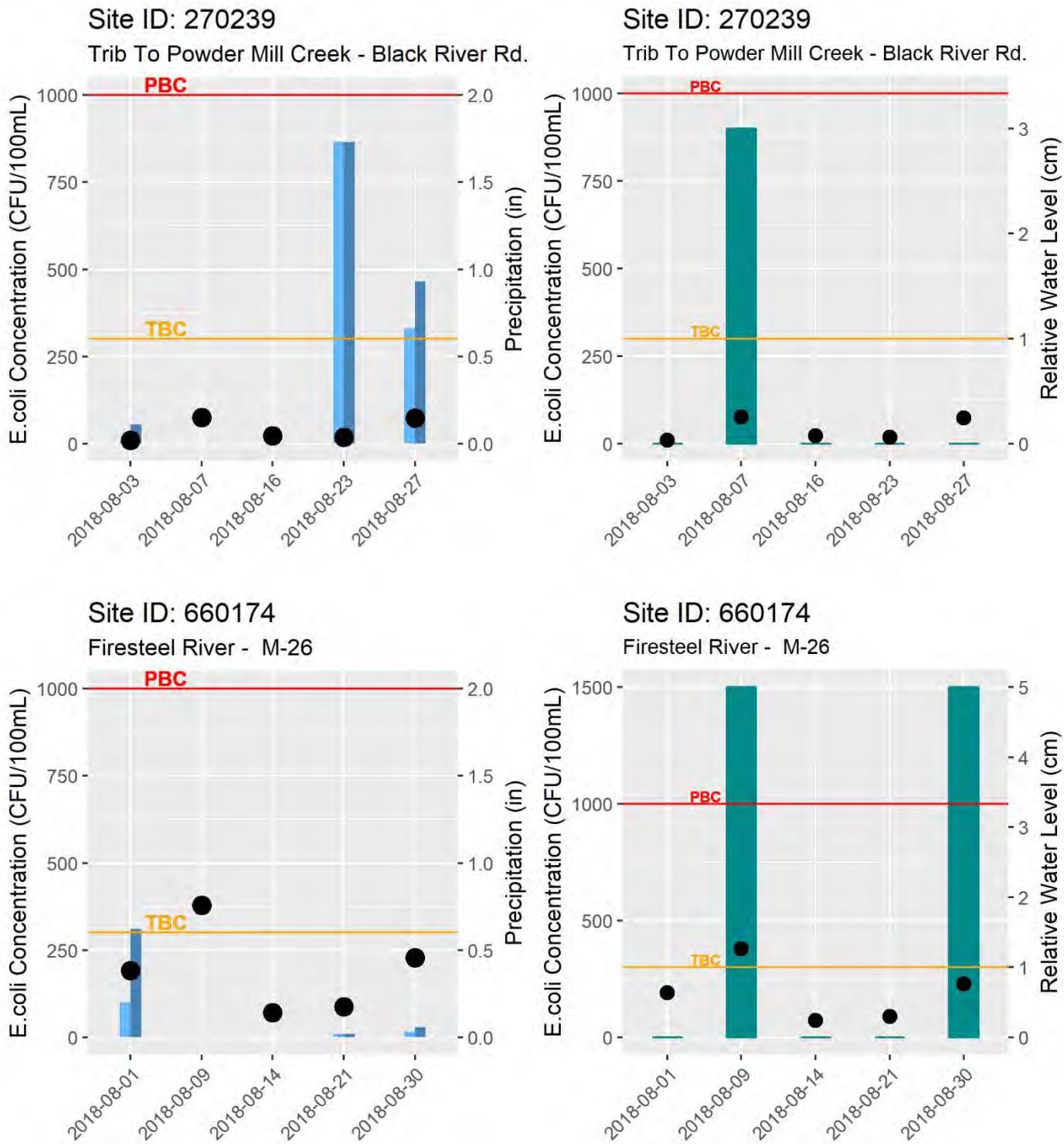
Appendix 4 (cont.). Black-Presque Isle and Keweenaw sites.



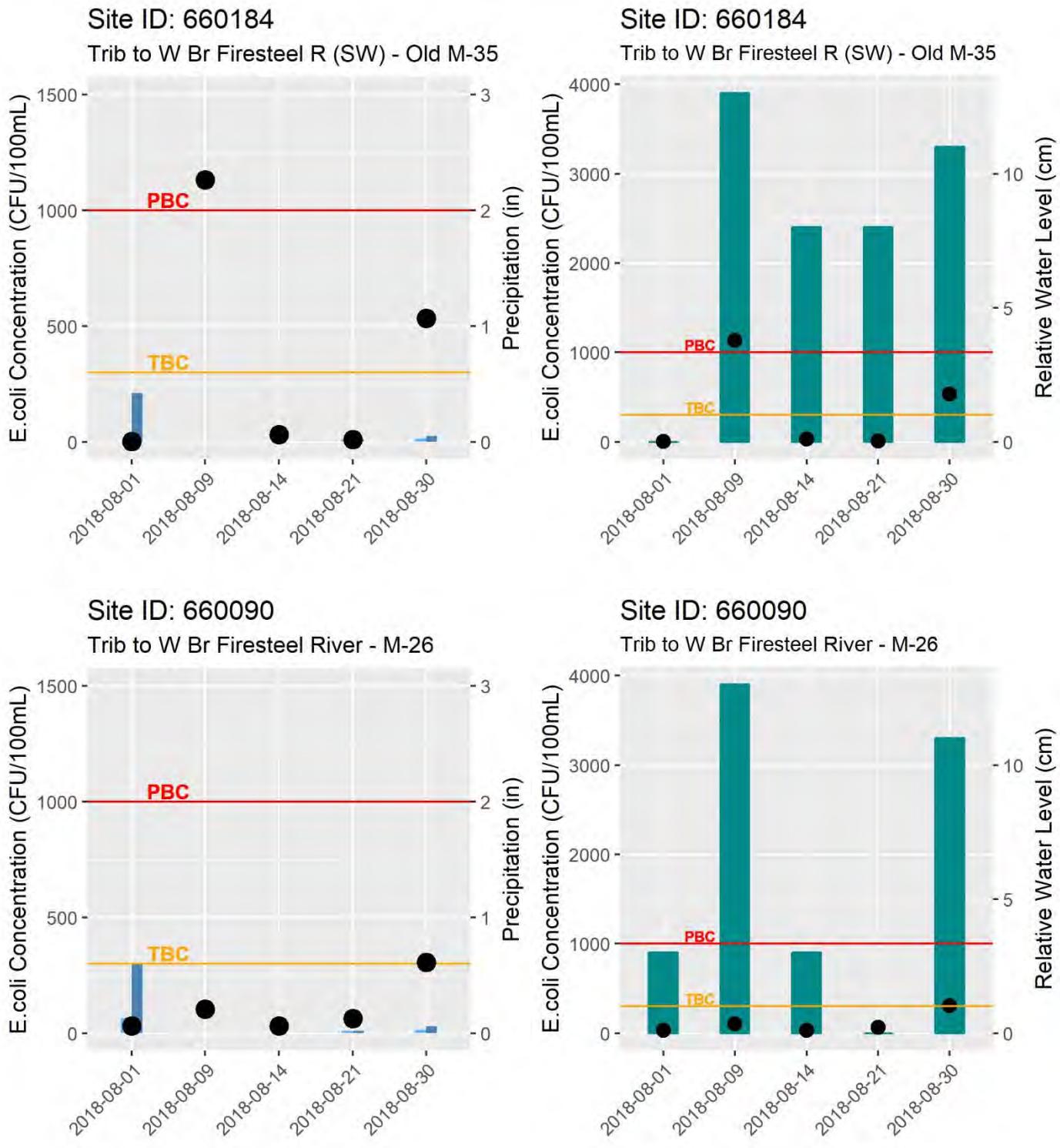
Appendix 4 (cont.). Black-Presque Isle and Keweenaw sites.



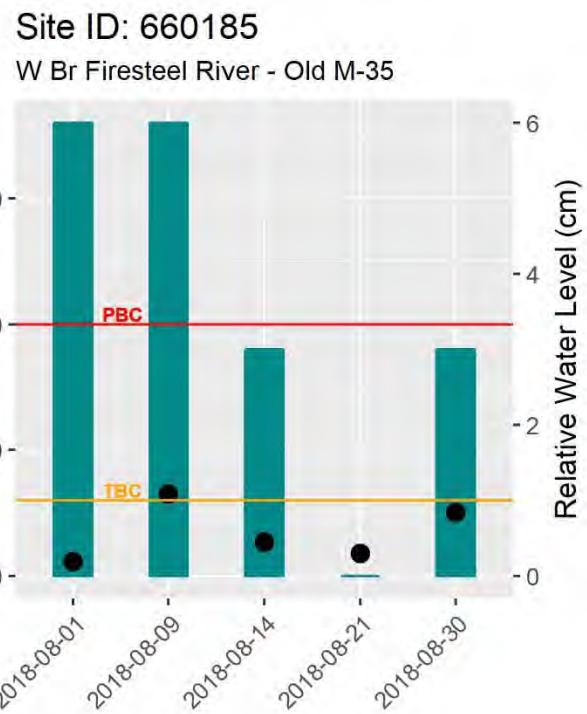
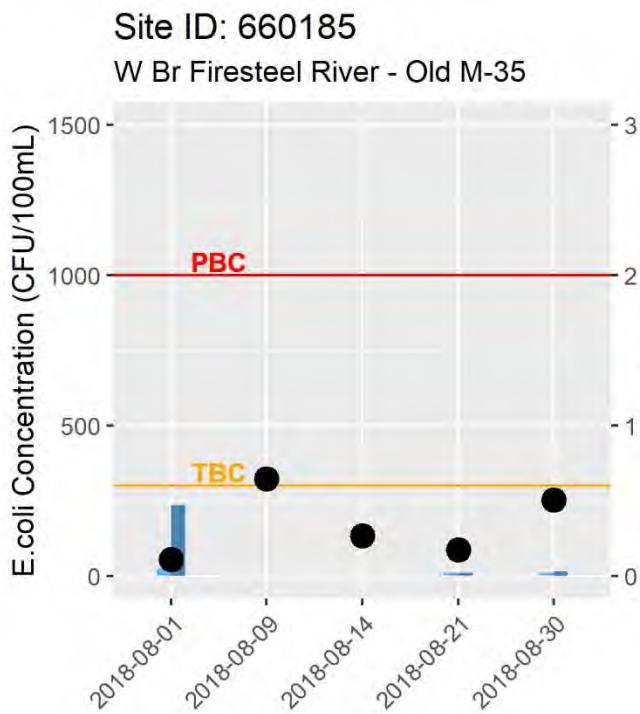
Appendix 4 (cont.). Black-Presque Isle and Keweenaw sites.



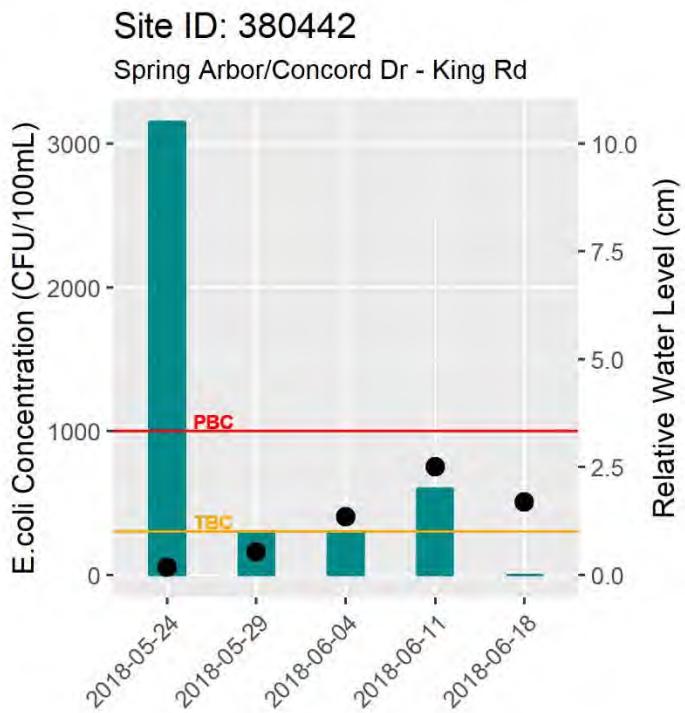
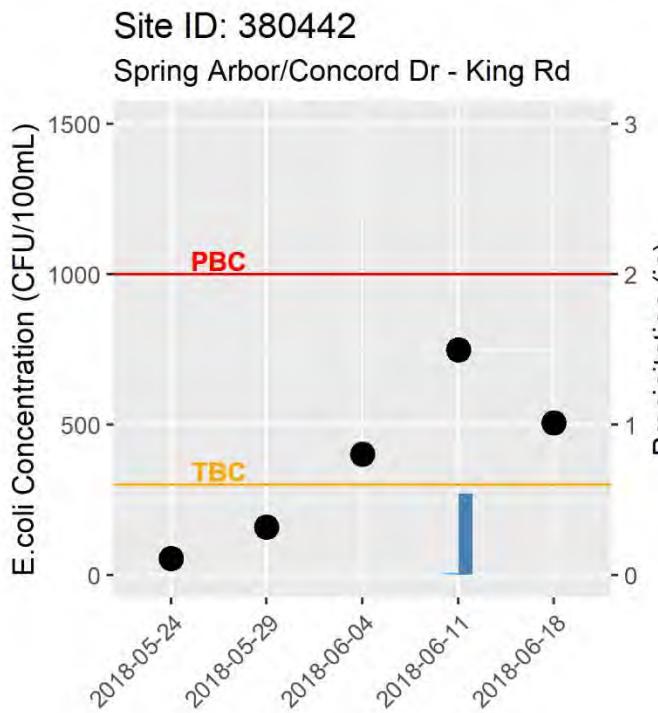
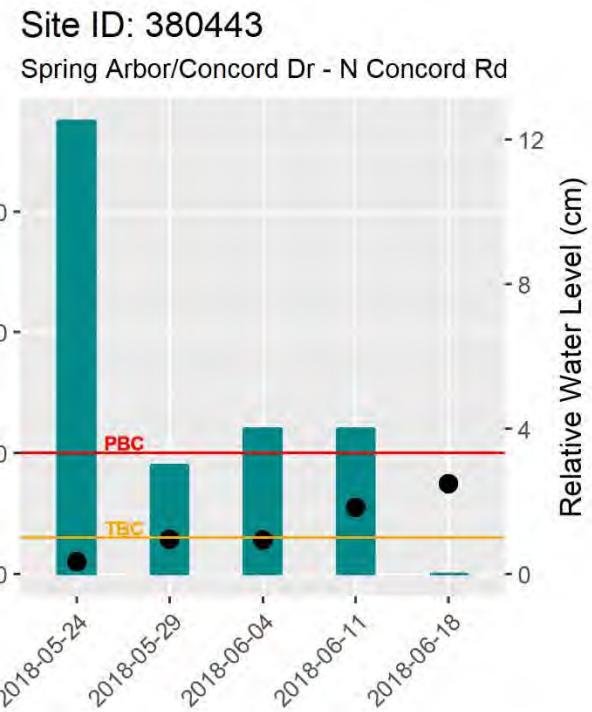
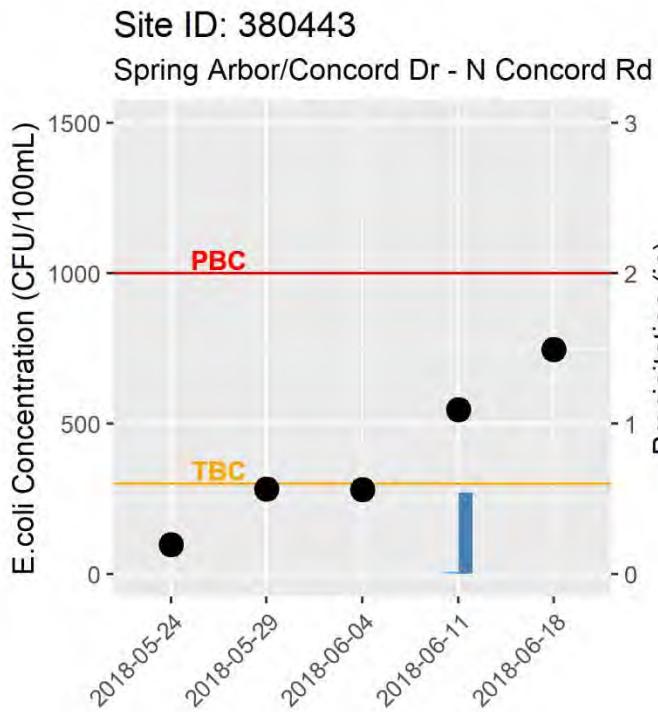
Appendix 4 (cont.). Black-Presque Isle and Keweenaw sites.



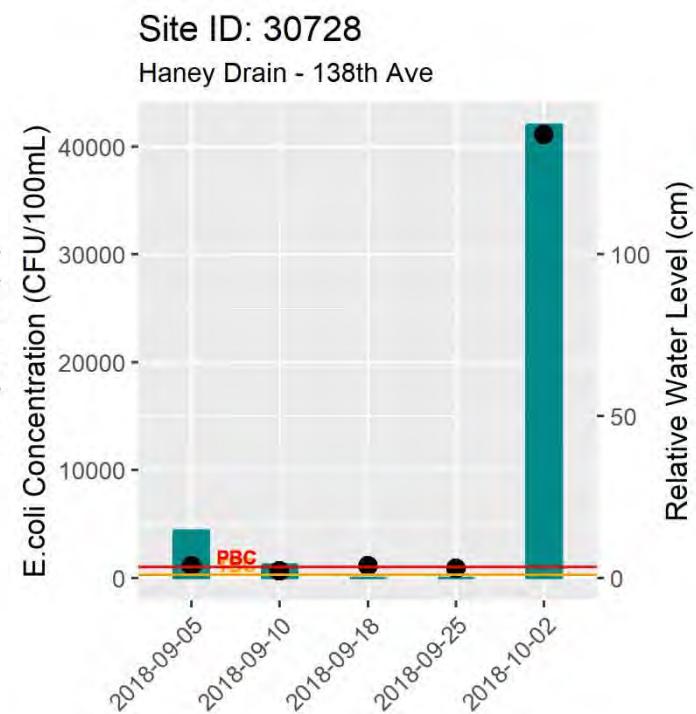
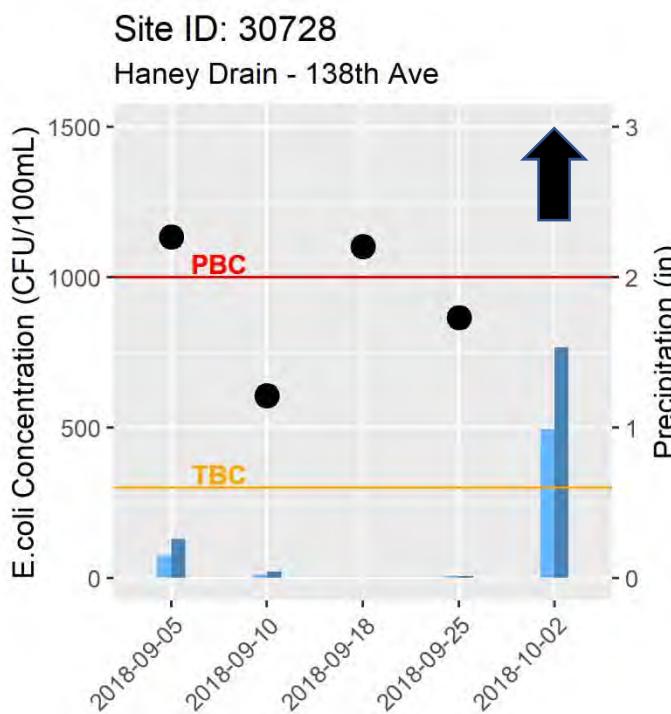
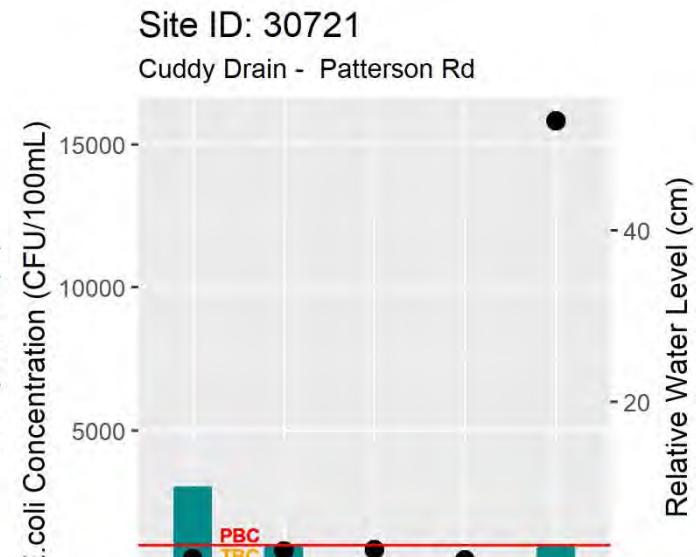
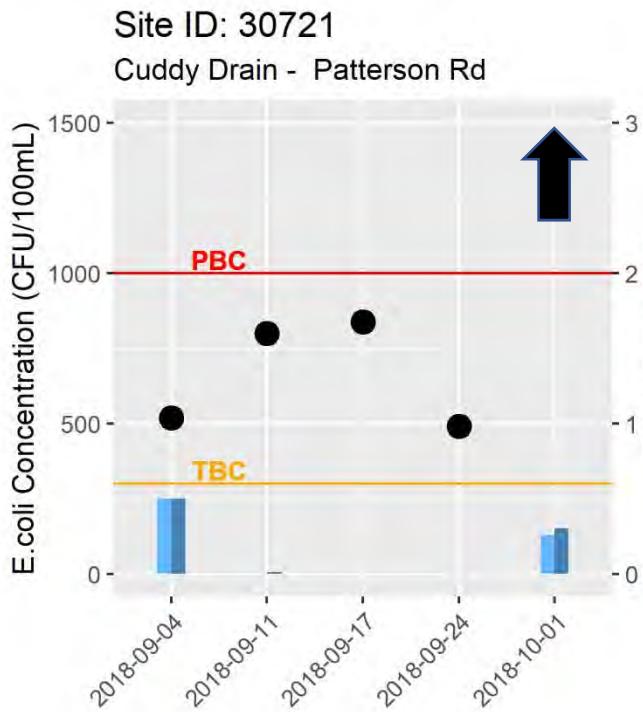
Appendix 4 (cont.). Black-Presque Isle and Keweenaw sites.



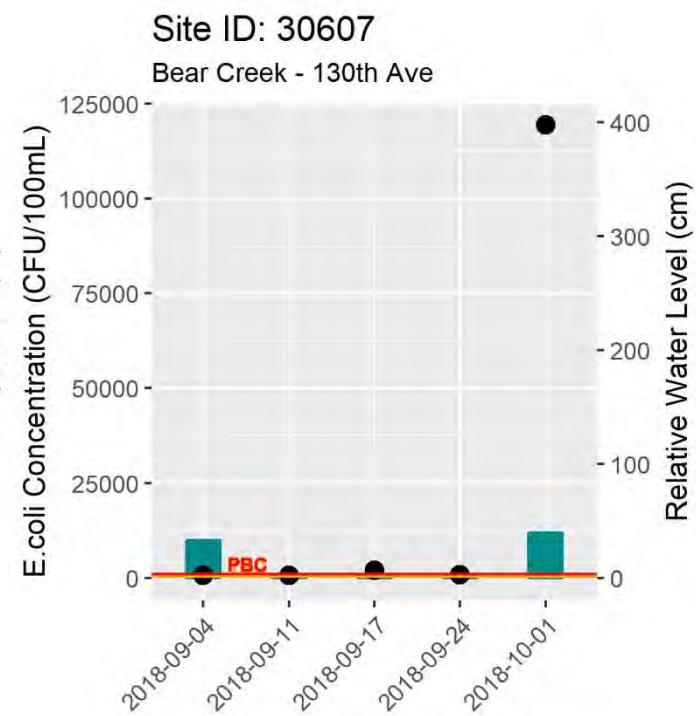
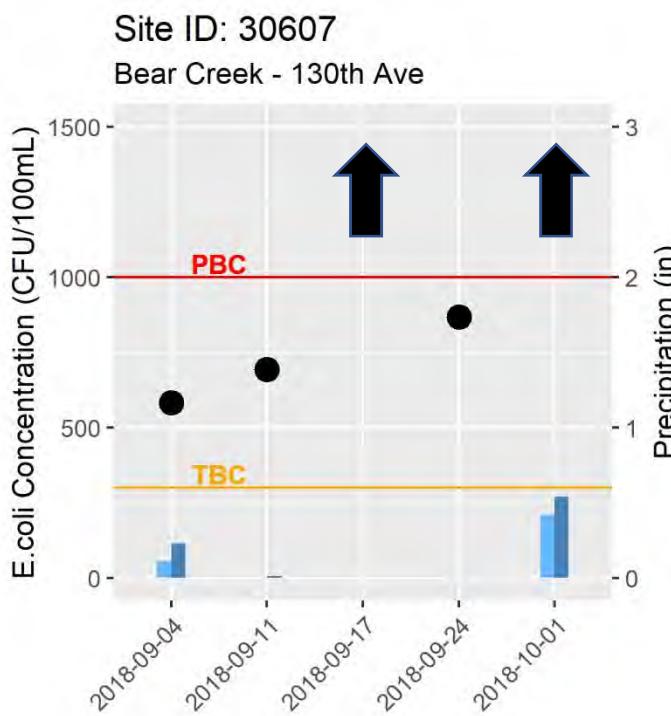
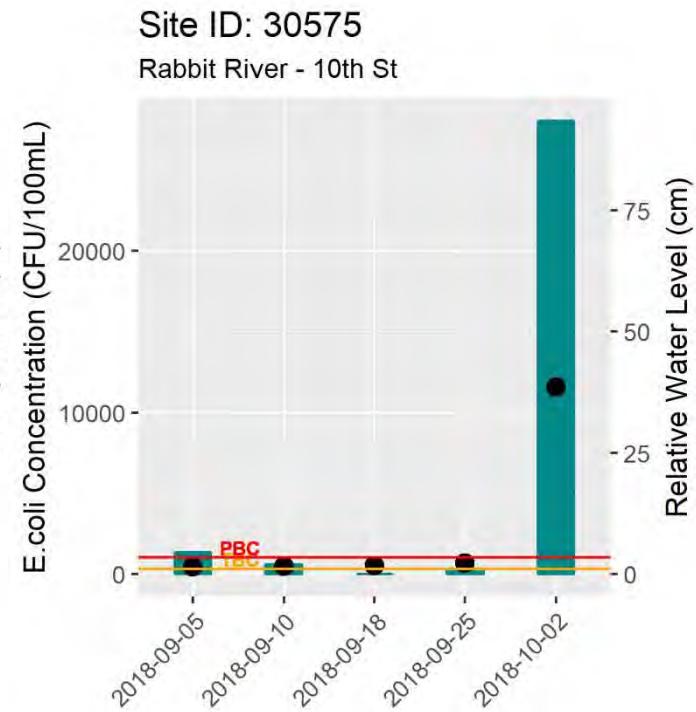
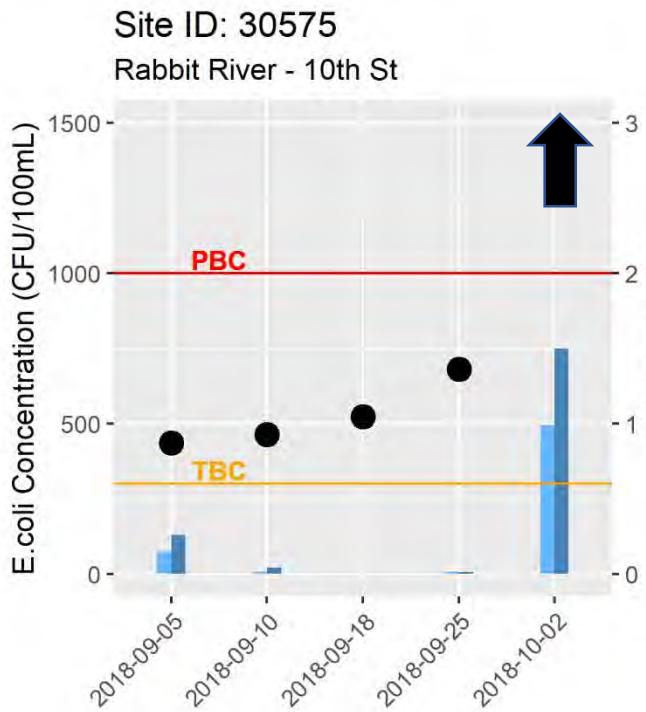
Appendix 4 (cont.). Kalamazoo sites.



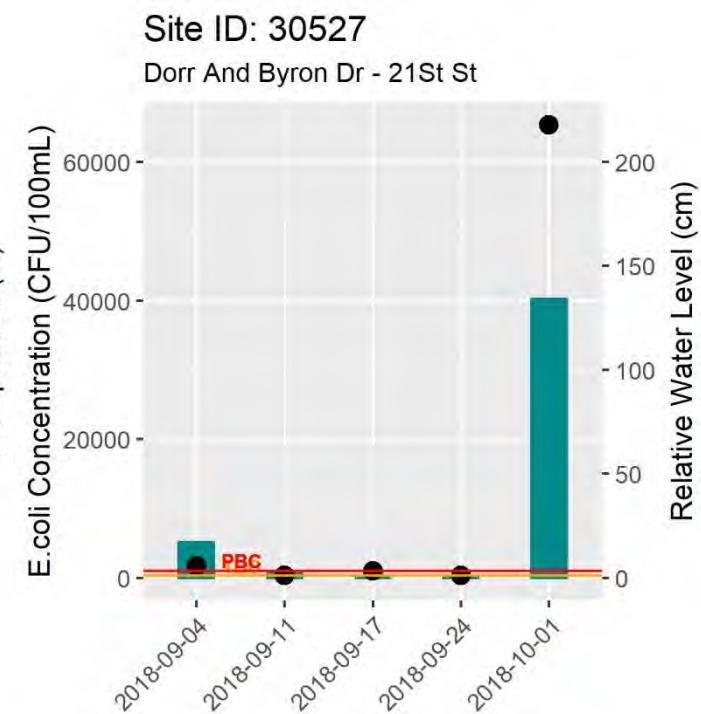
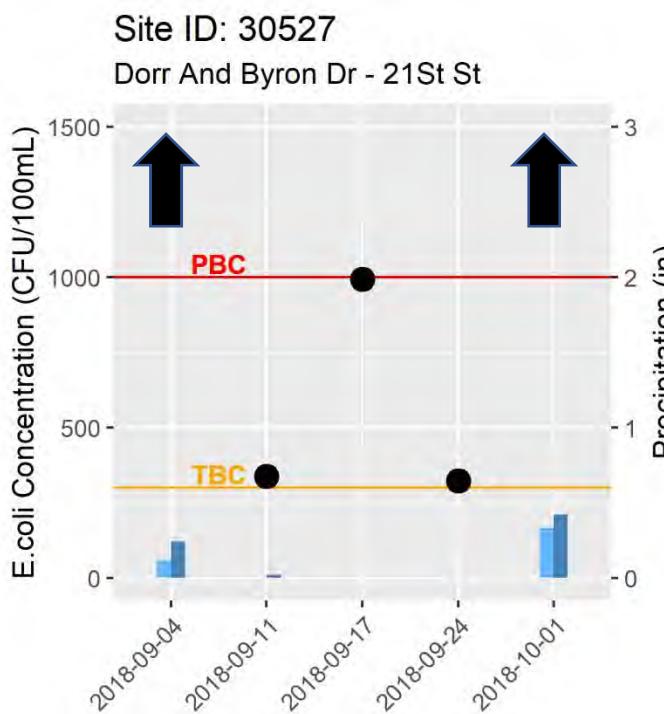
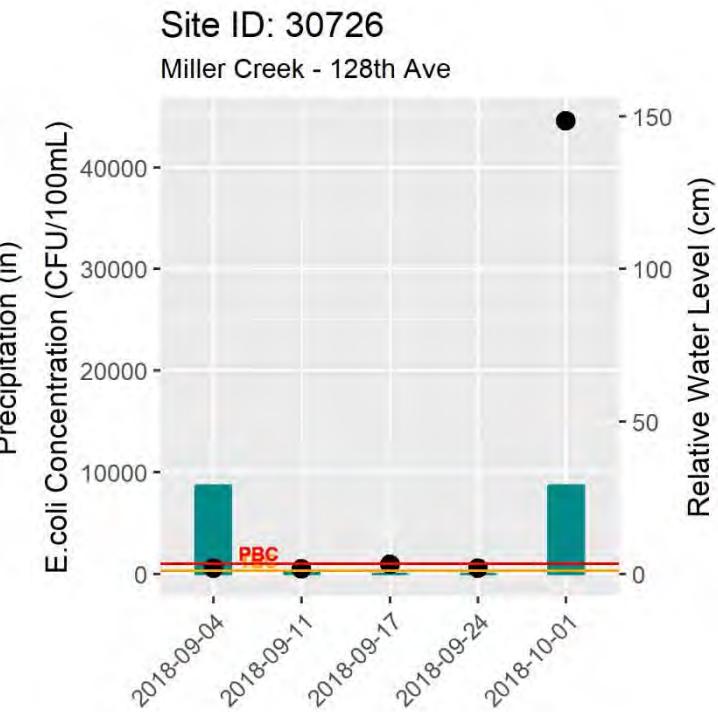
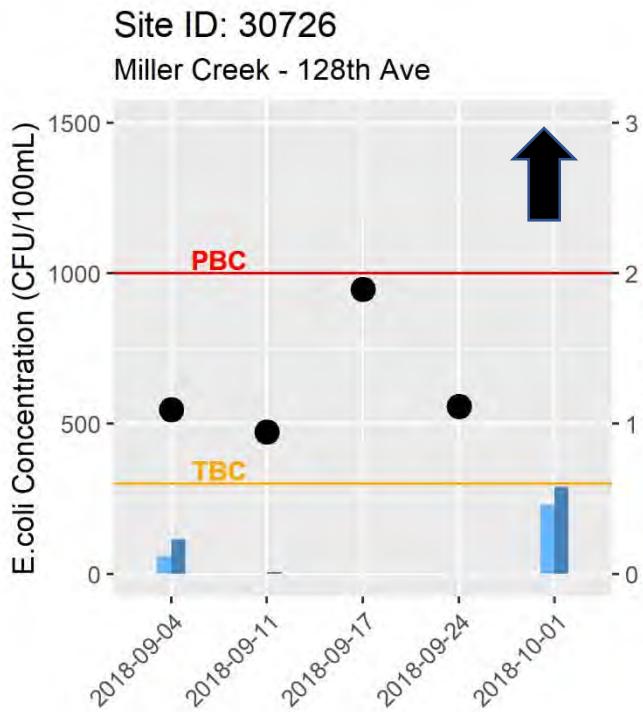
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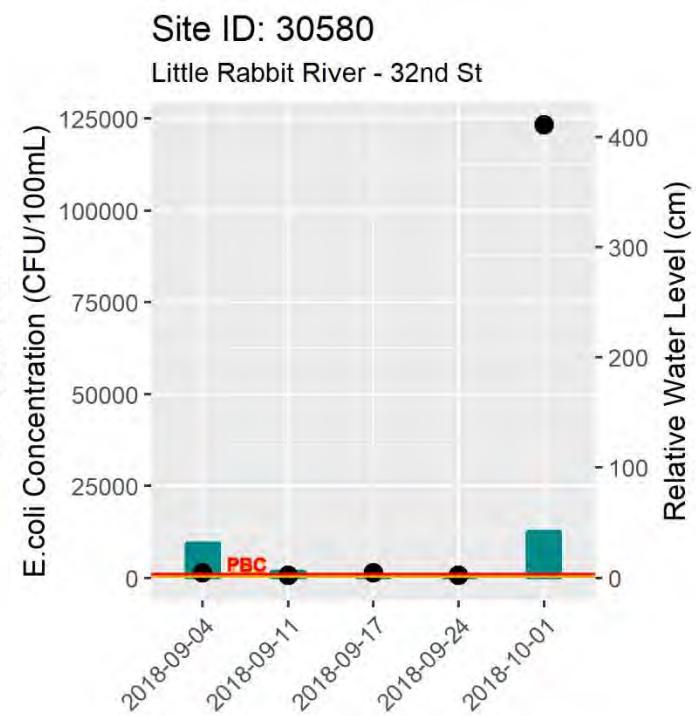
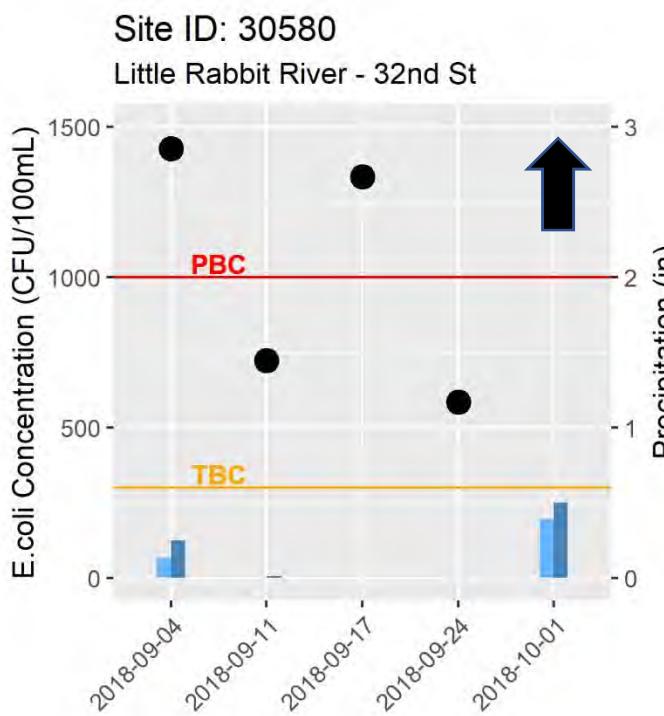
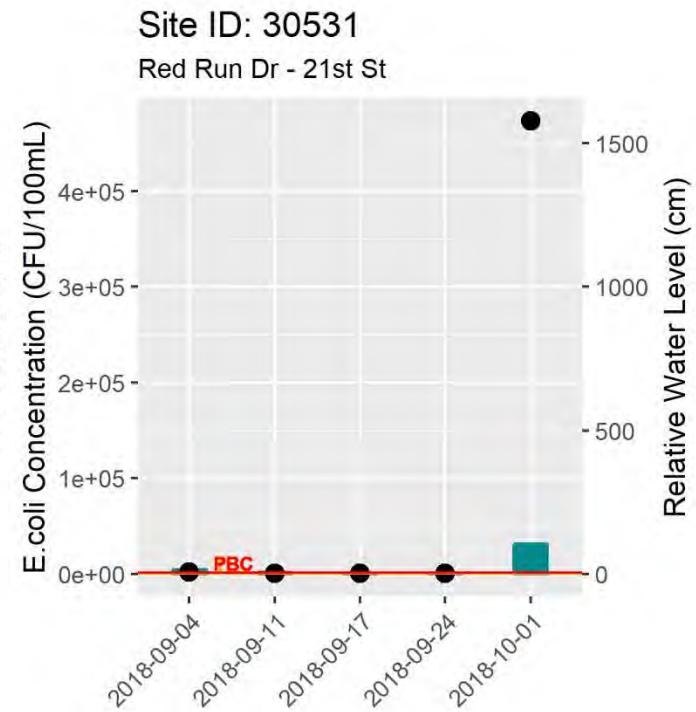
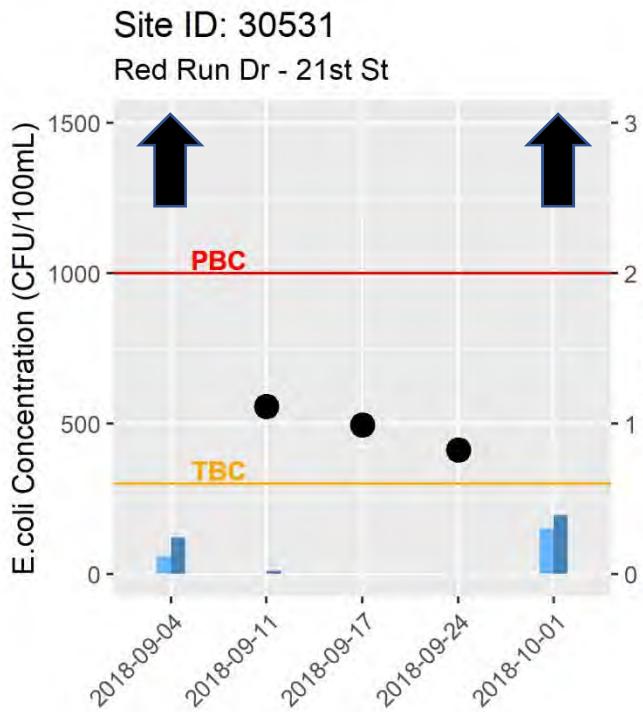
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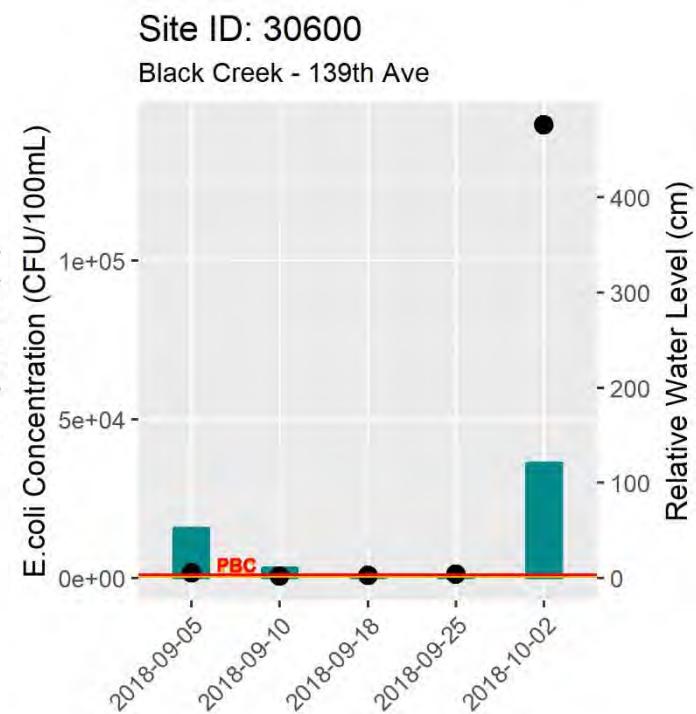
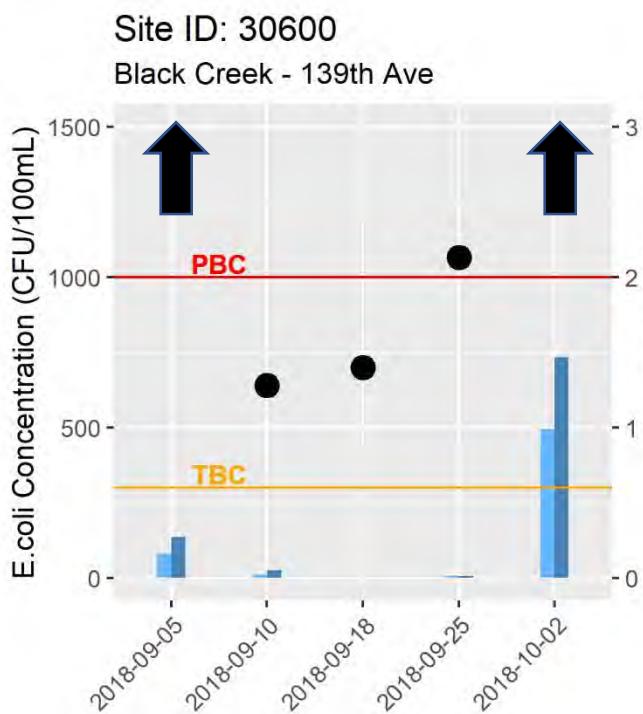
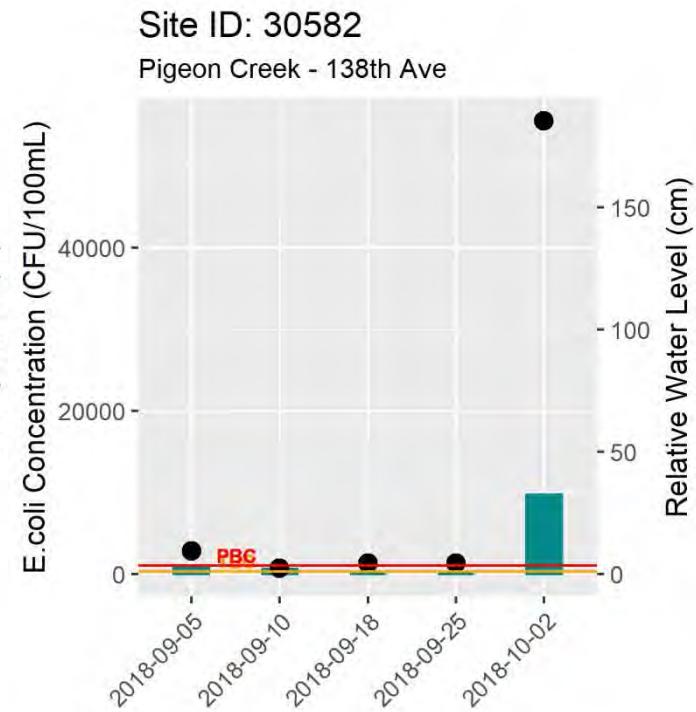
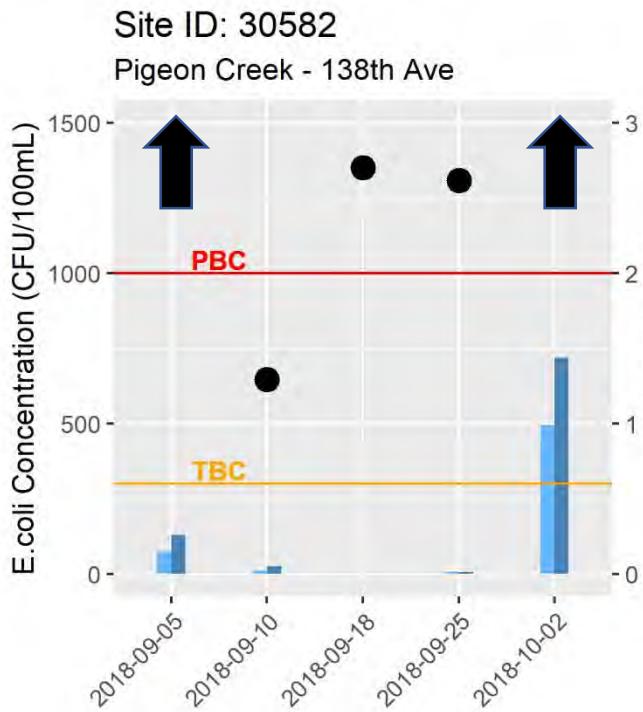
Appendix 4 (cont.). Kalamazoo sites.



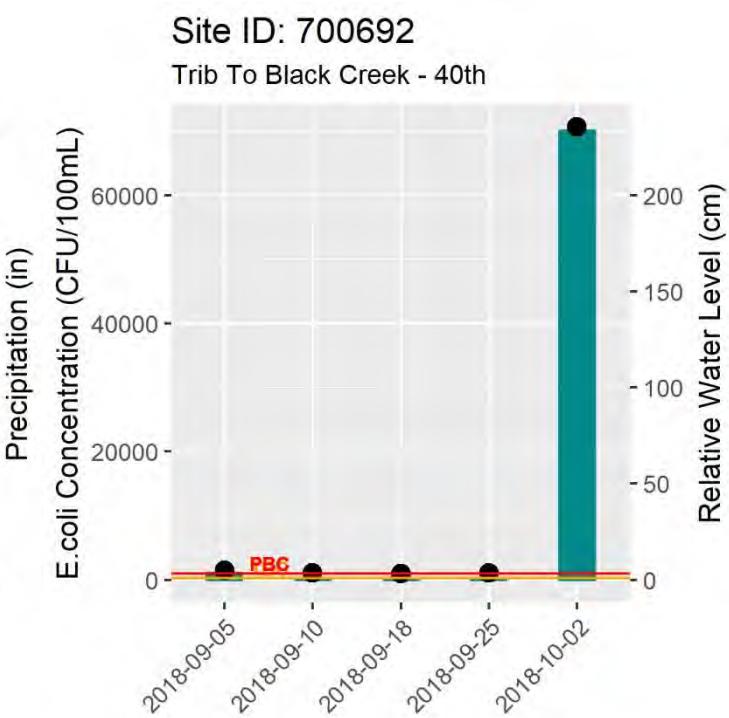
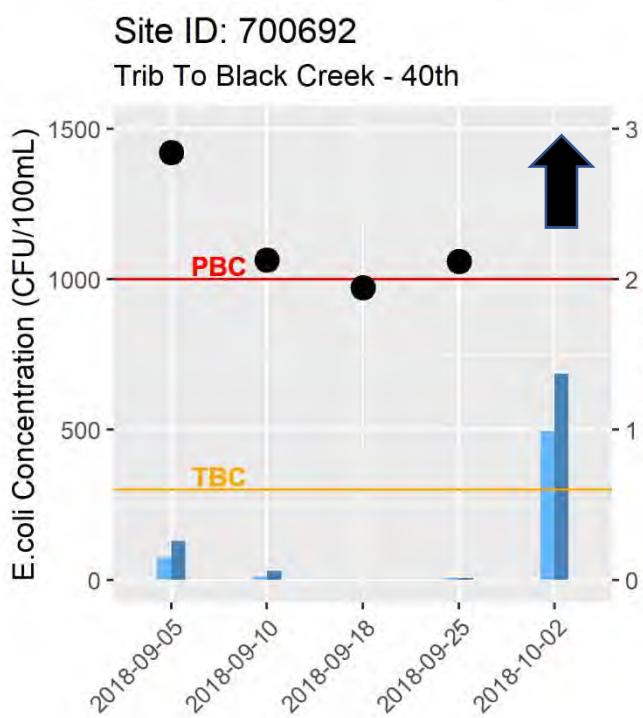
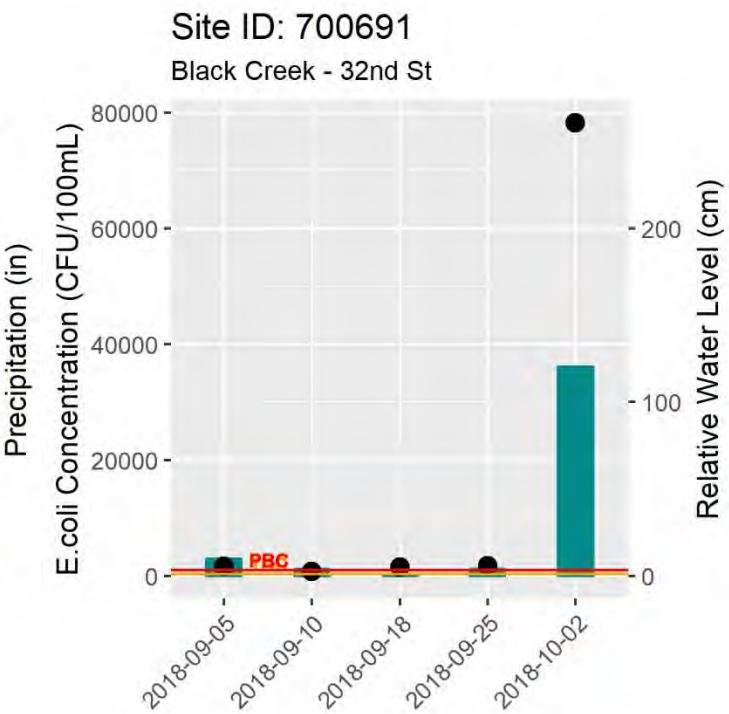
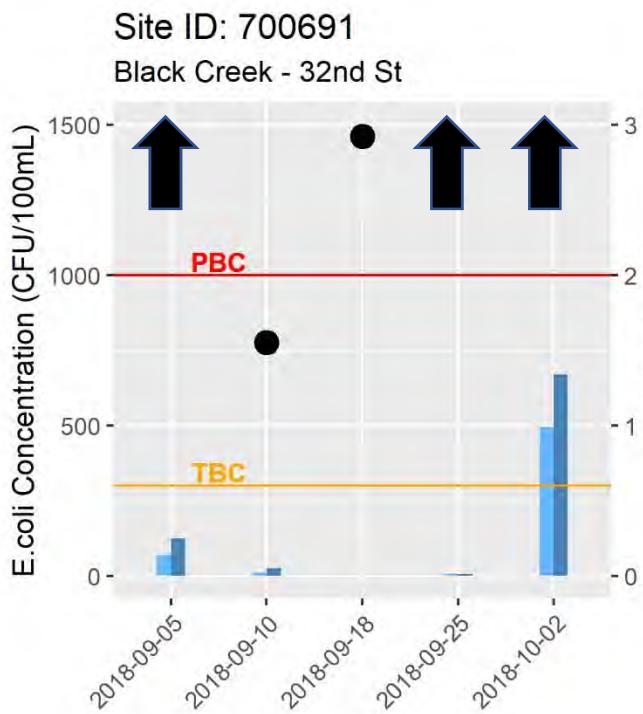
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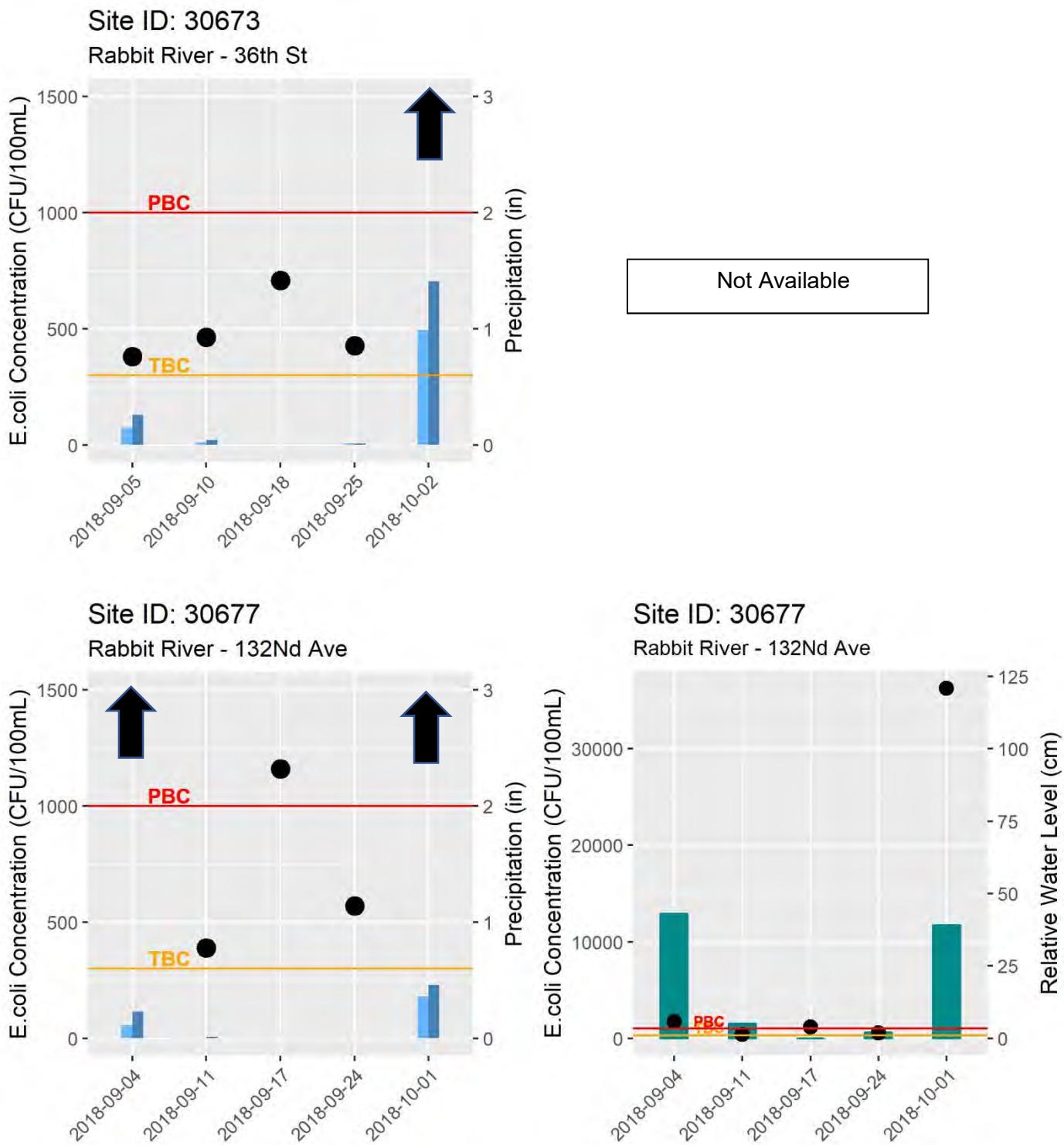
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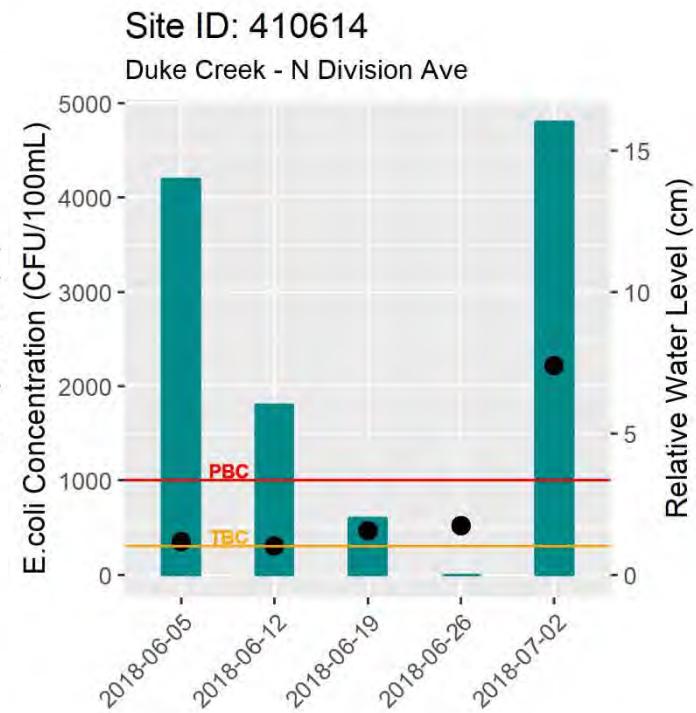
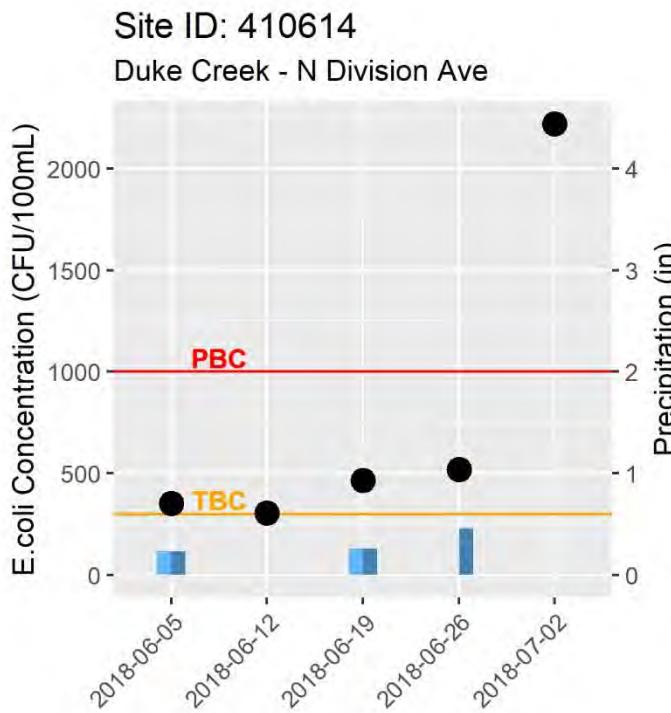
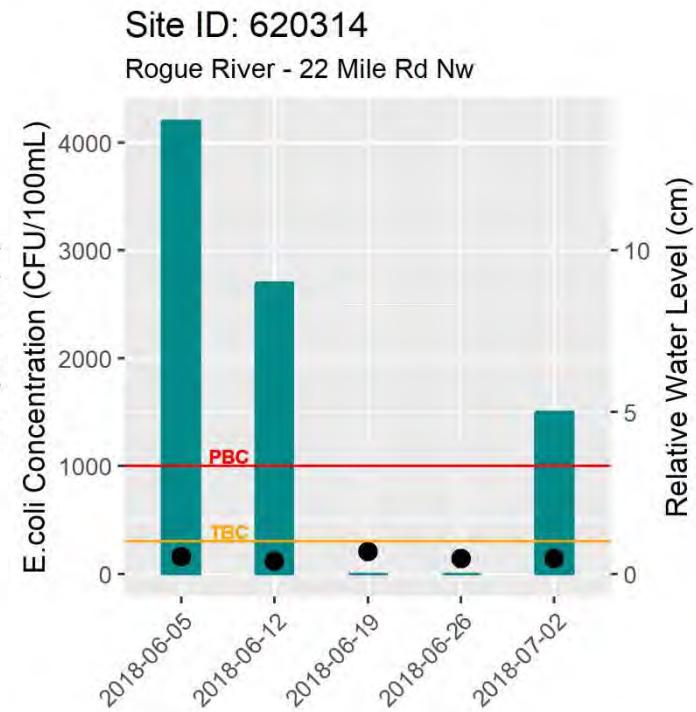
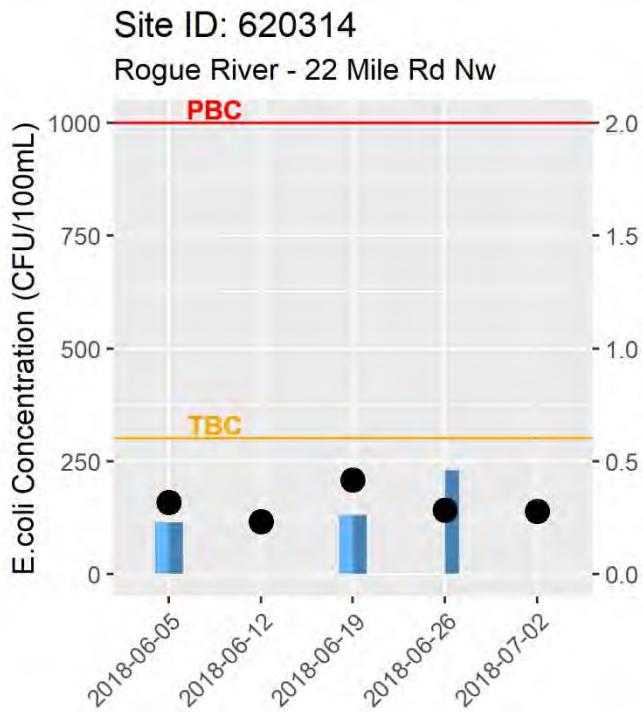
Appendix 4 (cont.). Kalamazoo sites.



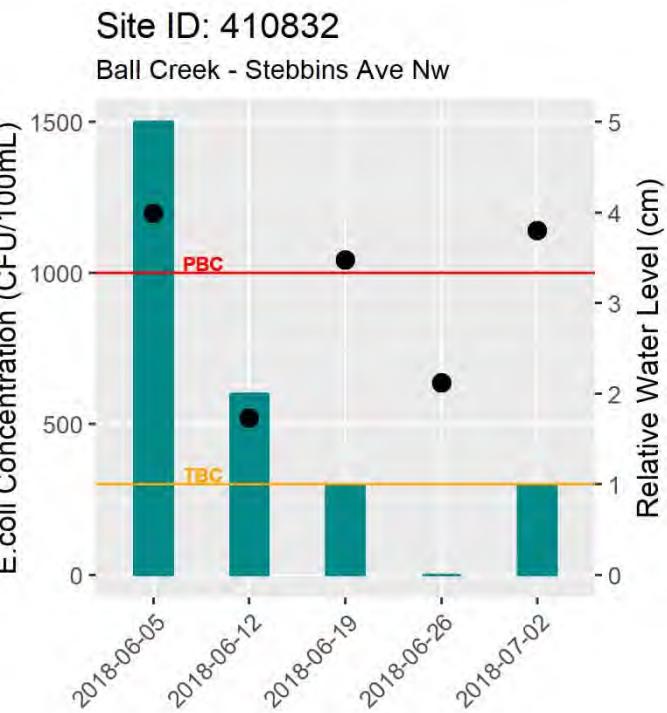
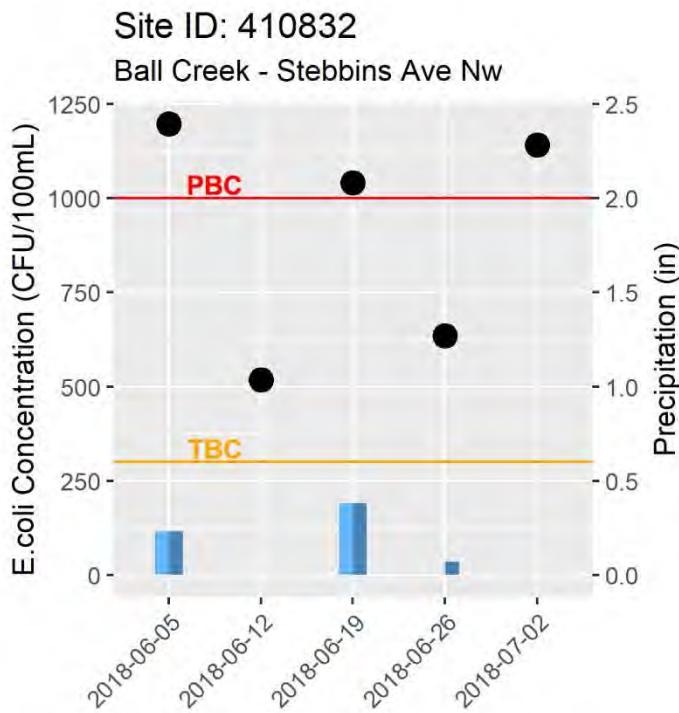
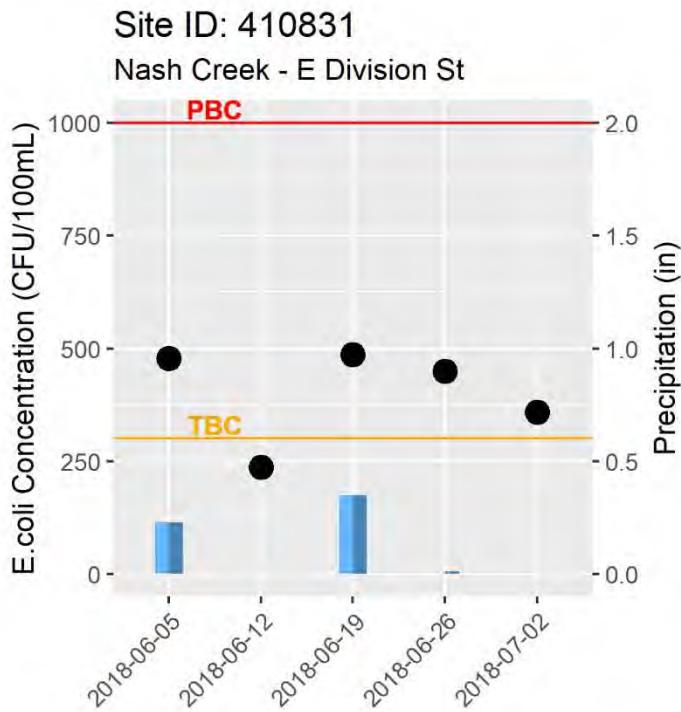
Appendix 4 (cont.). Kalamazoo sites.



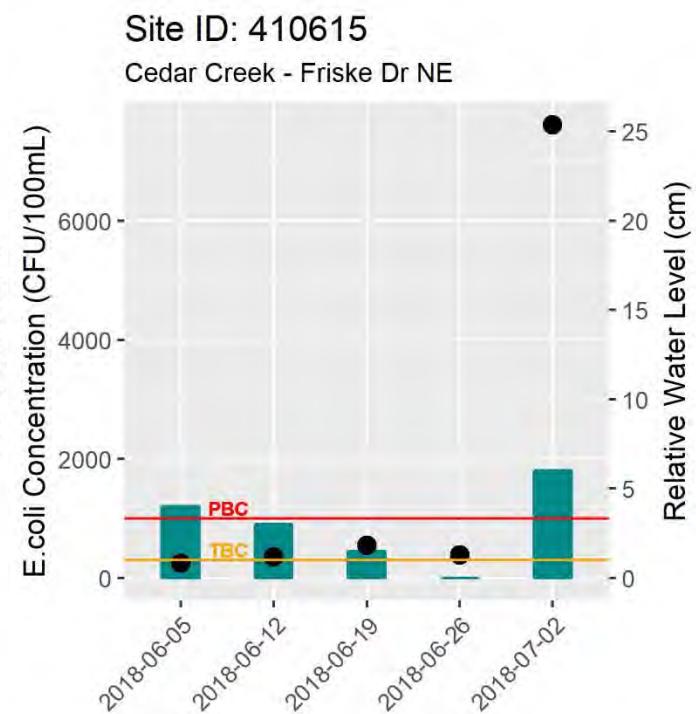
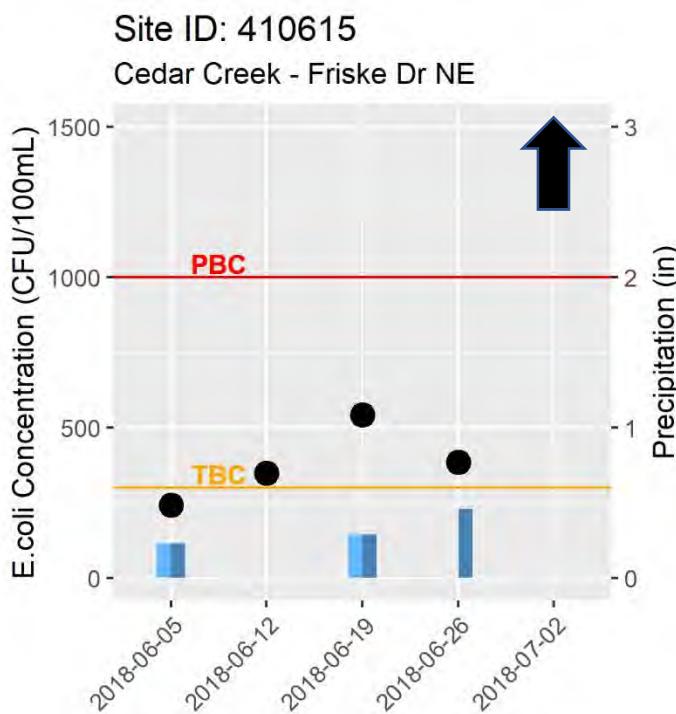
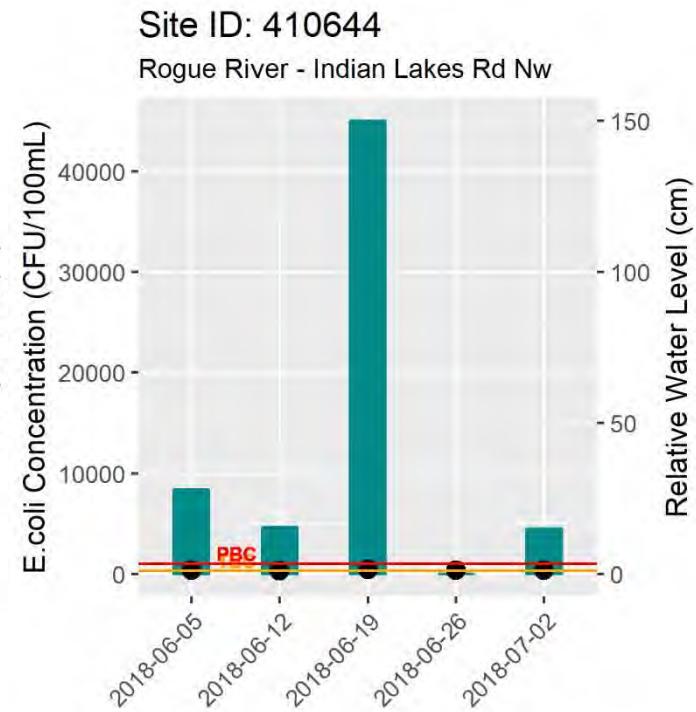
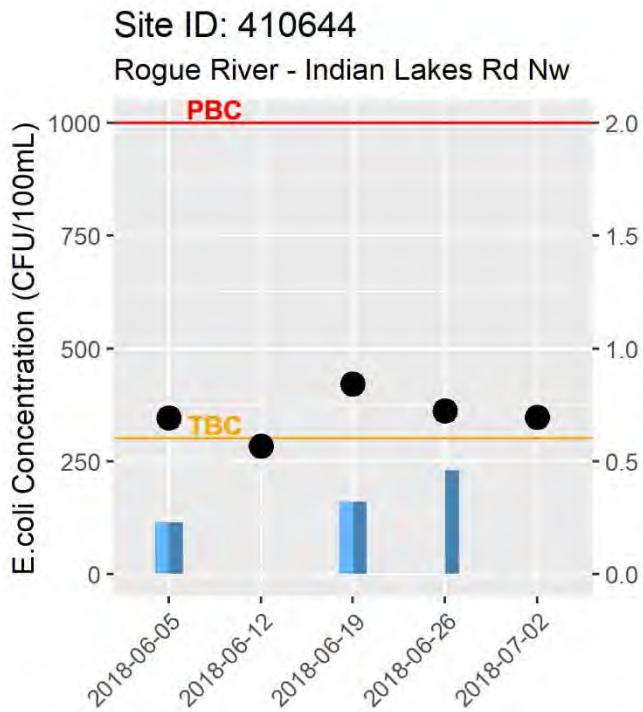
Appendix 4 (cont.). Lower Grand (Rogue River) sites.



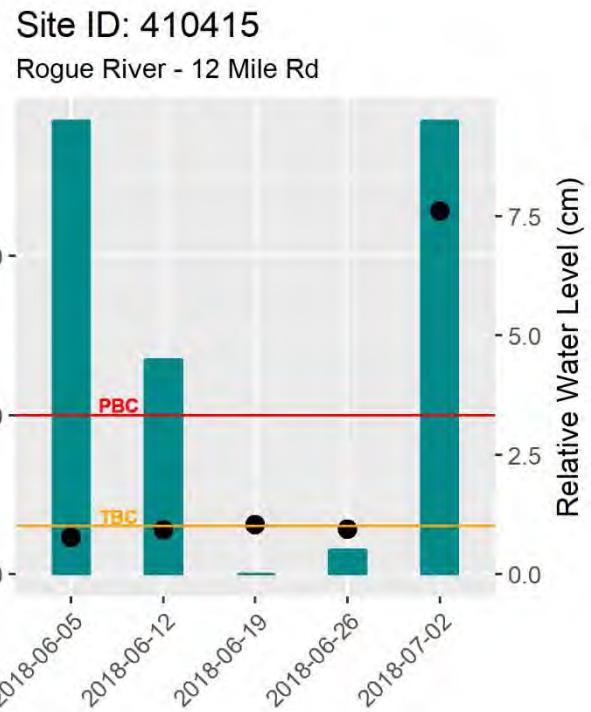
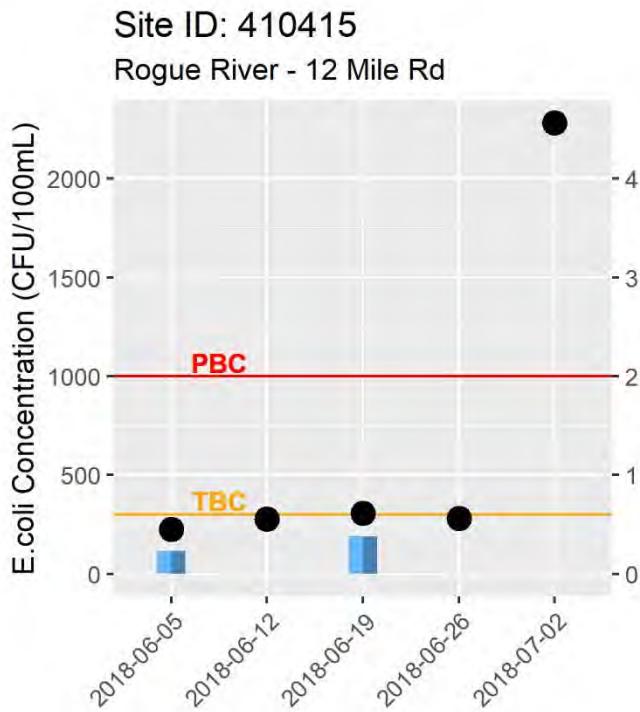
Appendix 4 (cont.). Lower Grand (Rogue River) sites.



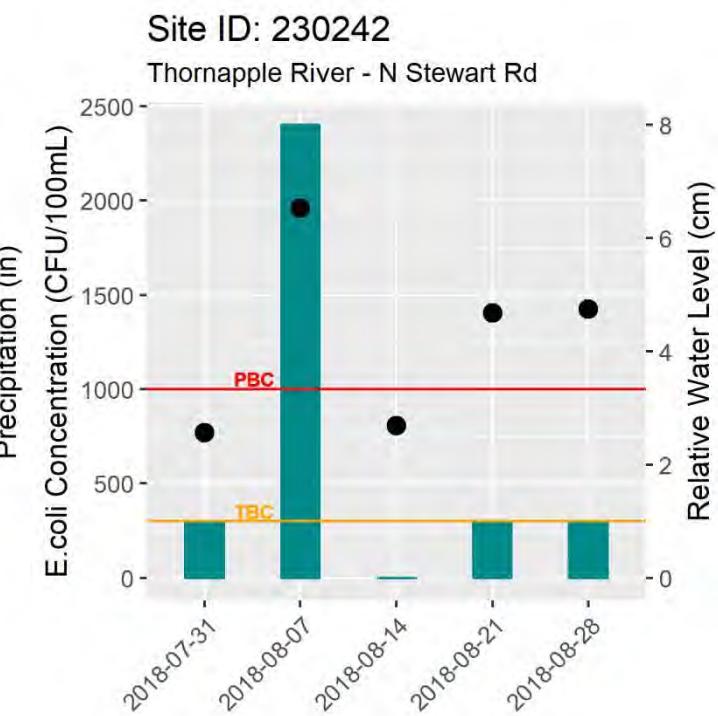
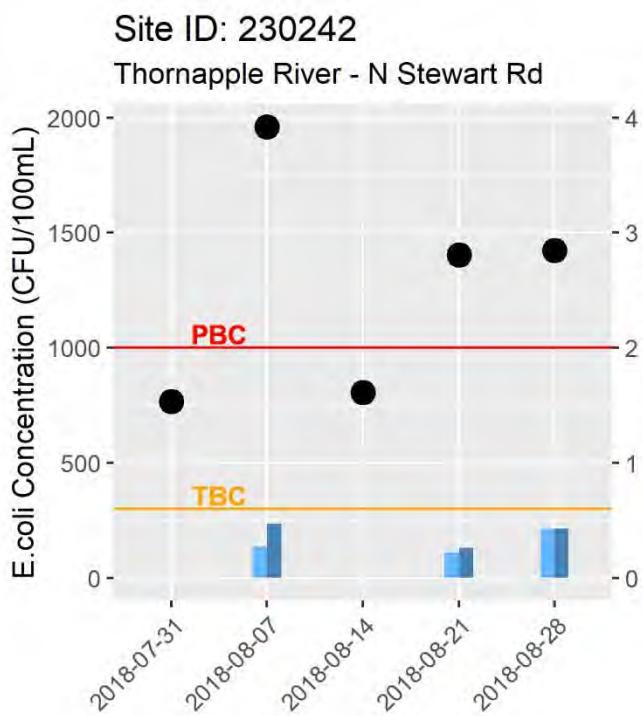
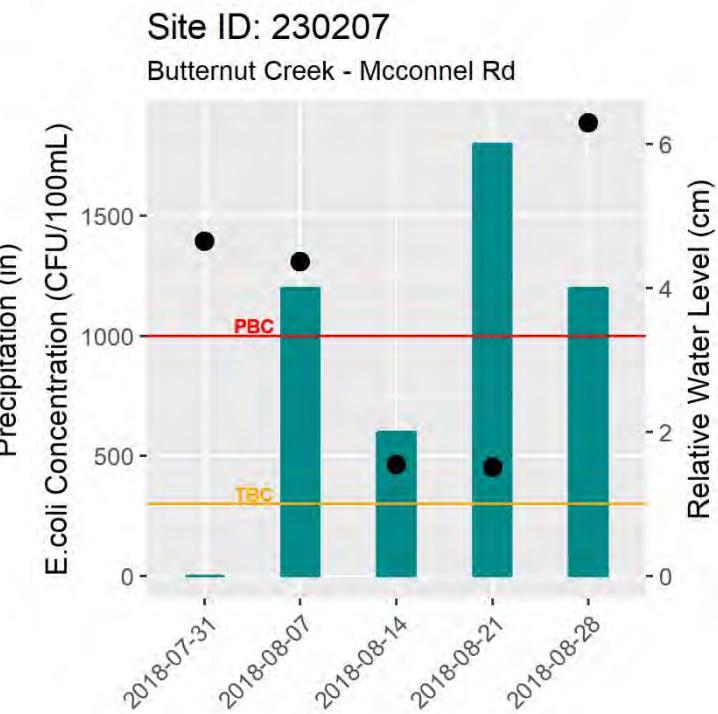
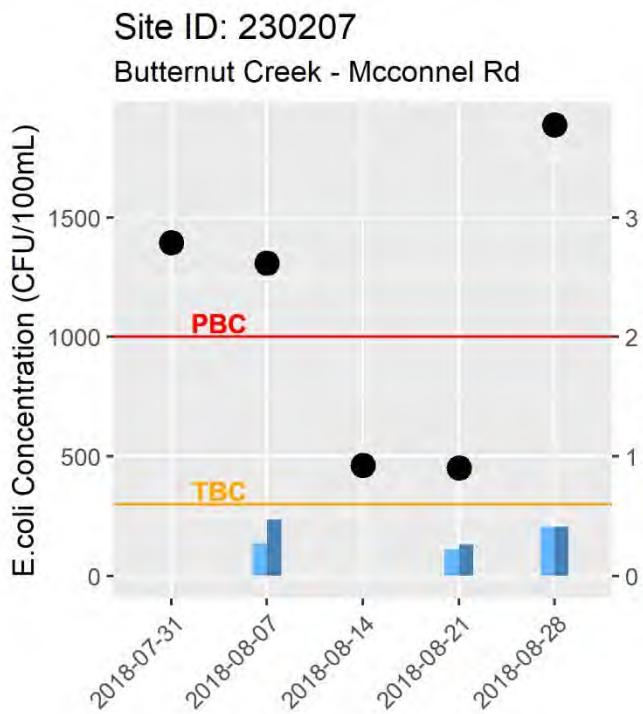
Appendix 4 (cont.). Lower Grand (Rogue River) sites.



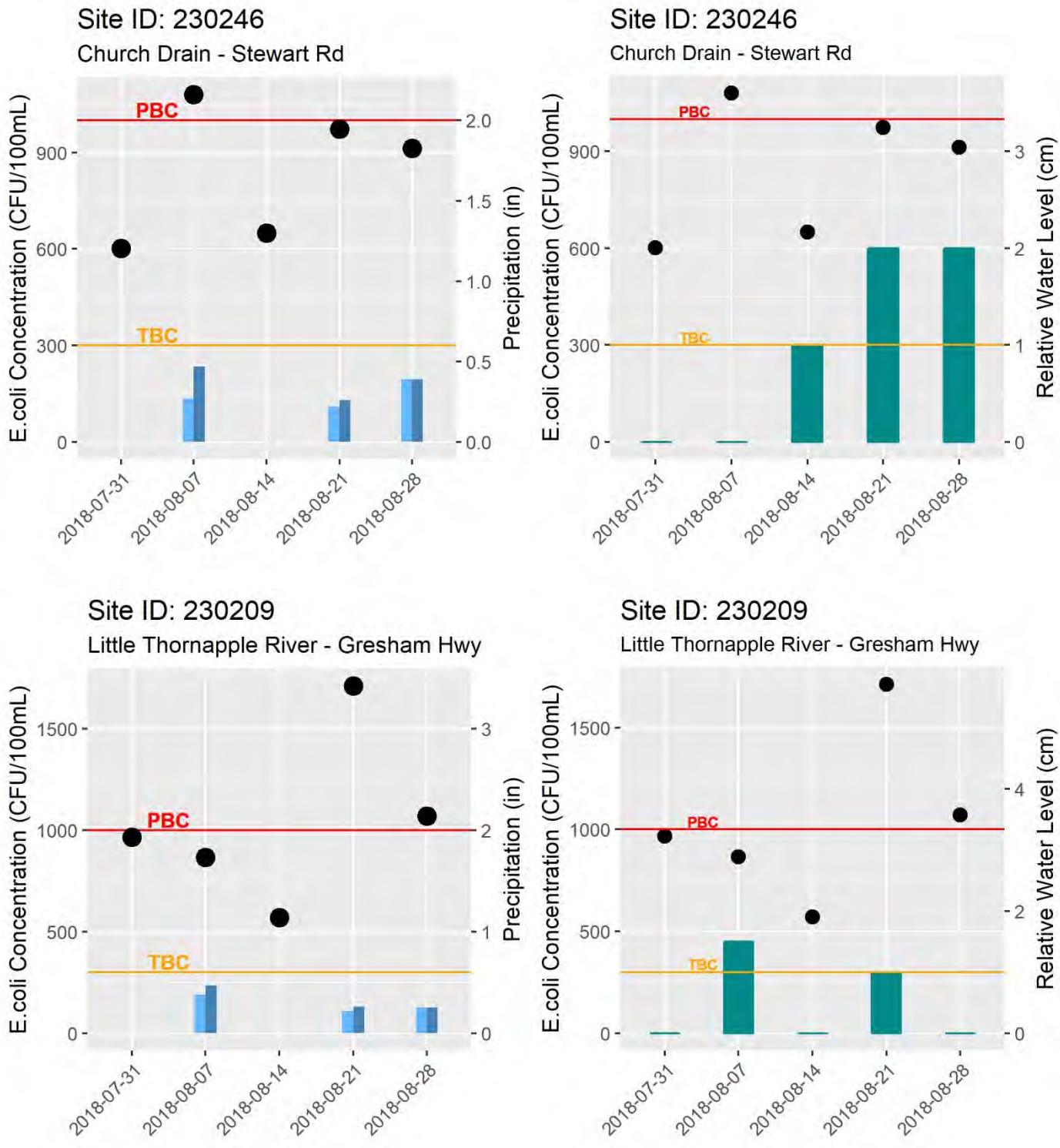
Appendix 4 (cont.). Lower Grand (Rogue River) sites.



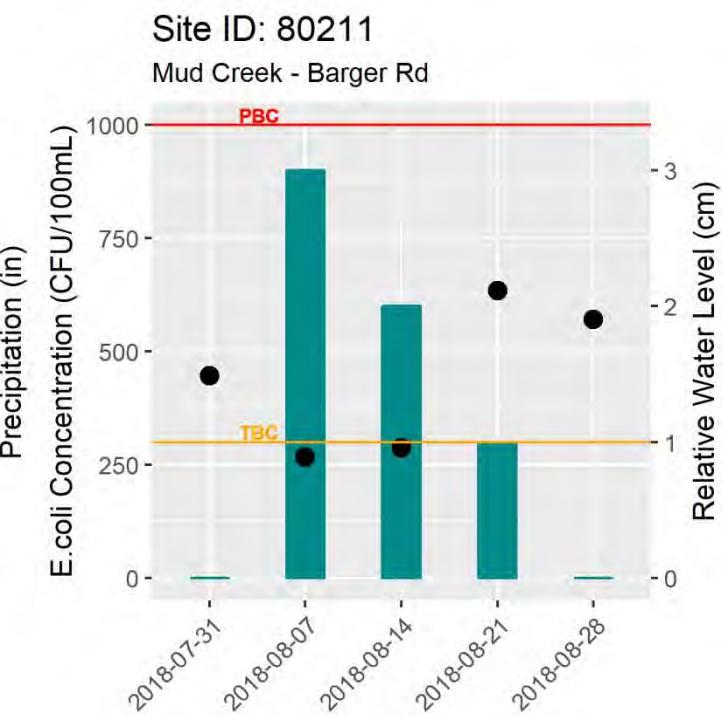
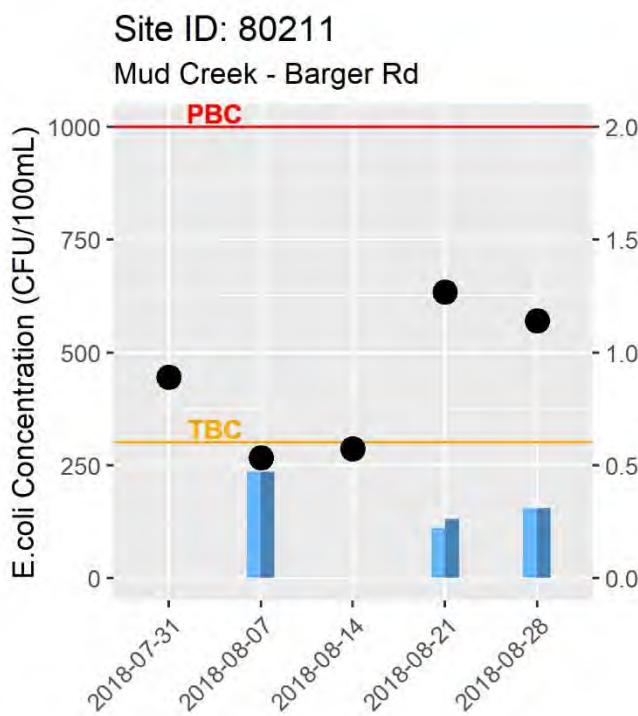
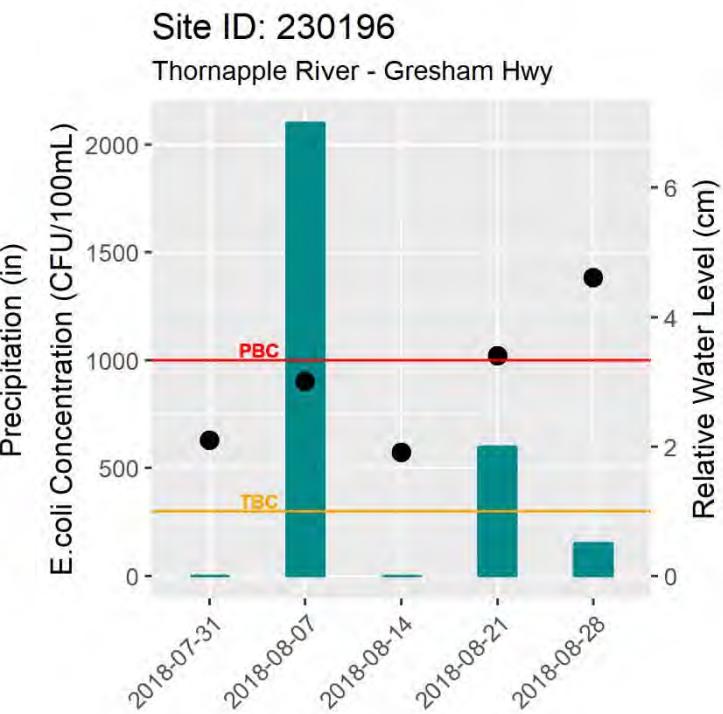
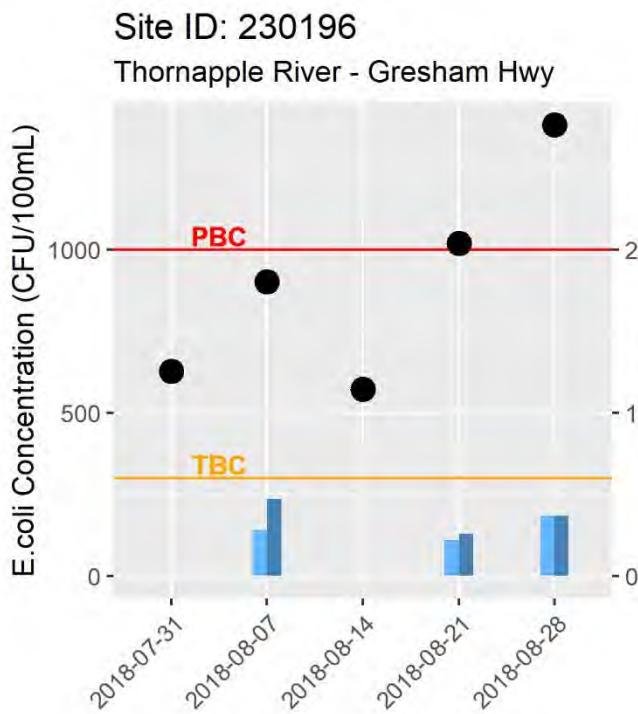
Appendix 4 (cont.). Thornapple River sites.



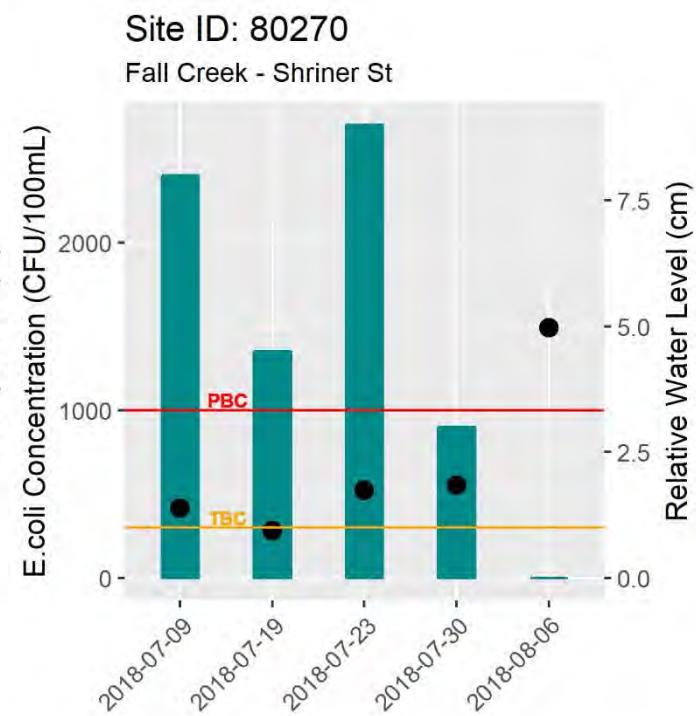
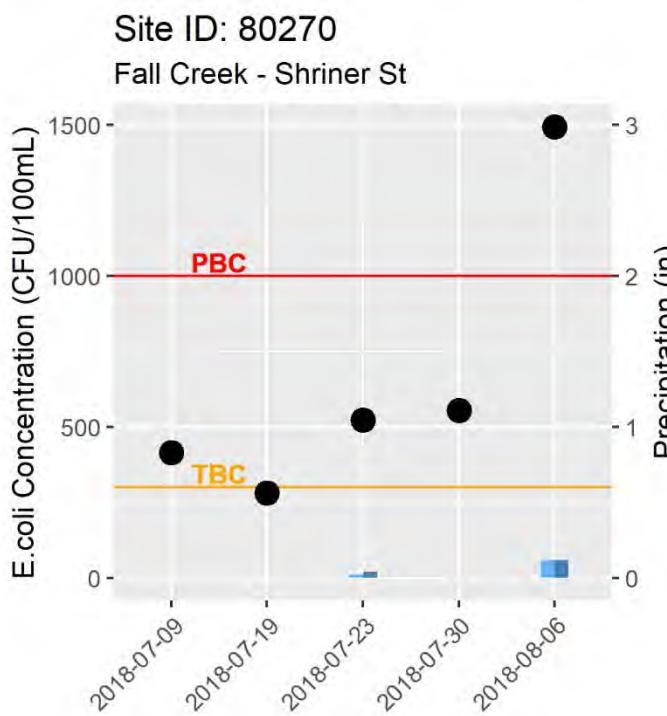
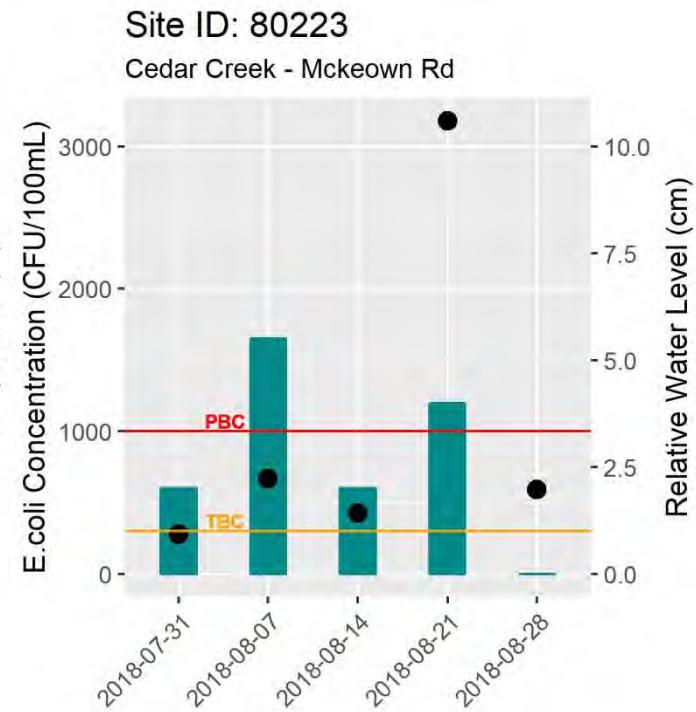
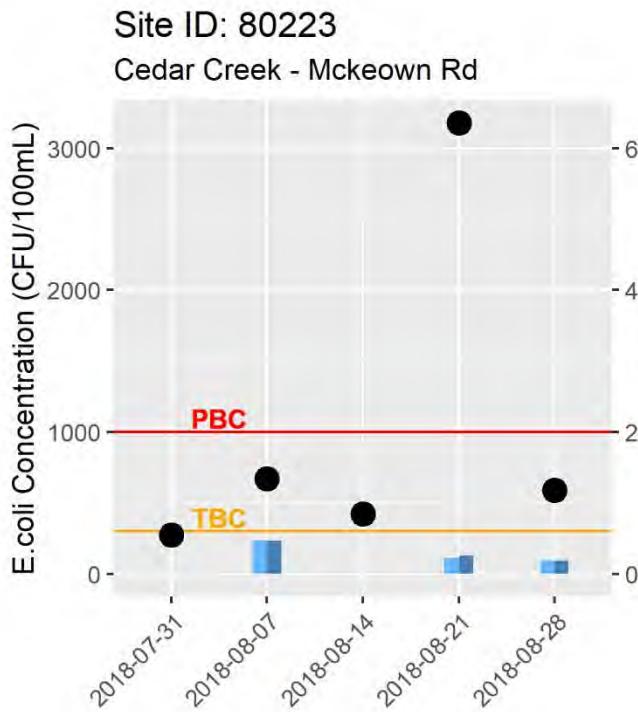
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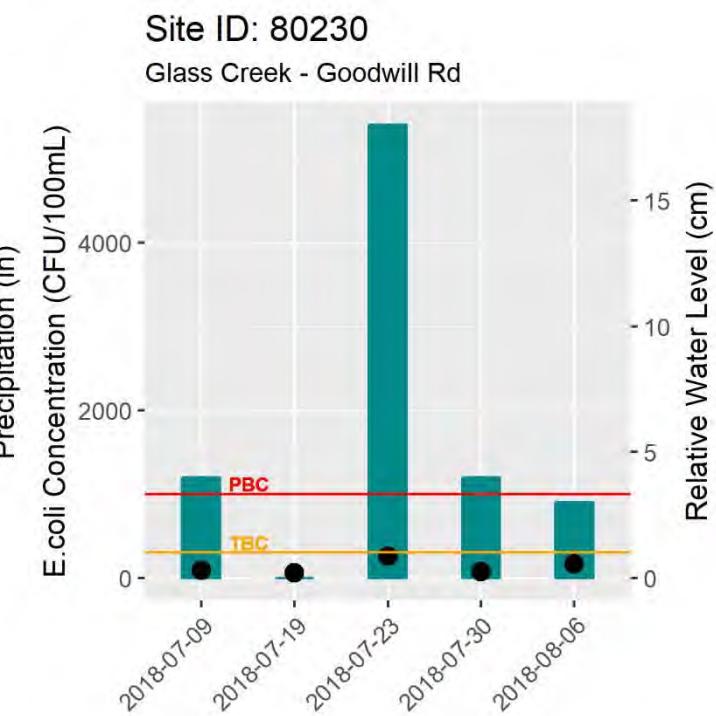
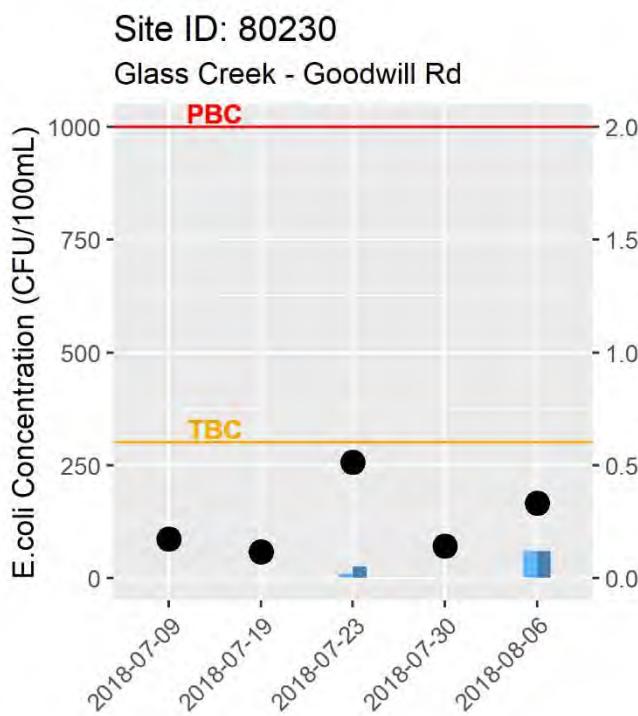
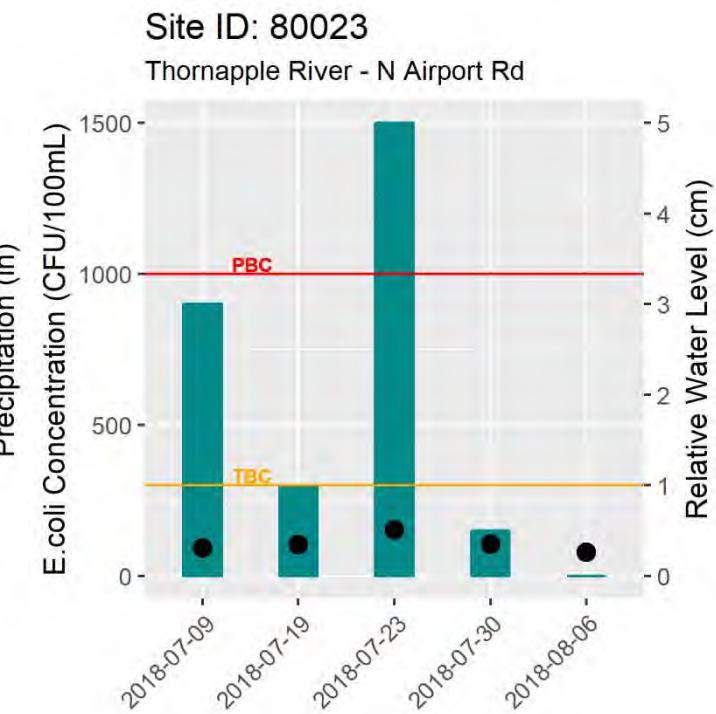
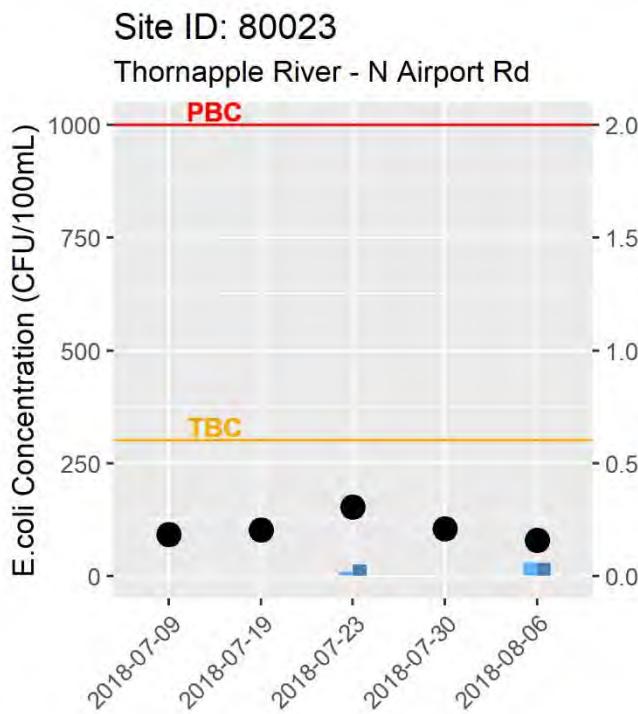
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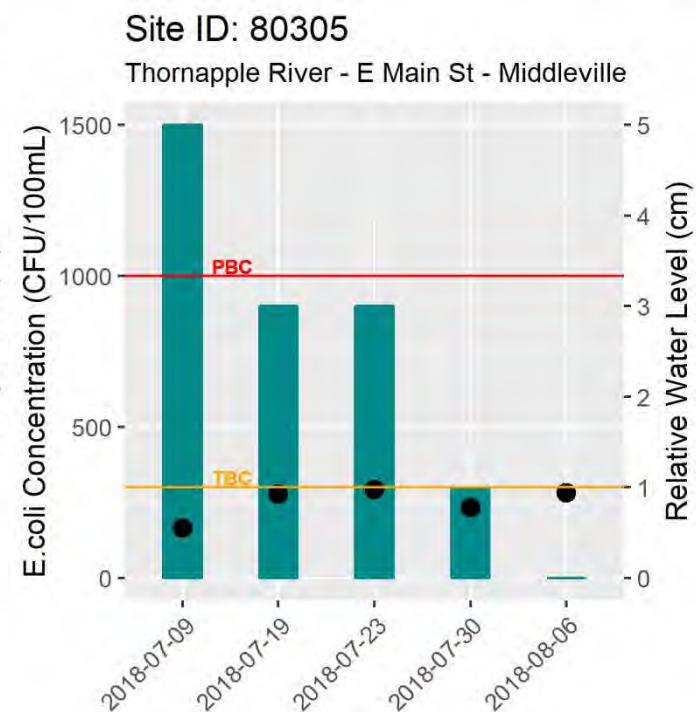
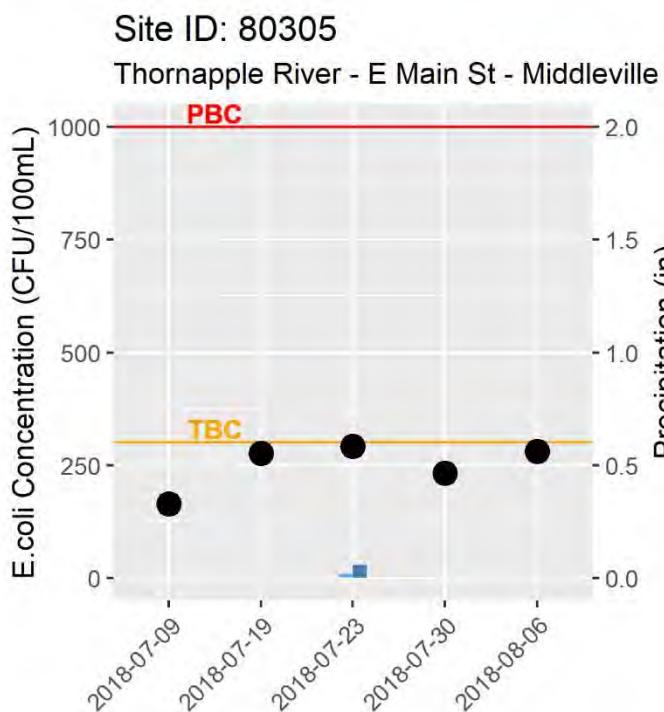
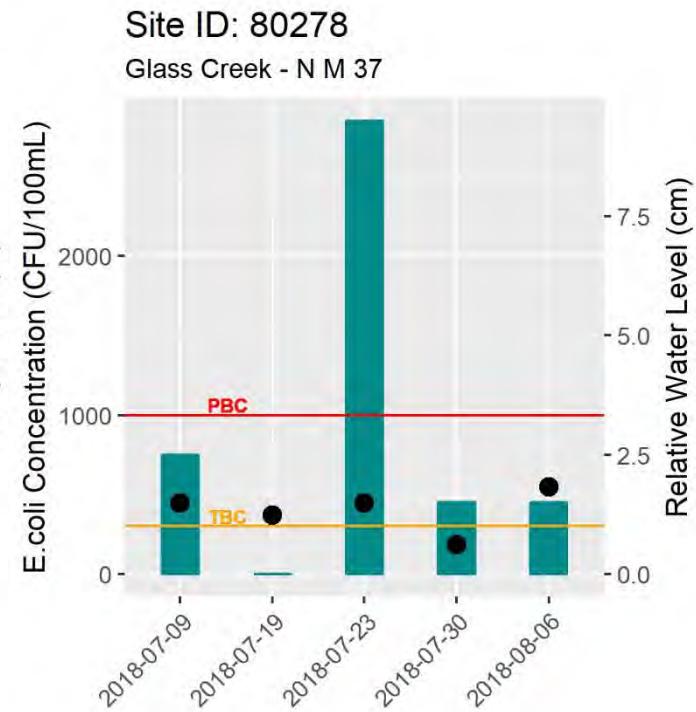
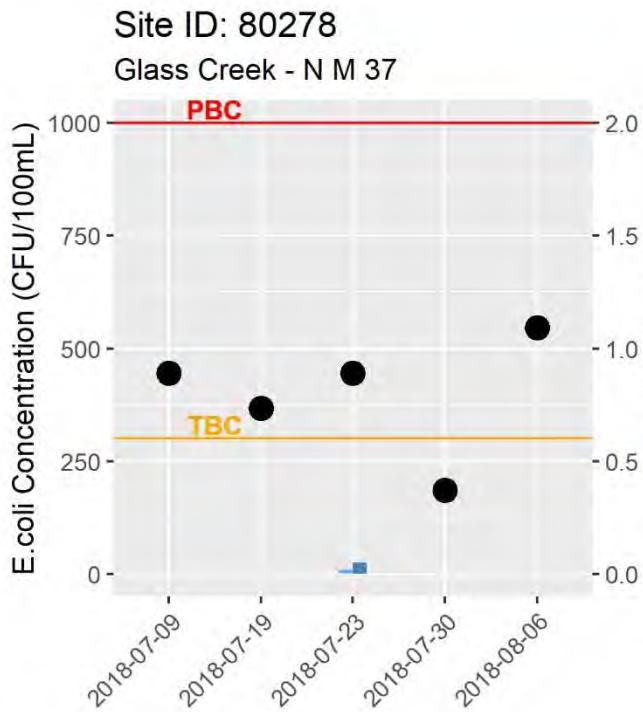
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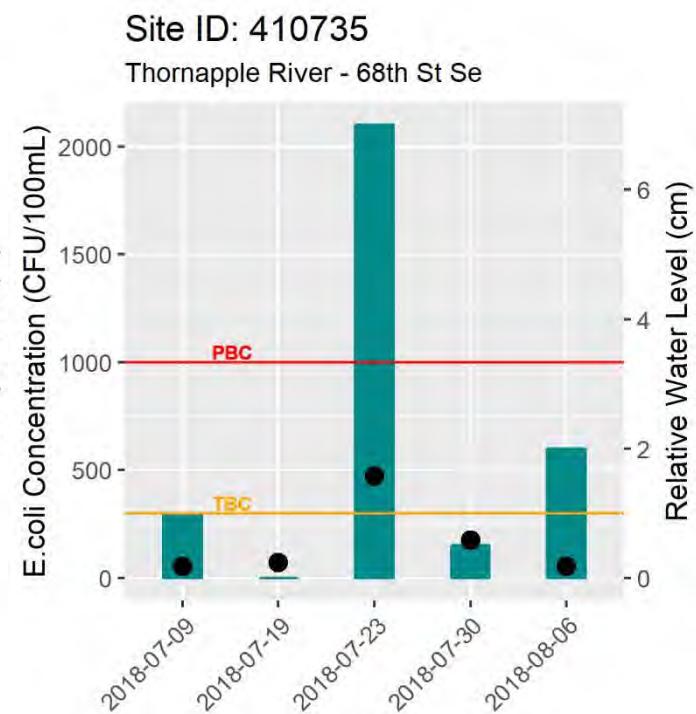
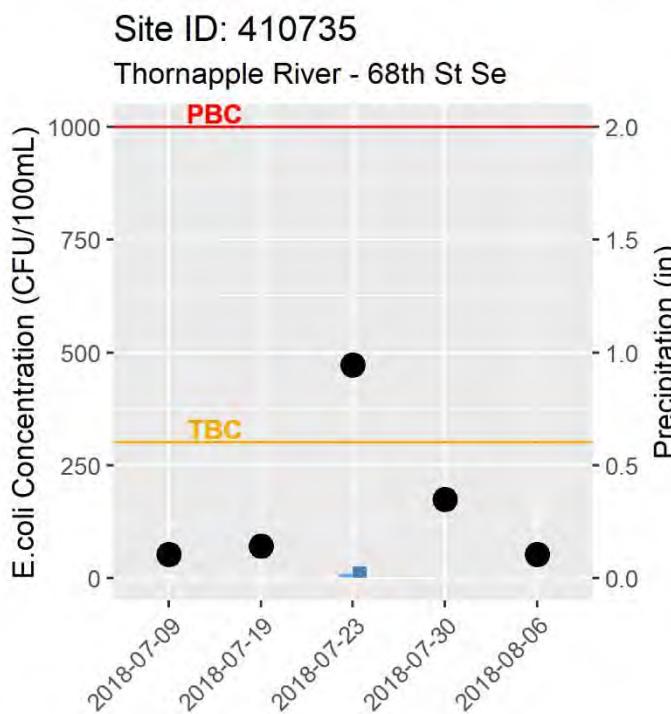
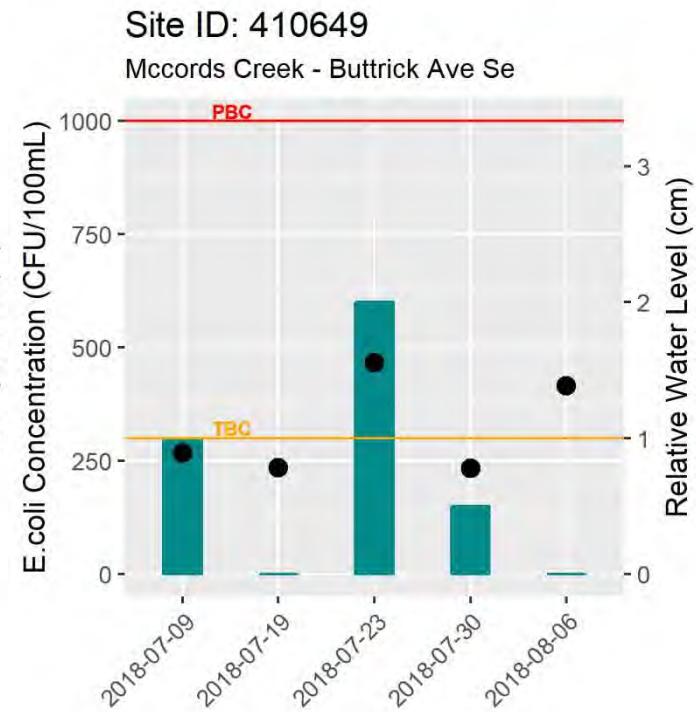
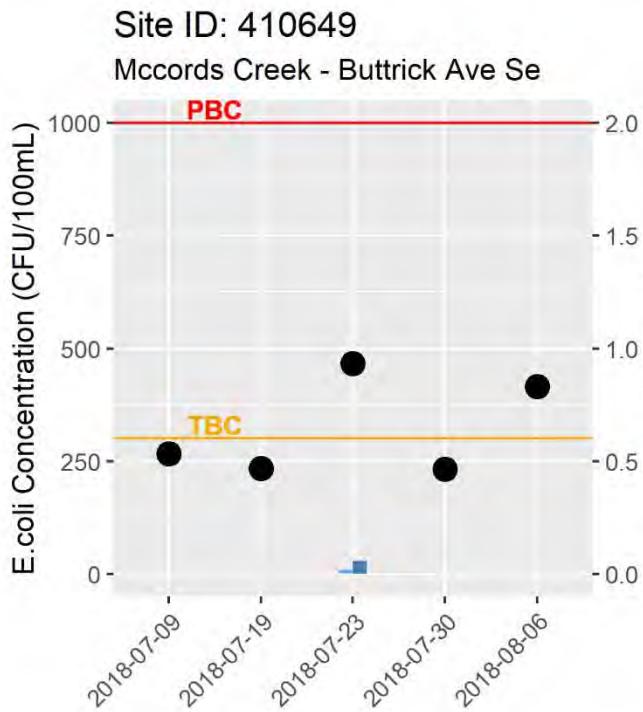
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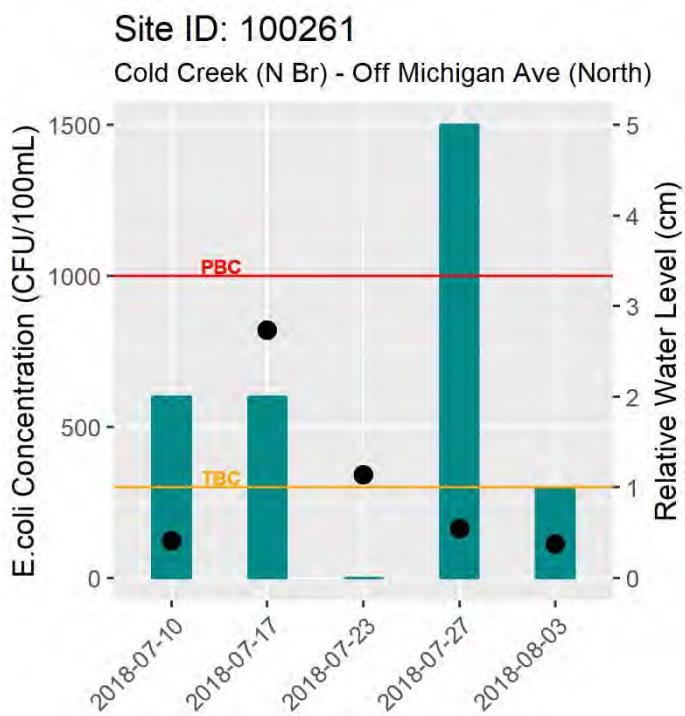
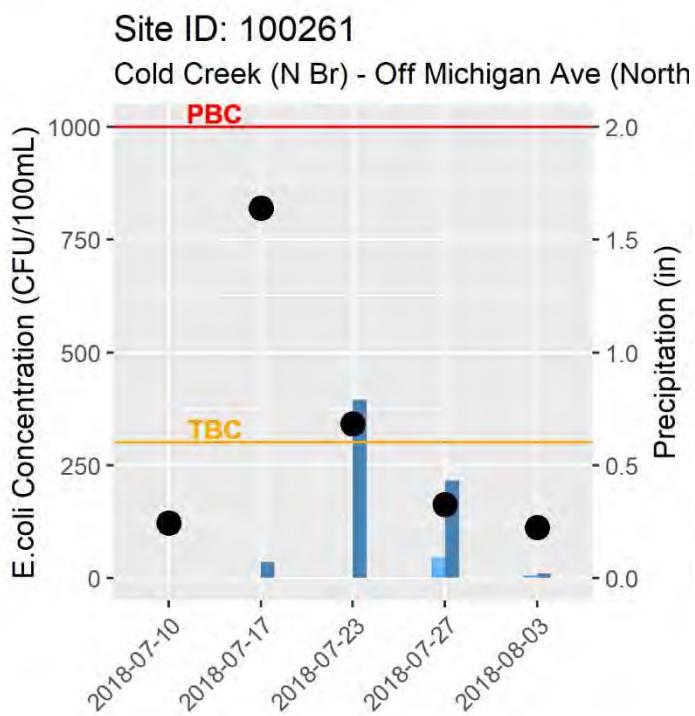
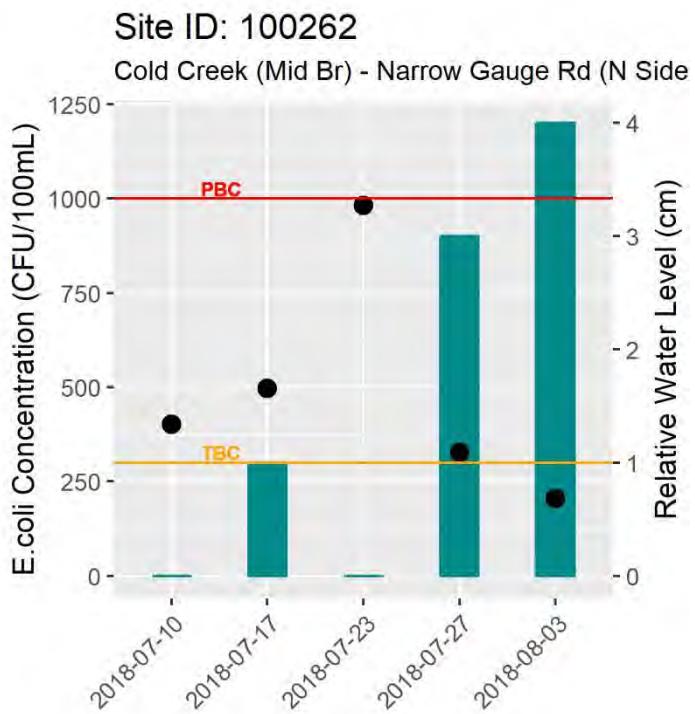
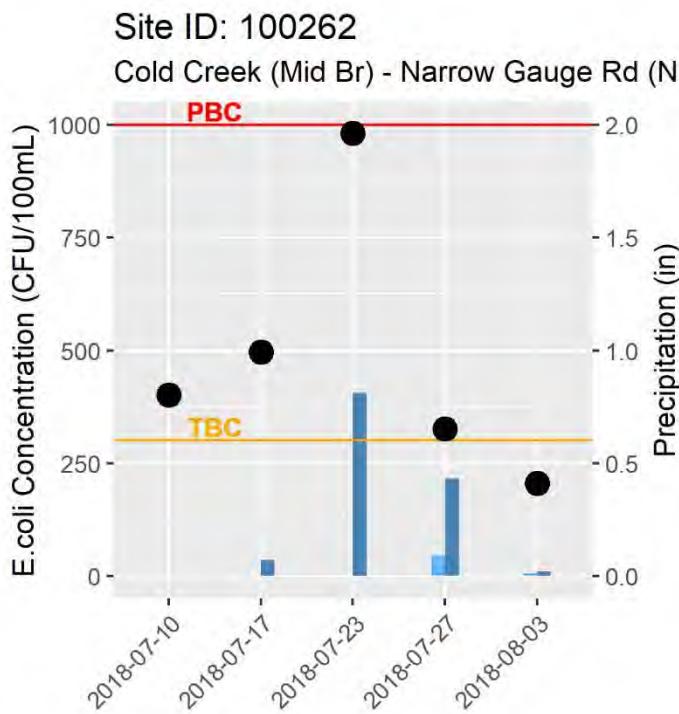
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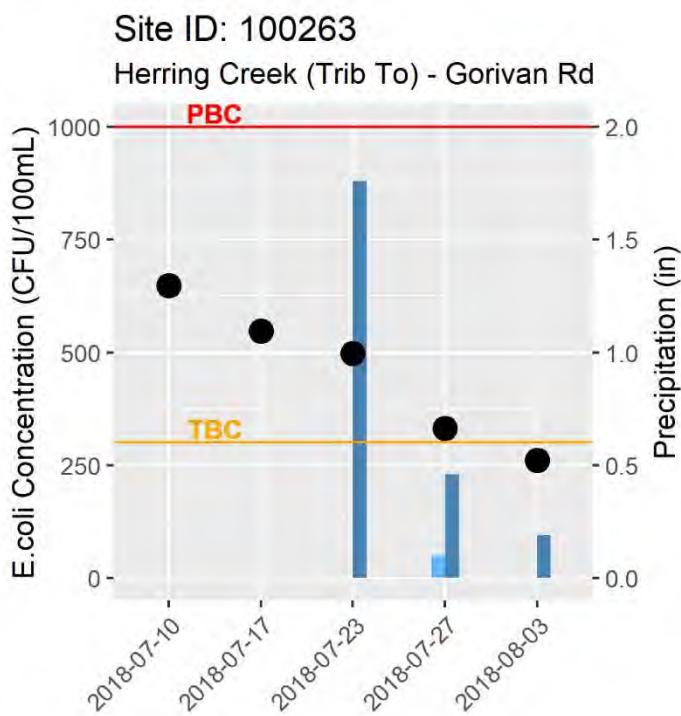
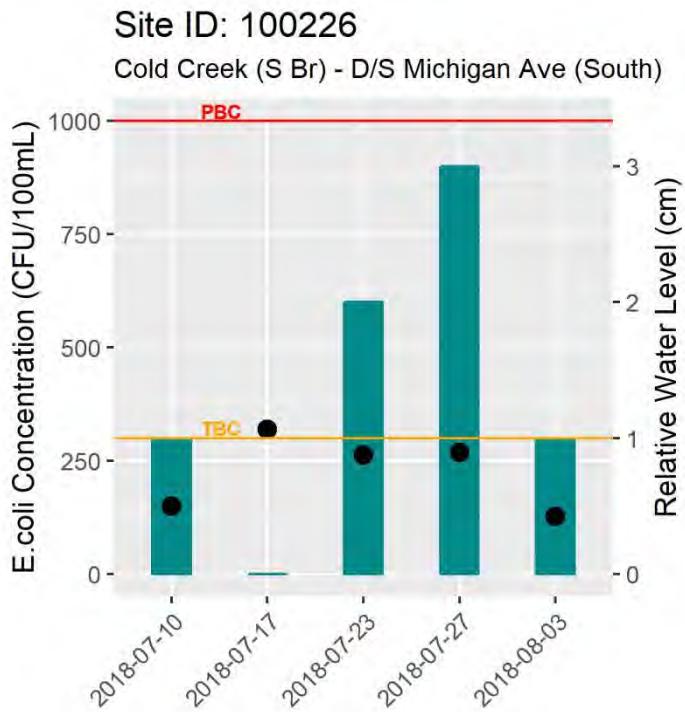
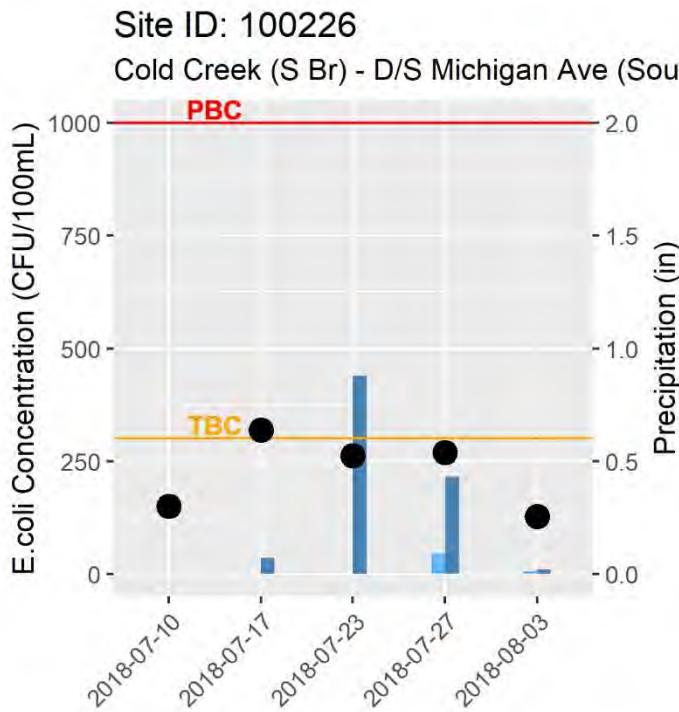
Appendix 4 (cont.). Thornapple River sites.



Appendix 4 (cont.). Betsie-Platte sites.

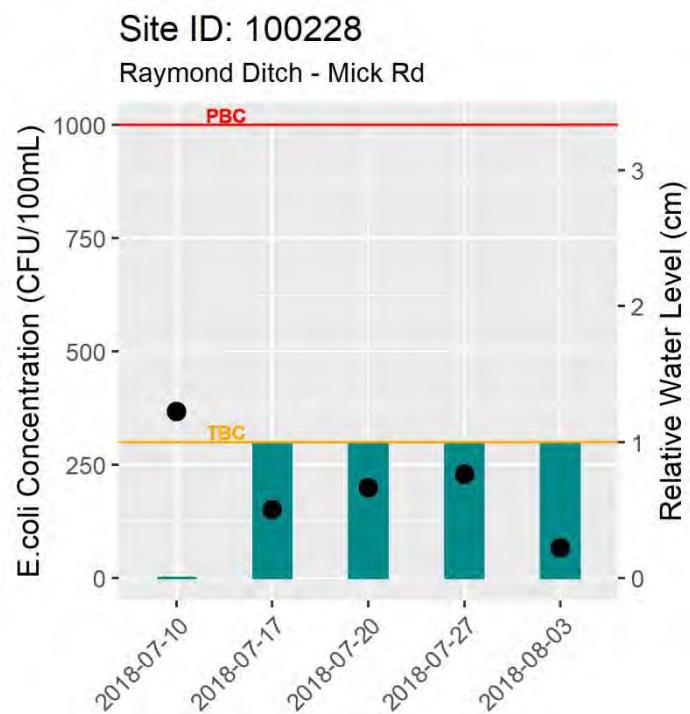
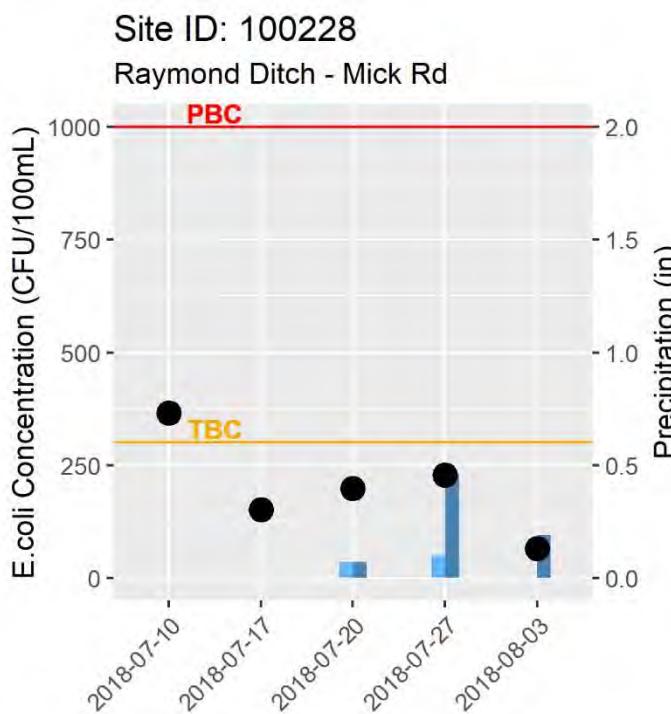
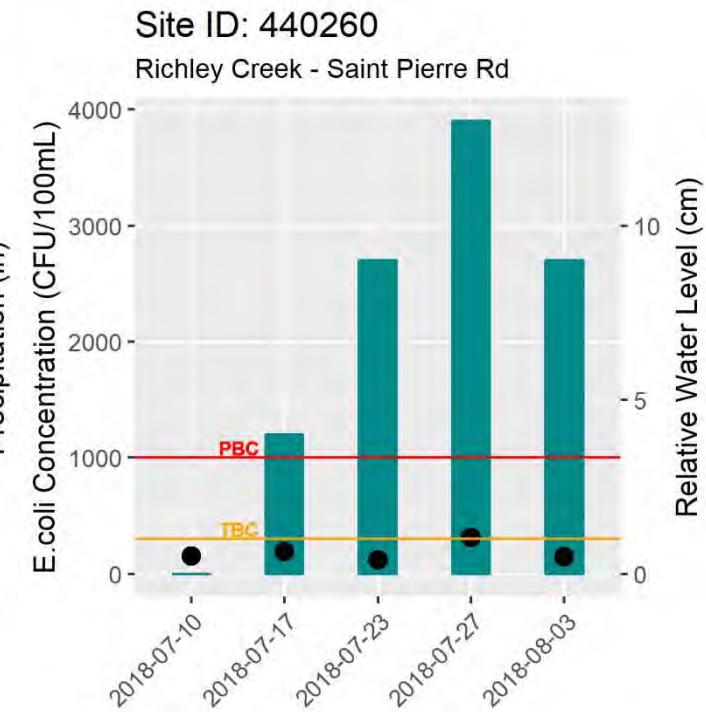
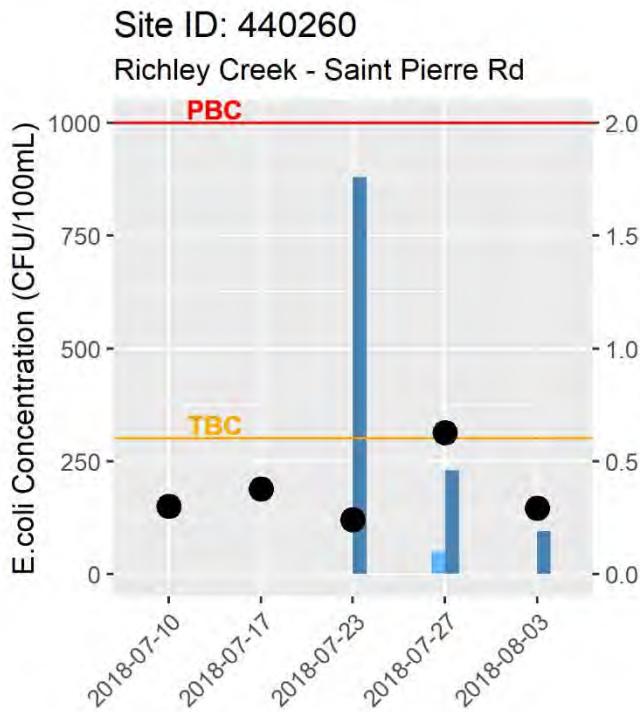


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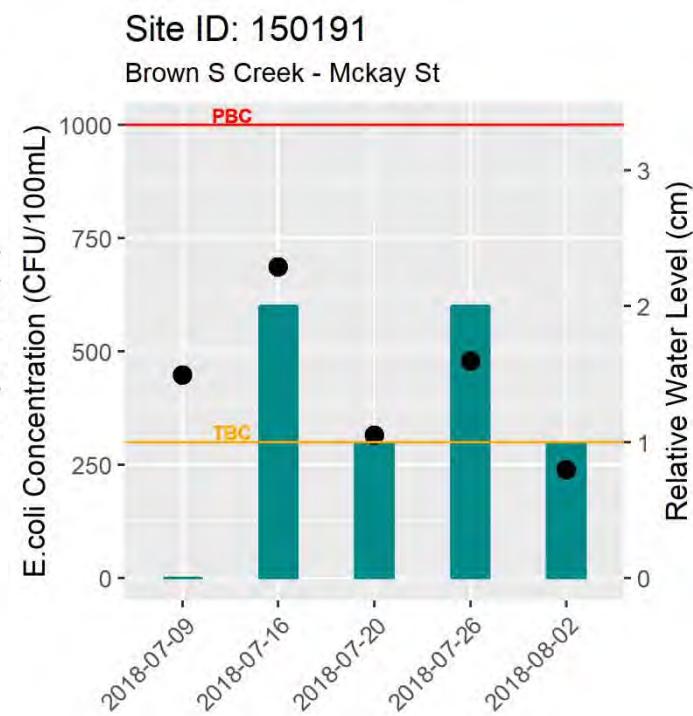
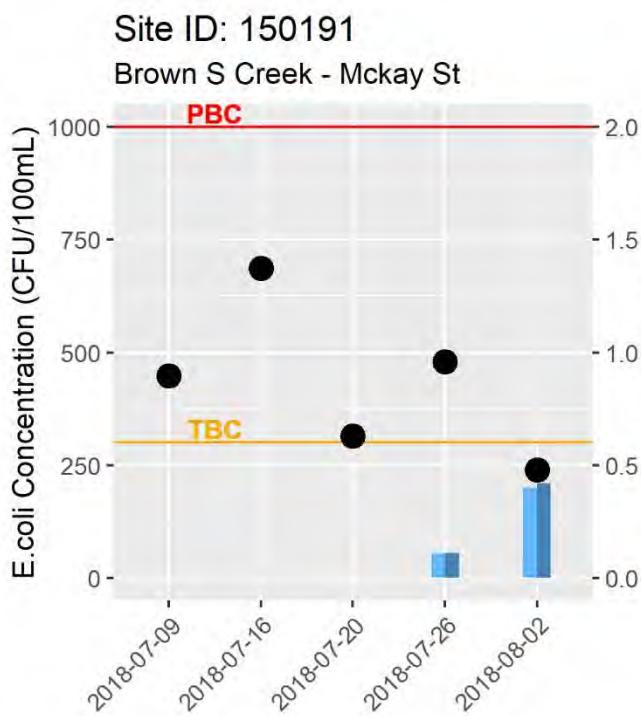
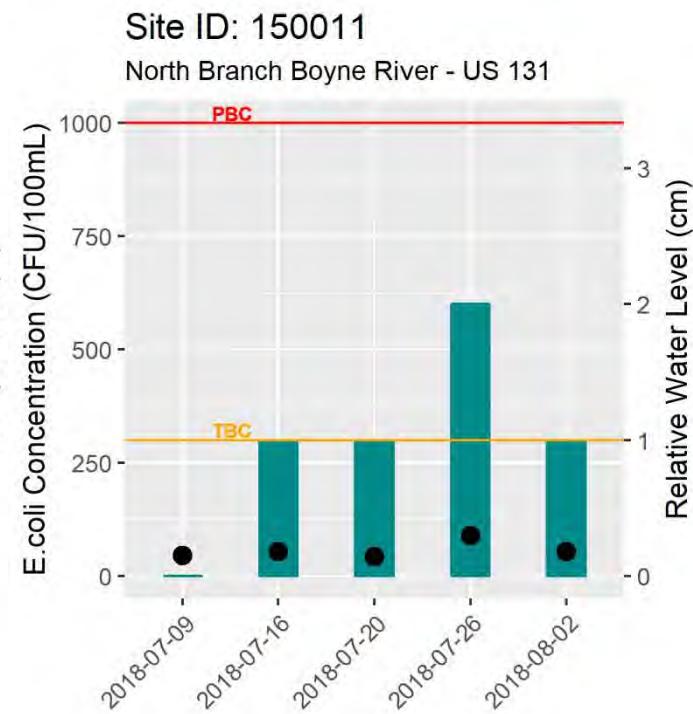
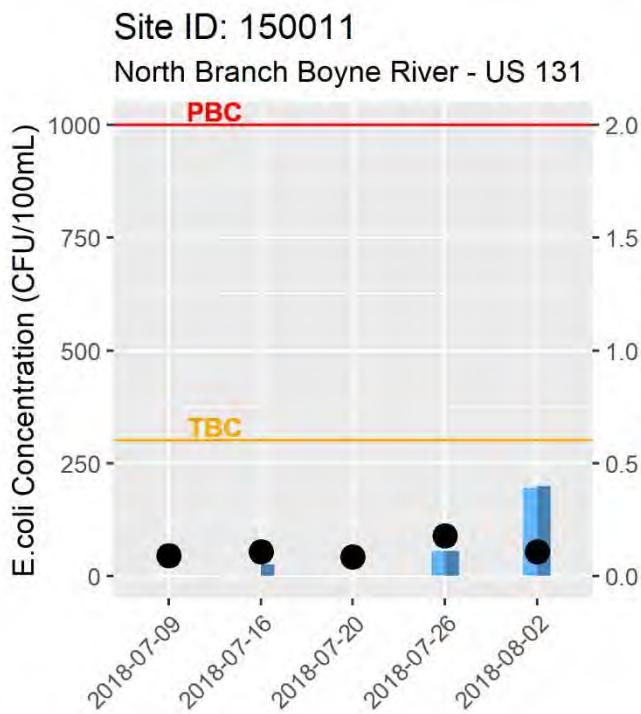


Not Available

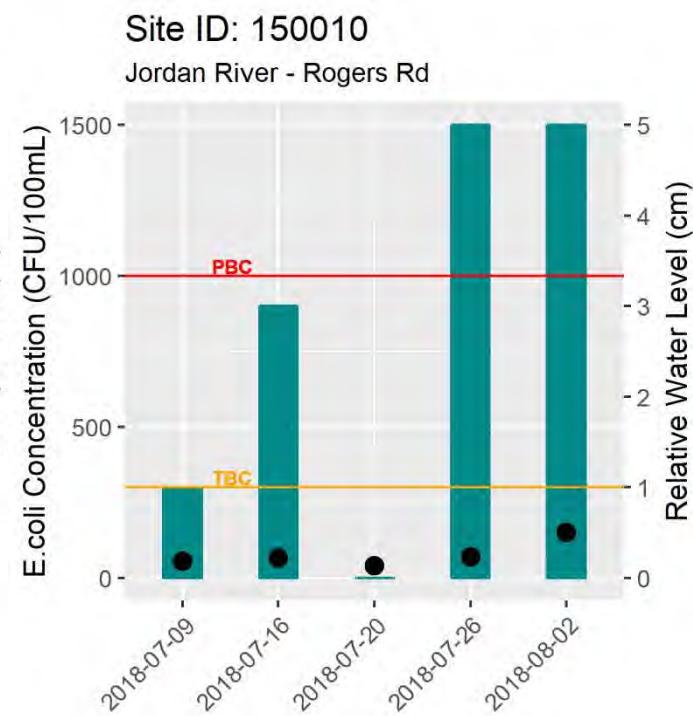
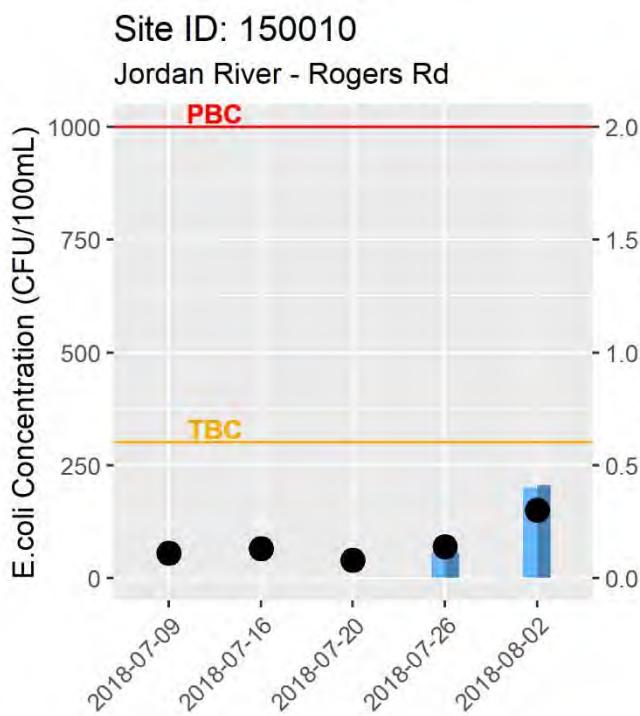
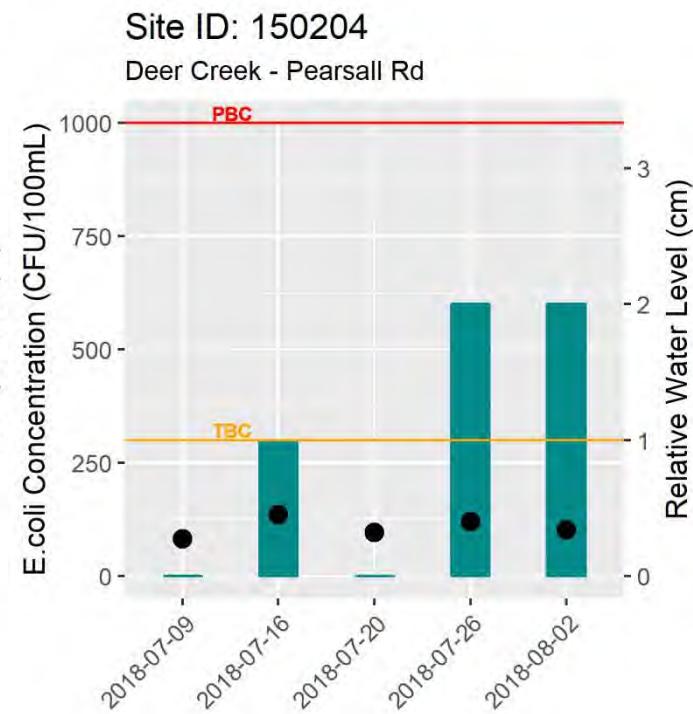
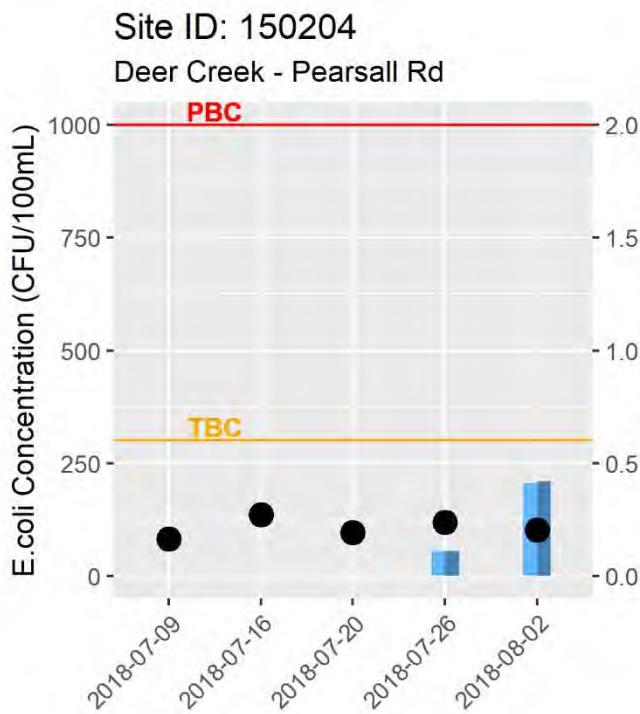
Appendix 4 (cont.). Betsie-Platte sites.



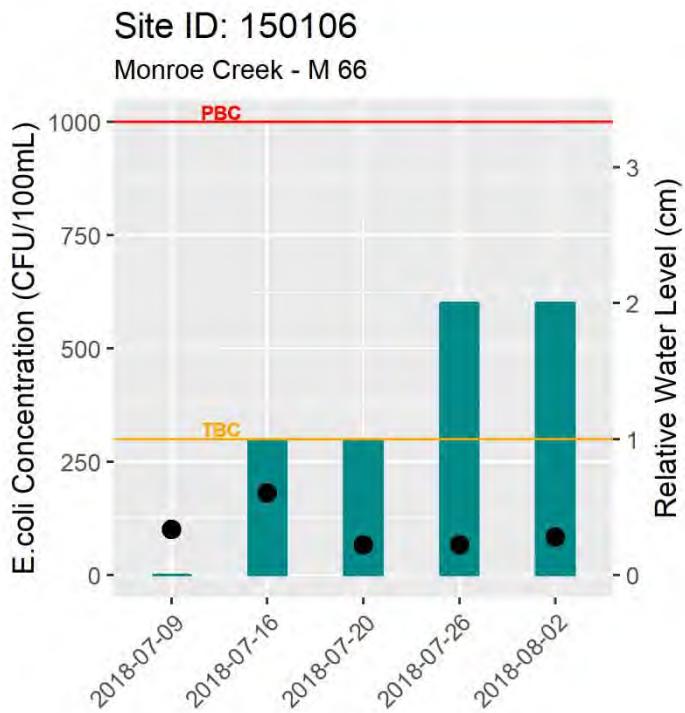
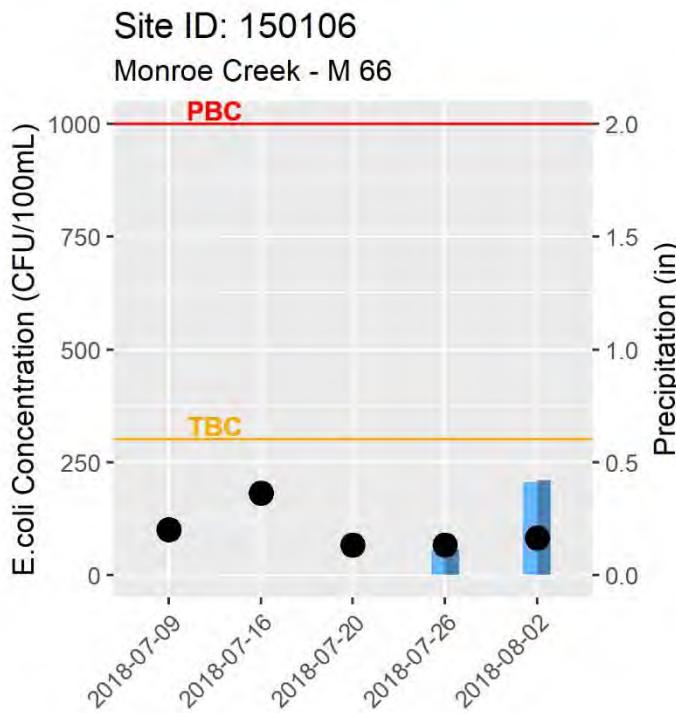
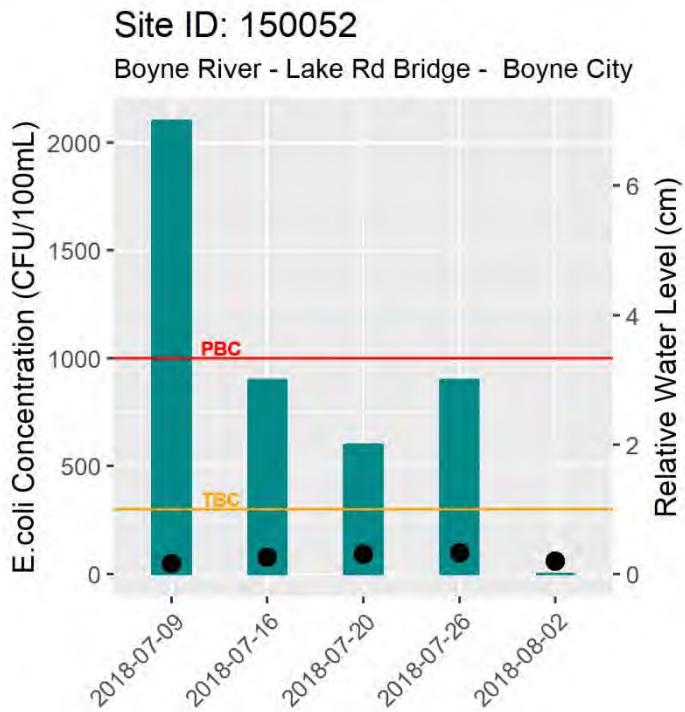
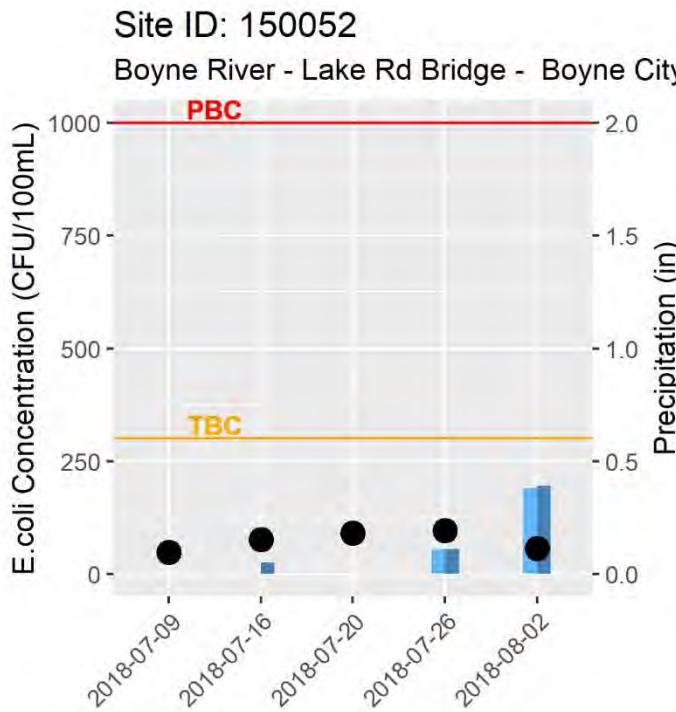
Appendix 4 (cont.). Boardman charlevoix sites.



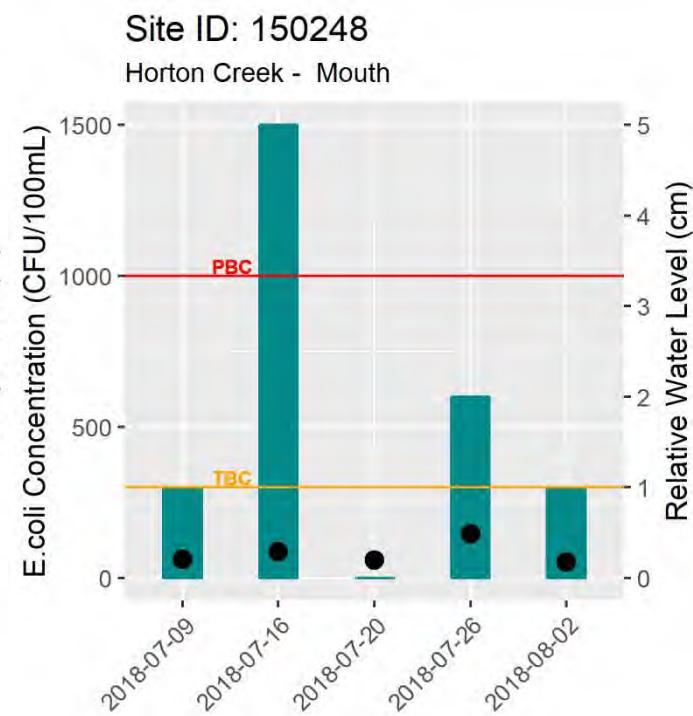
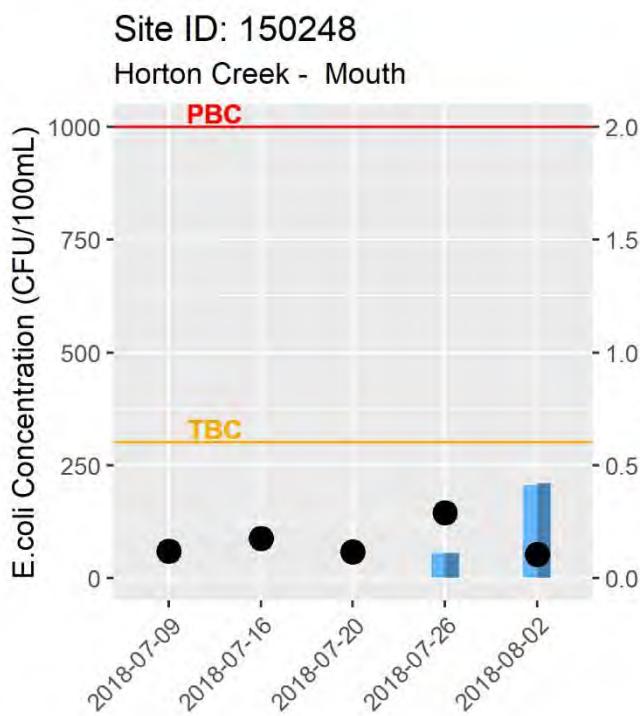
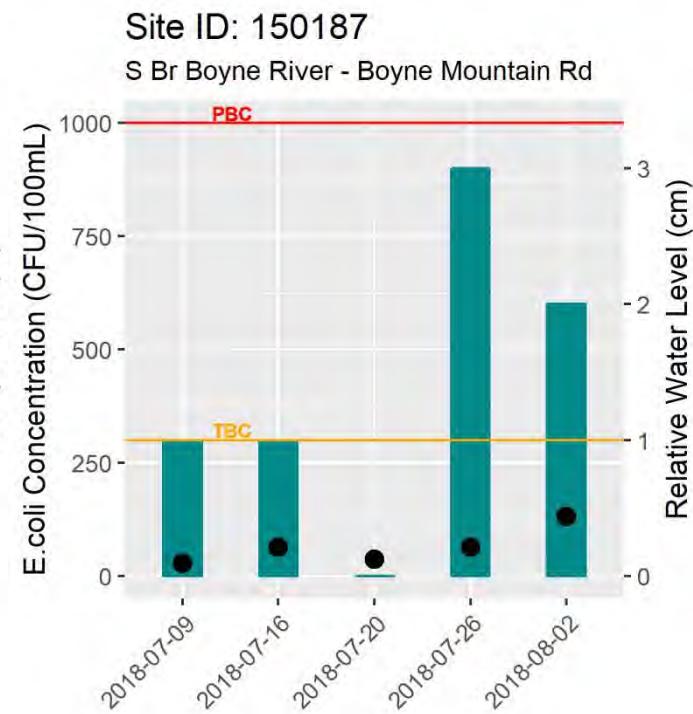
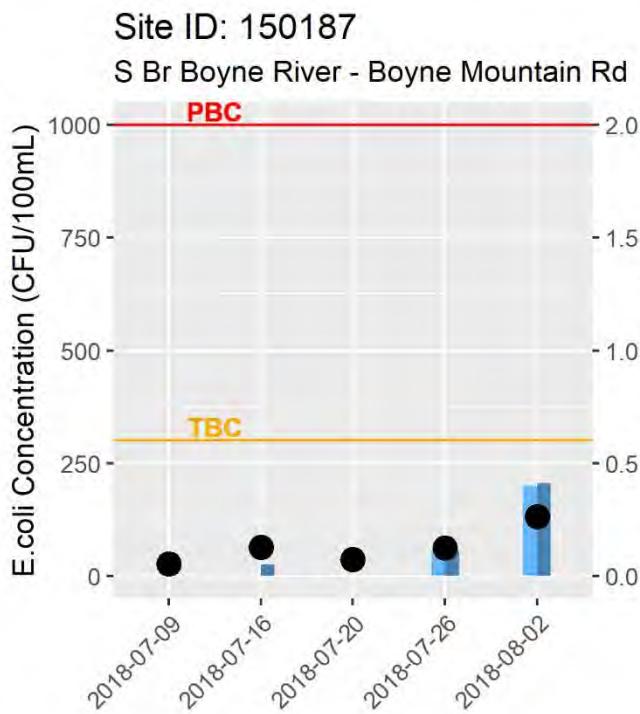
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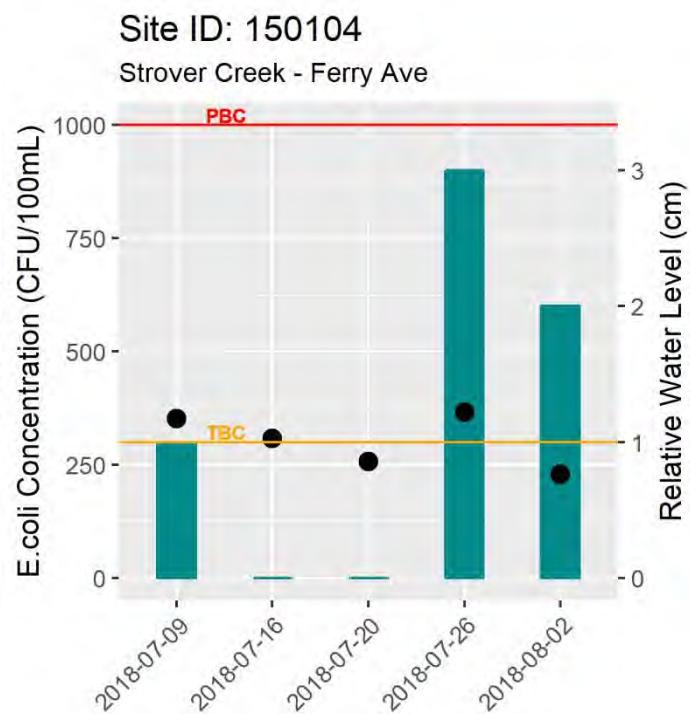
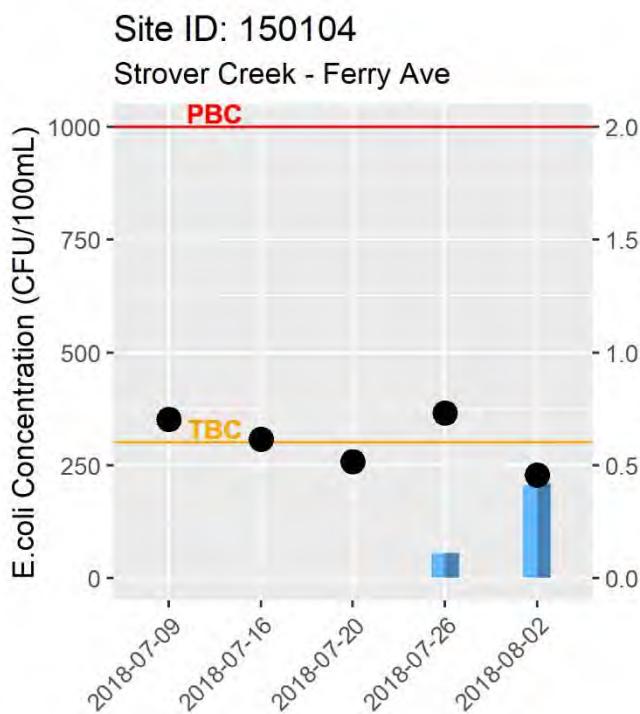
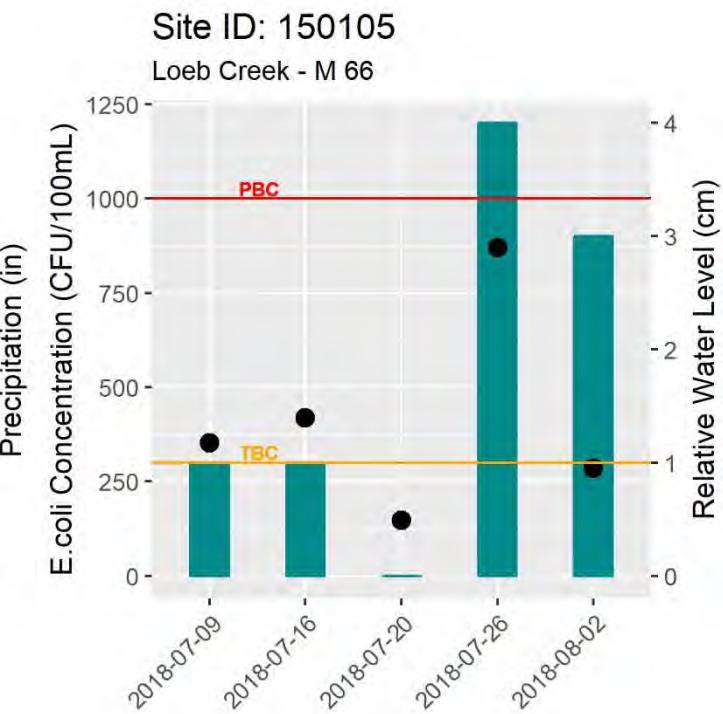
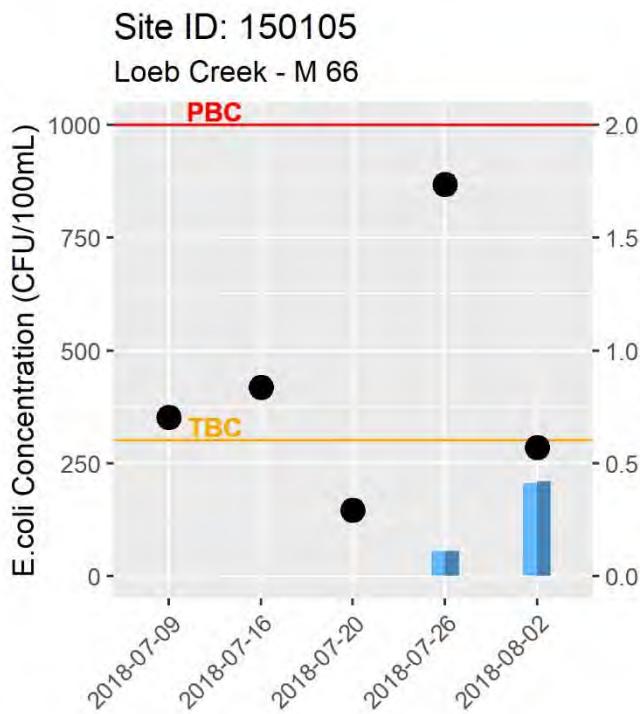
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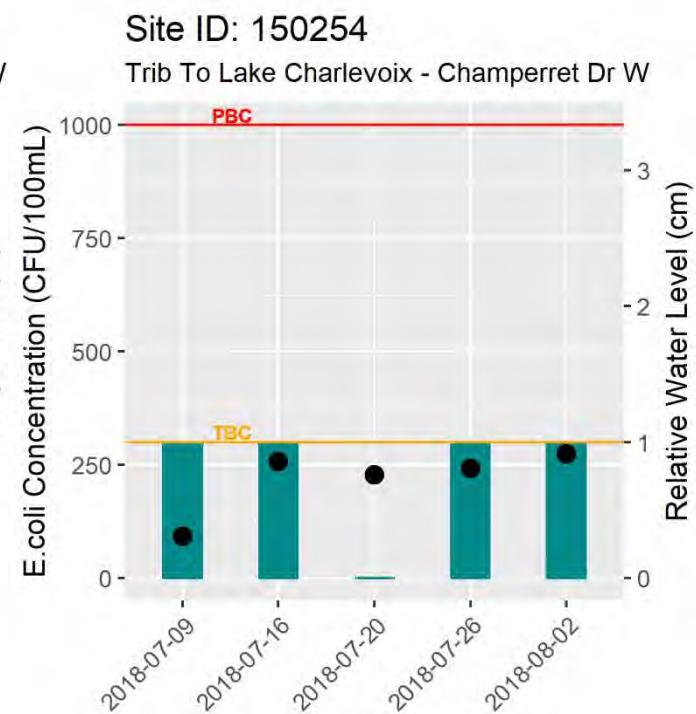
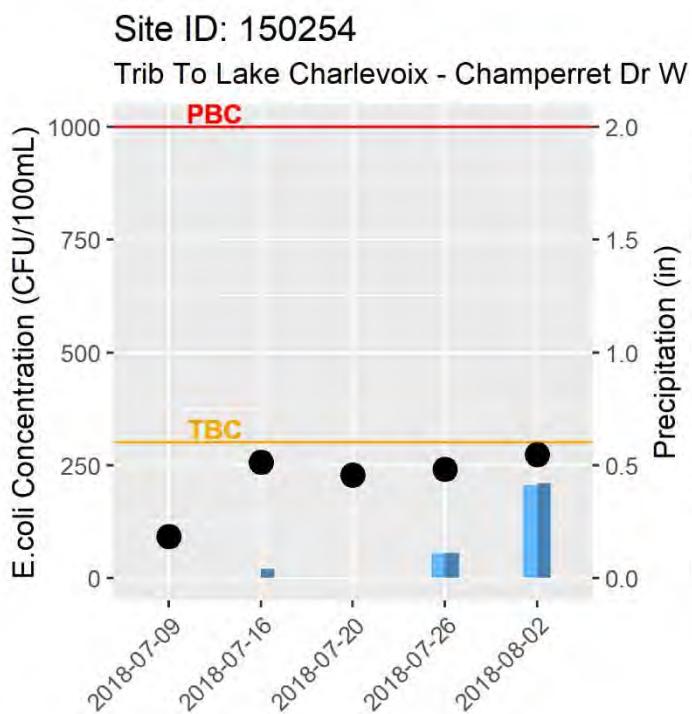
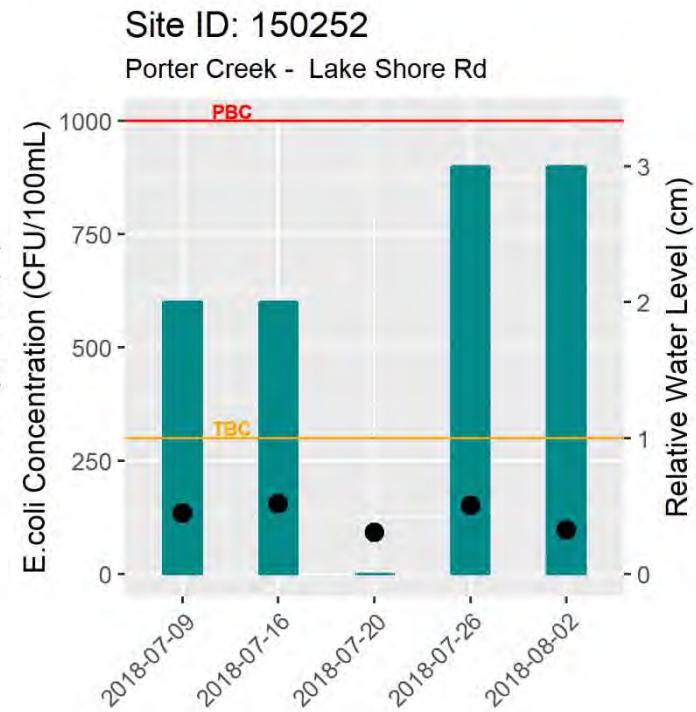
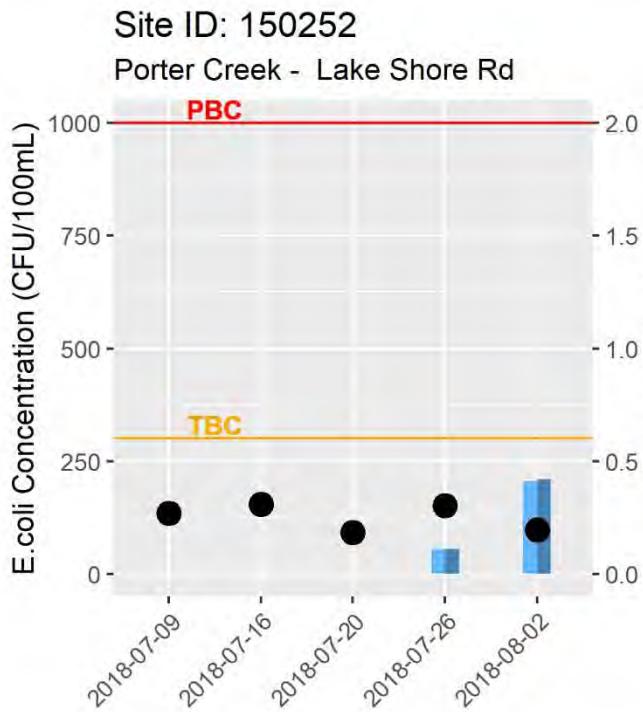
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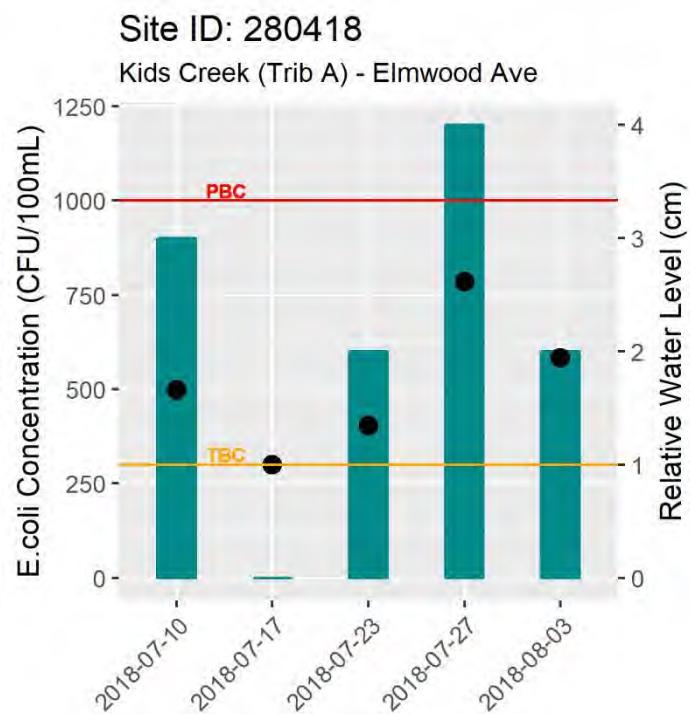
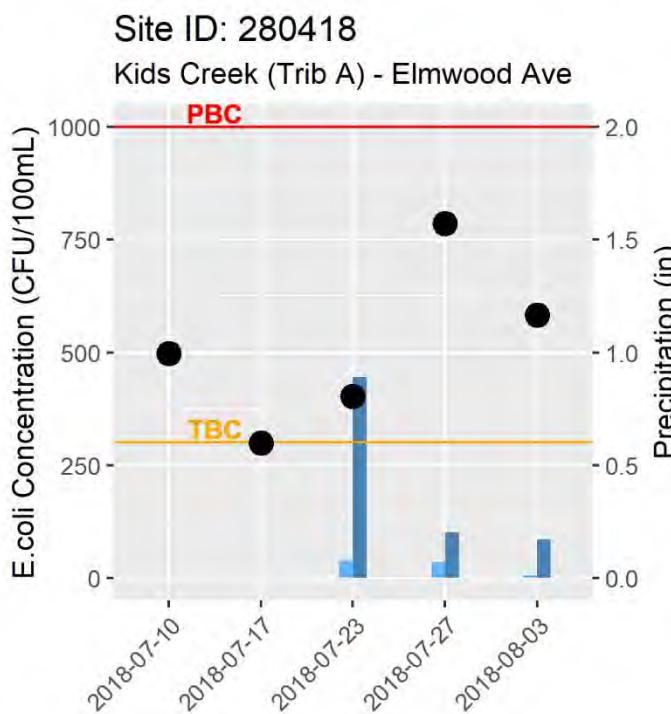
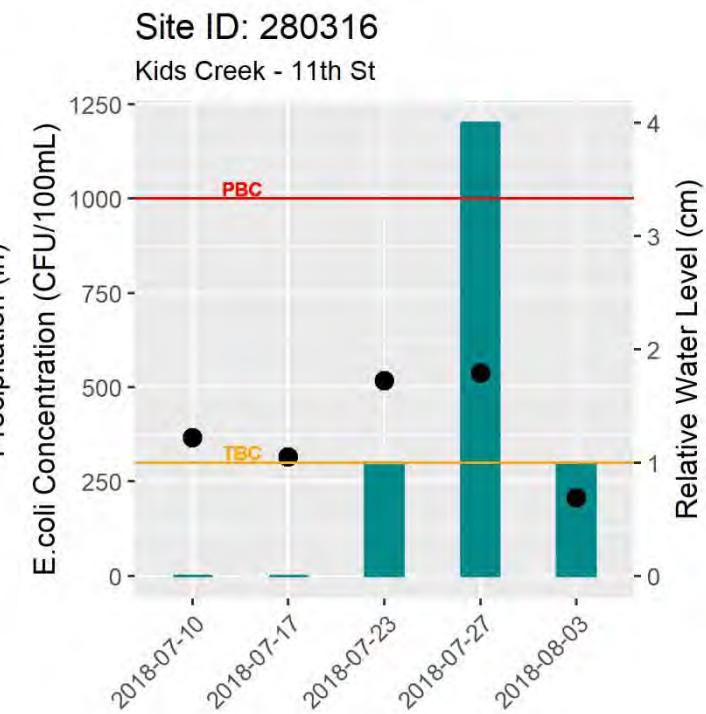
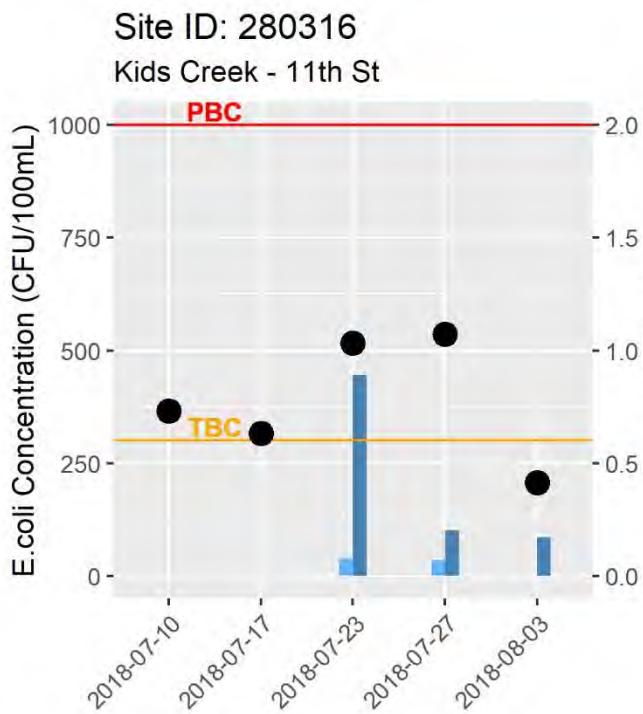
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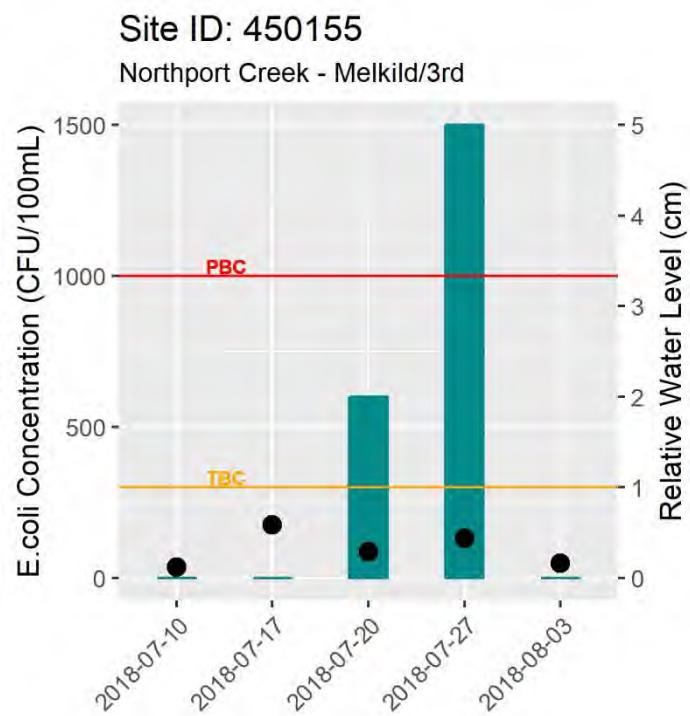
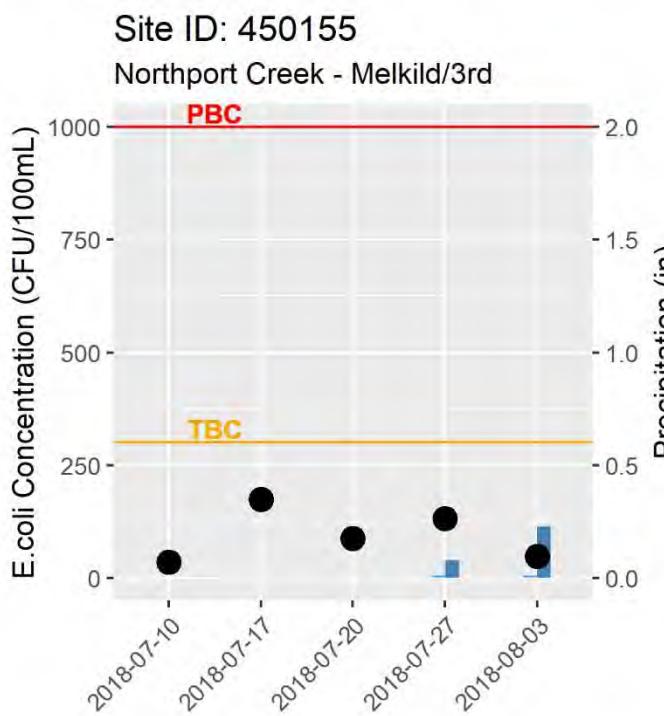
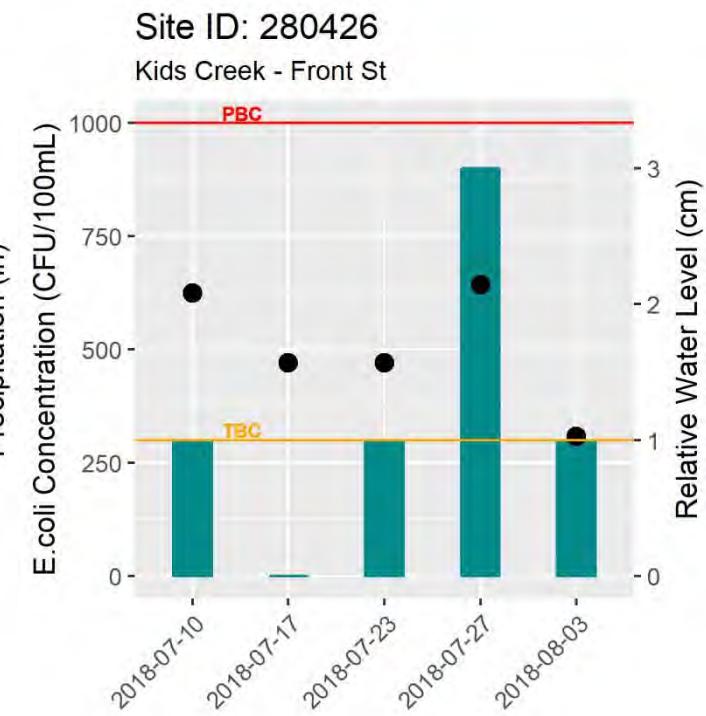
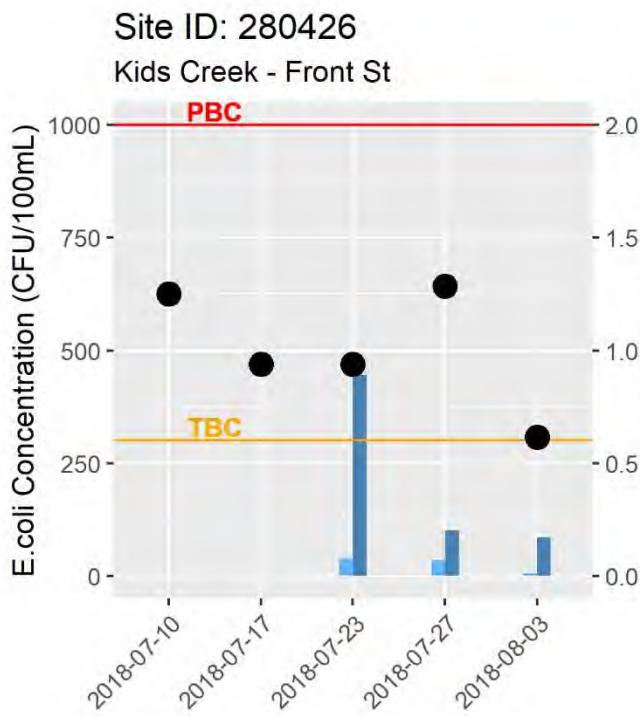
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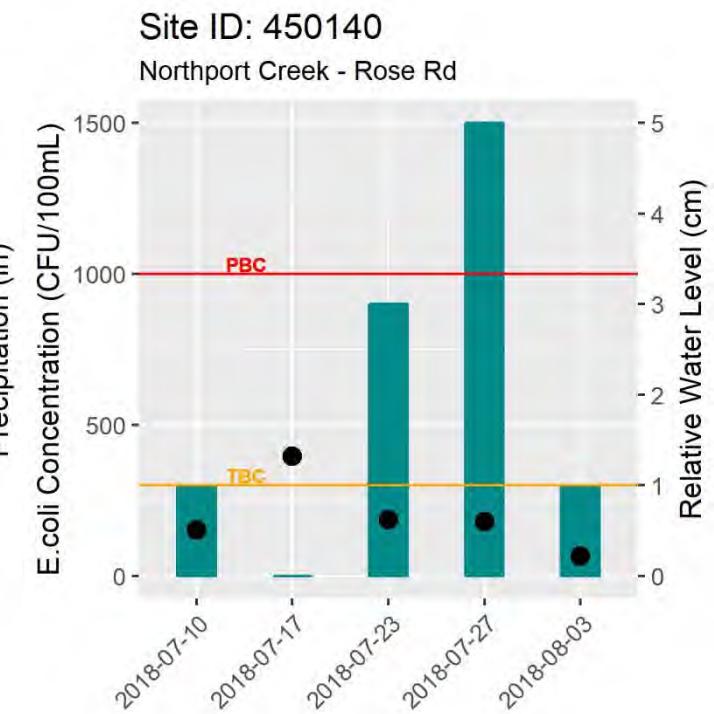
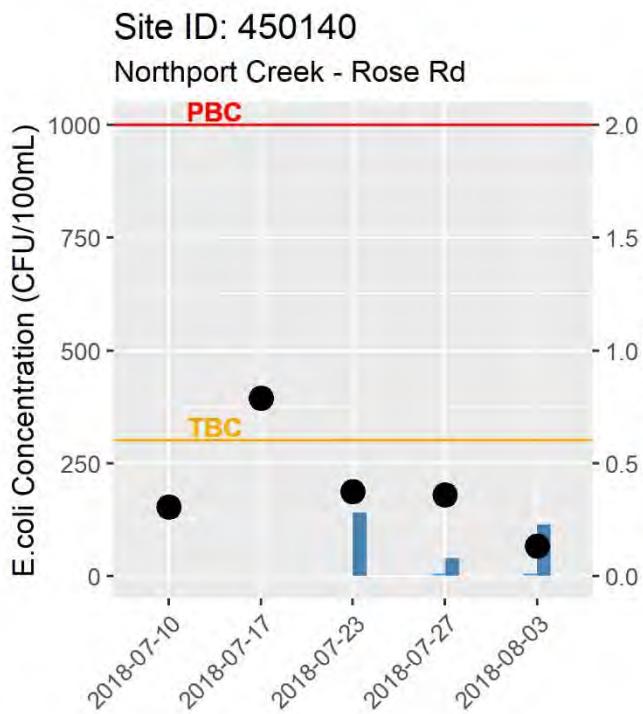
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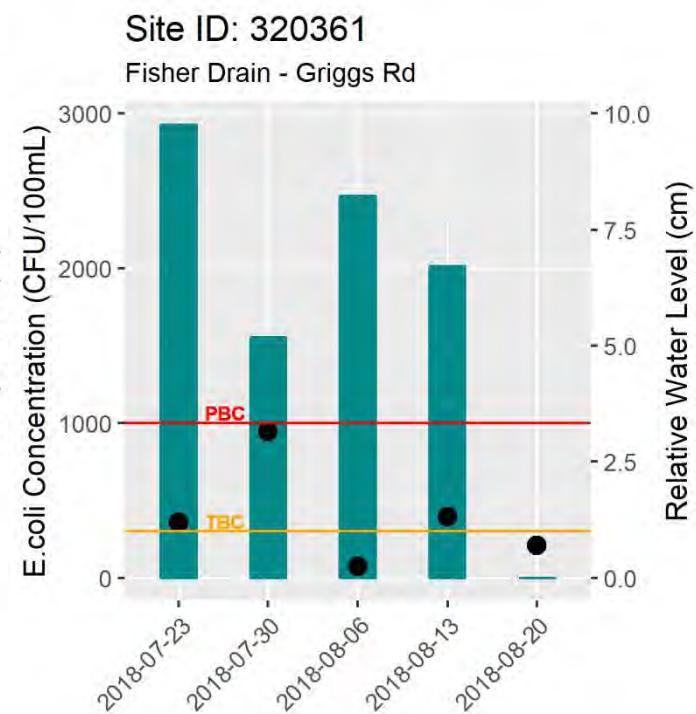
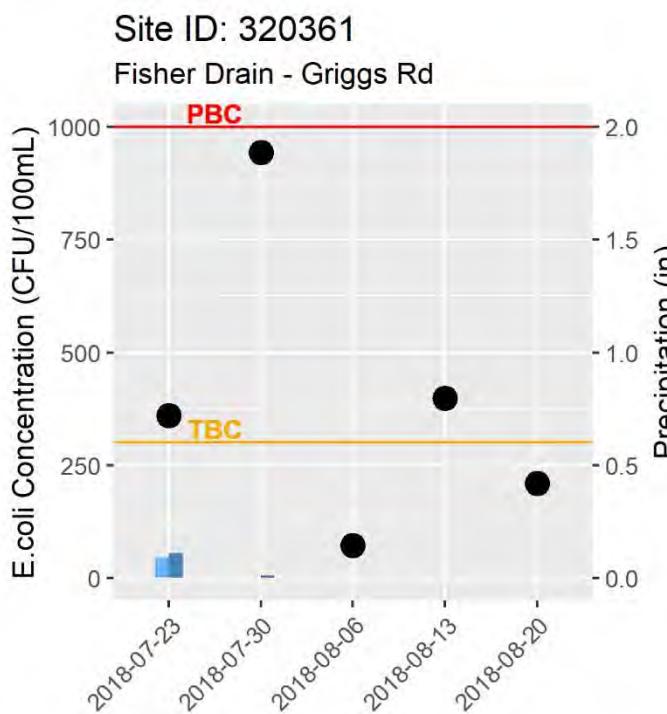
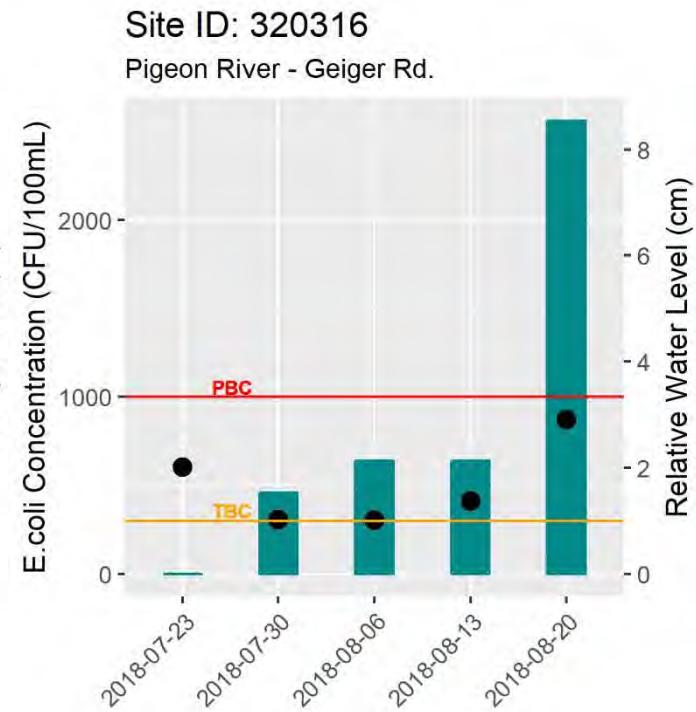
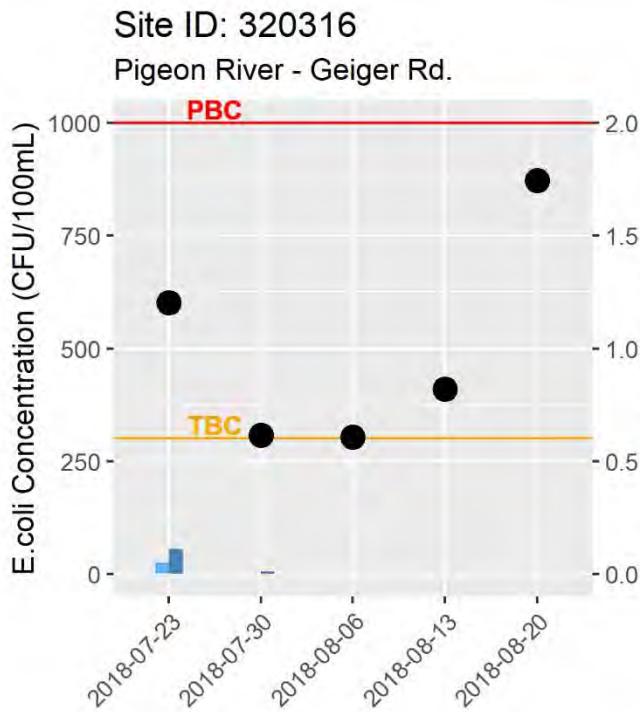
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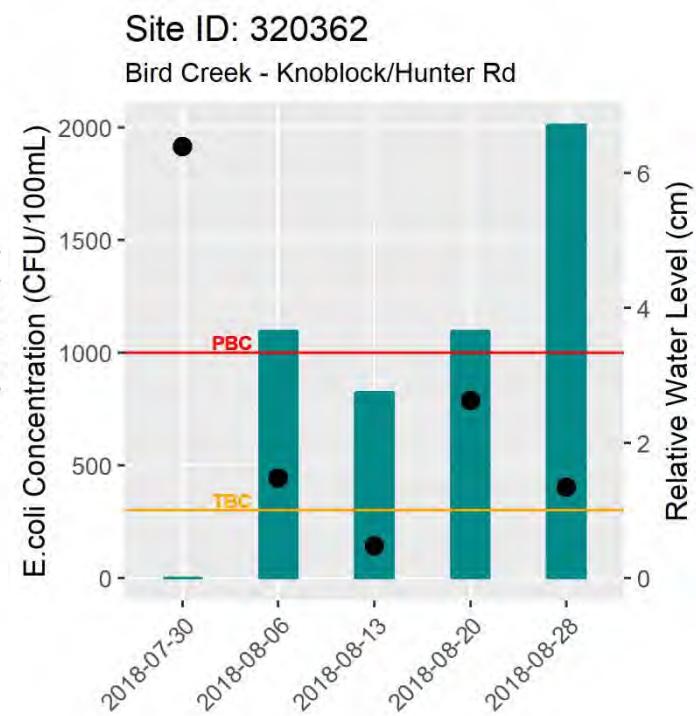
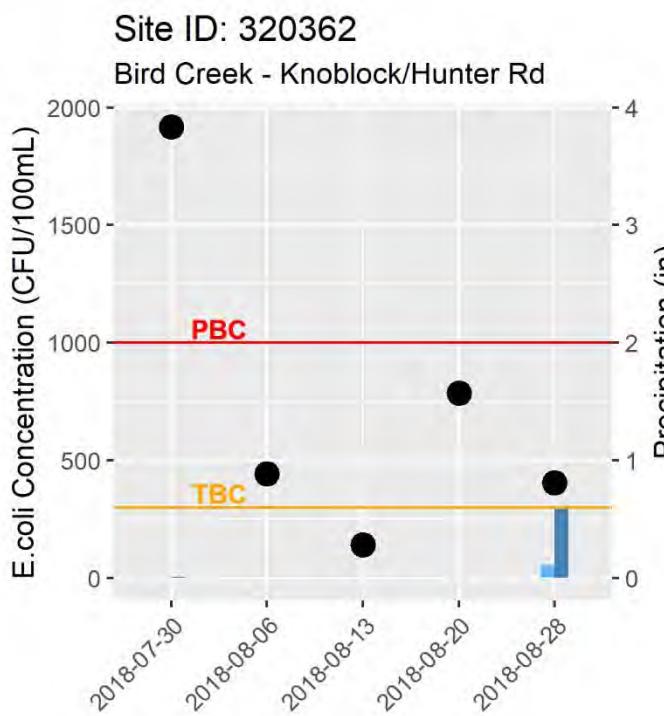
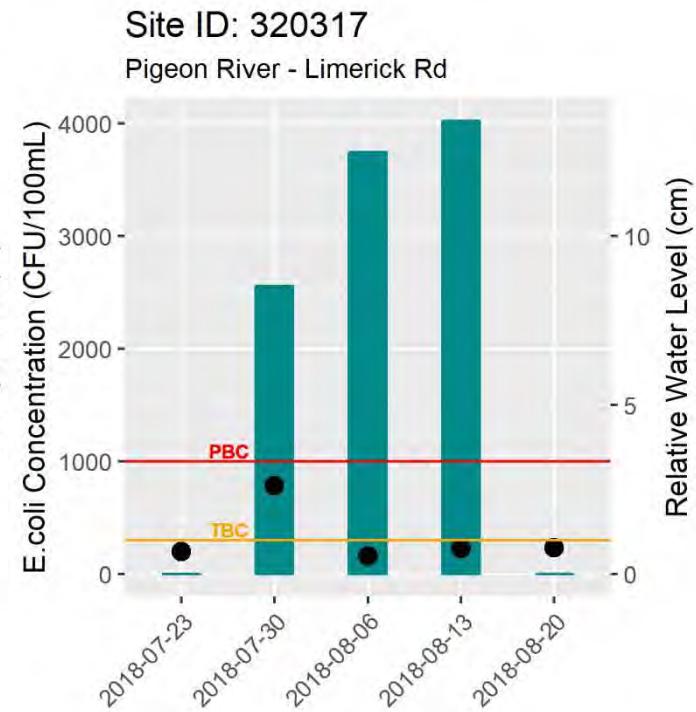
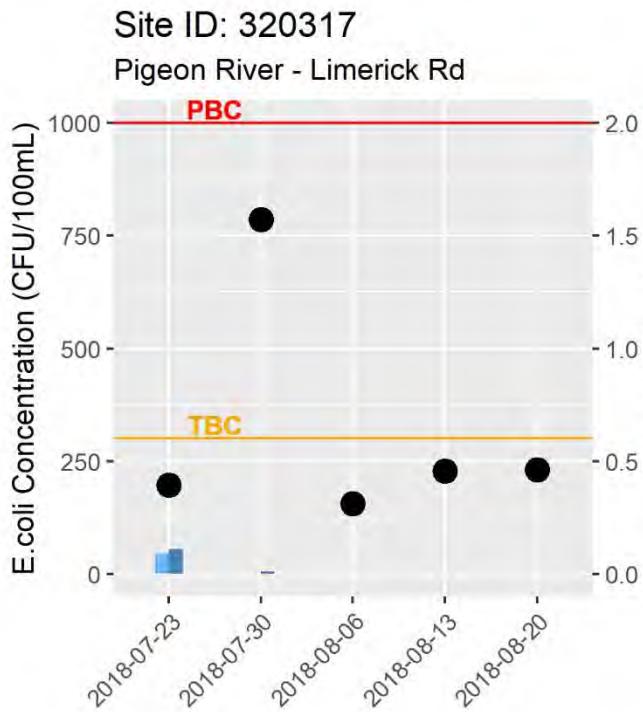
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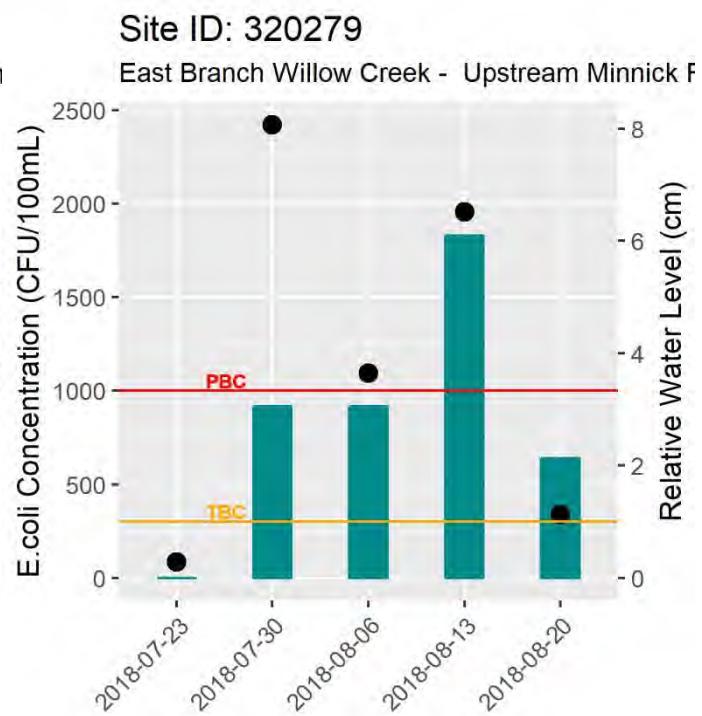
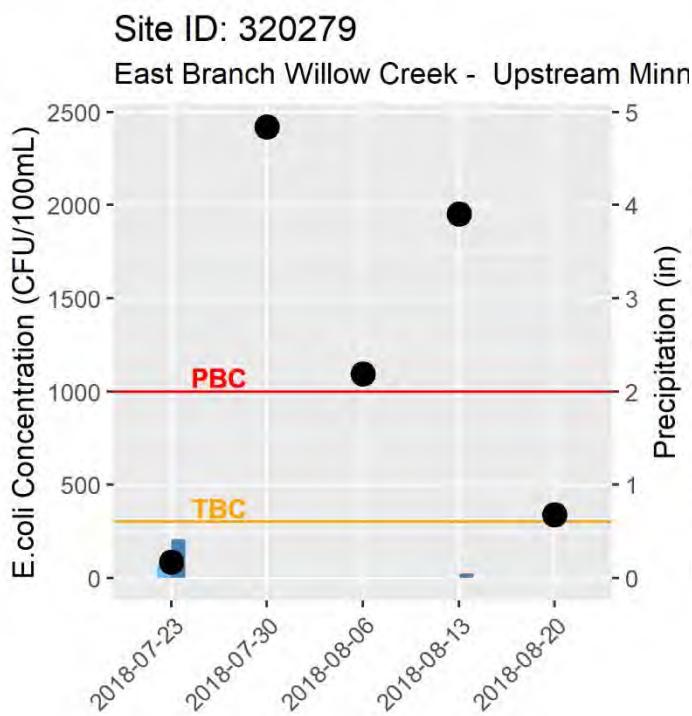
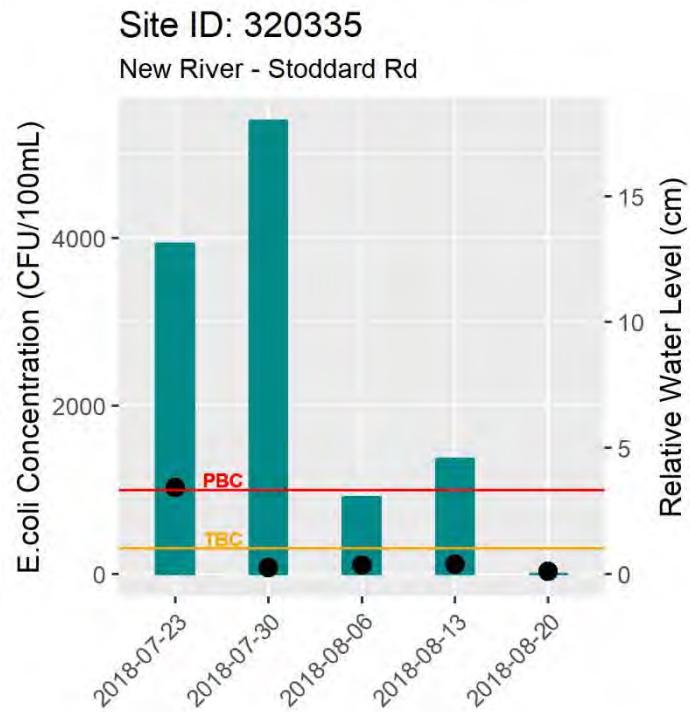
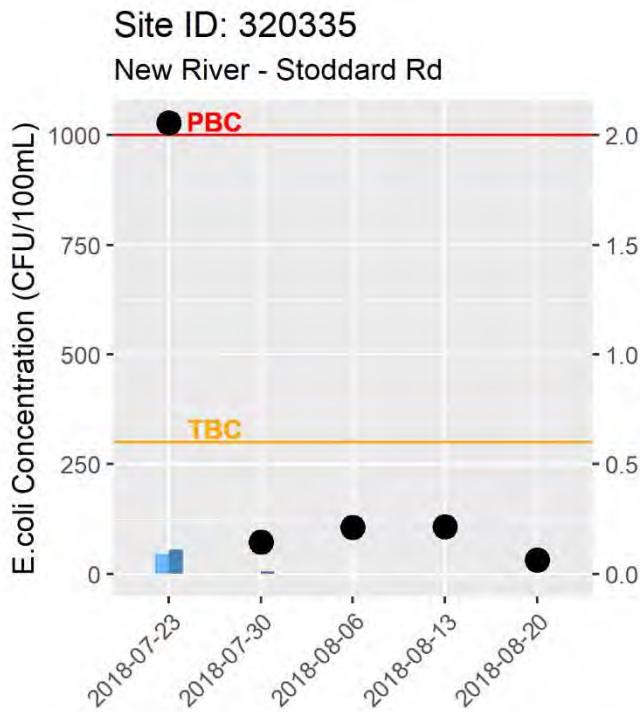
Appendix 4 (cont.). Pigeon-Wiscoggin and Birch-Willow sites.



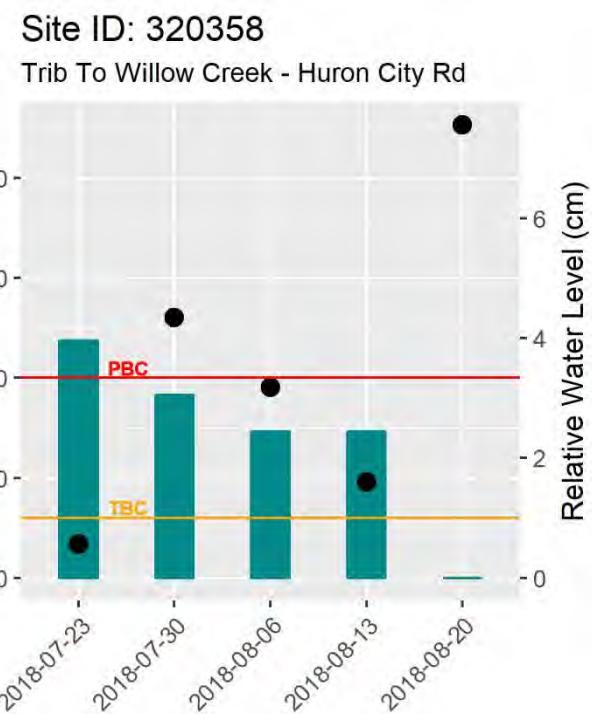
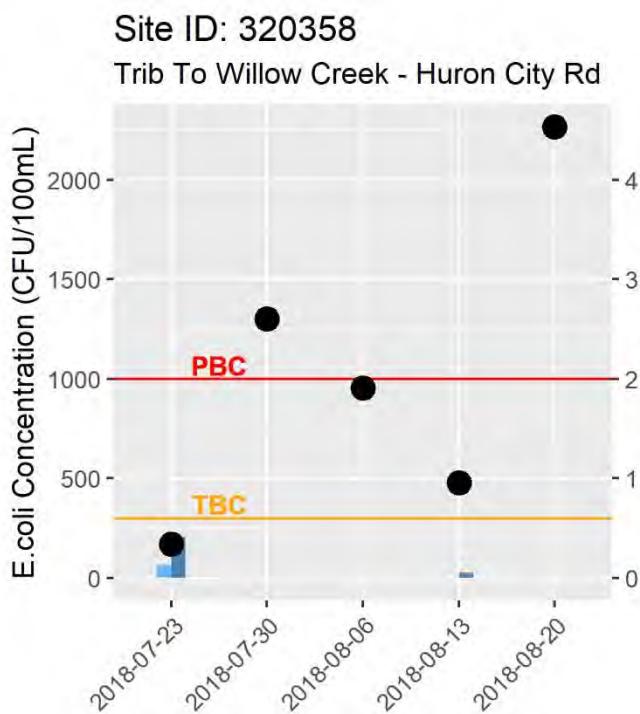
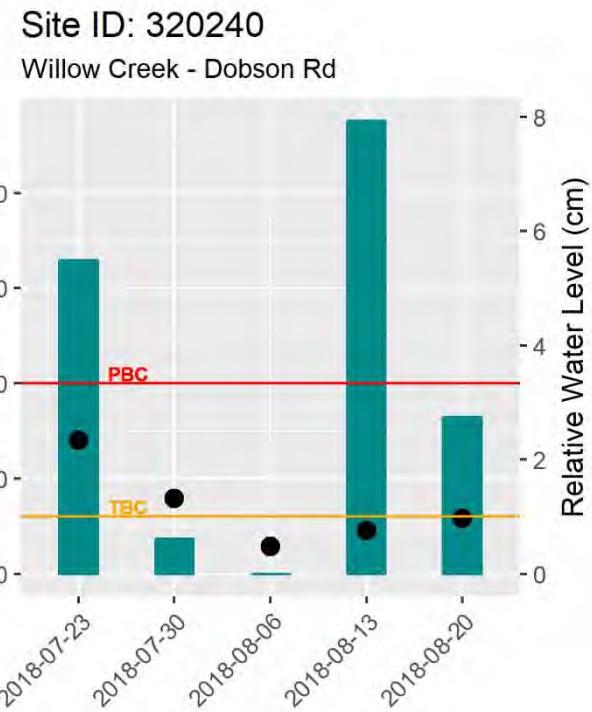
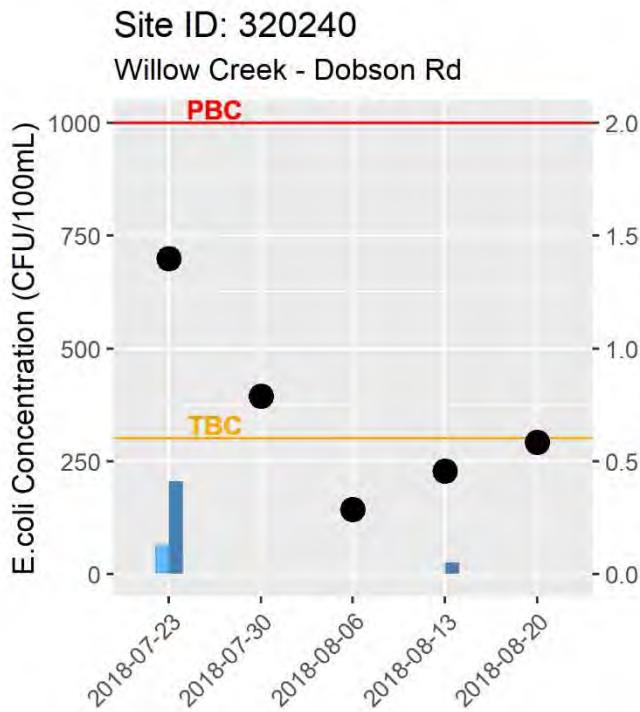
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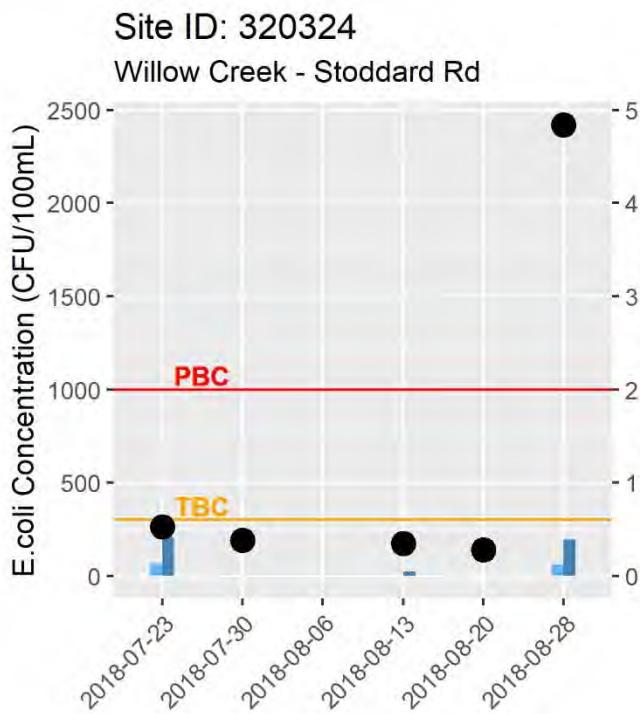
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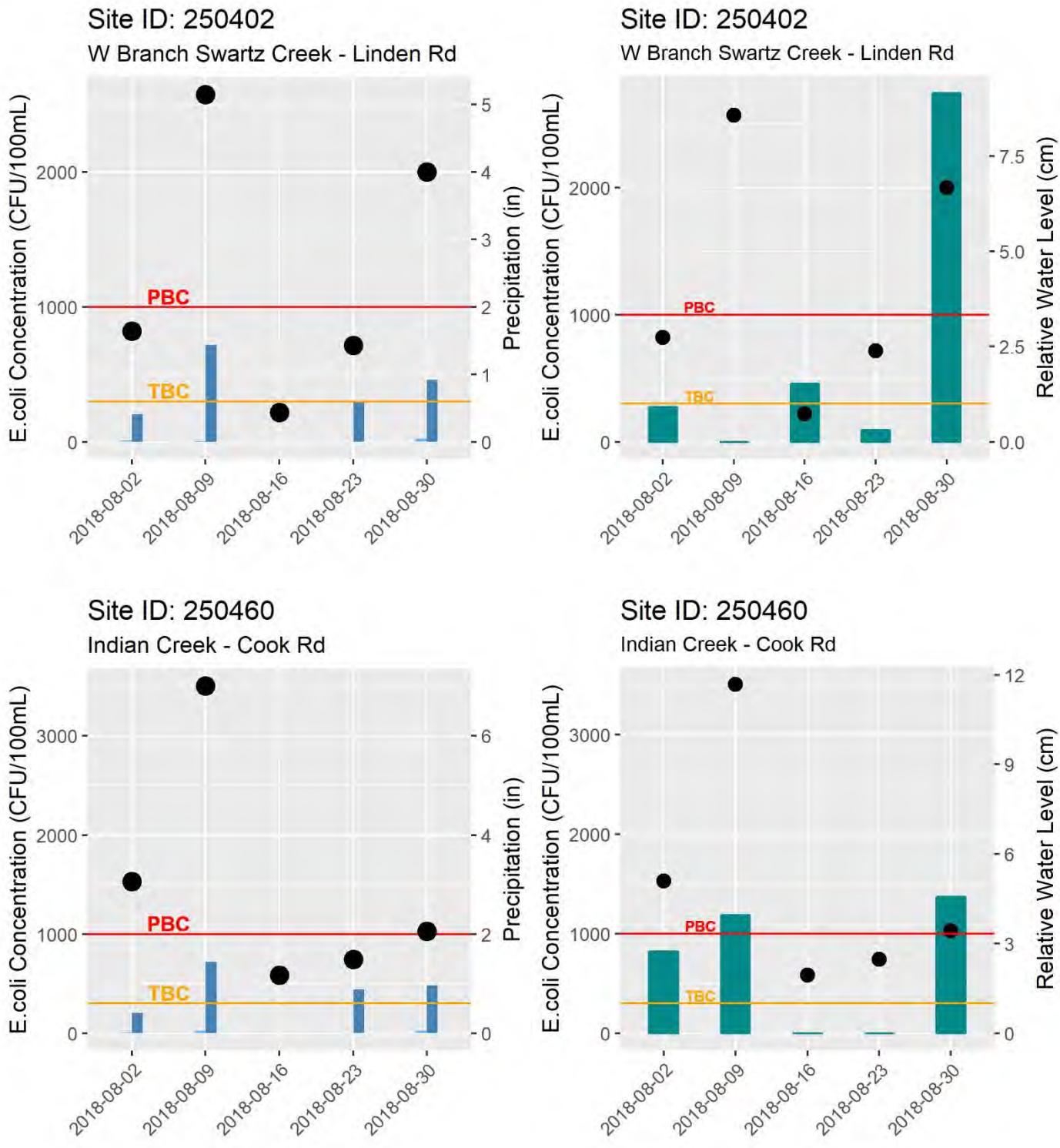
Appendix 4 (cont.). Pigeon-Wiscoggan and Birch-Willow sites.



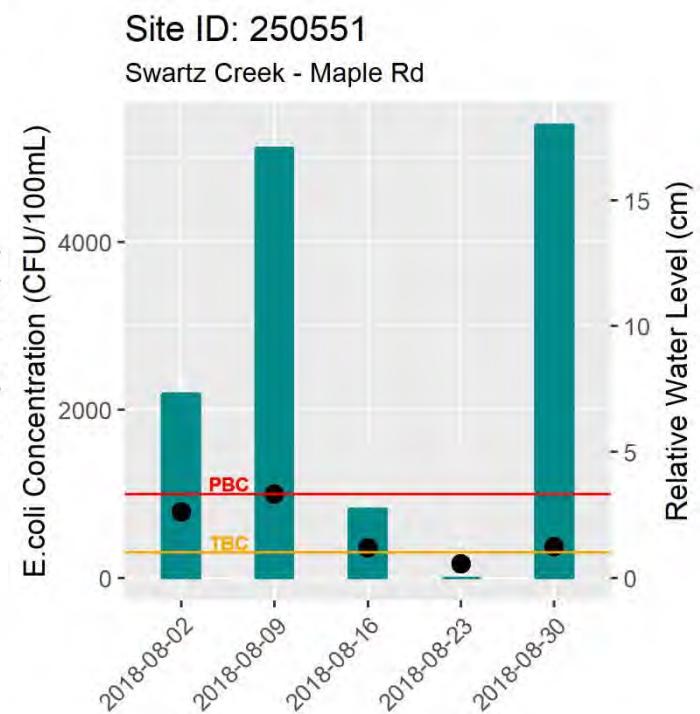
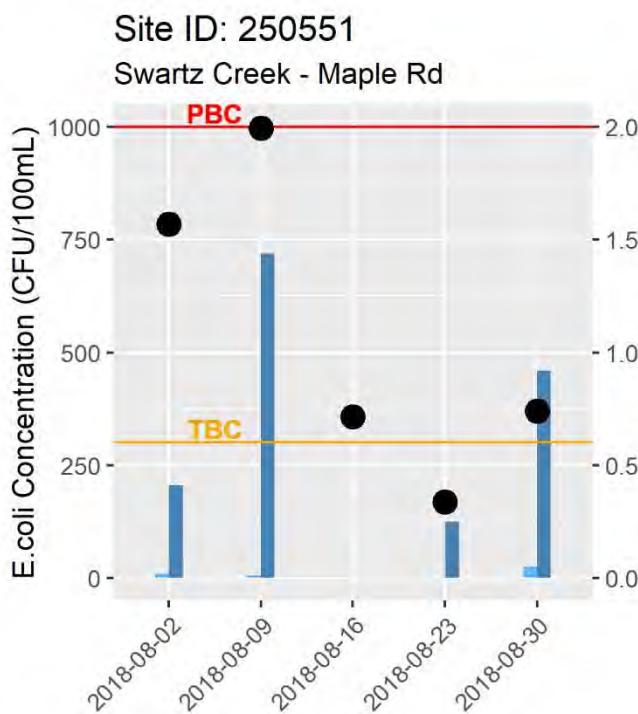
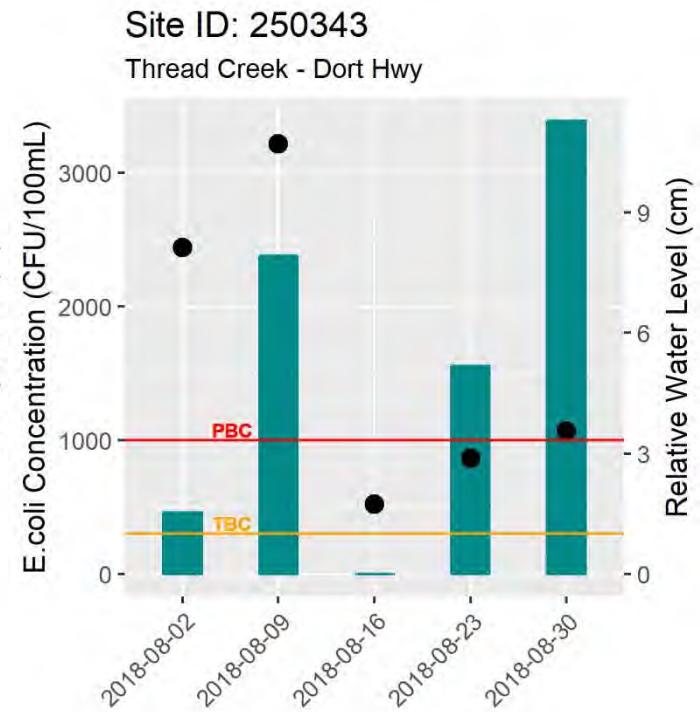
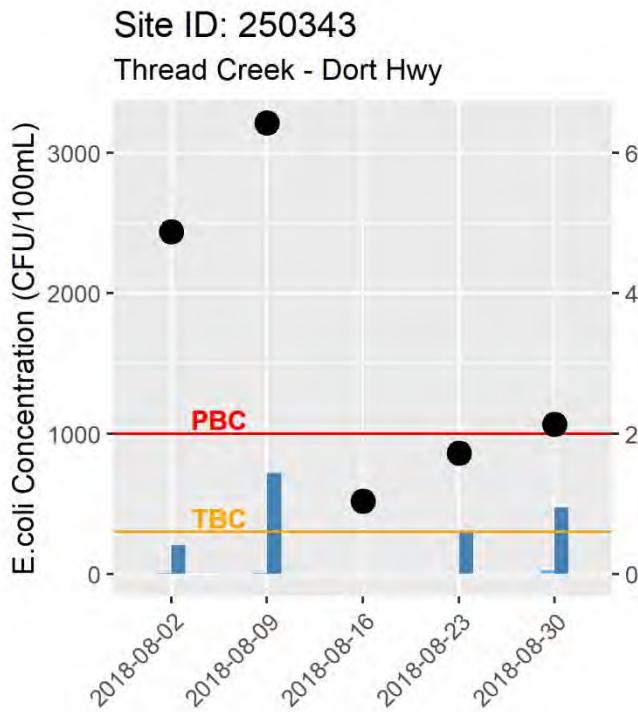
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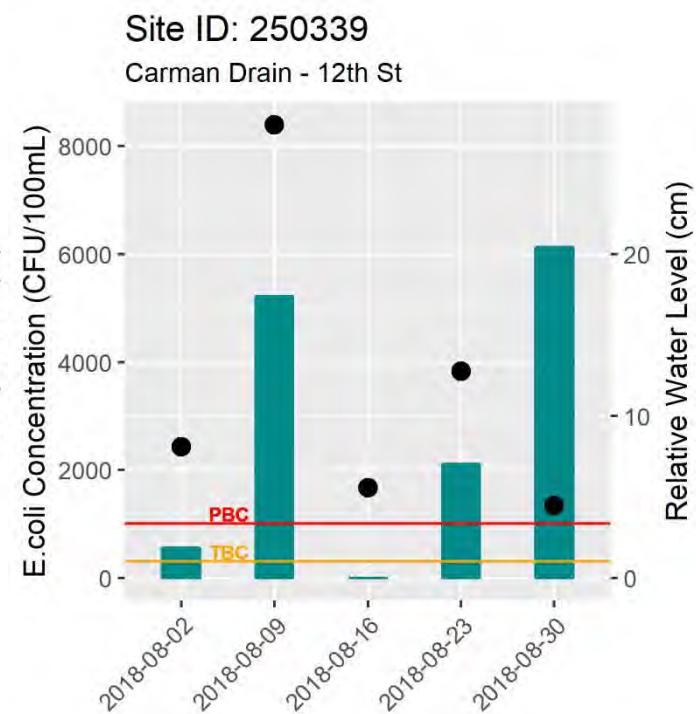
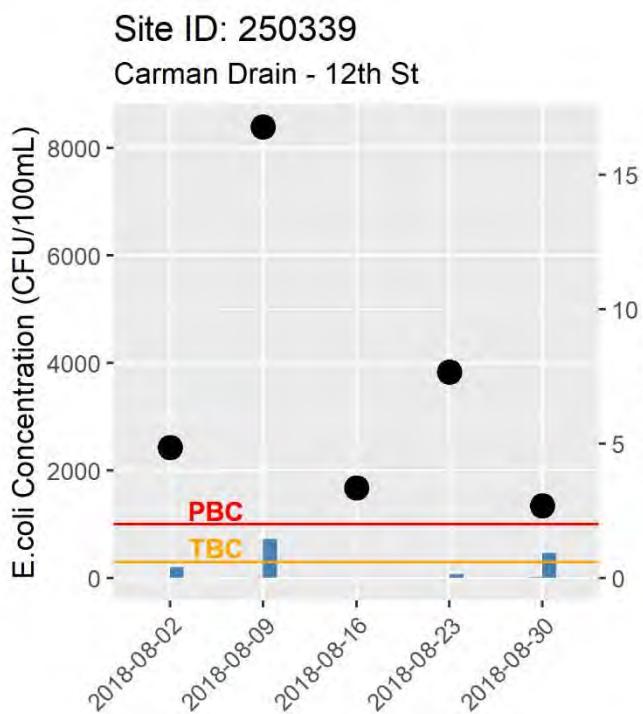
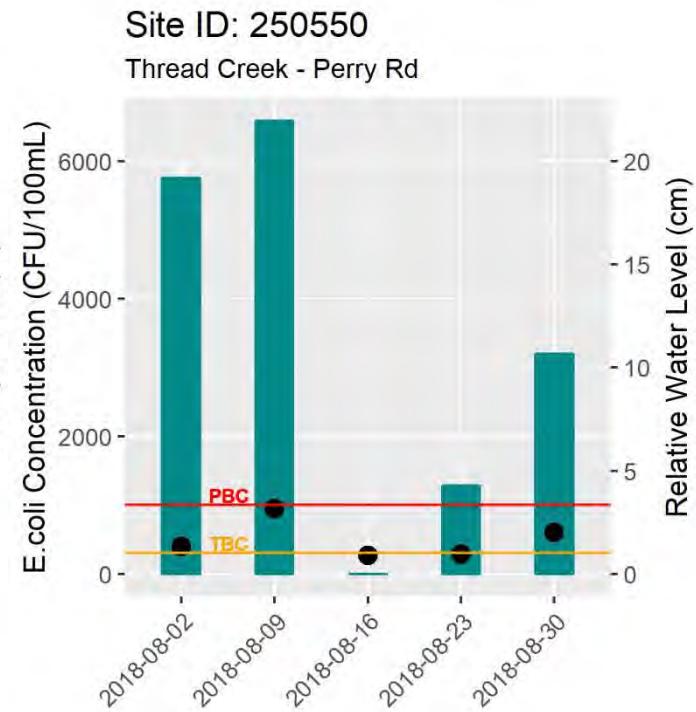
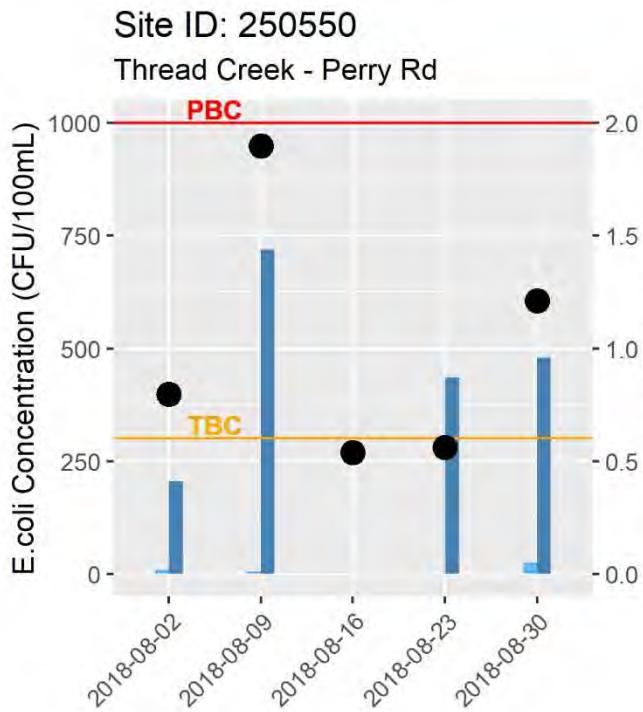
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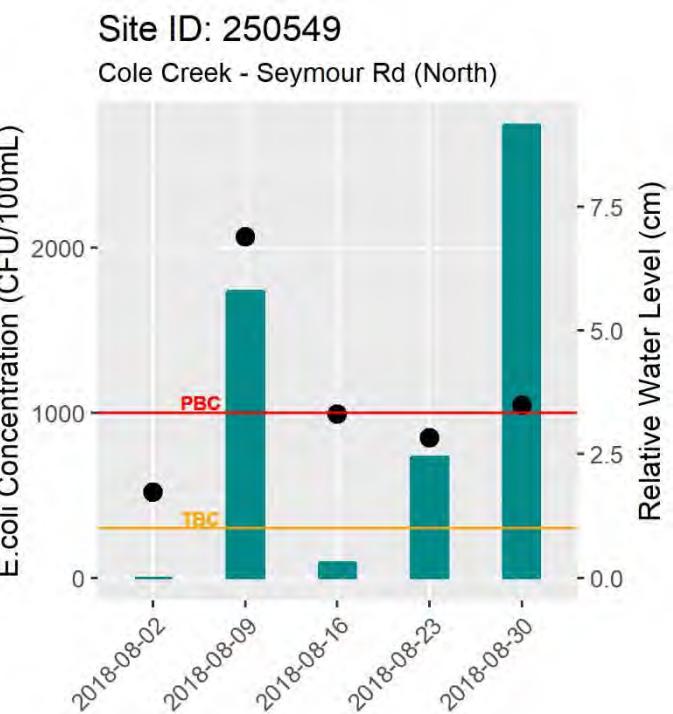
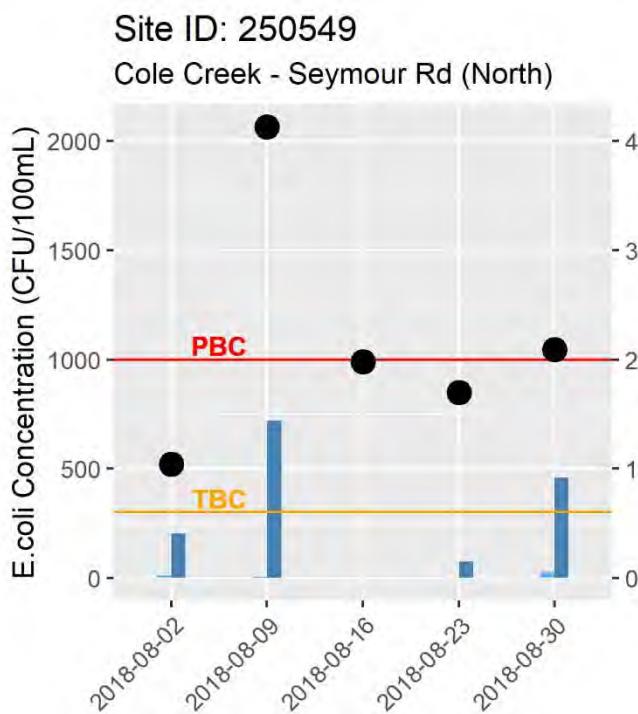
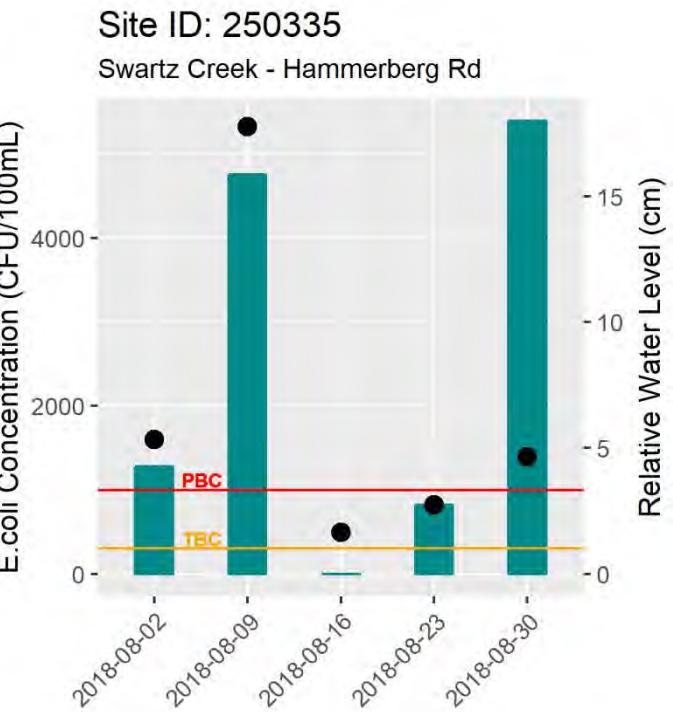
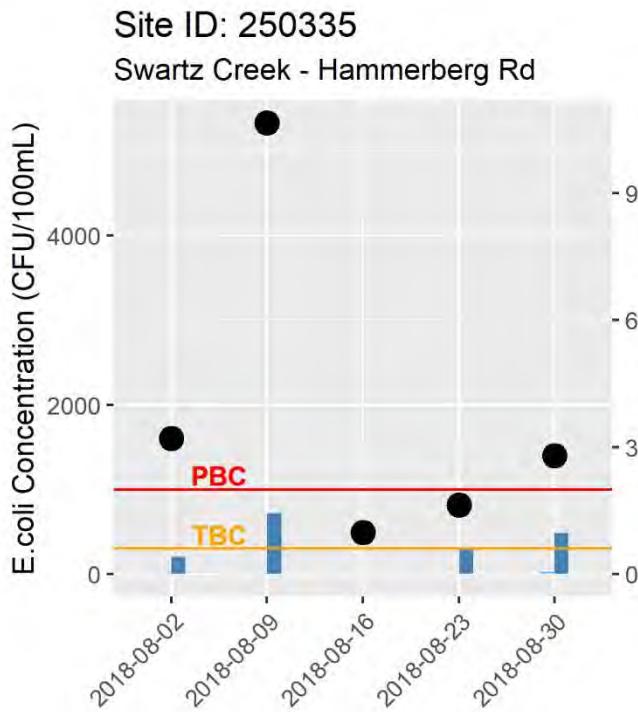
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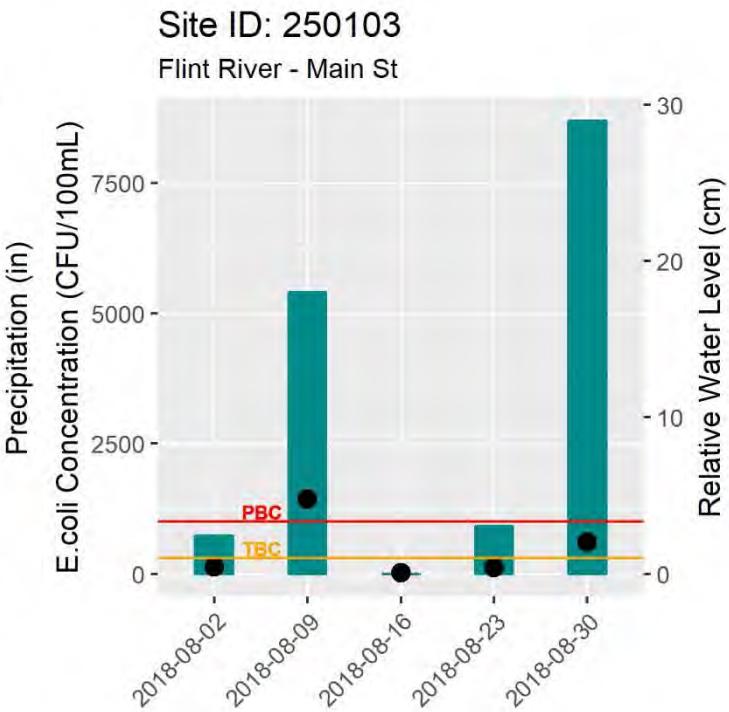
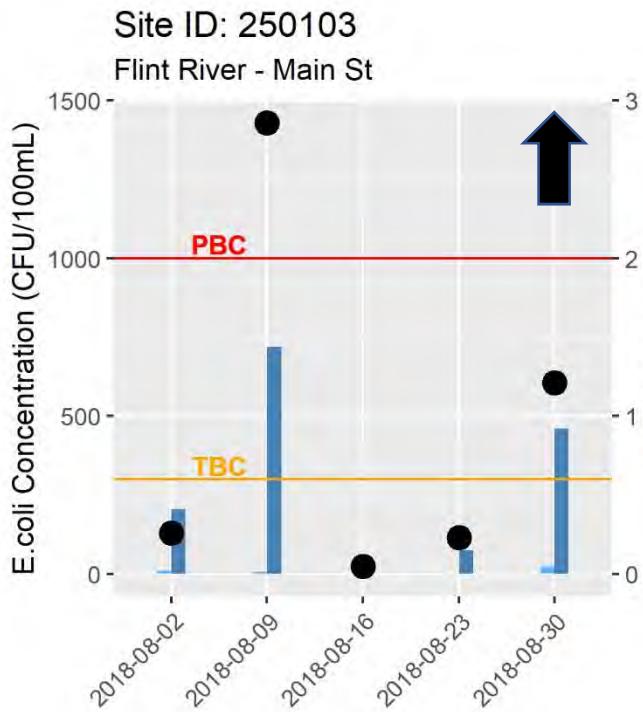
Appendix 4 (cont.). Flint sites.



Appendix 4 (cont.). Flint sites.



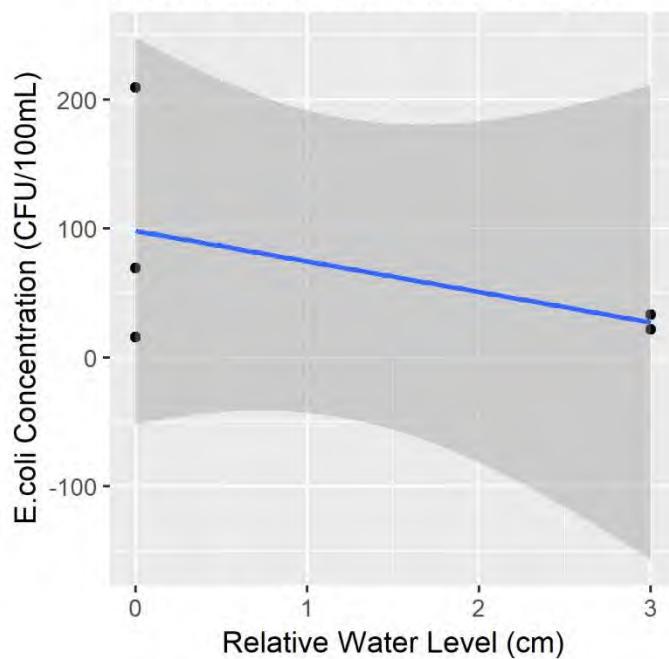
Appendix 4 (cont.). Flint sites.



Appendix 5. Relationships between *E. coli* and water levels for selected sites in the 2018 study. Water levels are relative to the lowest recorded water level during the study. The blue lines show statistical trends while the gray shaded area shows the confidence interval (the narrower the gray band, the more confidence in the relationship). Only sites with water level changes more than 2 cm are shown.

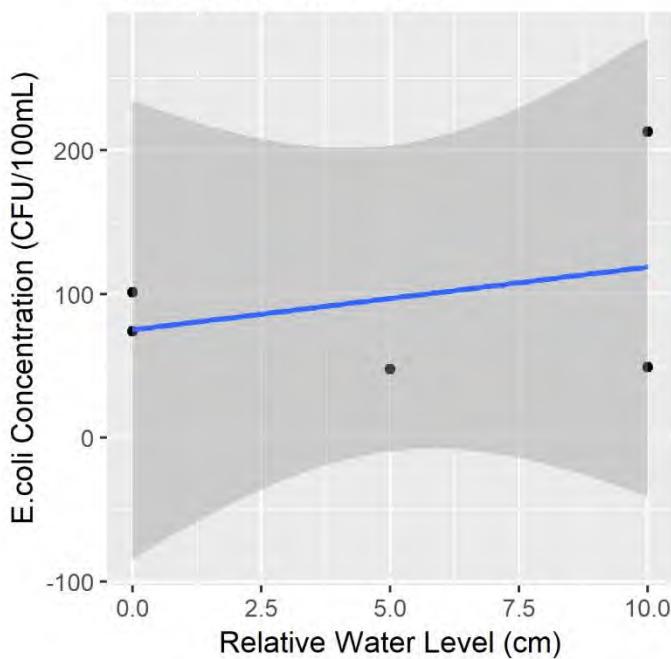
**Site ID: 270023**

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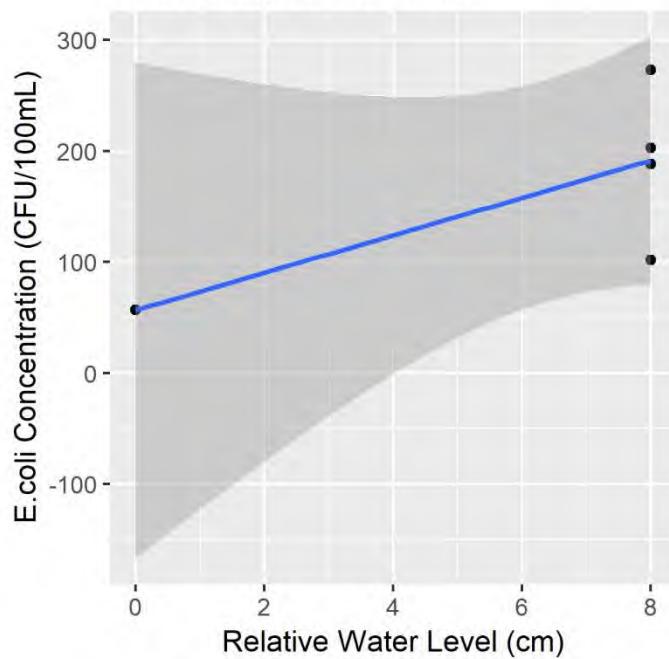
**Site ID: 270103**

Black River - Moore Rd.



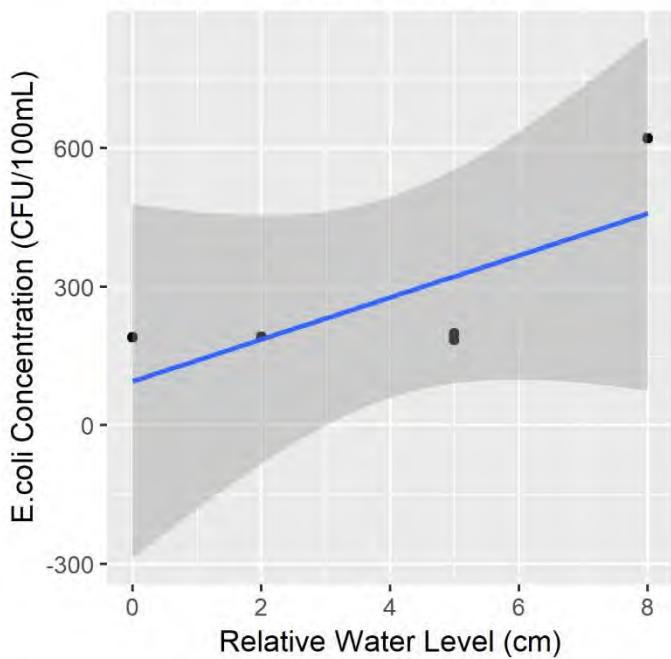
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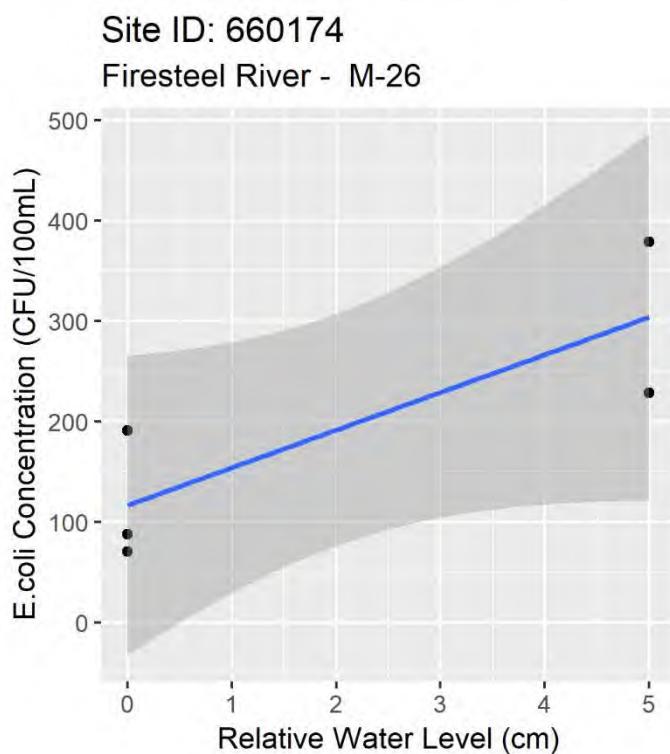
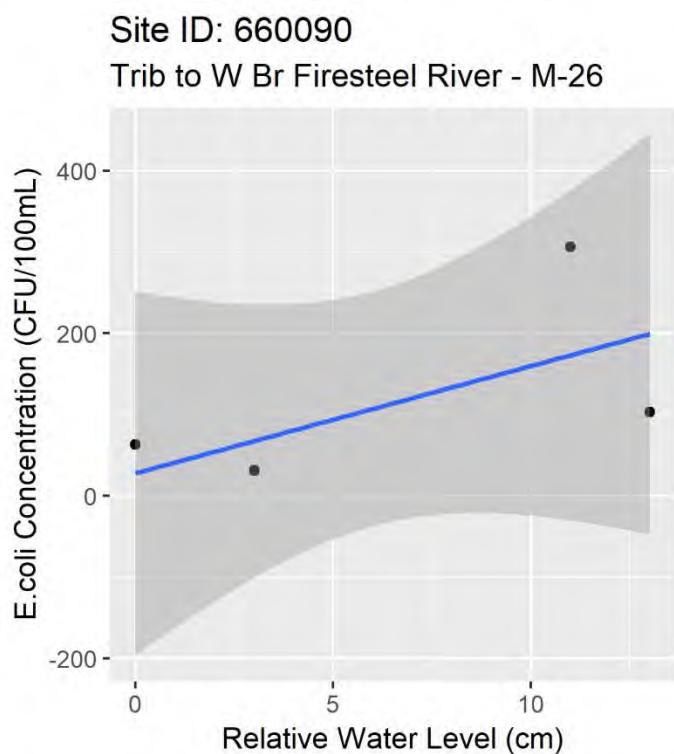
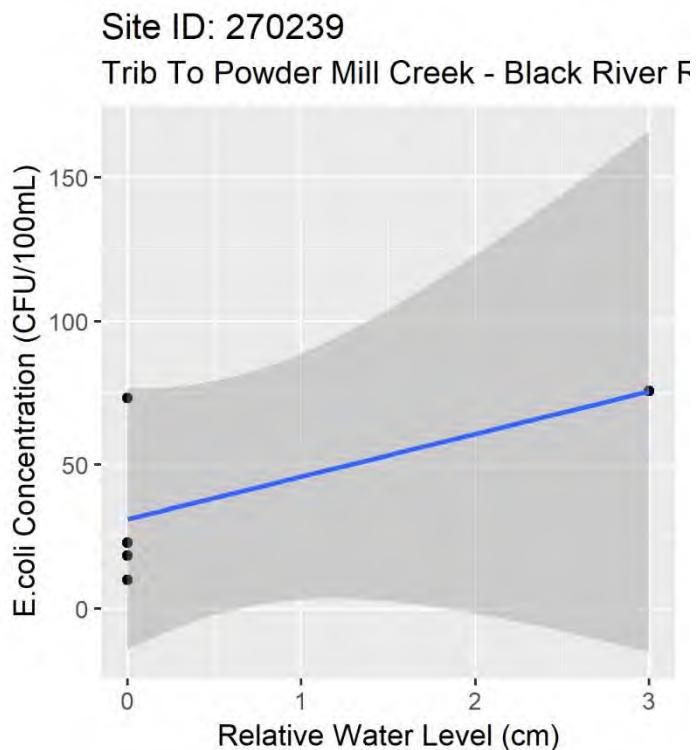
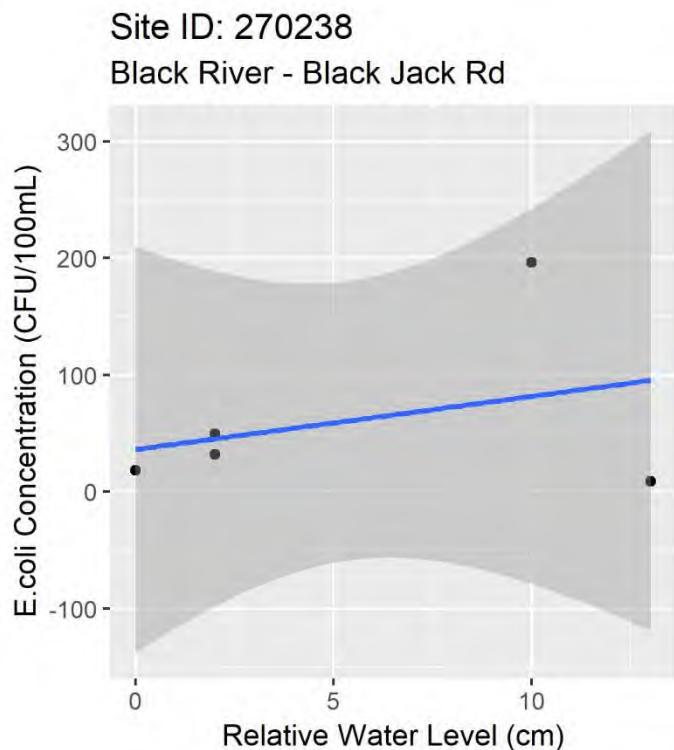
Powder Mill Creek - US2



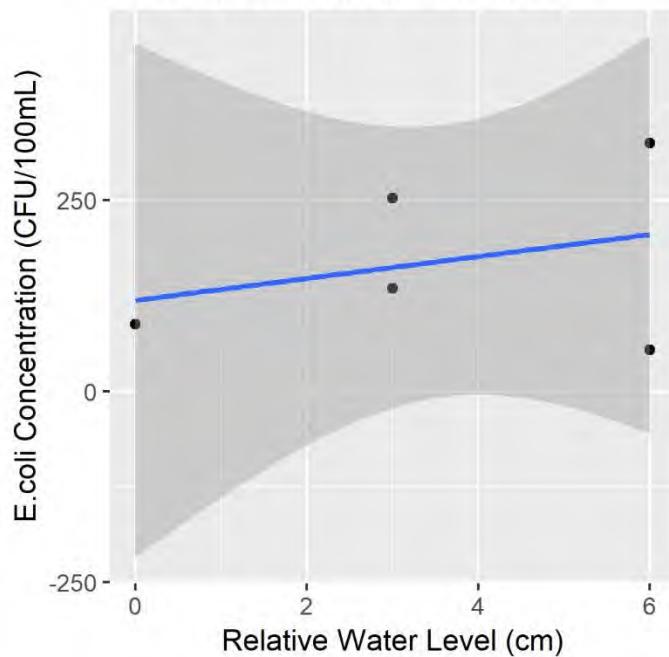
**Site ID: 270176**

Kallander Creek - Stone Rd.

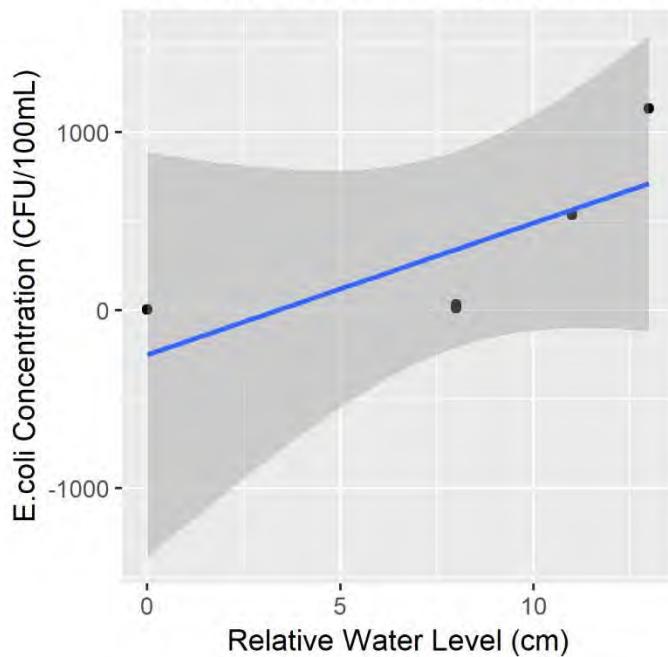




Site ID: 660185  
W Br Firesteel River - Old M-35



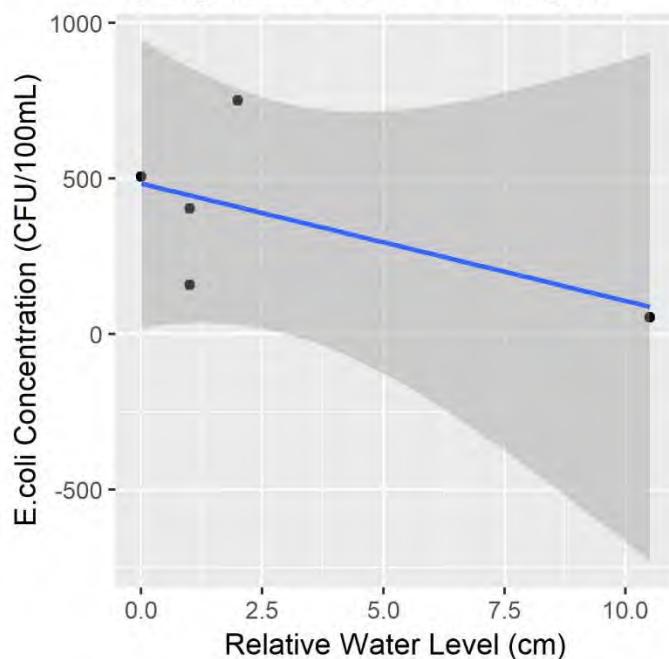
Site ID: 660184  
Trib to W Br Firesteel R (SW) - Old M-3



Appendix 5 (cont). Kalamazoo sites.

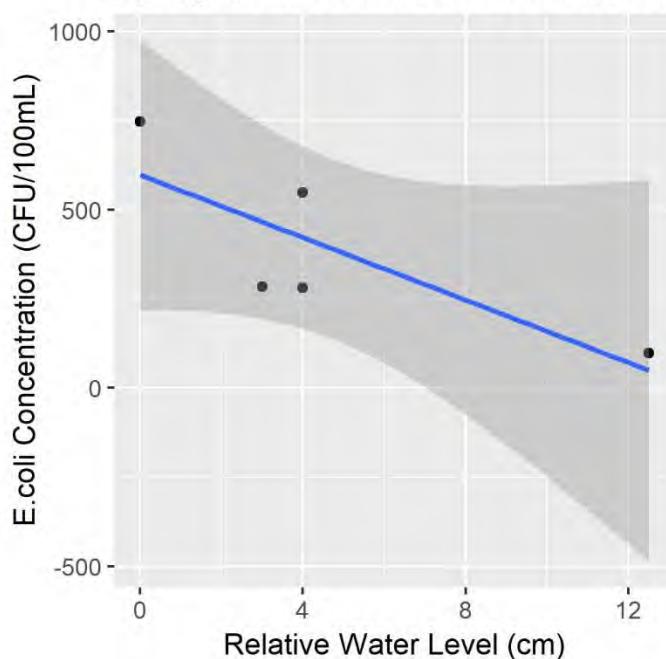
Site ID: 380442

Spring Arbor/Concord Dr - King Rd



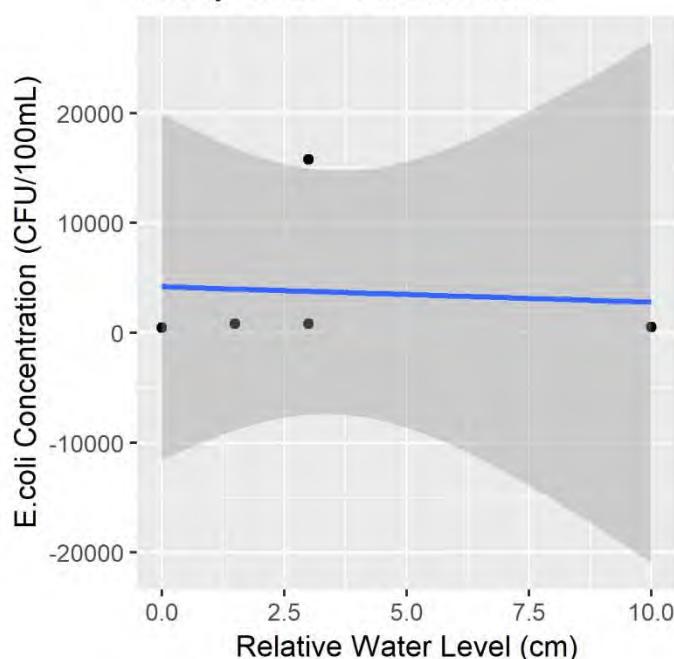
Site ID: 380443

Spring Arbor/Concord Dr - N Concord Rd



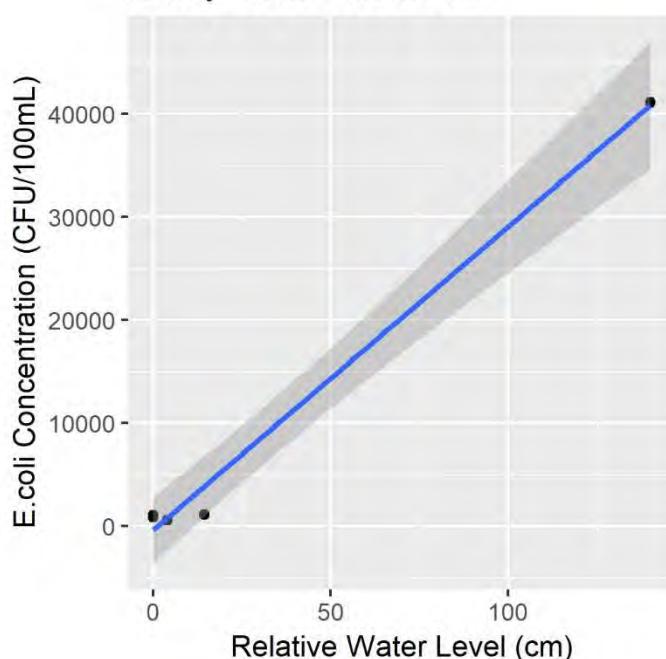
Site ID: 30721

Cuddy Drain - Patterson Rd



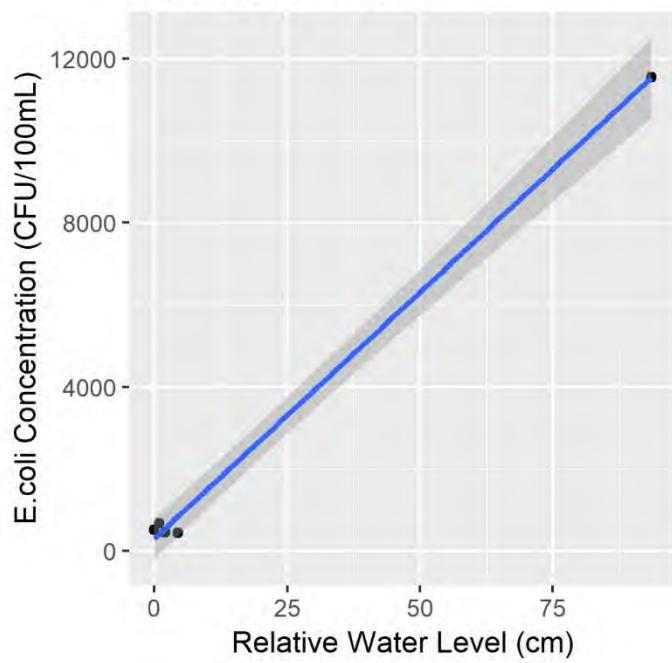
Site ID: 30728

Haney Drain - 138th Ave

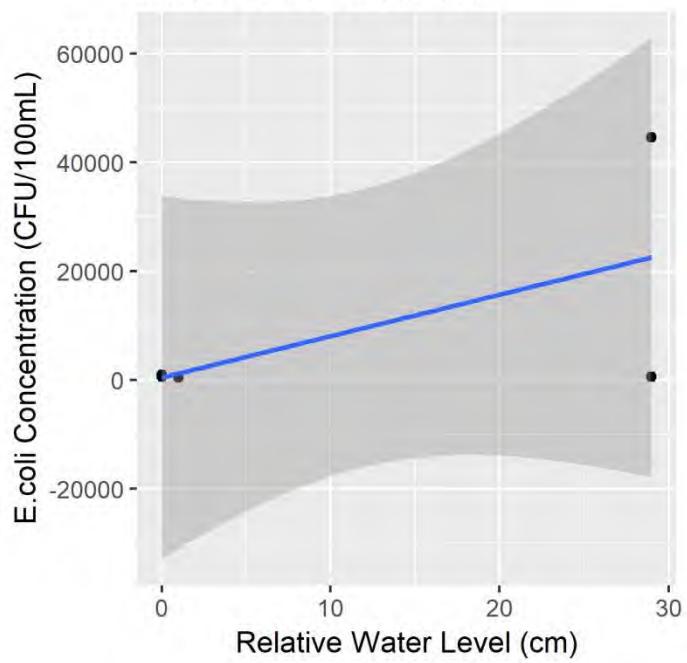


Appendix 5 (cont). Kalamazoo sites.

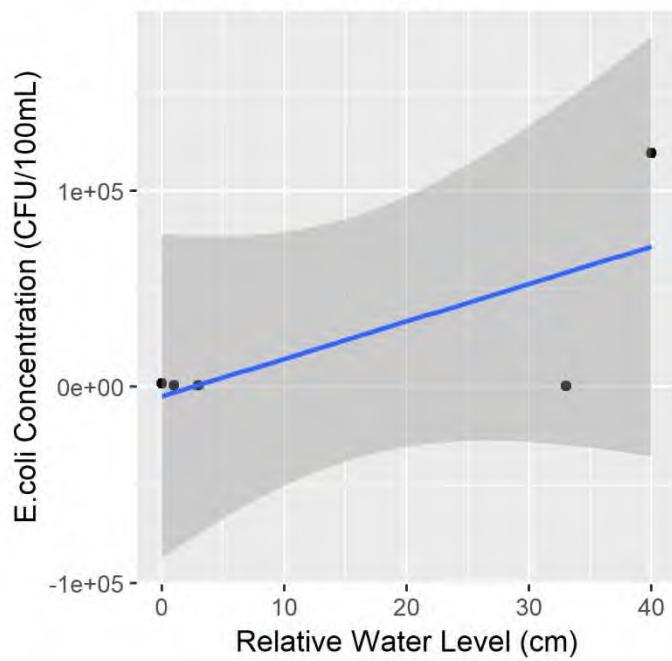
Site ID: 30575  
Rabbit River - 10th St



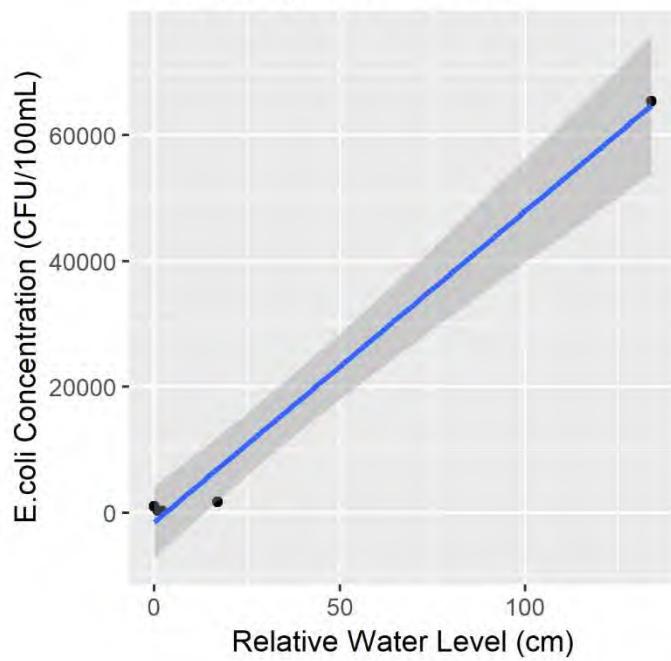
Site ID: 30726  
Miller Creek - 128th Ave



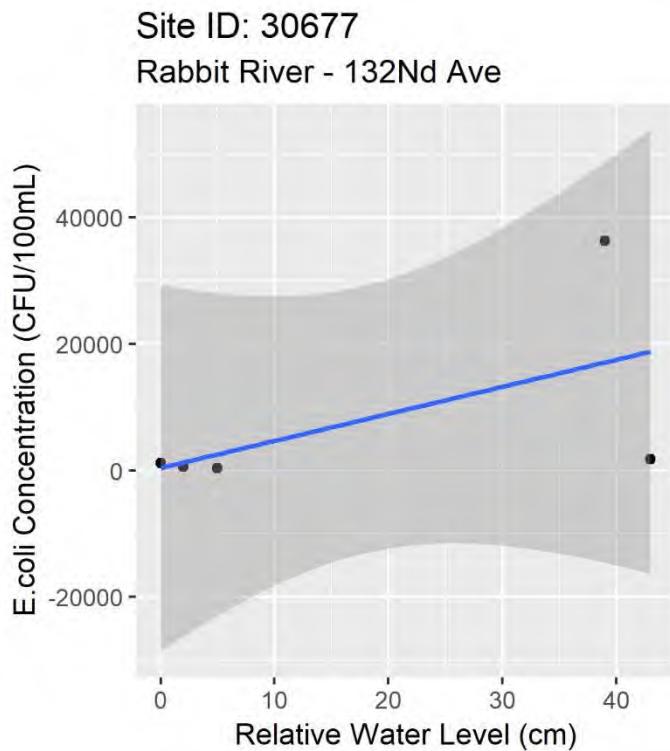
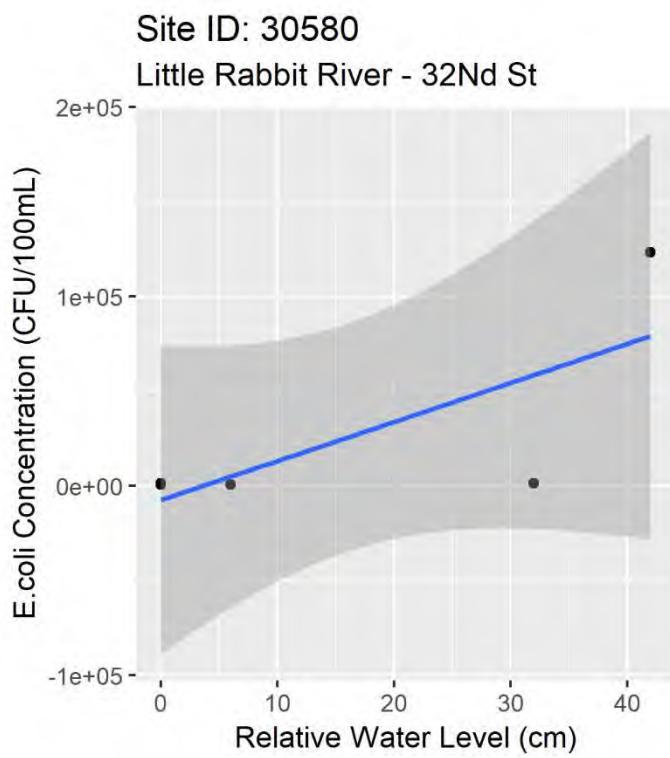
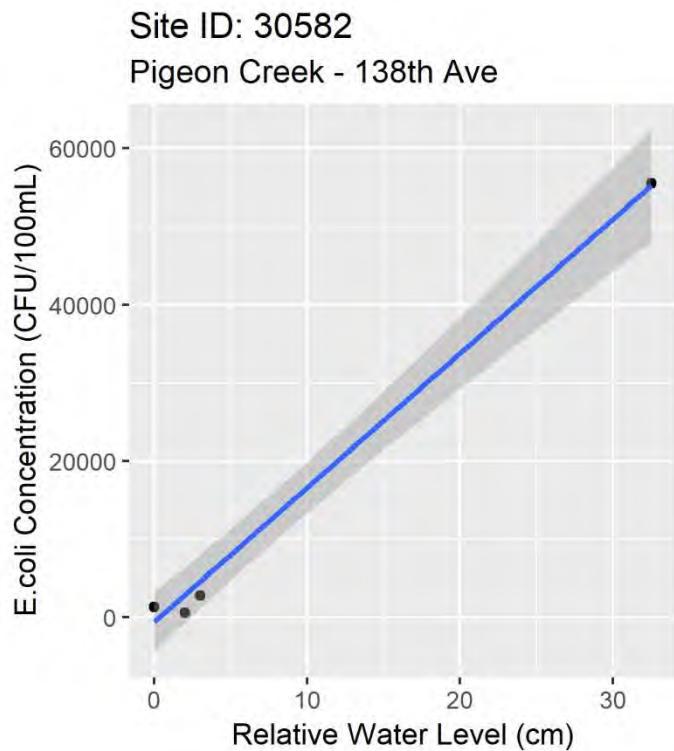
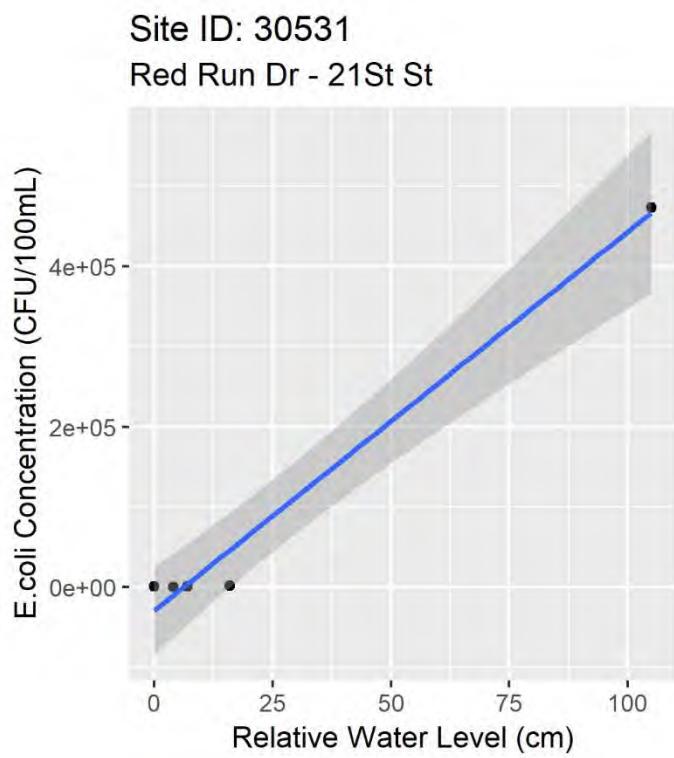
Site ID: 30607  
Bear Creek - 130th Ave



Site ID: 30527  
Dorr And Byron Dr - 21St St

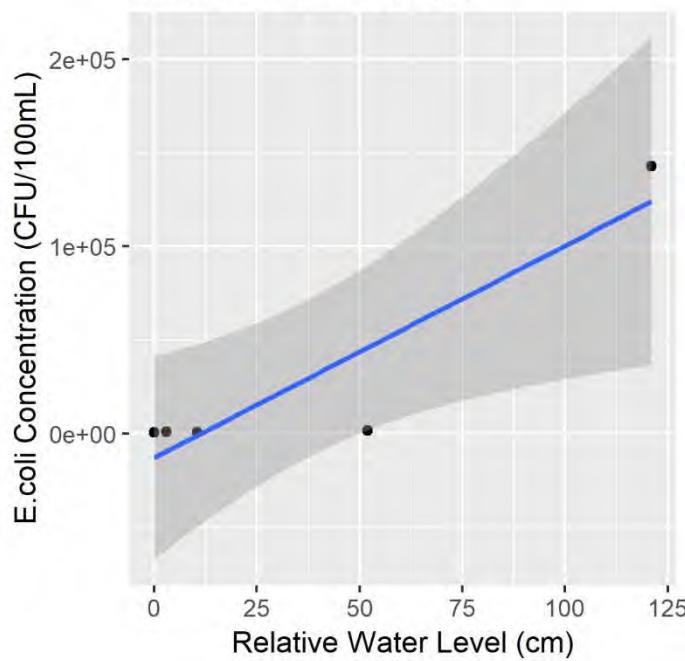


## Appendix 5 (cont). Kalamazoo sites.

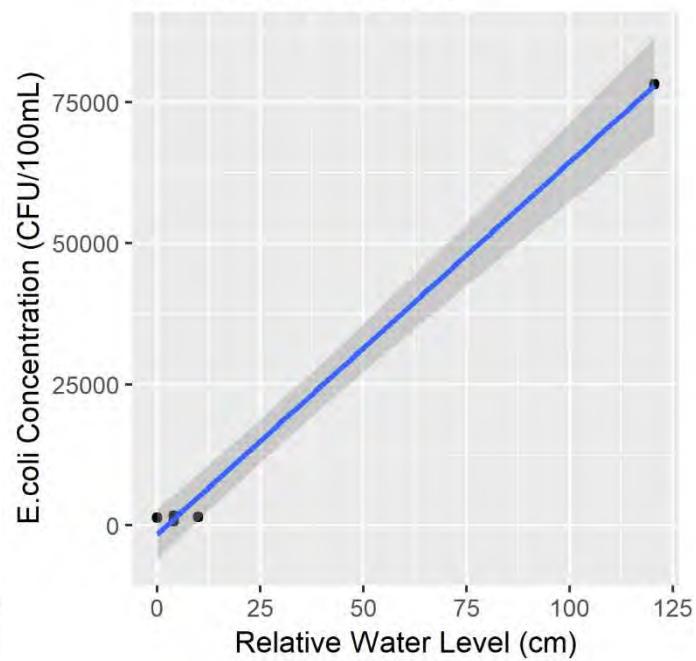


Appendix 5 (cont). Kalamazoo sites.

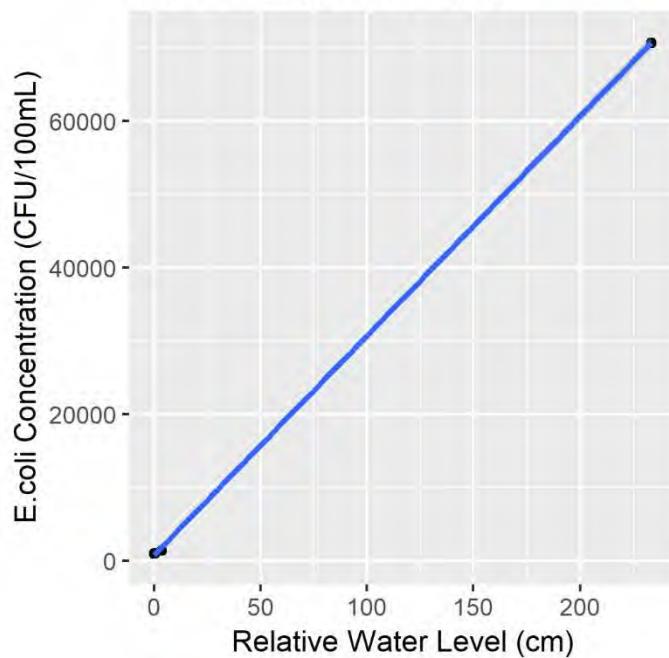
Site ID: 30600  
Black Creek - 139th Ave



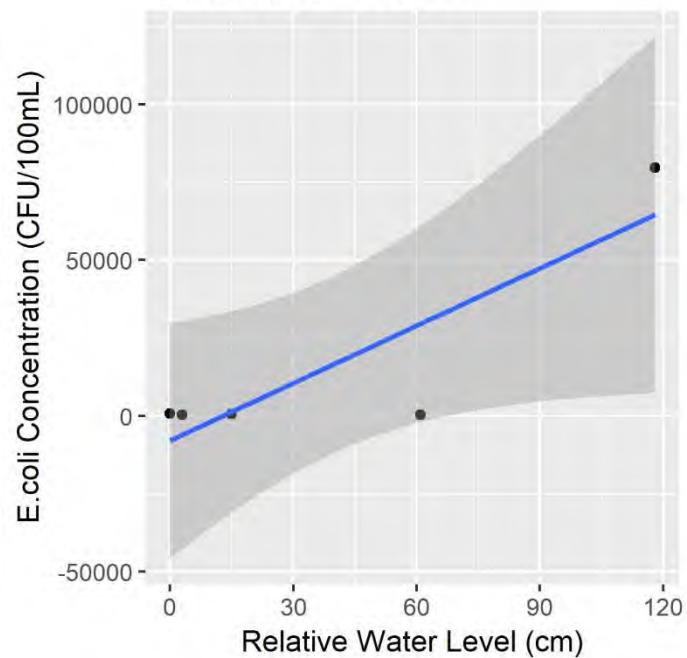
Site ID: 700691  
Black Creek - 32Nd St



Site ID: 700692  
Trib To Black Creek - 40th



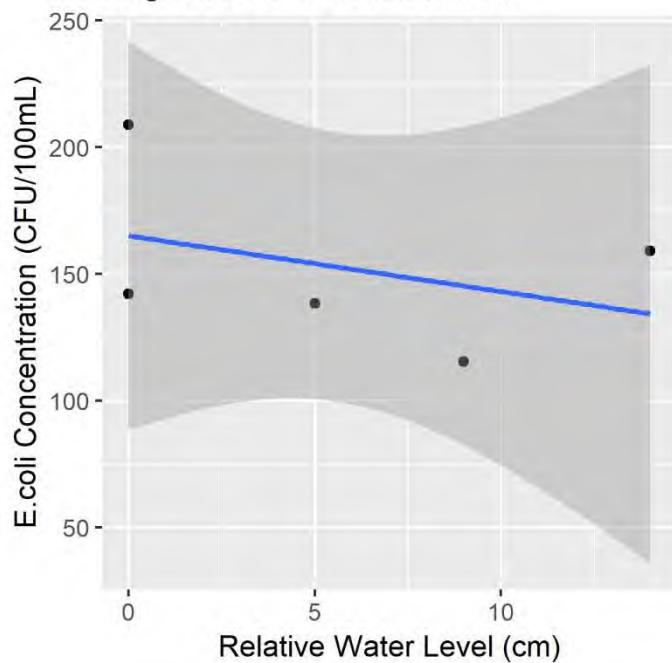
Site ID: 30673  
Rabbit River - 36th St



Appendix 5 (cont). Lower Grand (Rogue) sites.

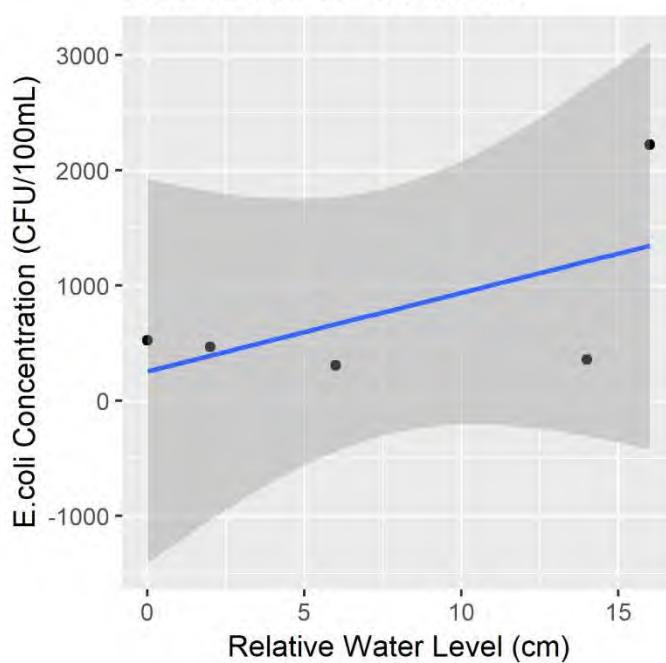
Site ID: 620314

Rogue River - 22 Mile Rd Nw



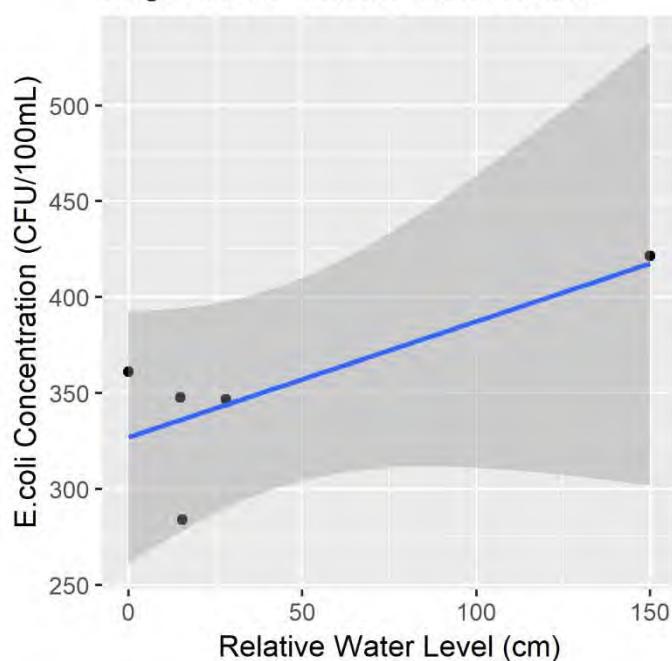
Site ID: 410614

Duke Creek - N Division Ave



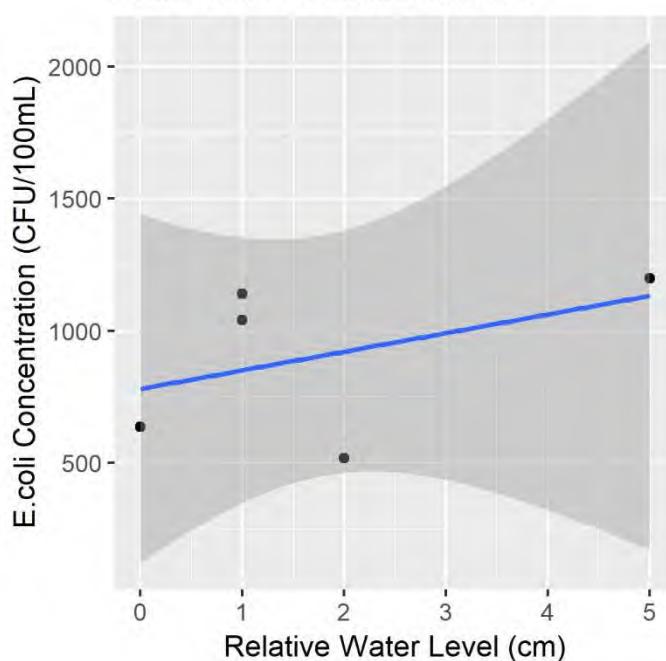
Site ID: 410644

Rogue River - Indian Lakes Rd Nw



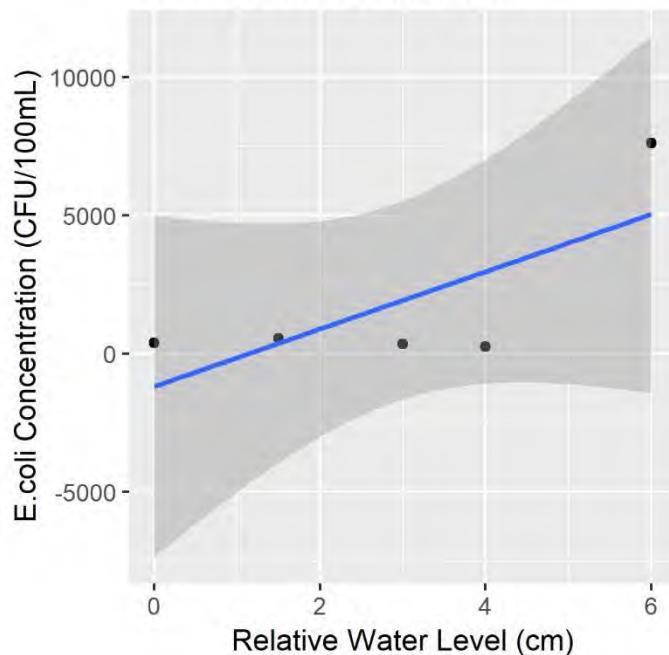
Site ID: 410832

Ball Creek - Stebbins Ave Nw

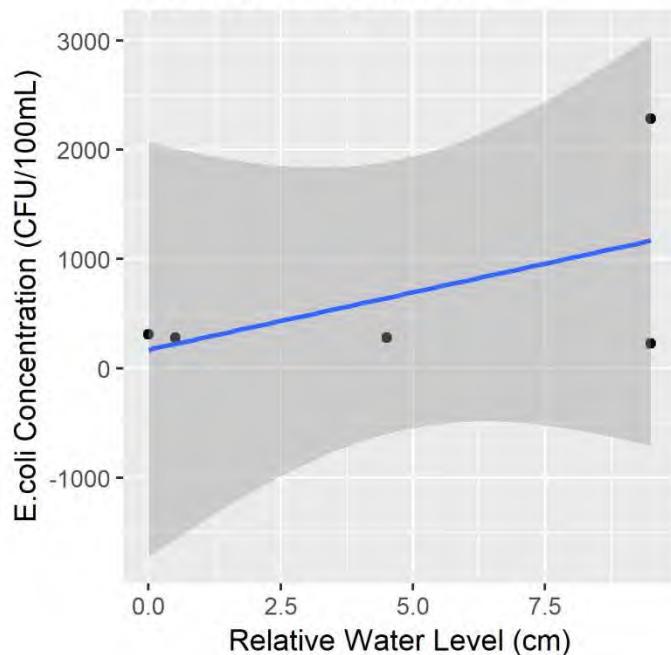


Appendix 5 (cont). Lower Grand (Rogue) sites.

Site ID: 410615  
Cedar Creek - Friske Dr Ne

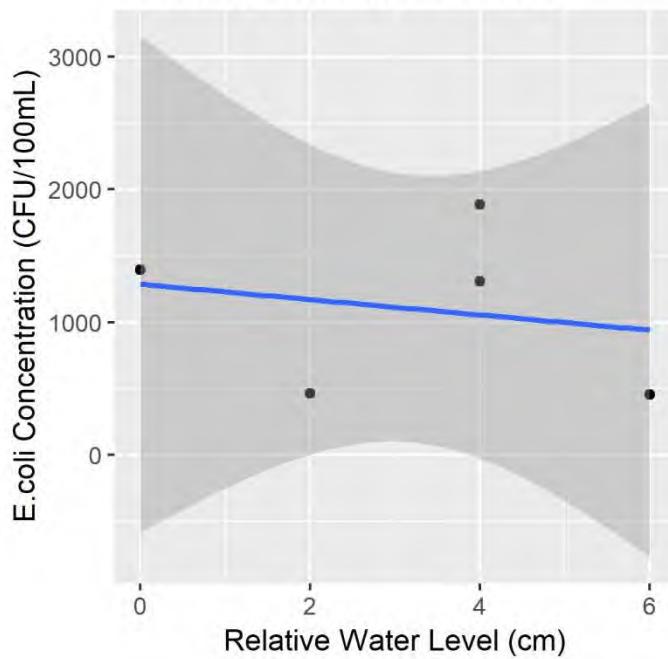


Site ID: 410415  
Rogue River - 12 Mile Rd

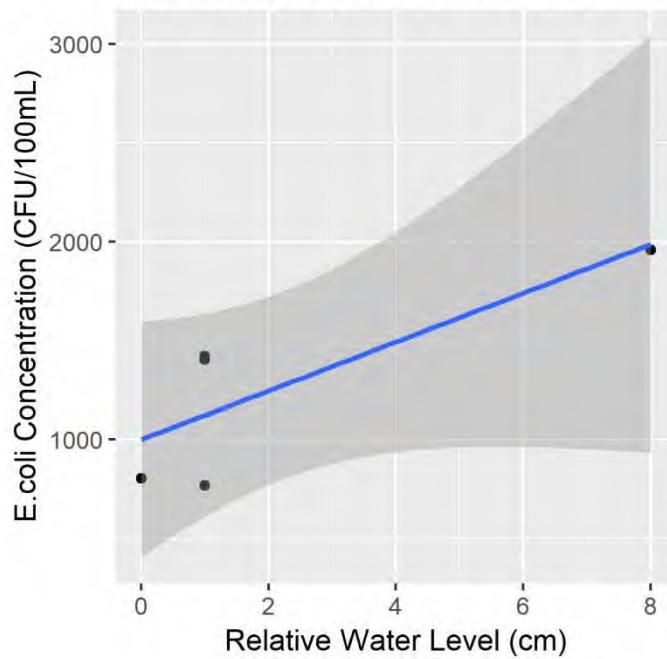


Appendix 5 (cont). Thornapple sites.

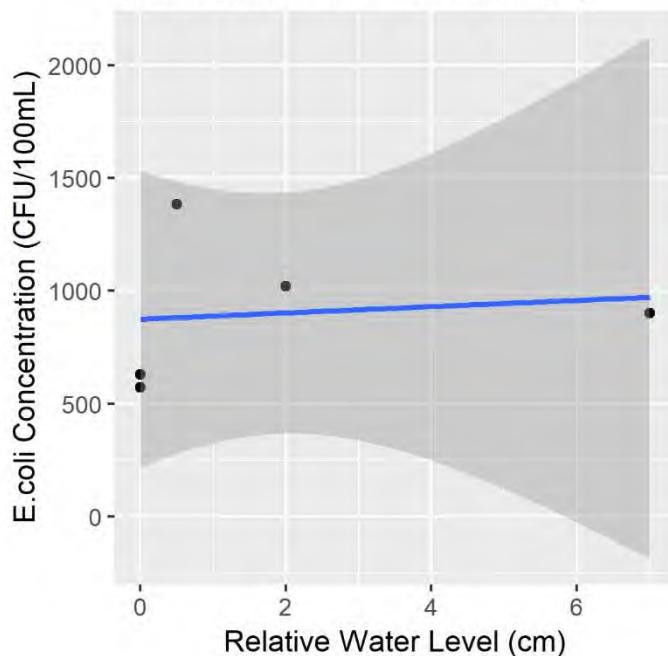
Site ID: 230207  
Butternut Creek - Mcconnel Rd



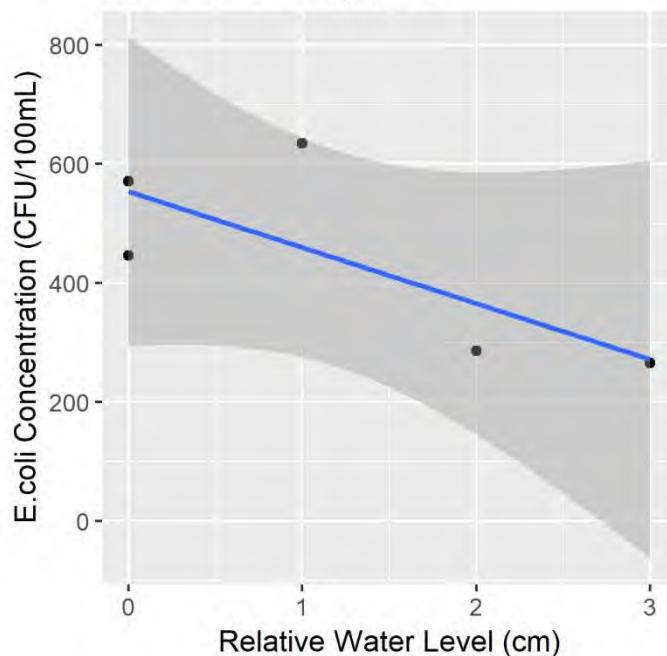
Site ID: 230242  
Thornapple River - N Stewart Rd



Site ID: 230196  
Thornapple River - Gresham Hwy



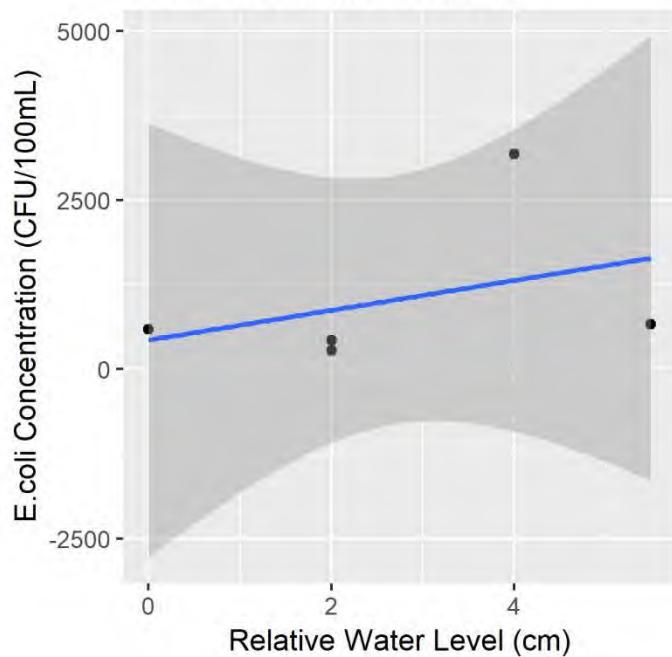
Site ID: 80211  
Mud Creek - Barger Rd



Appendix 5 (cont). Thornapple sites.

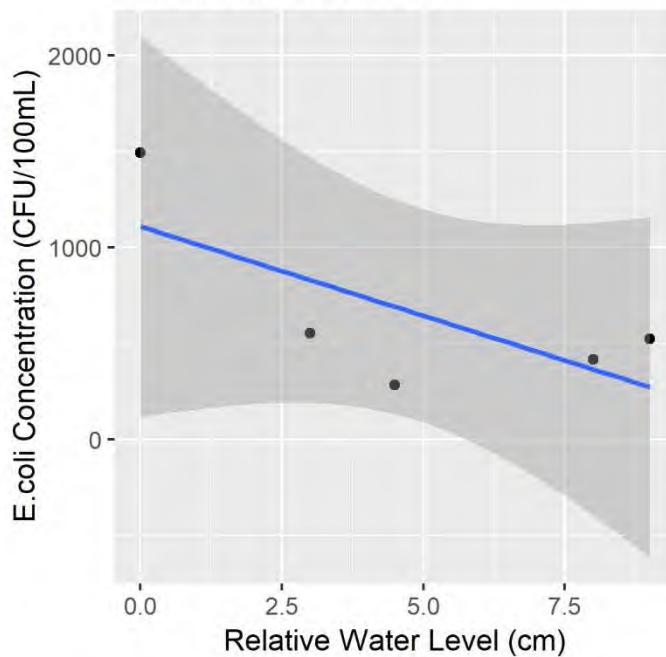
Site ID: 80223

Cedar Creek - McKeown Rd



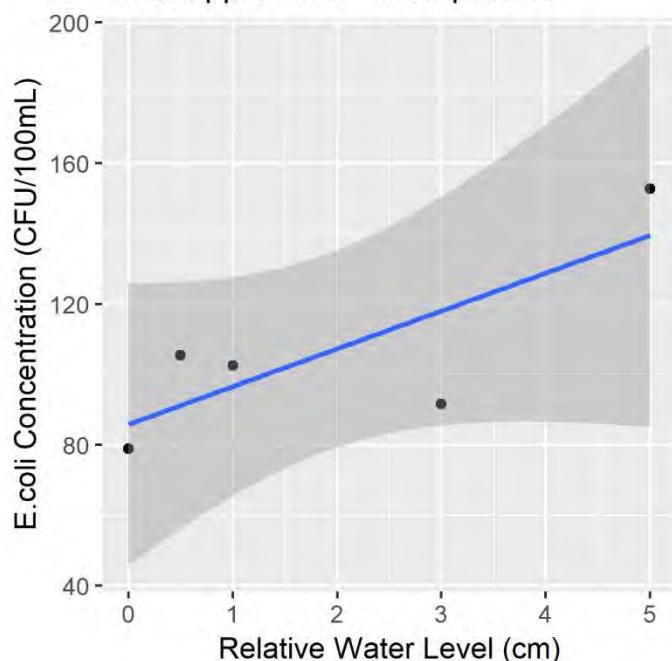
Site ID: 80270

Fall Creek - Shriner St



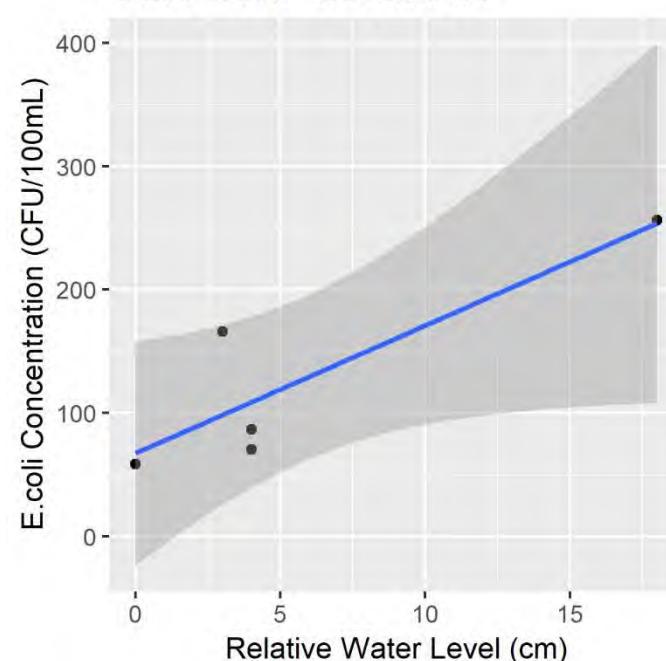
Site ID: 80023

Thornapple River - N Airport Rd



Site ID: 80230

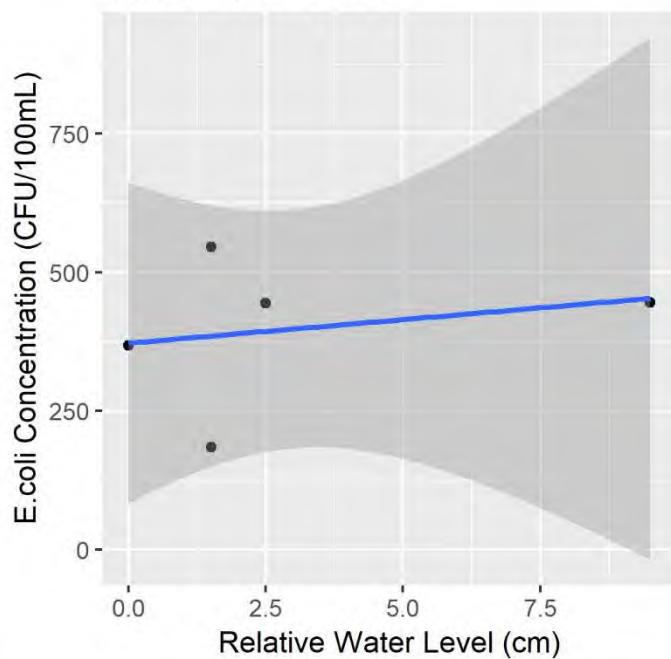
Glass Creek - Goodwill Rd



Appendix 5 (cont). Thornapple sites.

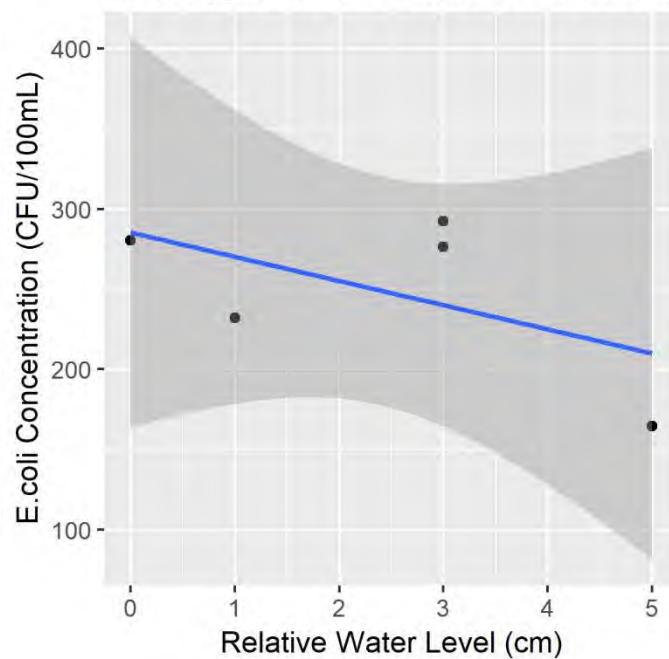
Site ID: 80278

Glass Creek - N M 37



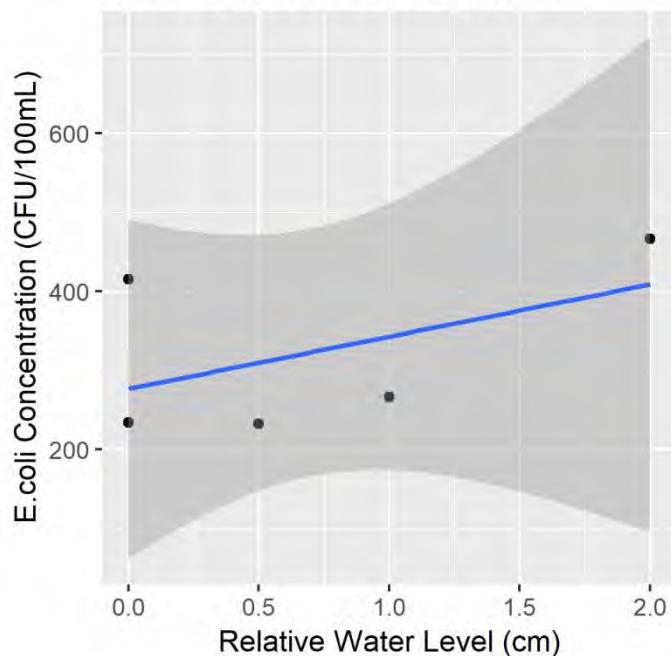
Site ID: 80305

Thornapple River - E Main St - Middleville



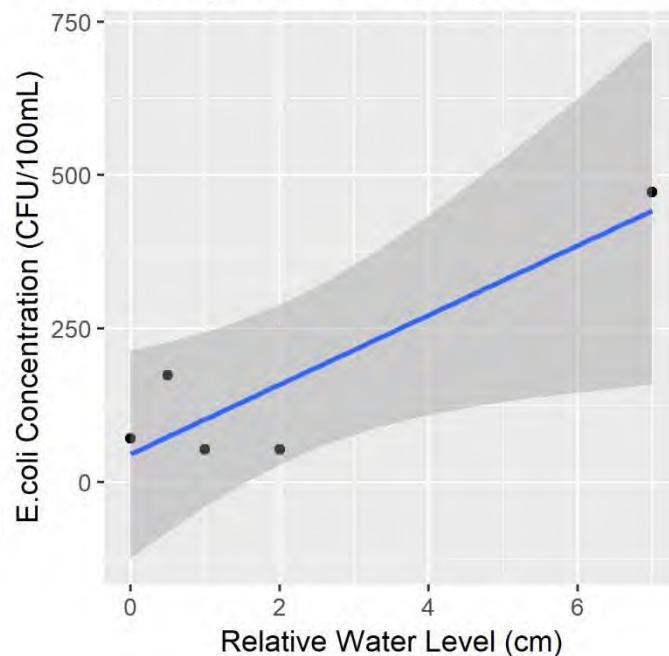
Site ID: 410649

Mccords Creek - Buttrick Ave Se



Site ID: 410735

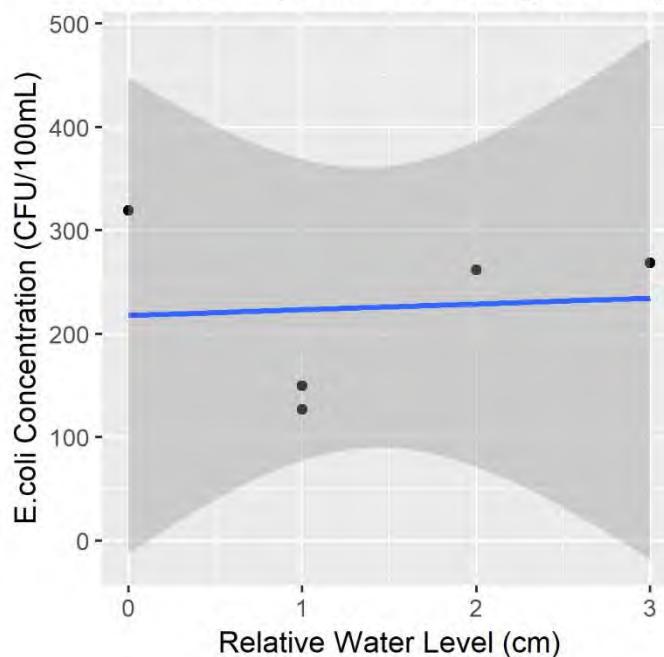
Thornapple River - 68th St Se



Appendix 5 (cont). Betsie-Platte sites.

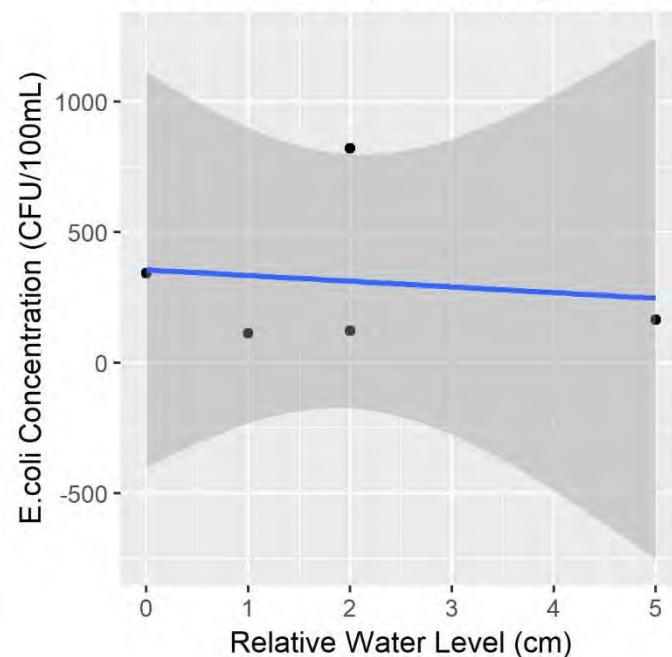
**Site ID: 100226**

Cold Creek (S Br) - D/S Michigan Ave (Sc)



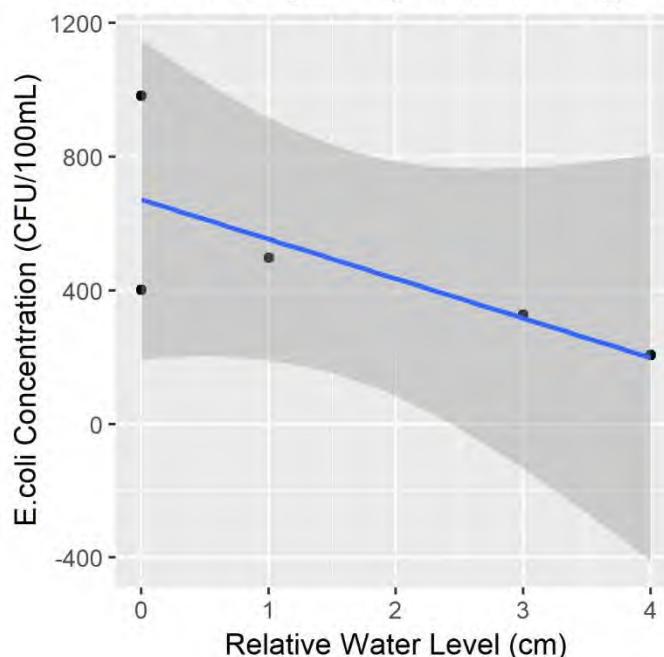
**Site ID: 100261**

Cold Creek (N Br) - Off Michigan Ave (N)



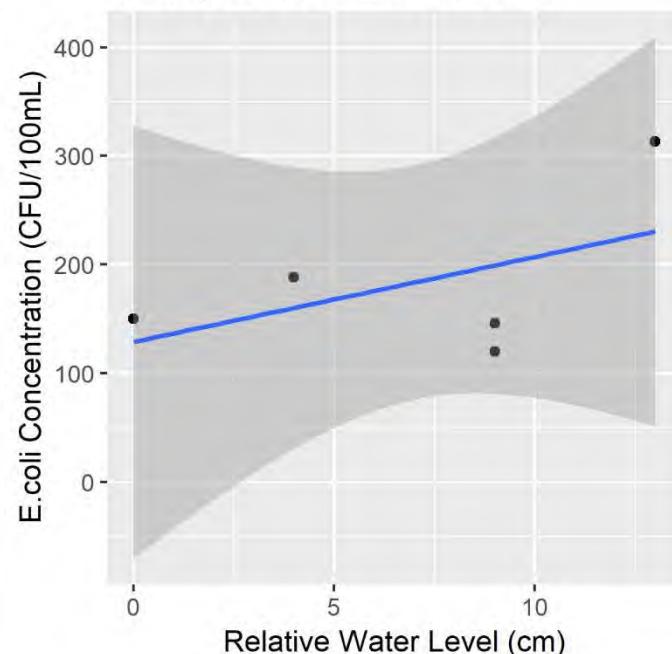
**Site ID: 100262**

Cold Creek (Mid Br) - Narrow Gauge Rd



**Site ID: 440260**

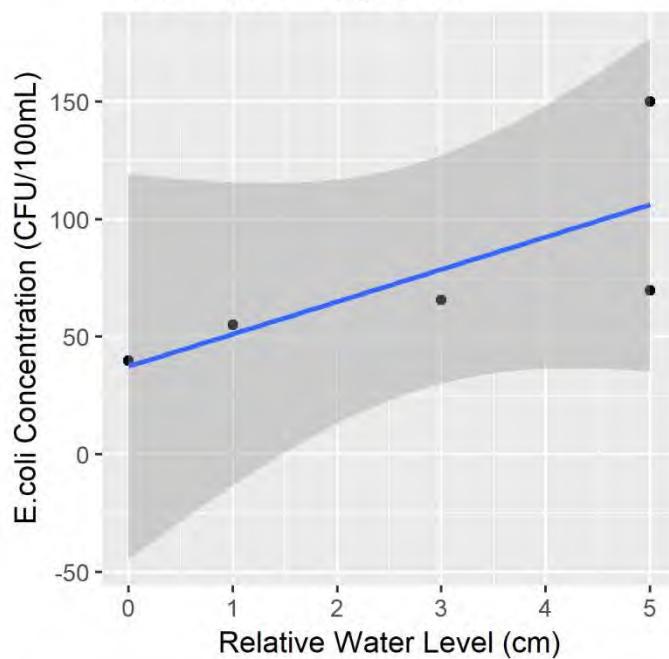
Richley Creek - Saint Pierre Rd



Appendix 5 (cont). Boardman-Charlevoix sites.

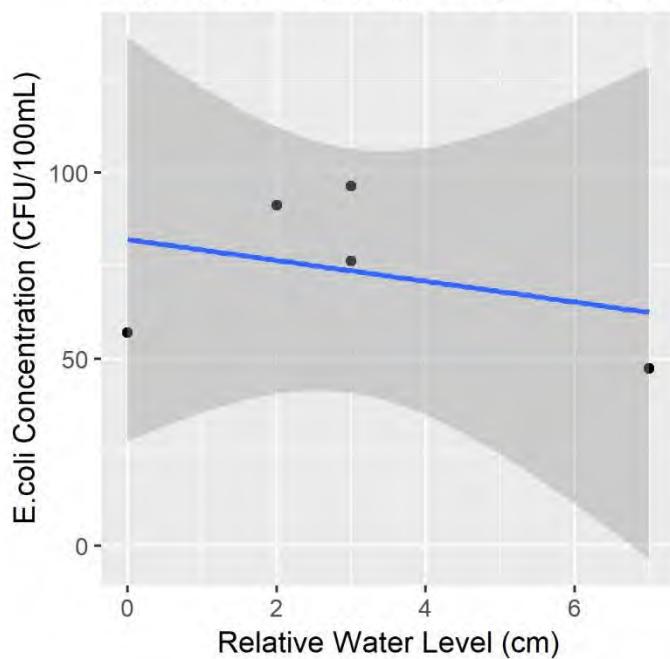
Site ID: 150010

Jordan River - Rogers Rd



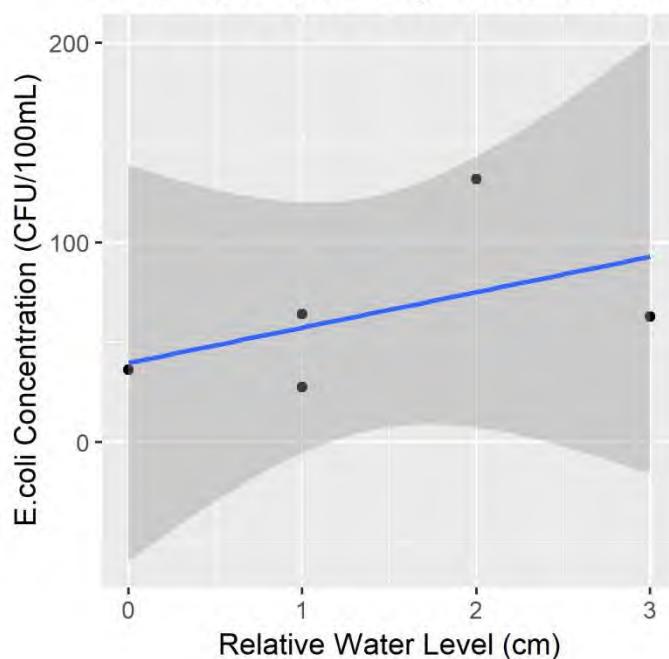
Site ID: 150052

Boyne River - Lake Rd Bridge - Boyne C



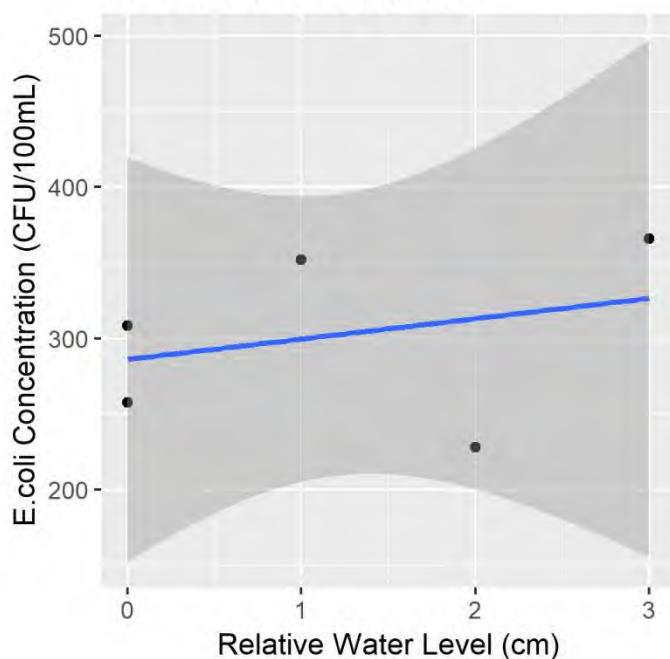
Site ID: 150187

S Br Boyne River - Boyne Mountain Rd



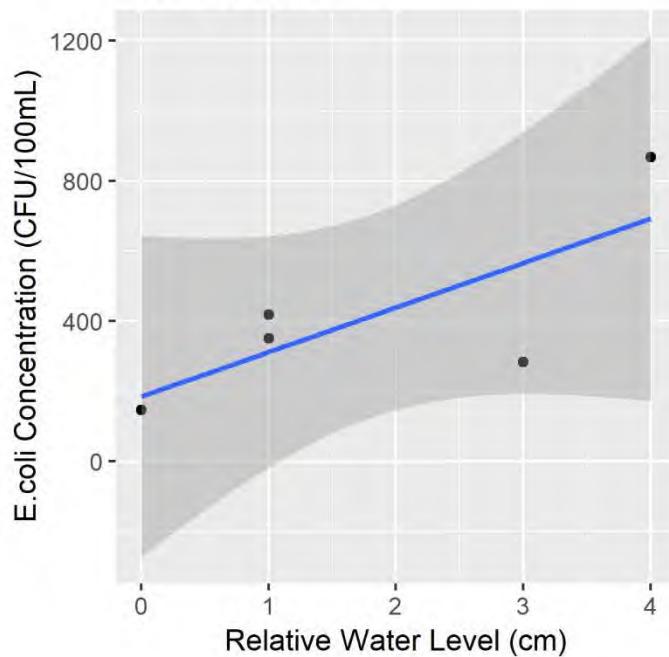
Site ID: 150104

Strover Creek - Ferry Ave

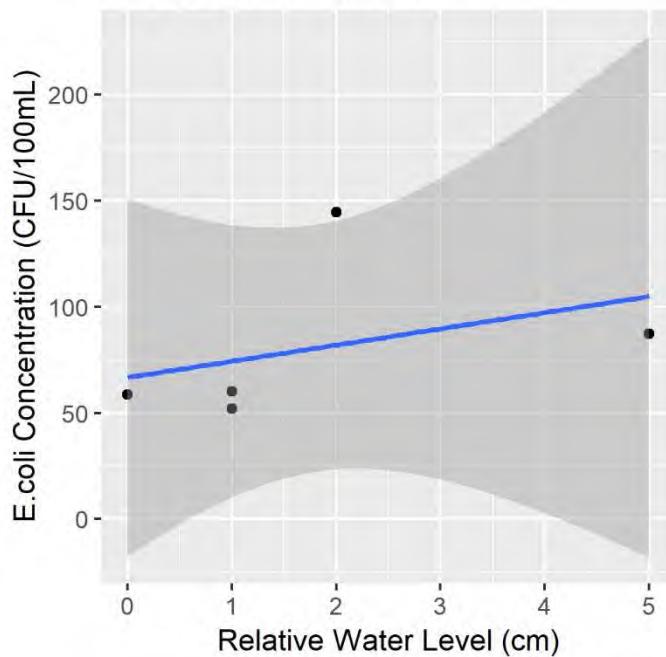


Appendix 5 (cont). Boardman-Charlevoix sites.

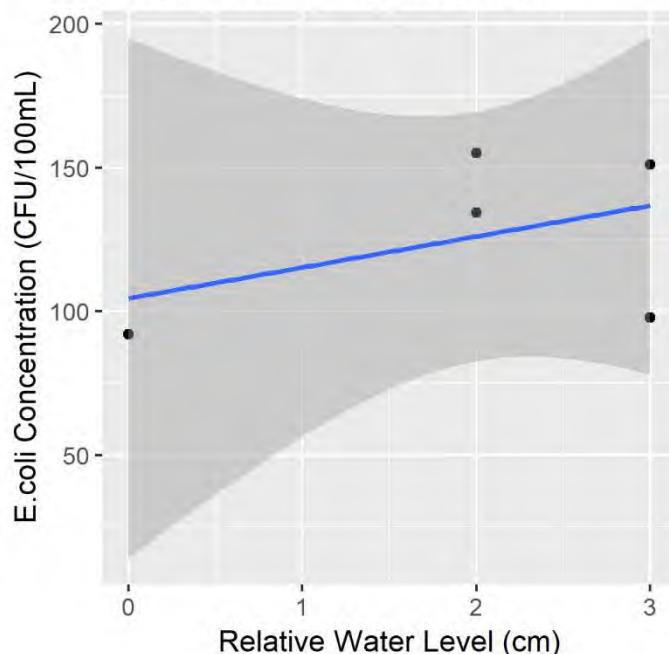
Site ID: 150105  
Loeb Creek - M 66



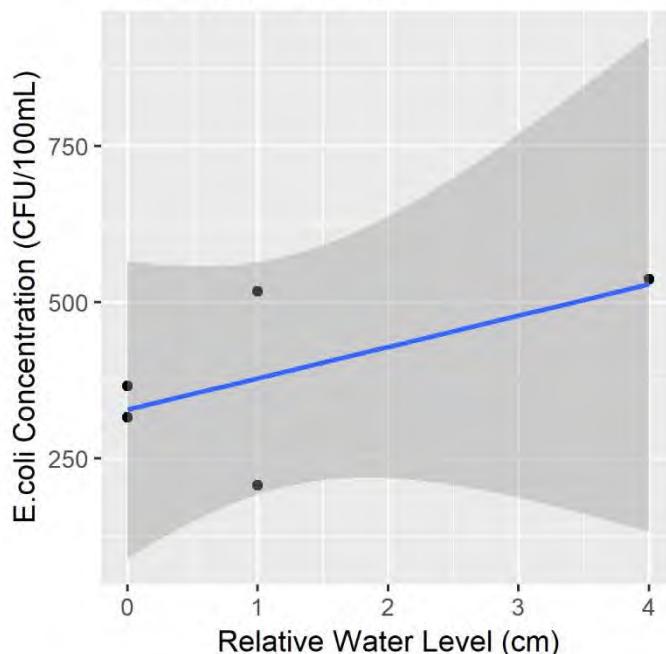
Site ID: 150248  
Horton Creek - Mouth



Site ID: 150252  
Porter Creek - Lake Shore Rd



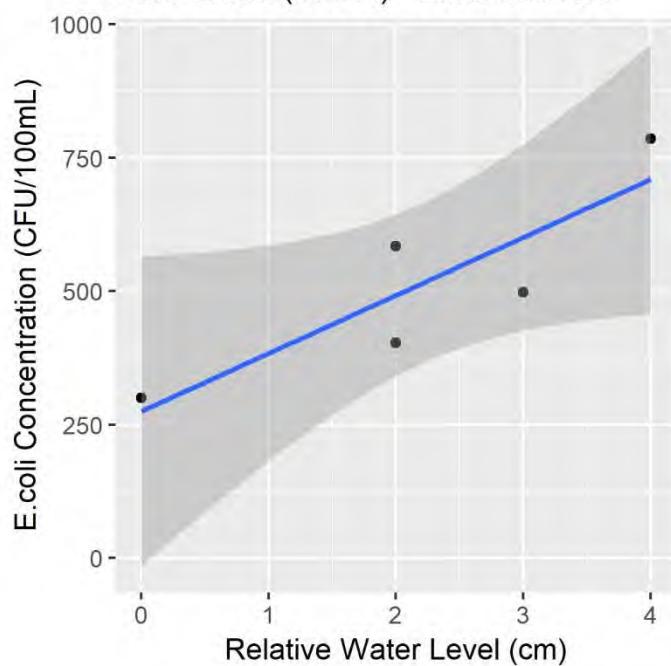
Site ID: 280316  
Kids Creek - 11th St



Appendix 5 (cont). Boardman-Charlevoix sites.

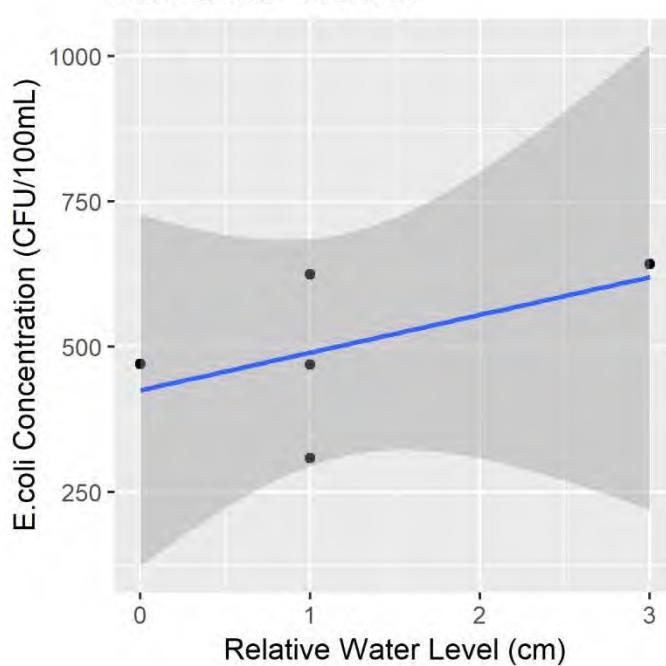
Site ID: 280418

Kids Creek (Trib A) - Elmwood Ave



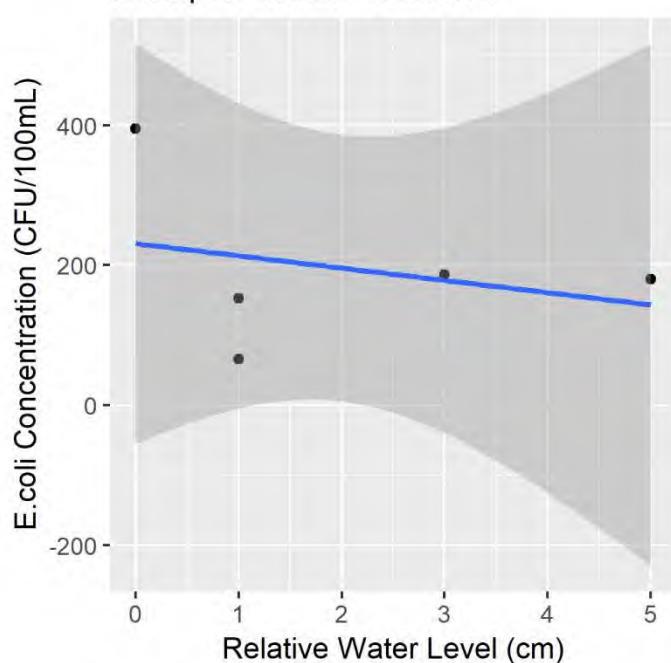
Site ID: 280426

Kids Creek - Front St



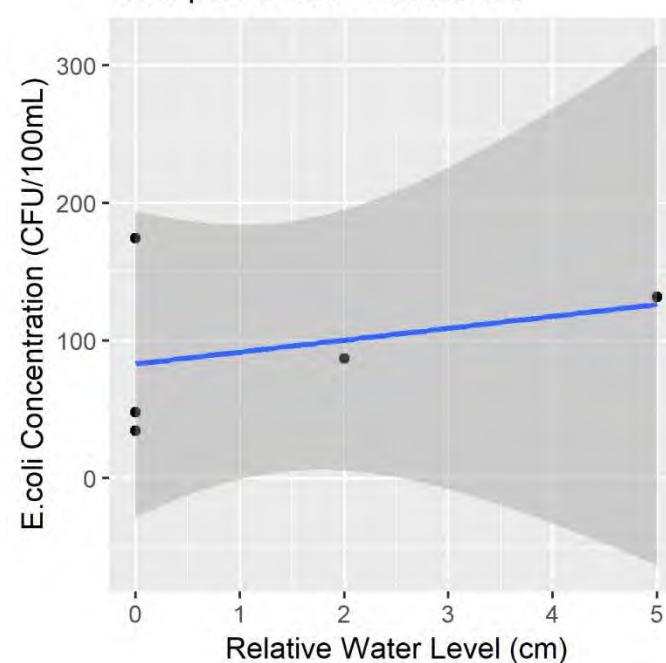
Site ID: 450140

Northport Creek - Rose Rd



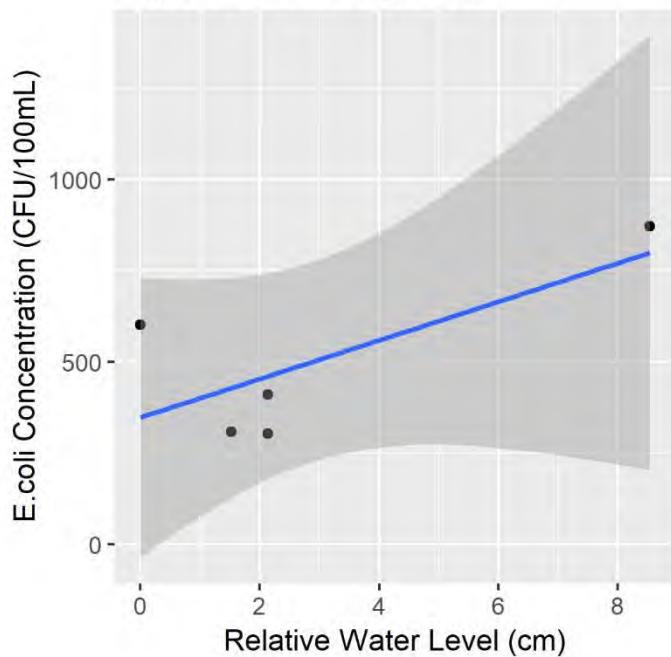
Site ID: 450155

Northport Creek - Melkild/3rd

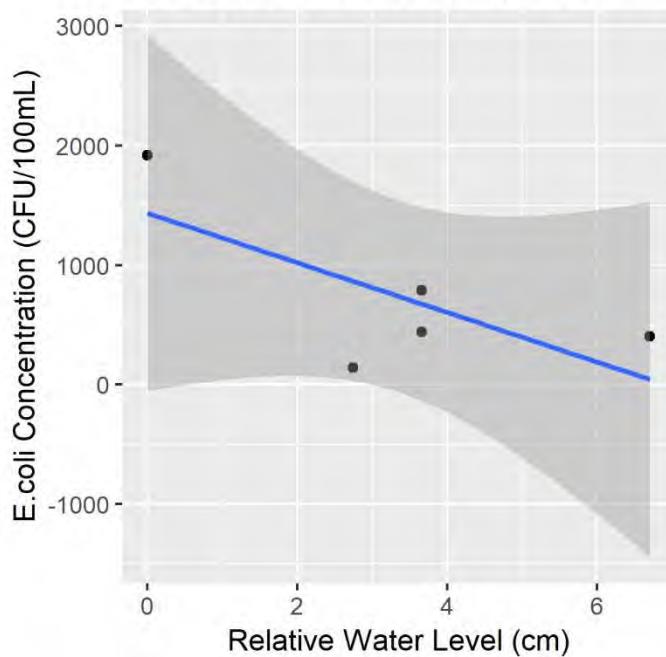


Appendix 5 (cont). Birch-Willow and Pigeon-Wiscoggan sites.

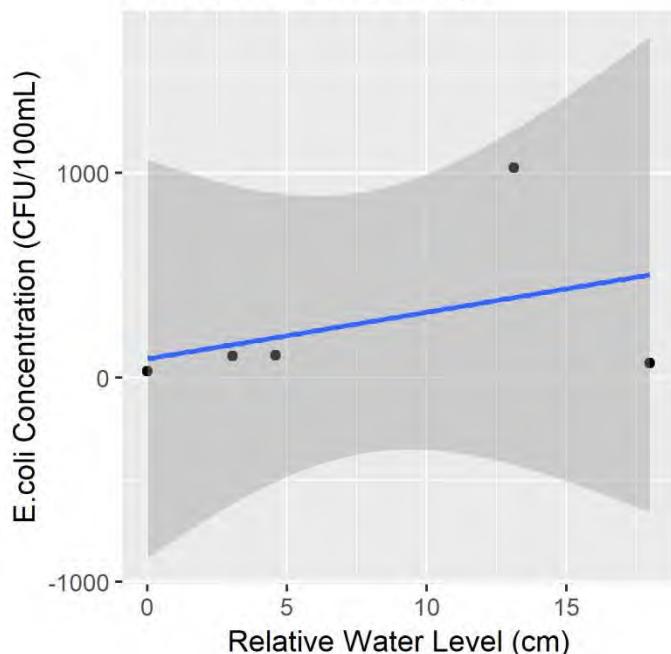
Site ID: 320316  
Pigeon River - Geiger Rd.



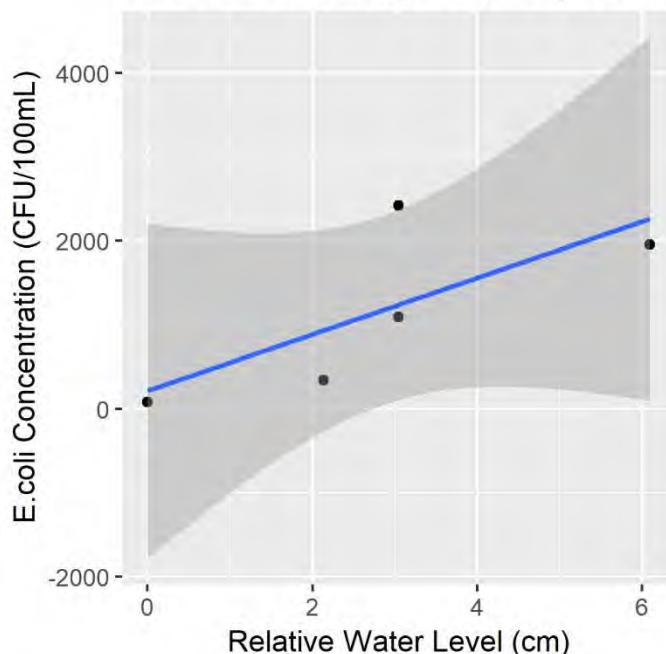
Site ID: 320362  
Bird Creek - Knoblock/Hunter Rd



Site ID: 320335  
New River - Stoddard Rd



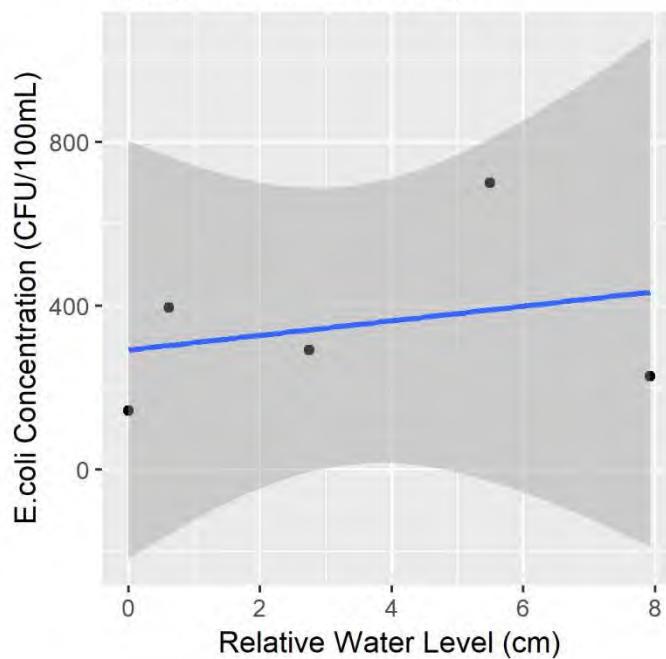
Site ID: 320279  
East Branch Willow Creek - Upstream I



Appendix 5 (cont). Birch-Willow and Pigeon-Wiscoggan sites.

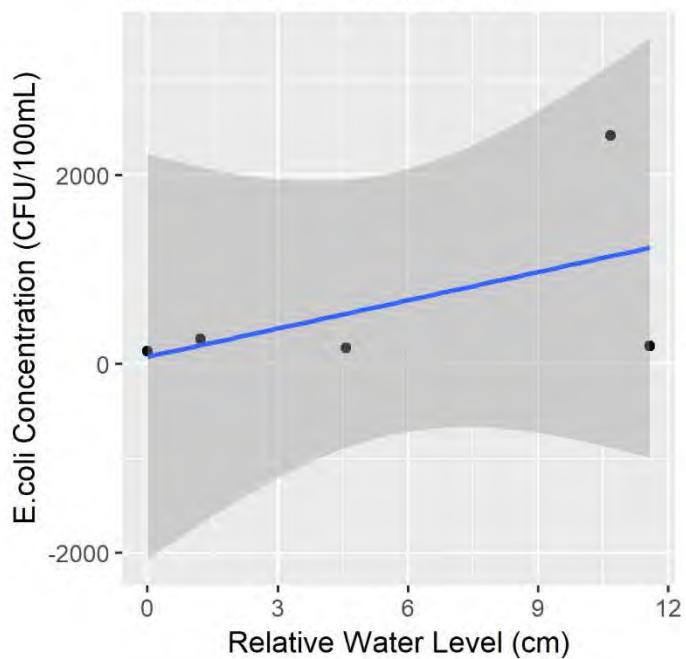
Site ID: 320240

Willow Creek - Dobson Rd



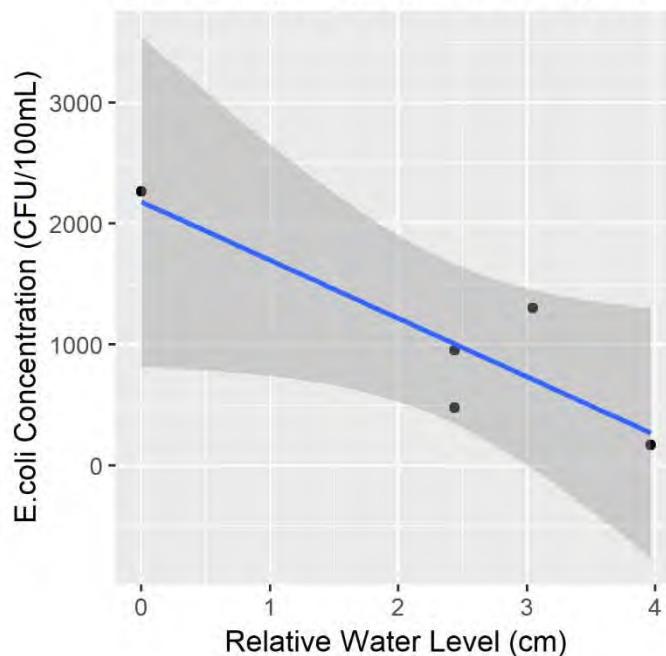
Site ID: 320324

Willow Creek - Stoddard Rd



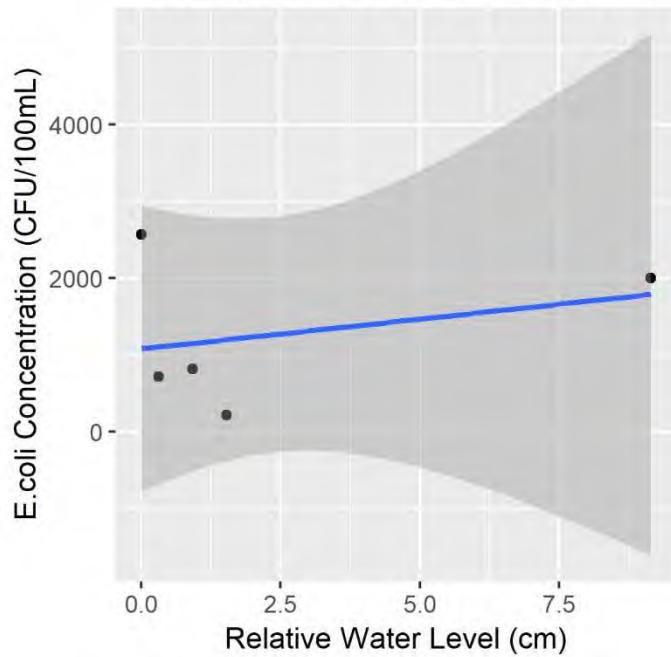
Site ID: 320358

Trib To Willow Creek - Huron City Rd

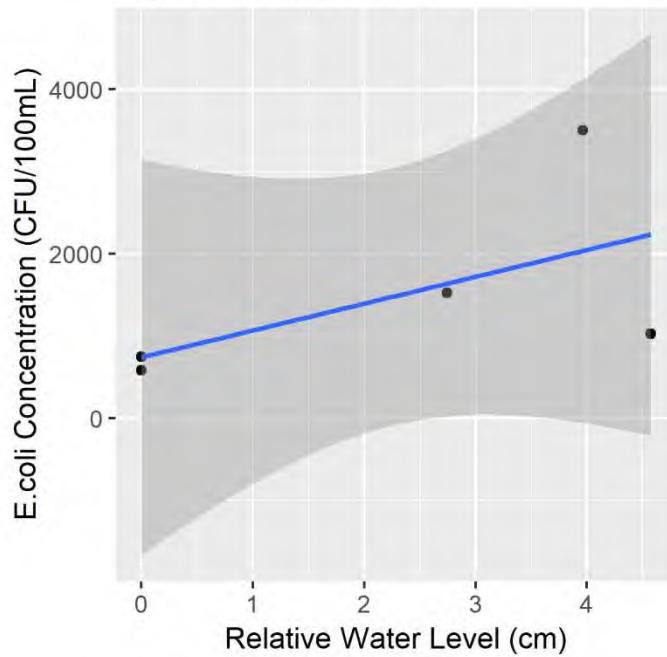


Appendix 5 (cont). Flint sites.

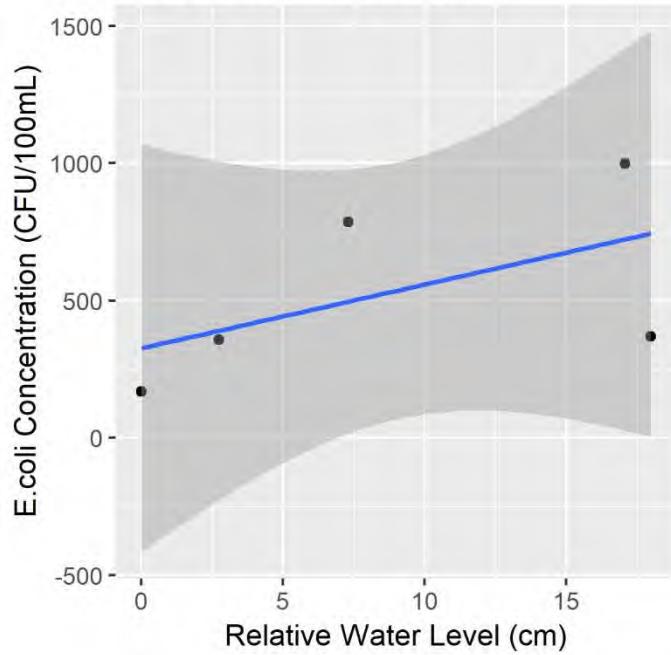
Site ID: 250402  
W Branch Swartz Creek - Linden Rd



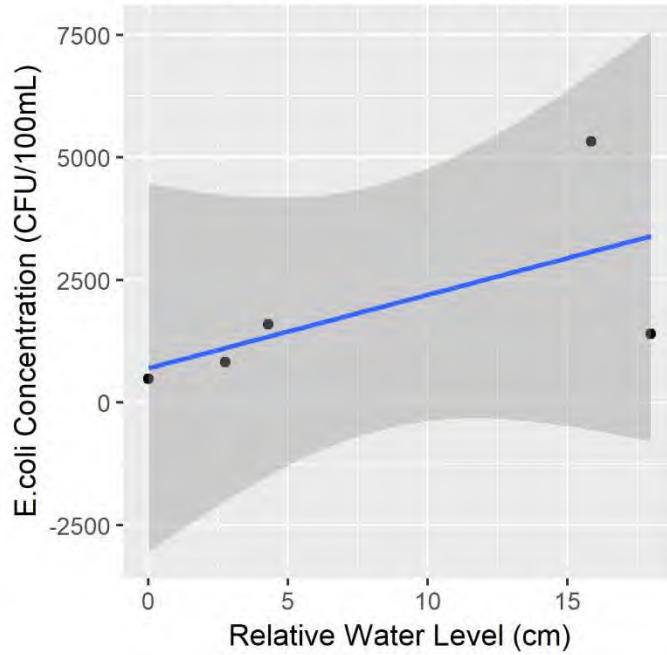
Site ID: 250460  
Indian Creek - Cook Rd



Site ID: 250551  
Swartz Creek - Maple Rd

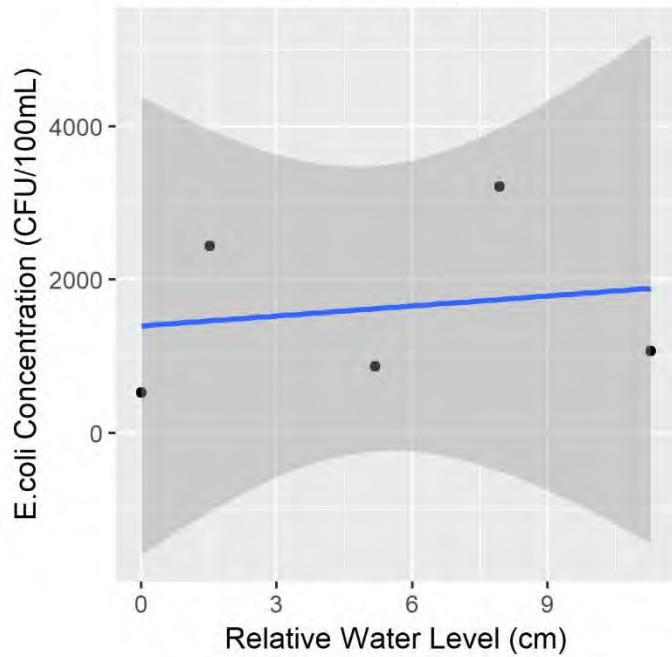


Site ID: 250335  
Swartz Creek - Hammerberg Rd

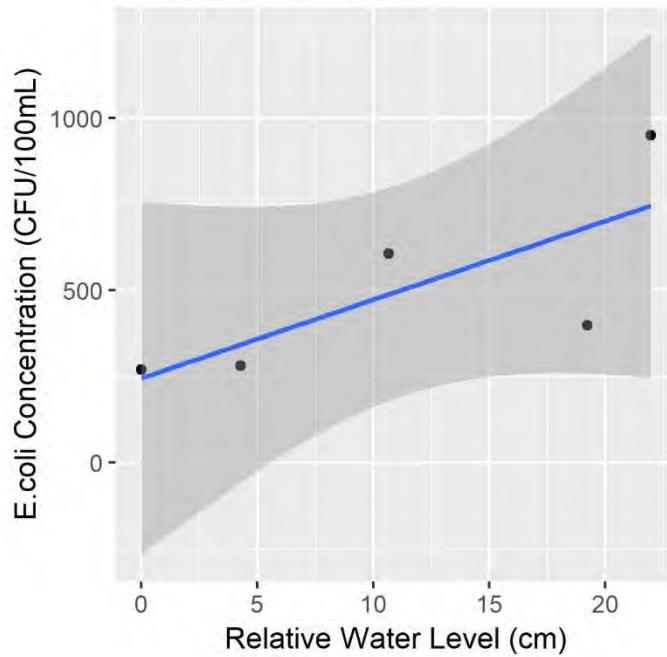


Appendix 5 (cont). Flint sites.

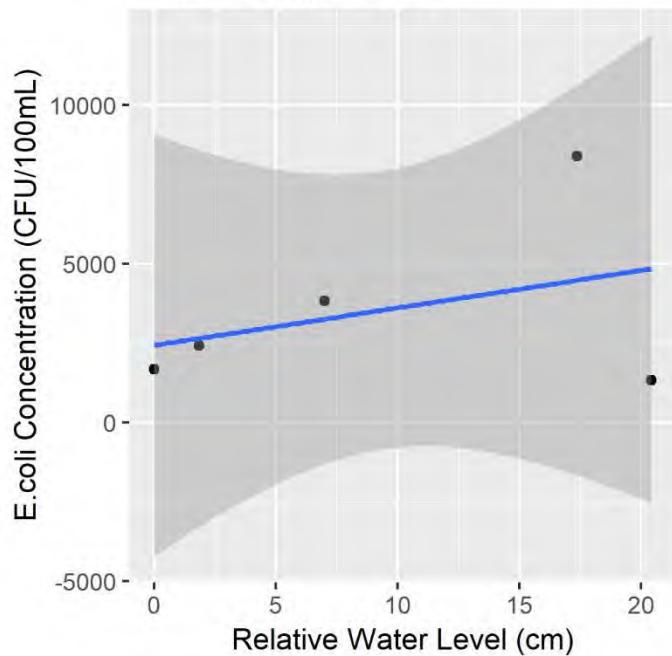
Site ID: 250343  
Thread Creek - Dort Hwy



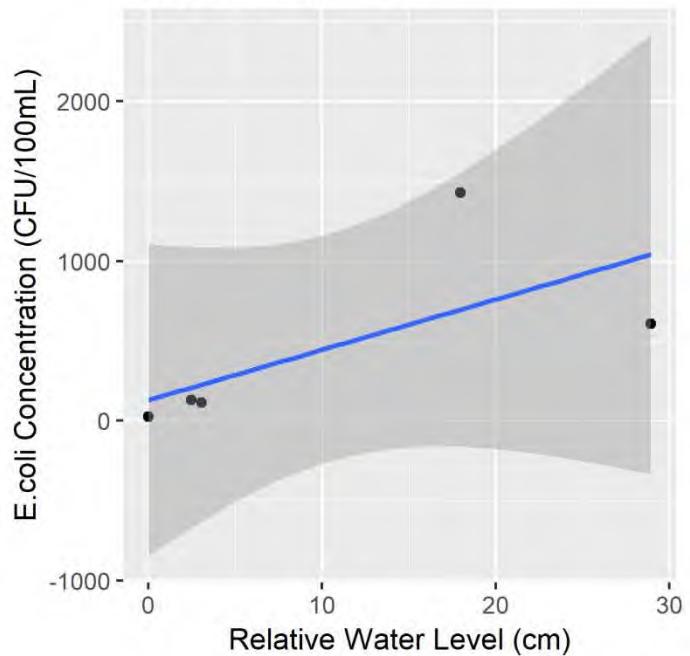
Site ID: 250550  
Thread Creek - Perry Rd



Site ID: 250339  
Carman Drain - 12th St



Site ID: 250103  
Flint River - Main St



Appendix 5 (cont). Flint sites.

Site ID: 250549  
Cole Creek - Seymour Rd (North)

