Appendix E

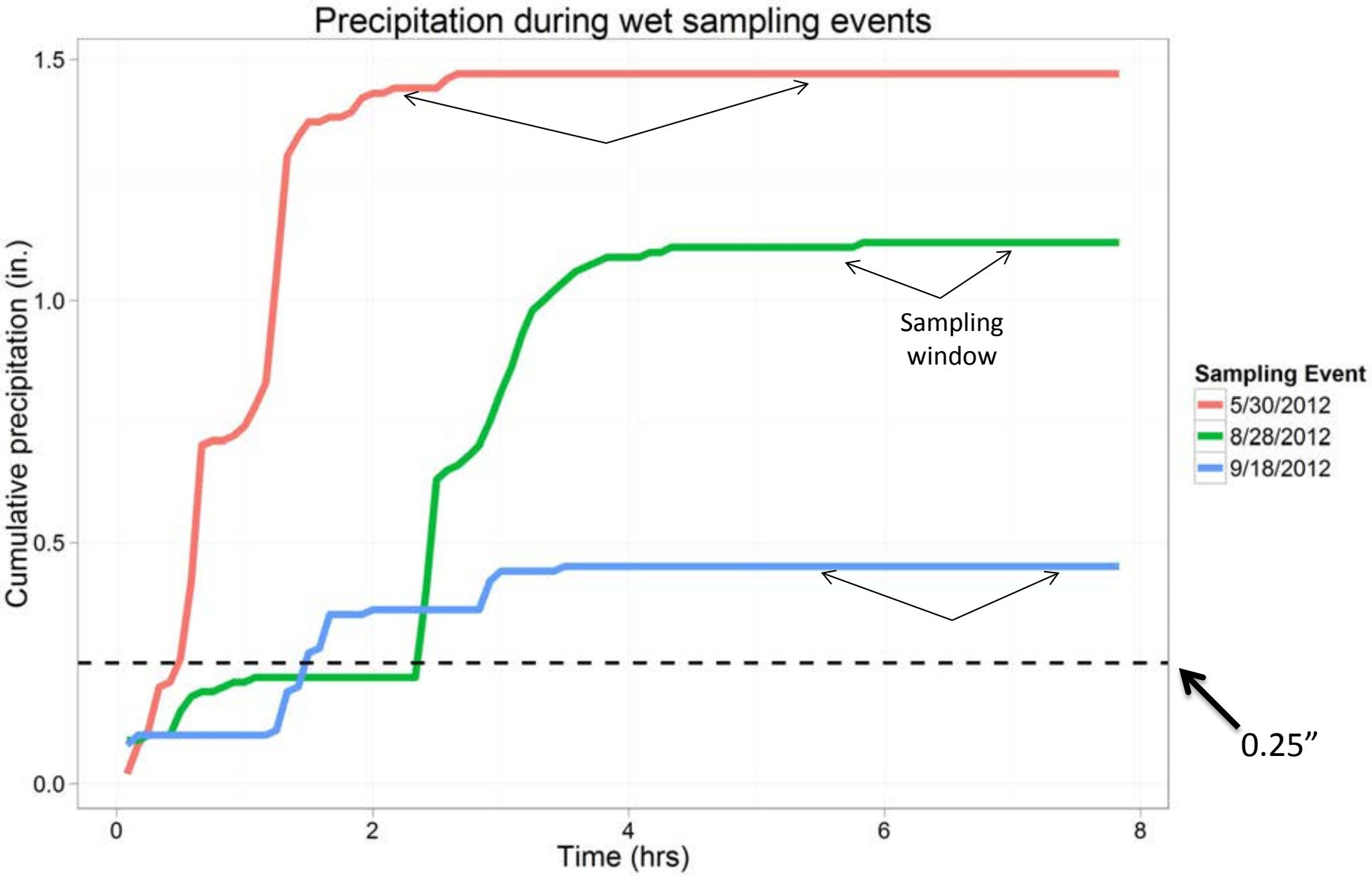
Additional Graphs

Note about Appendix E

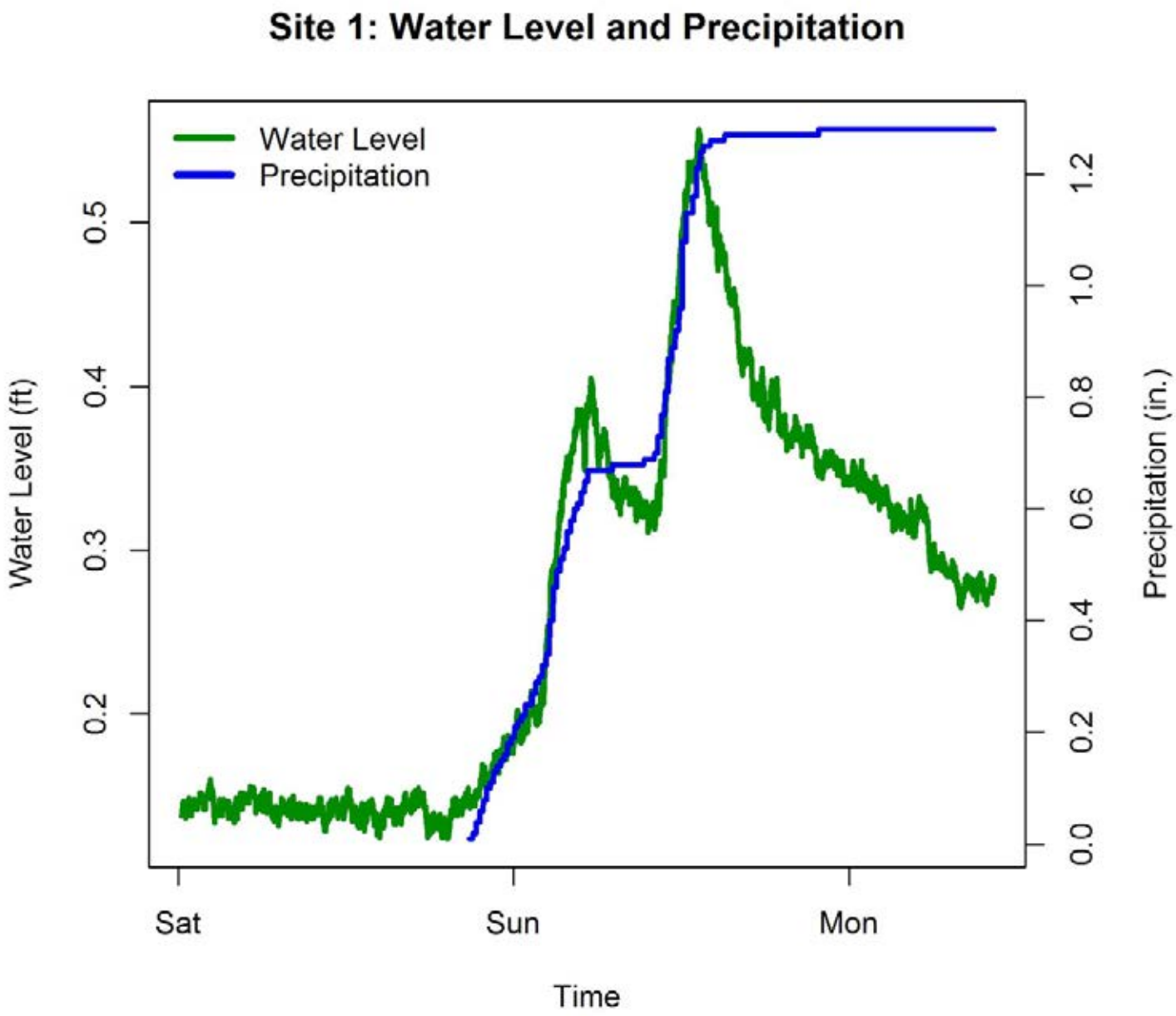
This appendix (E) servers as a reference containing graphs and tables used to interpret results for all parameters measured as part of the Withers Swash pilot MST project. Select graphs and tables contained here are shown in section 3 of the main project report and Appendix D. Discussion and further explanations about these figures and associated data are contained in section 3 and Appendix D.

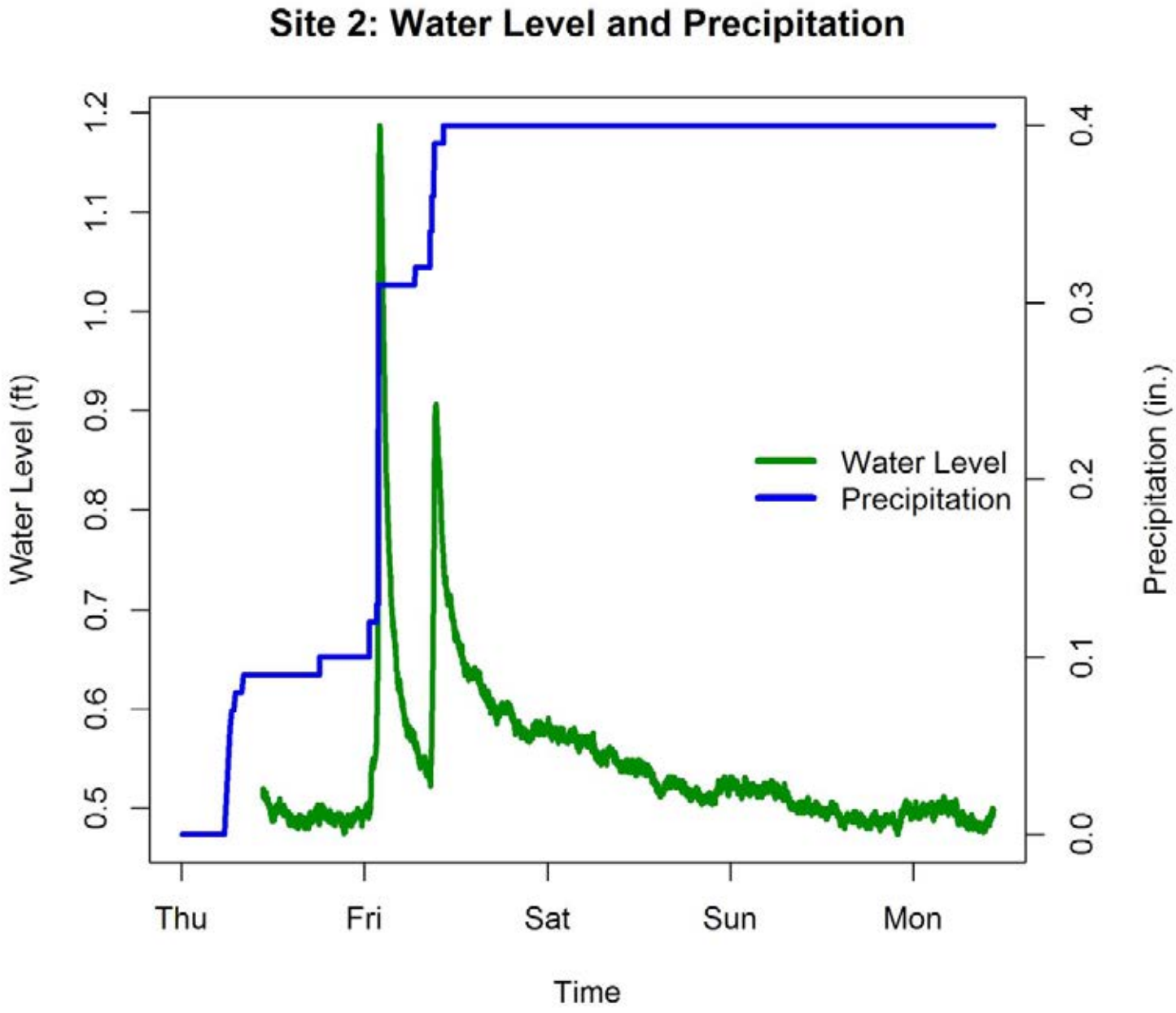
Figure Inventory

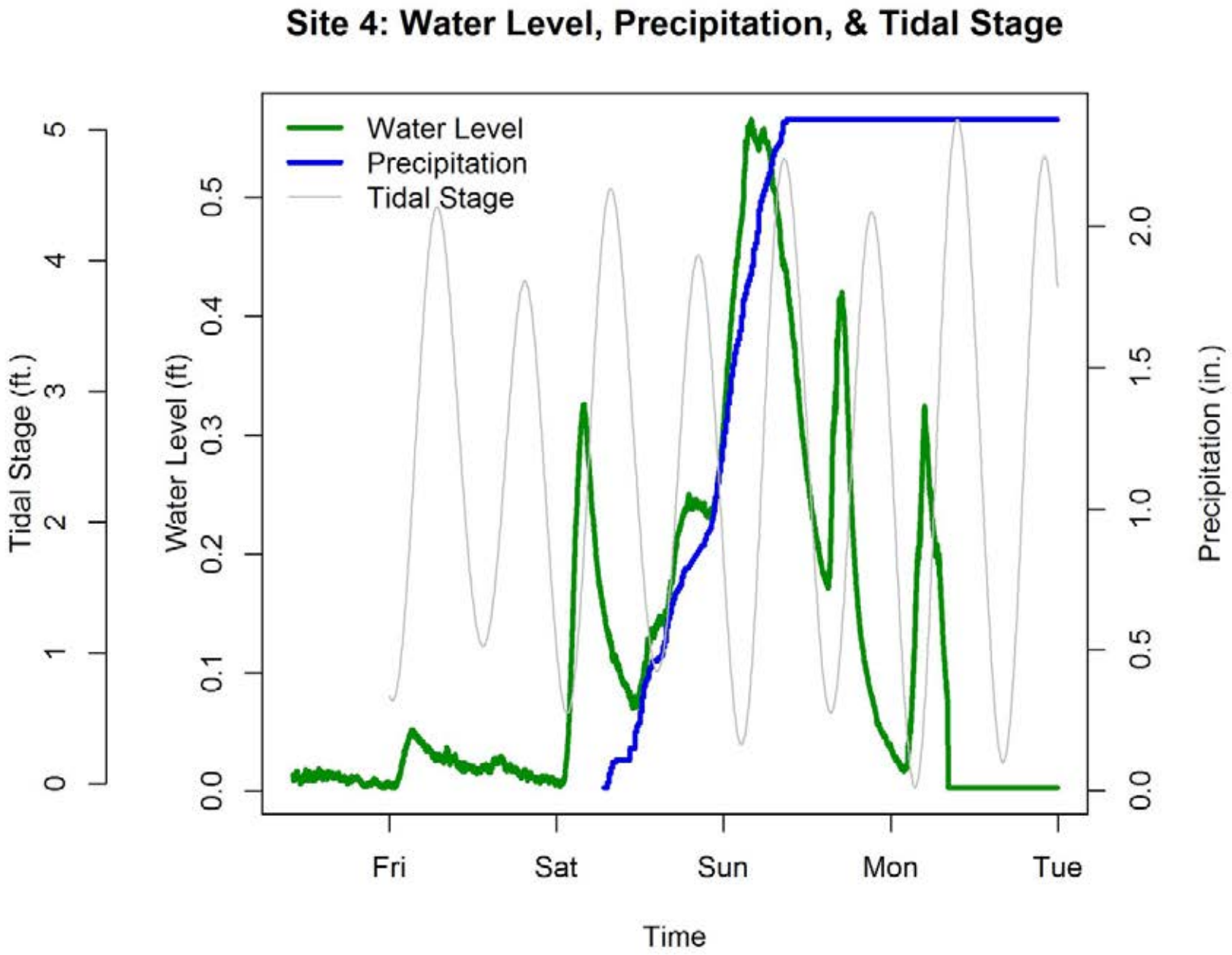
- Slide 4: Rainfall record for three wet sampling events
- Slides 5 – 14: Storm hydrographs for sites 1, 2, 4, 5, 6, 7, 9, 10 and 11
- Slides 15 – 36: GIS maps of water quality measurements
- Slides 37 – 61: Box Plots of Water Quality Parameters Comparing Wet and Dry Sampling Events
- Slides 62 – 89: Dot Plots of Water Quality Parameters
- Slides 90 – 90: FIB and Genetic Based Rank Order Figures
- Slides 100 – 106: Scatter Plots Showing Relationships between Measured Parameters

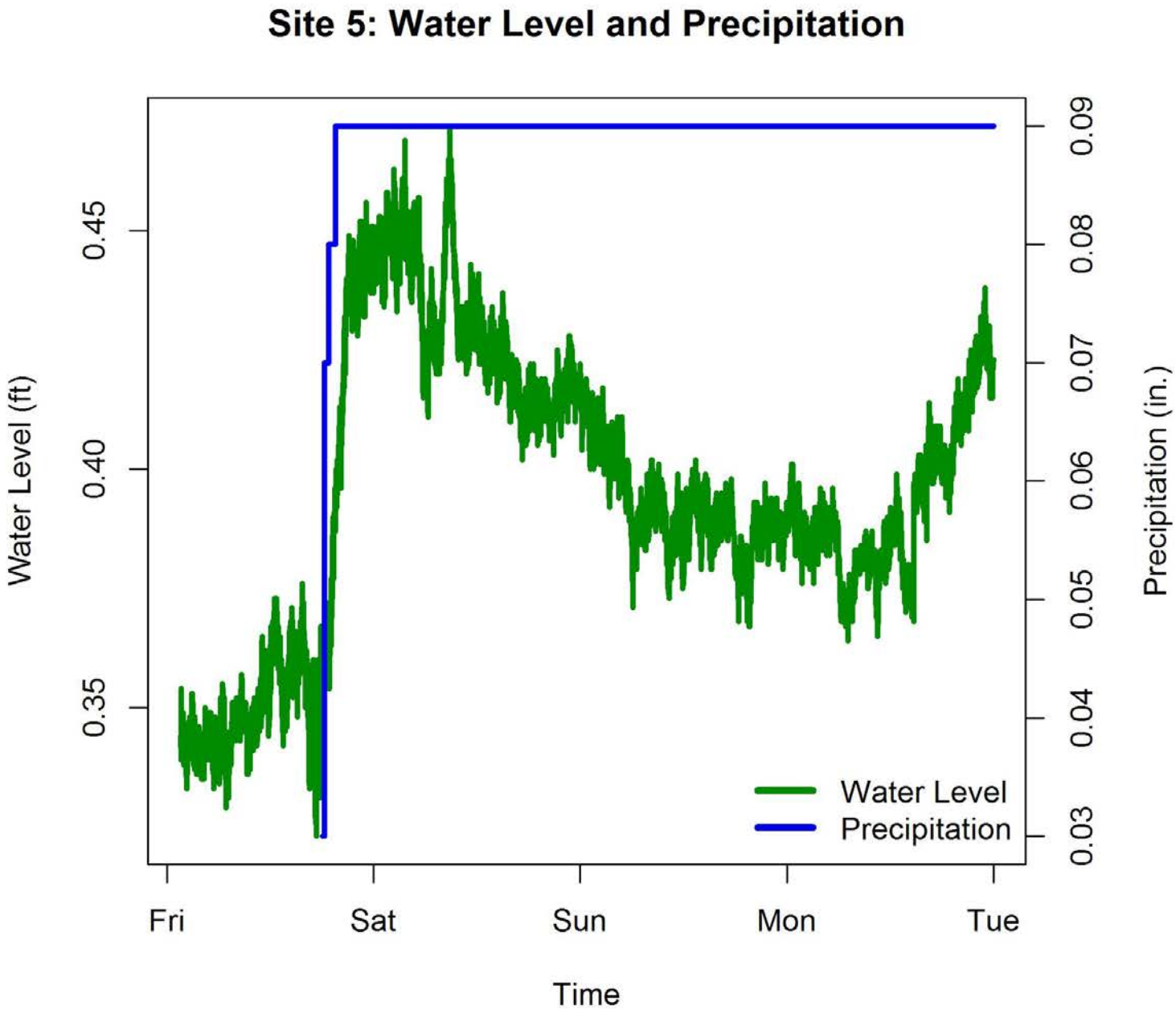

Precipitation during wet sampling events
Cumulative precipitation (in.)
1.5
1.0
0.5
0.0
0
2
4
6
8
Time (hrs)
Sampling window
Sampling Event
5/30/2012
8/28/2012
9/18/2012
0.25”

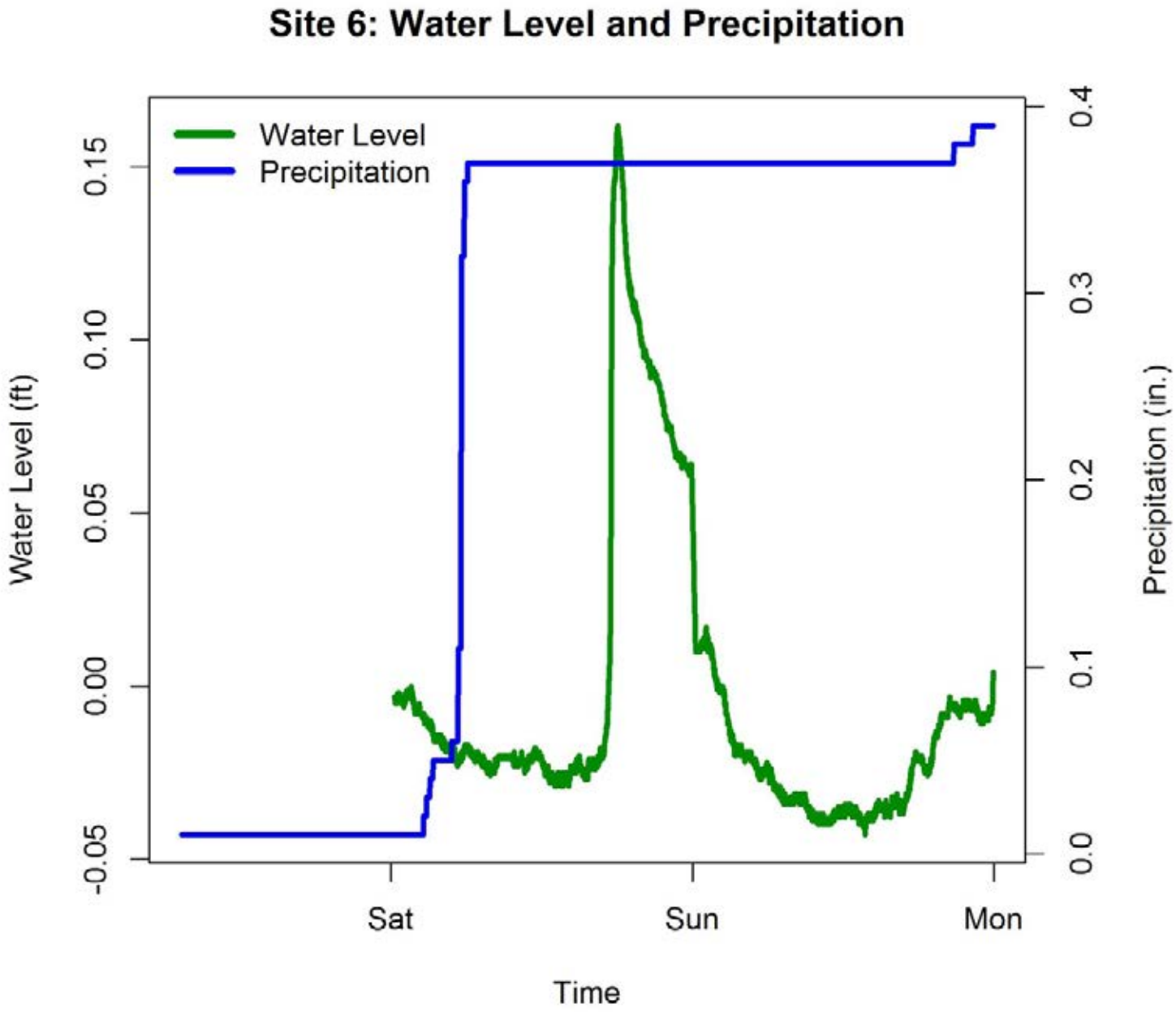
Site-specific Hydrographs

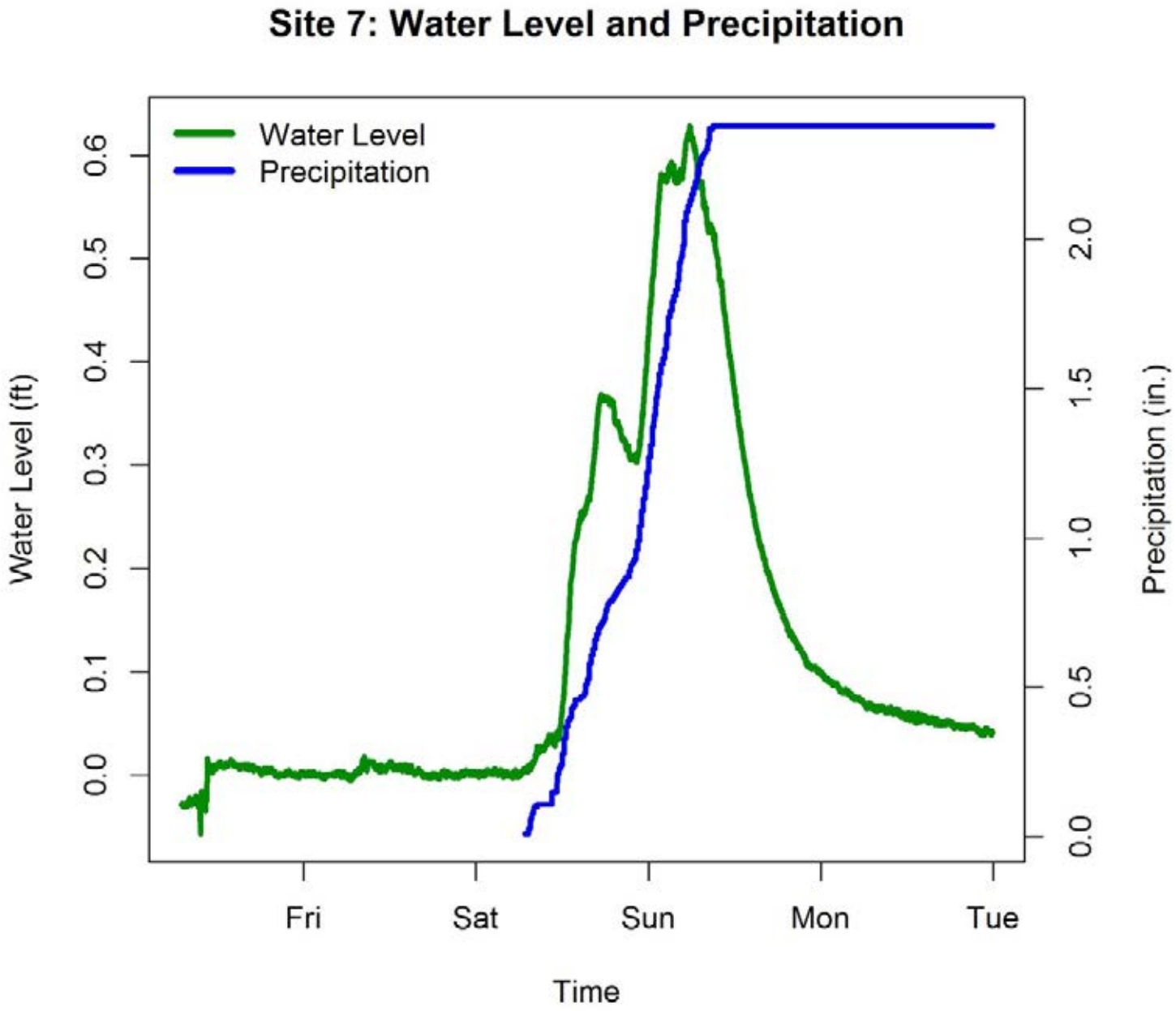

Site 1: Water Level and Precipitation
Water Level
Precipitation
Water Level (ft)
0.2
0.3
0.4
0.5
Precipitation (in.)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Sat
Sun
Mon
Time

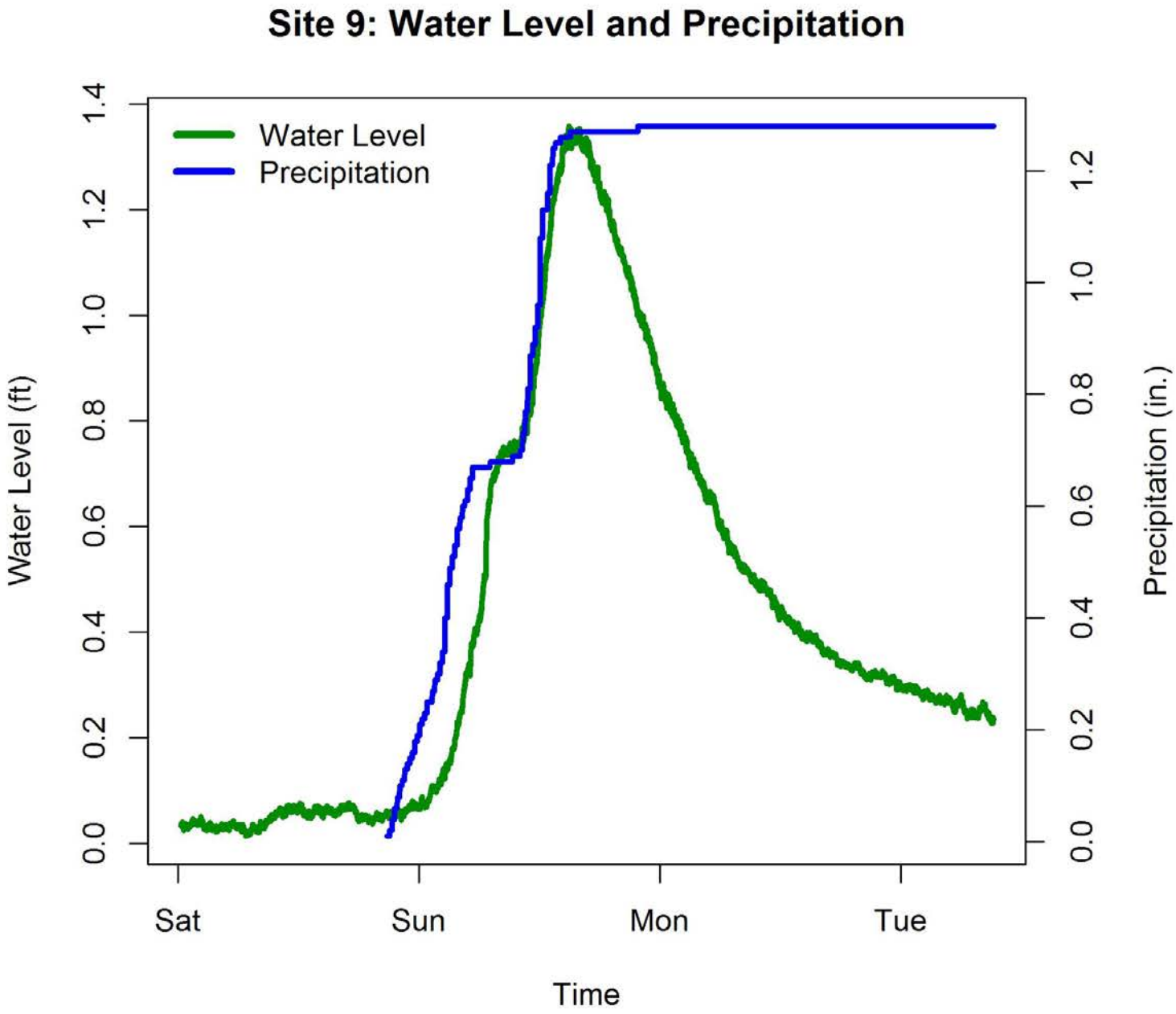

Site 2: Water Level and Precipitation
Water Level (ft)
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Precipitation (in.)
0.0
0.1
0.2
0.3
0.4
Water Level
Precipitation
Thu
Fri
Sat
Sun
Mon
Time

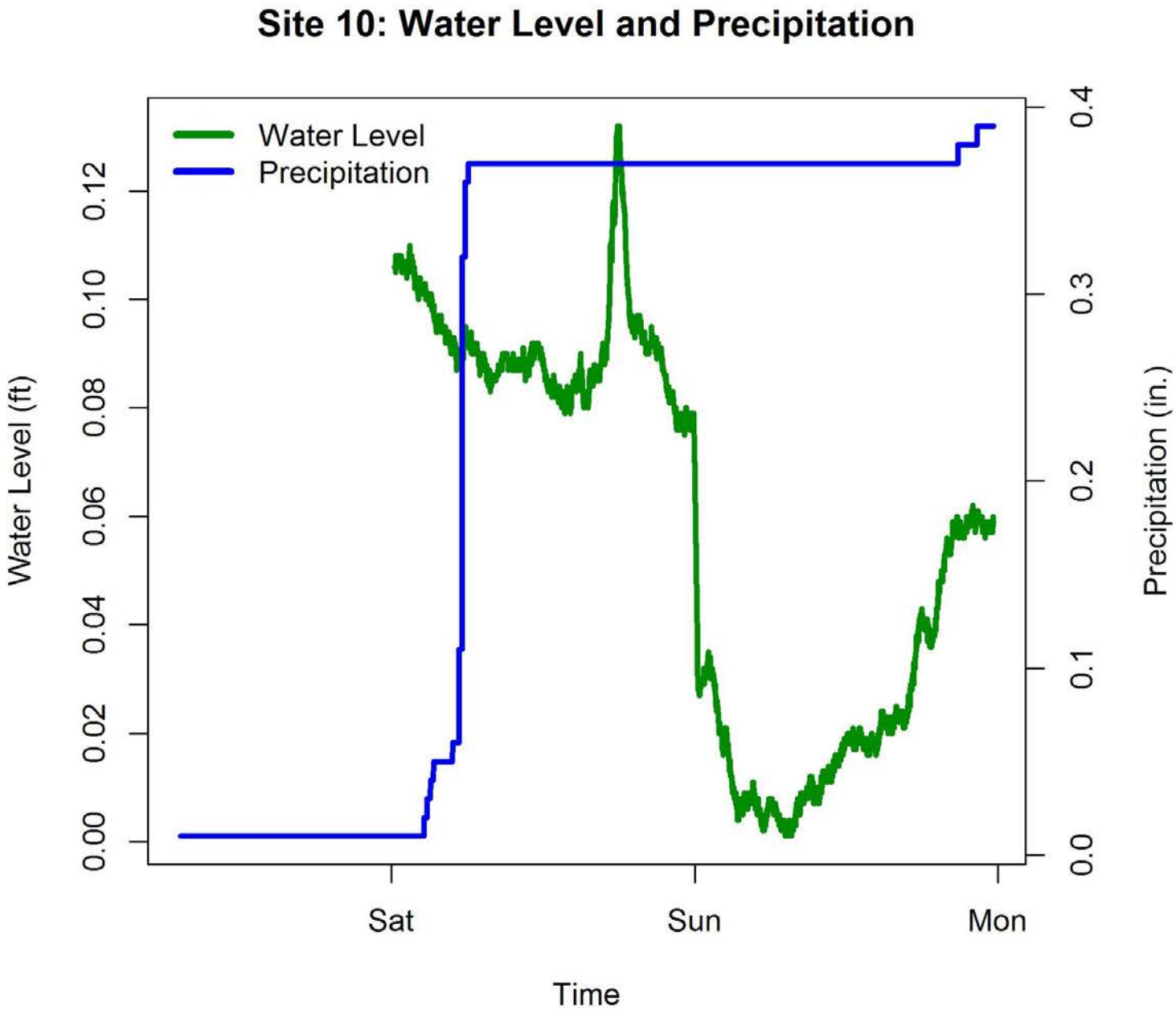

Site 4: Water Level, Precipitation, & Tidal Stage
Water Level
Precipitation
Tidal Stage
Tidal Stage (ft.)
Water Level (ft)
Precipitation (in.)
Fri
Sat
Sun
Mon
Tue
Time

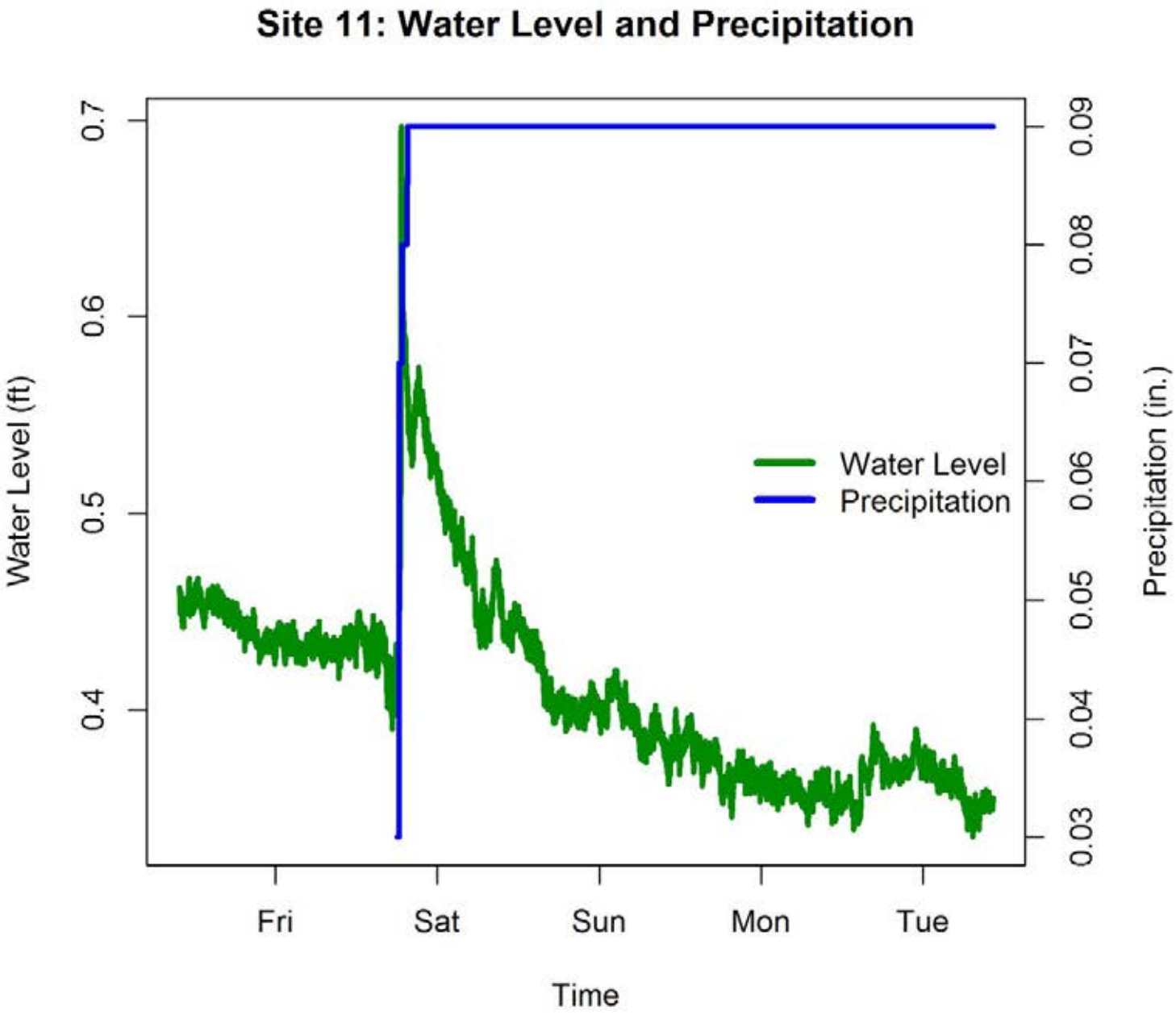

Site 5: Water Level and Precipitation
Water Level (ft)
0.35
0.40
0.45
Precipitation (in.)
0.03
0.04
0.05
0.06
0.07
0.08
0.09
Water Level
Precipitation
Fri
Sat
Sun
Mon
Tue
Time


Site 6: Water Level and Precipitation
Water Level
Precipitation
Water Level (ft)
-0.05
0.00
0.05
0.10
0.15
Precipitation (in.)
0.0
0.1
0.2
0.3
0.4
Sat
Sun
Mon
Time


Site 7: Water Level and Precipitation
Water Level
Precipitation
Water Level (ft)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Precipitation (in.)
0.0
0.5
1.0
1.5
2.0
Fri
Sat
Sun
Mon
Tue
Time


Site 9: Water Level and Precipitation
Water Level
Precipitation
Water Level (ft)
Precipitation (in.)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Sat
Sun
Mon
Tue
Time

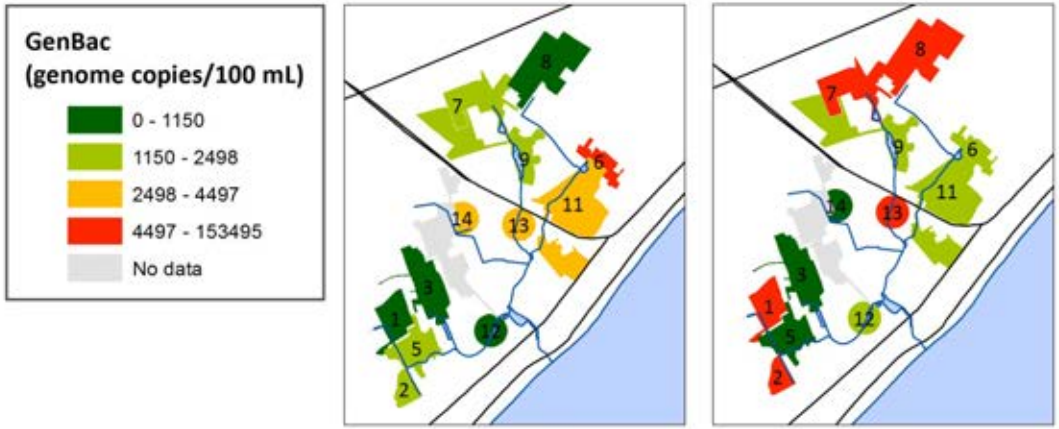

Site 10: Water Level and Precipitation
Water Level
Precipitation
Water Level (ft)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Precipitation (in.)
0.0
0.1
0.2
0.3
0.4
Sat
Sun
Mon
Time


Site 11: Water Level and Precipitation
Water Level (ft)
0.4
0.5
0.6
0.7
Precipitation (in.)
0.03
0.04
0.05
0.06
0.07
0.08
0.09
Water Level
Precipitation
Fri
Sat
Sun
Mon
Tue
Time

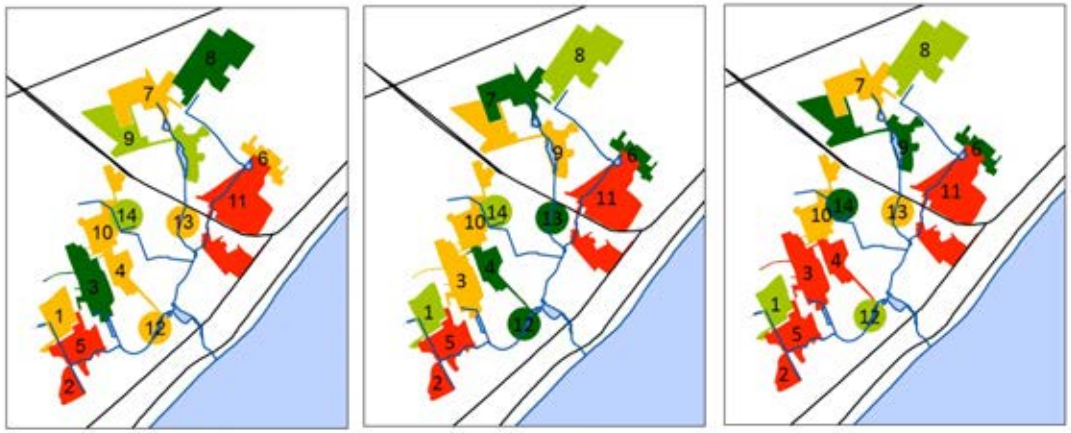
ArcGIS maps of Withers sub-watersheds

GenBac

Dry Events



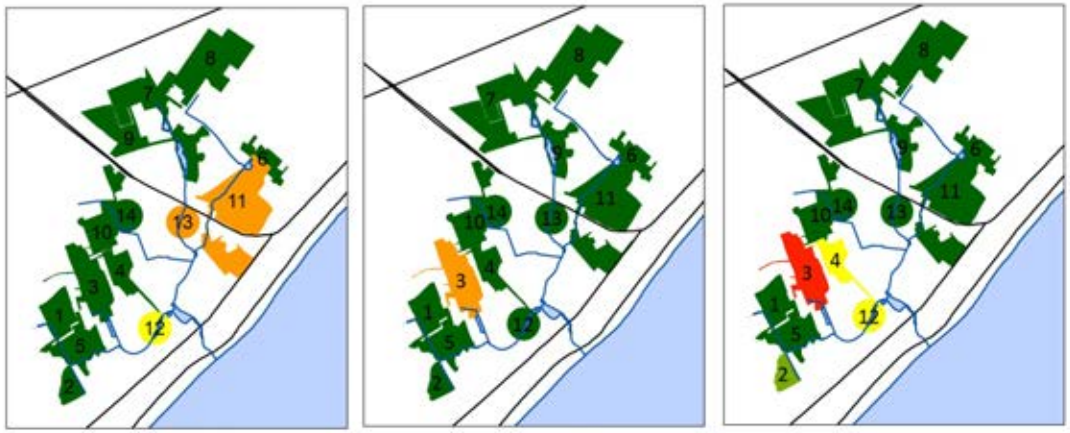
Wet Events



BacHum

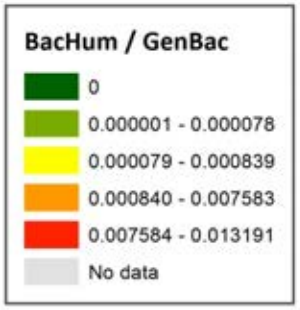
Dry Events

Wet Events



BacHum / GenBac

Dry Events



5/20/12

6/27/12

Wet Events

5/30/12

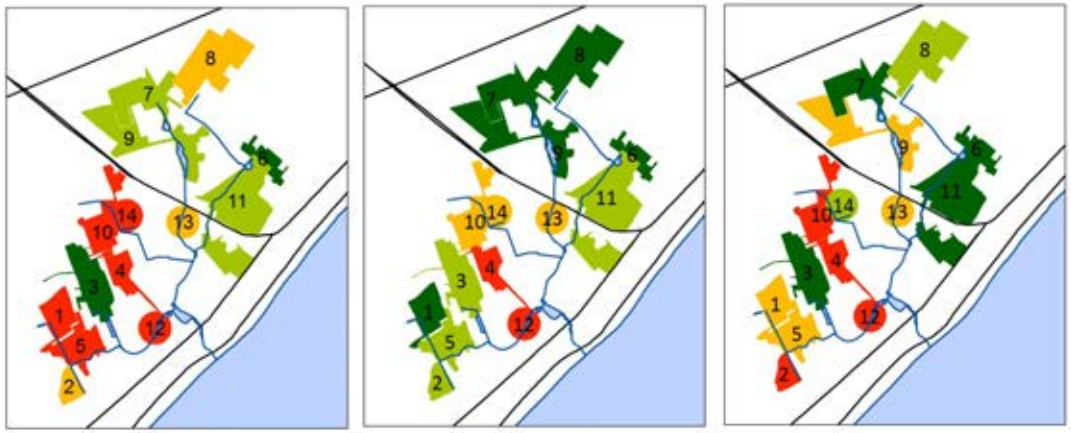
8/28/12

9/18/12

BacCan

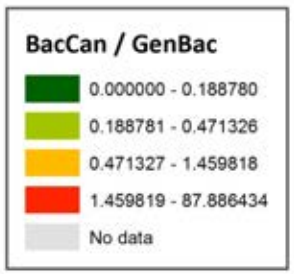
Dry Events

Wet Events



BacCan / GenBac

Dry Events



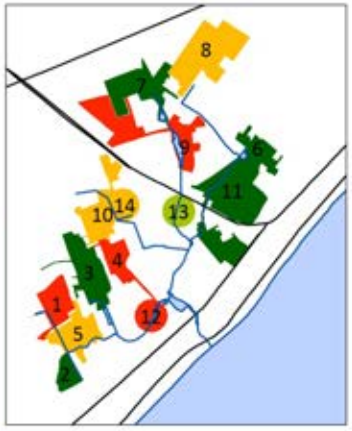
5/20/12

6/27/12

Wet Events

5/30/12

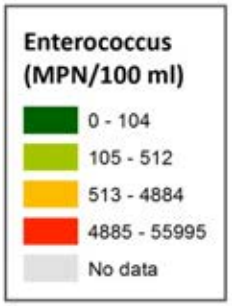
8/28/12



9/18/12

Enterococcus

Dry Events

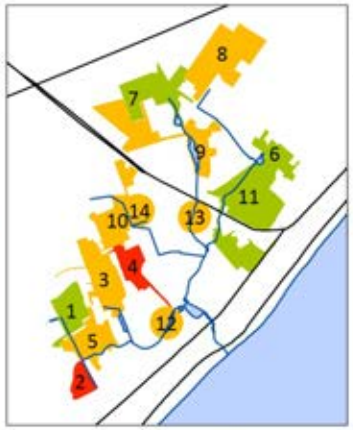


5/20/12

6/27/12

Wet Events

5/30/12

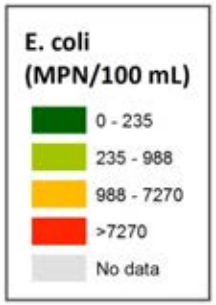


8/28/12

9/18/12

E. coli

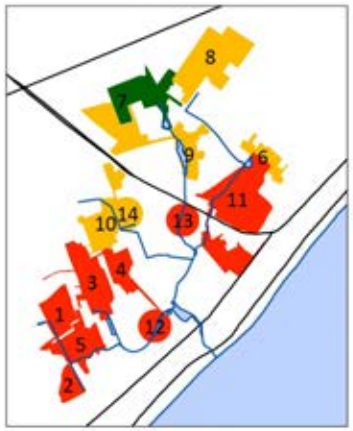
Dry Events



5/20/12

6/27/12

Wet Events



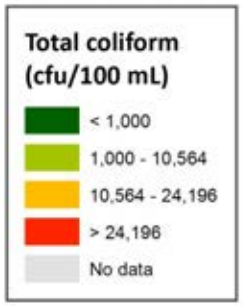
5/30/12

8/28/12

9/18/12

Total coliform

Dry Events



5/20/12

6/27/12

Wet Events

5/30/12

8/28/12

9/18/12

Water Quality Standard Type	NH4-N (mg/L) Water Quality Standard at pH=7.3 and Water Temperature = 26°C
Chronic toxicity with freshwater mussels present	0.501
Chronic toxicity with freshwater mussels absent	3.60
Acute toxicity with freshwater mussels present	8.24
Acute toxicity with freshwater mussels absent	14.3

Note: NH4-N water quality standards are pH and water temperature dependent. The standards above correspond to the median pH and water temperature at the sites sampled in this study.

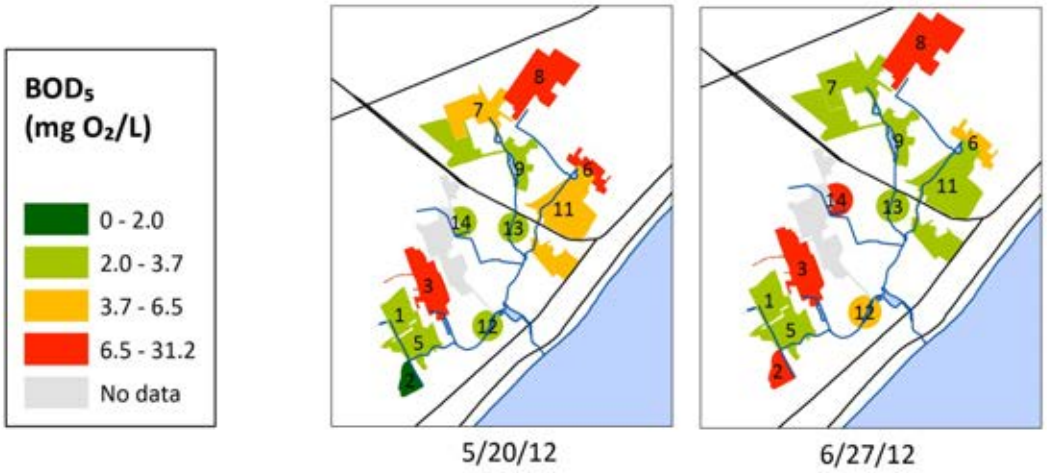
NH4-N

Dry Events

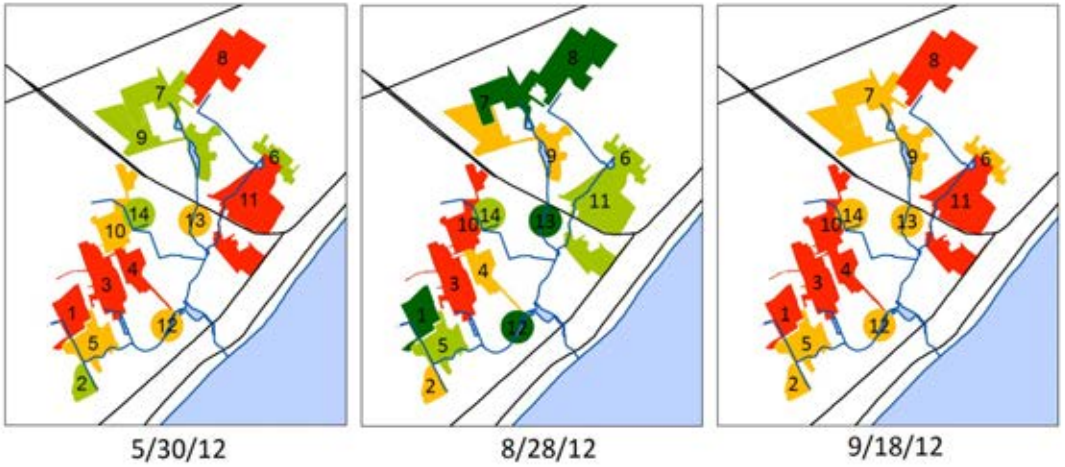
Wet Events

BOD_5

Dry Events



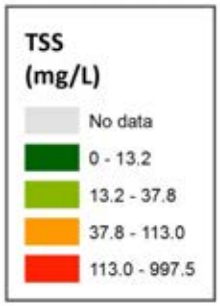
Wet Events



Percentiles were calculated after removing data below the water quality standard.

TSS

Dry Events

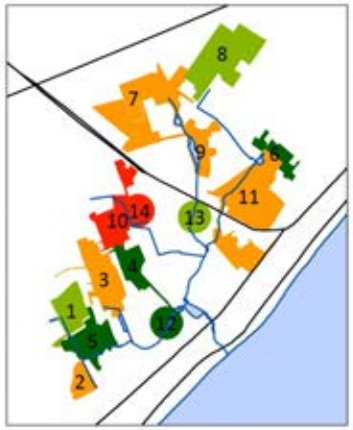


5/20/12

6/27/12

Wet Events

5/30/12

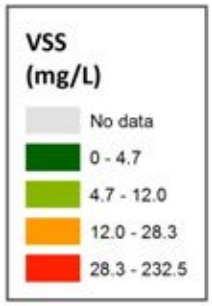


8/28/12

9/18/12

VSS

Dry Events

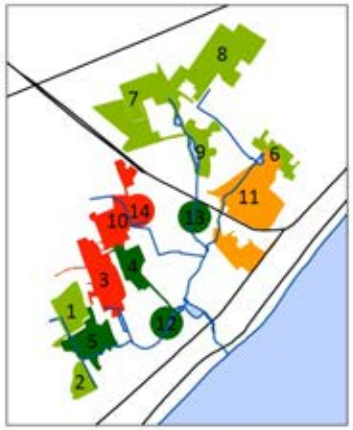


5/20/12

6/27/12

Wet Events

5/30/12

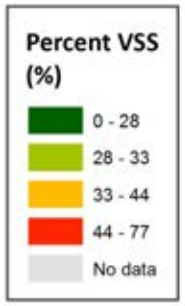


8/28/12

9/18/12

Percent VSS

Dry Events

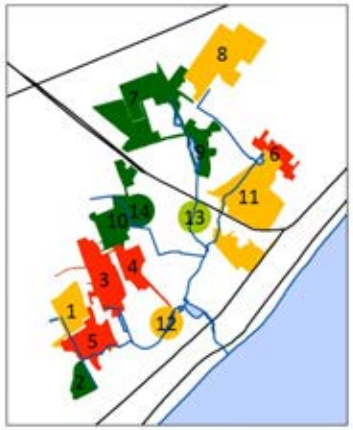


5/20/12

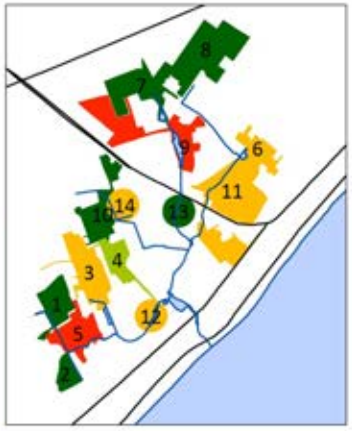
6/27/12

Wet Events

5/30/12



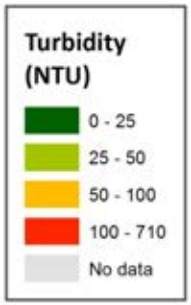
8/28/12



9/18/12

Turbidity

Dry Events



5/20/12

6/27/12

Wet Events

5/30/12

8/28/12

9/18/12

Toxicity

Dry Events

5/20/12

6/27/12

Wet Events

5/30/12

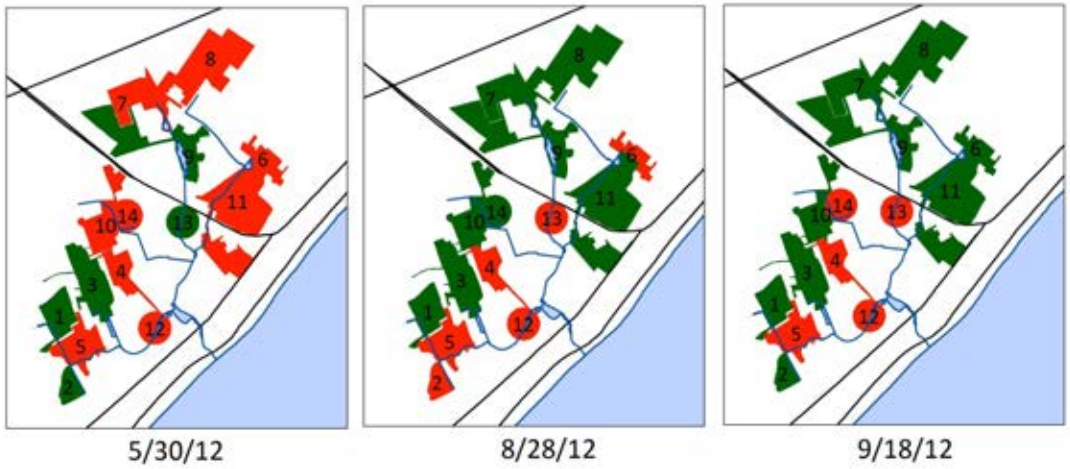
8/28/12

9/18/12

Optical Brighteners

Dry Events

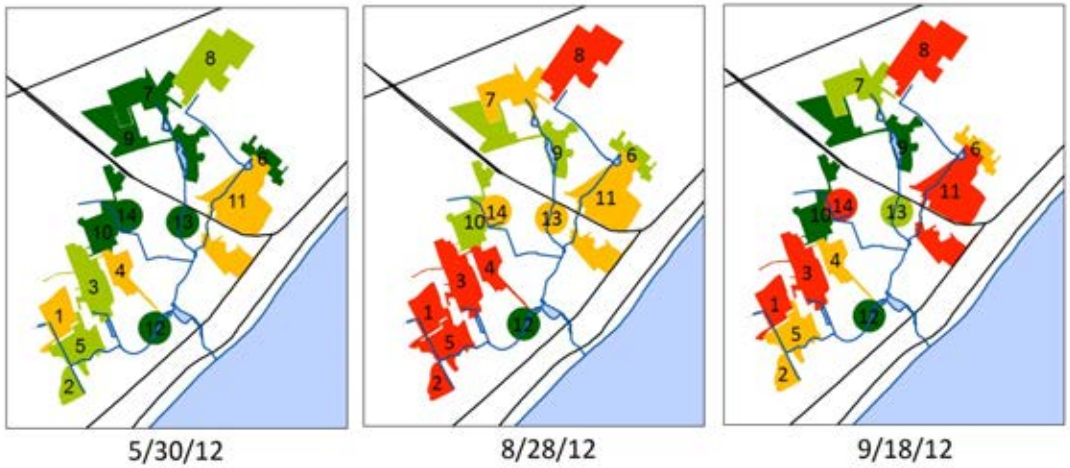
Wet Events



Optical Brighteners

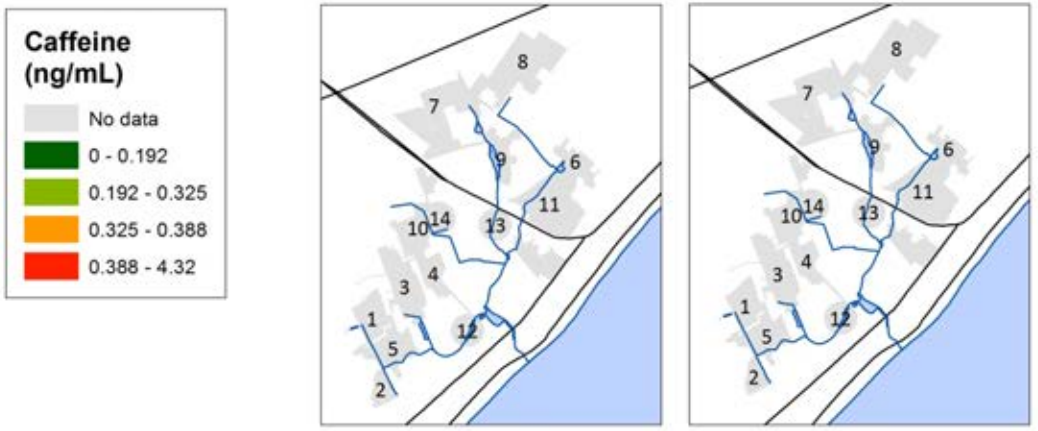
Dry Events

Wet Events

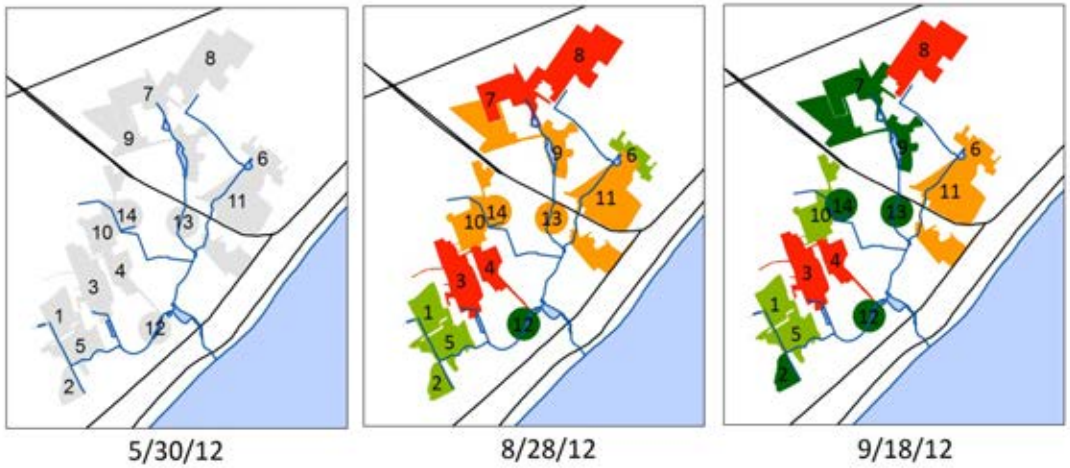


Caffeine

Dry Events

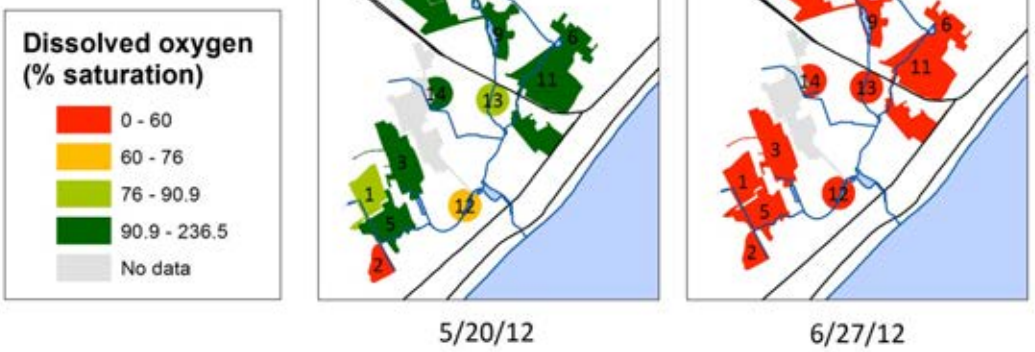


Wet Events

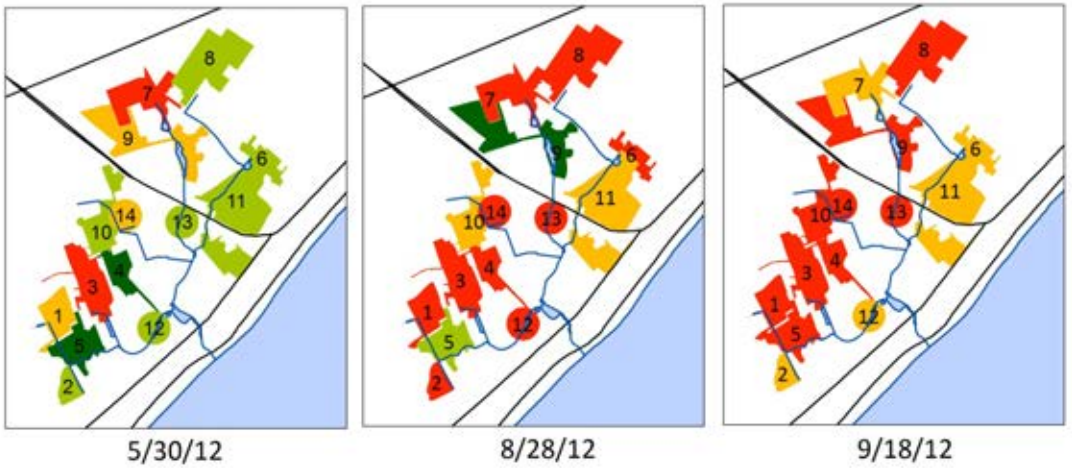


Dissolved oxygen

Dry Events



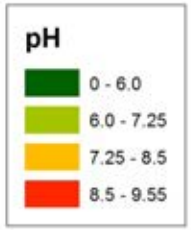
Wet Events



Percentiles were calculated after removing data below the water quality standard.

pH

Dry Events

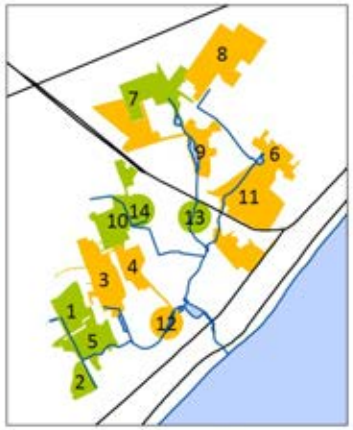


5/20/12

6/27/12

Wet Events

5/30/12

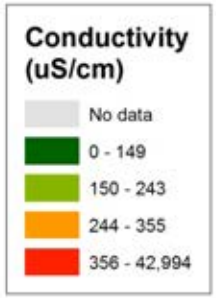


8/28/12

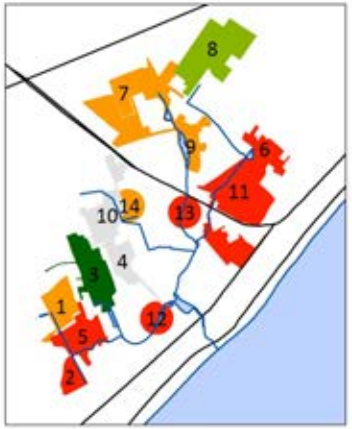
9/18/12

Conductivity

Dry Events



5/20/12



6/27/12

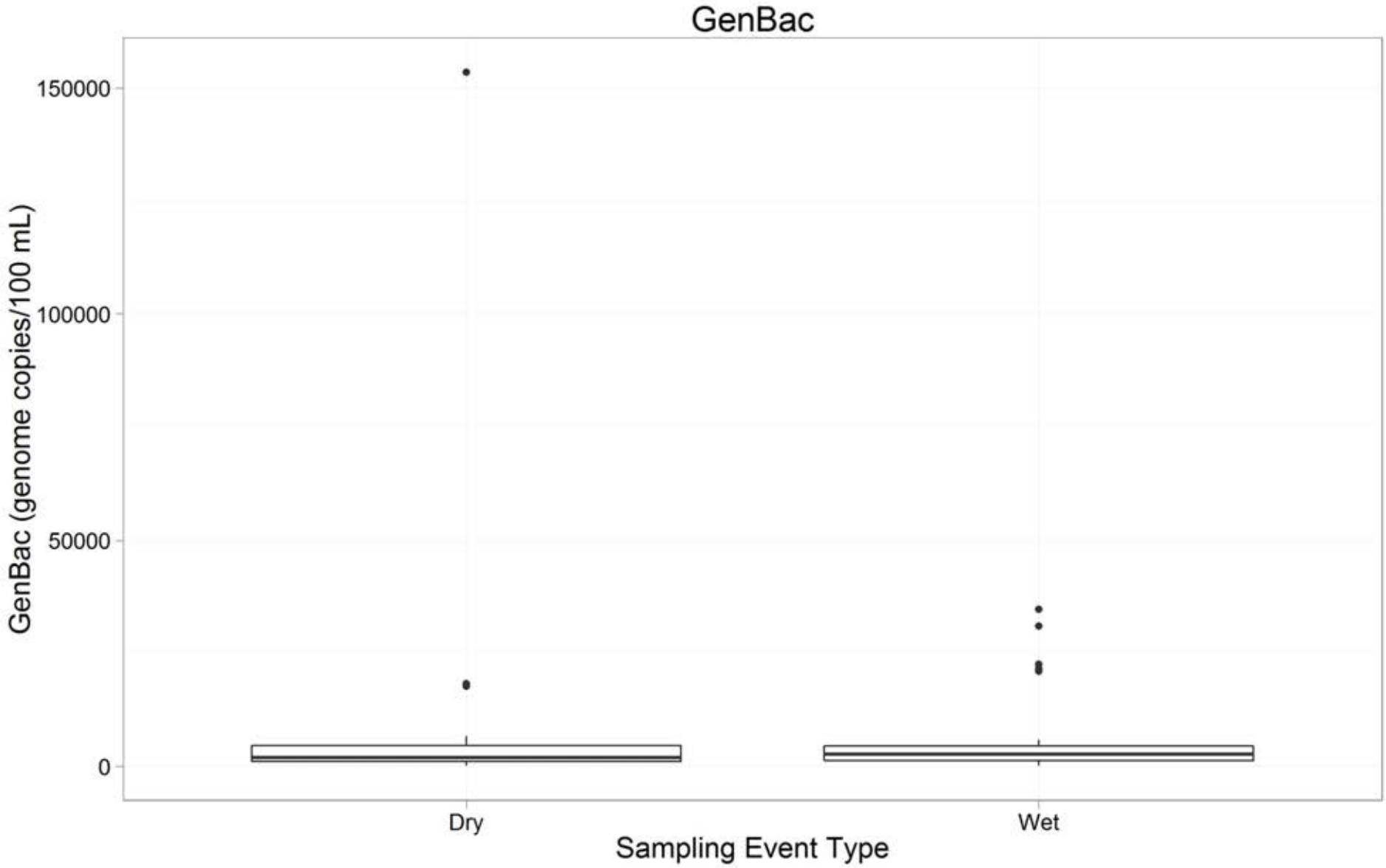
Wet Events

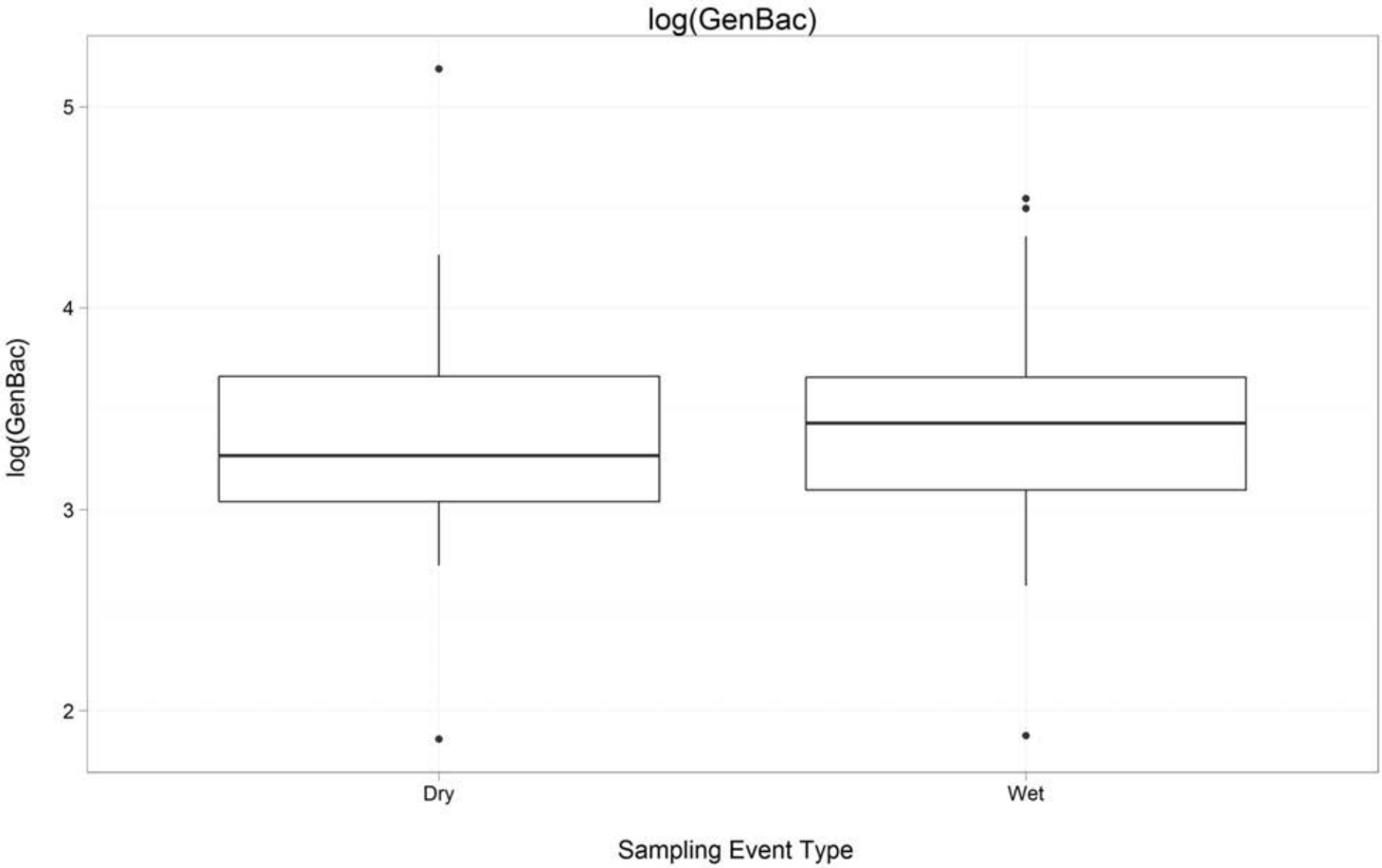
5/30/12

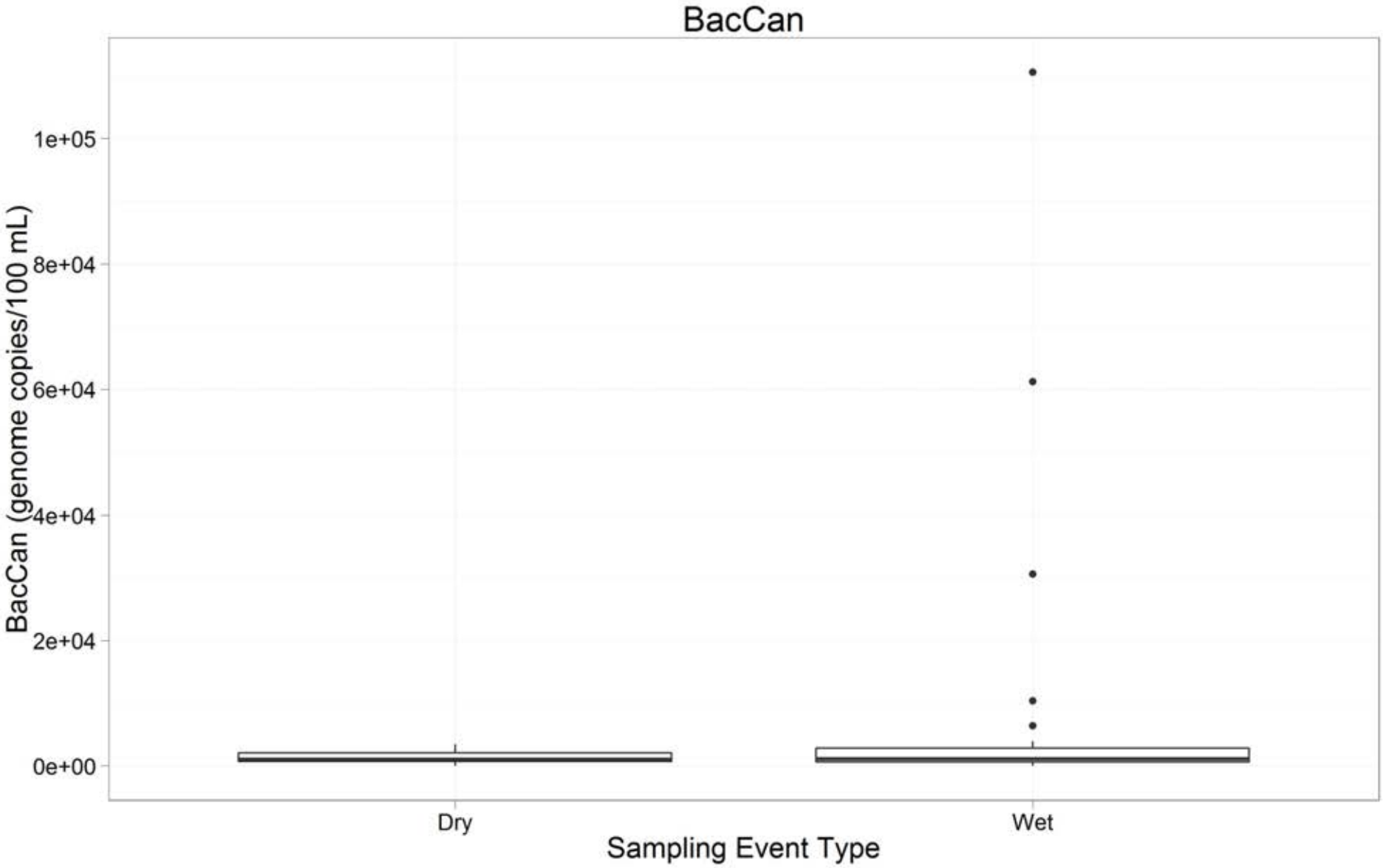
8/28/12

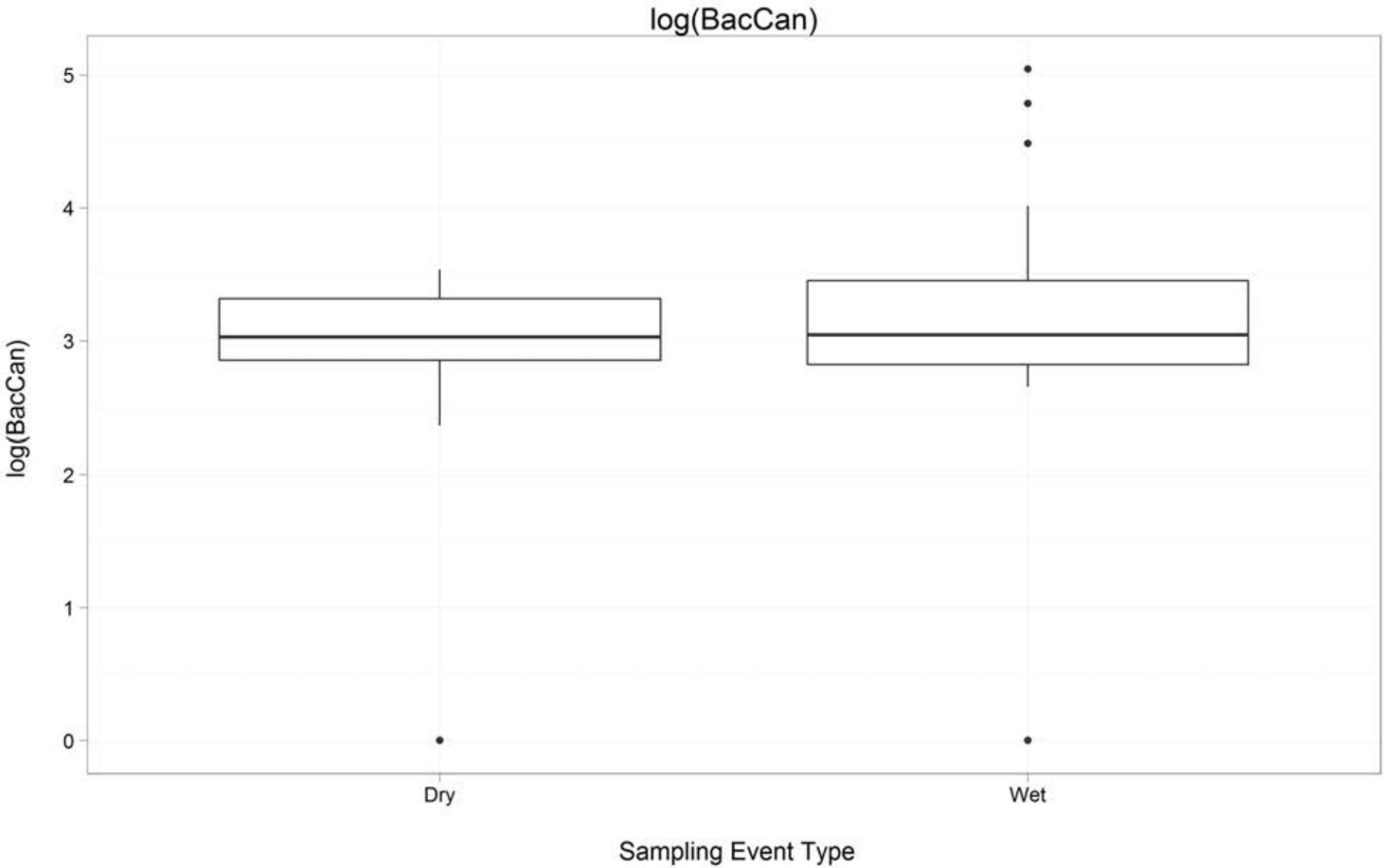
9/18/12

Box Plots of Water Quality Parameters Comparing Wet and Dry Sampling Events

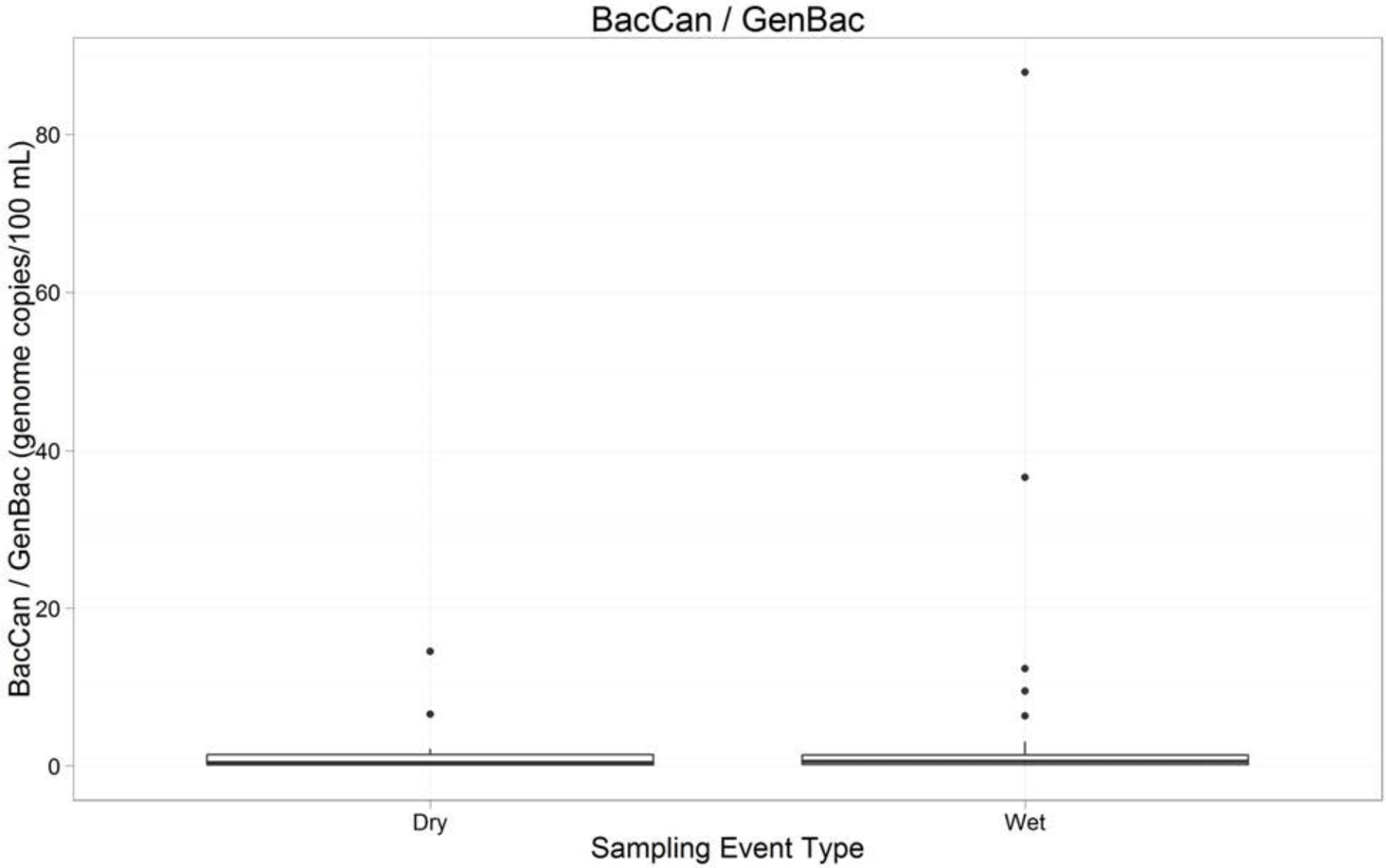

GenBac
150000
100000
50000
0
GenBac (genome copies/100 mL)
Dry
Wet
Sampling Event Type

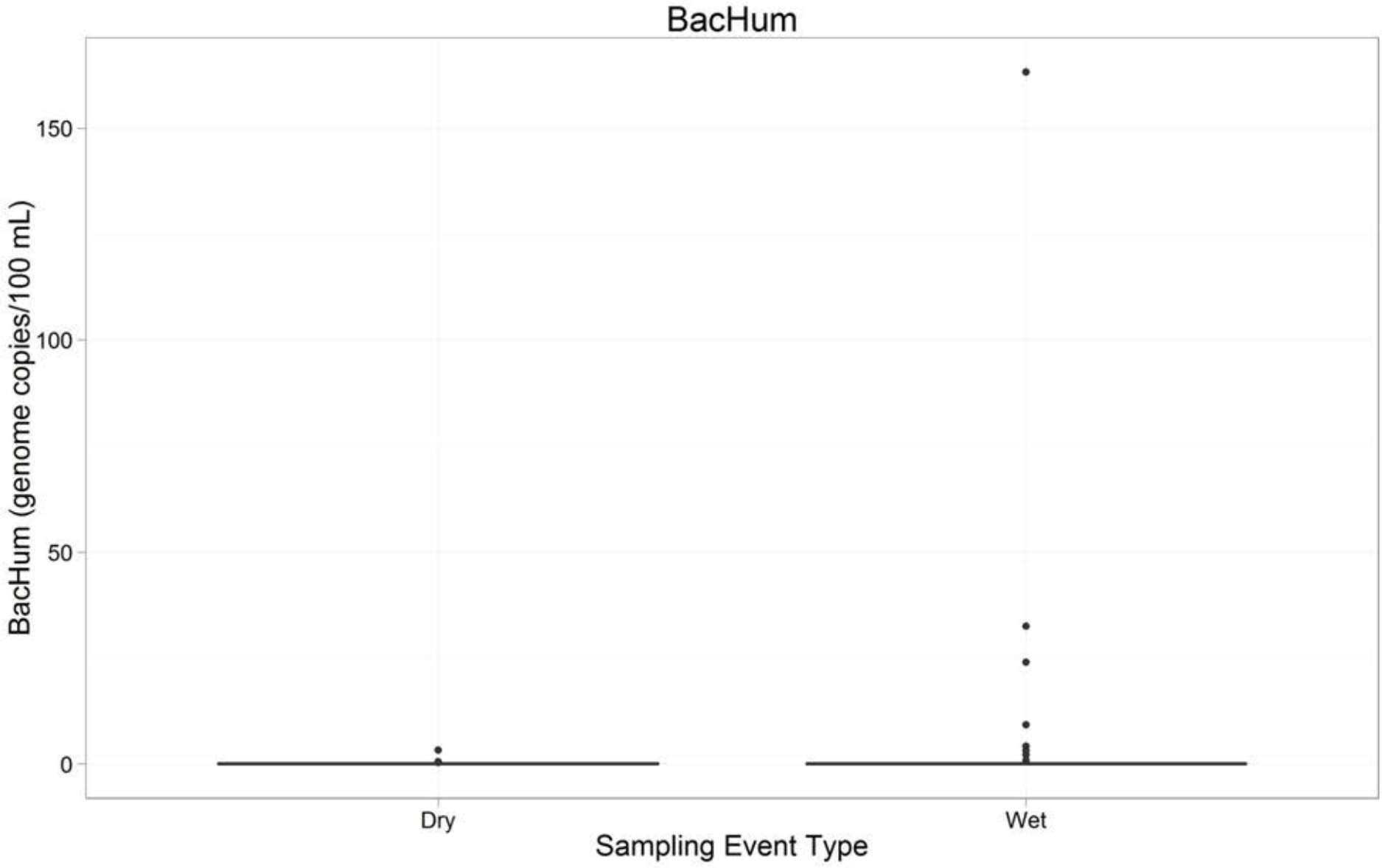

log(GenBac)
5
4
3
2
log(GenBac)
Dry
Wet
Sampling Event Type

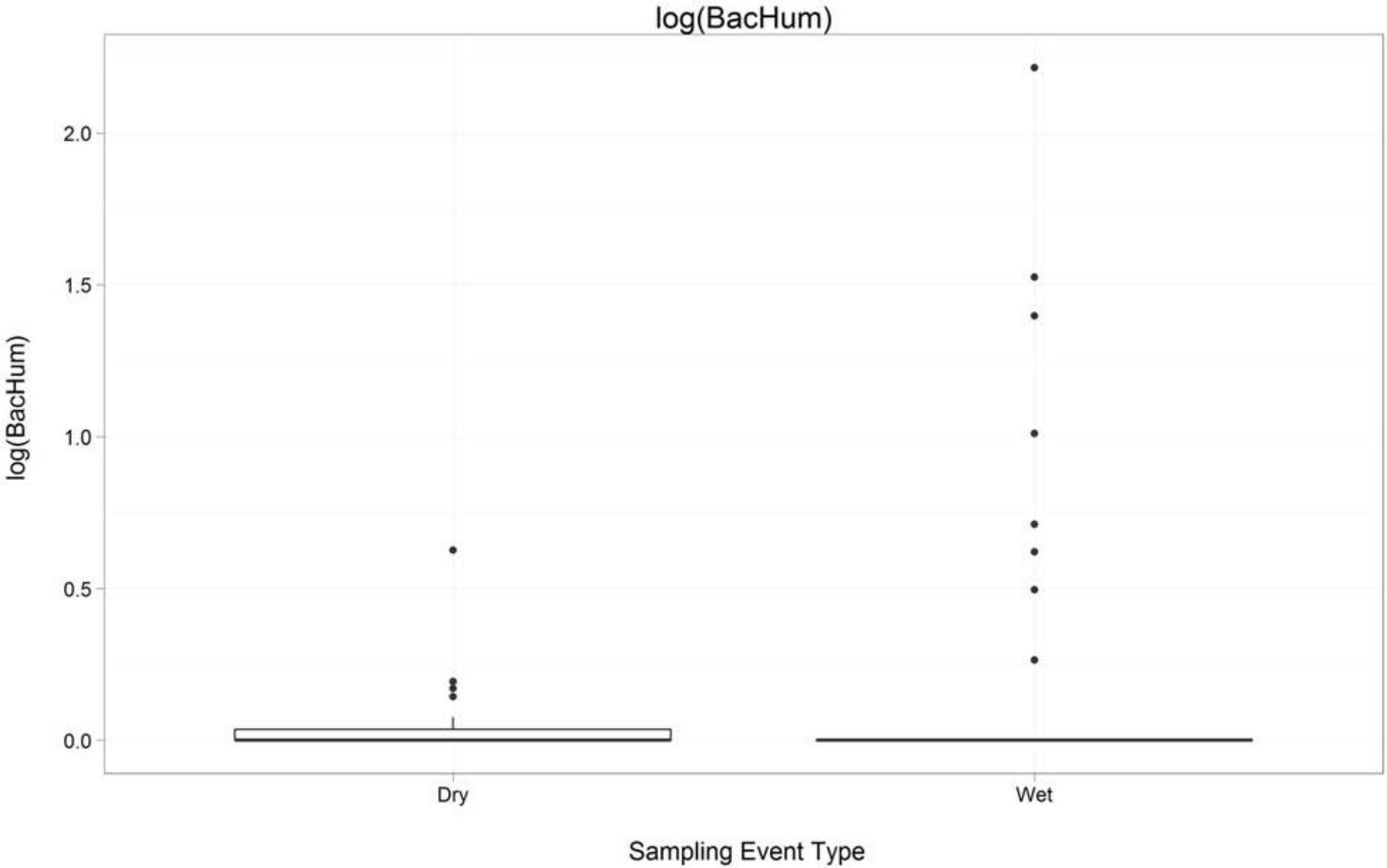

BacCan
BacCan (genome copies/100 mL)
1e+05
8e+04
6e+04
4e+04
2e+04
0e+00
Dry
Wet
Sampling Event Type



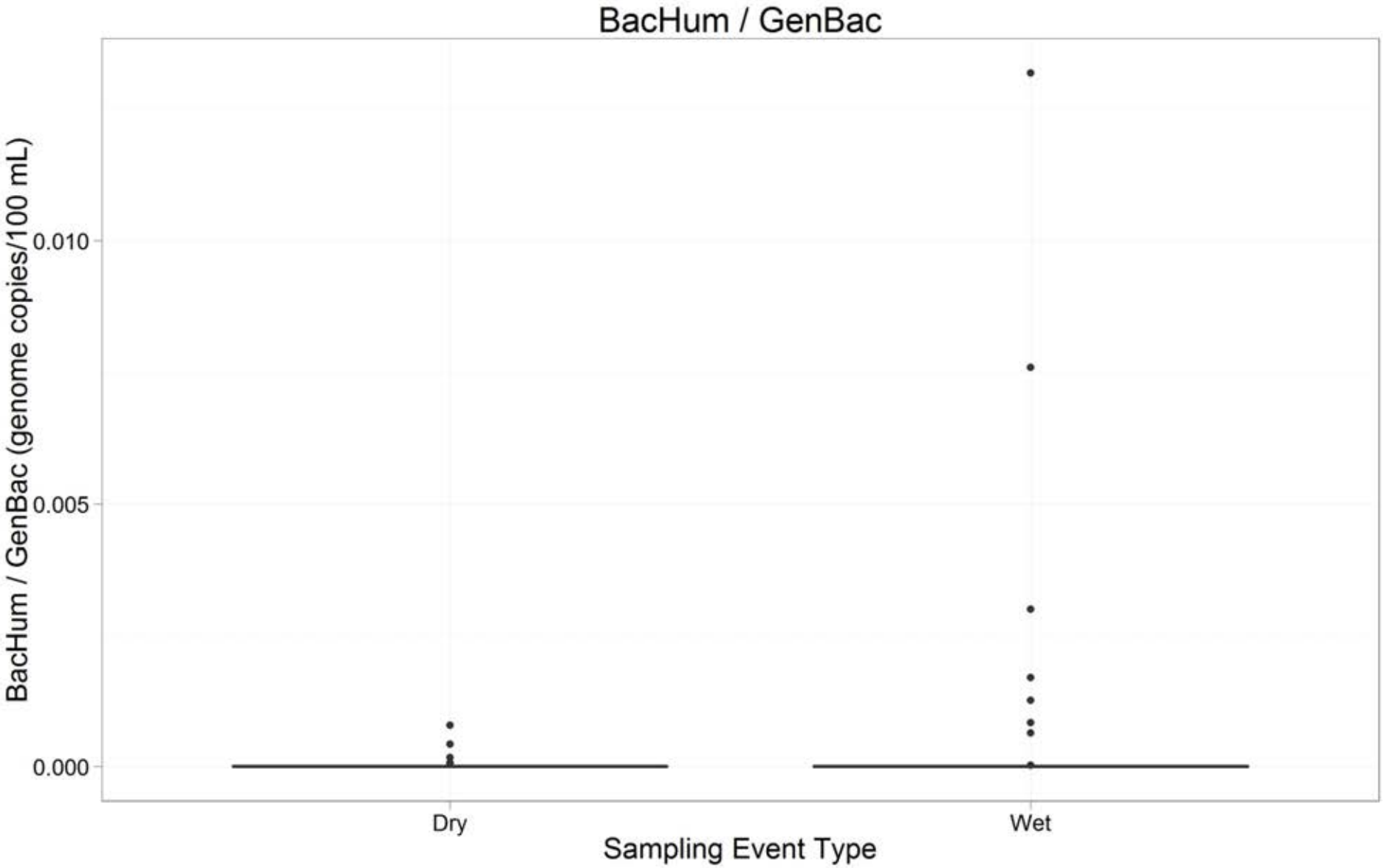
A value of 1 was added to each value before log-transforming to avoid losing the zeroes since log(0) is undefined.

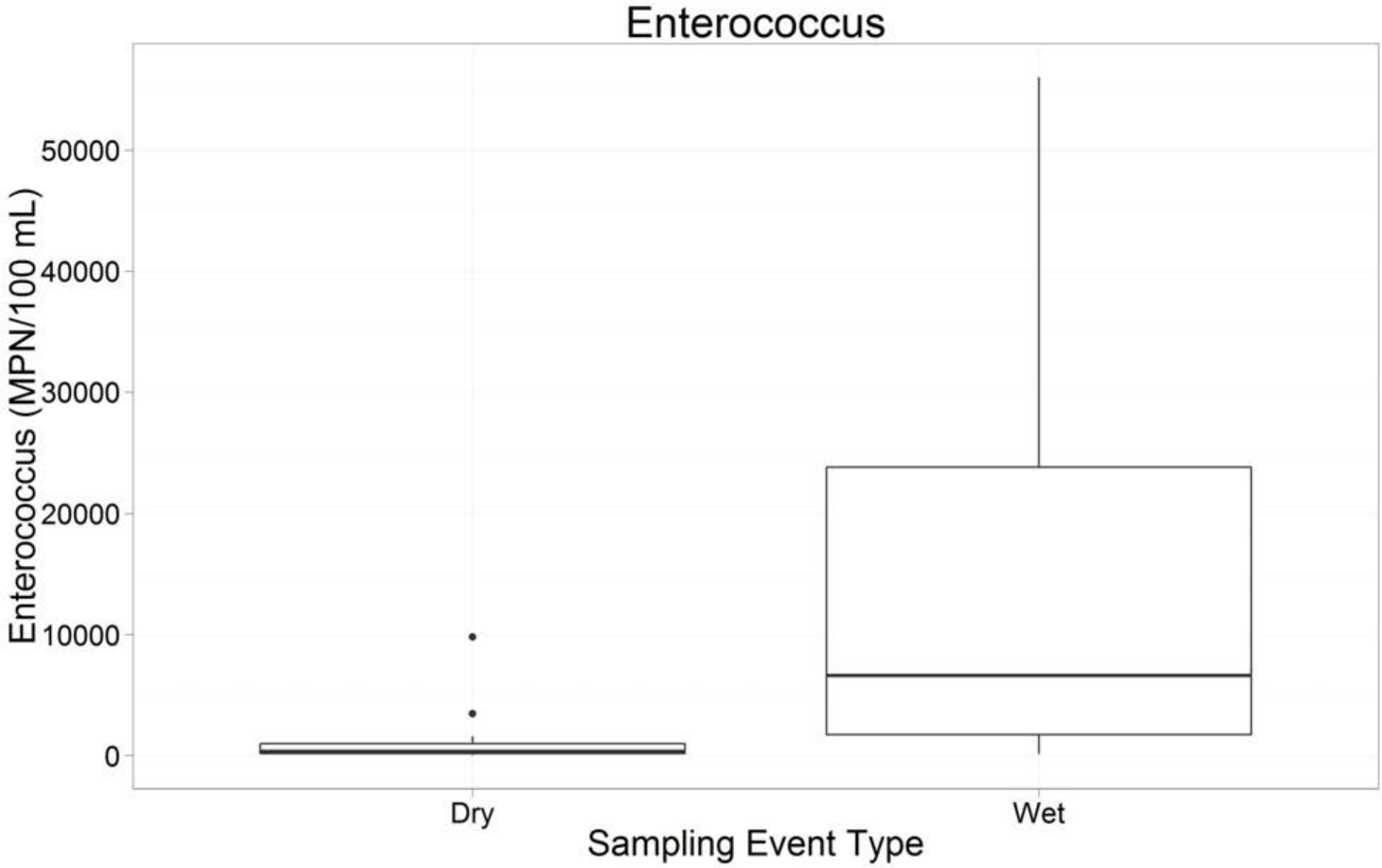

BacCan / GenBac
BacCan / GenBac (genome copies/100 mL)
80
60
40
20
0
Dry
Wet
Sampling Event Type

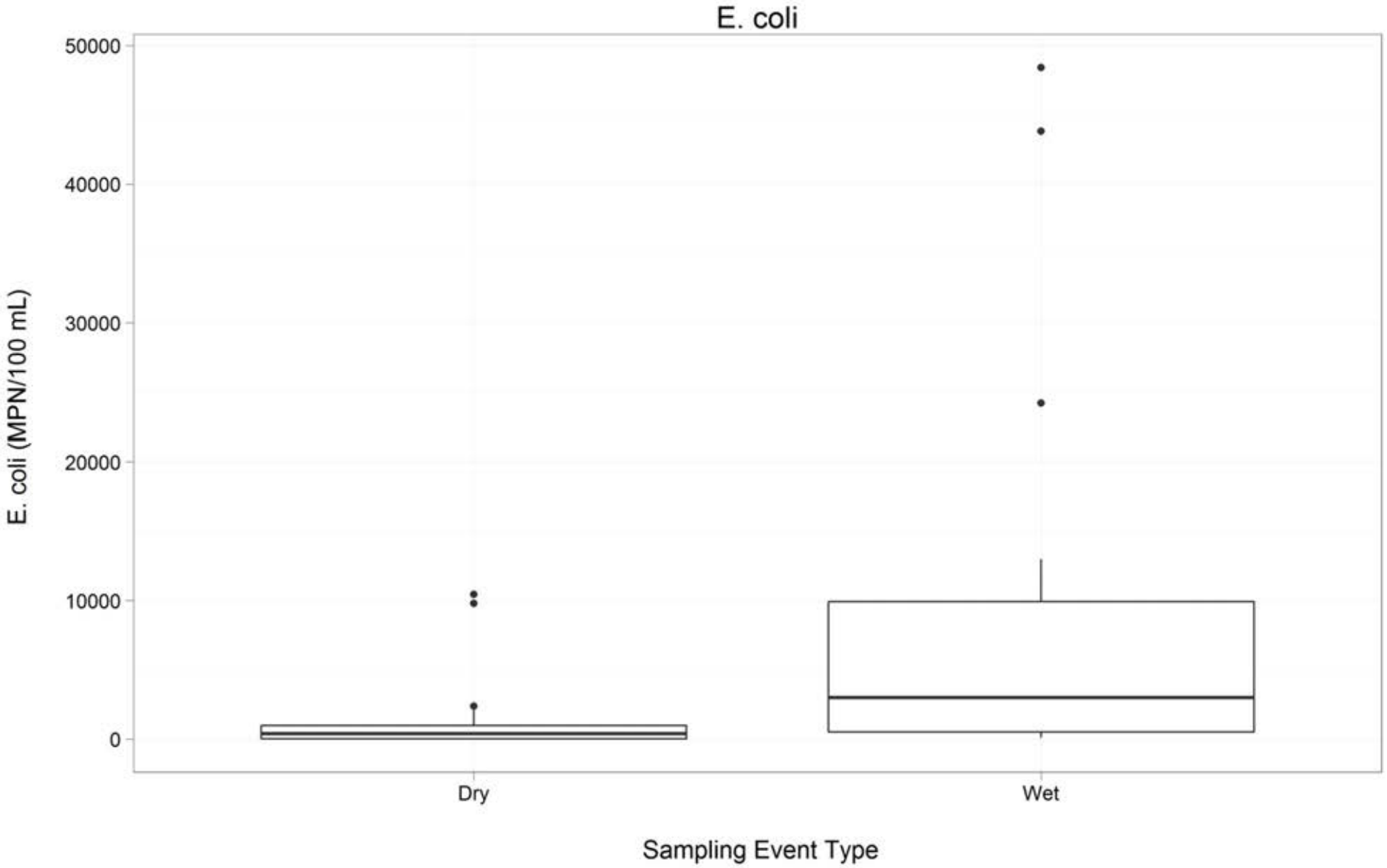

BacHum
150
100
50
0
BacHum (genome copies/100 mL)
Dry
Wet
Sampling Event Type

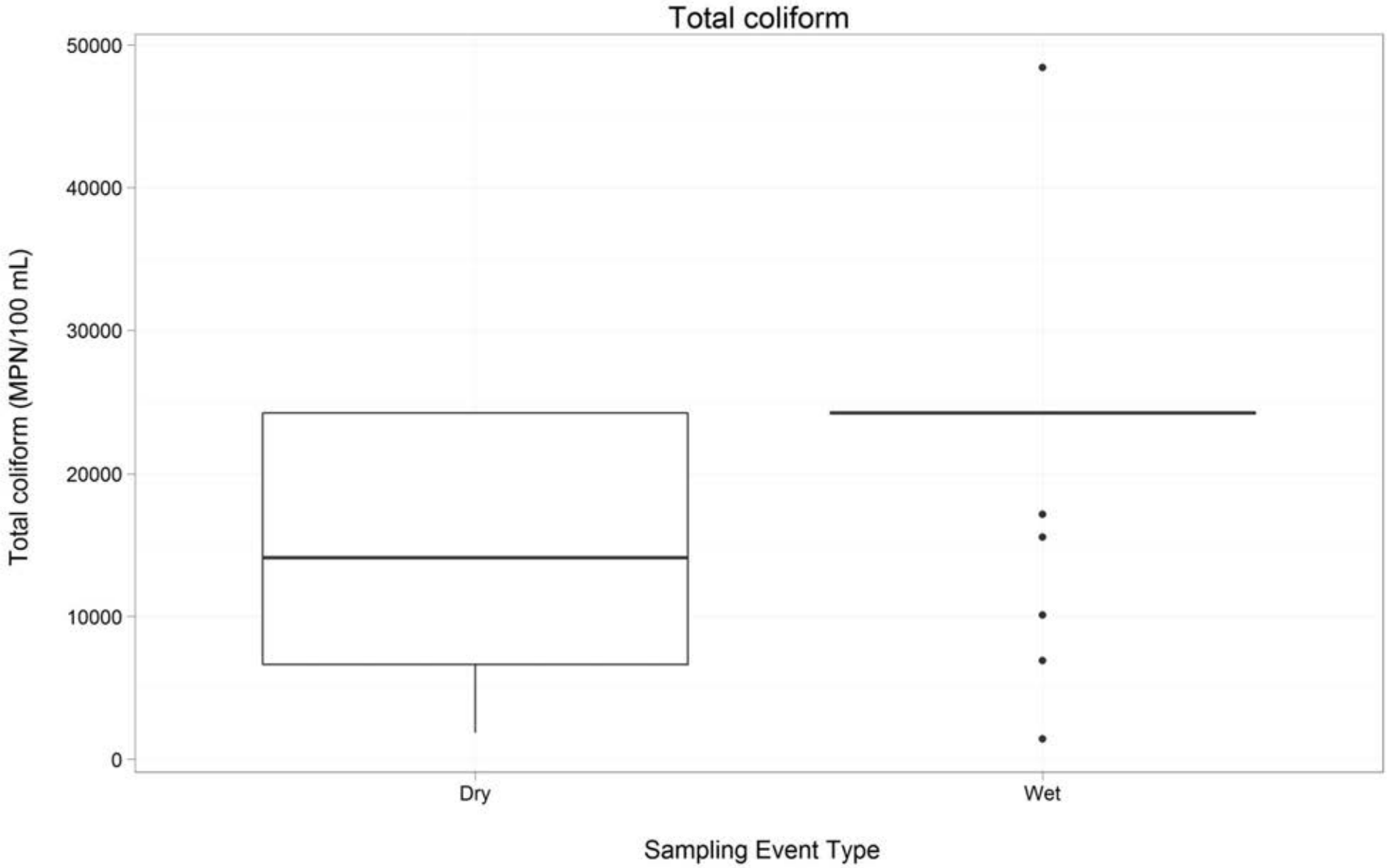


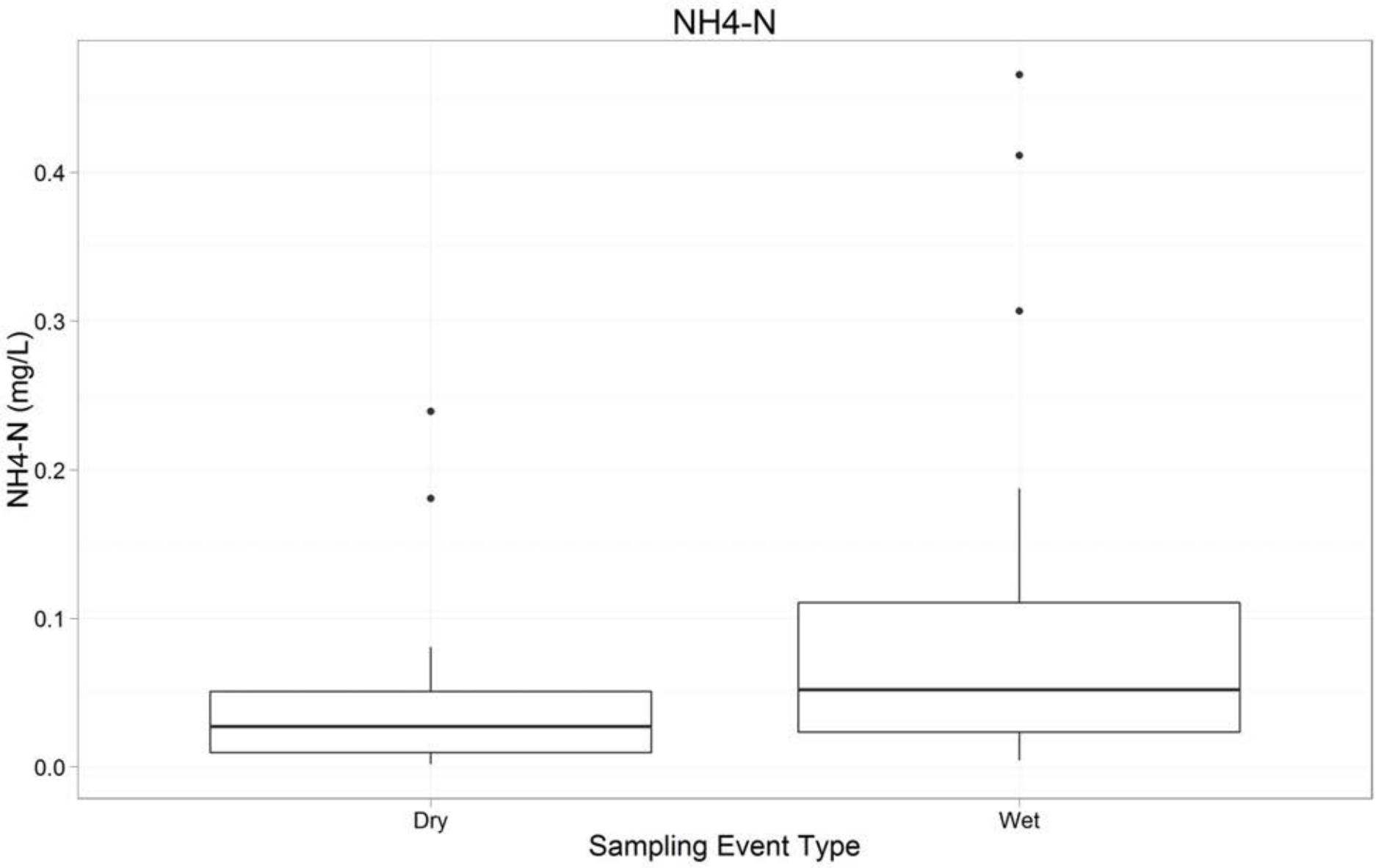
A value of 1 was added to each value before log-transforming to avoid losing the zeroes since log(0) is undefined.

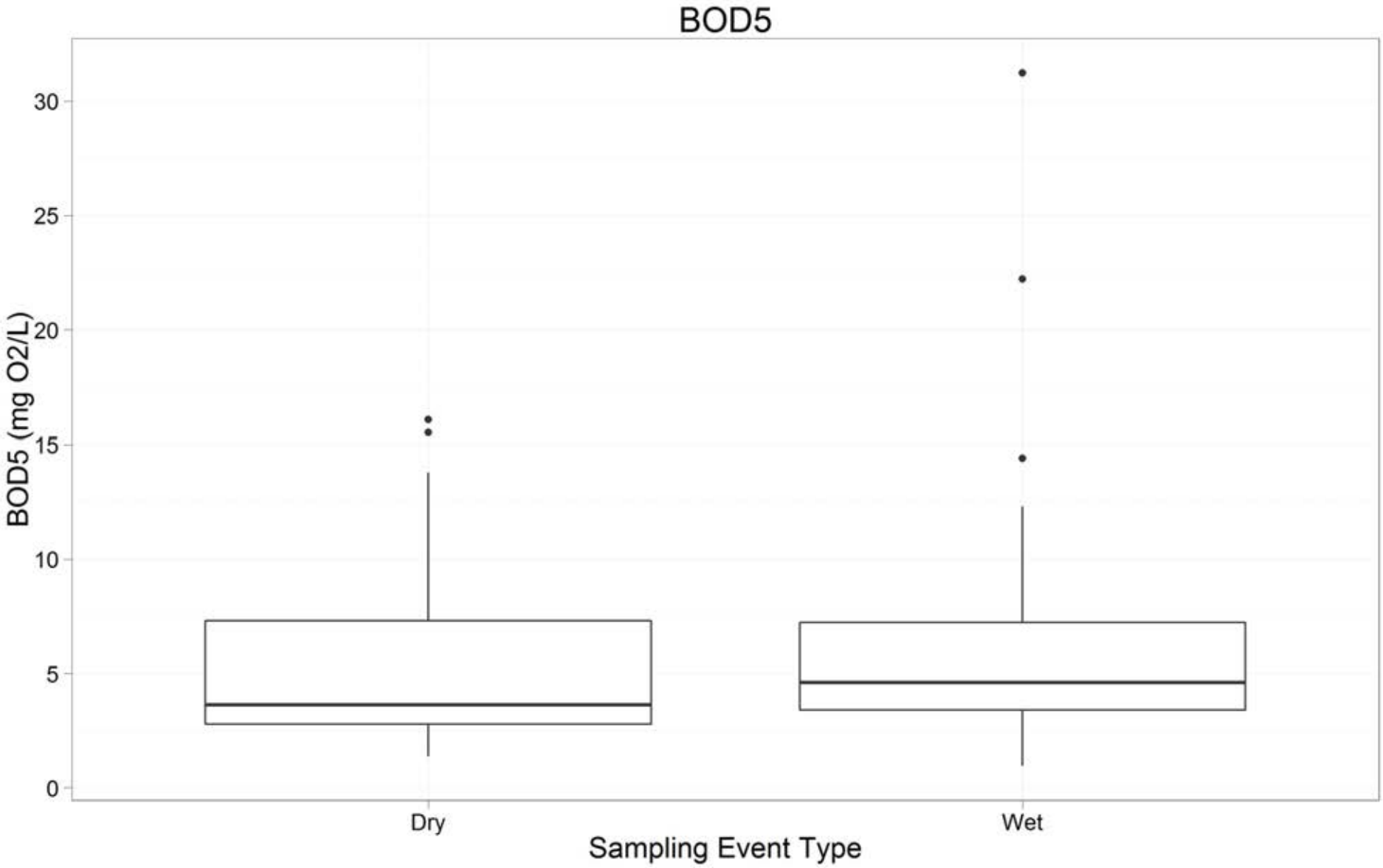

BacHum / GenBac
BacHum / GenBac (genome copies/100 mL)
0.010
0.005
0.000
Dry
Wet
Sampling Event Type

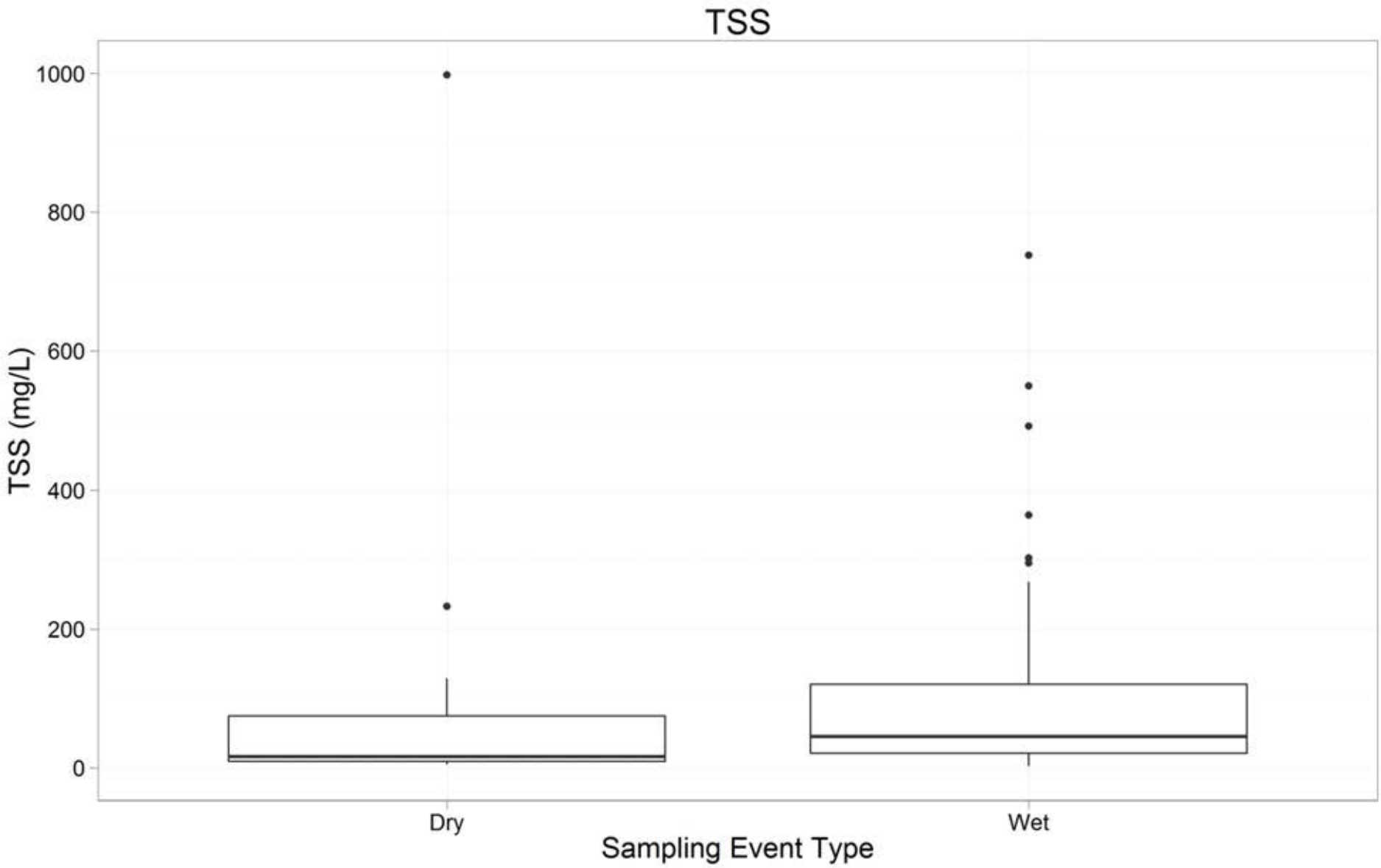

Enterococcus
Enterococcus (MPN/100 mL)
50000
40000
30000
20000
10000
0
Dry
Wet
Sampling Event Type

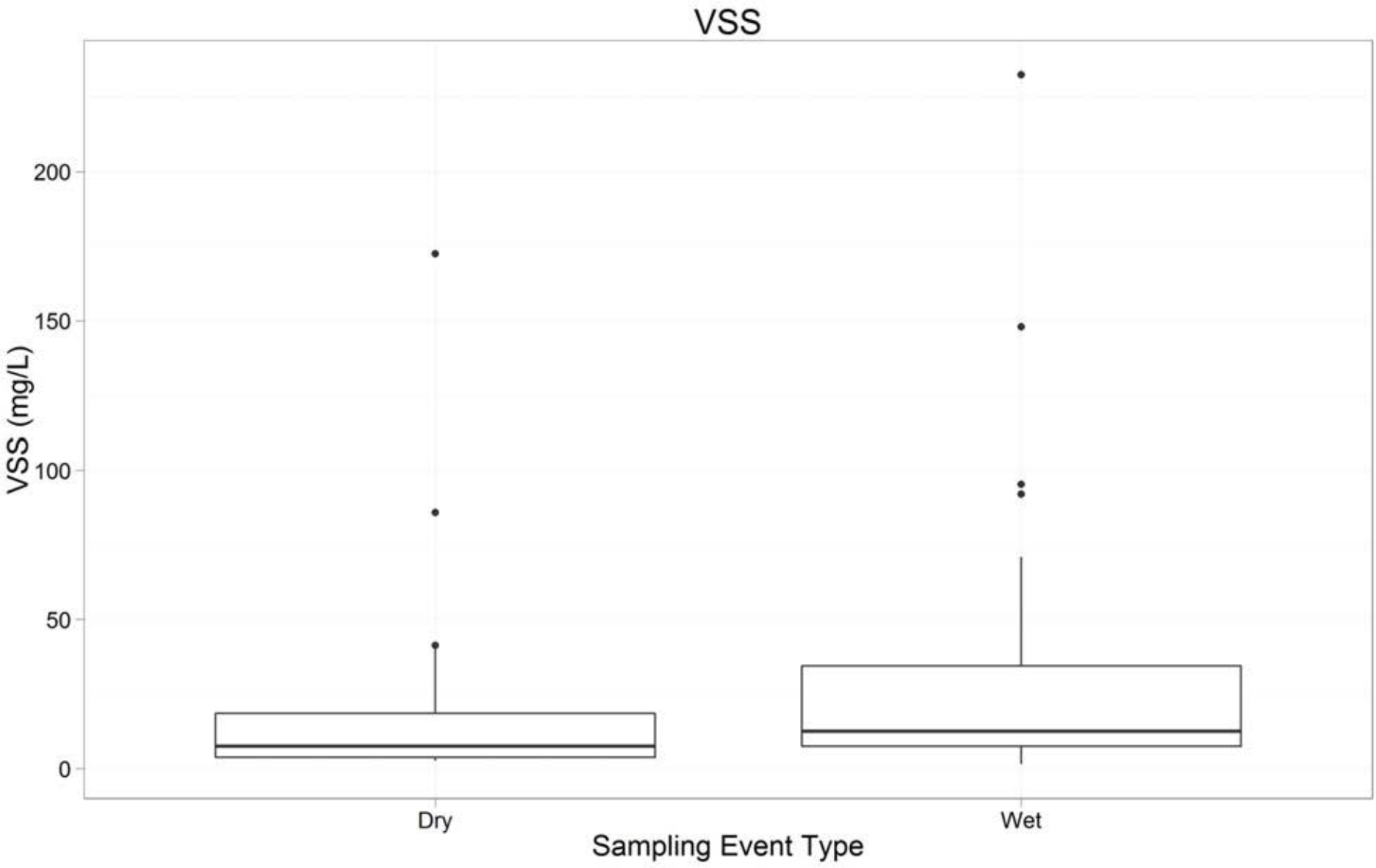

E. coli
50000
40000
30000
20000
10000
0
E. coli (MPN/100 mL)
Dry
Wet
Sampling Event Type

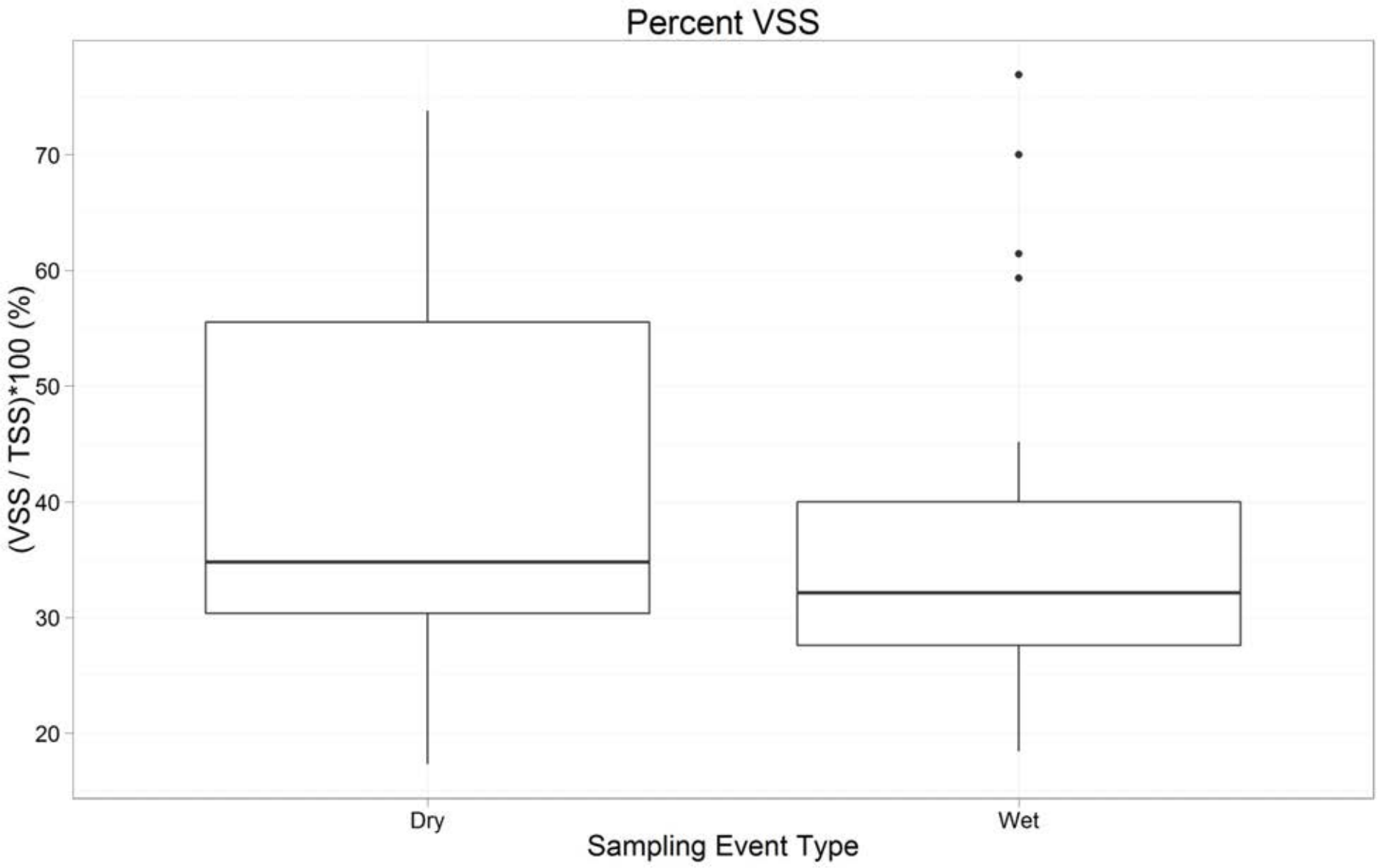

Total coliform
50000
40000
30000
20000
10000
0
Total coliform (MPN/100 mL)
Dry
Wet
Sampling Event Type

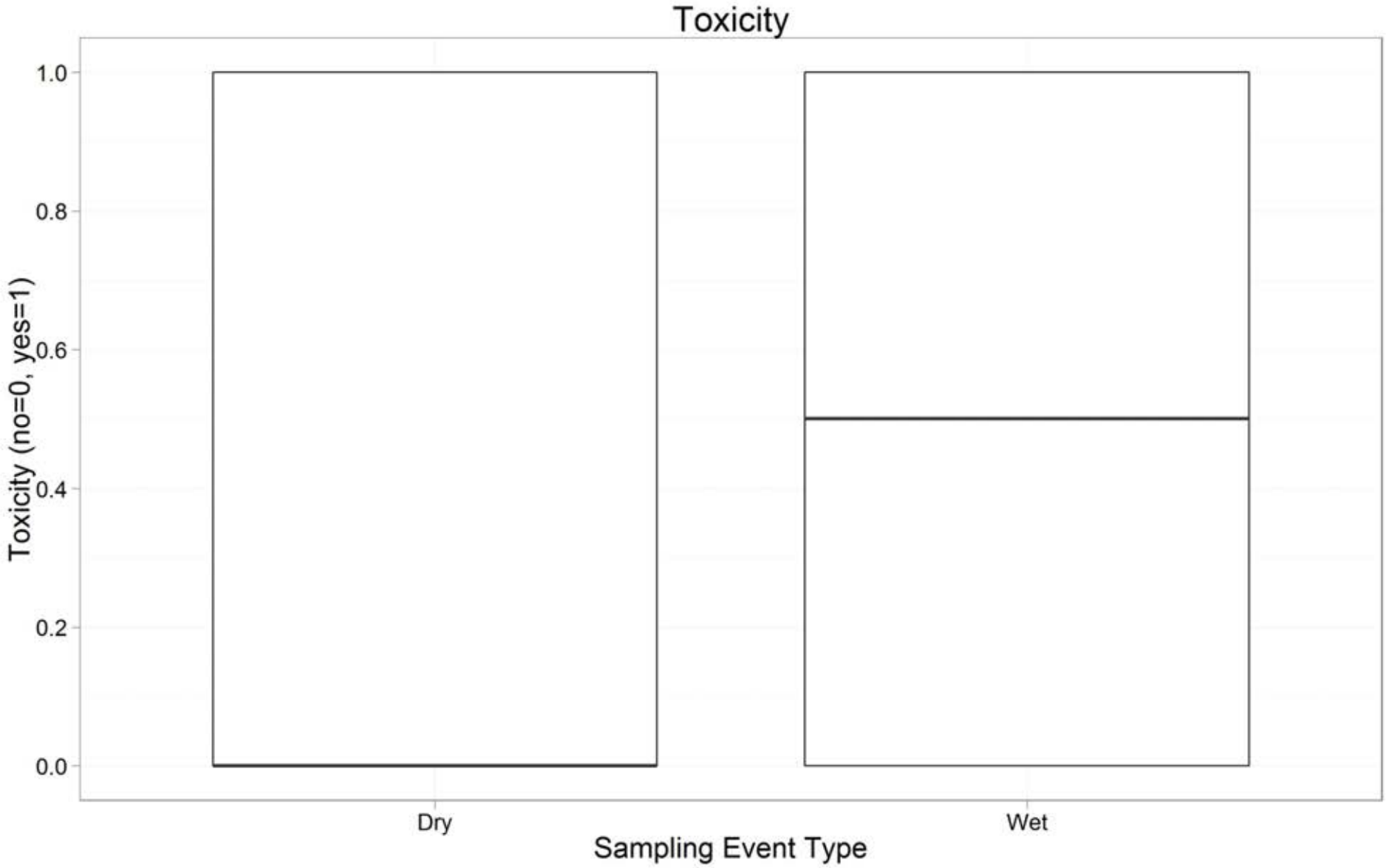

NH4-N
NH4-N (mg/L)
0.0
0.1
0.2
0.3
0.4
Dry
Wet
Sampling Event Type

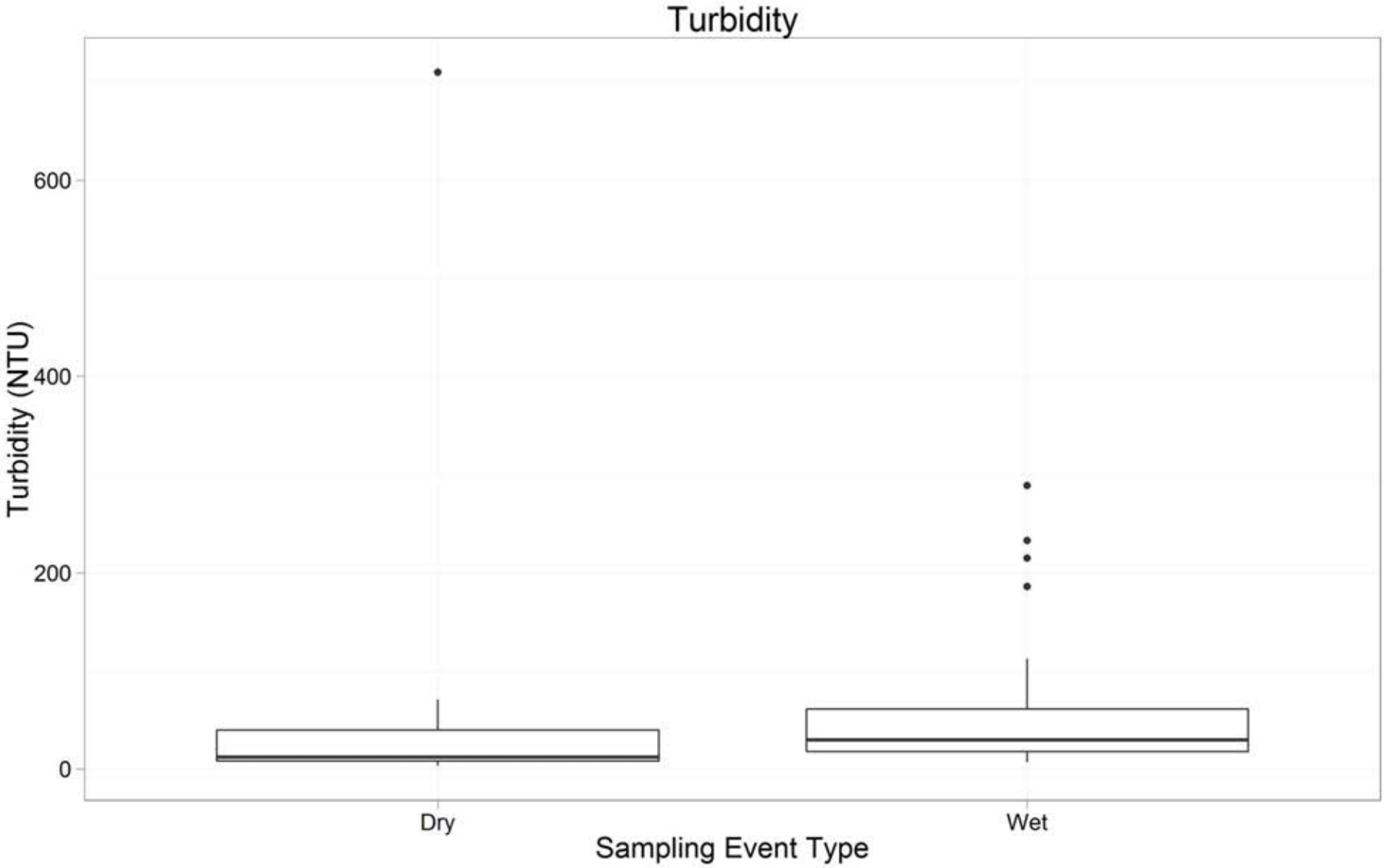

BOD5
BOD5 (mg O2/L)
30
25
20
15
10
5
0
Dry
Wet
Sampling Event Type

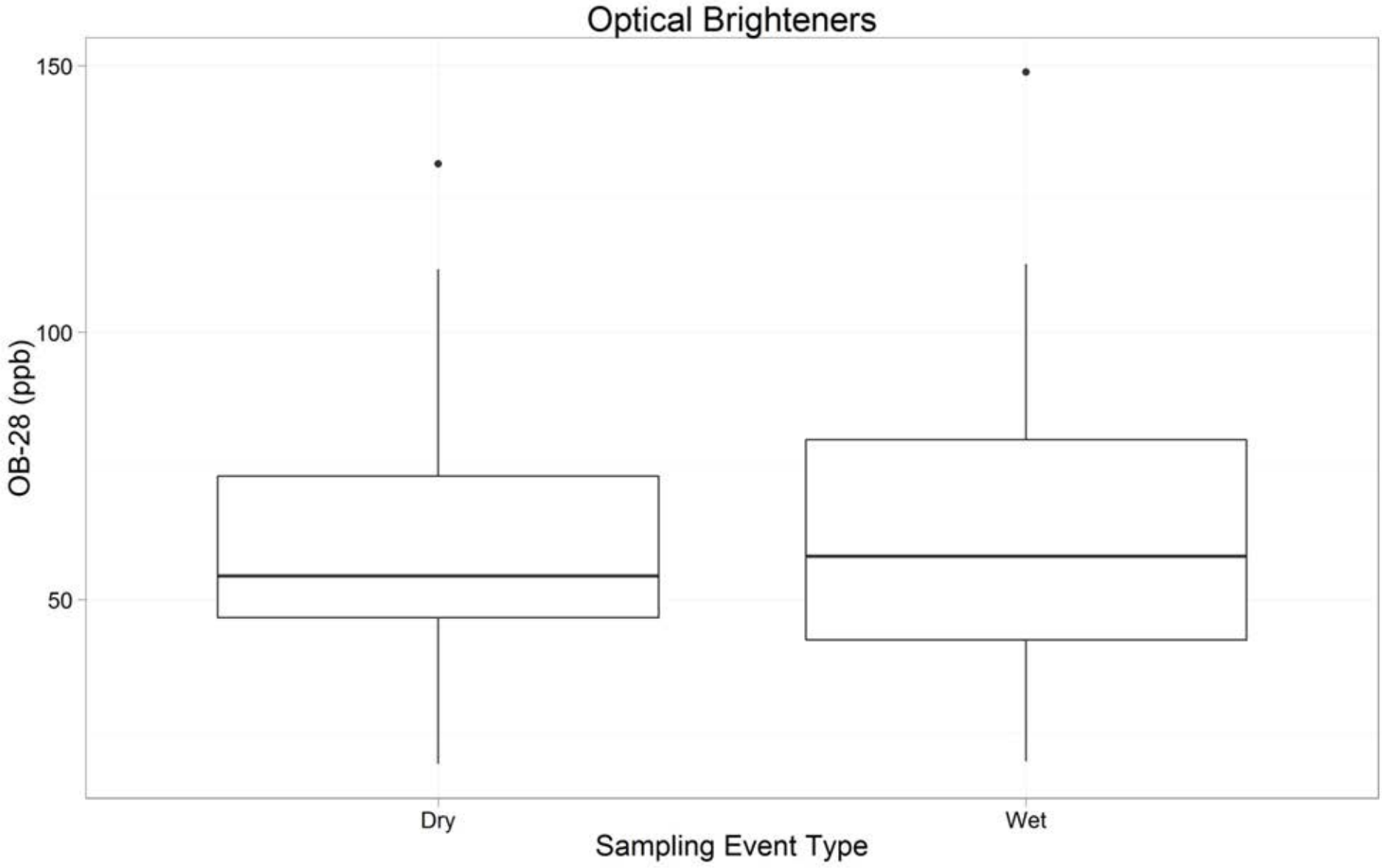

TSS
1000
800
600
400
200
0
TSS (mg/L)
Dry
Wet
Sampling Event Type

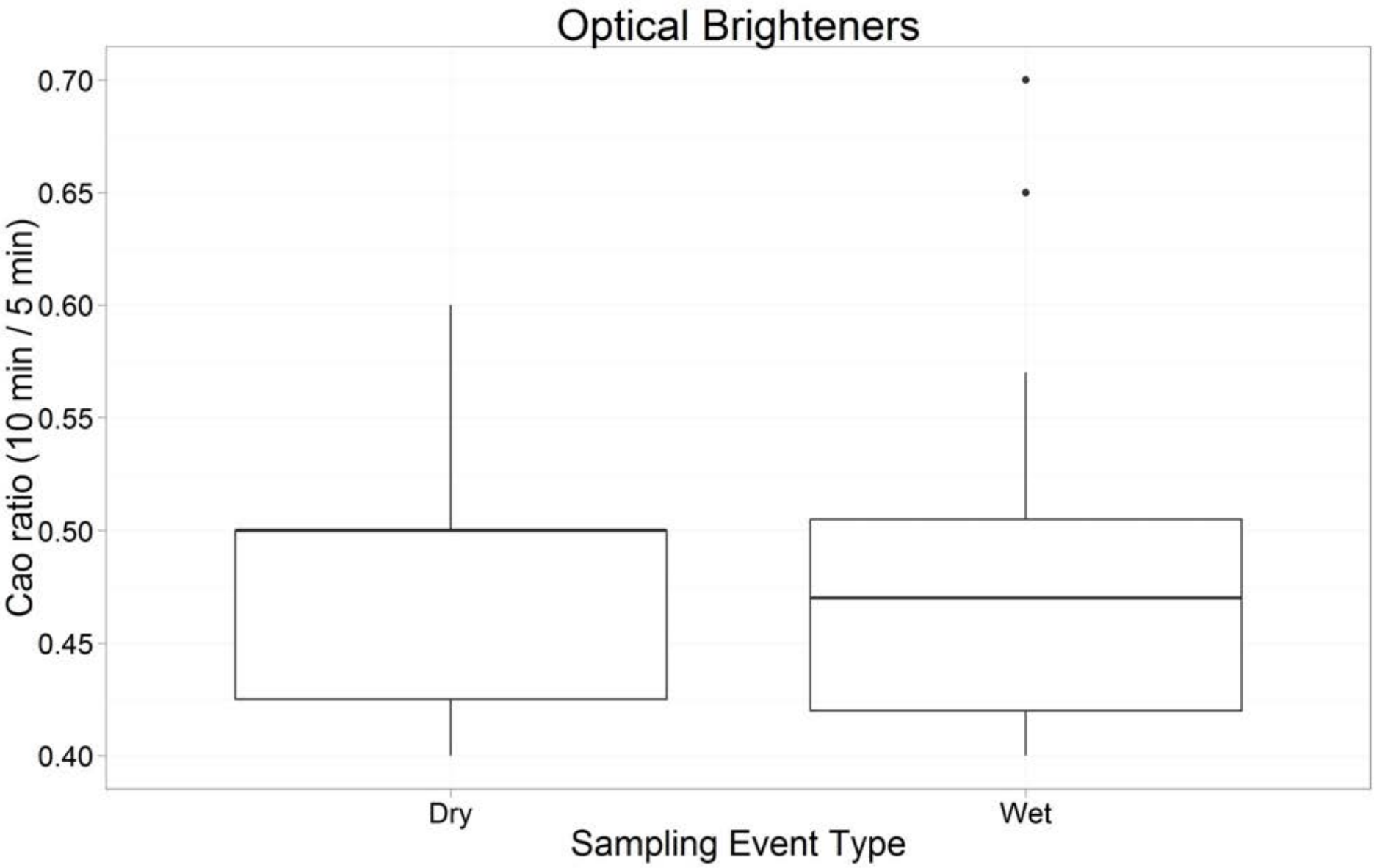

VSS
VSS (mg/L)
200
150
100
50
0
Dry
Wet
Sampling Event Type

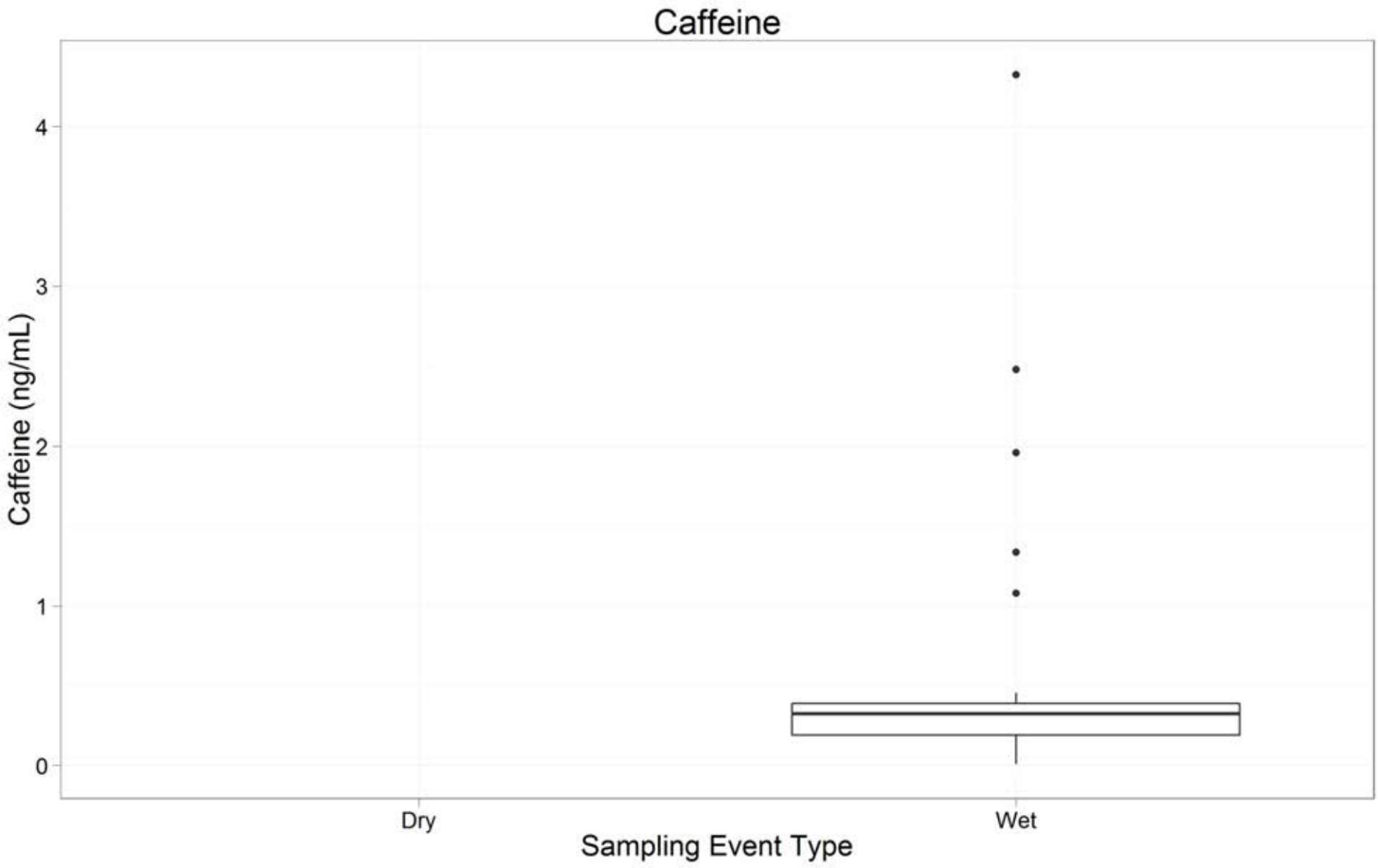

Percent VSS
(VSS / TSS)*100 (%)
70
60
50
40
30
20
Dry
Wet
Sampling Event Type

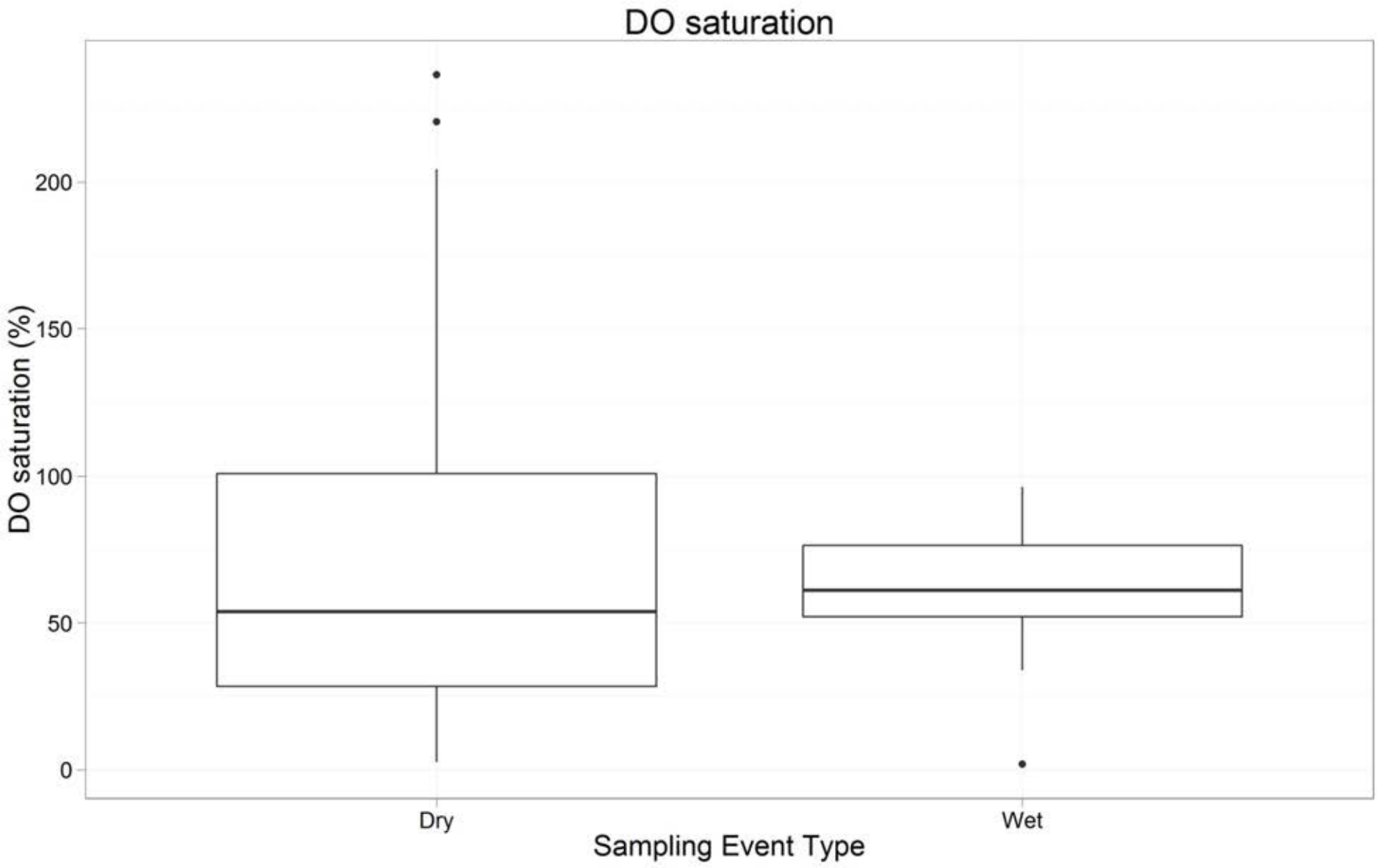

Toxicity
Toxicity (no=0, yes=1)
1.0
0.8
0.6
0.4
0.2
0.0
Dry
Wet
Sampling Event Type

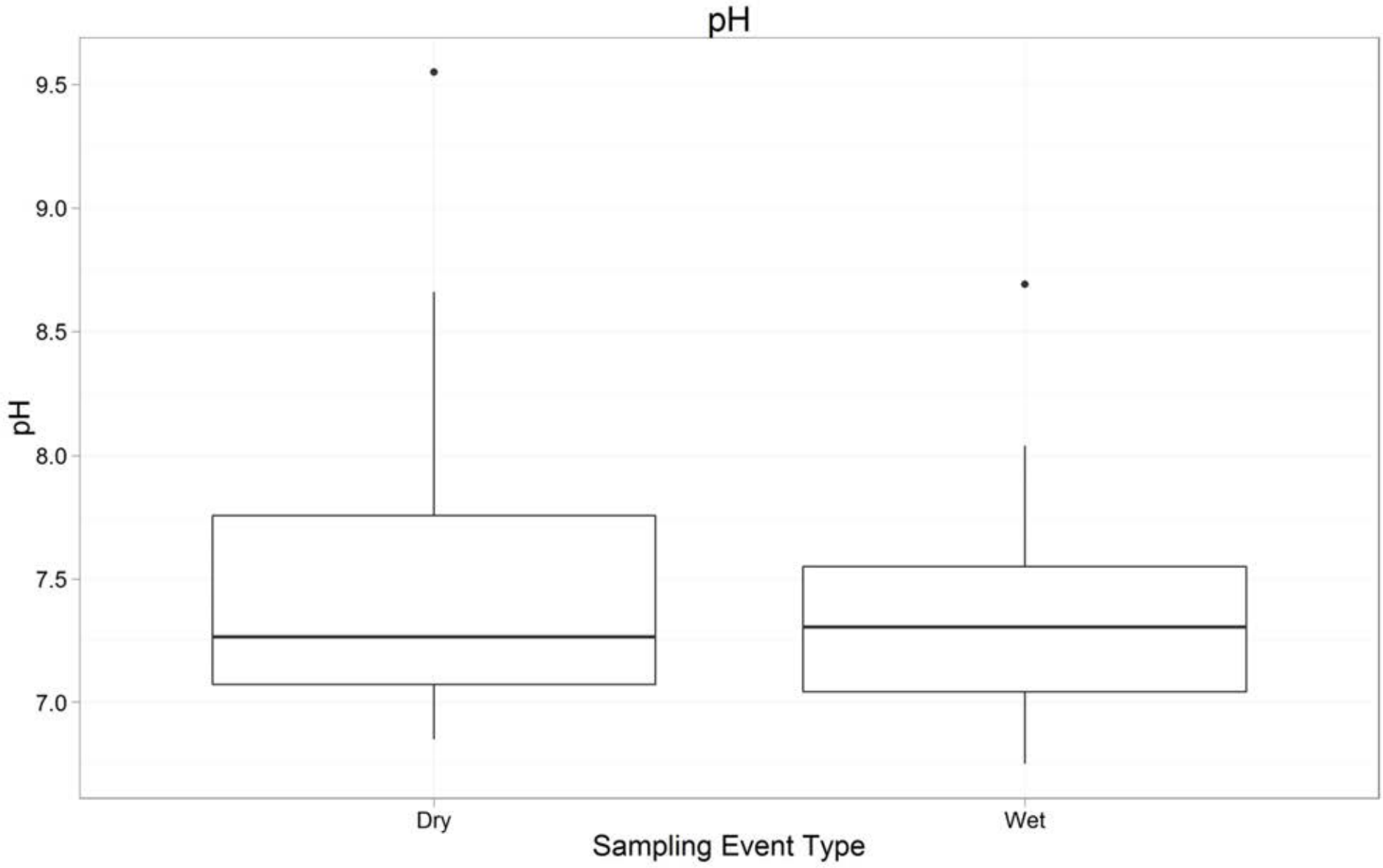

Turbidity
Turbidity (NTU)
600
400
200
0
Dry
Wet
Sampling Event Type

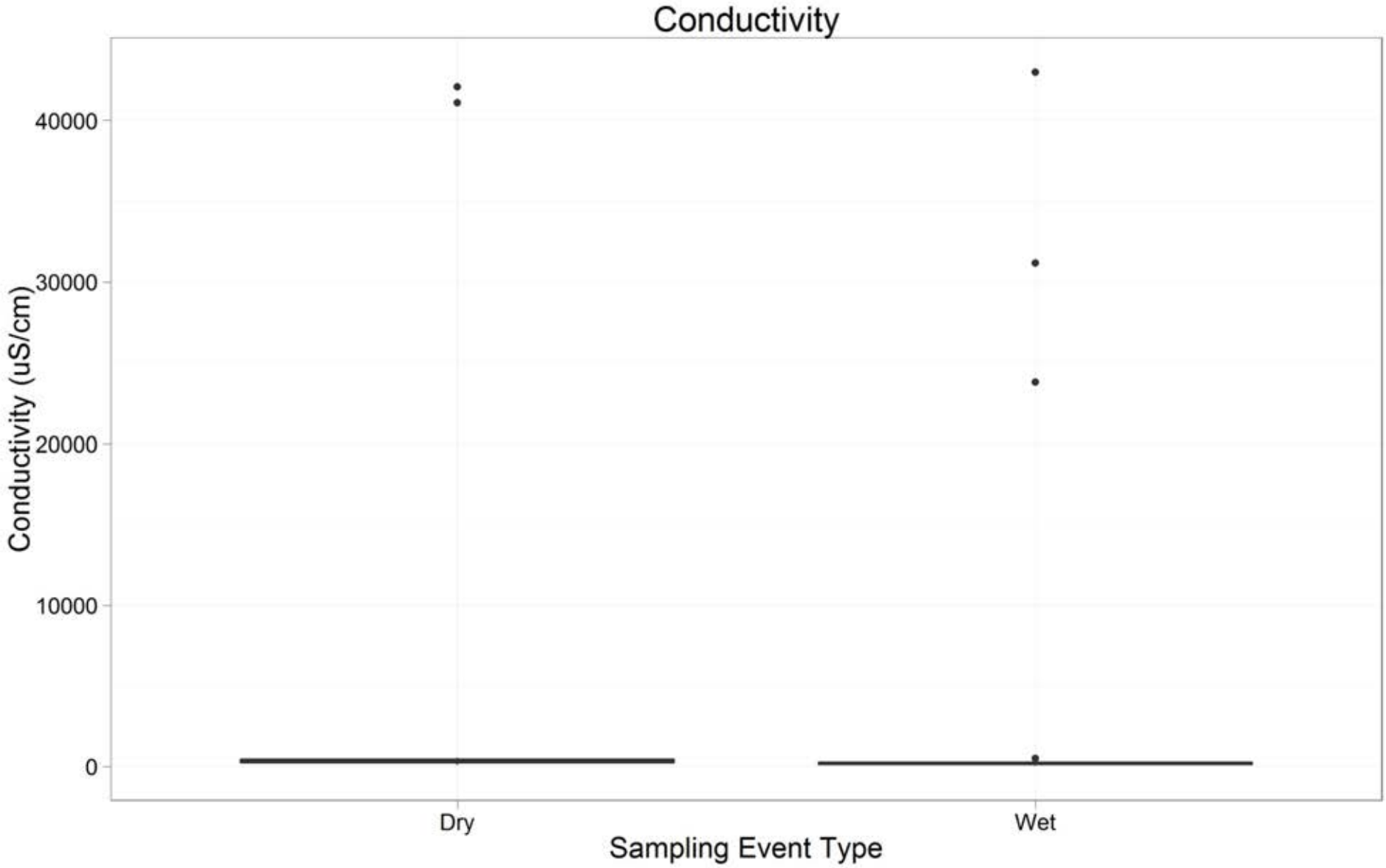

Optical Brighteners
150
100
50
OB-28 (ppb)
Dry
Wet
Sampling Event Type


Optical Brighteners
0.70
0.65
0.60
0.55
0.50
0.45
0.40
Cao ratio (10 min / 5 min)
Dry
Wet
Sampling Event Type

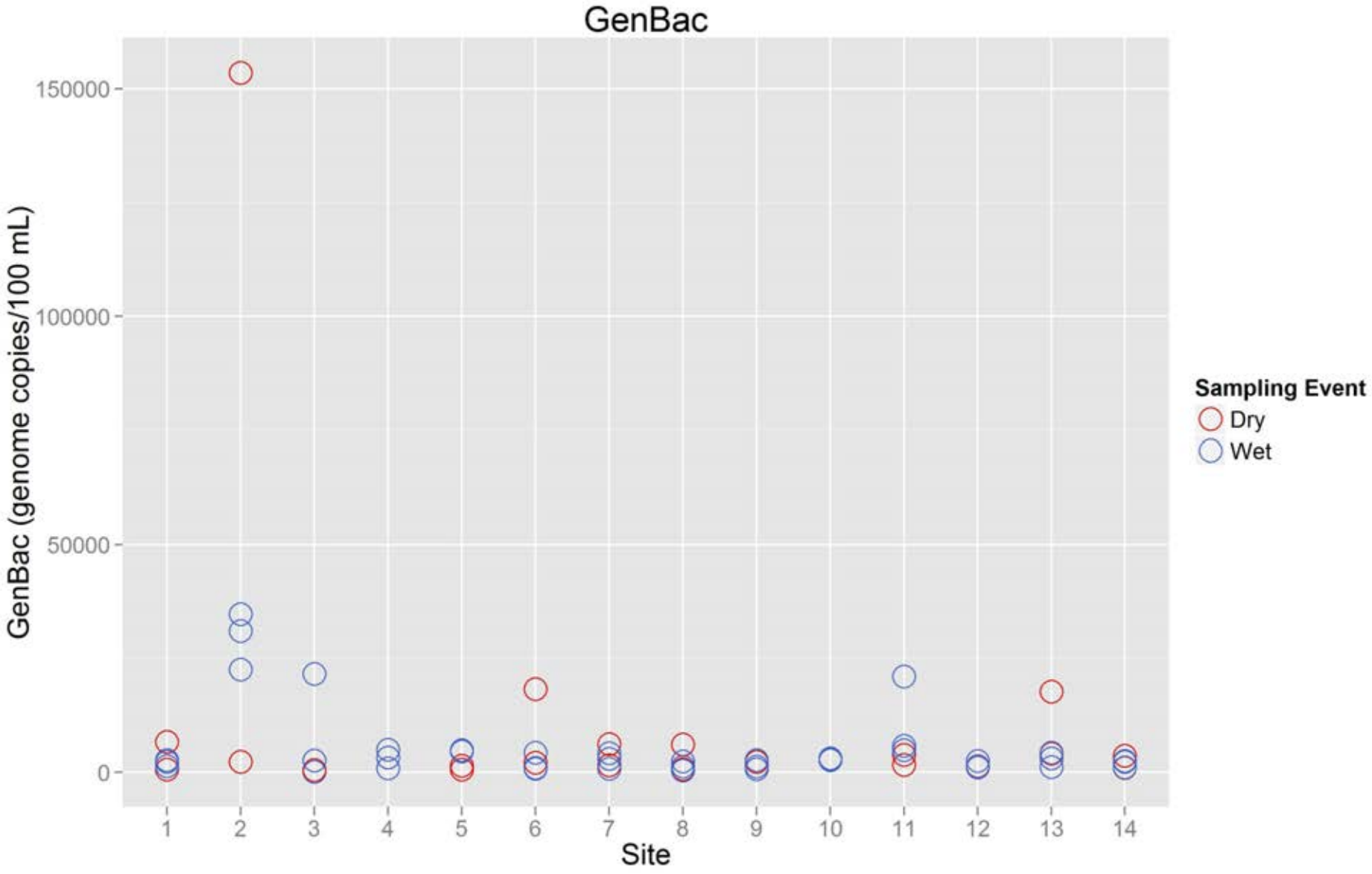

Caffeine
Caffeine (ng/mL)
4
3
2
1
0
Dry
Wet
Sampling Event Type

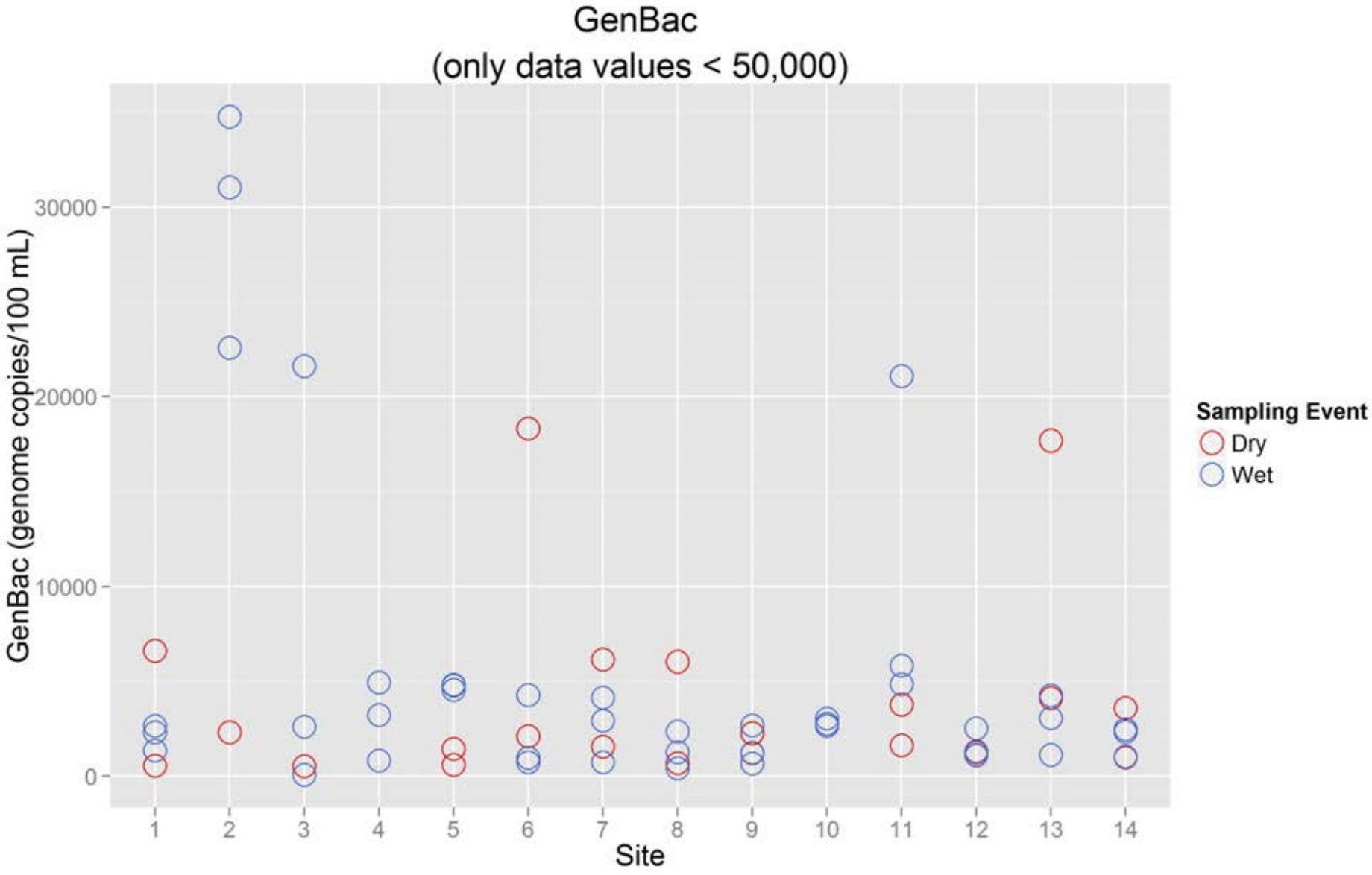

DO saturation
DO saturation (%)
200
150
100
50
0
Dry
Wet
Sampling Event Type

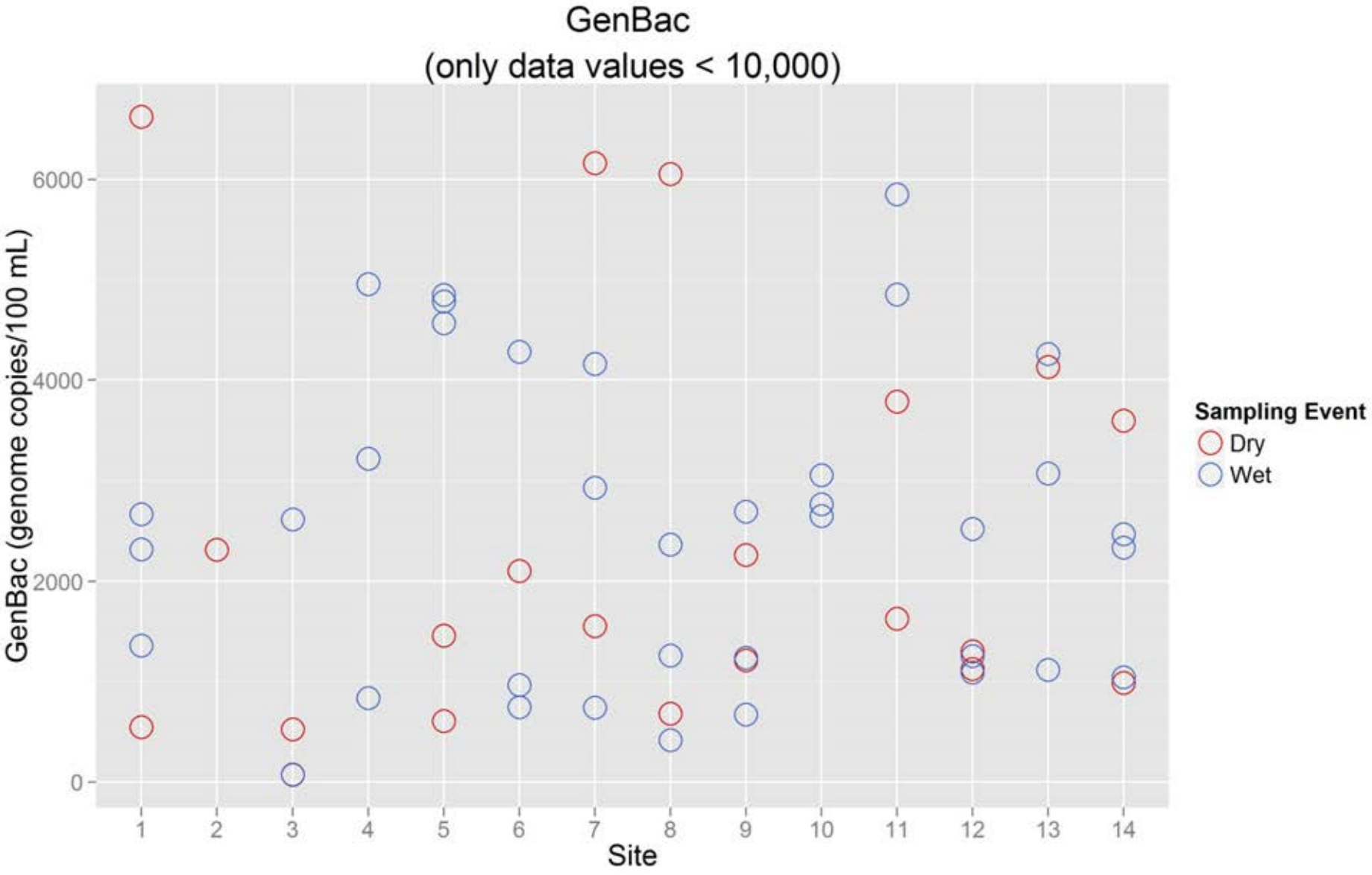

pH
9.5
9.0
8.5
8.0
7.5
7.0
pH
Dry
Wet
Sampling Event Type

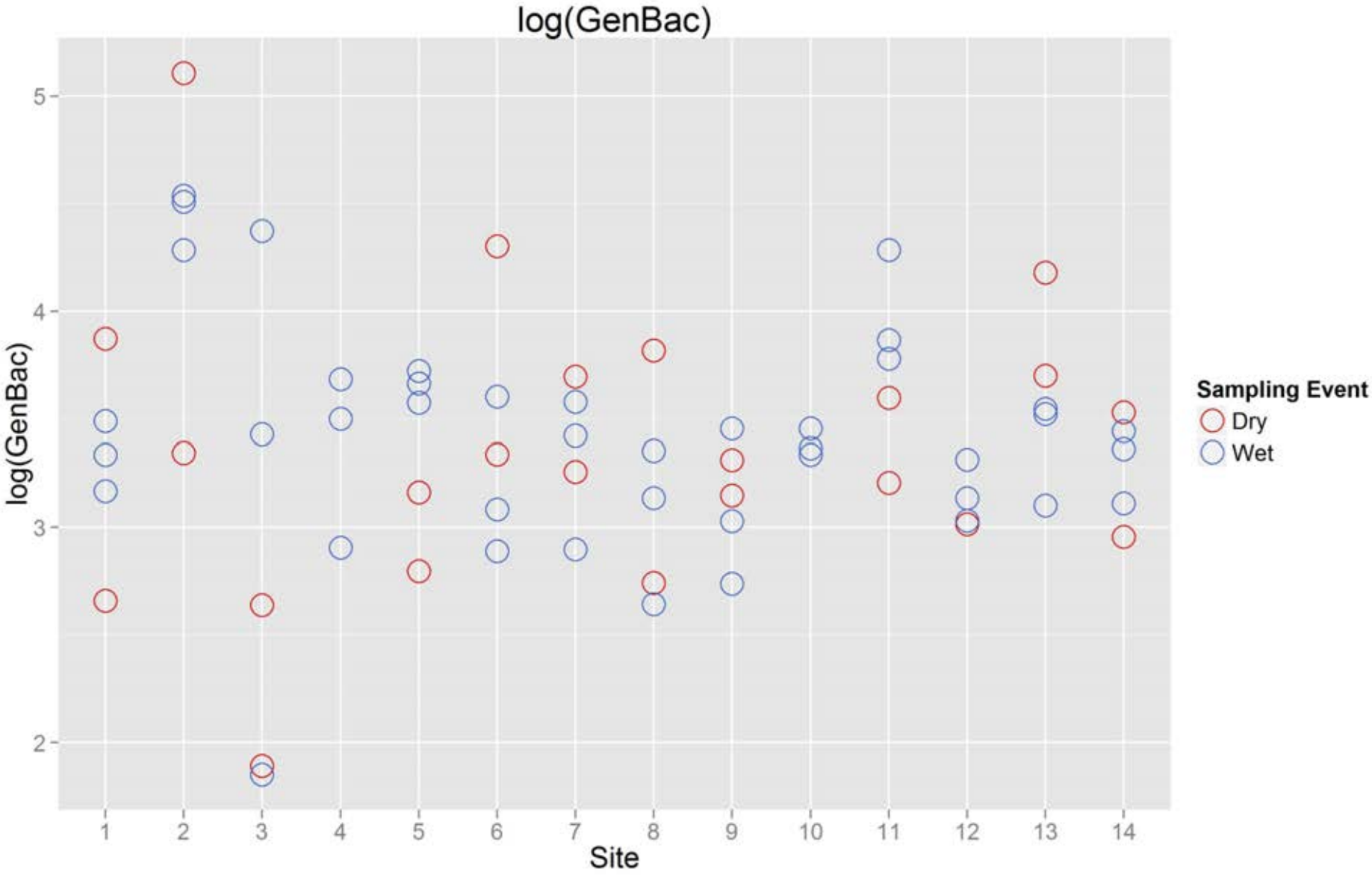

Conductivity
40000
30000
20000
10000
0
Conductivity (uS/cm)
Dry
Wet
Sampling Event Type

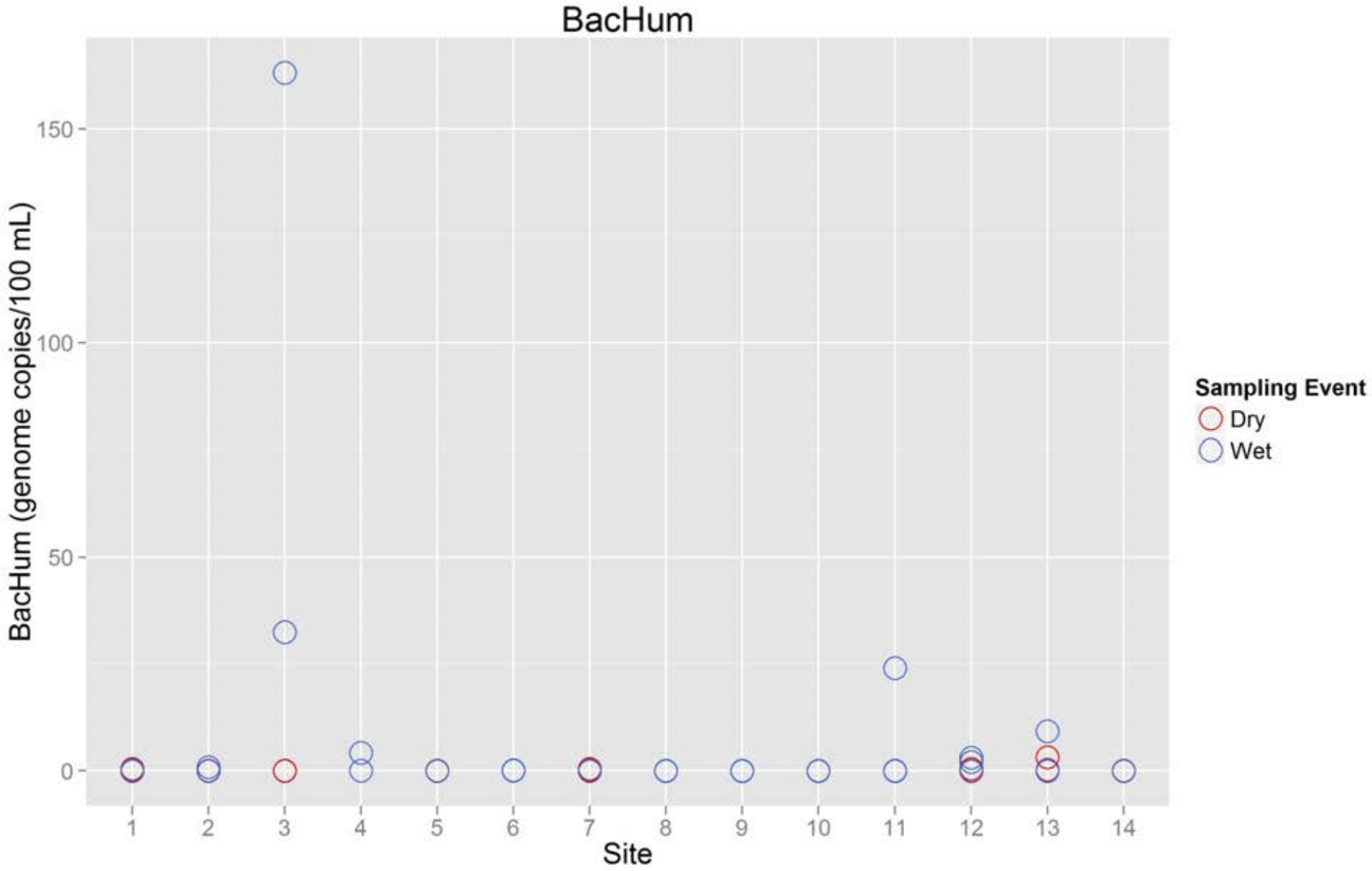
Dot Plots of Water Quality Parameters

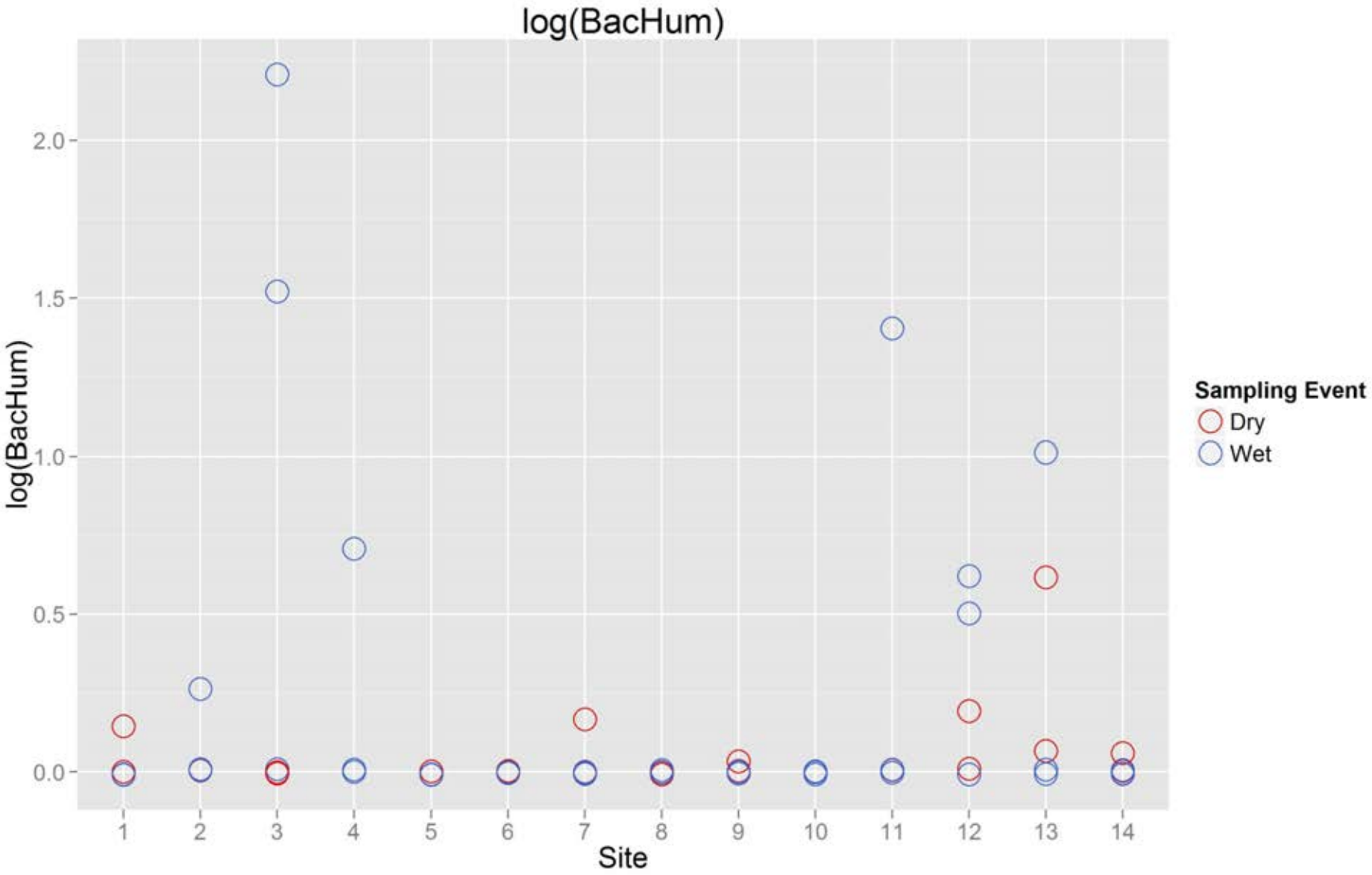

GenBac
GenBac (genome copies/100 mL)
150000
100000
50000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


GenBac
(only data values < 50,000)
GenBac (genome copies/100 mL)
30000
20000
10000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

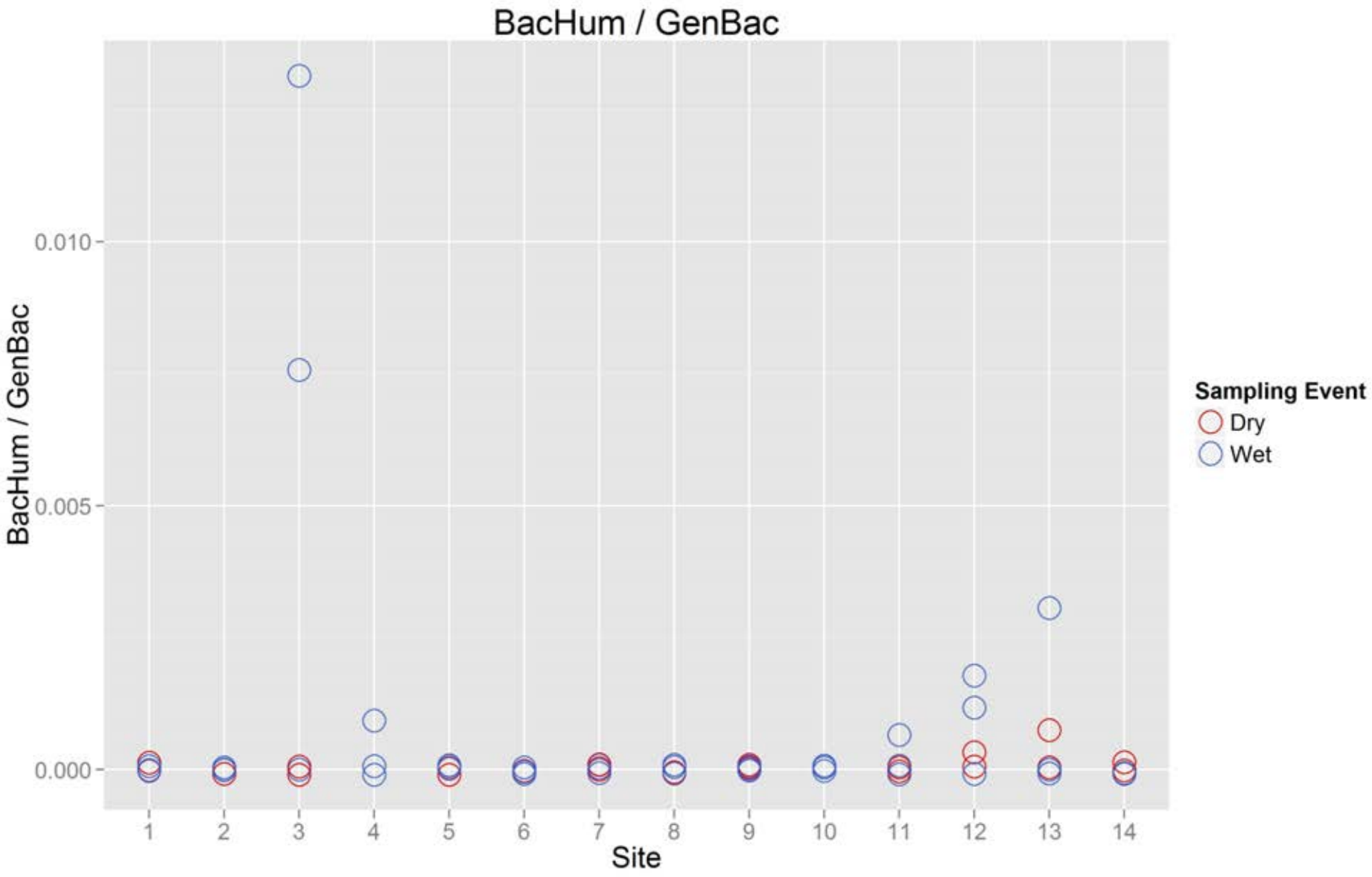

GenBac
(only data values < 10,000)
GenBac (genome copies/100 mL)
6000
4000
2000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

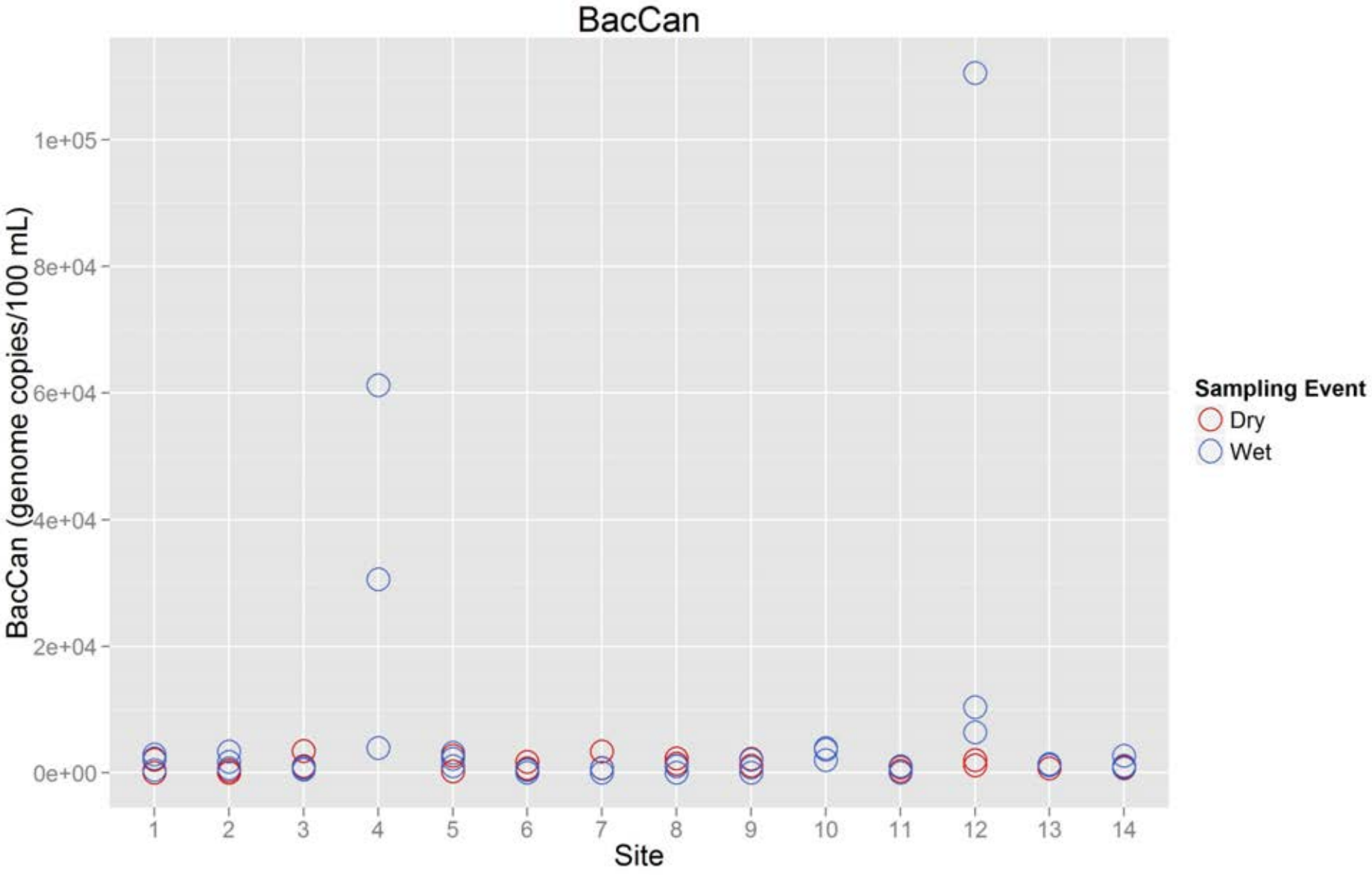

log(GenBac)
log(GenBac)
5
4
3
2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

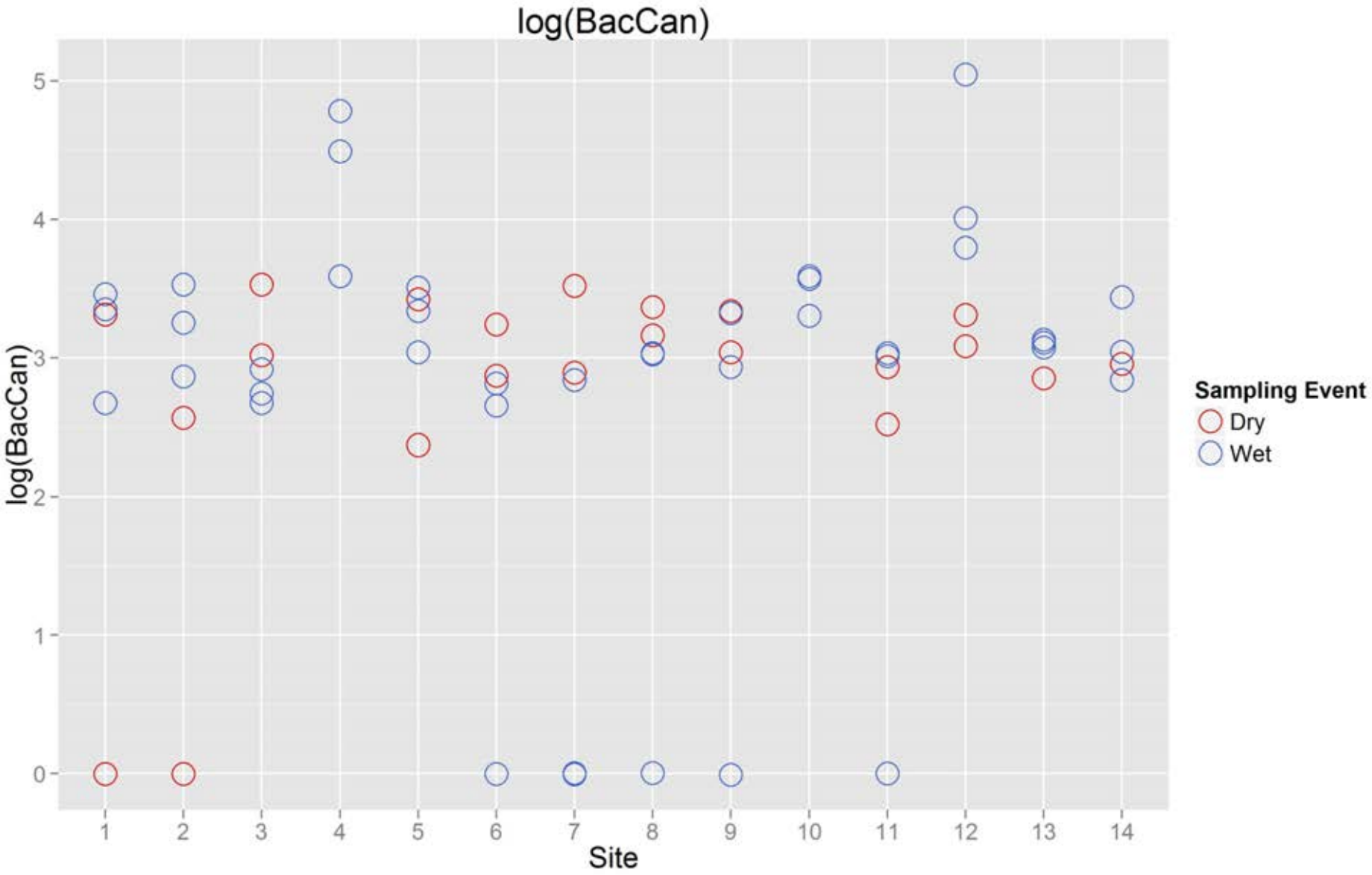

BacHum
BacHum (genome copies/100 mL)
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet



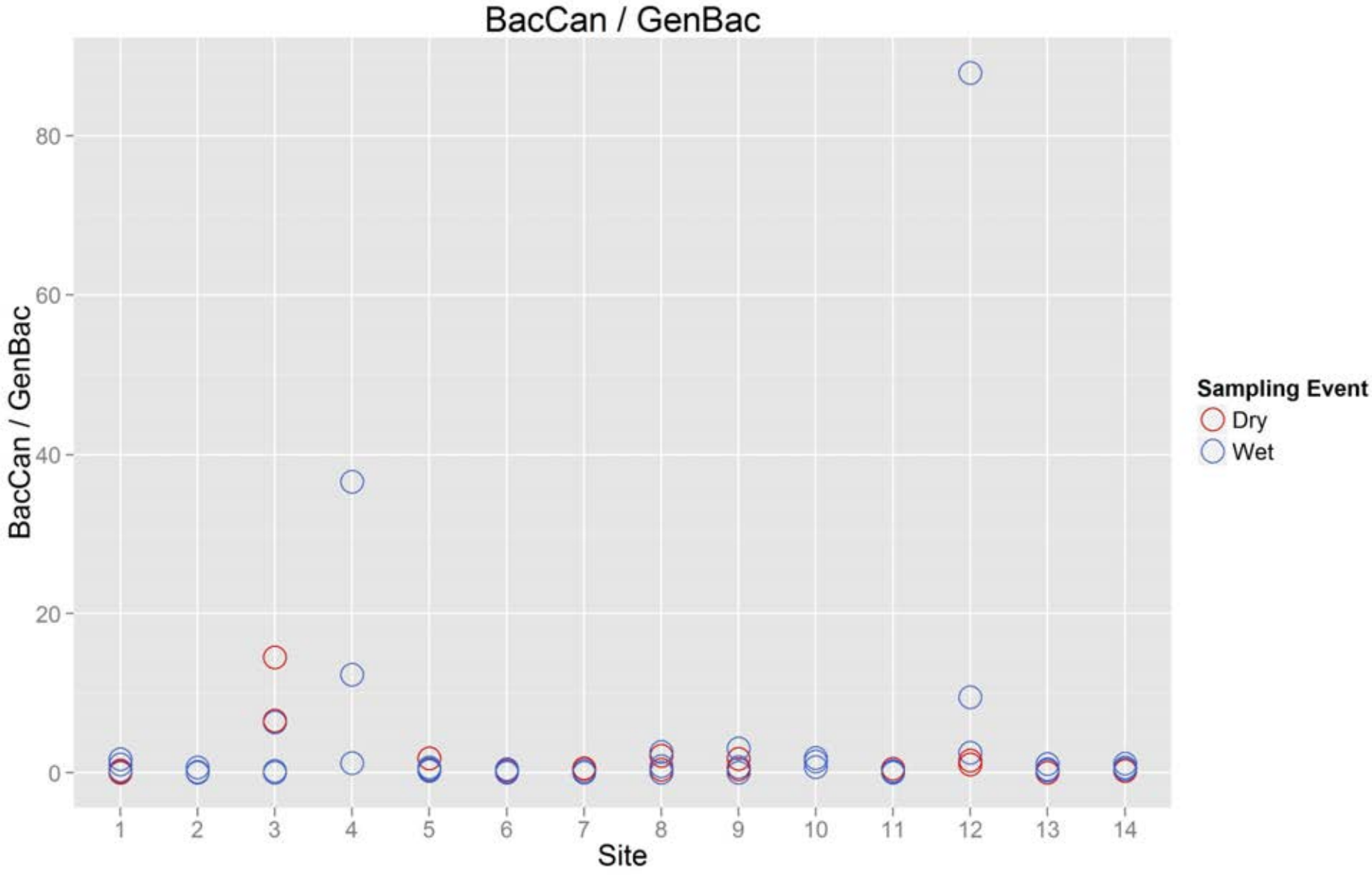
A value of 1 was added to each value before log-transforming to avoid losing the zeroes since log(0) is undefined.

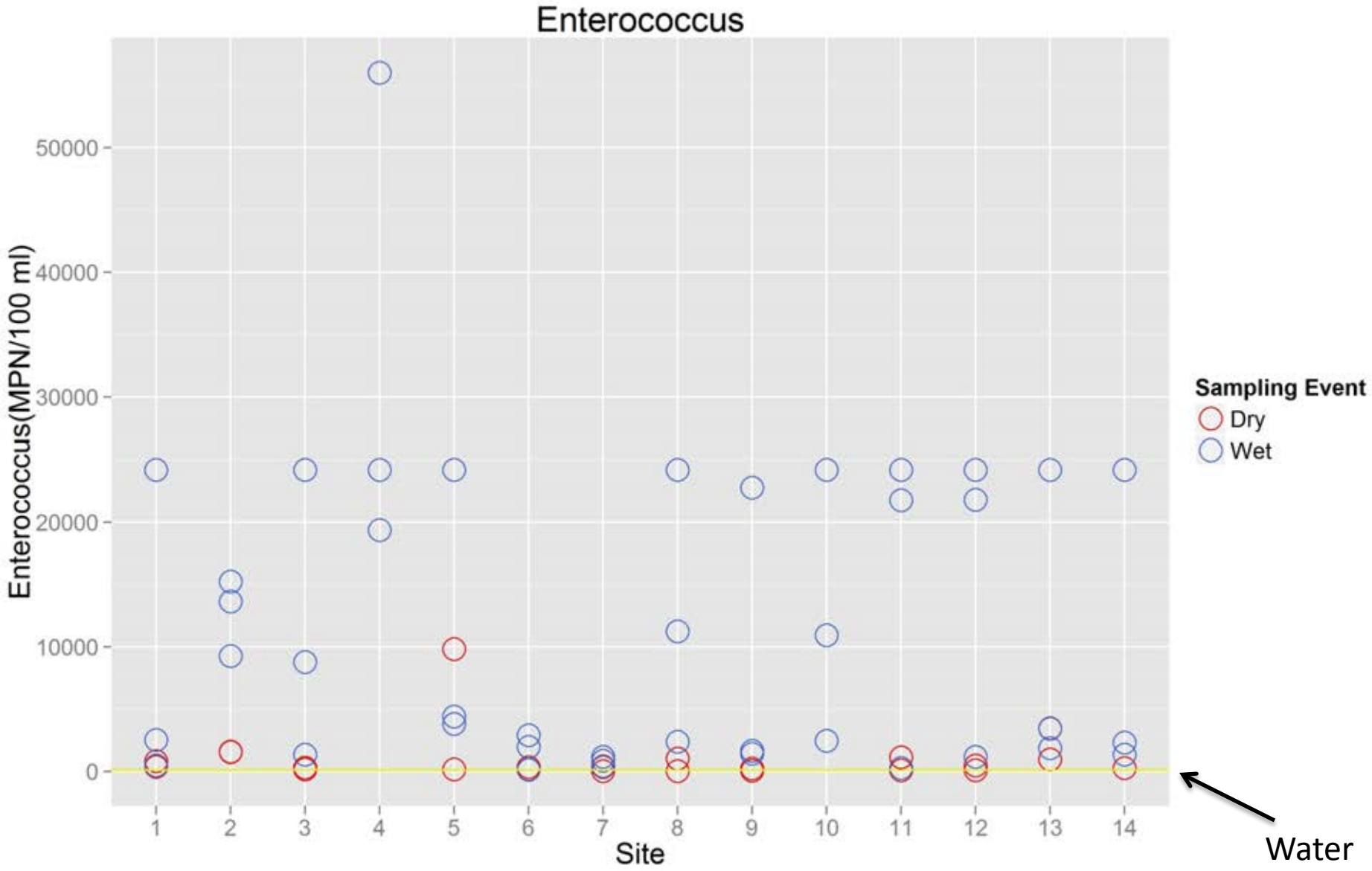

BacHum / GenBac
BacHum / GenBac
0.010
0.005
0.000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


BacCan
BacCan (genome copies/100 mL)
1e+05
8e+04
6e+04
4e+04
2e+04
0e+00
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

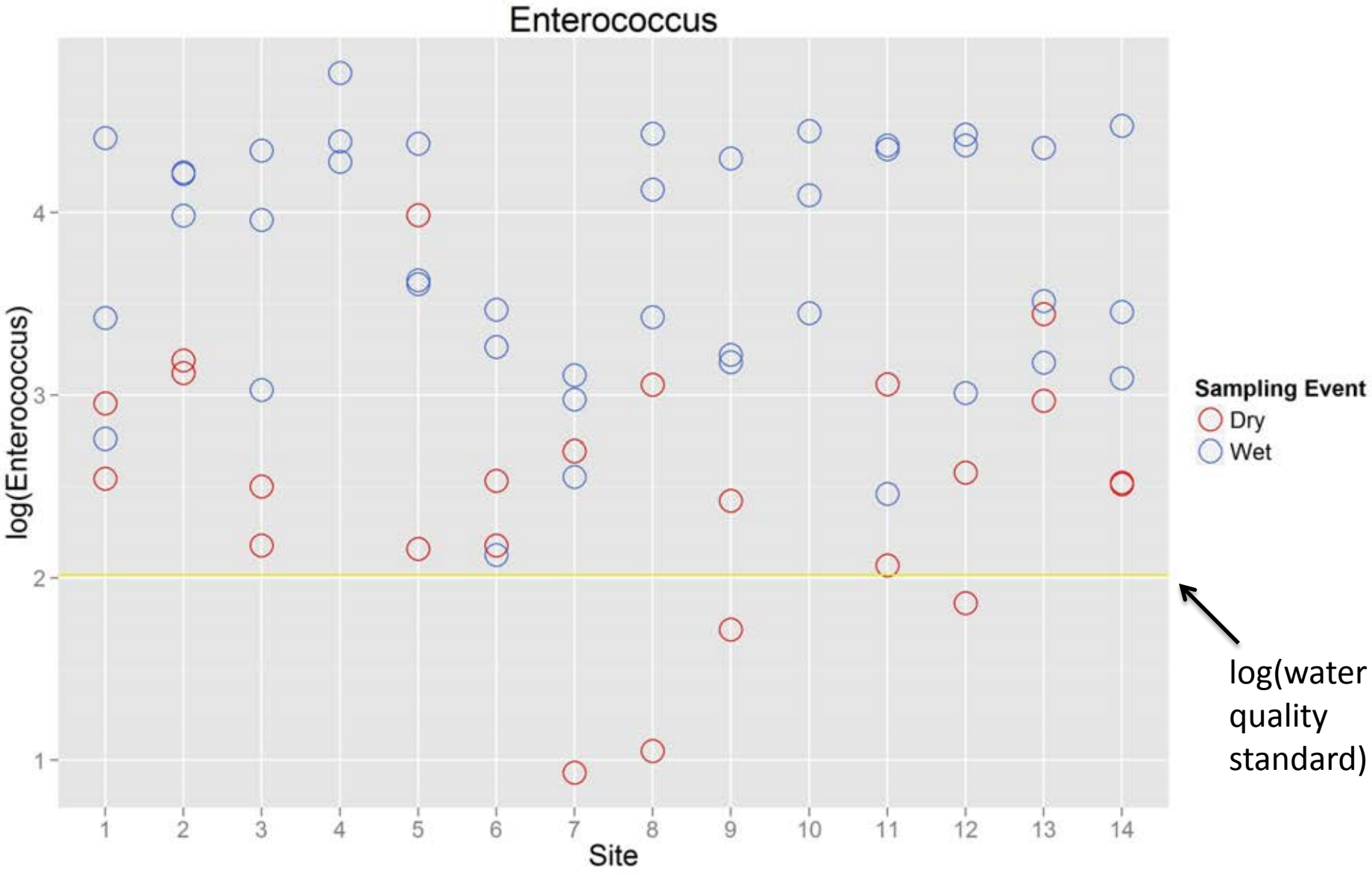


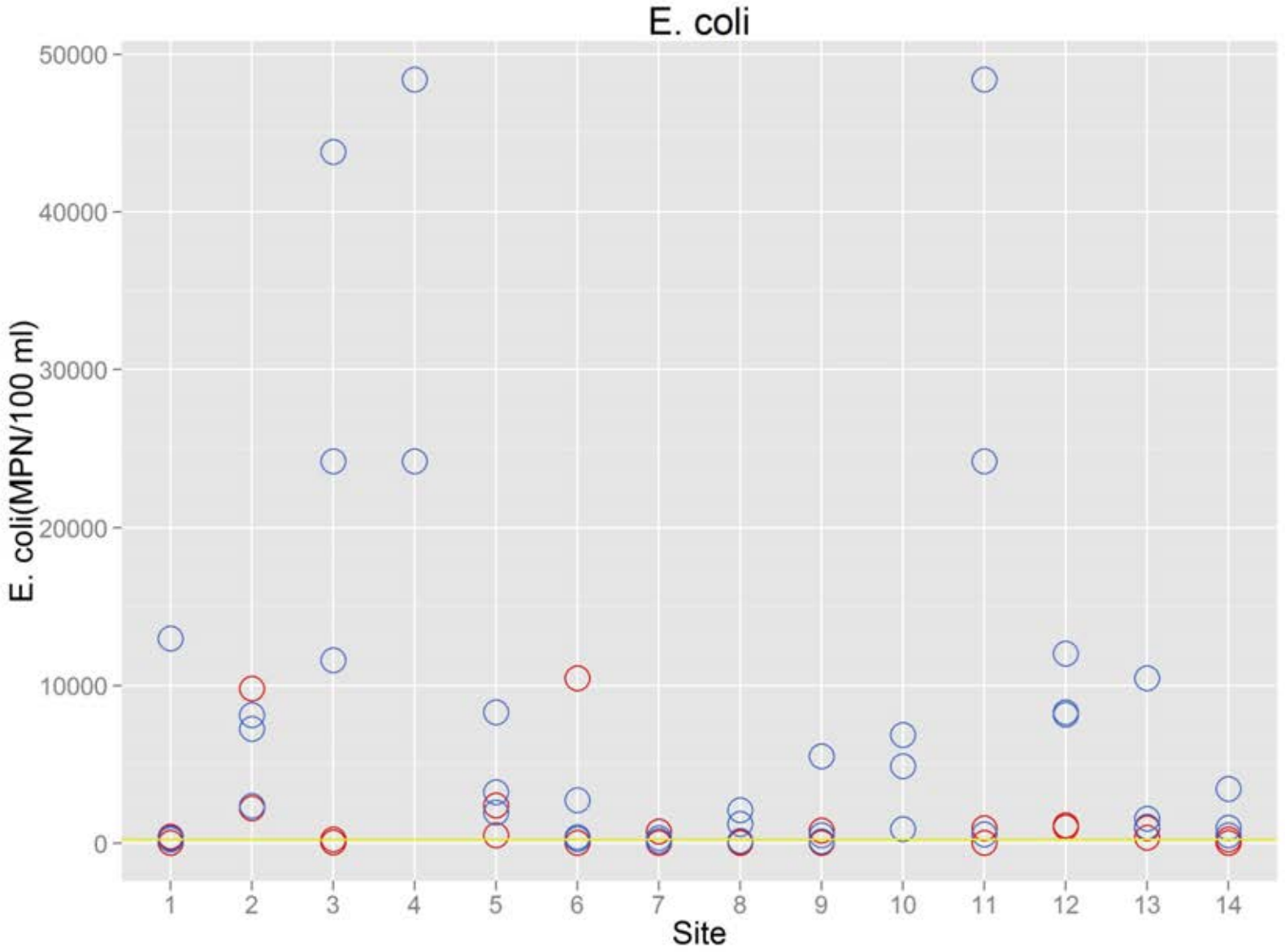
A value of 1 was added to each value before log-transforming to avoid losing the zeroes since log(0) is undefined.


BacCan / GenBac
BacCan / GenBac
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

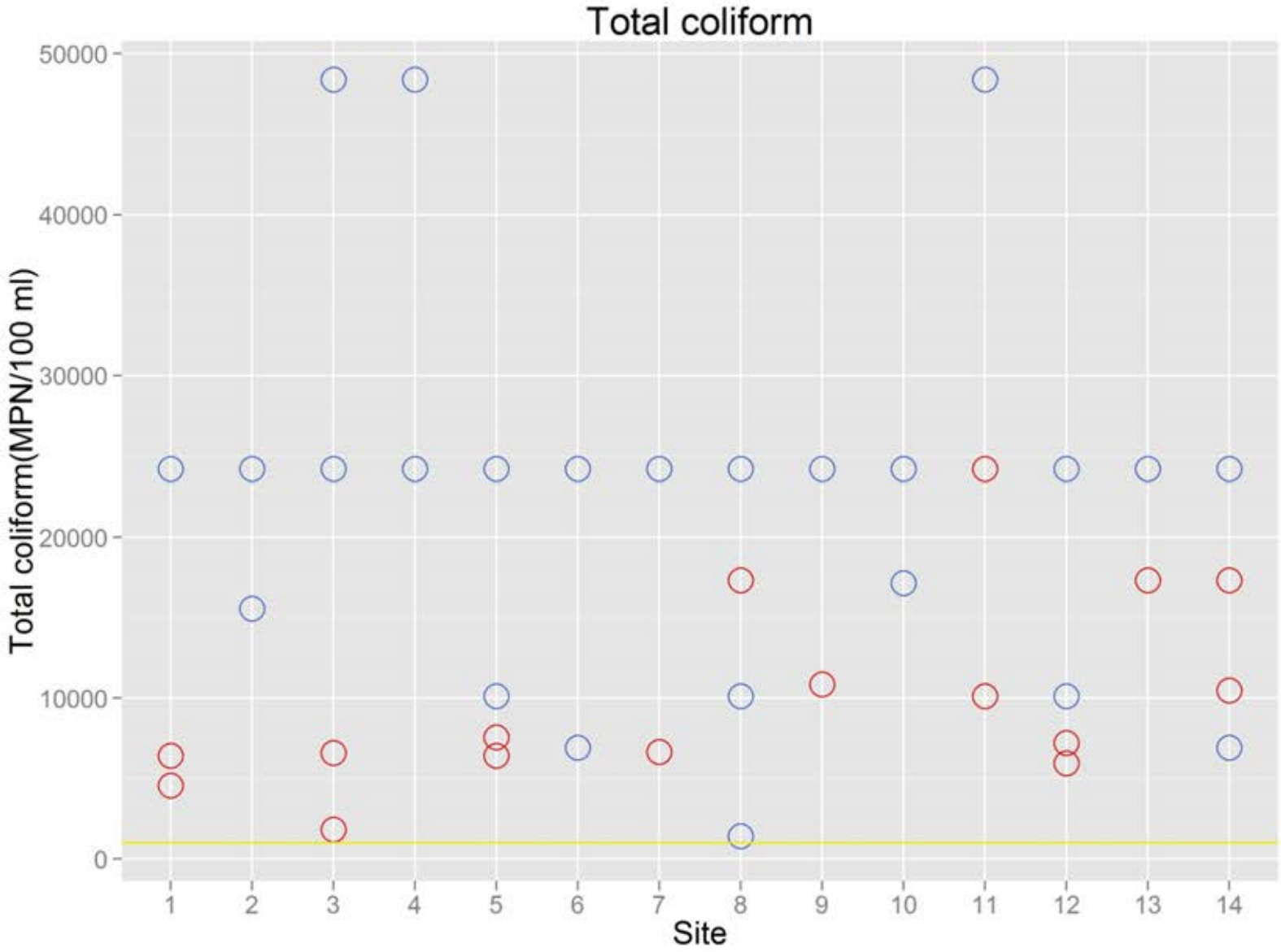


Water quality standard

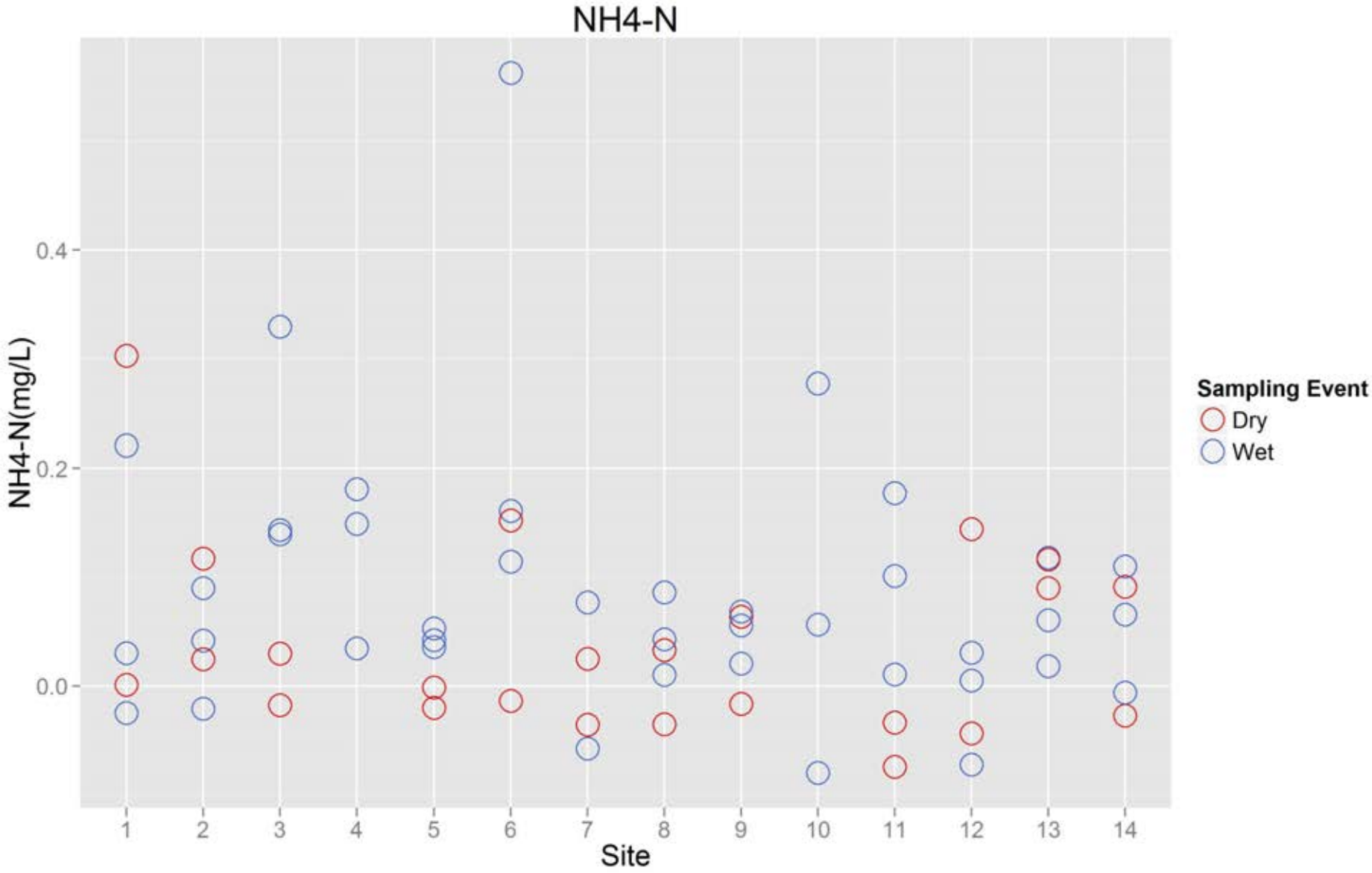

Enterococcus
log(Enterococcus)
4
3
2
1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet
log(water quality standard)

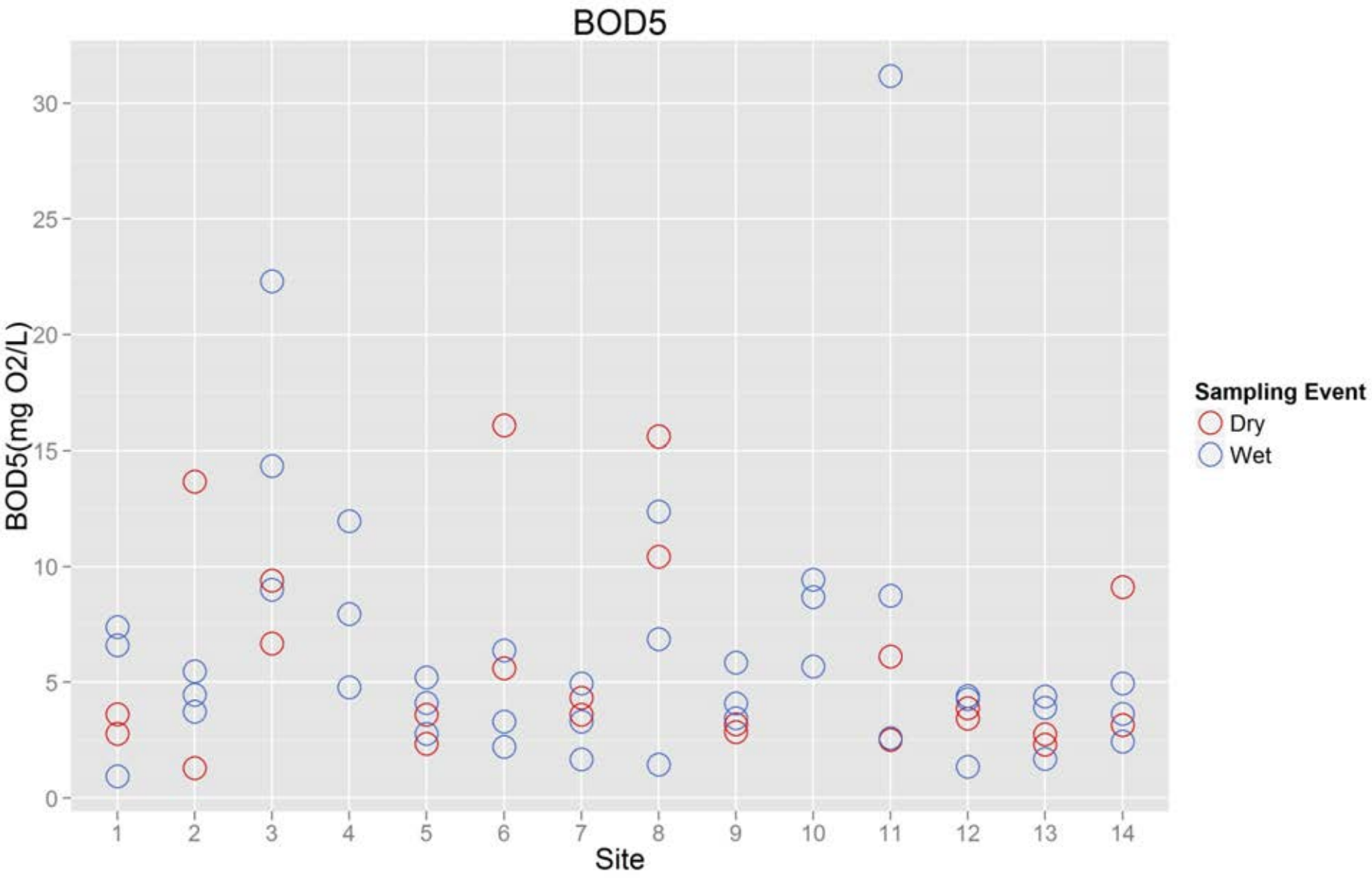


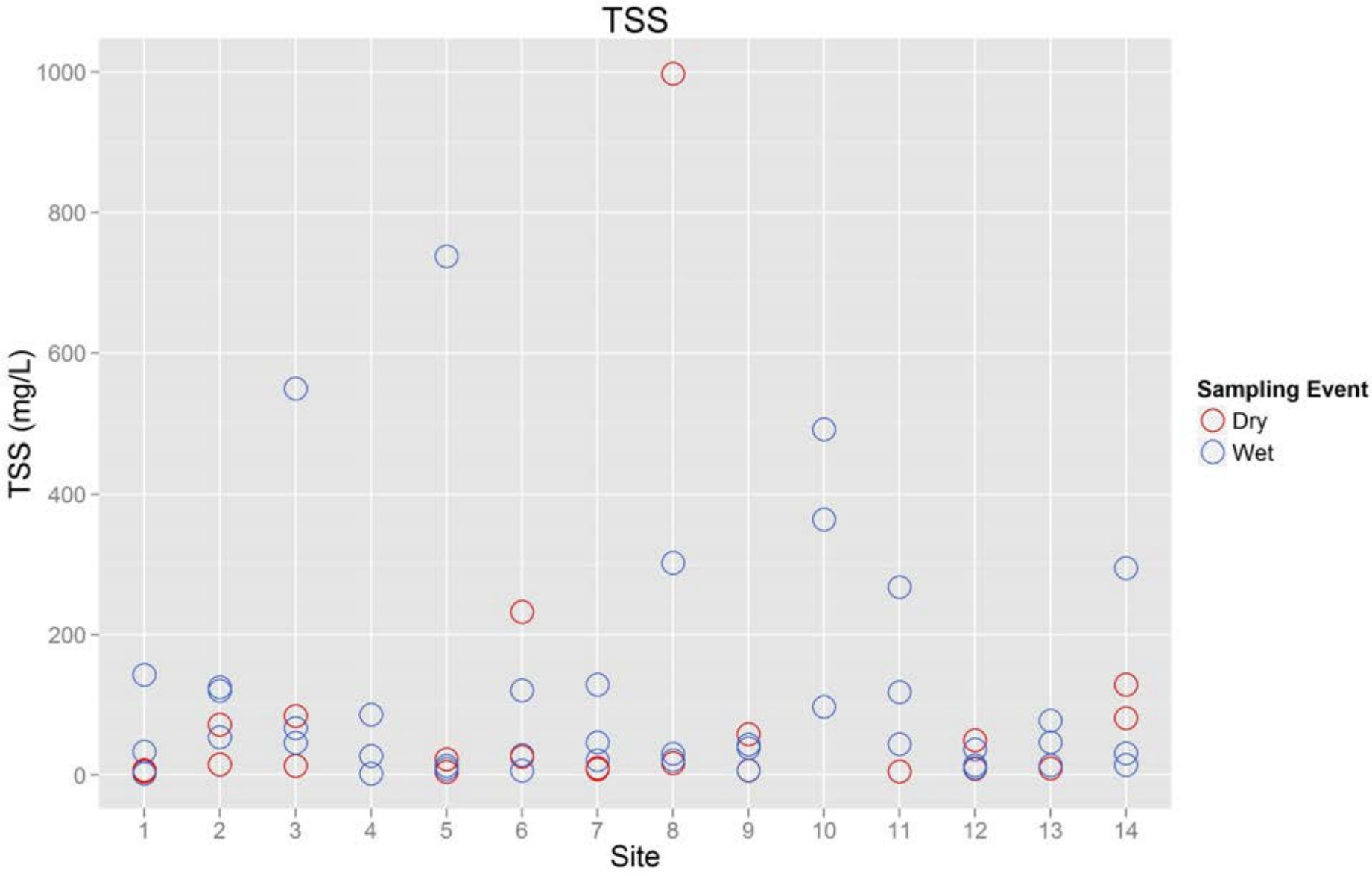
Water quality standard

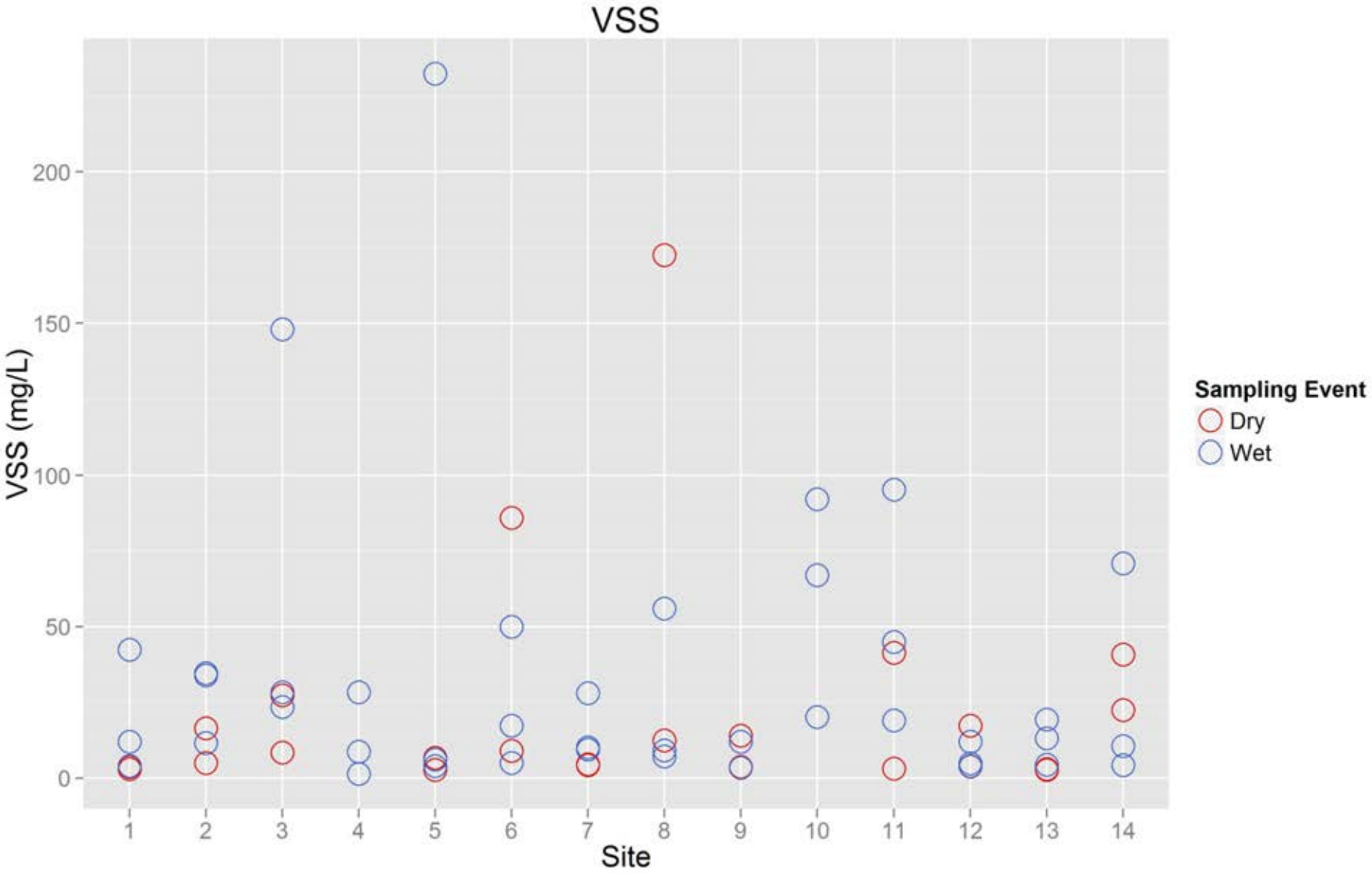


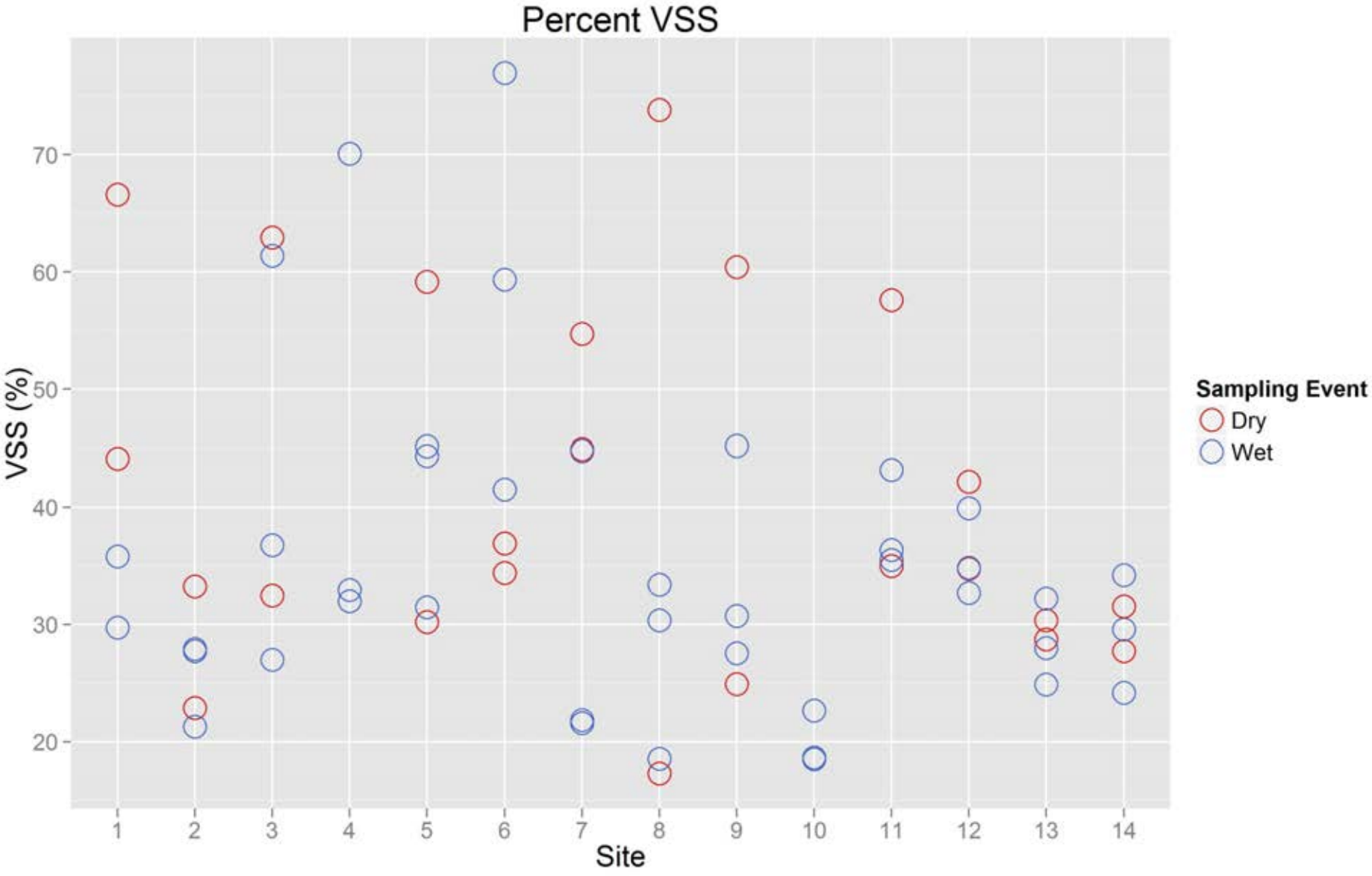
Water quality standard

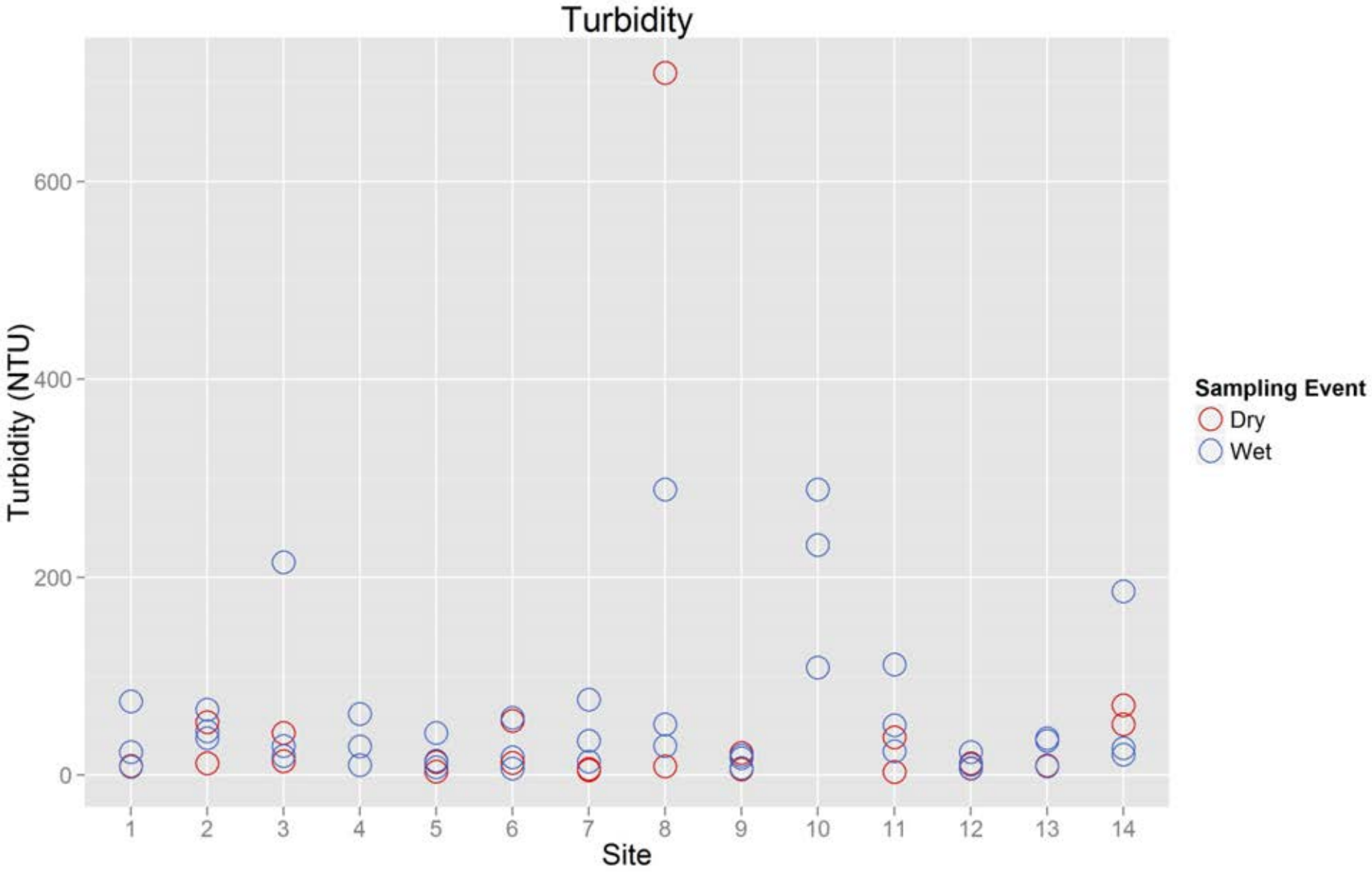

NH4-N
NH4-N(mg/L)
0.4
0.2
0.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

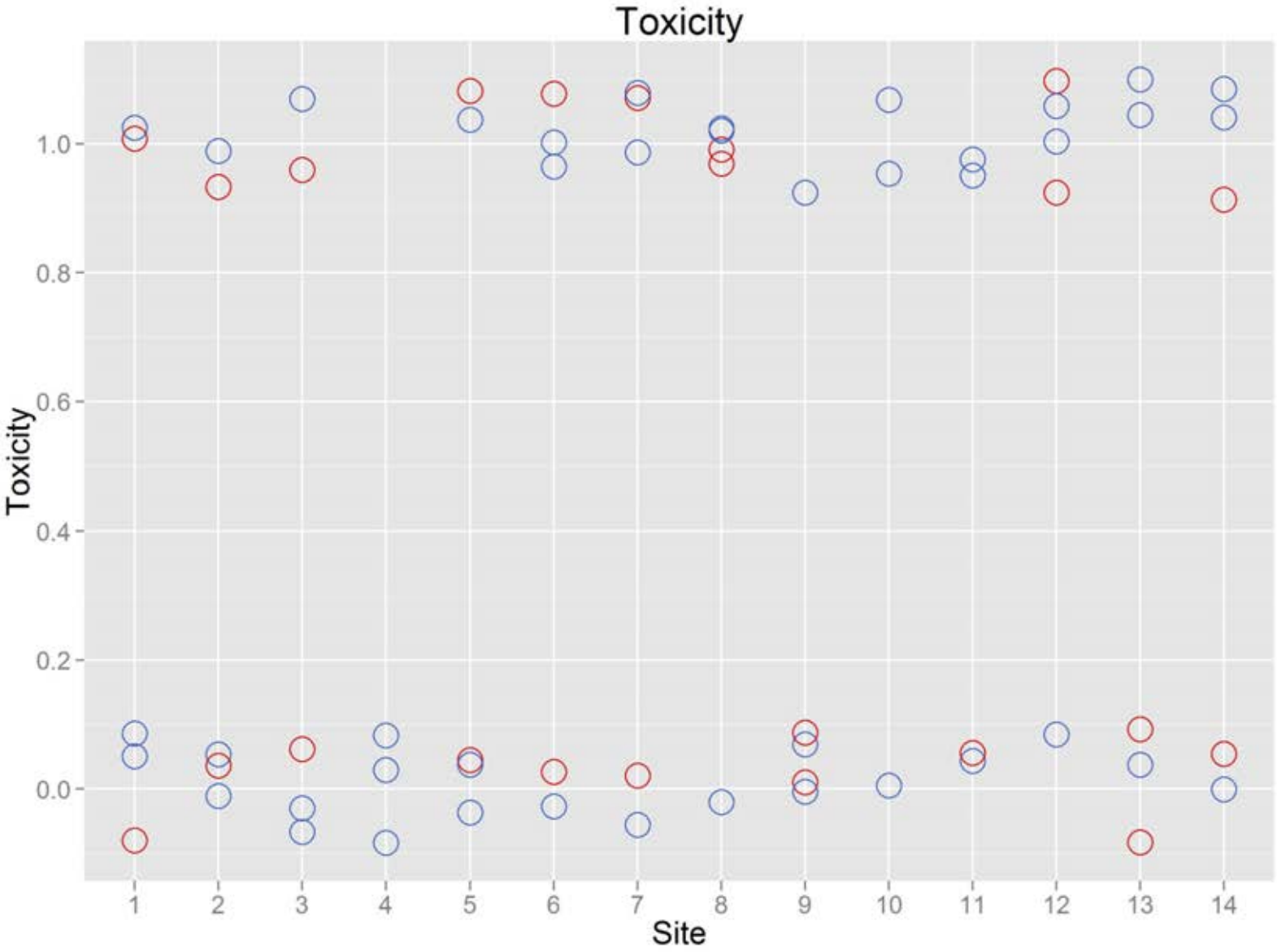

BOD5
BOD5(mg O2/L)
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


TSS
TSS (mg/L)
1000
800
600
400
200
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


VSS
VSS (mg/L)
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


Percent VSS
VSS (%)
70
60
50
40
30
20
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

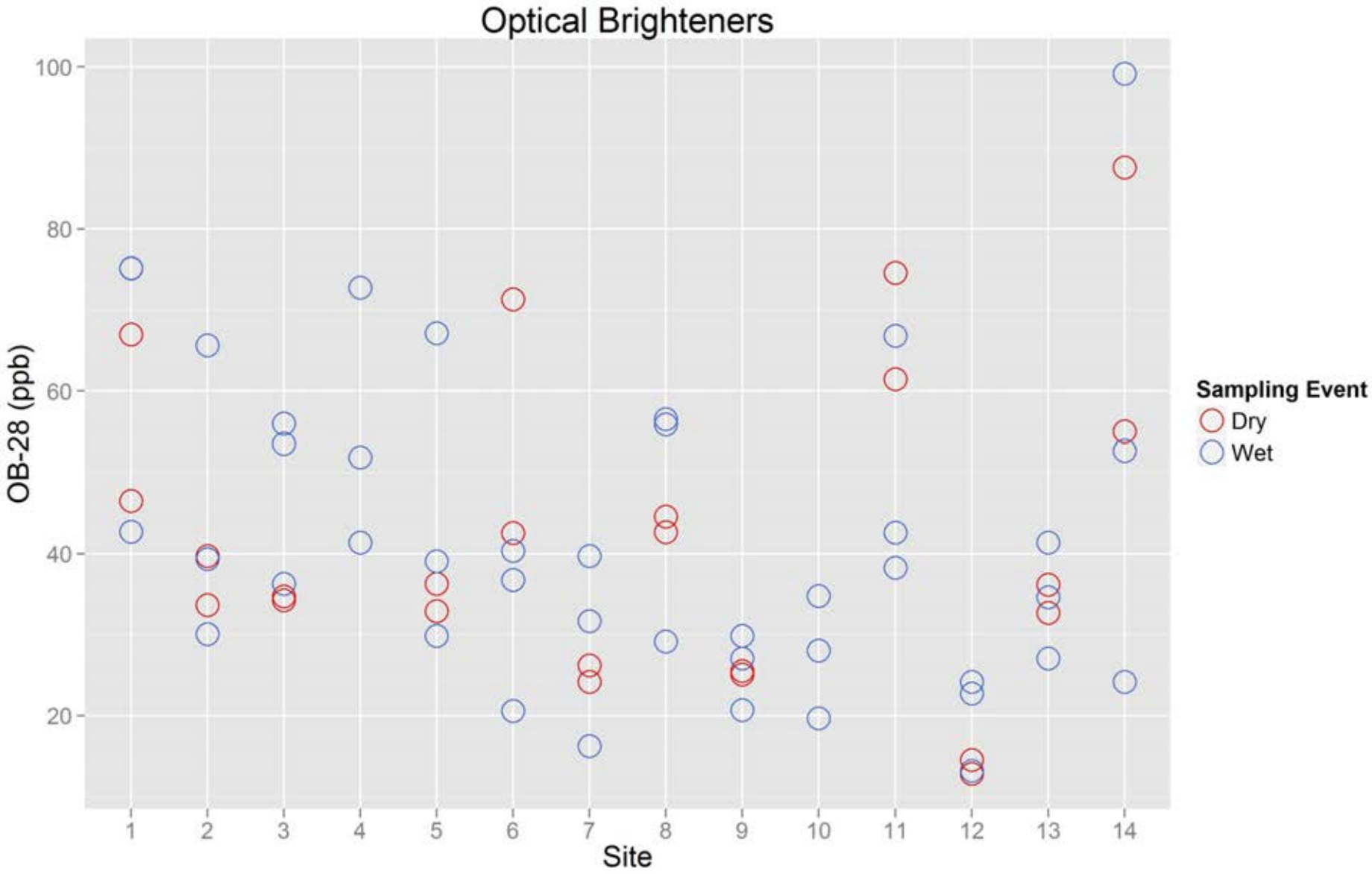

Turbidity
Turbidity (NTU)
600
400
200
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

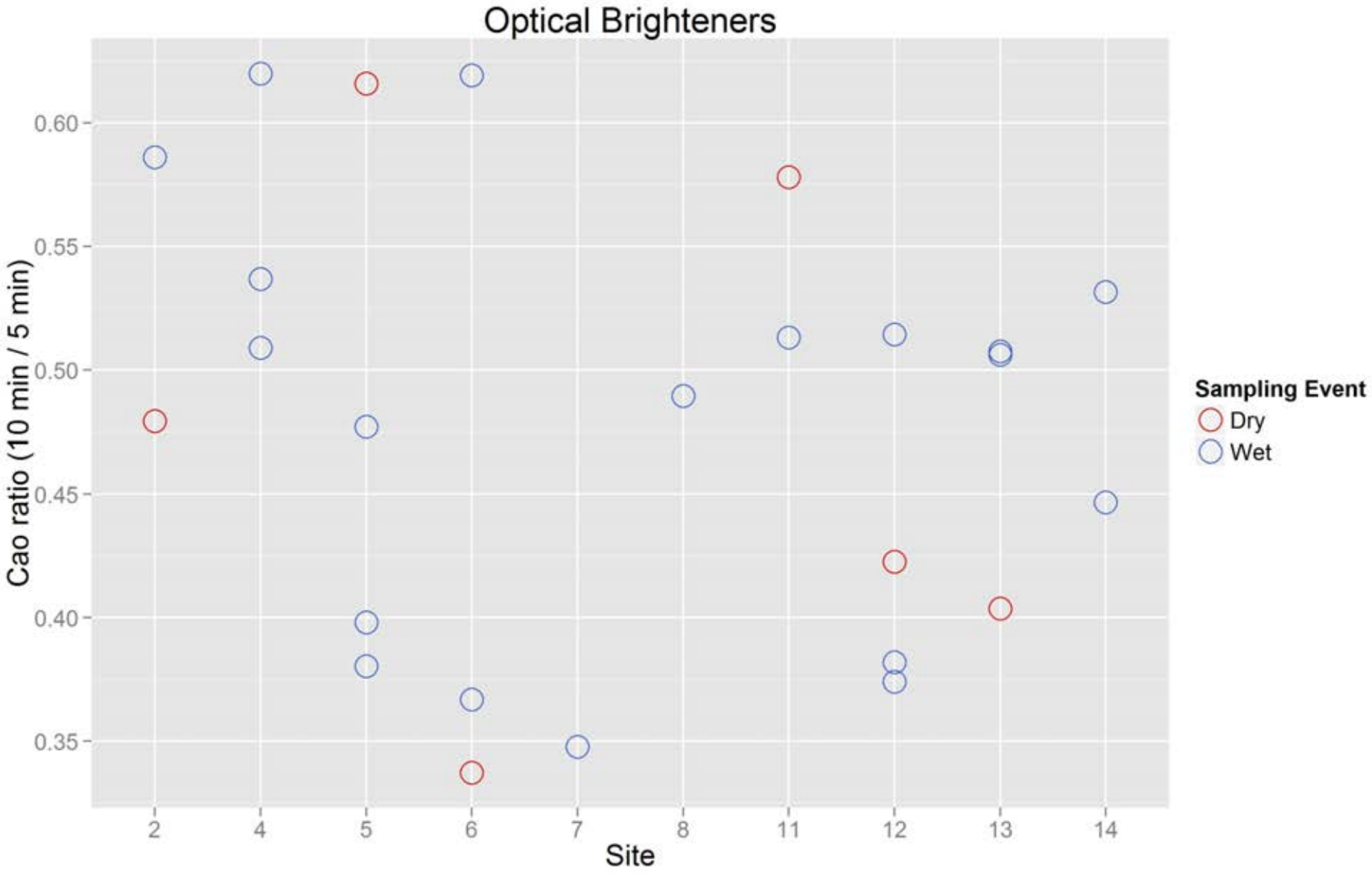


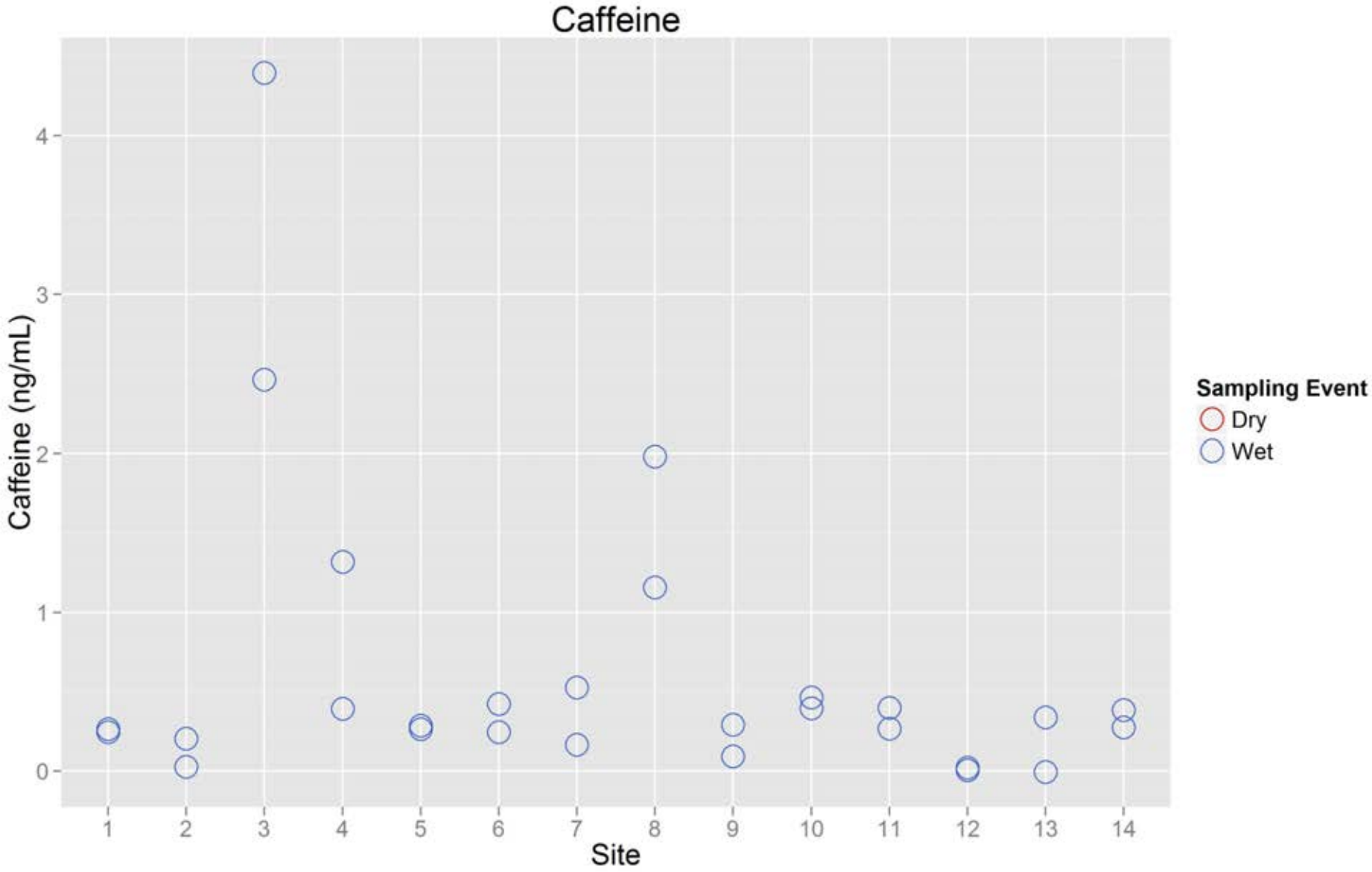
0 = No

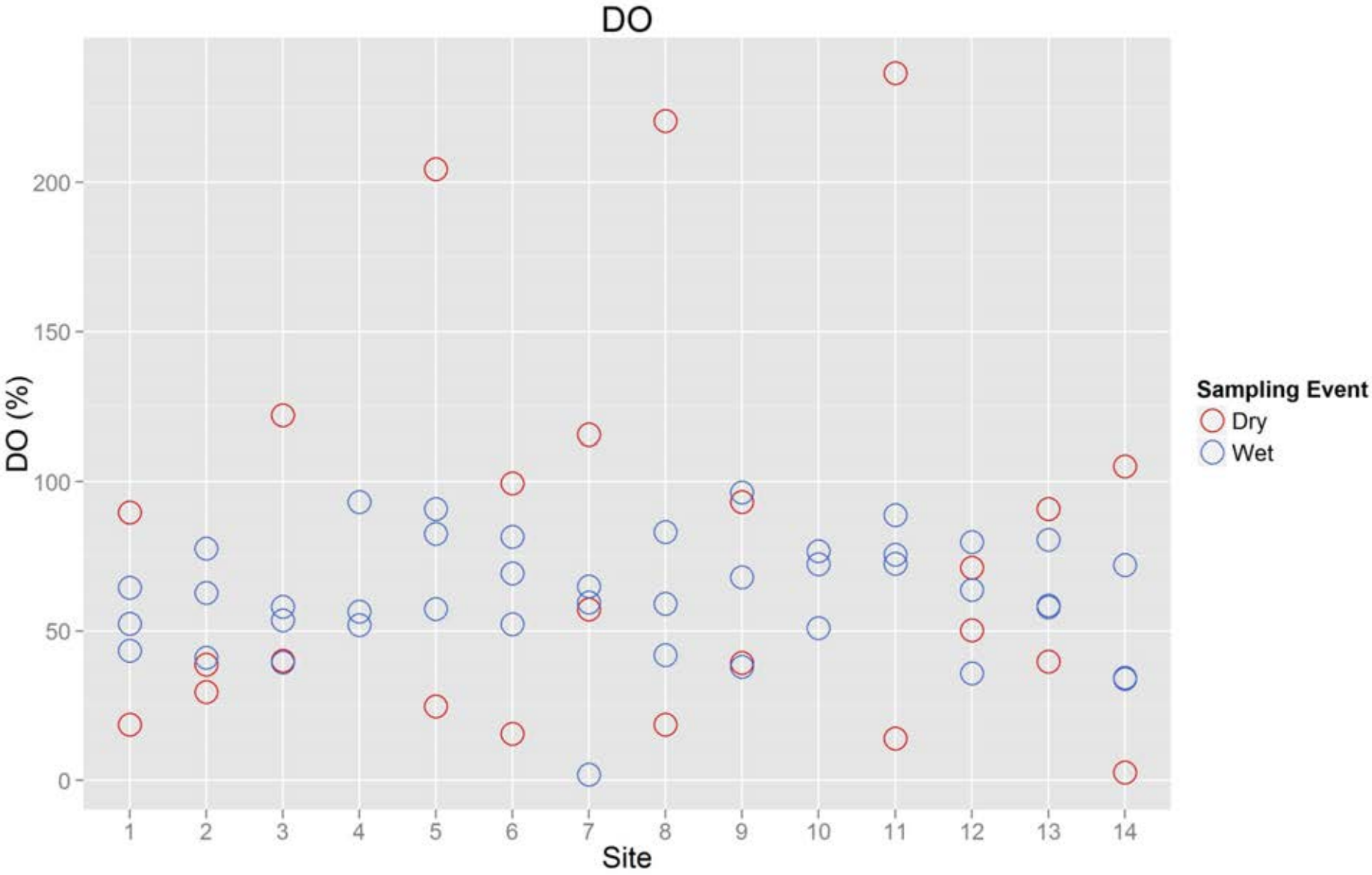
1 = Yes

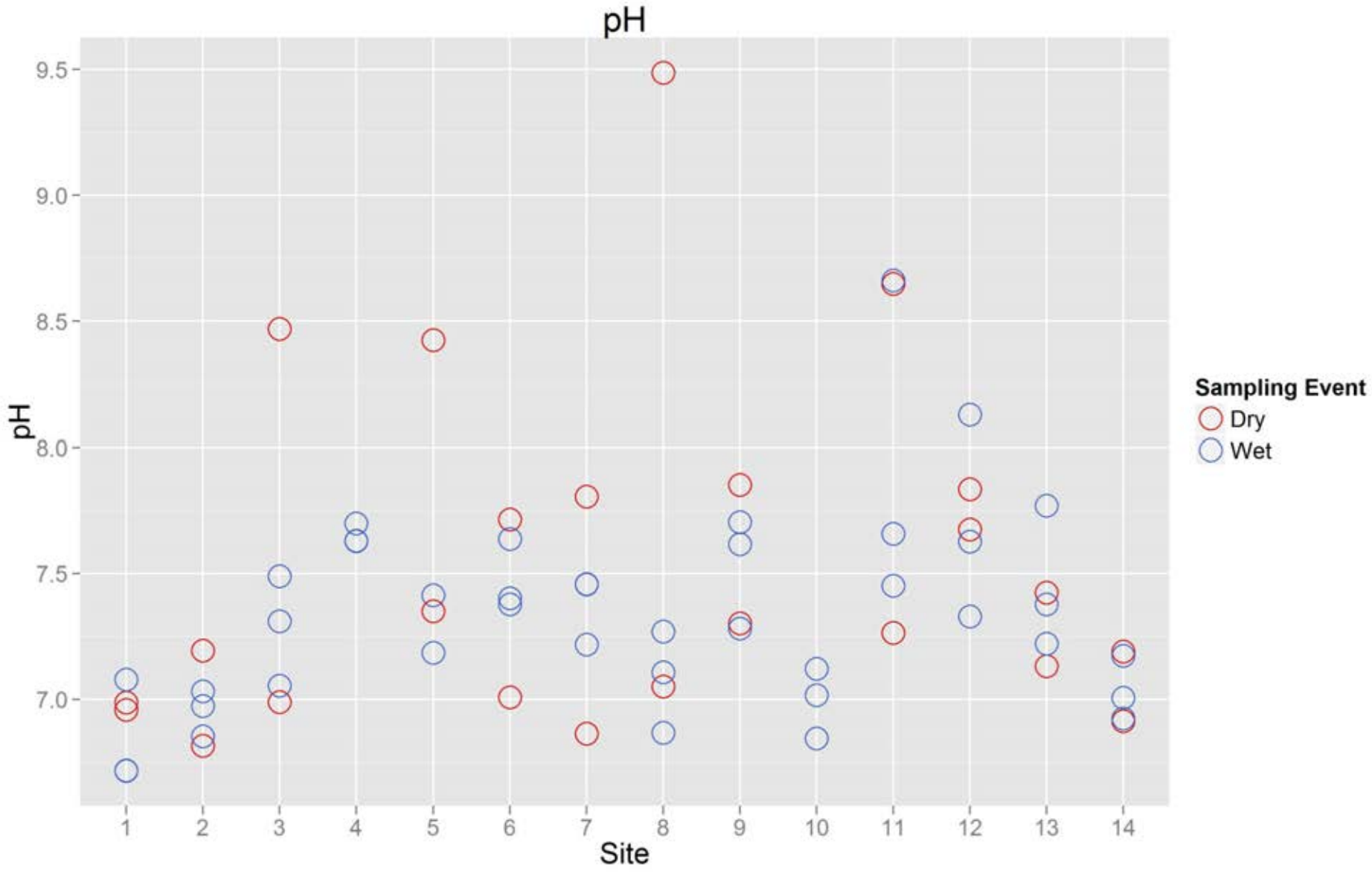
Note: to prevent all the symbols from being on top of each other, values have been jittered (spread out) – so there is no significance to the differences between the values concentrated around 0 or those concentrated around 1

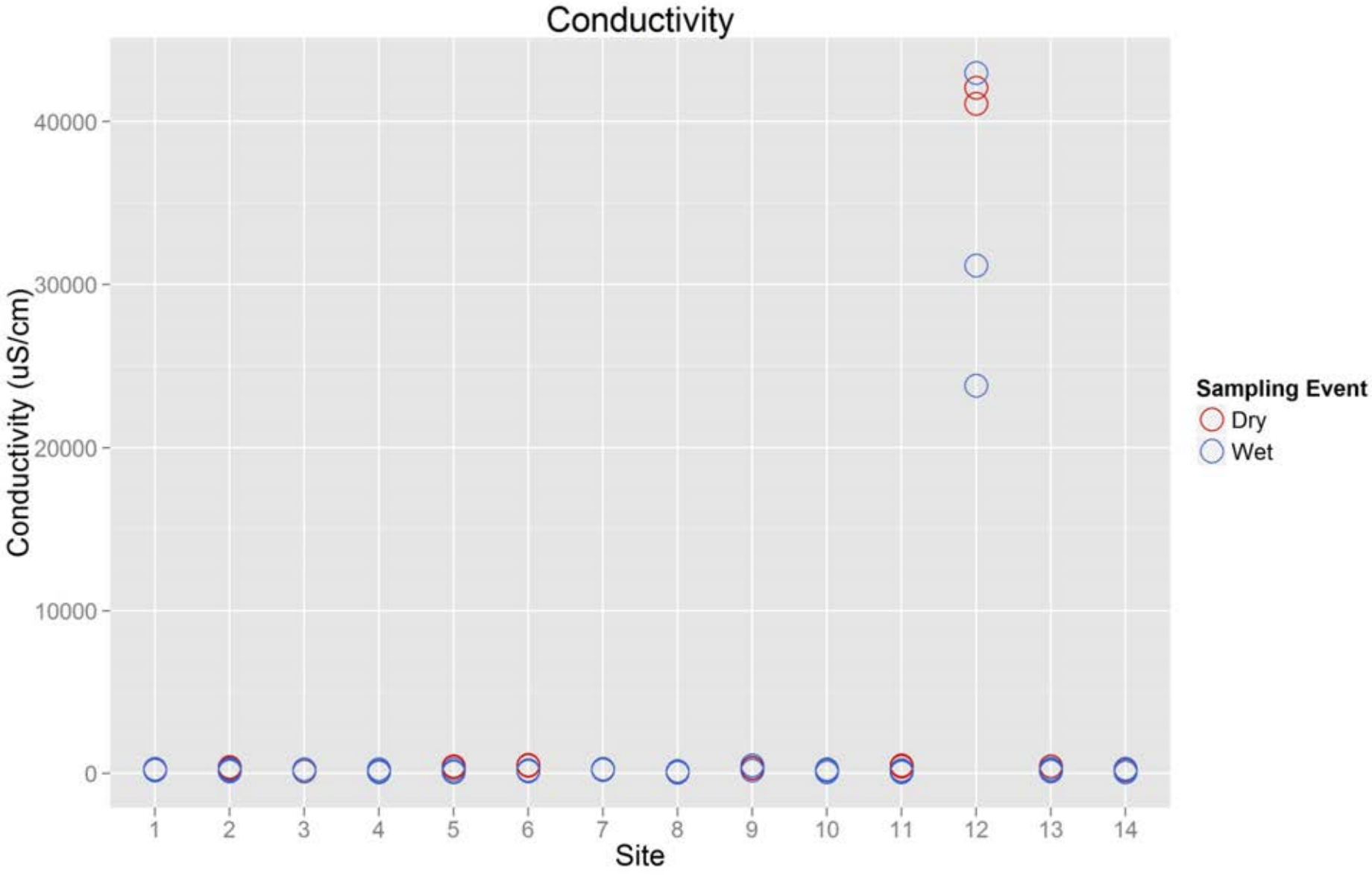

Optical Brighteners
OB-28 (ppb)
100
80
60
40
20
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


Optical Brighteners
Cao ratio (10 min / 5 min)
0.60
0.55
0.50
0.45
0.40
0.35
2
4
5
6
7
8
11
12
13
14
Site
Sampling Event
Dry
Wet


Caffeine
Caffeine (ng/mL)
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


DO
DO (%)
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


pH
9.5
9.0
8.5
8.0
7.5
7.0
pH
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet


Conductivity
Conductivity (uS/cm)
40000
30000
20000
10000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site
Sampling Event
Dry
Wet

FIB and Genetic Based Rank Order Figures

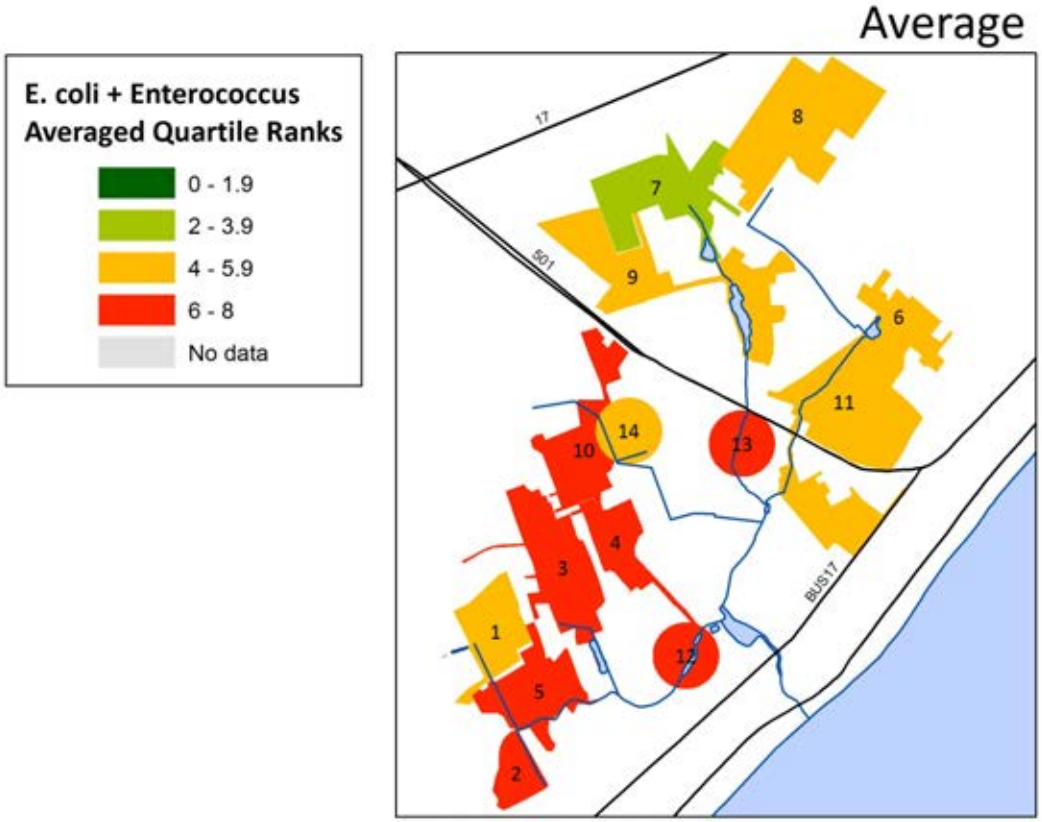
GenBac, BacCan, & BacHum
Ranking Method

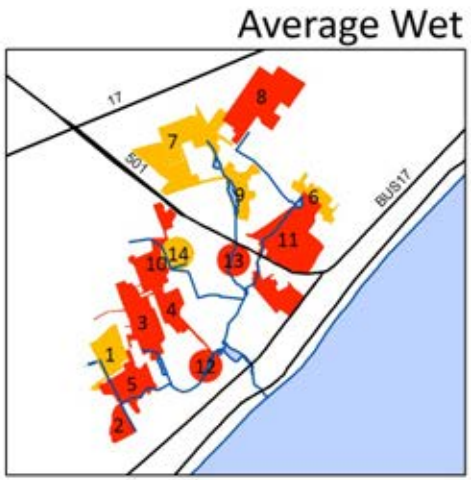
Rank	Percentile (%)	GenBac (genome copies/100 mL)	BacCan (genome copies/100 mL)	BacHum (genome copies/100 mL) *
0	-	-	-	0
1	0 - 25	72 - 1150	0 - 678	0 -1
2	25 - 50	1150 - 2498	678 - 1099	1 - 5
3	50 -75	2498 - 4497	1099 - 2291	5 - 50
4	75 - 100	4497 - 153496	2291 - 110588	> 50

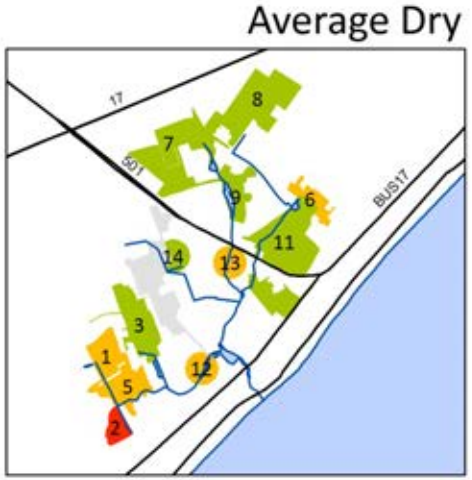
E. coli + Enterococcus

site	5/20/2012	6/27/2012	5/30/2012	8/28/2012	9/18/2012	Average Wet	Average Dry	Average
1	5	3	8	3	5	5.3	4.0	4.8
2	6	7	8	7	7	7.3	6.5	7.0
3	4	3	8	7	8	7.7	3.5	6.0
4			8	8	8	8.0		8.0
5	4	7	8	6	6	6.7	5.5	6.2
6	6	3	6	4	5	5.0	4.5	4.8
7	2	4	4	3	5	4.0	3.0	3.6
8	2	4	7	4	7	6.0	3.0	4.8
9	2	4	7	5	4	5.3	3.0	4.4
10			7	5	7	6.3		6.3
11	5	2	8	4	8	6.7	3.5	5.4
12	4	5	8	7	8	7.7	4.5	6.4
13	5	5	8	6	6	6.7	5.0	6.0
14	4	3	7	5	5	5.7	3.5	4.8

Sites Ranked by Indicator Bacteria



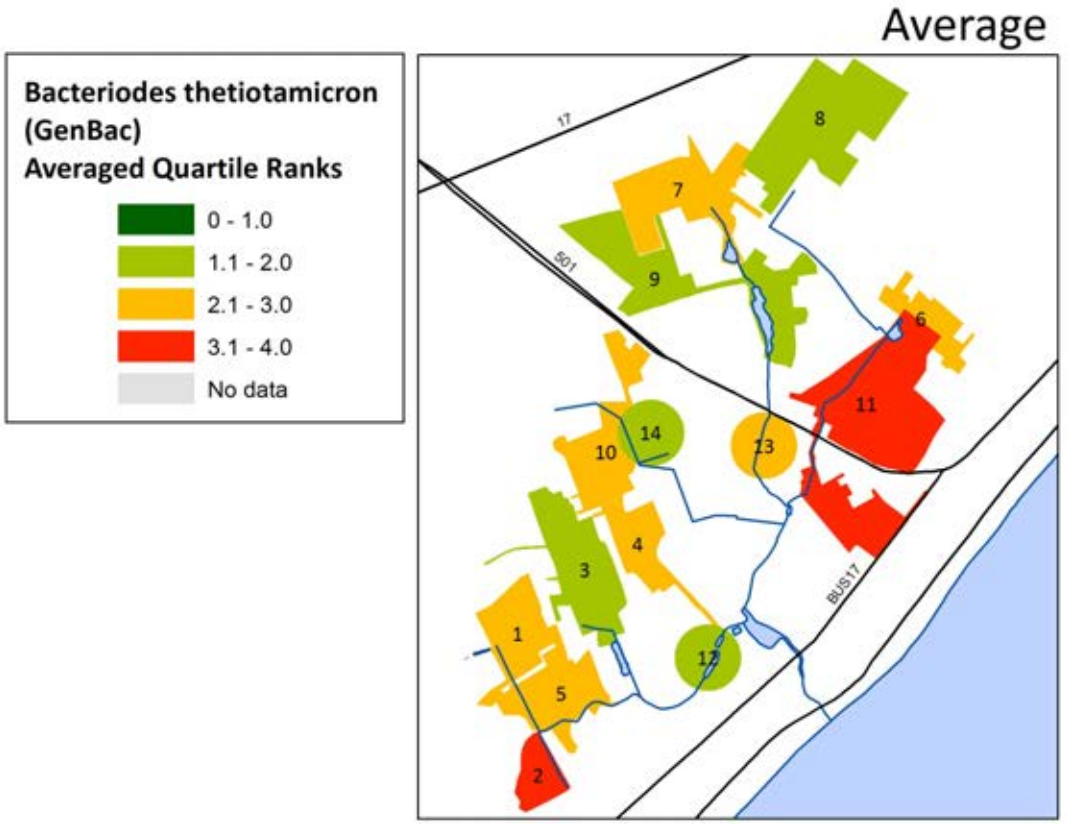


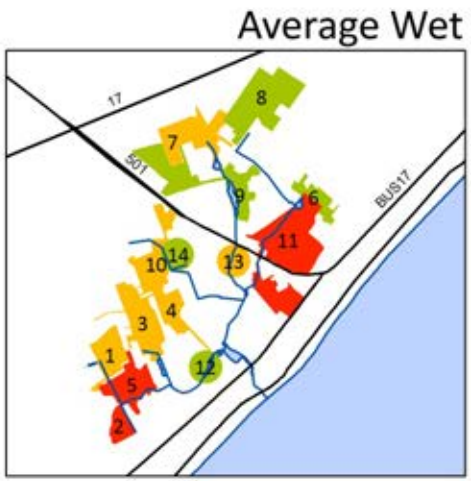


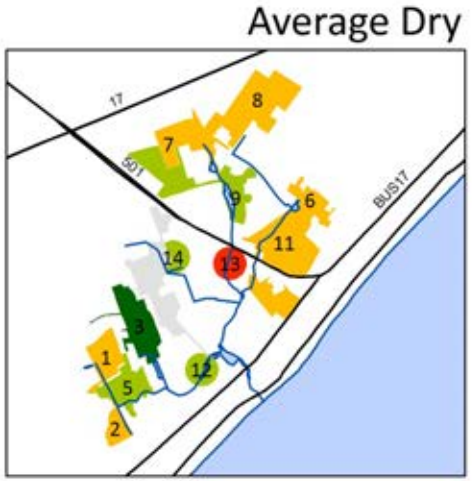
Mammalian source: *Bacteriodes thetaiotamicron*

site	5/20/2012	6/27/2012	5/30/2012	8/28/2012	9/18/2012	Average Wet	Average Dry	Average
1	1	4	3	2	2	2.3	2.5	2.4
2	2	4	4	4	4	4.0	3.0	3.6
3	1	1	1	3	4	2.7	1.0	2.0
4	NA	NA	3	1	4	2.7		2.7
5	2	1	4	4	4	4.0	1.5	3.0
6	4	2	3	1	1	1.7	3.0	2.2
7	2	4	3	1	3	2.3	3.0	2.6
8	1	4	1	2	2	1.7	2.5	2.0
9	2	2	2	3	1	2.0	2.0	2.0
10	NA	NA	3	3	3	3.0		3.0
11	3	2	4	4	4	4.0	2.5	3.4
12	1	2	3	1	2	2.0	1.5	1.8
13	3	4	3	1	3	2.3	3.5	2.8
14	3	1	2	2	1	1.7	2.0	1.8

Sites Ranked by qPCR Mammalian Source Hits



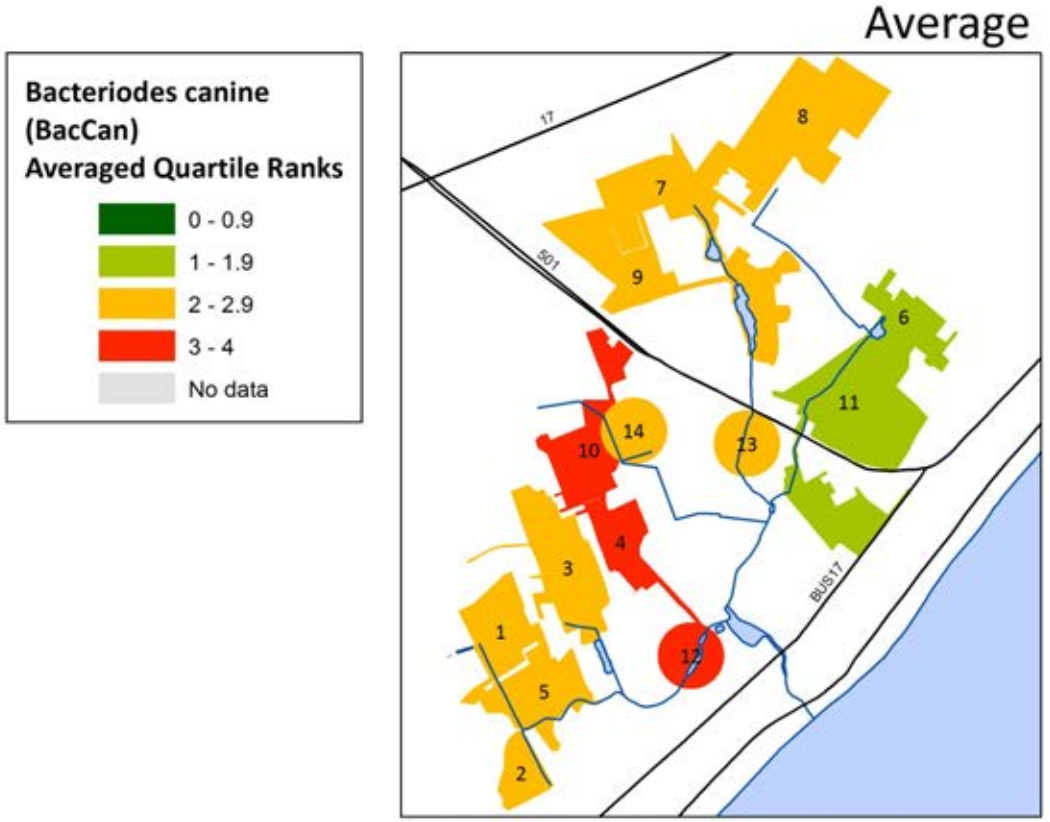


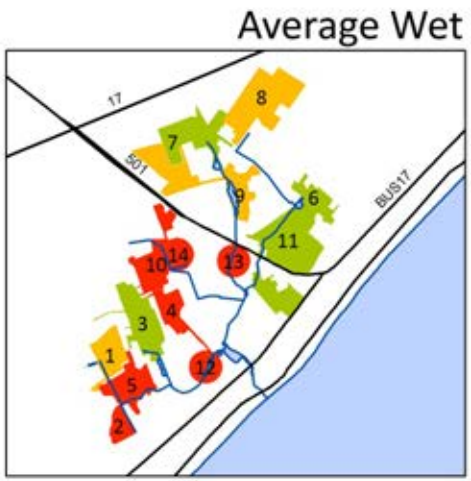


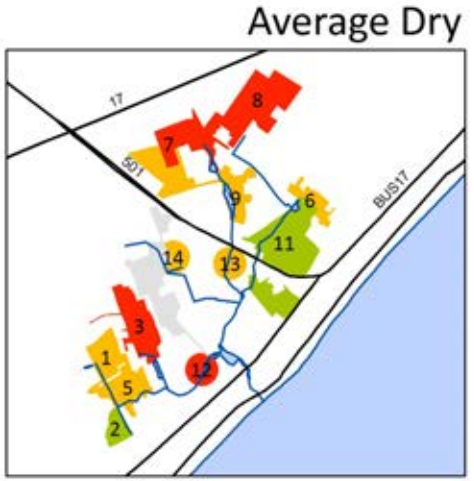
Canine source: *Bacteriodes canine*

site	5/20/2012	6/27/2012	5/30/2012	8/28/2012	9/18/2012	Average Wet	Average Dry	Average
1	1	3	4	1	3	2.7	2.0	2.4
2	1	1	3	2	4	3.0	1.0	2.2
3	2	4	1	2	1	1.3	3.0	2.0
4	NA	NA	4	4	4	4.0		4.0
5	4	1	4	2	3	3.0	2.5	2.8
6	3	2	1	1	1	1.0	2.5	1.6
7	2	4	2	1	1	1.3	3.0	2.0
8	3	4	3	1	2	2.0	3.5	2.6
9	3	2	2	1	3	2.0	2.5	2.2
10	NA	NA	4	3	4	3.7		3.7
11	1	2	2	2	1	1.7	1.5	1.6
12	3	3	4	4	4	4.0	3.0	3.6
13	NA	2	3	3	3	3.0	2.0	2.8
14	2	NA	4	3	2	3.0	2.0	2.8

Sites Ranked by qPCR Canine Source Hits



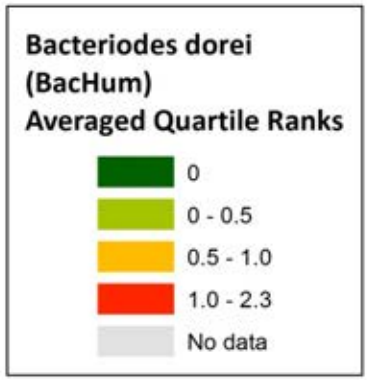




Human source: *Bacteriodes dorei*

site	5/20/2012	6/27/2012	5/30/2012	8/28/2012	9/18/2012	Average Wet	Average Dry	Average
1	0	1	0	0	0	0.0	0.5	0.2
2	0	0	0	0	1	0.3	0.0	0.2
3	0	0	0	3	4	2.3	0.0	1.4
4	NA	NA	0	0	2	0.7		0.7
5	0	0	0	0	0	0.0	0.0	0.0
6	0	0	0	0	0	0.0	0.0	0.0
7	0	1	0	0	0	0.0	0.5	0.2
8	0	0	0	0	0	0.0	0.0	0.0
9	0	1	0	0	0	0.0	0.5	0.2
10	NA	NA	0	0	0	0.0		0.0
11	0	0	3	0	0	1.0	0.0	0.6
12	0	1	2	0	2	1.3	0.5	1.0
13	2	1	3	0	0	1.0	1.5	1.2
14	0	1	0	0	0	0.0	0.5	0.2

Sites Ranked by qPCR Human Source Hits

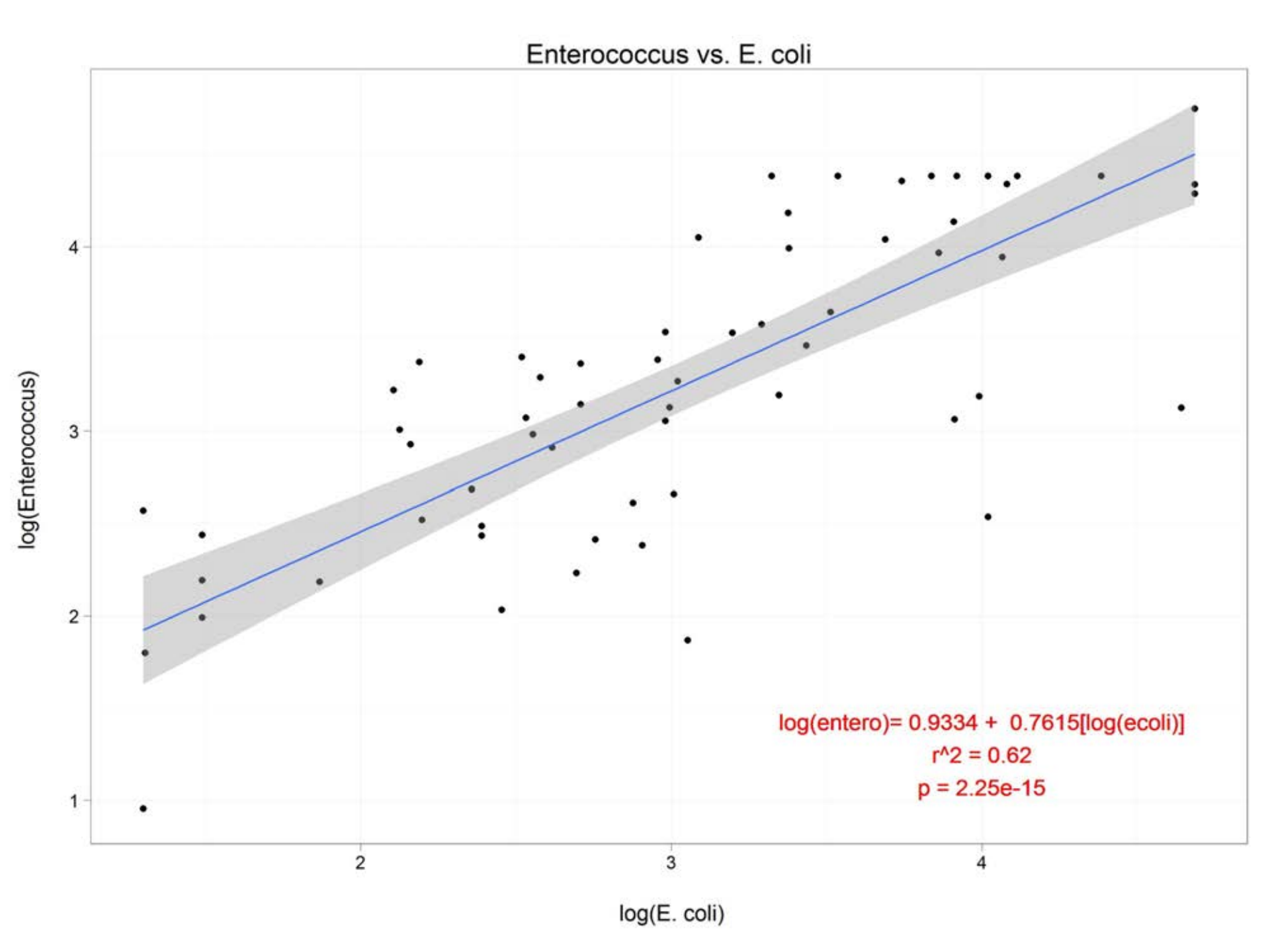


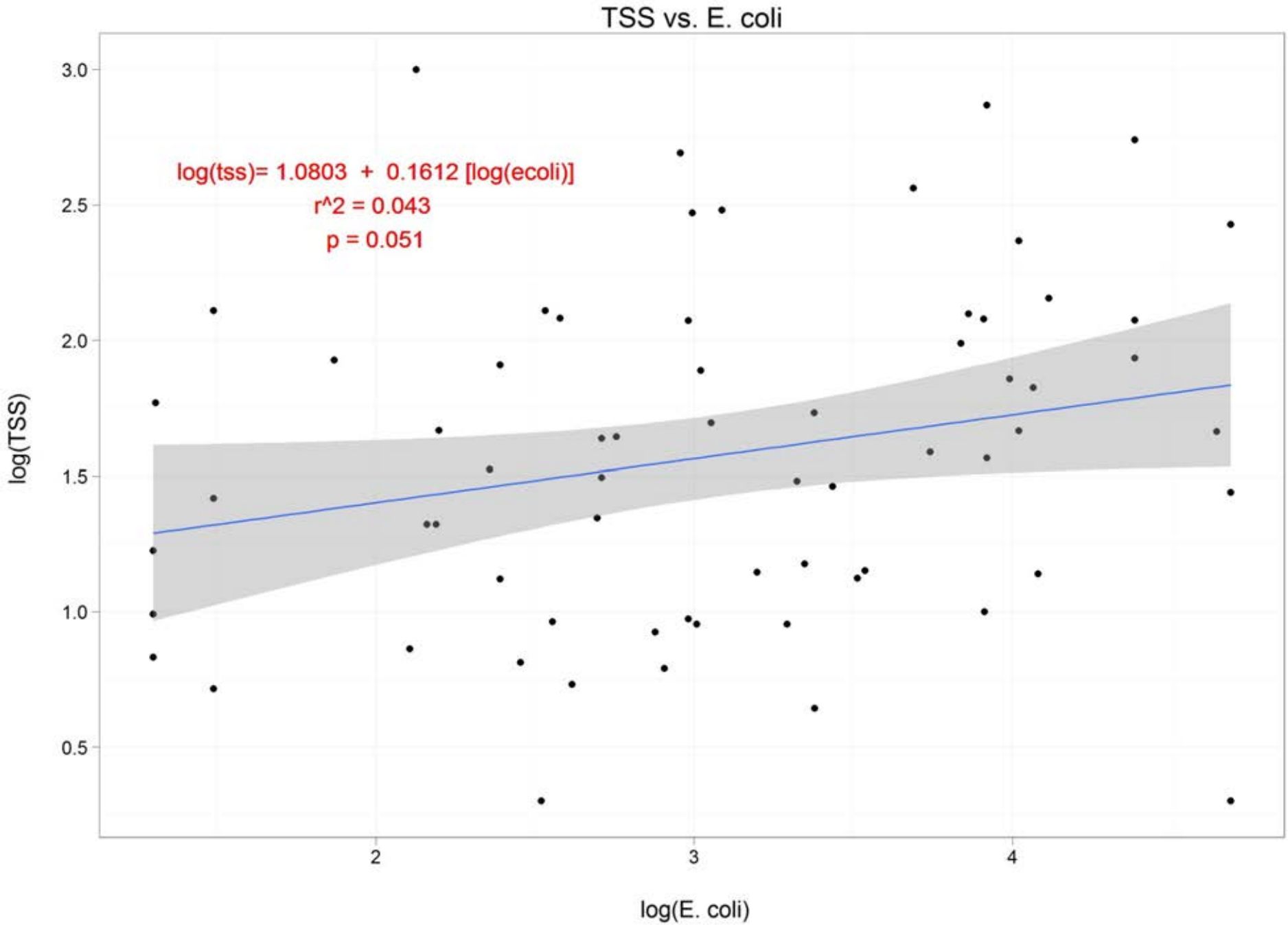
Average

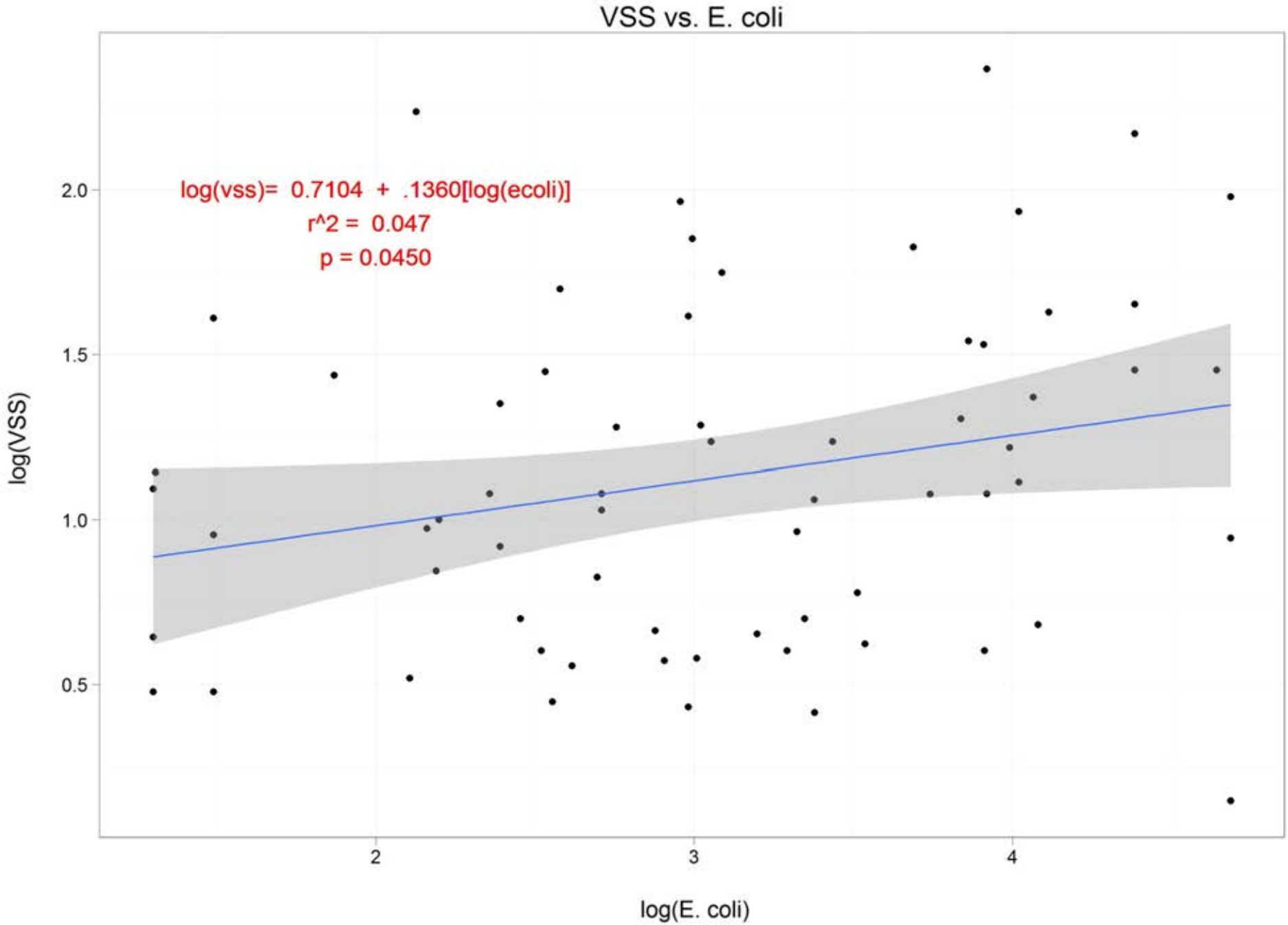
Average Wet

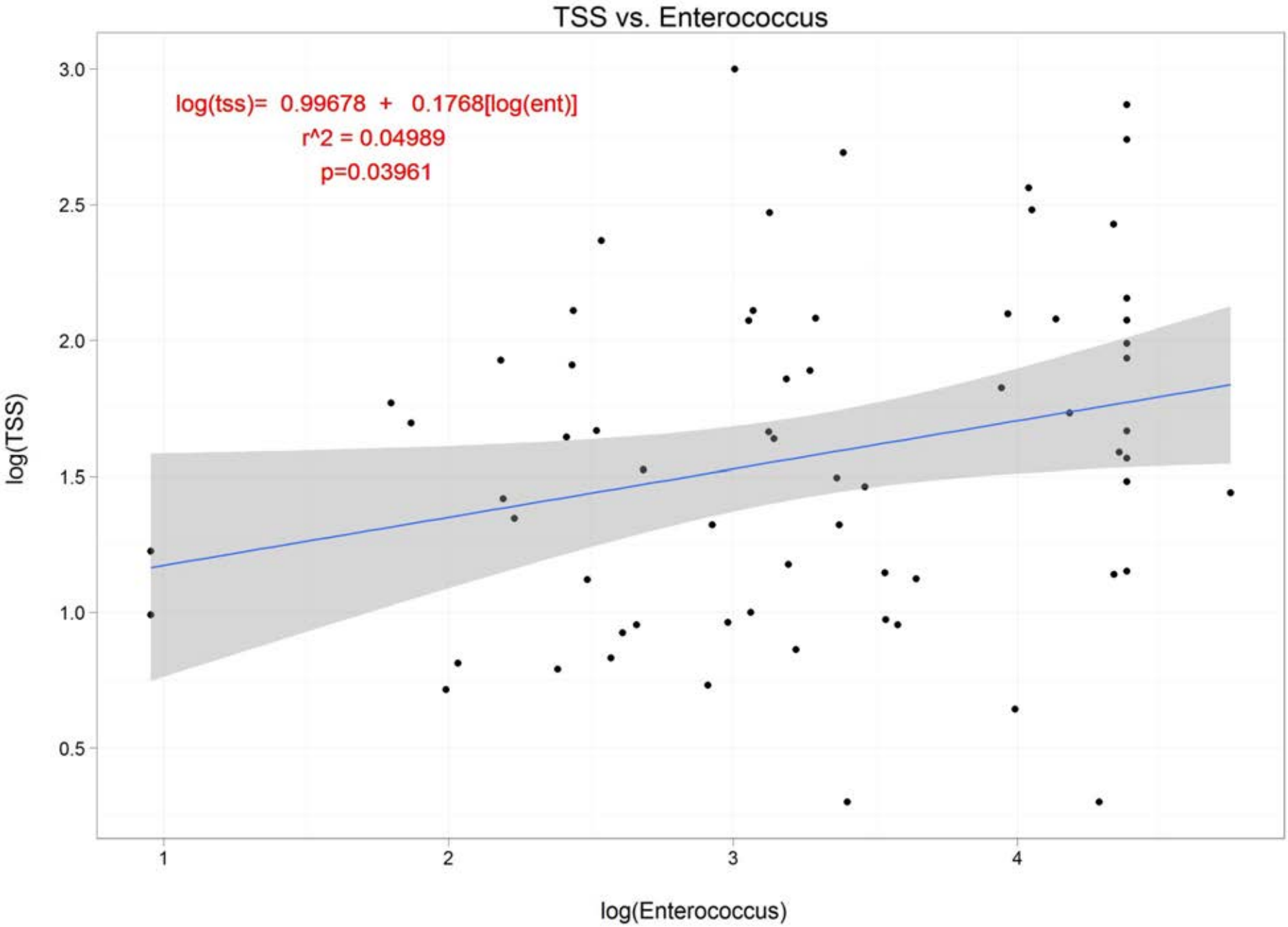
Average Dry

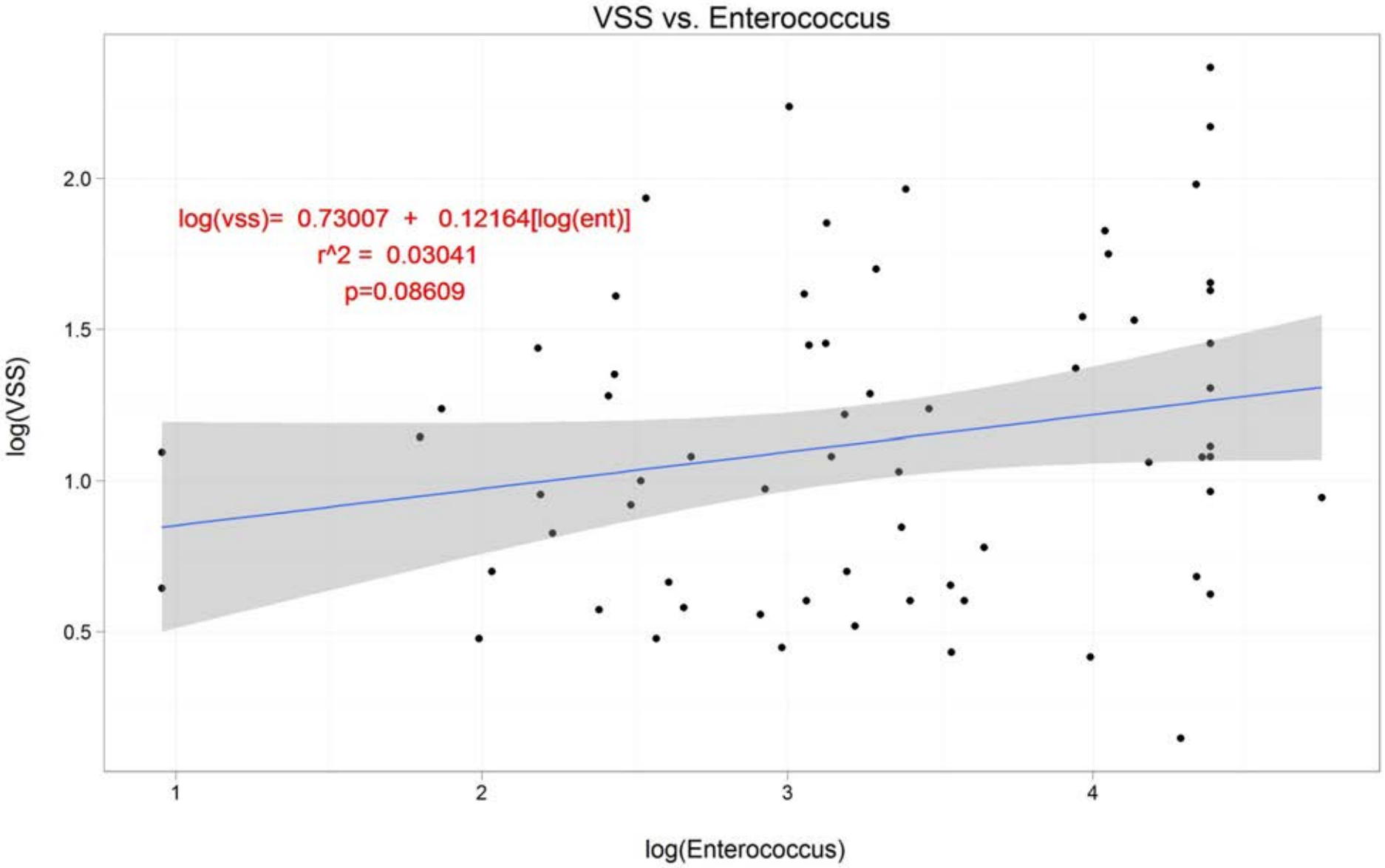
Scatter Plots Showing Relationships between Measured Parameters

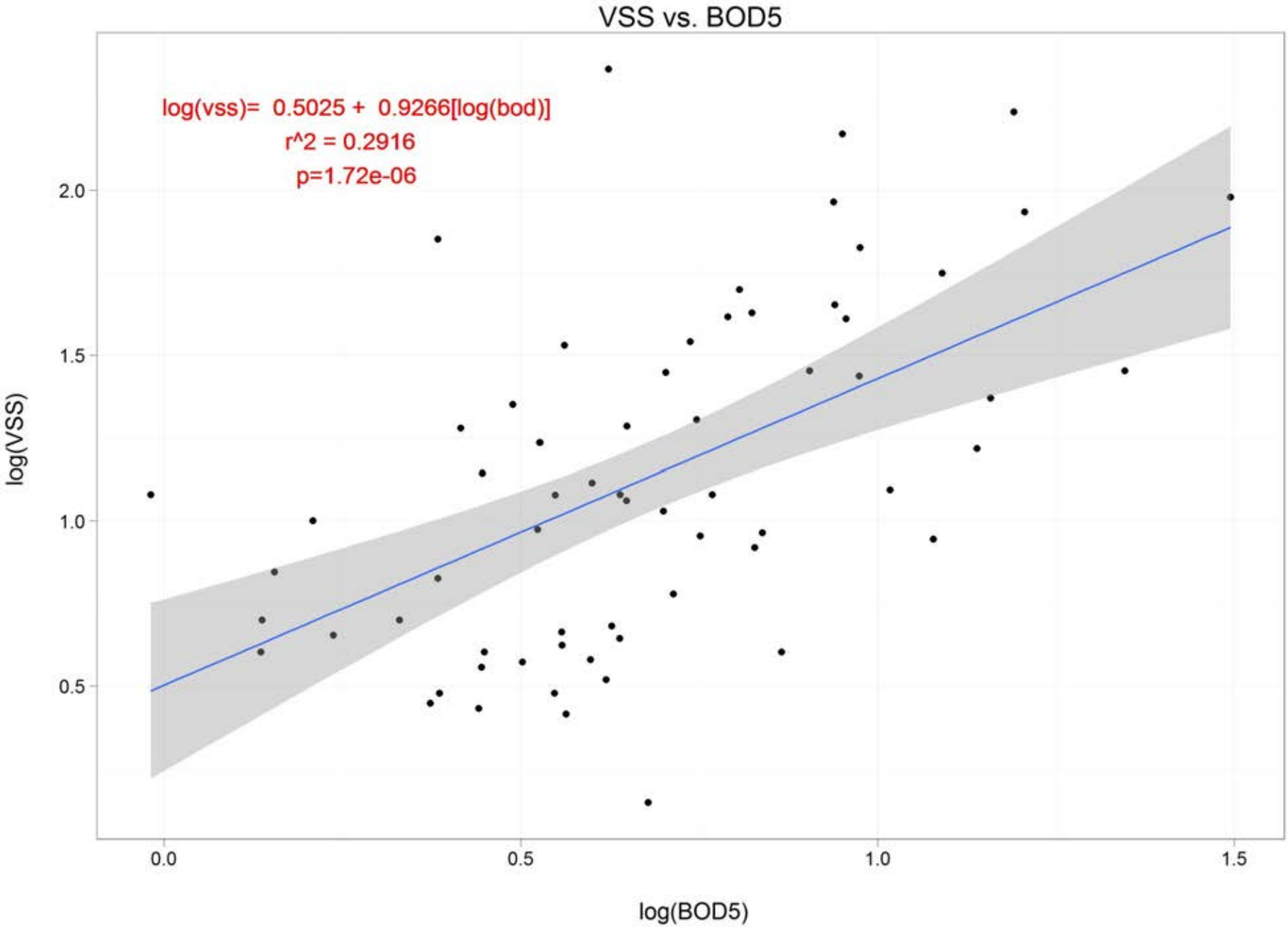

Enterococcus vs. E. coli
log(Enterococcus)
log(E. coli)
1
2
3
4
2
3
4
log(entero)= 0.9334 + 0.7615[log(ecoli)]
r^2 = 0.62
p = 2.25e-15


TSS vs. E. coli
log(tss)= 1.0803 + 0.1612 [log(ecoli)]
r^2 = 0.043
p = 0.051
log(TSS)
log(E. coli)
3.0
2.5
2.0
1.5
1.0
0.5
2
3
4


VSS vs. E. coli
log(vss)= 0.7104 + .1360[log(ecoli)]
r^2 = 0.047
p = 0.0450
2.0
1.5
1.0
0.5
log(VSS)
2
3
4
log(E. coli)


TSS vs. Enterococcus
log(tss)= 0.99678 + 0.1768[log(ent)]
r^2 = 0.04989
p=0.03961
log(TSS)
log(Enterococcus)
3.0
2.5
2.0
1.5
1.0
0.5
1
2
3
4


VSS vs. Enterococcus
log(vss)= 0.73007 + 0.12164[log(ent)]
r^2 = 0.03041
p=0.08609
log(VSS)
2.0
1.5
1.0
0.5
1
2
3
4
log(Enterococcus)


VSS vs. BOD5
log(vss)= 0.5025 + 0.9266[log(bod)]
r^2 = 0.2916
p=1.72e-06
log(VSS)
log(BOD5)
0.0
0.5
1.0
1.5
2.0