



Evaluation of
Water Quality
Effects of
Stormwater
Pond
Construction in
Horry County,
South Carolina

**Environmental Quality Lab
Burroughs & Chapin Center for Marine and Wetland Studies
Coastal Carolina University**

February 2010



FINAL RESULTS SUMMARIES AND COMPARISONS

for

Evaluation of Effects of Detention Pond Construction behind Surfside Bowl Bowling Alley on Highway 17 in Surfside Beach, South Carolina

by

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RESULTS

Summaries of field and laboratory measurement results for selected water characteristics and chemical parameters in runoff water in vicinity of Surfside Bowl bowling alley on Highway 17 in Surfside Beach both prior to and after construction of a runoff detention pond and covering the ditch next to the bowling alley are provided in Tables 1 through 4 and in Figures 1 through 10. Tables 1 and 2 summarize results for pre-construction samplings. Table 1 summarizes results for “dry weather” conditions (i.e., no rainfall for at least 72 hours prior to sampling event). Table 2 summarizes results for “wet weather” conditions (i.e., significant rainfall within 24 hours of sampling event). Tables 3 and 4, dry weather and wet weather, respectively, summarize results for post-construction samplings. Because the average values provided in the tables are in most cases averages of measurements on only two sampling dates, the ranges of the values are provided on the tables but confidence intervals for the averages were not determined.

Figures 1 through 10 compare the pre-construction and post-construction results for individual parameters for all sampling sites. Because of the limited number of samples and measurements for each category (i.e., usually two), it was not possible to estimate representative error bars (i.e., confidence intervals) for the averages compared. In spite of the limited sampling events and limited measurements obtained, the comparisons provide several notable observations:

- Prior to construction of the enlarged pond behind the bowling alley, the concentration of enterococci bacteria on the average in water flowing into the small preexisting pond decreased by about 45% (range 0% to 84%) before flowing out of the pond (Figures 1 and 2).
- After completion of construction that enlarged the pond behind the bowling alley and establishment of vegetation around the pond, the concentration of enterococci bacteria on the average in water flowing into the pond decreased by about 82% (range 60% to 97%) before reaching the pond outlet (Figures 1 and 2).

- Both prior to and after the best management practice (BMP) construction (i.e., runoff detention pond and covering the ditch next to the bowling alley), turbidity levels were generally low (i.e., <10 NTU), but the BMP construction did appear to reduce turbidity levels in the water at the pond's outlet in wet weather (Figures 3 and 4).
- During pre-construction sampling events (Tables 1 and 2), dissolved oxygen levels at all sites were within SC DHEC water quality standards for freshwater (i.e., >5 mg/L).
- After BMP construction (Tables 3 and 4), dissolved oxygen levels in water flowing into the pond in both dry and wet weather were below SC DHEC water quality standards for freshwater. The BMP construction activities included piping and covering some of the primary ditch flowing into the pond. Compared to pre-construction sampling events, the sunlight blocked from some of the ditch by post-construction piping probably hindered photosynthesis and oxygen production in the ditch water and the warmer temperatures during post-construction sampling (Figures 8 and 9) probably increased bacterial decomposition and oxygen consumption in the ditch water.
- Both prior to and after BMP construction, flows at the sampling sites were highly variable (Tables 1 – 4) with, as expected, higher flows during wet weather and increasing flows the further downstream the sampling site (Figure 10). It should be noted, however, that in both dry and wet weather after BMP construction flow out of the BMP pond into the outlet weir was never observed. All wet weather sampling was conducted one day or less after a rainstorm of at least 0.5 inches of precipitation.

Table 1. Summary of dry weather measurement results in runoff water in vicinity of Surfside Bowl bowling alley in Surfside Beach, South Carolina. Measurements were conducted prior to completion of construction of a detention pond and covering the ditch next to the bowling alley.

Parameters and Units	Applicable Water Quality Standards or Criteria	Average ^a Dry Weather ^b Concentrations, (Range of Concentrations), and ((Number of Samples))			
		Pond Inflow	Pond Outflow	Ditch Flowing from Pond to Lake Elizabeth	Lake Elizabeth Outflow
Enterococci bacteria (MPN/100mL)	<35	1785 (1317 - 2419) ((n = 2))	835 (727 - 959) ((n = 2))	1136 (821 - 1483) ((n = 4))	89 (89) ((n = 1))
Turbidity (NTU)	<25	3.1 (1.6 - 4.6) ((n = 2))	6.55 (2.7 - 10.4) ((n = 2))	3.6 ^c (3.1 - 4.1) ((n = 2))	4.1 (4.1) ((n = 1))
Conductivity (µS/cm)	Not Established	380 (304 - 455) ((n = 2))	356 (303 - 406) ((n = 2))	357 (317 - 397) ((n = 4))	357 (357) ((n = 1))
Dissolved Oxygen (mg/L)	>5.0	6.14 (5.44 - 6.83) ((n = 2))	6.51 (5.54 - 7.48) ((n = 2))	6.15 (5.20 - 7.17) ((n = 4))	9.62 (9.62) ((n = 1))
Dissolved Oxygen (% saturation)	Not Established	66.0 (61.4 - 70.5) ((n = 2))	69.9 (62.5 - 77.2) ((n = 2))	60.1 (41.0 - 69.9) ((n = 4))	95.5 (95.5) ((n = 1))
pH (-log H ⁺ activity)	>6.5, <8.5	7.12 (7.02 - 7.22) ((n = 2))	7.06 (6.99 - 7.13) ((n = 2))	6.99 (6.87 - 7.11) ((n = 4))	7.61 (7.61) ((n = 1))
Water Temperature (°C)	Not Established	19.1 (16.88 - 21.28) ((n = 2))	19.0 (16.74 - 21.30) ((n = 2))	18.2 (14.74 - 21.58) ((n = 4))	15.1 (15.07) ((n = 1))
Air Temperature (°C)	Not Established	25.5 (23 - 28) ((n = 2))	25.5 (24 - 27) ((n = 2))	24.8 (22 - 27) ((n = 4))	23.0 (23) ((n = 1))
Flow (L/sec)	Not Established	16.1 (11.6 - 20.6) ((n = 2))	21.6 (18.6 - 24.6) ((n = 2))	76.9 (67.8 - 81.7) ((n = 4))	85.8 (85.8) ((n = 1))
Flow (GPM)	Not Established	255 (184 - 327) ((n = 2))	342 (295 - 390) ((n = 2))	1219 (1074 - 1296) ((n = 4))	1359 (1359) ((n = 1))

^a For enterococci bacteria the average concentrations listed are geometric mean values.
^b No rainfall occurred within 72 hours of sampling. Sampling dates were 11/1/07 and 11/13/07, while last rainfall was on 10/27/07.
^c Turbidity measurements from 11/1/07 sampling not used because of substantial turbidity increase in ditch caused by construction activities at pond.

Table 2. Summary of wet weather measurement results in runoff water in vicinity of Surfside Bowl bowling alley in Surfside Beach, South Carolina. Measurements were conducted prior to completion of construction of a detention pond and covering the ditch next to the bowling alley. To equally weight results for individual sampling dates, this table was revised slightly from the Table 2 provided in the pre-construction results report issued 5/26/08.

Parameters and Units	Applicable Water Quality Standards or Criteria	Average ^a Wet Weather ^b Concentrations, (Range of Concentrations), and ((Number of Samples))			
		Pond Inflow	Pond Outflow	Ditch Flowing from Pond to Lake Elizabeth	Lake Elizabeth Outflow
Enterococci bacteria (MPN/100mL)	<35	6297 (3635 - 9677) ((n = 3))	2520 (657 - 9677) ((n = 2))	1738 (380 - 7945) ((n = 2))	904 (626 - 1633) ((n = 3))
Turbidity (NTU)	<25	10.1 (4.0 - 16.1) ((n = 3))	18.3 (3.7 - 32.8) ((n = 2))	25.4 (5.5 - 45.3) ((n = 2))	13.4 (9.5 - 17.6) ((n = 3))
Conductivity (µS/cm)	Not Established	316 (172 - 462) ((n = 3))	243 (132 - 354) ((n = 2))	232 (130 - 334) ((n = 2))	372 (359 - 385) ((n = 3))
Dissolved Oxygen (mg/L)	>5.0	9.48 (9.13 - 9.78) ((n = 3))	8.32 (7.05 - 9.59) ((n = 2))	8.20 (6.71 - 9.69) ((n = 2))	9.36 (9.02 - 9.70) ((n = 3))
Dissolved Oxygen (% saturation)	Not Established	84.4 (80.0 - 88.5) ((n = 3))	75.6 (64.4 - 86.7) ((n = 2))	74.0 (60.4 - 87.5) ((n = 2))	87.2 (80.3 - 94.0) ((n = 3))
pH (-log H ⁺ activity)	>6.5, <8.5	7.26 (7.18 - 7.35) ((n = 3))	7.20 (7.14 - 7.26) ((n = 2))	7.23 (7.19 - 7.27) ((n = 2))	7.74 (7.68 - 7.79) ((n = 3))
Water Temperature (°C)	Not Established	10.16 (9.34 - 10.90) ((n = 3))	11.10 (10.85 - 11.34) ((n = 2))	10.64 (10.46 - 10.82) ((n = 2))	12.13 (10.37 - 13.89) ((n = 3))
Air Temperature (°C)	Not Established	13.3 (13 - 14) ((n = 3))	13 (13 - 13) ((n = 2))	13.5 (13 - 14) ((n = 2))	13 (13 - 13) ((n = 3))
Flow (L/sec)	Not Established	151 (31.5 - 270) ((n = 3))	313 (8.1 - 619) ((n = 2))	405 (45.2 - 764) ((n = 2))	389 (69.0 - 709.7) ((n = 3))
Flow (GPM)	Not Established	2395 (499 - 4287) ((n = 3))	4968 (128 - 9808) ((n = 2))	6417 (716 - 12117) ((n = 2))	6172 (1094 - 11250) ((n = 3))

^a For enterococci bacteria the average concentrations listed are geometric mean values.
^b Heavy rainfall (i.e., >0.3 inches) occurred within 24 hours of sampling. Sampling dates were 12/16/07 and 1/17/08.

Table 3. Summary of dry weather measurement results in runoff water in vicinity of Surfside Bowl bowling alley in Surfside Beach, South Carolina. Measurements were conducted after completion of construction of a detention pond and covering the ditch next to the bowling alley.

Parameters and Units	Applicable Water Quality Standards or Criteria	Average ^a Dry Weather ^b Concentrations, (Range of Concentrations), and ((Number of Samples))			
		Pond Inflow	Pond Outflow	Ditch Flowing from Pond to Lake Elizabeth	Lake Elizabeth Outflow
Enterococci bacteria (MPN/100mL)	<35	10829 (7766 - 12098) ((n = 3))	361 (108 - 1049) ((n = 3))	529 (256 - 1094) ((n = 2))	26.2 (10 - 68.7) ((n = 2))
Turbidity (NTU)	<25	3.10 (2.42 - 4.63) ((n = 3))	5.50 (5.06 - 6.62) ((n = 3))	5.50 (3.86 - 7.13) ((n = 2))	4.78 (3.66 - 5.91) ((n = 2))
Conductivity (µS/cm)	Not Established	461 (437 - 484) ((n = 3))	409 (394 - 425) ((n = 3))	406 (393 - 420) ((n = 2))	350 (300 - 400) ((n = 2))
Dissolved Oxygen (mg/L)	>5.0	4.24 (2.97 - 5.50) ((n = 3))	9.16 (8.60 - 9.47) ((n = 3))	6.64 (6.43 - 6.85) ((n = 2))	7.51 (6.89 - 8.13) ((n = 2))
Dissolved Oxygen (% saturation)	Not Established	47.7 (36.9 - 58.3) ((n = 3))	109.5 (93.9 - 122.6) ((n = 3))	78.9 (70.3 - 87.4) ((n = 2))	91.0 (90.2 - 91.8) ((n = 2))
pH (-log H ⁺ activity)	>6.5, <8.5	7.30 (7.18 - 7.42) ((n = 3))	7.43 (7.41 - 7.45) ((n = 3))	7.36 (7.26 - 7.47) ((n = 2))	7.80 (7.51 - 8.08) ((n = 2))
Water Temperature (°C)	Not Established	21.4 (17.3 - 25.6) ((n = 3))	23.4 (18.7 - 27.5) ((n = 3))	22.9 (19.0 - 26.8) ((n = 2))	25.0 (20.5 - 29.4) ((n = 2))
Air Temperature (°C)	Not Established	23.5 (17.0 - 32.0) ((n = 3))	25.8 (18.6 - 33.0) ((n = 3))	25.6 (20.1 - 31.0) ((n = 2))	23.6 (17.1 - 30.0) ((n = 2))
Flow (L/sec)	Not Established	12.0 (10.2 - 14.3) ((n = 3))	0.0 (0.0 - 0.0) ((n = 3))	13.0 (11.6 - 14.4) ((n = 2))	29.9 (22.0 - 37.7) ((n = 2))
Flow (GPM)	Not Established	191 (162 - 227) ((n = 3))	0.0 (0.0 - 0.0) ((n = 3))	207 (184 - 229) ((n = 2))	474 (350 - 598) ((n = 2))
^a For enterococci bacteria the average concentrations listed are geometric mean values. ^b No rainfall occurred within 72 hours of sampling. Sampling dates were 6/22/09 and 11/3/09, while last rainfalls were on 6/16/09 and 10/31/09, respectively.					

Table 4. Summary of wet weather measurement results in runoff water in vicinity of Surfside Bowl bowling alley in Surfside Beach, South Carolina. Measurements were conducted after completion of construction of a detention pond and covering the ditch next to the bowling alley.

Parameters and Units	Applicable Water Quality Standards or Criteria	Average ^a Wet Weather ^b Concentrations, (Range of Concentrations), and ((Number of Samples))			
		Pond Inflow	Pond Outflow	Ditch Flowing from Pond to Lake Elizabeth	Lake Elizabeth Outflow
Enterococci bacteria (MPN/100mL)	<35	5052 (2603 - 9804) ((n = 2))	1242 (379 - 3255) ((n = 3))	1722 (911 - 3255) ((n = 2))	127 (80 - 177.5) ((n = 2))
Turbidity (NTU)	<25	4.39 (3.23 - 5.55) ((n = 2))	7.62 (5.50 - 9.90) ((n = 3))	6.04 (5.36 - 6.73) ((n = 2))	8.38 (3.77 - 9.92) ((n = 2))
Conductivity (µS/cm)	Not Established	330 (300 - 359) ((n = 2))	302 (281 - 322) ((n = 3))	300 (284 - 317) ((n = 2))	312 (251 - 372) ((n = 2))
Dissolved Oxygen (mg/L)	>5.0	3.08 (2.73 - 3.43) ((n = 2))	5.34 (4.54 - 6.15) ((n = 3))	6.24 (5.92 - 6.56) ((n = 2))	7.41 (5.54 - 9.28) ((n = 2))
Dissolved Oxygen (% saturation)	Not Established	38.8 (34.2 - 43.4) ((n = 2))	68.1 (57.2 - 79.0) ((n = 3))	79.9 (75.2 - 84.6) ((n = 2))	95.6 (70.1 - 121.4) ((n = 2))
pH (-log H ⁺ activity)	>6.5, <8.5	7.04 (6.91 - 7.18) ((n = 2))	7.22 (7.14 - 7.27) ((n = 3))	7.17 (7.10 - 7.24) ((n = 2))	7.66 (7.17 - 8.16) ((n = 2))
Water Temperature (°C)	Not Established	27.2 (26.5 - 27.9) ((n = 2))	27.2 (26.6 - 27.7) ((n = 3))	28.2 (27.5 - 28.9) ((n = 2))	28.4 (27.2 - 29.7) ((n = 2))
Air Temperature (°C)	Not Established	30.5 (29 - 32) ((n = 2))	31 (30 - 33) ((n = 3))	31 (29 - 33) ((n = 2))	31 (30 - 32) ((n = 2))
Flow (L/sec)	Not Established	32.6 (20.1 - 45.0) ((n = 2))	0.0 (0.0 - 0.0) ((n = 3))	24.4 (17.9 - 31.0) ((n = 2))	71.5 (0 - 143) ((n = 2))
Flow (GPM)	Not Established	516 (319 - 714) ((n = 2))	0.0 (0.0 - 0.0) ((n = 3))	387 (283 - 491) ((n = 2))	1134 (0 - 2268) ((n = 2))

^a For enterococci bacteria the average concentrations listed are geometric mean values.
^b Heavy rainfall (i.e., >0.3 inches) occurred within 24 hours of sampling. Sampling dates were 6/17/09 and 7/14/09.

Figure 1.

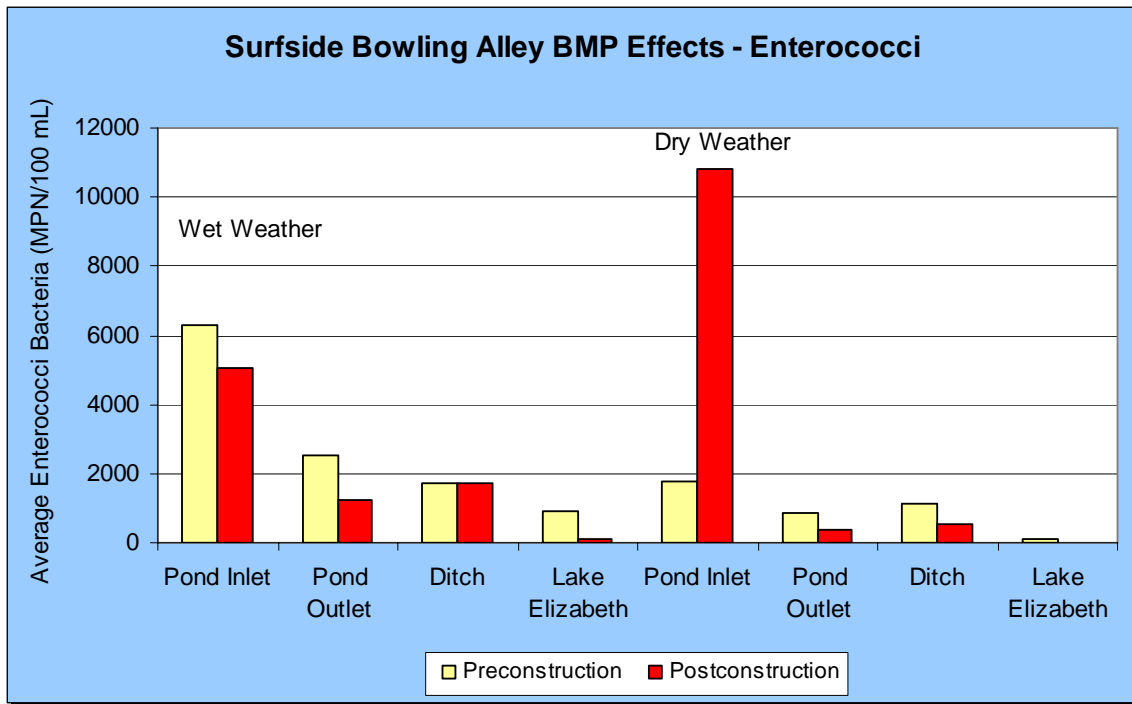


Figure 2.

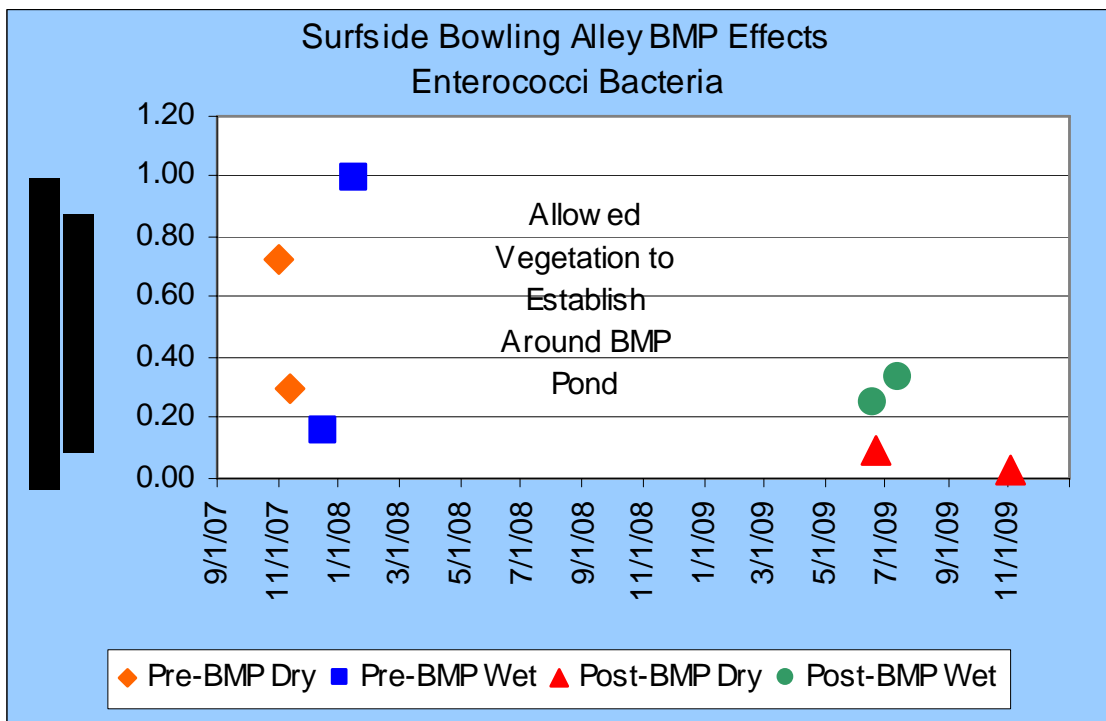


Figure 3.

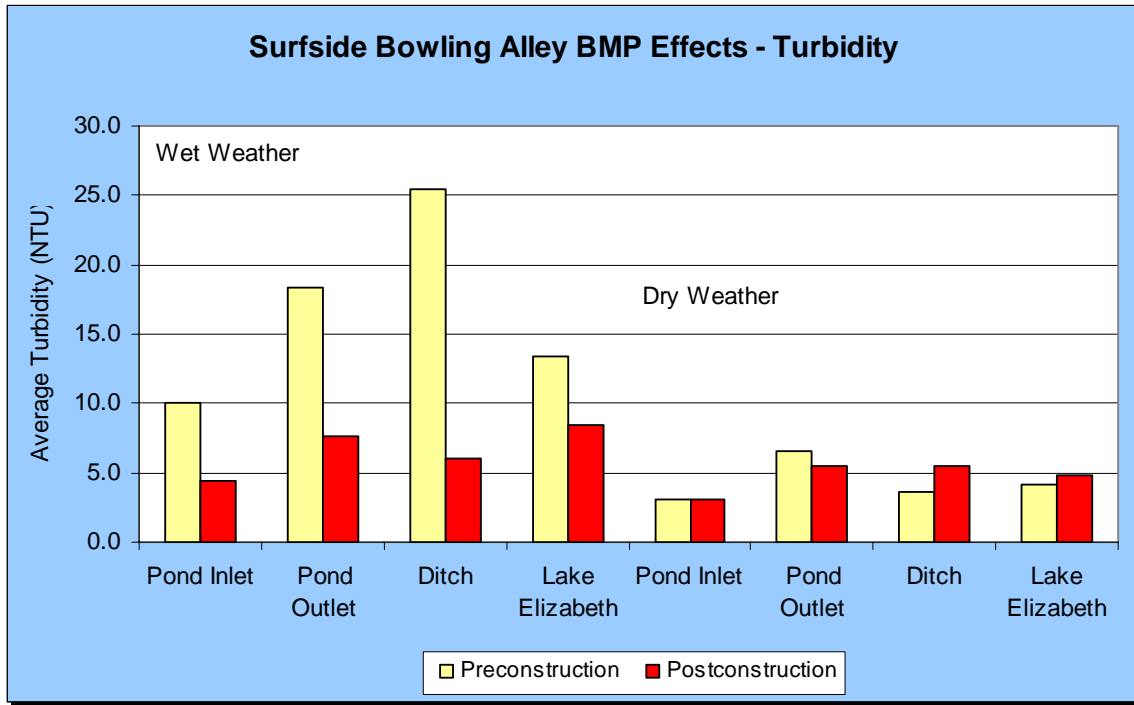


Figure 4.

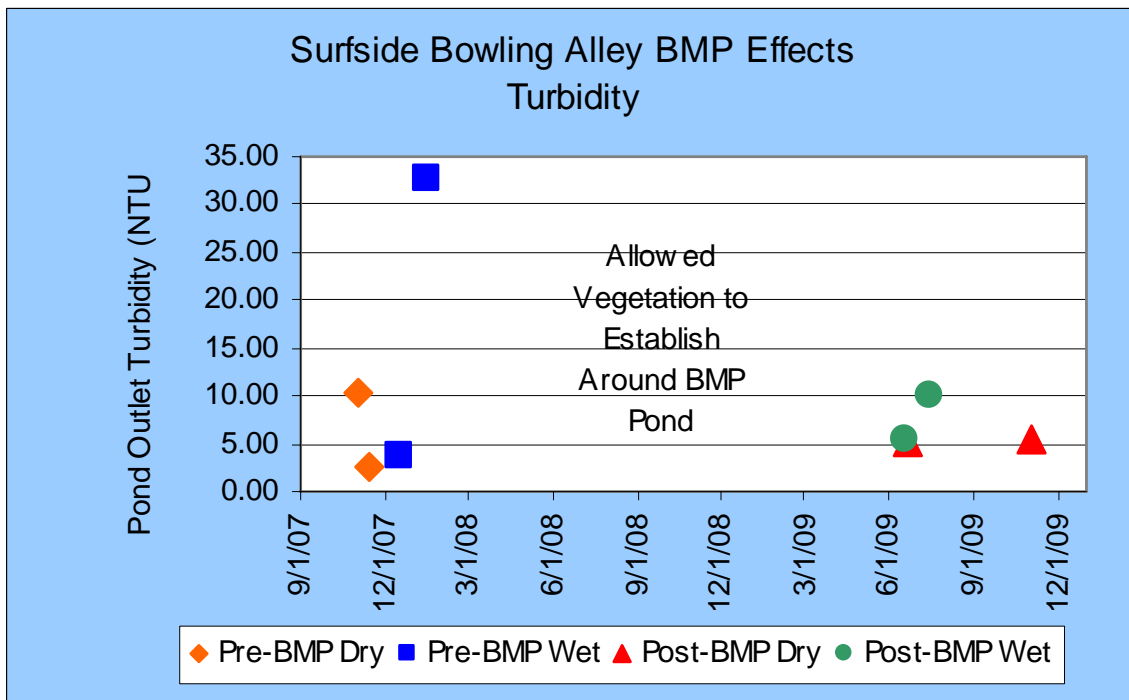


Figure 5.

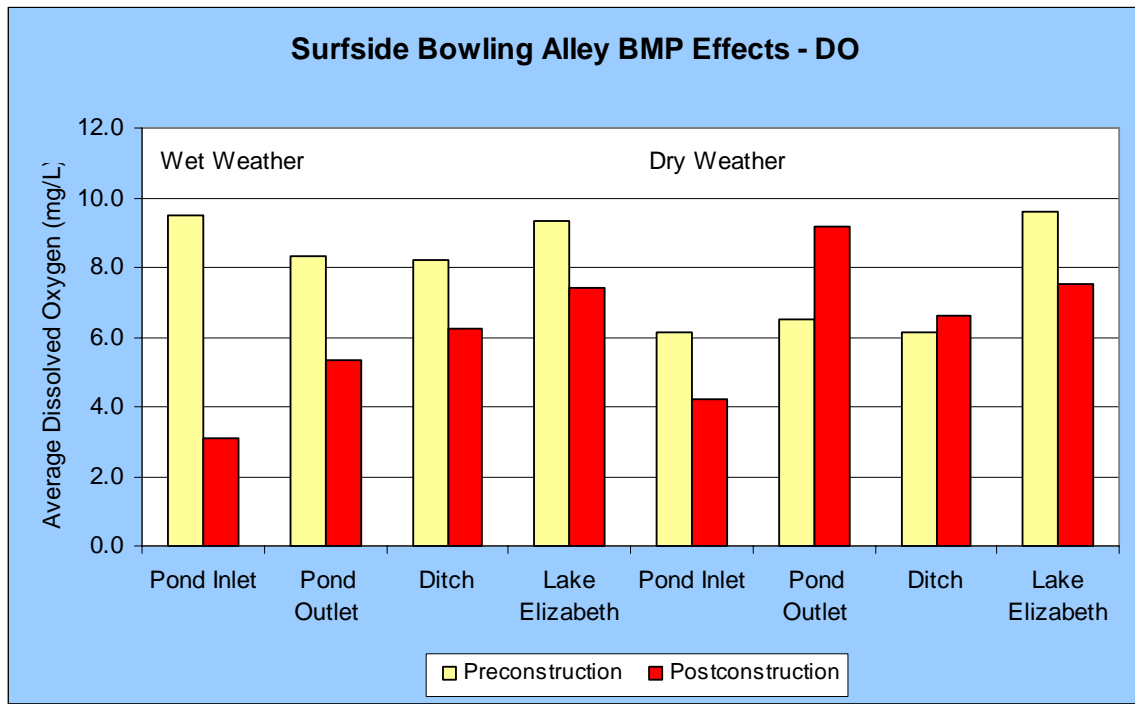


Figure 6.

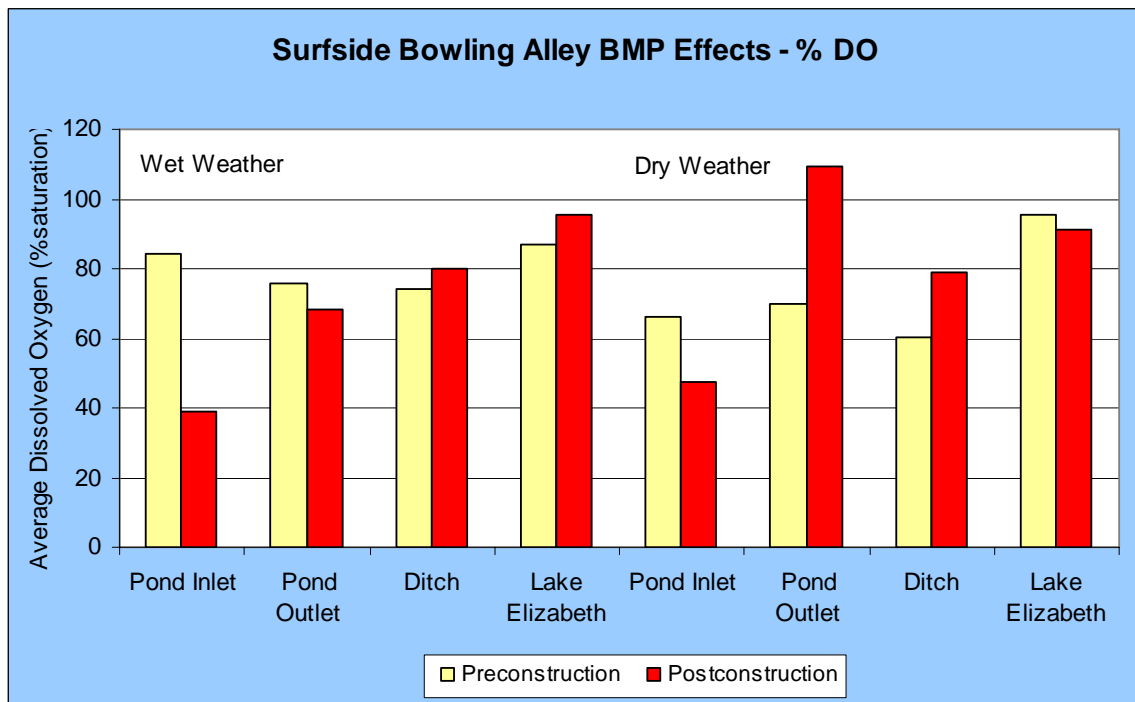


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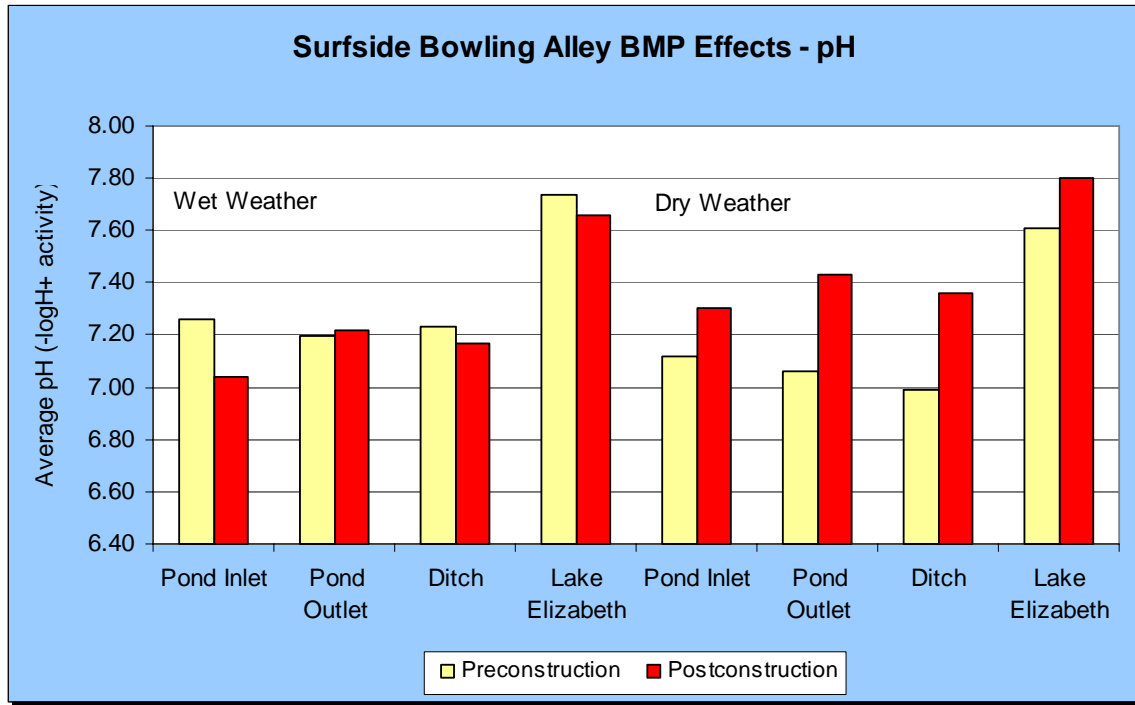


Figure 8.

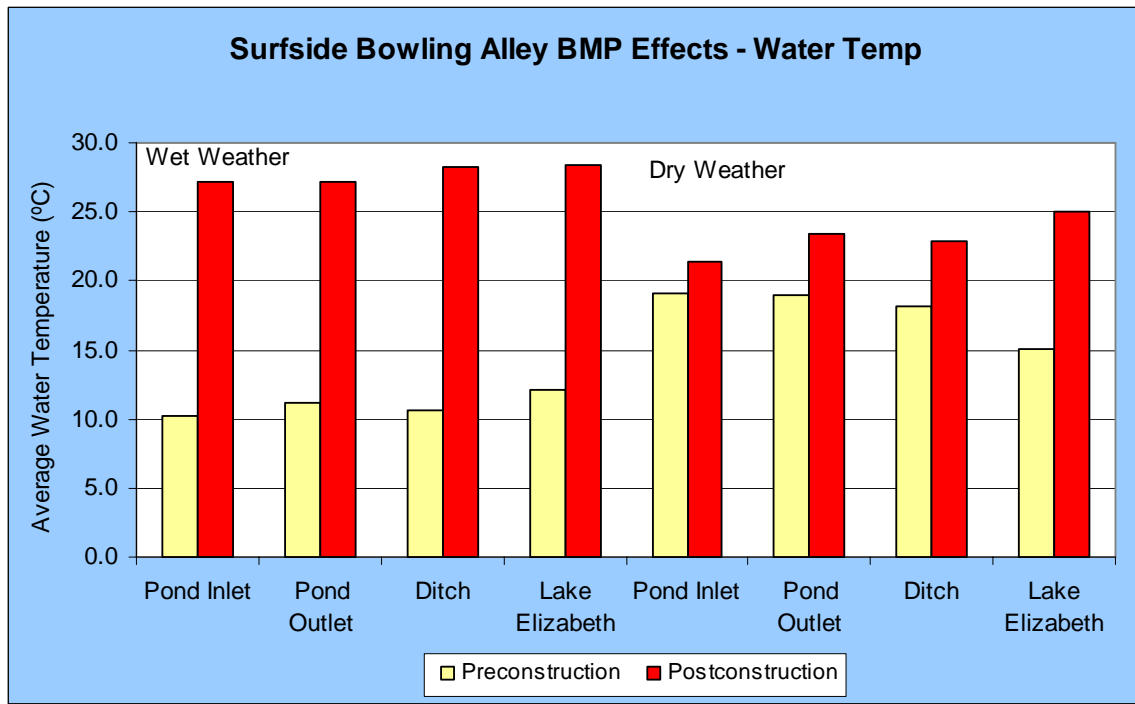


Figure 9.

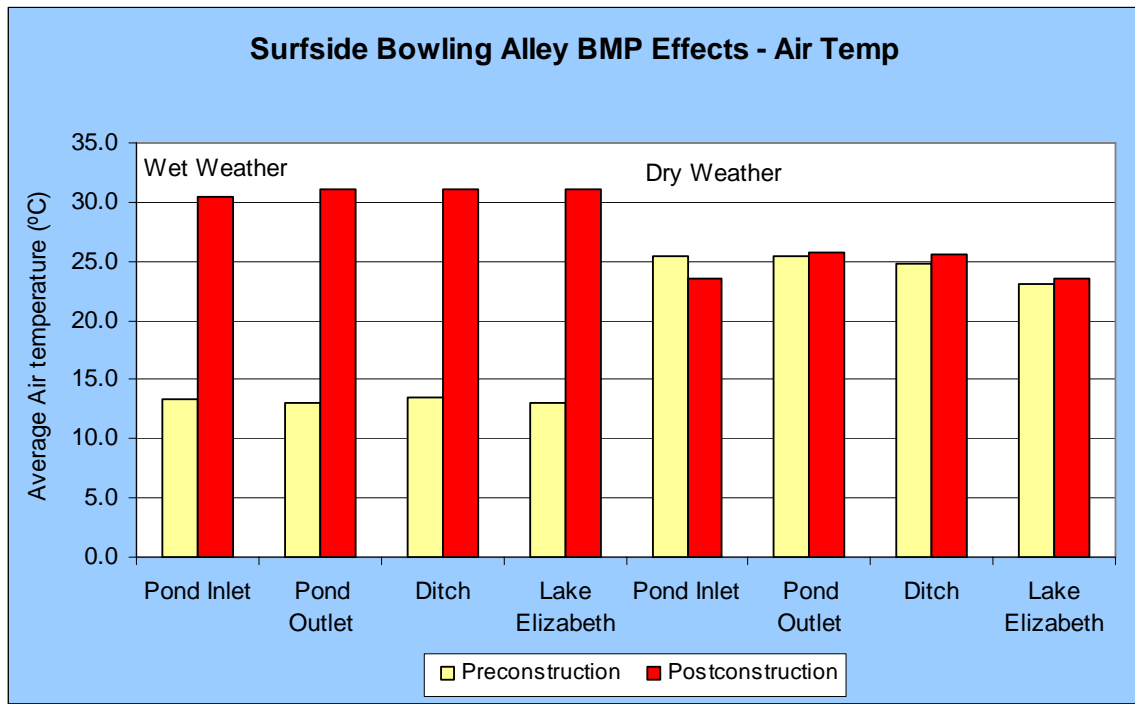
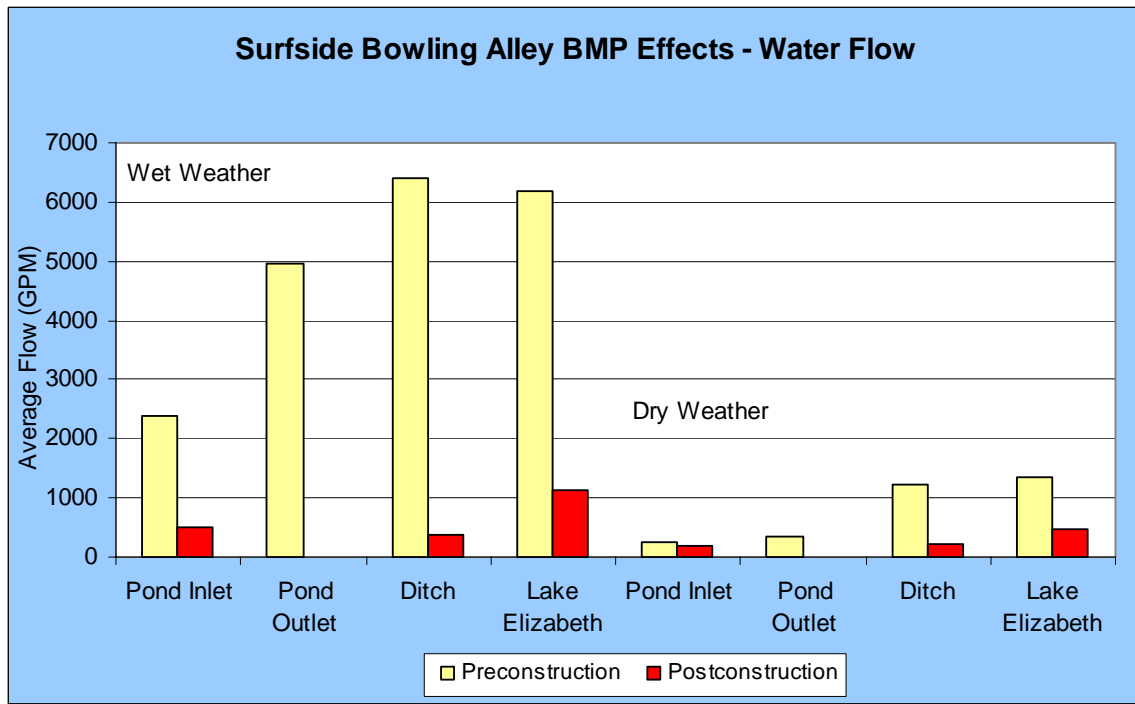


Figure 10.



Please do not hesitate to contact me if you have any questions concerning the information provided or if you desire additional information.

Sincerely yours,

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