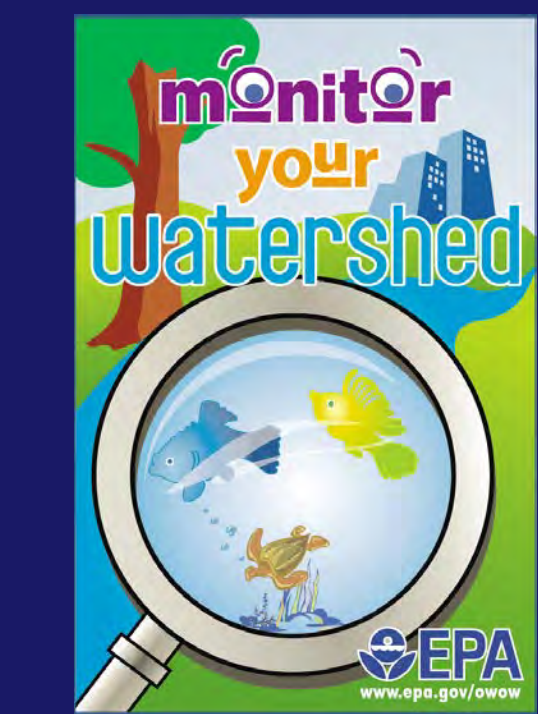


# Use of volunteer water quality monitoring in the management of water quality in the tidal creeks of Murrells Inlet and Surfside Beach, SC

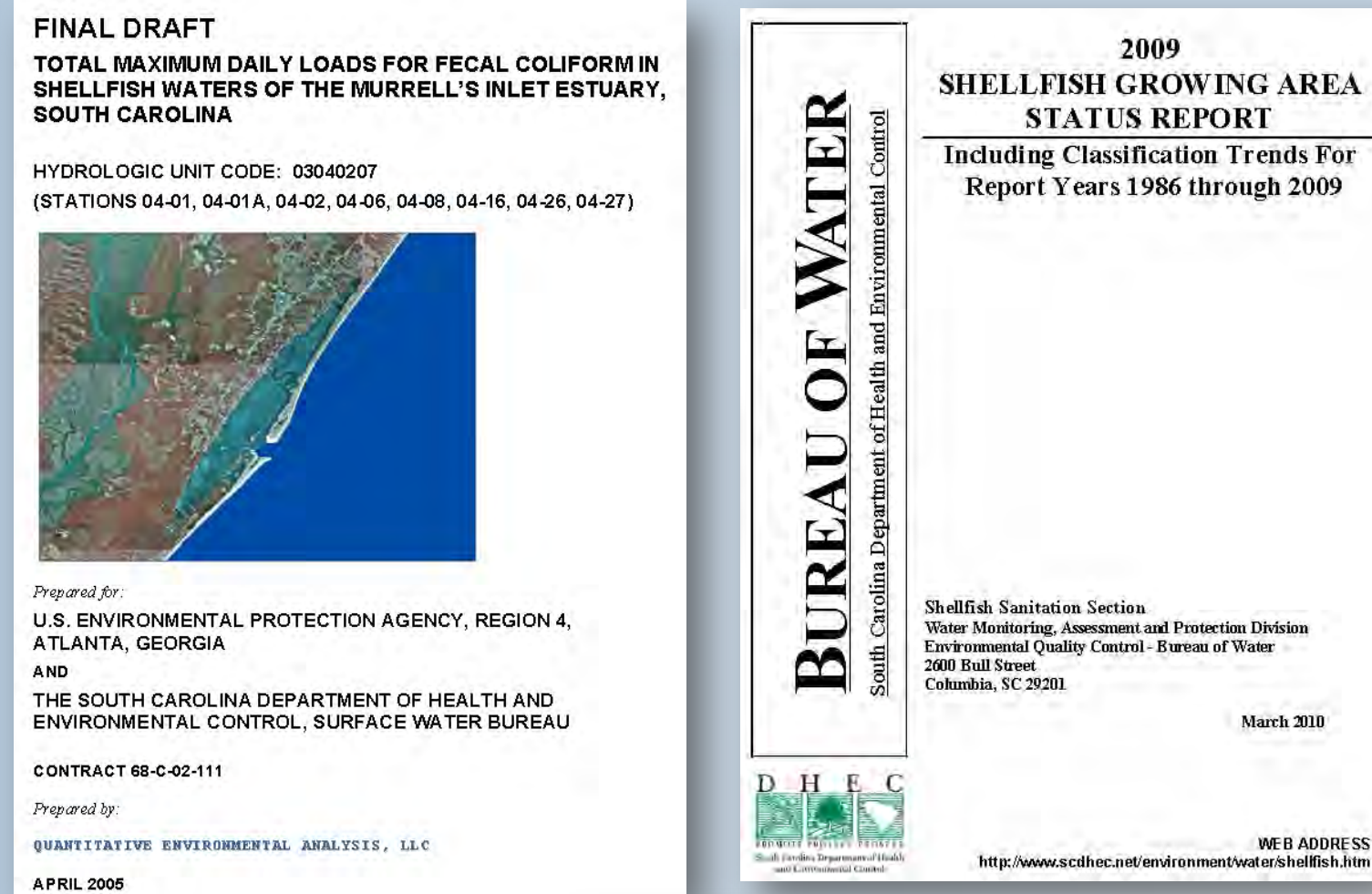
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## PROBLEM

- Chronic exceedances of fecal indicator bacteria (FIB) water quality standards have been documented in Murrells Inlet since the 1970's.
- Eight monitoring sites were placed on the federal 303(d) list of impaired waterbodies.
- A TMDL was approved by the US EPA in 2005.
- This TMDL does not include a source assessment. To facilitate implementation of the TMDL, information on FIB sources is needed.
- To meet this need, a volunteer water quality monitoring program was established in 2006, relying on the efforts of about 15 citizen scientists and led by a local community group, Murrells Inlet 2020. This program provides other benefits, including addressing Clean Water Act NPDES Phase II Stormwater program requirements.



## WHAT IS Volunteer Monitoring?

- When trained citizen volunteers collect scientific data.
- Examples: water quality, bird counts, turtle counts, weather, oysters (SCORE)

## WHAT ARE THE BENEFITS?

- Leverages brains, experience and insights of the volunteers
- Get more sampling done.
- Better connect data collection to community concerns and policy decisions
- Help meet local NPDES Phase II Stormwater Program requirements
- Promotes environmental stewardship
- Intergenerational activity

## PHYSIOGRAPHIC DESCRIPTION

Murrells Inlet is a well-mixed, meso-tidal, bar-built estuary located in the Pee Dee Coastal Frontage Basin (HUC 03040208) in northeastern South Carolina (Figure 1). It is approximately 5.5 naut mi in length with an average width of less than 1 naut mi. Main channel depths are approximately 4 m. It drains approximately 10,250 acres of land comprised of forest (31%), open water/beach (27%), urban buildup (24%), wetlands (16%), and urban/recreational grasses (2%). The inlet is characterized by ebb and flood tidal deltas, expansive intertidal mud flats, and intertidal oyster reefs. Small meandering creeks and high marsh areas are common and dominated by smooth cord grass (*Spartina alterniflora*). The mouth of the inlet is a rubble jetty system (completed in 1980), extending approximately 1,000 m seaward which serves to stabilize the inlet entrance channel. Tides are semidiurnal with a mean tidal range from 4.2 to 4.5 ft, dependent upon location. Spring tides range from 4.7 to 5.3 ft.

There are a total of 92 stream mi, 149 a lake waters, and 2,366 a estuarine areas in this watershed. All streams in the watershed are classified by SC DHEC under their Clean Water Act ambient water quality program as Shellfish Harvesting Waters (SFH), i.e. Suitable for primary and secondary contact recreation, crabbing, and fishing. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora. The inlet contains 3,108 a of habitat suitable for production of shellfish and is considered to be the most economically important shellfish producing area along South Carolina's northern coast.

Eight tidal creeks drain into Murrells Inlet: Whale Creek, Main Creek, Woodland Creek, Parsonage Creek, Flagg Creek, Allston Creek, Oaks Creek, and Oyster Cove. Freshwater input is limited to these small creek, thus salinities are generally greater than 30 psu throughout the estuary although values less than 20 psu can occur drainage ditches and the mouths of the tidal creeks. Precipitation is generally heaviest during late summer and early autumn. Tropical storms or hurricanes also produce large amounts of rainfall when they occur. During winter months, rainfall amounts usually decline and events are more uniform in occurrence. However, winter thunderstorms associated with rapidly moving low-pressure systems can generate heavy rains. Annual precipitation averages about 57 in.

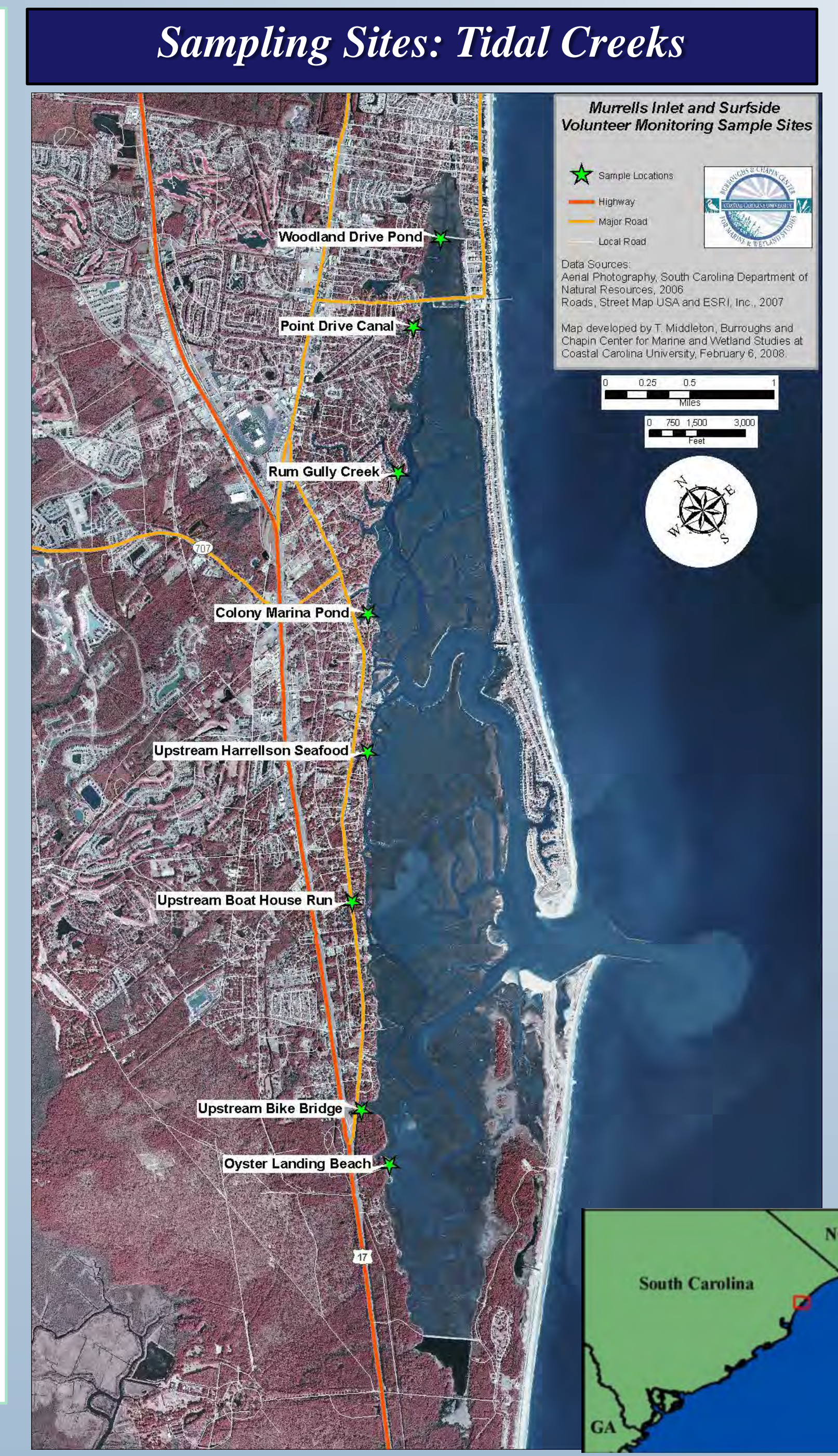


Figure 1. Murrells Inlet Estuary

## METHODS

### WHAT IS MEASURED AND HOW?

Biweekly year round ....

- Bacteria (*E. coli* and Total Coliform) – Easygel incubation with dual confirmation (Visible and fluorescent light)
- Nutrients (ammonia, nitrate, nitrite) – test strips
- Turbidity – desktop meter
- Salinity, temperature, oxygen, pH – field meters

### QA/QC Program

- Quality Assurance Project Plan
- Training and initial demonstration of capability (IDC)
- Calibration and field calibration checks
- Control charting of field replicates

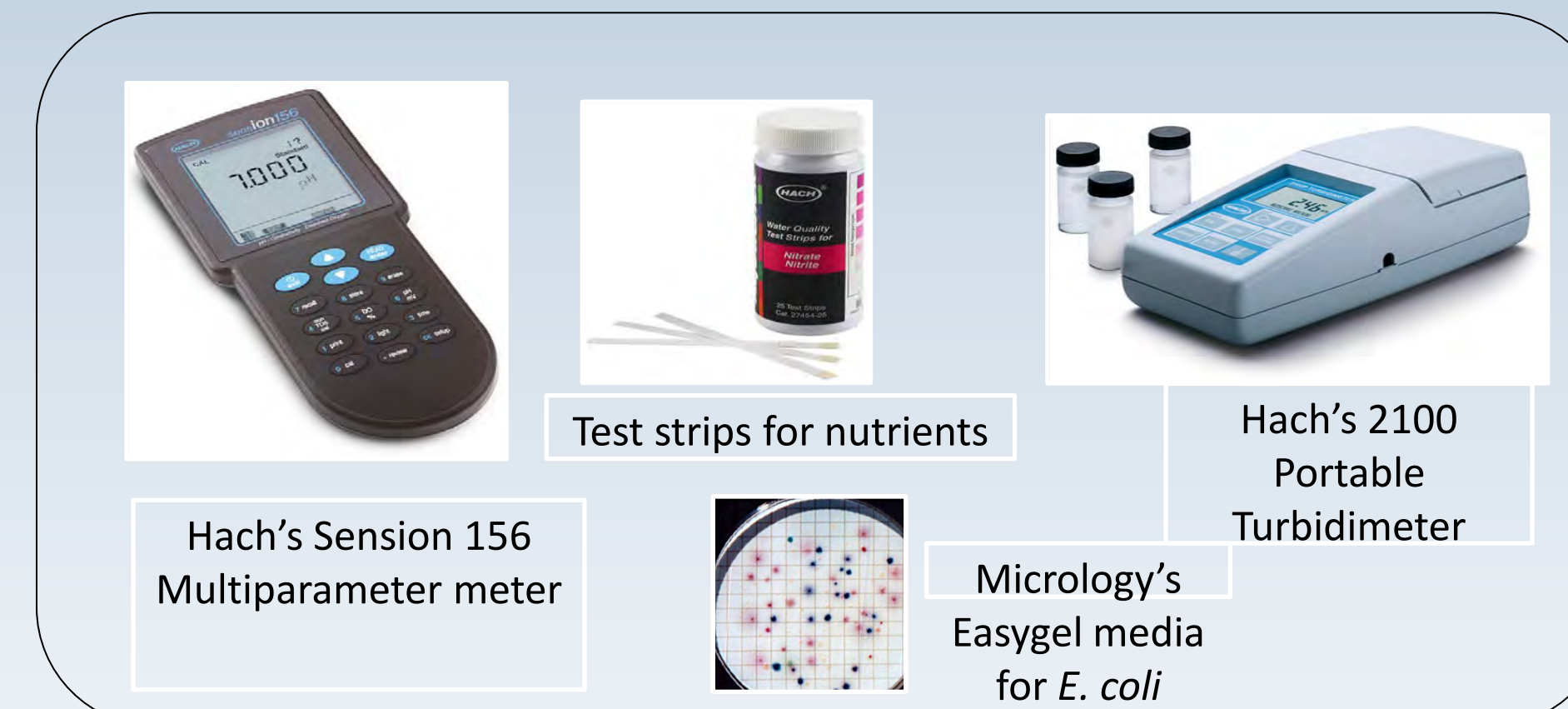


Figure 2. Volunteer Monitoring Equipment

## SAMPLING PLAN AND DATA MANAGEMENT

Figure 3. Water Sampling in the Inlet

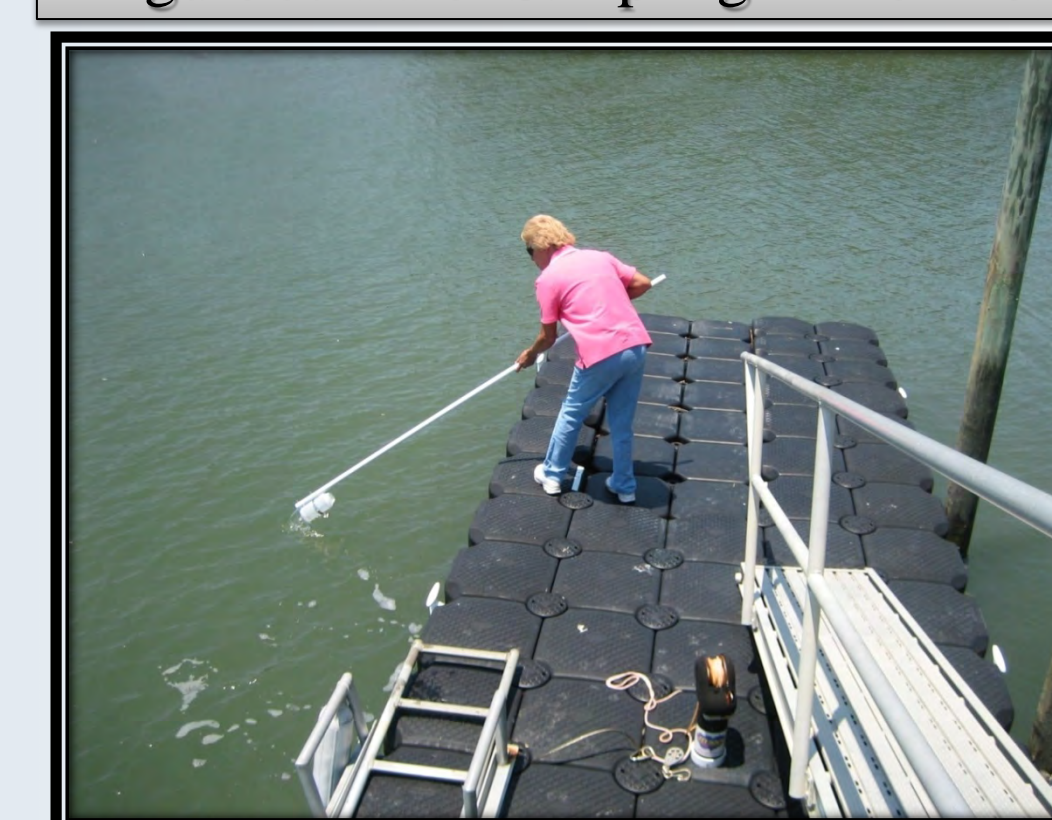


Figure 4. On Site Sampling Analysis

- Sampling sites located in 8 tidal creeks to test hypothesis that tidal creeks are a significant source of FIB to Murrells Inlet.
- Grab samples collected at 6 upstream (freshwater) sites and 2 downstream (saltwater) sites biweekly year round during wet and dry weather.
- Related water quality issues investigated
  - Eutrophication
  - Hypoxia
  - Sediment pollution

- Measurements are made on site except for FIB which requires an 18-hr incubation.
- Volunteers have site specific parameter ranges (Table 1). Values outside of these ranges are considered anomalous and reported to the volunteer monitoring coordinator via cell phone to facilitate a rapid illicit discharge investigation by the municipality's stormwater manager.
- FIB incubations and counts are performed by master samplers using home-based equipment.

### Data Management

- Online data entry by volunteers
- Provisional report generated in one week for illicit discharge follow ups using rapid response protocol shown in Figure 7.
- QC'd data are released to permanent database
- Permanent database drives public web portal



Figure 5. Public web portal to database

## RESULTS & REPORTING

- Dissolved oxygen, ammonia, and *E. coli* levels frequently contravene state and USEPA recommended water quality standards (Figures 8 and 9).
- To focus illicit discharge efforts, site specific parameter norms were developed from the first three years of data (Table 1).
- A rapid reporting protocol based on the site specific norms is used in the field by the volunteers to alert the stormwater managers of a potential severe illicit discharge (Figure 7).
- Data will be used for long-term trend analyses. Once five years of data are collected the seasonal Mann-Kendall test will be used to discover temporal trends.
- Data should be useful in refining state water quality standards for dissolved oxygen and turbidity in tidal creeks and in the transition to use of *E. coli* as the regulatory FIB in freshwater.

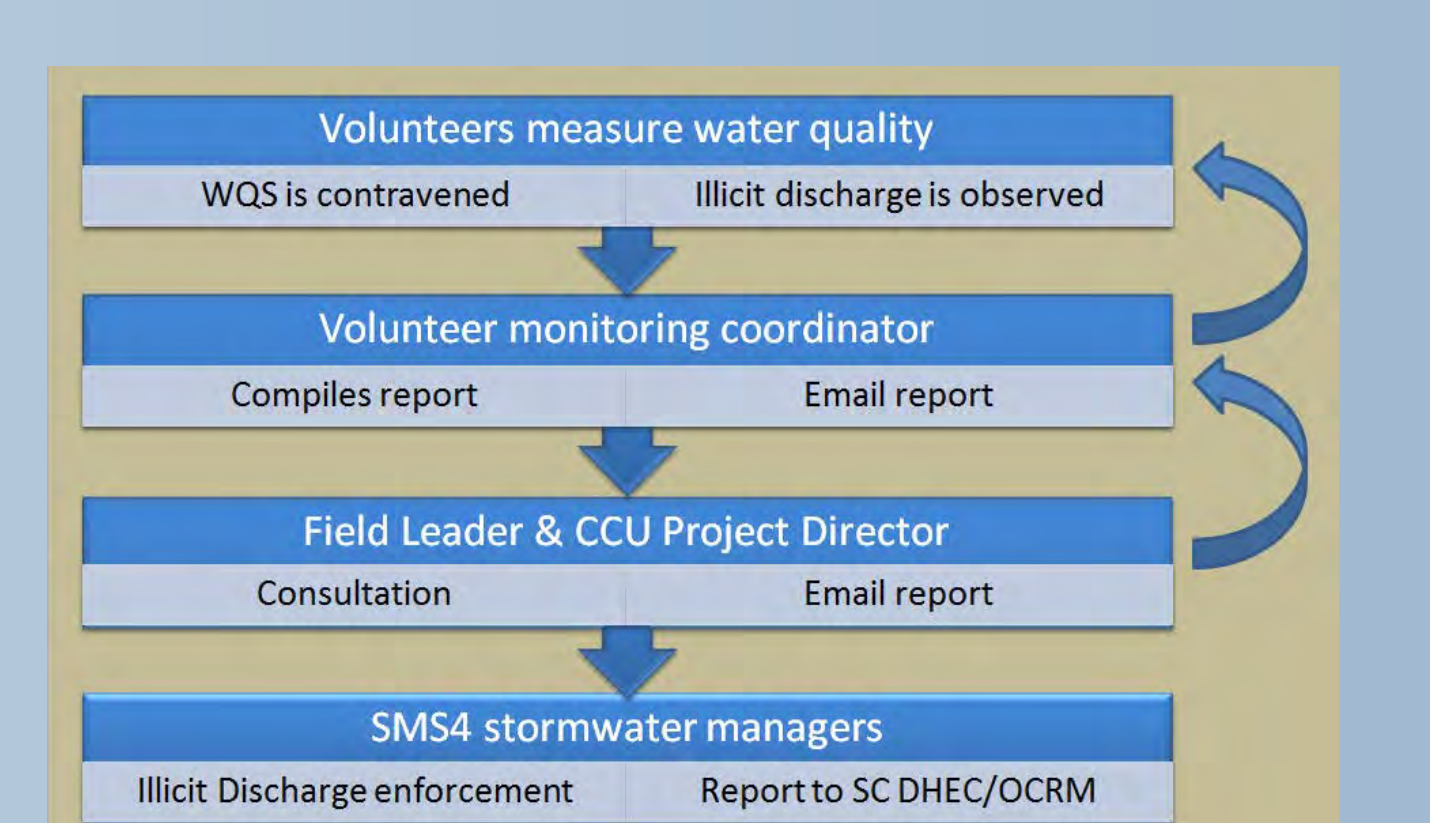


Figure 7. Rapid Response Reporting Protocol

Table 1. Site Specific Parameter Ranges

Murrells Inlet Volunteer Water Quality Monitoring Program  
Site Specific Ranges for June 2006 to April 2011

Values are highly unusual if they are outside of this range

Parameter	WDP Range	PDC Range	RGC Range	CMP Range	HS Range	BHR Range	BB Range	OLB Range
Cond (uS/cm)	233 to 1563	127 to 369	45400 to 54800	247 to 589	180 to 1732	248 to 27429	297 to 6716	47400 to 54800
TDS (mg/L)	112 to 767	59 to 199	28200 to 34700	109 to 292	19 to 853	119 to 16854	143 to 3451	30200 to 34900
pH	6.6 to 7.8	6.2 to 7.5	6.9 to 8.1	6.0 to 8.1	6.4 to 7.7	6.6 to 7.9	5.8 to 7.9	6.6 to 8.1
Turbidity (NTU)	2.9 to 10.8	0.6 to 7.1	1.5 to 15.2	0.7 to 5.8	1.9 to 8.0	1.7 to 8.2	1.4 to 11.3	2.0 to 25.4
Nitrate (mg N/L)	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00
Nitrite (mg N/L)	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00
Ammonia (mg N/L)	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.50	0.00 to 0.88	0.00 to 0.00
E. Coli (CFU/100 mL)	0 to 3551	0 to 333	0 to 83	0 to 291	0 to 4250	0 to 13600	0 to 982	0 to 0
Total Coliform (CFU/100 mL)	0 to 16325	33 to 3784	0 to 250	0 to 2526	200 to 19300	0 to 28900	100 to 4901	0 to 168
DO (mg/L) > 20 C	1.3 to 4.8	1.0 to 5.9	2.2 to 5.9	0.3 to 2.9	3.0 to 6.2	2.3 to 6.7	1.2 to 5.4	2.0 to 6.9
DO (mg/L) < 20 C	3.2 to 10.1	2.9 to 9.2	3.5 to 10.9	0.3 to 7.7	2.8 to 8.8	2.8 to 8.0	1.5 to 10.5	3.8 to 12.0
%DO > 20 C	16 to 56	12 to 71	25 to 59	1 to 32	36 to 66	27 to 74	15 to 65	25 to 90
%DO < 20 C	34 to 84	28 to 87	35 to 88	4 to 80	32 to 74	26 to 80	18 to 86	40 to 111
Temp > 20 C	20 to 30	20 to 32	20 to 30	20 to 31	21 to 28	21 to 28	20 to 30	20 to 30
Temp < 20 C	4 to 20	3 to 14	4 to 20	5 to 20	7 to 19	7 to 20	6 to 20	4 to 19

Values are somewhat unusual if they are outside of this range

Parameter	WDP Range	PDC Range	RGC Range	CMP Range	HS Range	BHR Range	BB Range	OLB Range
Cond (uS/cm)	393 to 861	253 to 337	49600 to 52400	376 to 461	424 to 947	881 to 11500	389 to 2920	50700 to 52900
TDS (mg/L)	190 to 421	121 to 162	31200 to 33200	177 to 223	205 to 464	464 to 7020	188 to 1493	32300 to 33700
pH	7.2 to 7.5	6.7 to 7.1	7.4 to 7.8	6.6 to 7.2	7.0 to 7.4	7.1 to 7.6	6.6 to 7.2	7.4 to 7.9
Turbidity (NTU)	4.0 to 6.8	1.4 to 3.7	3.5 to 8.2	1.6 to 3.3	2.9 to 5.0	3.3 to 5.2	2.4 to 6.0	5.5 to 13.5
Nitrate (mg N/L)	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00
Nitrite (mg N/L)	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00
Ammonia (mg N/L)	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.00	0.00 to 0.20	0.00 to 0.25	0.00 to 0.35	0.00 to 0.00
E. Coli (CFU/100 mL)	133 to 1500	0 to 133	0 to 33	33 to 100	167 to 1800	267 to 5600	67 to 433	0 to 0
Total Coliform (CFU/100 mL)	125 to 7325	325 to 1708	0 to 100	233 to 1150	1800 to 8800	2400 to 13000	525 to 2275	0 to 67
DO (mg/L) > 20 C	2.2 to 3.3	2.3 to 3.7	0.8 to 1.6	0.8 to 1.6	3.5 to 4.6	3.6 to 4.8	2.1 to 3.8	3.3 to 5.5
DO (mg/L) < 20 C	5.3 to 7.5	4.4 to 6.6	5.3 to 7.5	2.7 to 5.7	4.6 to 6.3	4.8 to 6.1	4.8 to 7.2	7.1 to 9.9
%DO > 20 C	27 to 39	30 to 46	33 to 43	10 to 19	43 to 52	43 to 56	26 to 44	42 to 64
%DO < 20 C	50 to 69	44 to 61	52 to 66	26 to 51	48 to 58	46 to 59	48 to 68	66 to 89
Temp > 20 C	24 to 29	23 to 28	23 to 28	23 to 27	23 to 25	23 to 26	23 to 26	24 to 26
Temp < 20 C	11 to 16	6 to 12	10 to 15	10 to 17	12 to 17	12 to 17	11 to 17	10 to 15

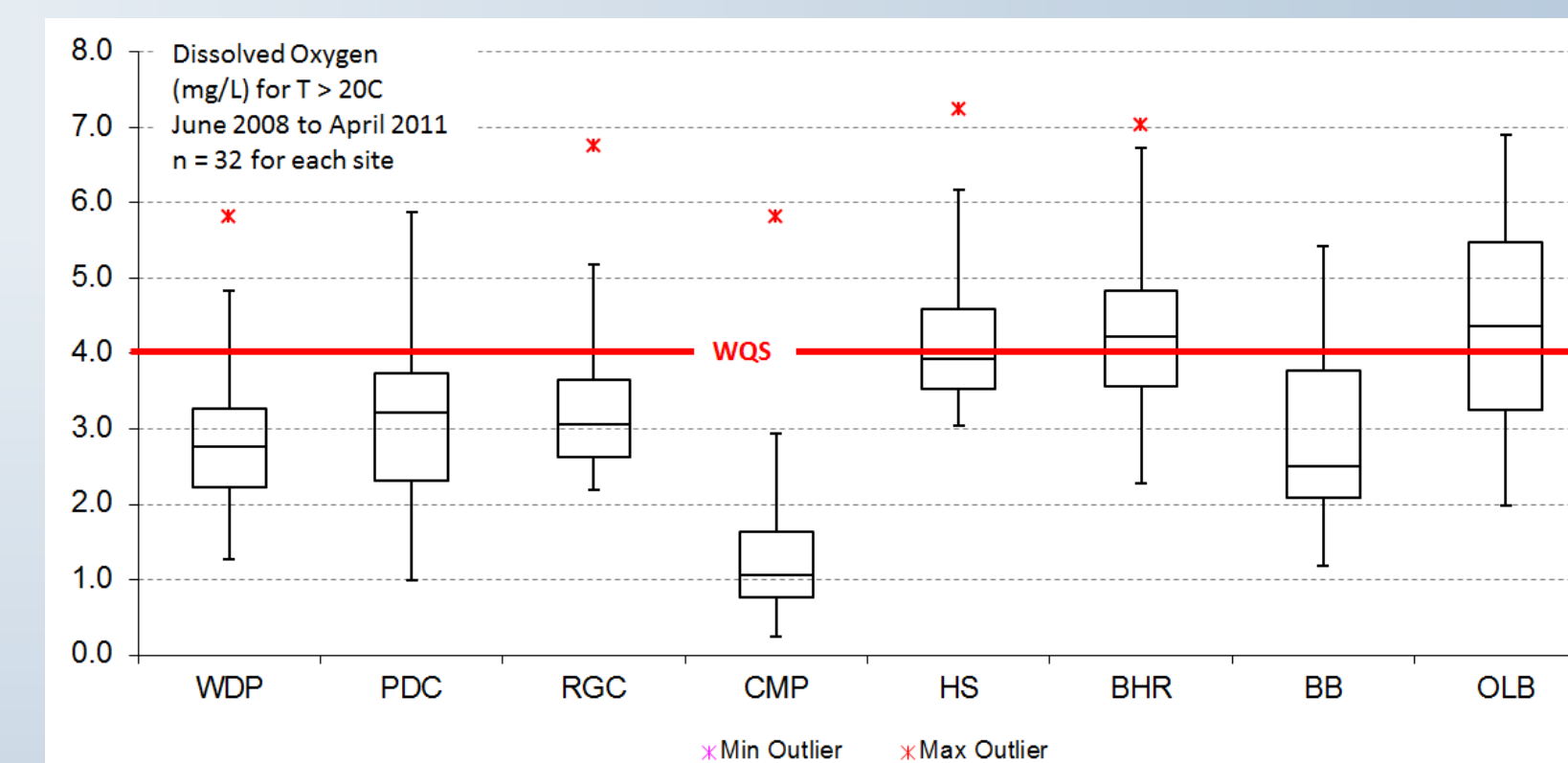


Figure 8. Boxplot of dissolved oxygen for warm weather samples. SC DHEC WQS is 4 mg/L (red line).

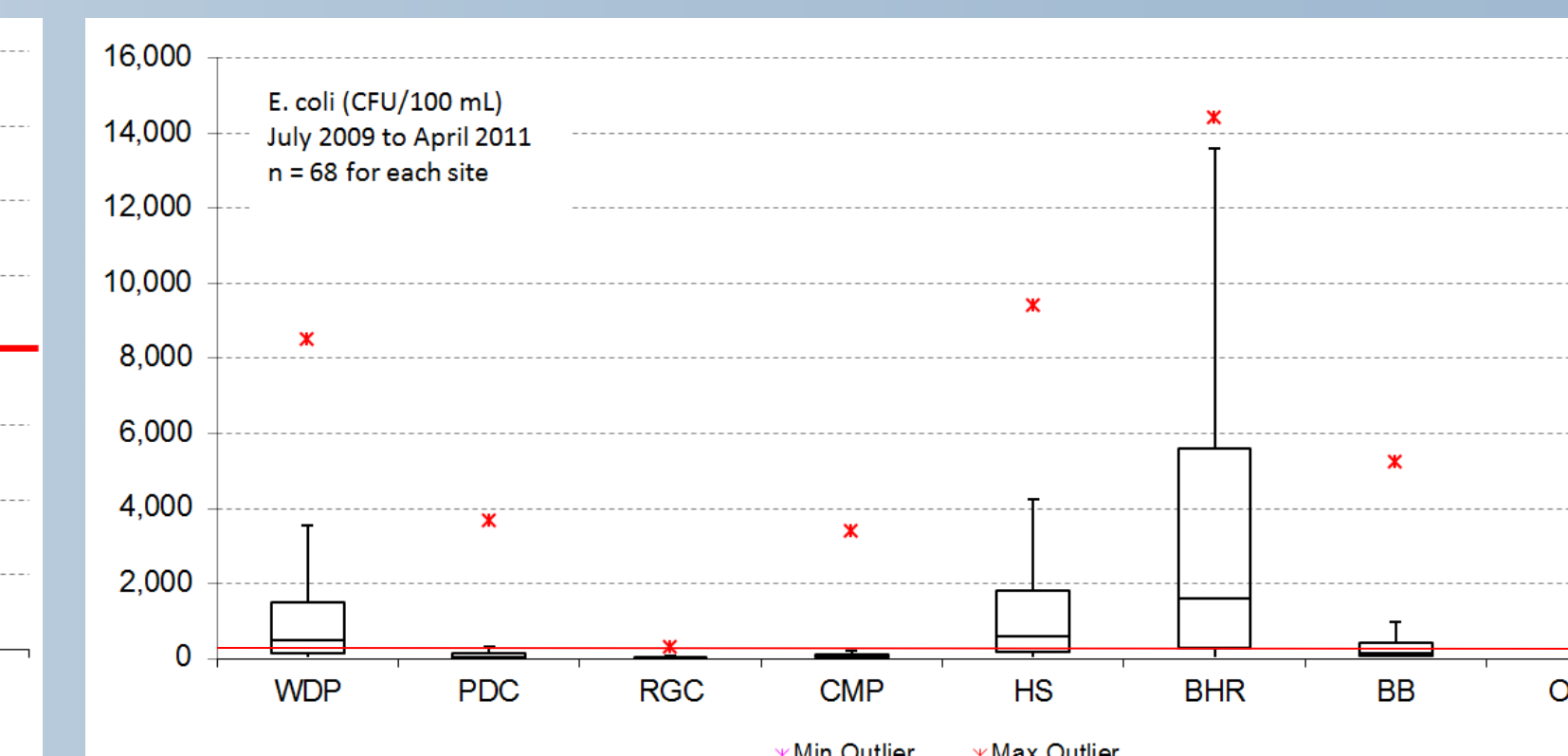


Figure 9. Boxplot of *E. coli* data. USEPA Recreational WQS is 235 CFU/100 mL (red line).

## CONCLUSIONS

- Four of the tidal creeks have very high *E. coli* levels during wet and dry weather.
- Almost all of the sites have relatively low oxygen levels, especially during warm weather.
- These findings have stimulated research projects to locate pollution sources upstream of the sampling sites using sedimentary bacteria, optical brighteners and qPCR-based techniques.
- Management responses implemented include reduction of pet waterfowl populations and road improvements by SC DOT.

## ACKNOWLEDGEMENTS

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### Funding Sources

- Horry County
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- Surfside Beach