Microbial Source Tracking

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NJDEP Water Monitoring and Standards

Bureau of Marine Water Monitoring

OVERVIEW

New Jersey's Application of Microbial Source Tracking Techniques

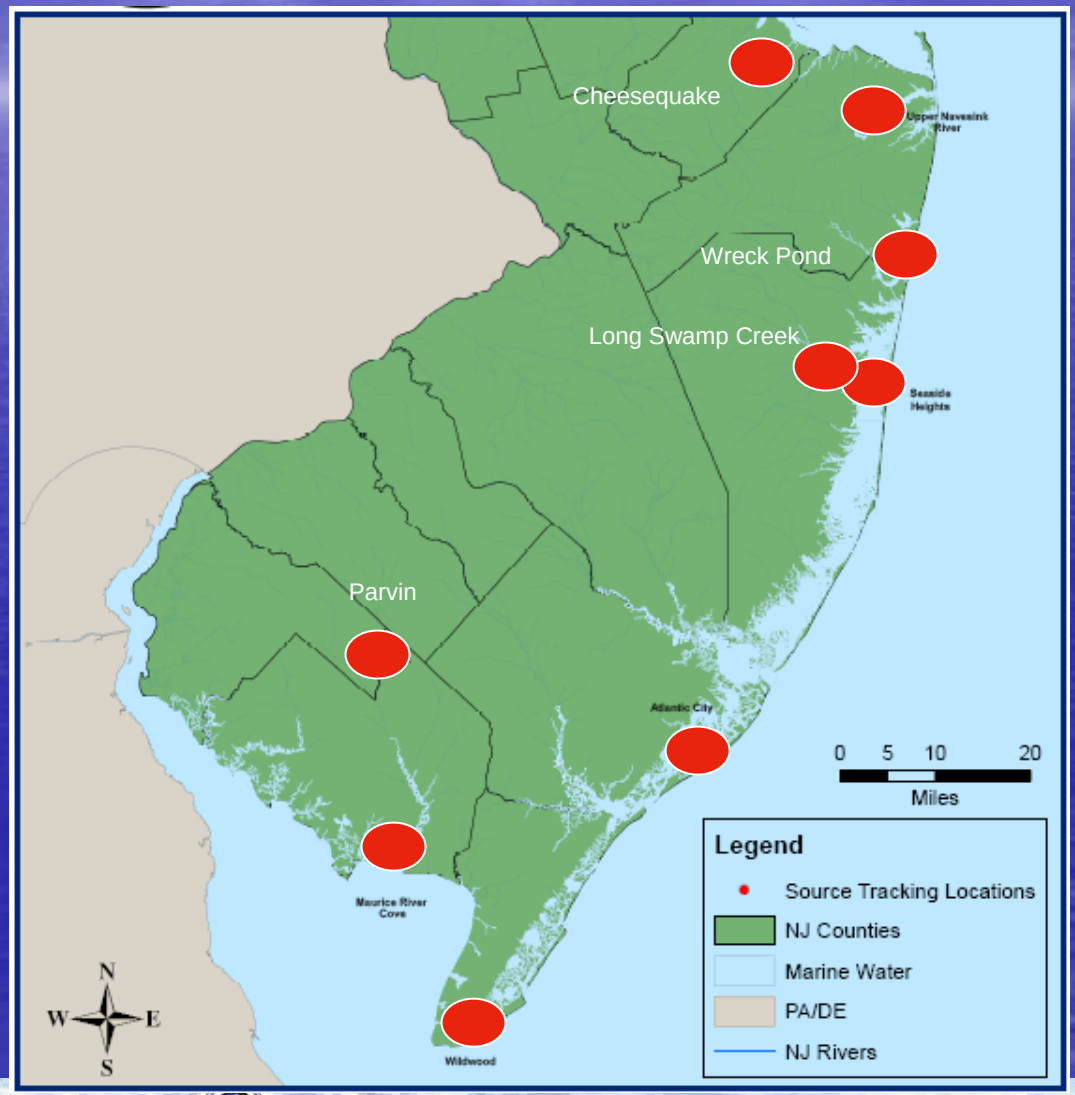
- New Jersey's tiered approach to microbial source tracking studies
- Laboratory methods used to distinguish sources of fecal contamination
- MST case study at impaired shellfish growing areas
- MST case study at impaired recreational waters

Nonpoint Source Microbial Source Tracking

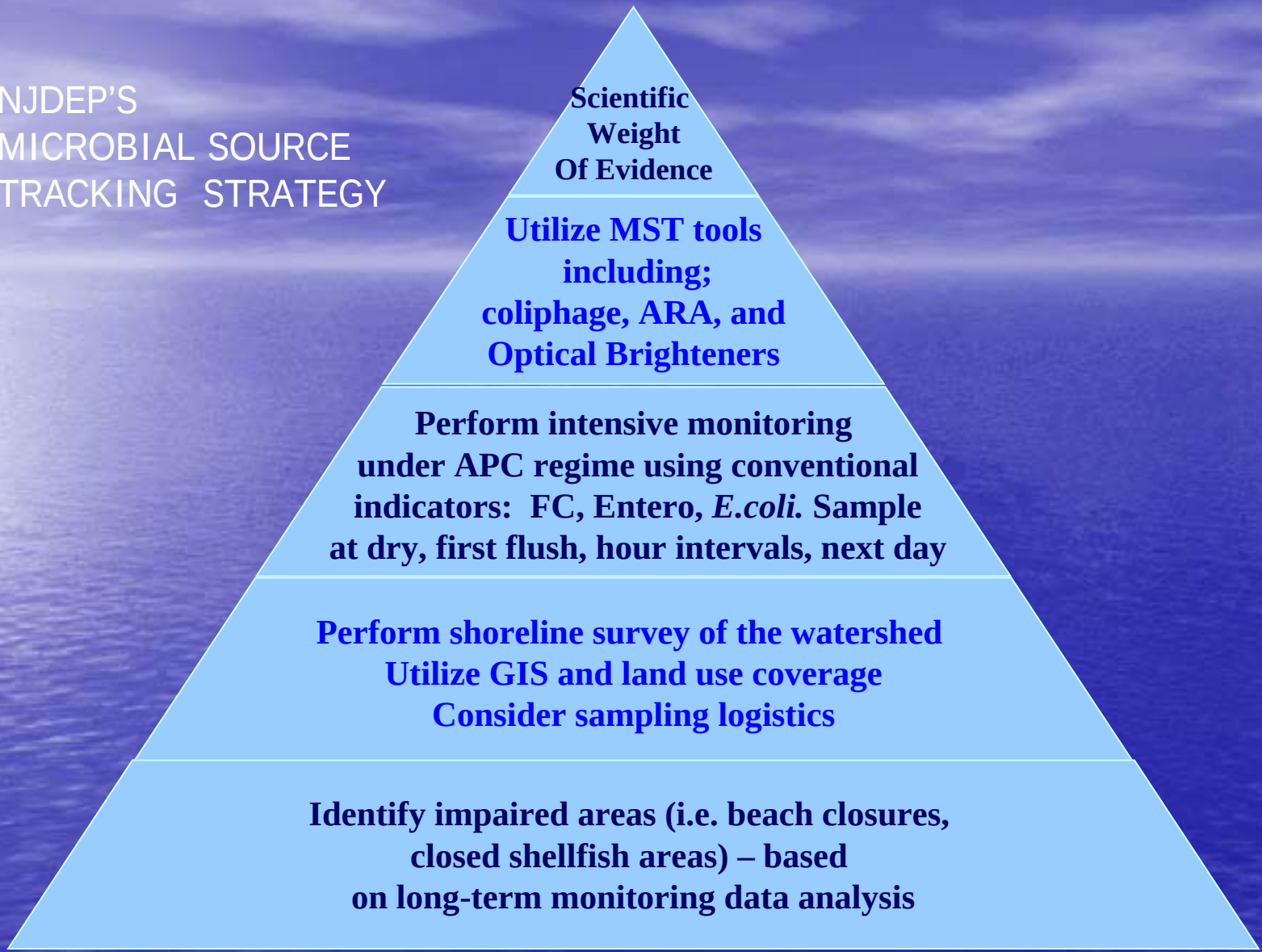
A high percentage of NJ's water quality impairments are related to pathogens.

Microbial source tracking efforts are becoming increasing common in NJ surface waters.

There are currently 9 different source tracking efforts underway in NJ.



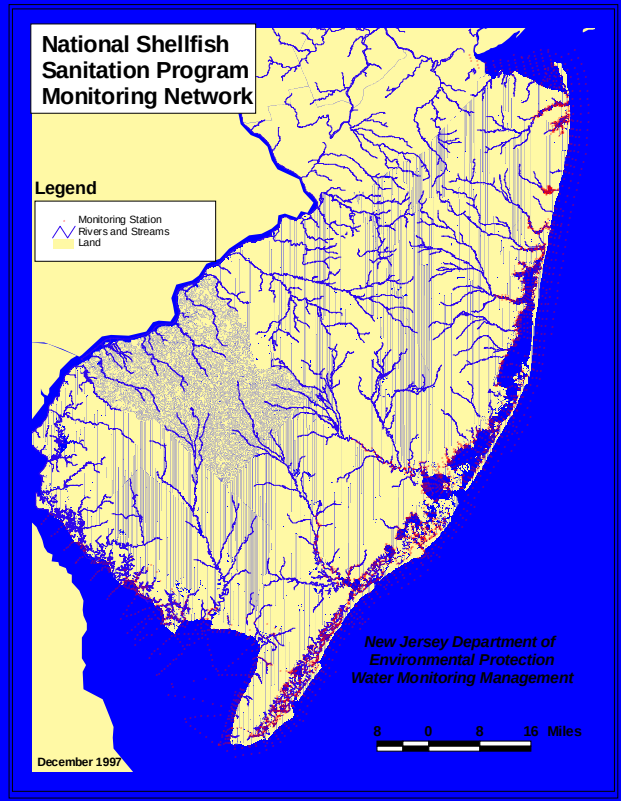
NJDEP'S MICROBIAL SOURCE TRACKING STRATEGY



ADVANCED MICROBIOLOGY LABORATORY AT LEEDS POINT

NSSP Monitoring Network

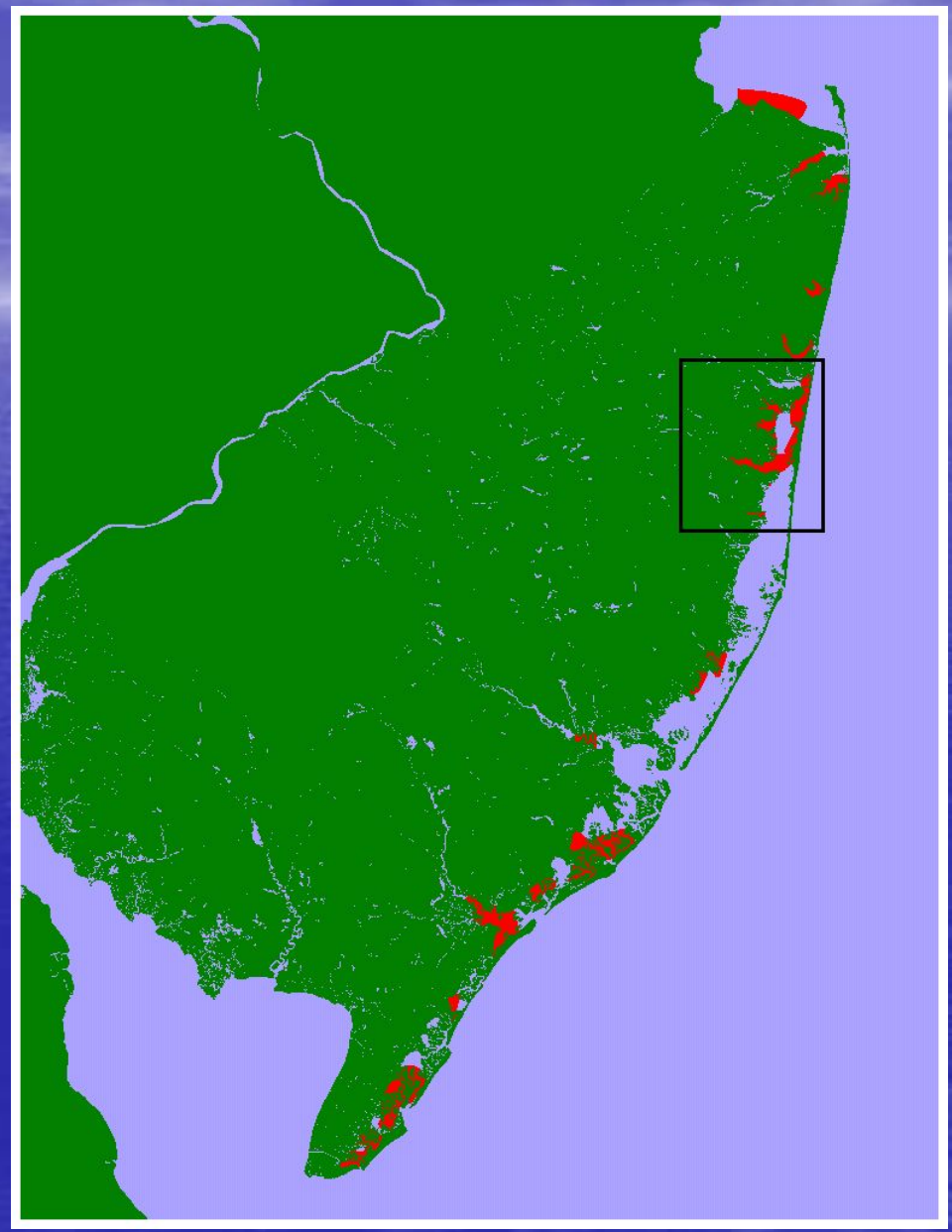
- 2500 active monitoring locations
- Sampling 5-12 times/year
- Total and fecal coliform bacteria
- Approximately 15,000 samples/year



Stormwater Effects on the Coast

Areas shaded red - coastal water quality degraded following storm events.

Evaluation based on 10 years of data - generated by Leeds Point staff.



Questions that need to be answered when designing a MST Study

- Is the Impairment Adequately Defined?
  - beach closures
  - shellfish growing waters
- Has An Adequate Sanitary Survey Been Conducted?
- How Many Sources Were Identified In the Sanitary Survey?

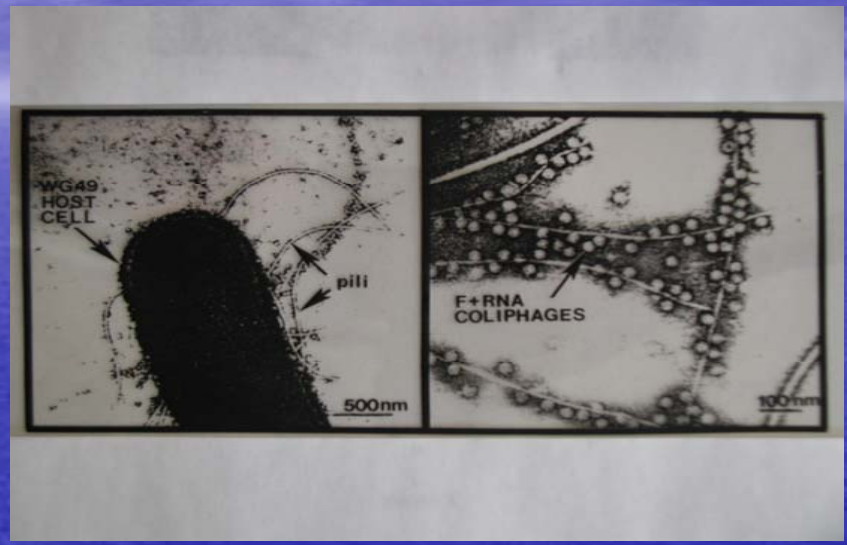
Questions - continued

- Levels of Discrimination
  - Humans vs. all other sources
  - Species specific (humans, cows, geese, dogs, etc.)
  - Host Group (humans vs. livestock vs. wildlife)
  - Individual hosts (cows from a certain farm vs. other farms)

  - *Accuracy decreases as level of discrimination increases*

F+ RNA Coliphages

- Viruses that infect bacterial cells
- Similar in size, shape and morphology to HEV including; HAV and Norwalk therefore: good viral pathogen indicator
- More resistant to chlorination than the conventional indicators therefore: good wastewater effluent indicator



Coliphage - NJDEP Findings

- Monitoring at known fecal contaminated sites
  - point human - wasterwater discharge outfall
  - point animal - wildlife refuge discharge
  - non-point human - malfunctioning septic tank discharge
  - non-point animal - rural creek w/animal population

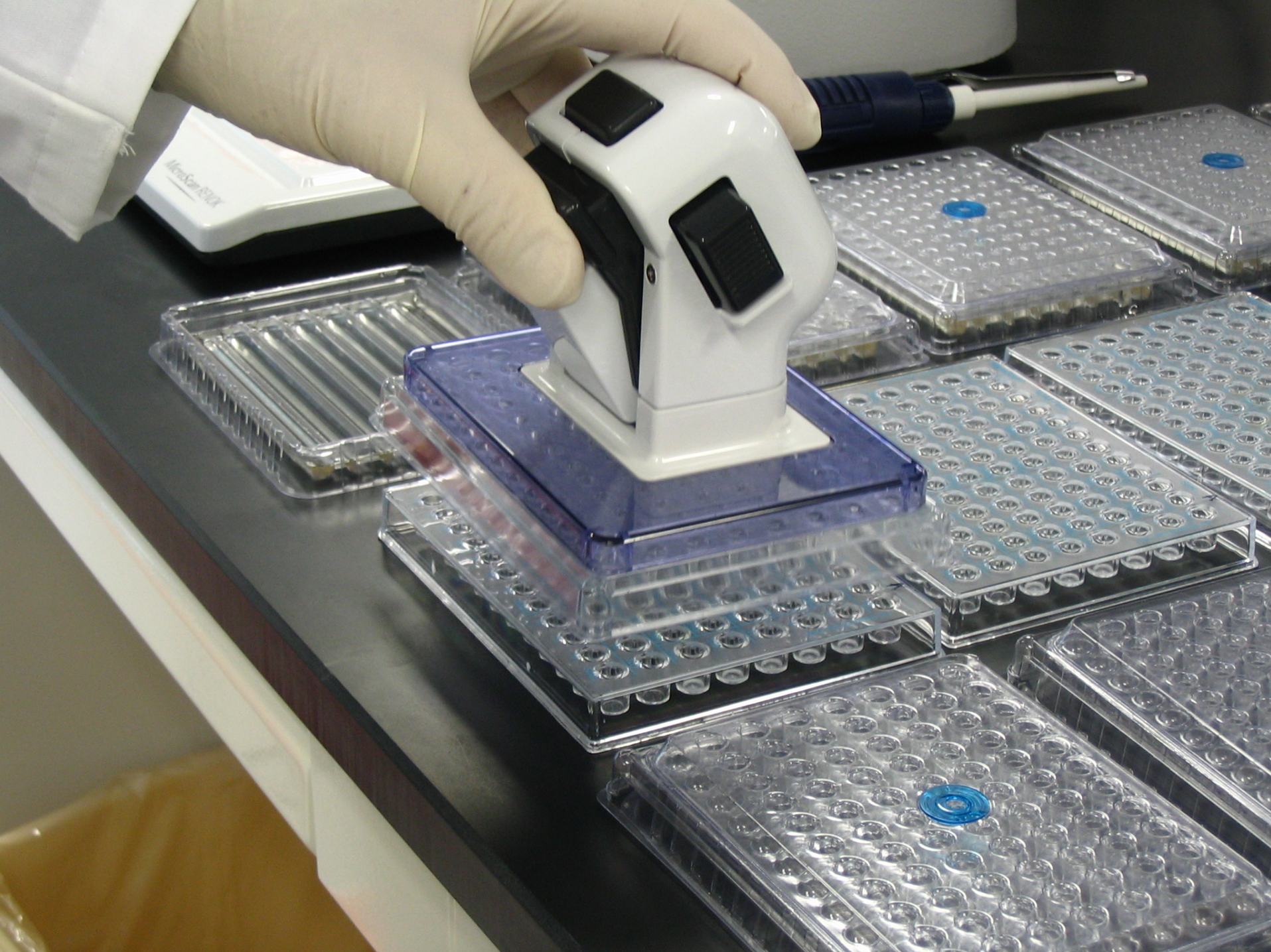
  - Findings:
    - Verified the presence of coliphage at these sites and validated the procedure
    - Genotyping) of the phages provides a promising system for distinguishing human and animal fecal contamination

Genotyping of coliphages

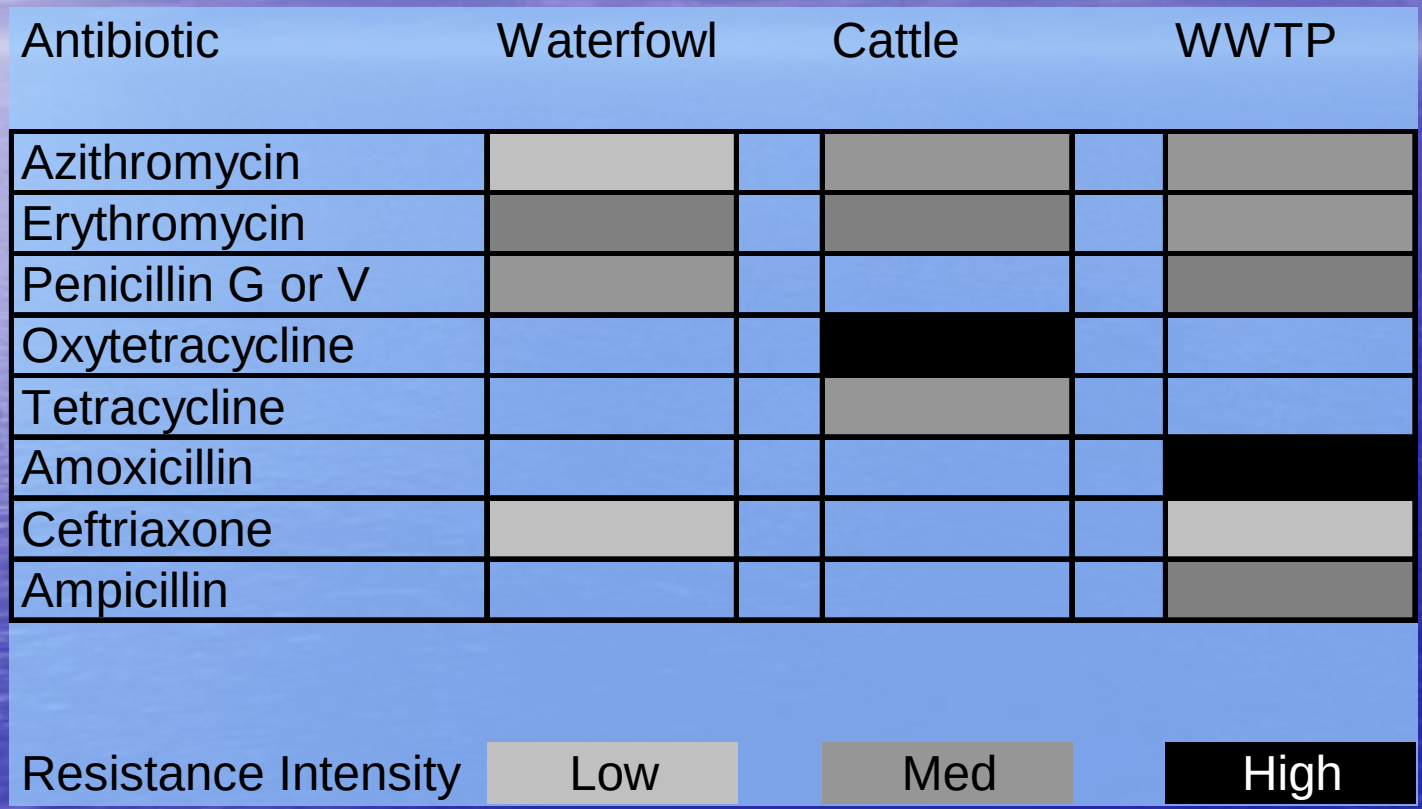
- Group I - Animal
- Group II - Human
- Group III - Human
- Group IV - Animal

ARA – Antibiotic Resistance Analysis

- **ARA - Antibiotic Resistance Analysis**
  - identifies *E. coli* that are resistant to antibiotics used to treat bacterial infections in humans and domesticated animals.
  - Procedure uses 96 well microplate containing 26 antibiotics typically administered to humans and domesticated animals



ARA Results


Antibiotic
Waterfowl
Cattle
WWTP
Azithromycin
Erythromycin
Penicillin G or V
Oxytetracycline
Tetracycline
Amoxicillin
Ceftriaxone
Ampicillin
Resistance Intensity
Low
Med
High

WILDLIFE

NOAA Panel Date 3-21-06 Coll. Time 11:00 Sample # REFUGE ID # EAST GATE

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Ofl	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 Cfx	8	16	32	64 Cax	4	8	16	32 Cf
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

MODIFIED mTec

Vol.	Colony Count	CFU's/100mLs
30	12	40

Phage	PFU's/100mLs
—	<1

DOMESTICATED ANIMAL

NOAA Panel Date 3-2-04 Coll. Time _____ Sample # _____ ID # ALLDWAY

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Ofl	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 Cfx	8	16	32	64 Cax	4	8	16	32 Cf
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

Vol.	MODIFIED mTec Colony Count	CFU's/100mLs
_____	_____	_____

Phage	PFU's/100mLs
_____	_____

HUMAN

NOAA Panel Date 3-27-04 Coll. Time _____ Sample # ACUA ID # EFFLUENT

G	2	4	8	16 Imp	1	2	4	8 Mox	1	2	4 Cp
1	2	4	8	16 Mer	1	2	4	8 Ofl	250 Sz	500	2
2	4	16					8	16	32 C		4
4 Azi	8	32	4	8	16	32 Otet	4	8	16	32 NA	8 T
8	16	64	4	8	16	32 Te	8	16	32	64 Ak	2/38
16	32 E	128 St	2	4	8	16 Gm	16	32	64	128 Fd	4/76 T/S
32 Apr	8	16	32 Cfx	8	16	32	64 Cax	4	8	16	32 Cf
8	16	32	64 P	4	8	16	32 Amx	4	8	16	32 Am

MODIFIED mTec		
Vol.	Colony Count	CFU's/100mLs
100	12	12

Phage	PFU's/100mLs
	11,280

Optical Brighteners

- Fluorescent Whitening Agents (FWAs) are compounds that can be measured and studied as an indicator of human sources of pollution
- Laundry detergents contain FWAs and are discharged in substantial quantities with household wastewater
- Fluorometric Detection – Turner Fluorometer

CASE HISTORY-IMPAIRED SHELLFISH GROWING WATERS and Recreational Waters

- Study area in bay waters adjacent to Seaside Park, NJ
- Small cove with impaired shellfish waters and recreational waters
- Area typical of many N.J. barrier island coastal towns – aging infrastructure and numerous stormwater discharges

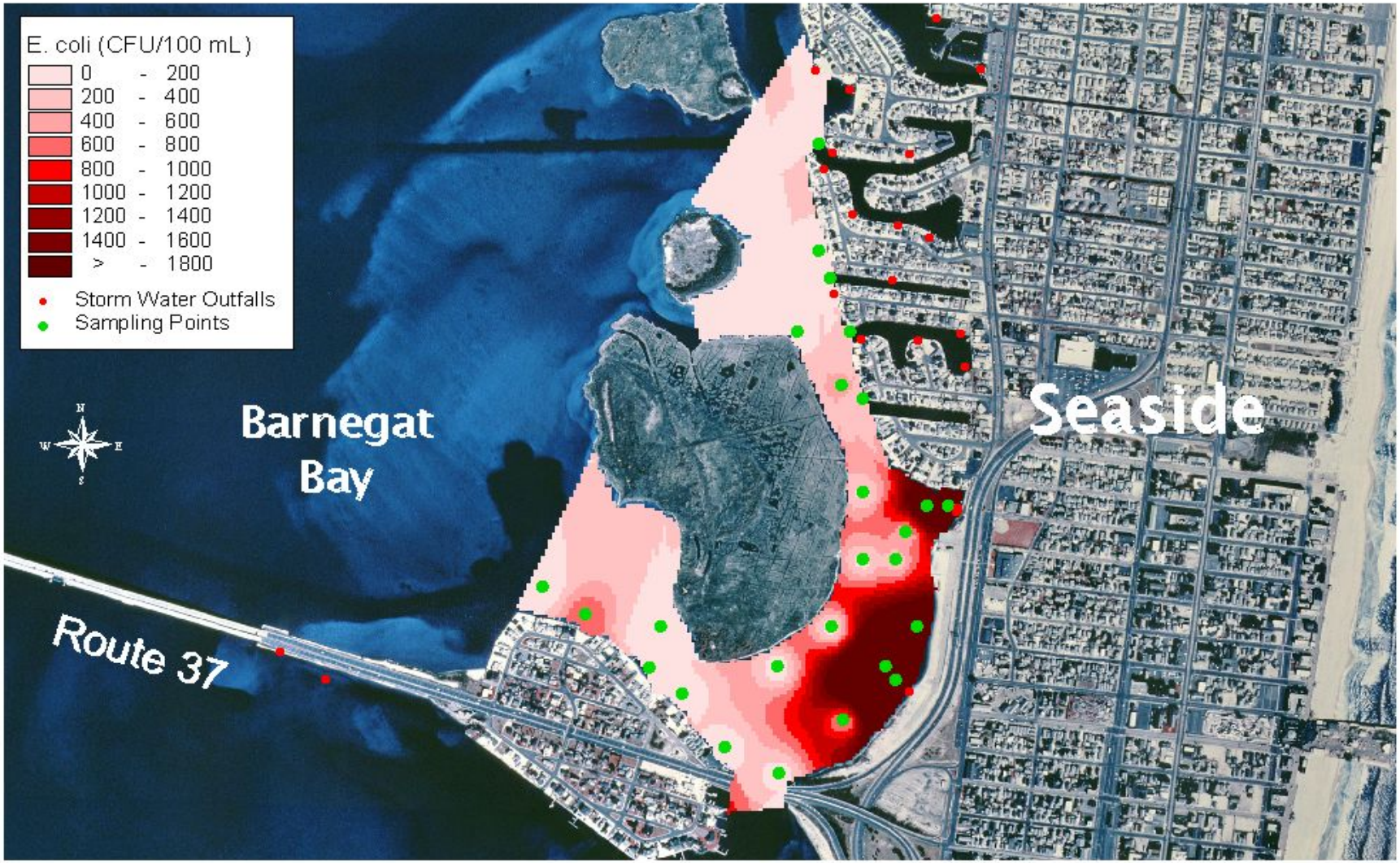
Seaside Storm Water Project

Prior to Rainfall

NJDEP
Bureau of Marine Water Monitoring

Seaside Storm Water Project

1 Hour After Storm Event Began



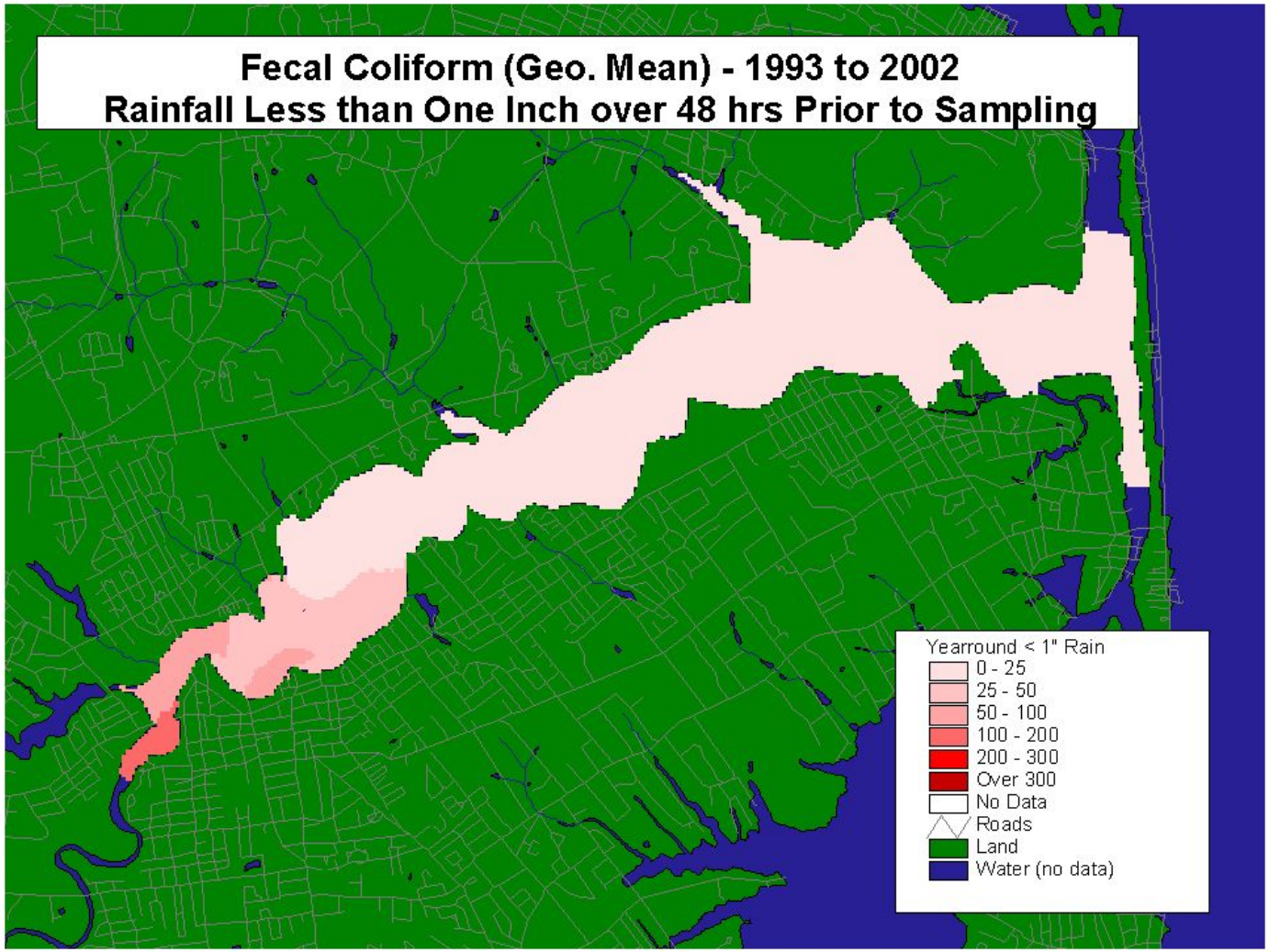
NJDEP

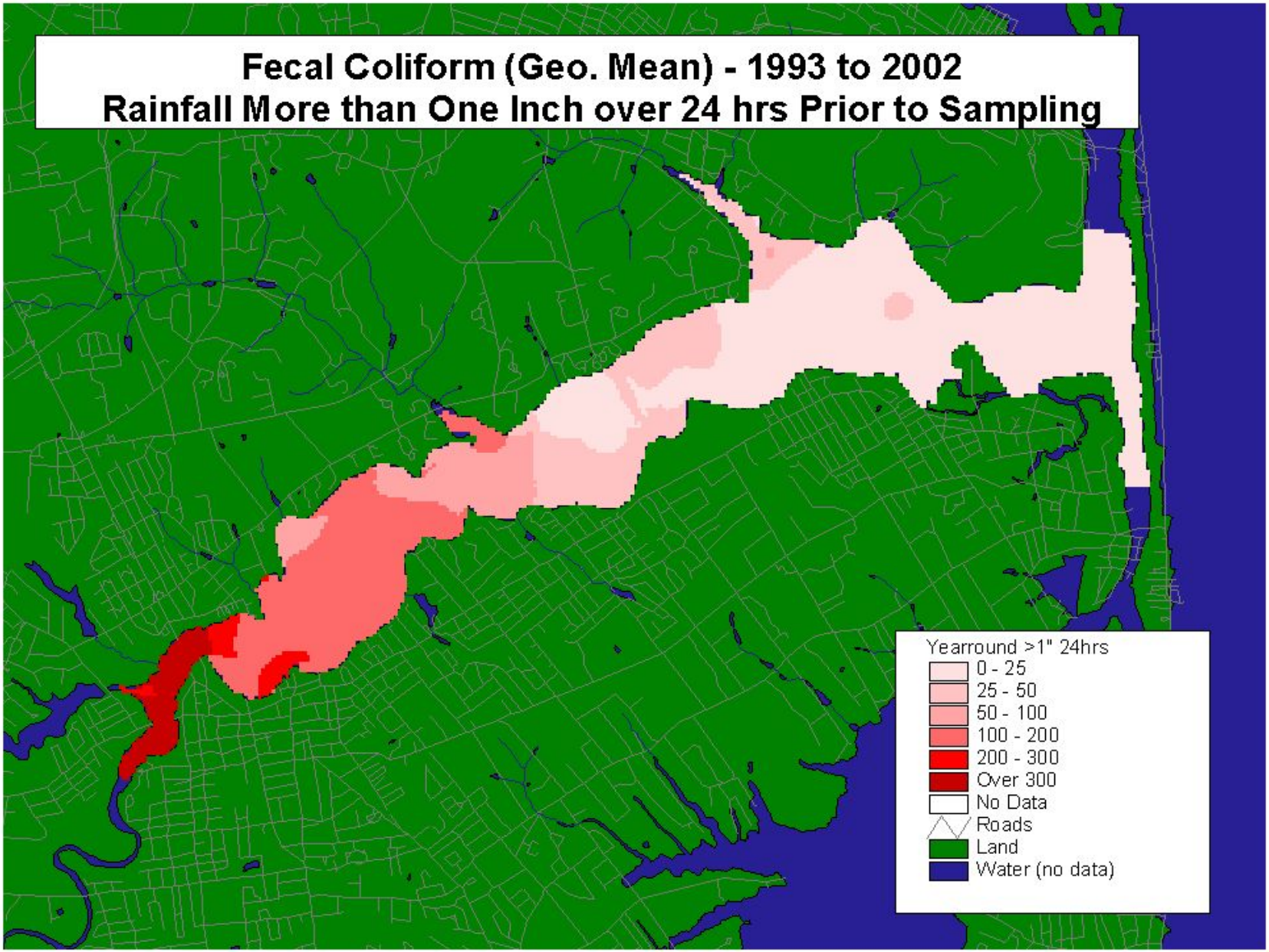
Bureau of Marine Water Monitoring

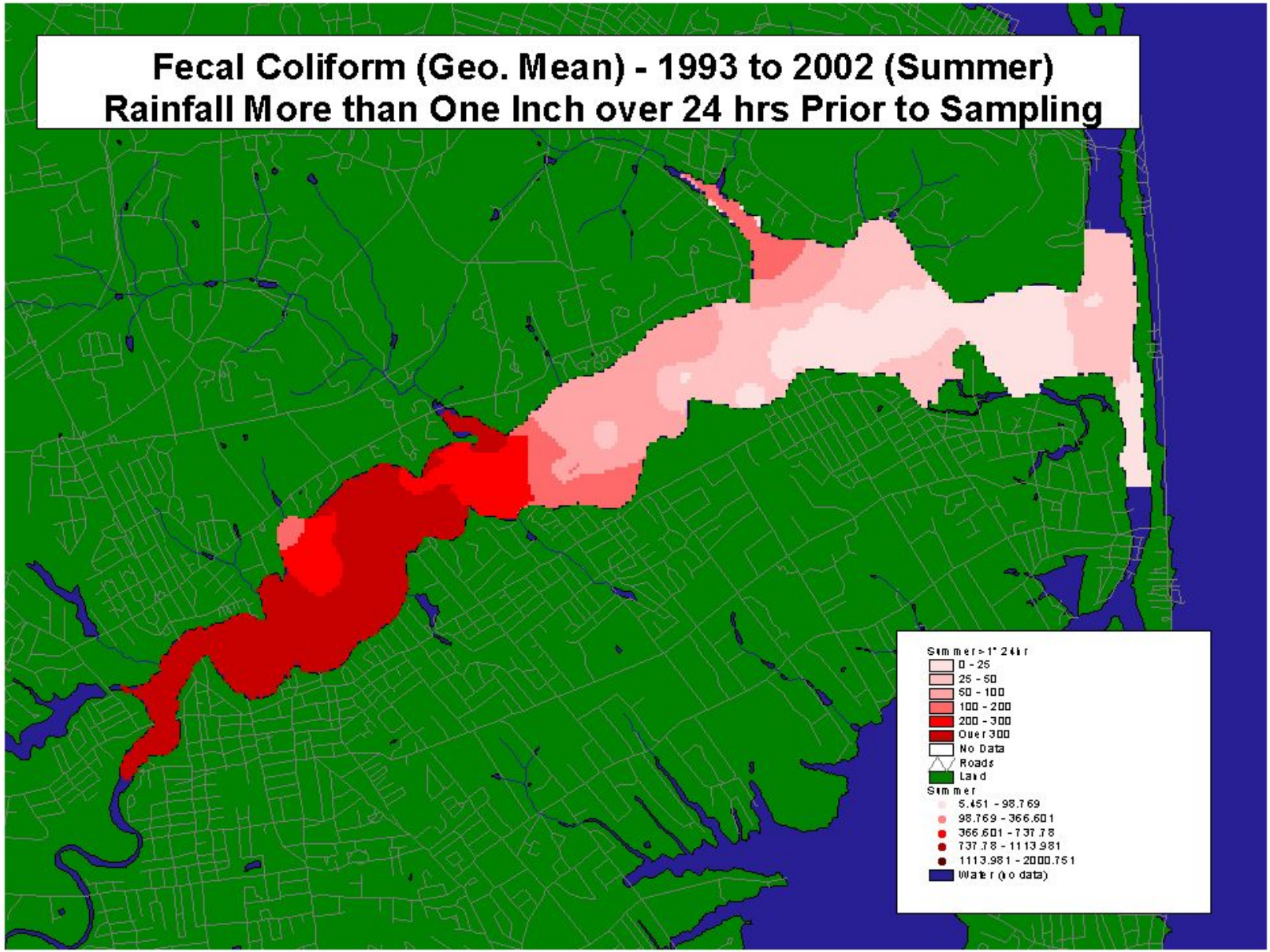
CASE HISTORY-IMPAIRED SHELLFISH GROWING WATERS

- Navesink River – Monmouth County, N.J.
- Tidal river approx. 8 miles long with numerous small creeks – draining an area of 95 square miles
- Contains significant hard clam resource – approved waters and special restricted waters
- Upper portion of the river recently downgraded to prohibited status – prompting MST study to determine sources of bacterial contamination

First Step – Evaluate long-term data




Fecal Coliform (Geo. Mean) - 1993 to 2002
Rainfall More than One Inch over 24 hrs Prior to Sampling
Yearround >1" 24hrs
0 - 25
25 - 50
50 - 100
100 - 200
200 - 300
Over 300
No Data
Roads
Land
Water (no data)


Fecal Coliform (Geo. Mean) - 1993 to 2002 (Summer)
Rainfall More than One Inch over 24 hrs Prior to Sampling
Summer >1" 24 hr
0 - 25
25 - 50
50 - 100
100 - 200
200 - 300
Over 300
No Data
Roads
Land
Summer
5.451 - 98.769
98.769 - 366.601
366.601 - 737.78
737.78 - 1113.981
1113.981 - 2000.751
Water (no data)

Designing the Study: Actual and Potential Sources of Pollution

Oyster Point

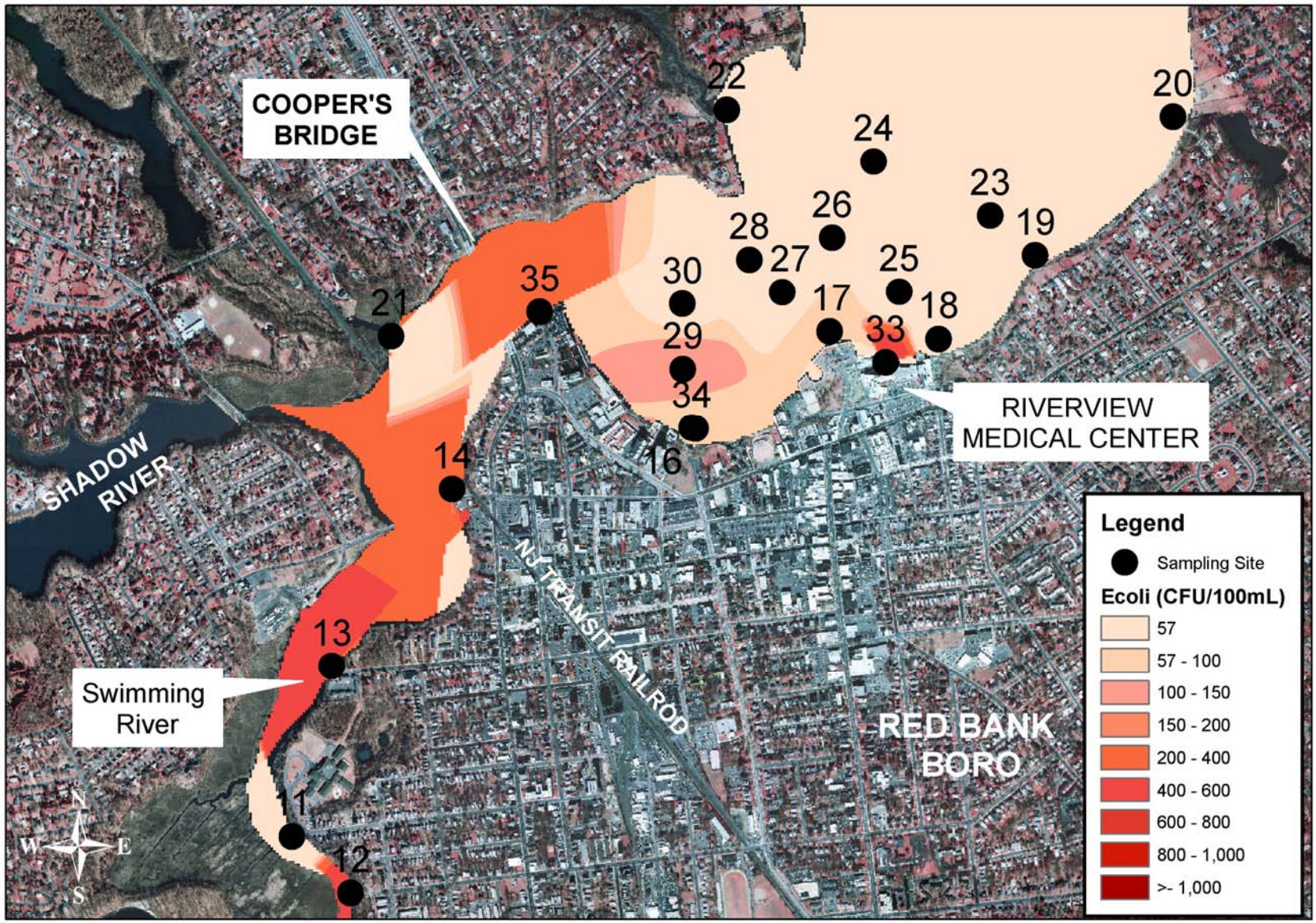
Stormdrain @ Newman Springs Rd.

Stormdrain Upstream Swimming River

Marsh Area in Vicinity of GSP

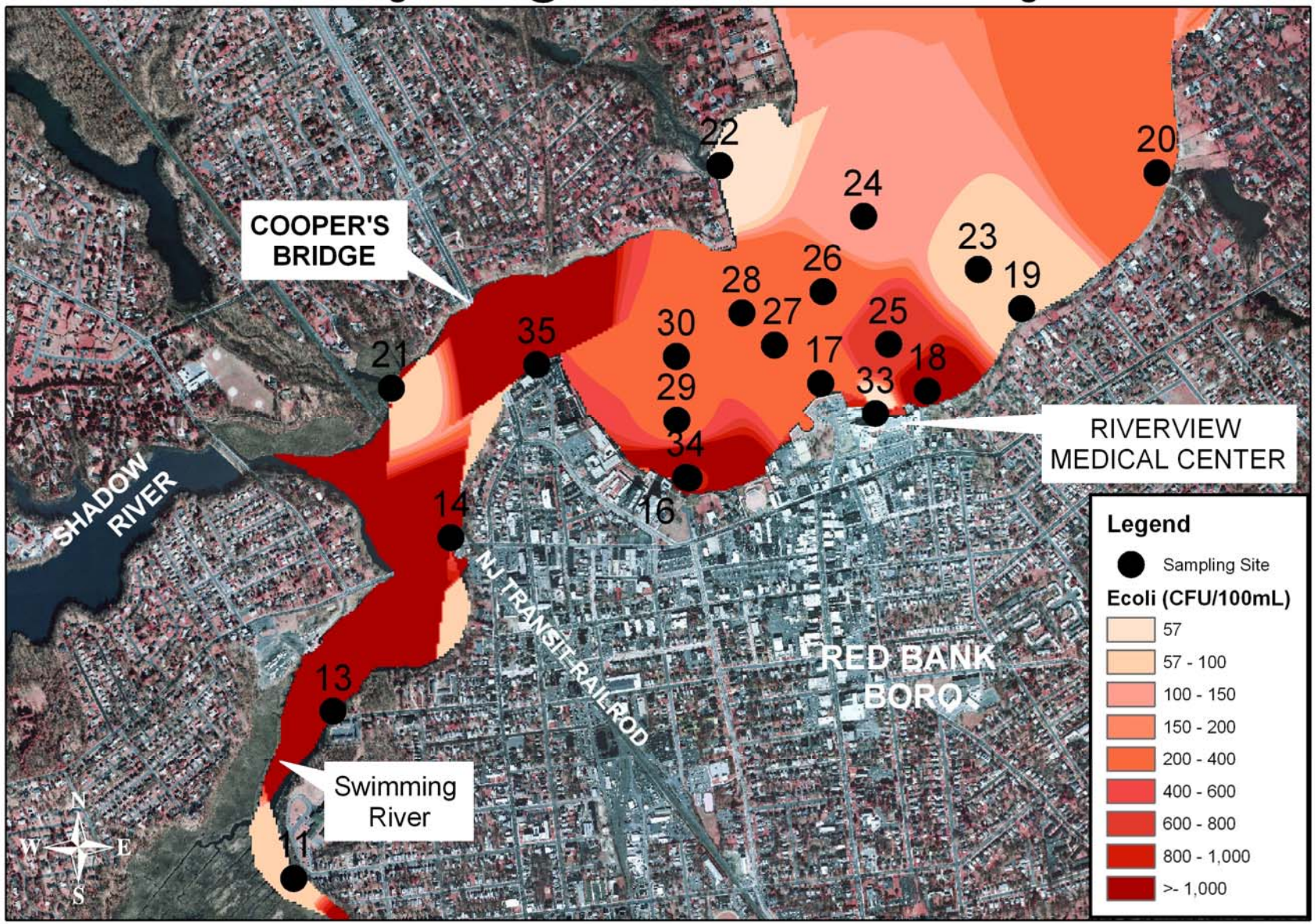
Navesink River NPS Study

Average Ecoli At Initial Sampling



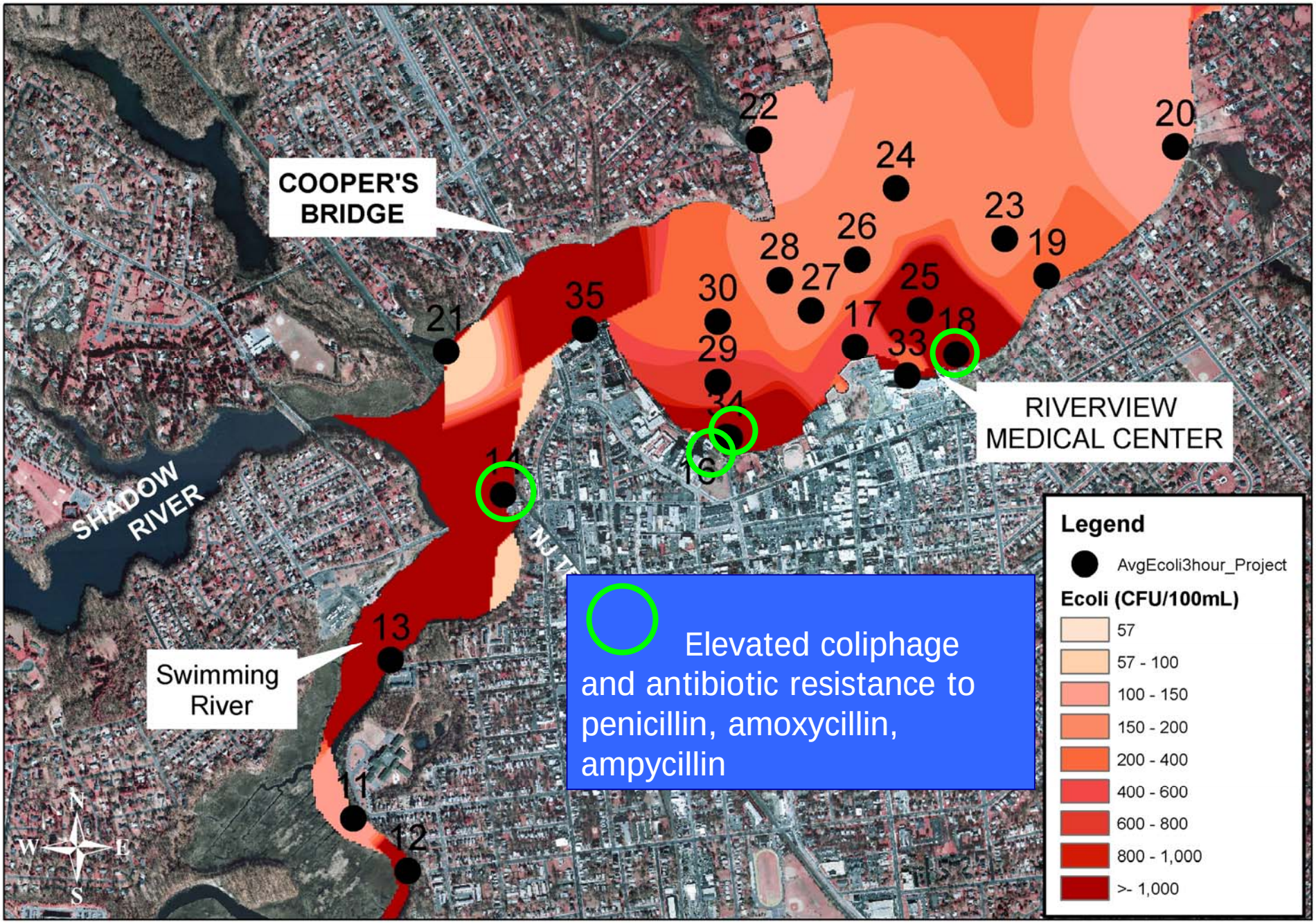
Navesink River NPS Study

Average Ecoli @ 1 Hour After Storm Event Began



Navesink River NPS Study

Average Ecoli @ 3 Hours After Storm Event Began



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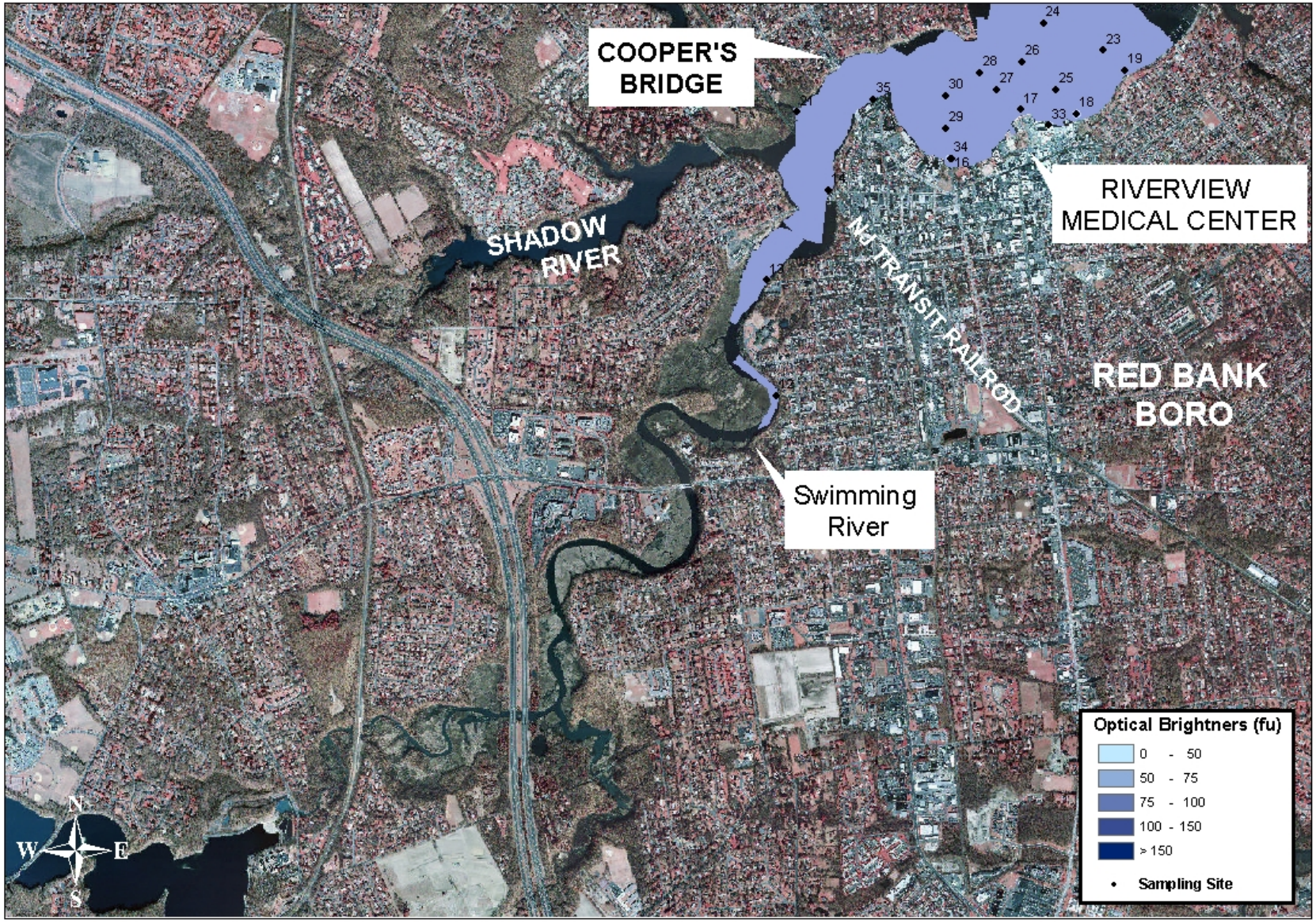
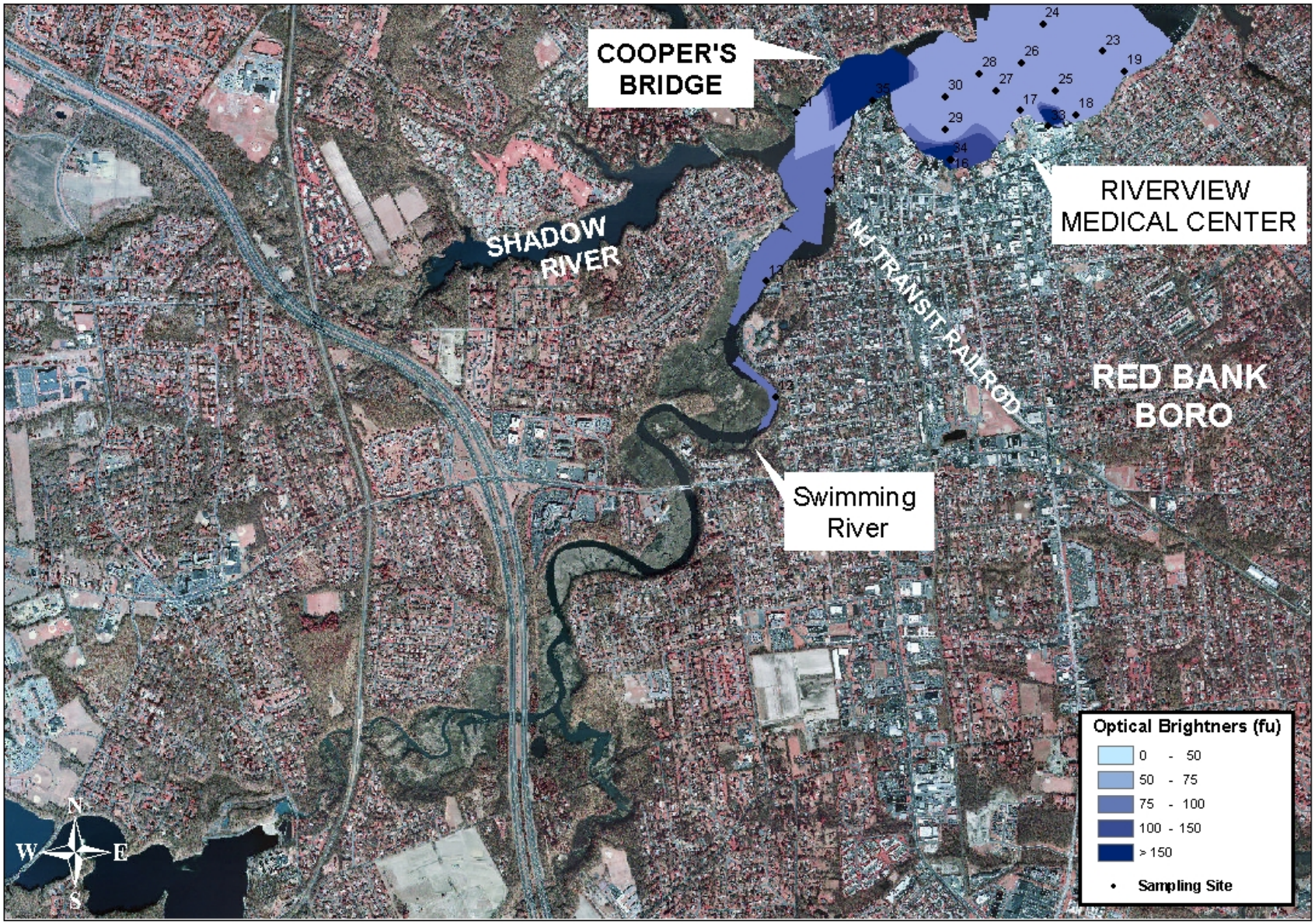
Navesink River NPS Study

Optical Brightners Average Value (Background)



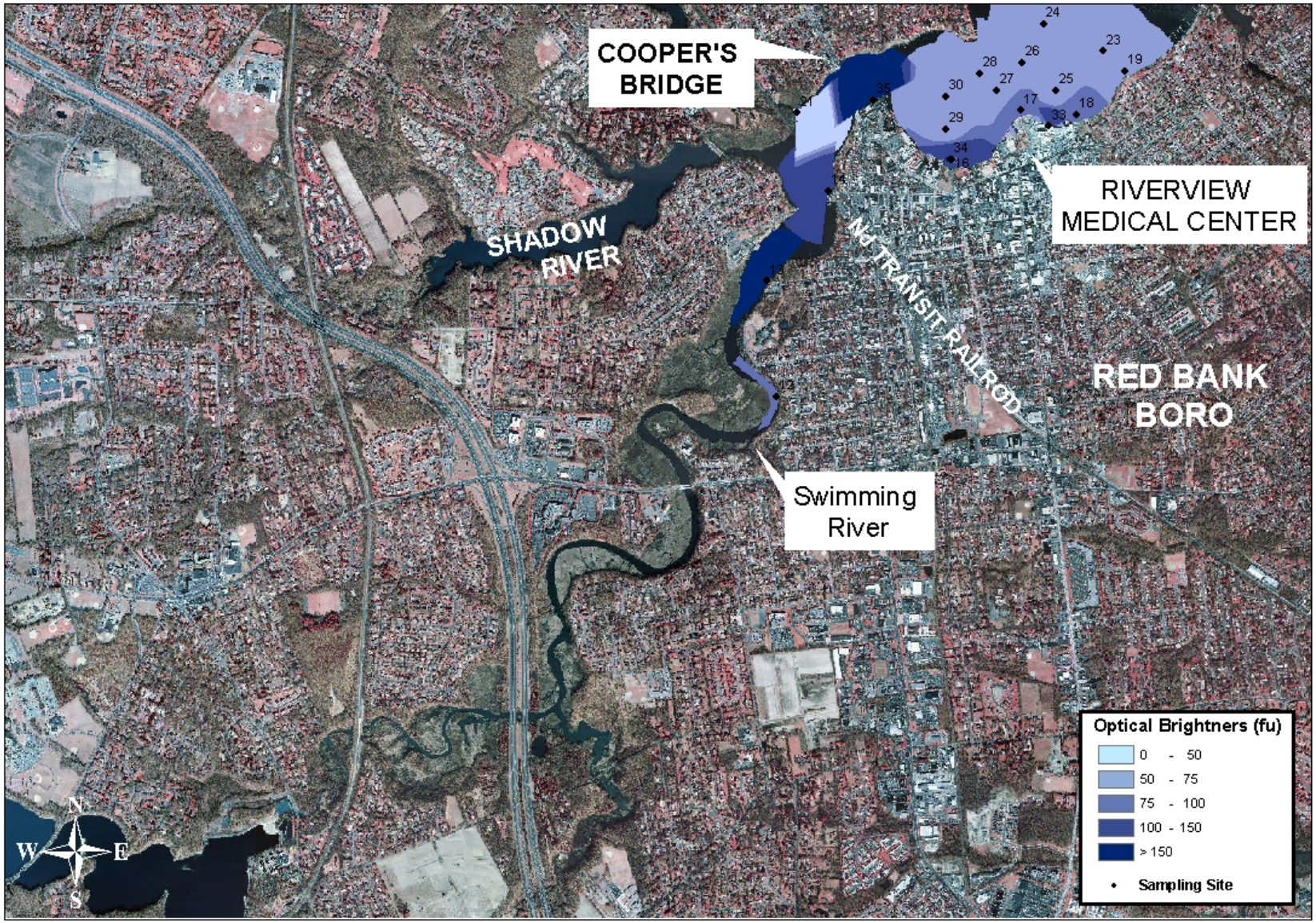
Navesink River NPS Study

Optical Brightners Average Value (1 Hour)



Navesink River NPS Study

Optical Brightners Average Value (3 Hours)



CASE HISTORY-IMPAIRED RECREATIONAL BATHING WATERS

- Wreck Pond – discharges via a spillway and 300’ outfall to the ocean
- Elevated bacterial levels (enterococus) following rainfall impacts ocean bathing beaches in the vicinity of the outfall
- This has resulted in a “precautionary closure” of these beaches following rain events >0.1”


Park Ave
Atlantic Ave
North Branch of Wreck Pond
Monmouth Ave
Essex Ave
Prospect Ave
Villa Park
Salem Ave
Ocean Rd
Pennsylvania Ave
Central Ave
Shore Rd
Jersey Ave
Wreck Pond
Union Ave
York Ave
Brown Ave
Ocean Ave
Edgemere Park
The Terrace
Beacon Blvd
Chicago Blvd
Brooklyn Blvd
New York Blvd
Baltimore Blvd
18
71
20
49
1000 ft
Spring Lake
Manasquan
Terms of Use

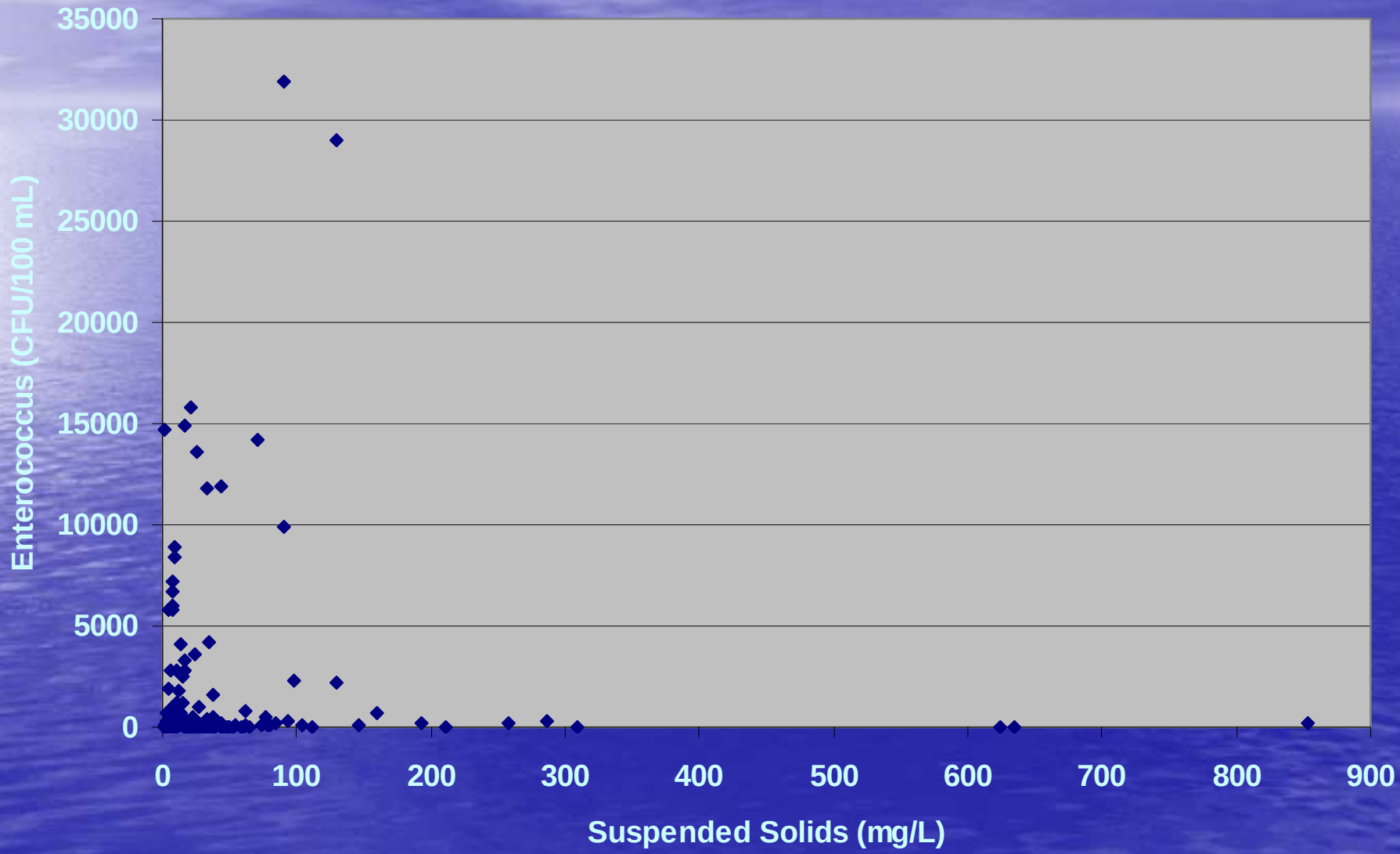
Potential Pollutant Sources

- Upper Watershed
- Wreck Pond
- Stormwater discharges
- Resuspension of bacteria in sediments
- Offshore Impacts

Our Evaluation of Offshore/Ocean Impacts

- NJDEP Monitoring – 0.25 – 3.0 nm offshore
- >3,800 samples collected in the vicinity of Wreck Pond from 1993 – 2007
- Maximum level found was 95 FC MPN/100 mL
- 99.8% of the results were < 10 FC MPN/100 mL

Enterococcus vs Suspended Solids

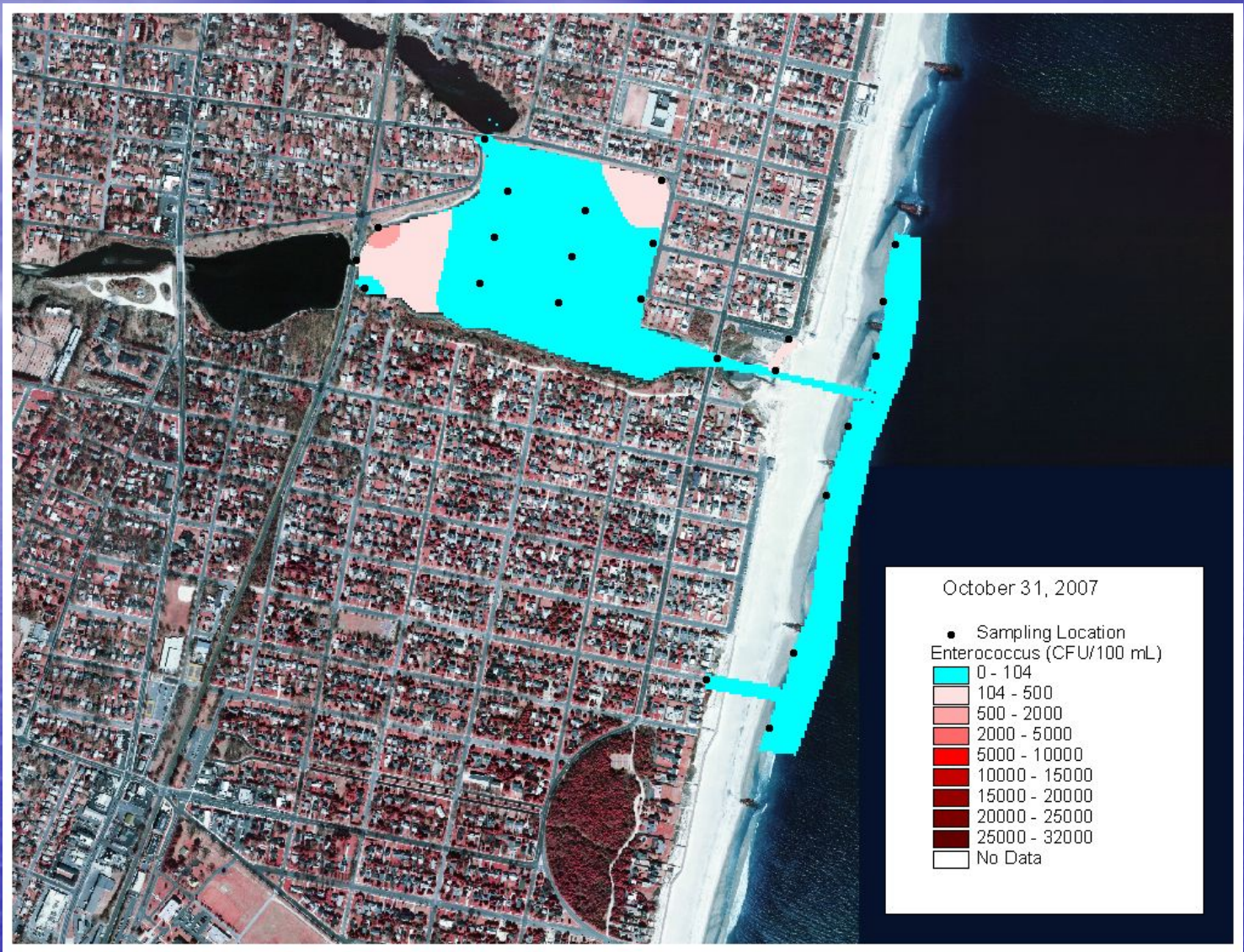


Sampling

Enterococcus Levels

Spring Lake / Sea Girt

10/31/2007 @ 10 AM



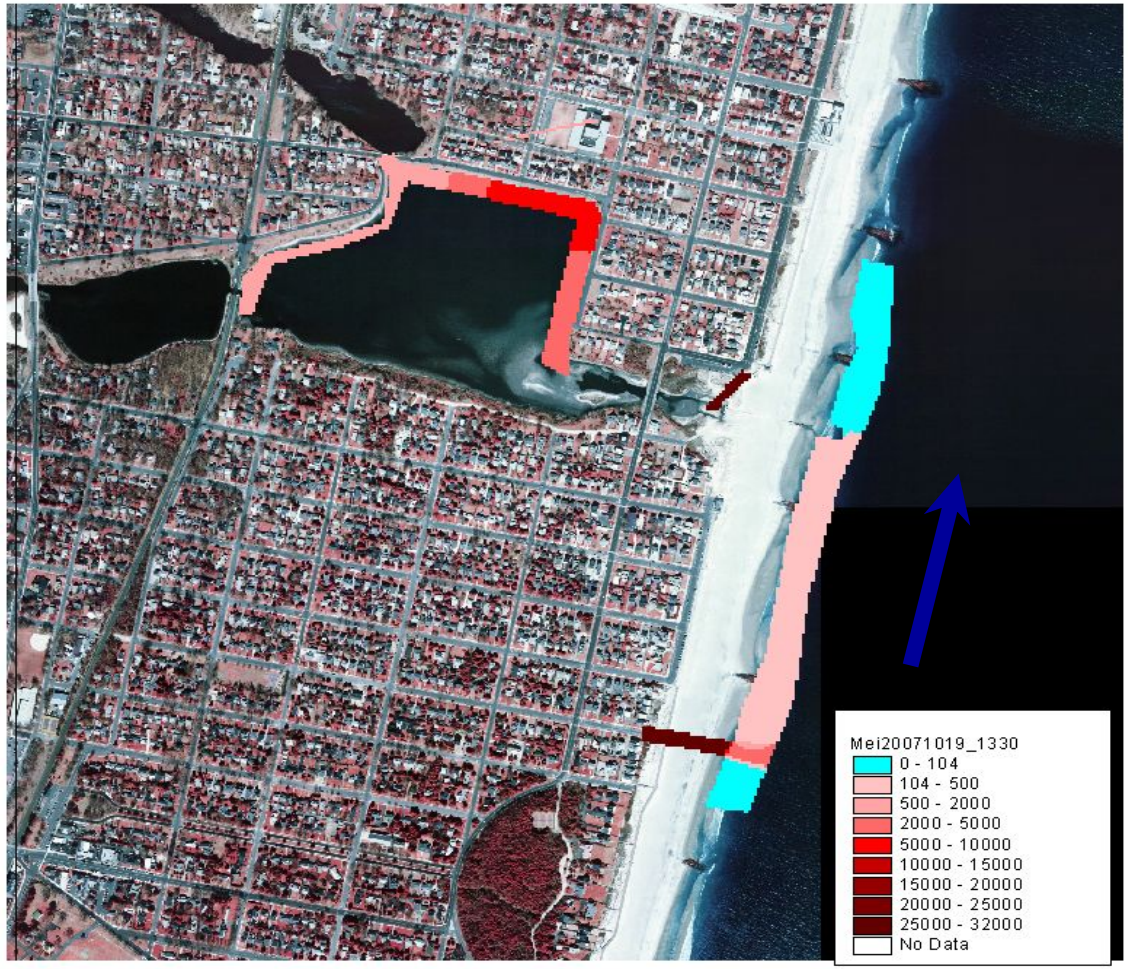
No appreciable rainfall 3 days prior.

Wind Speed: ~10 kts
Wind Direction: SE
Total 24 hr. rainfall: 0.0”

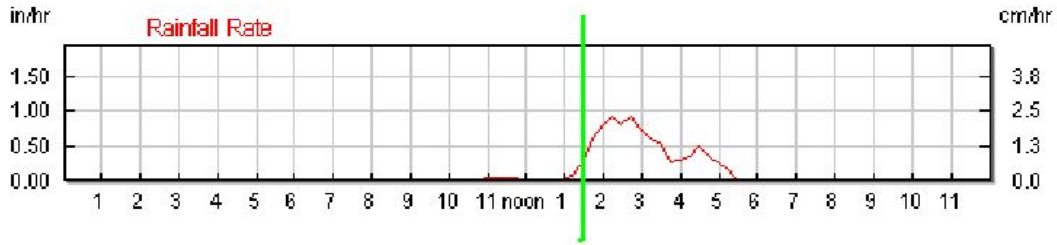
Enterococcus Levels
Spring Lake / Sea Girt
10/19/2007 @ 1:30 PM

- Early in storm event
- Elevated levels in Wreck Pond near discharge from Spring Lake
- Very high levels at Baltimore Ave. stormwater discharge
- Predominant nearshore ocean current is south to north.

Wind: S
Tide: 2.58 ft > MLW
24 hr. Rainfall: 2.20”



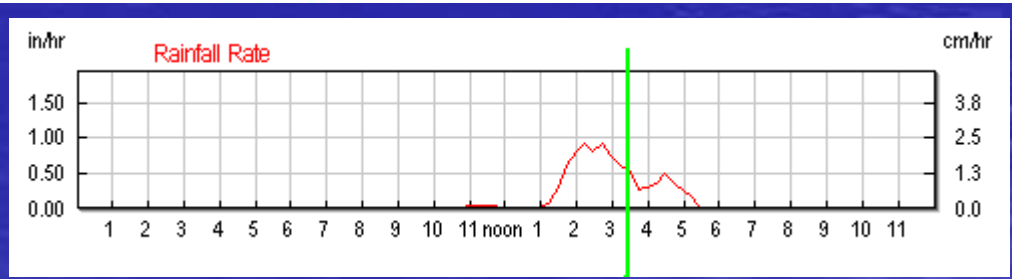
2007, NJDEP, Bureau of Marine Water Monitoring Levels reported as Enterococcus CFU/100 mL



Enterococcus Levels
Spring Lake / Sea Girt
10/19/2007 @ 3:30 PM

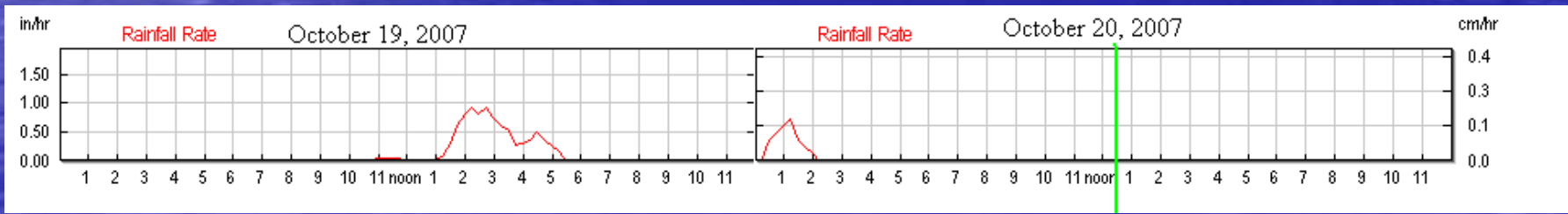
Wind: S
Tide: 4.13 ft > MLW

Green Circles show where ARA suggests human source.



Enterococcus Levels
Spring Lake / Sea Girt
10/20/2007 @ 12:30 PM

Tide: 2.22 ft > MLW



Enterococcus Levels
Spring Lake / Sea Girt
10/22/2007 @ 9:30 AM

Tide: 4.31 ft > MLW

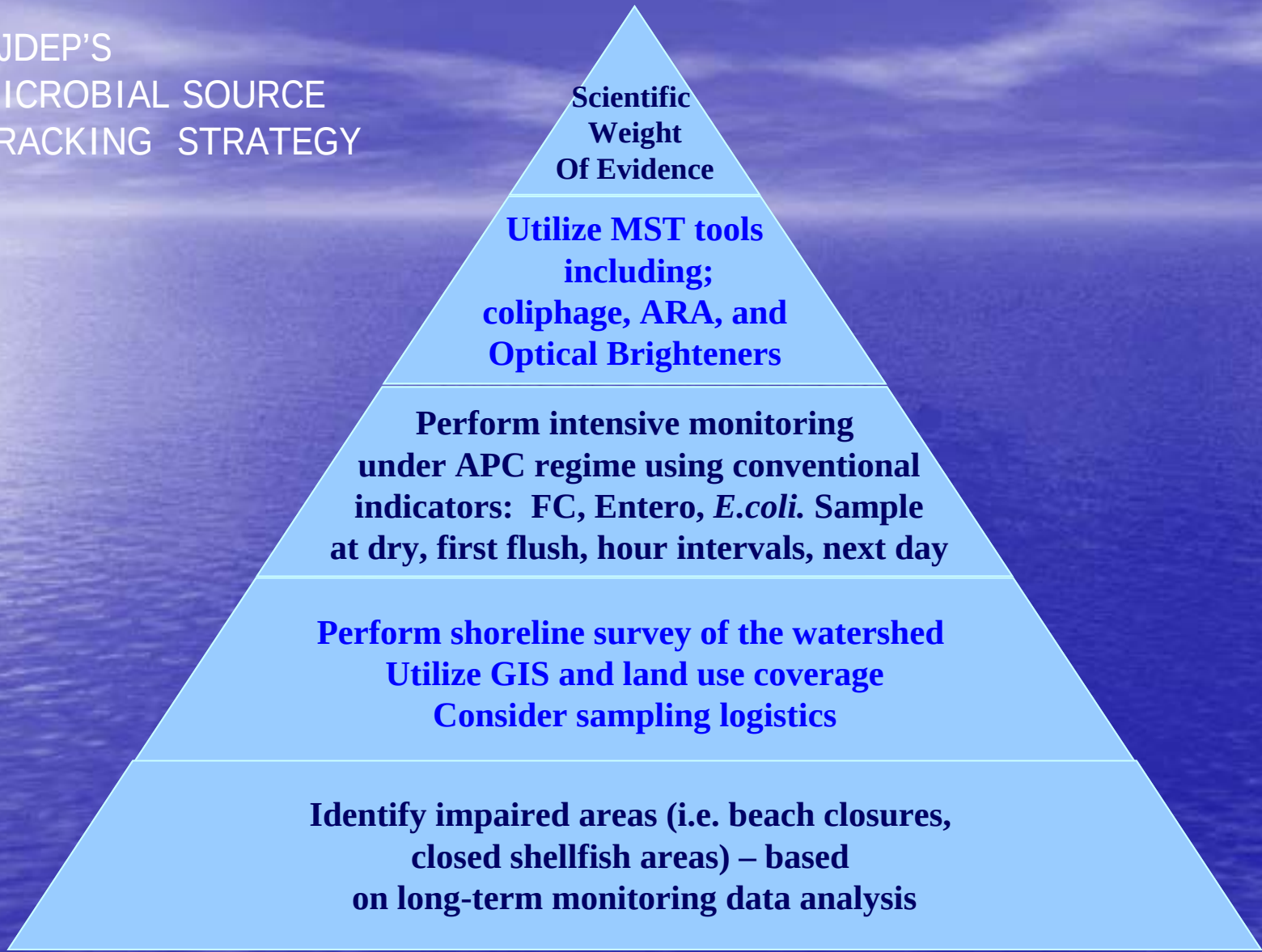
Enterococcus Sources

- Upper Watershed – not impacting within 24 hrs.
- Wreck Pond (stormwater discharges to it)
- Stormwater discharges (Baltimore Ave)
- ~~Resuspension o~~f bacteria in sediments – no evidence of this as a major impact to beaches.
- Offshore Impacts – no evidence of this as a major impact to beaches.

LESSONS LEARNED

- Importance of the shoreline survey (site selection, sampling logistics
- Need for intensive monitoring including APC, first flush, temporal and spatial considerations
- No “silver bullet” Need to use multiple MST lab methods
- Evaluation of the data collectively to build “Scientific Weight of Evidence”

NJDEP'S MICROBIAL SOURCE TRACKING STRATEGY



Contact Information

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- http://www.nj.gov/dep/bmw/