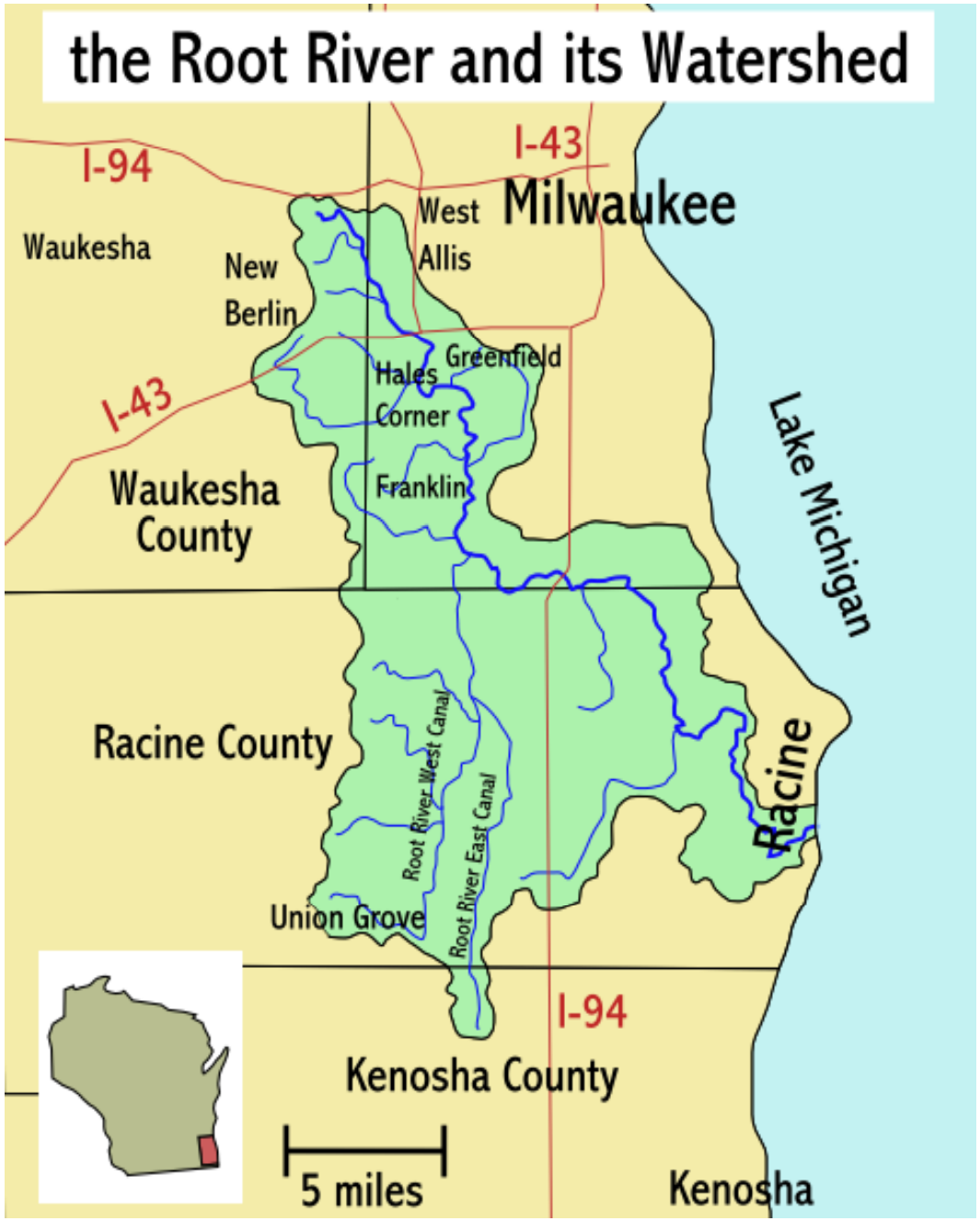
Guiding remediation along the Root River through the use of an integrated source tracking program

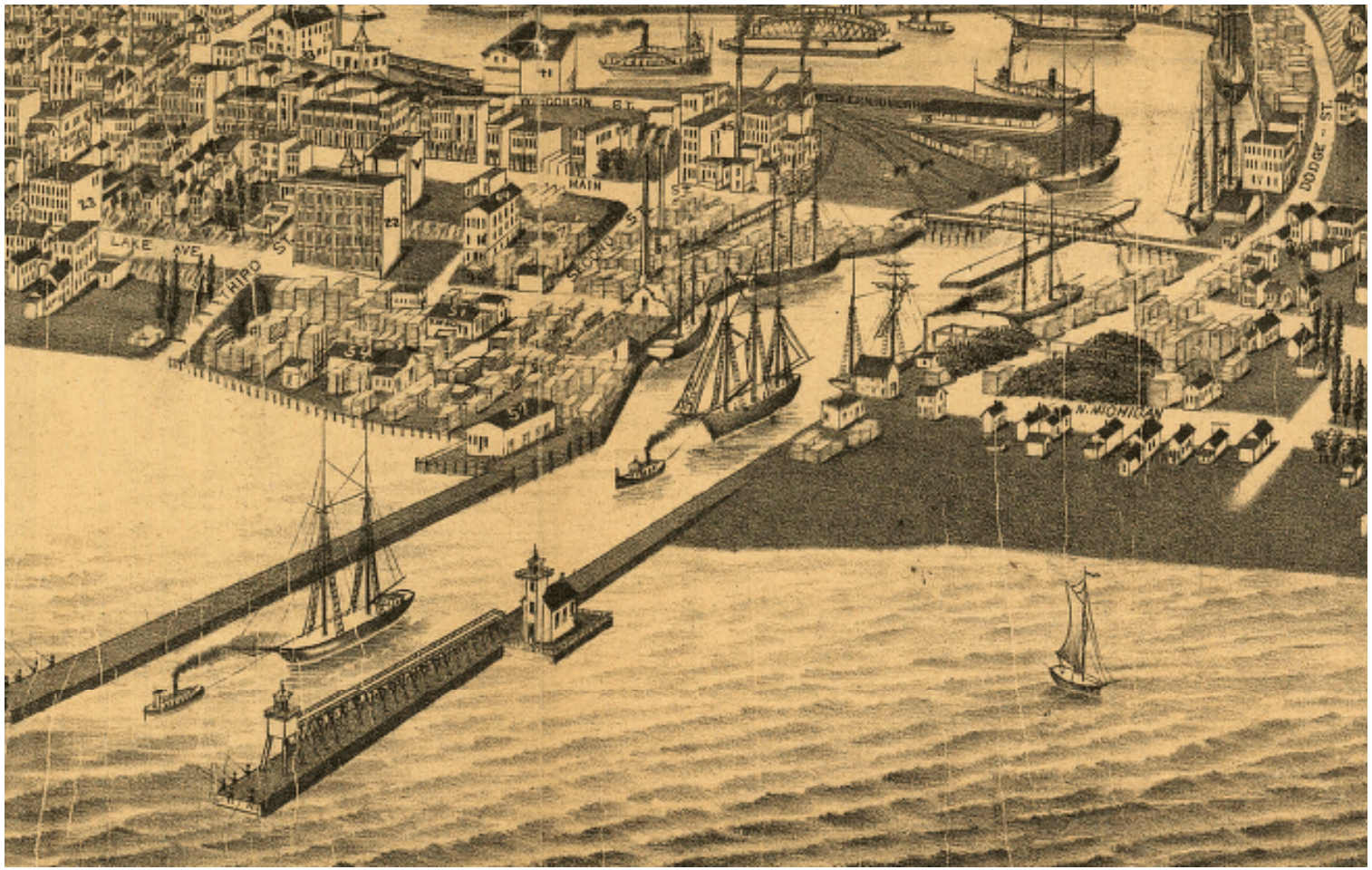
Julie Kinzelman
City of Racine, WI

7th Annual Clean Rivers, Clean Lake Conference
September 15, 2010



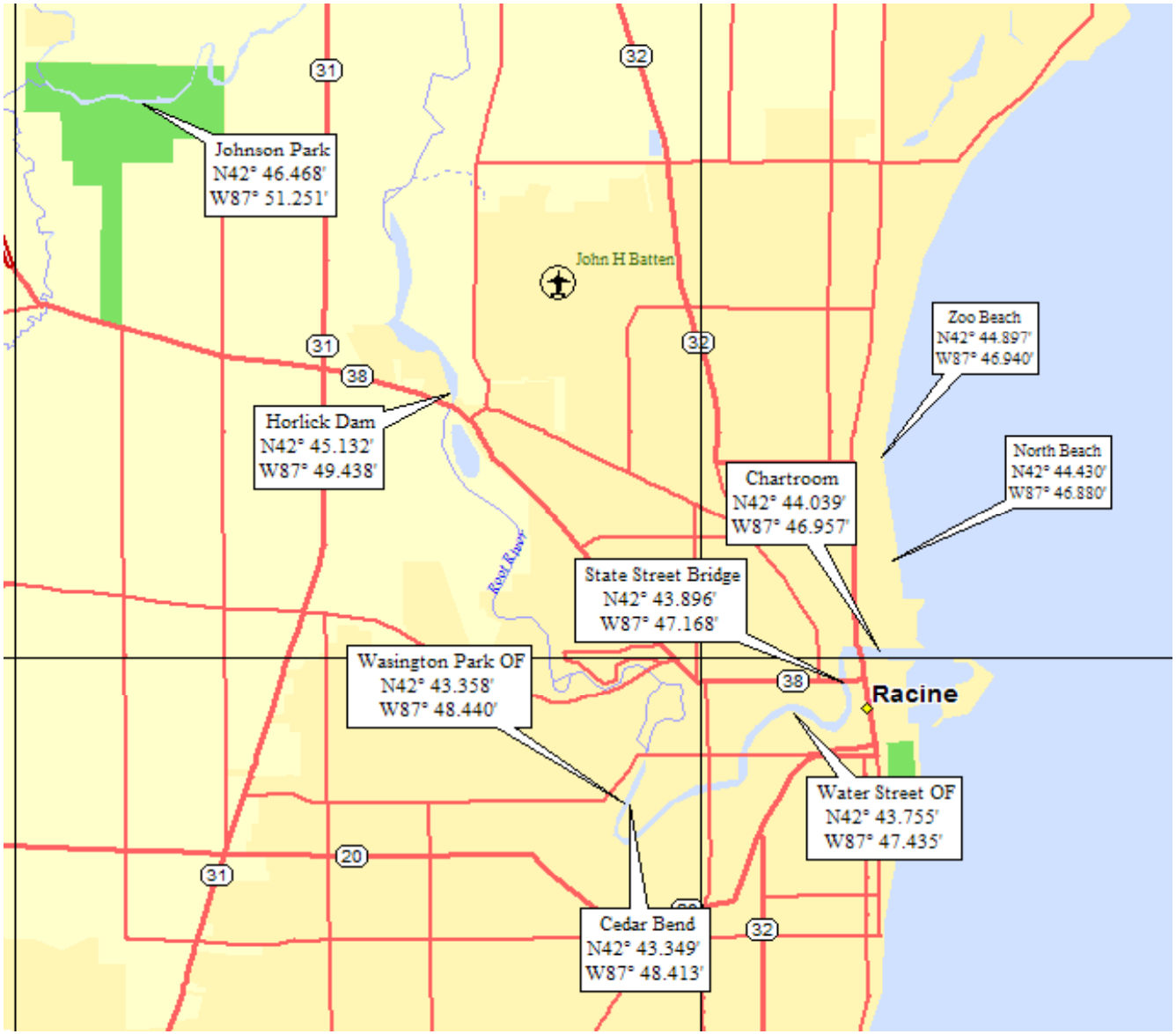
Over 1.6 million residents from Kenosha, Milwaukee, Racine and Waukesha Counties interact with and impact the watershed on a daily basis

Historic Monitoring

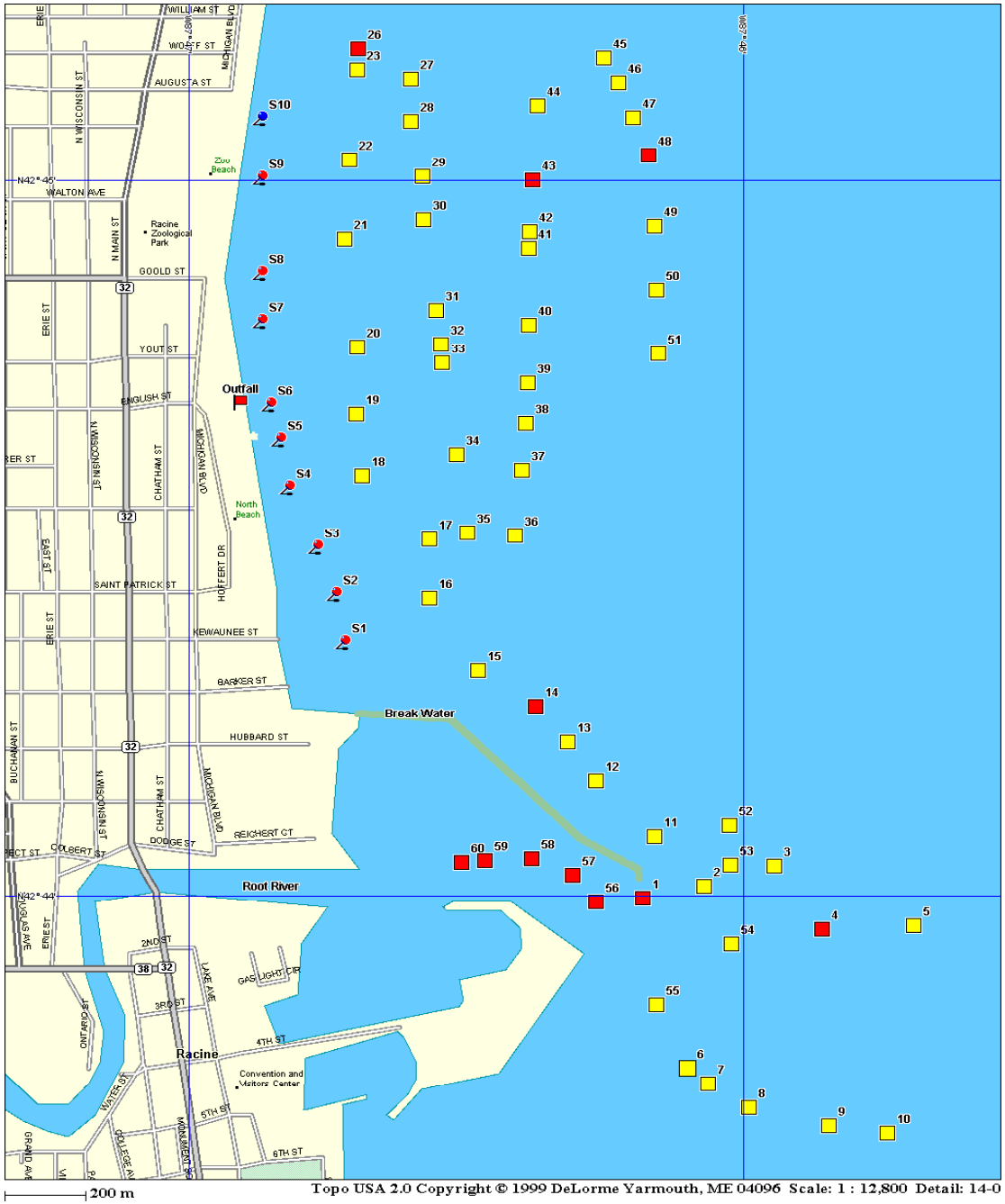


Mouth of Root River c. 1883, Racine Heritage Museum

Racine had 7 monitoring stations



Root River *E. coli* Densities – 2004		
SITE	**MEAN *E. coli* MPN/100 ml**	**RANGE**
Johnson Park (R1)	**1518**	**10 – 14,136**
Horlick Dam (R2)	**1431**	**10 – 12,997**
Cedar Bend (R3)	**3705**	**0 – 12,997**
Washington Park Storm Outlet (R4)	**38,856**	**0 – 198,628**
Water Street Storm Outlet (R5)	**18,020**	**100 – 173,287**
State Street Bridge (R6)	**1372**	**63 – 11,199**
Chartroom (R7)	**1098**	**20 - 9804**



2004 Spatial Distribution Study

80 samples by wading or boat

Pre-rainfall, Rainfall, and Post-rainfall samples

Look for elevated levels of *E. coli*

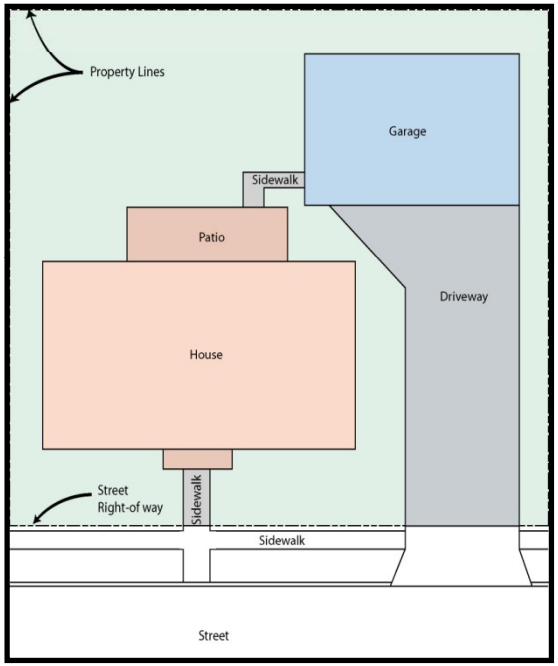
Definite plume from the Root River

Identifying Sources of Pollution

- Physical Assessments
- Sanitary Surveys
- Source Tracking

Impacts of Urbanization

Racine Storm Water Utility



Residential Average Impervious Area = 2,844 square feet (or 1 Equivalent Residential/Runoff Unit (ERU))

Downtown Customer Example

Industrial Customer Example

2005 Streambank Erosion & OF Study

- Commissioned by City of Racine
- Evaluate condition of storm sewer OF
- Streambank condition
- Erosion potential
- Develop baseline data
- Identify problems associated with hydromodifications

Goal of Sanitary Surveys – Beaches

- To explore and accurately characterize beaches
- To identifying possible sources of microbial pollution entering the beach area
- To assemble a database of ambient conditions and water quality data
- To provide for targeted remediation measures

Environmental Data Collected
Routine/Daily Surveys

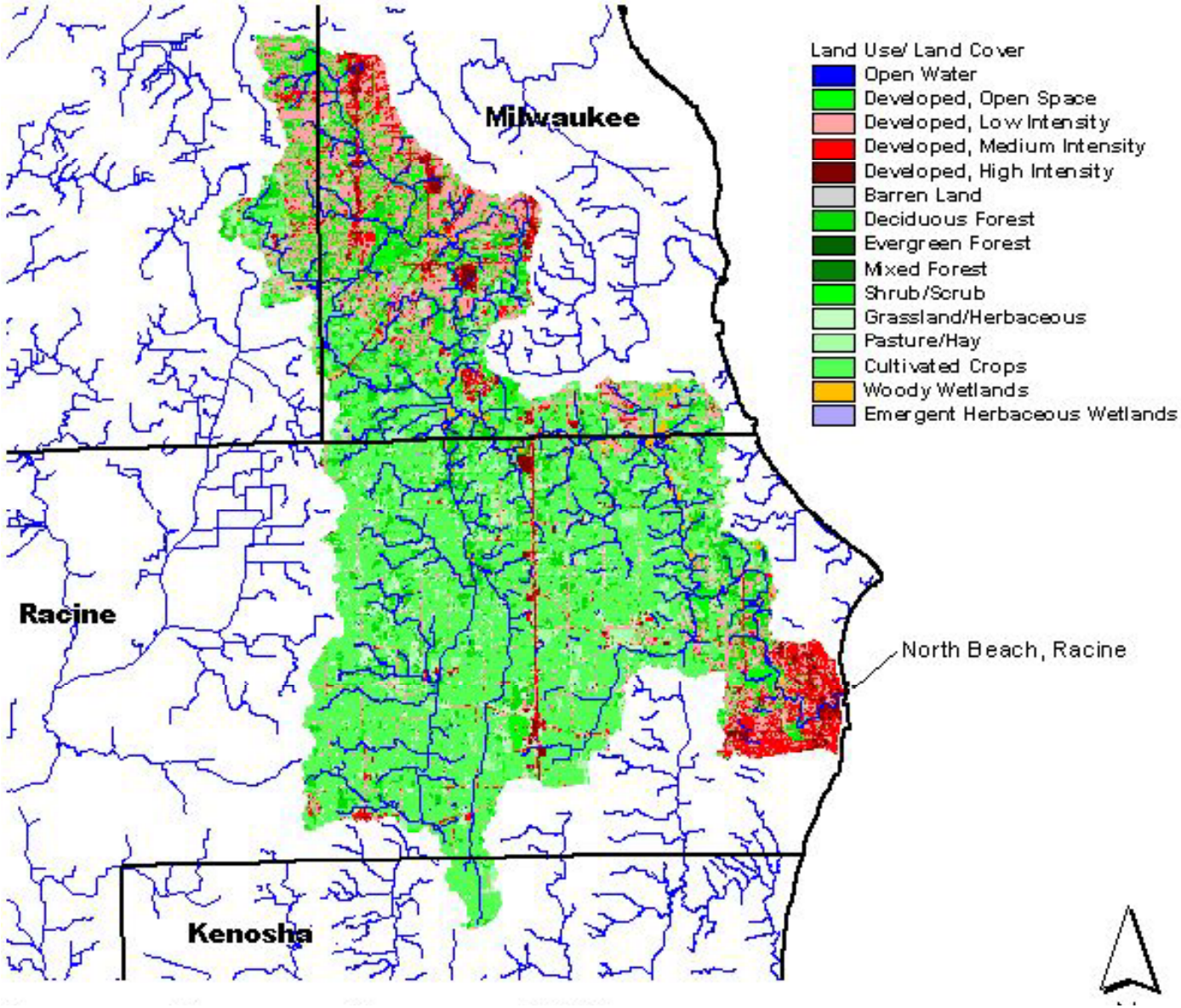
- **General Beach Conditions**
  - Air temperature
  - Wind speed/direction
  - Rainfall
  - Weather condition (sunny, etc.)
  - Current speed/direction
  - Wave Height
- **Water Quality**
  - FIB concentrations
  - Water temperature
  - Water color/odor
  - Turbidity (clarity)
- **Bather Load**
  - Total number of people at beach
  - Swimmers/non-swimmers
- **Potential Pollution Sources**
  - Sources of discharge
    - Rivers, outfalls, wetlands, etc.
  - Floatables
  - Amount of debris/litter
  - Amount of algae
    - Stranded on beach
    - Floating/submerged in water
  - Presence of wildlife
    - Gull counts
    - Geese, deer, other
  - Presence of domestic animals
    - Dogs, Horses

Land Use/Source ID Data – Annual Survey

- Wastewater discharge points
- Septic systems
- Subsurface sewage disposal
- Storm water outfalls
- Rivers, creeks & streams
- Agricultural run-off
- Urban run-off
- Industrial waste
- Marinas & harbors
- Moored boats
- Land Use (local & watershed)
- Annual bather load

- Combined sewage overflows
- Caged Animal Feeding Operations (CAFOs)
- Wildlife
- Domestic animals
- Stream bank erosion
- Landfills, open dumps
- Ground water
- Bathhouse toilet facilities
- Drains & pipes
- Wetland drainage
- Hydrological assessments
- Sediment/Sand assessments

Land Use – Root River Watershed



Sanitary Surveys and Predictive Models

- Environmental data collected as part of a sanitary survey can be used to begin constructing a predictive model

- Virtual Beach (USEPA model building tool)
- Allows correlations between parameters and water quality (i.e. wave height, wind direction, rainfall, etc.)

- Can be combined with hydrodynamic impact models to look at influence of land use on fecal loading (L-THIA)

- Data limitations may prevent full use, i.e. you will likely need multiple years of data

2008 Site Survey

Site: Island Park footbridge behind Racine Lutheran High School

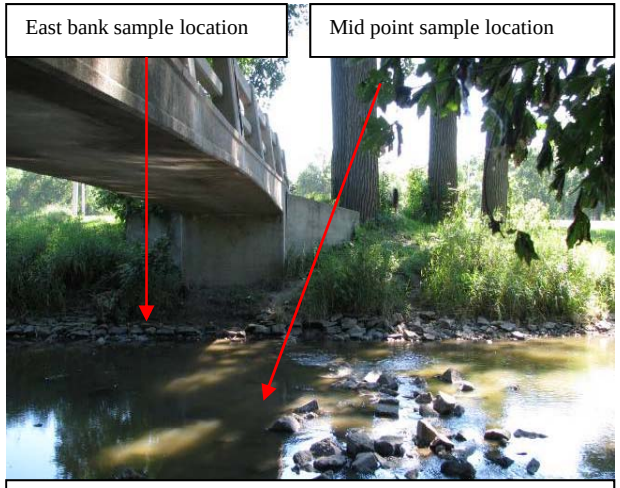
Location and surrounding area:
Located on the western branch of the river which splits around Island Park. Land to the west is residential and to the east is open space/parkland (mainly grass).

Stream bank conditions
Stream banks are in good condition with recent restoration work undertaken on the east bank adjacent to site and approximately 120m u/s (after 2005 Earth Tech stream bank assessment)

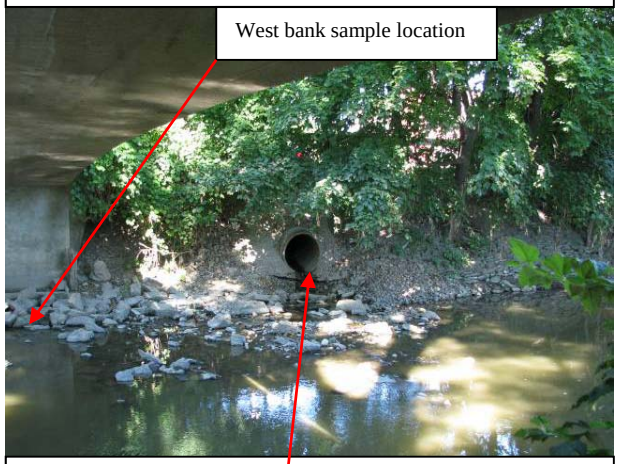
Infrastructure
Outfall (RR17) off Glenn Street adjacent to footbridge and sample locations exhibits a constant DWF.

Other comments:
This outfall is suspected of contributing to the high levels of *E. coli* at the sample site.

View south, downstream, from the footbridge. Both banks are in good condition.



View from the west bank across to the east bank sample location.

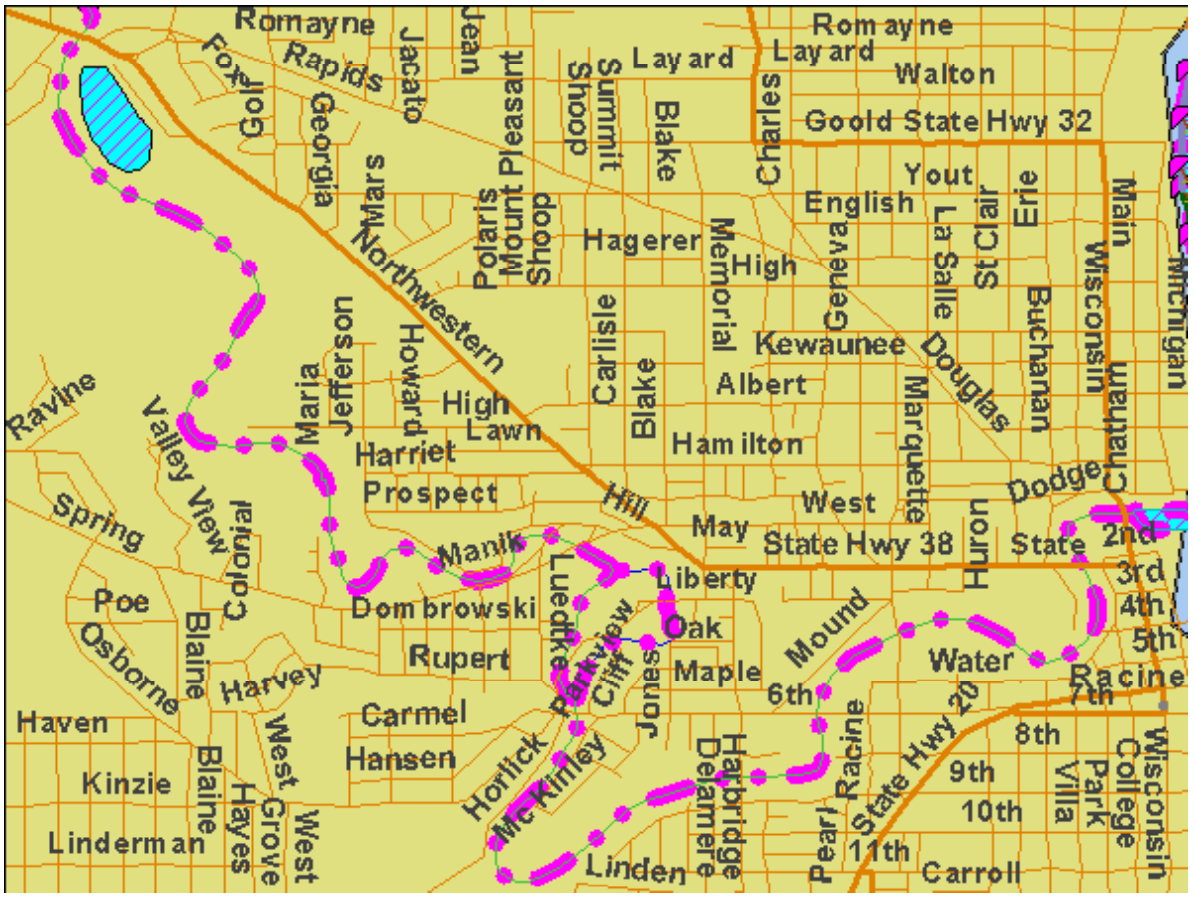


View of the outfall off Glenn Street exhibiting DWF.

View looking north from footbridge at east bank. Conditions = high grass and little sign of erosion.

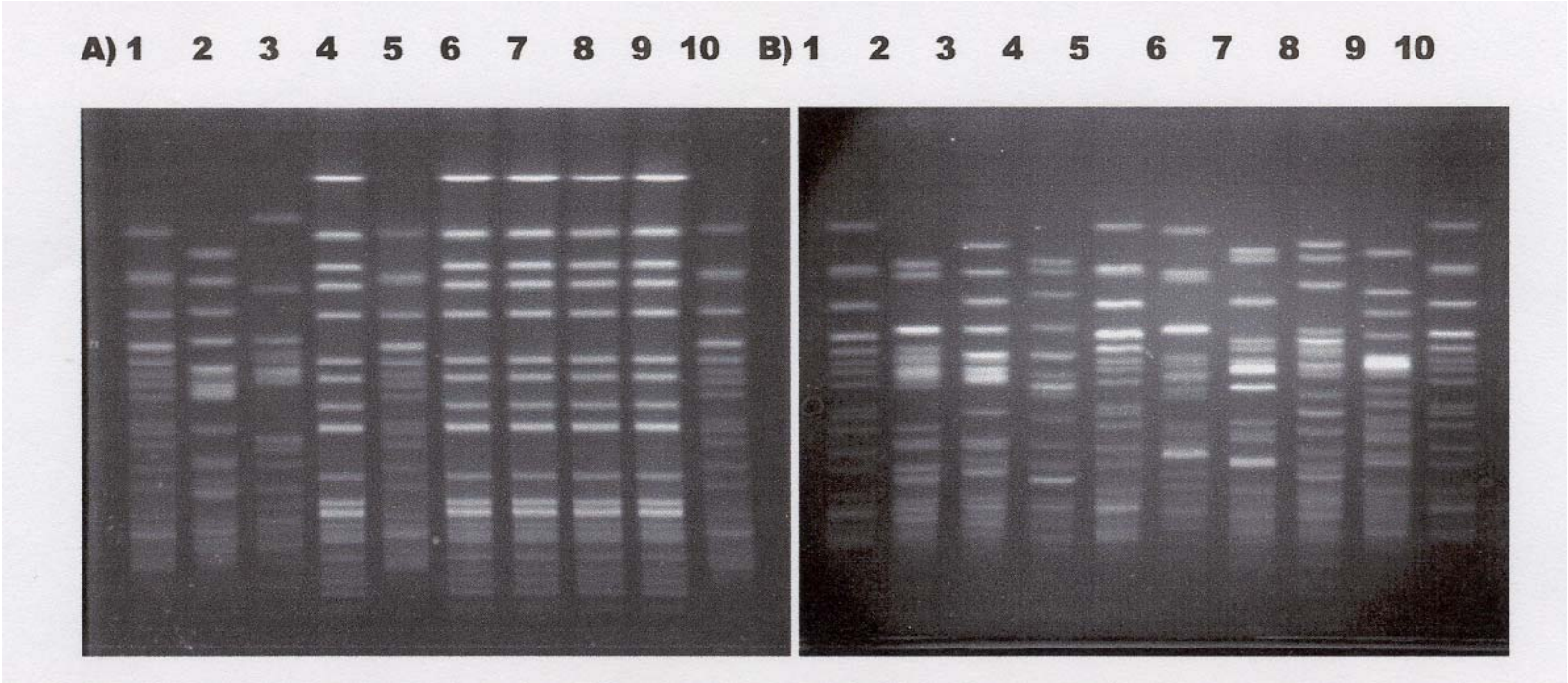
Chemical Indicators

- pH
- Temperature
- Turbidity
- Conductivity
- Detergents
- Chlorine
- Copper
- Phenols



Biological Indicators

- *E. coli*
- Human specific *Bacteroides*



Stepwise Approach

- Weight of evidence
  - May be no definitive association
    - FIO
    - Alternative or secondary indicators (bacteria, viruses, chemical tracers)
    - MST
    - Sanitary surveys
    - Mathematical modeling
  - Need for exposure interventions still necessary in spite of limitations

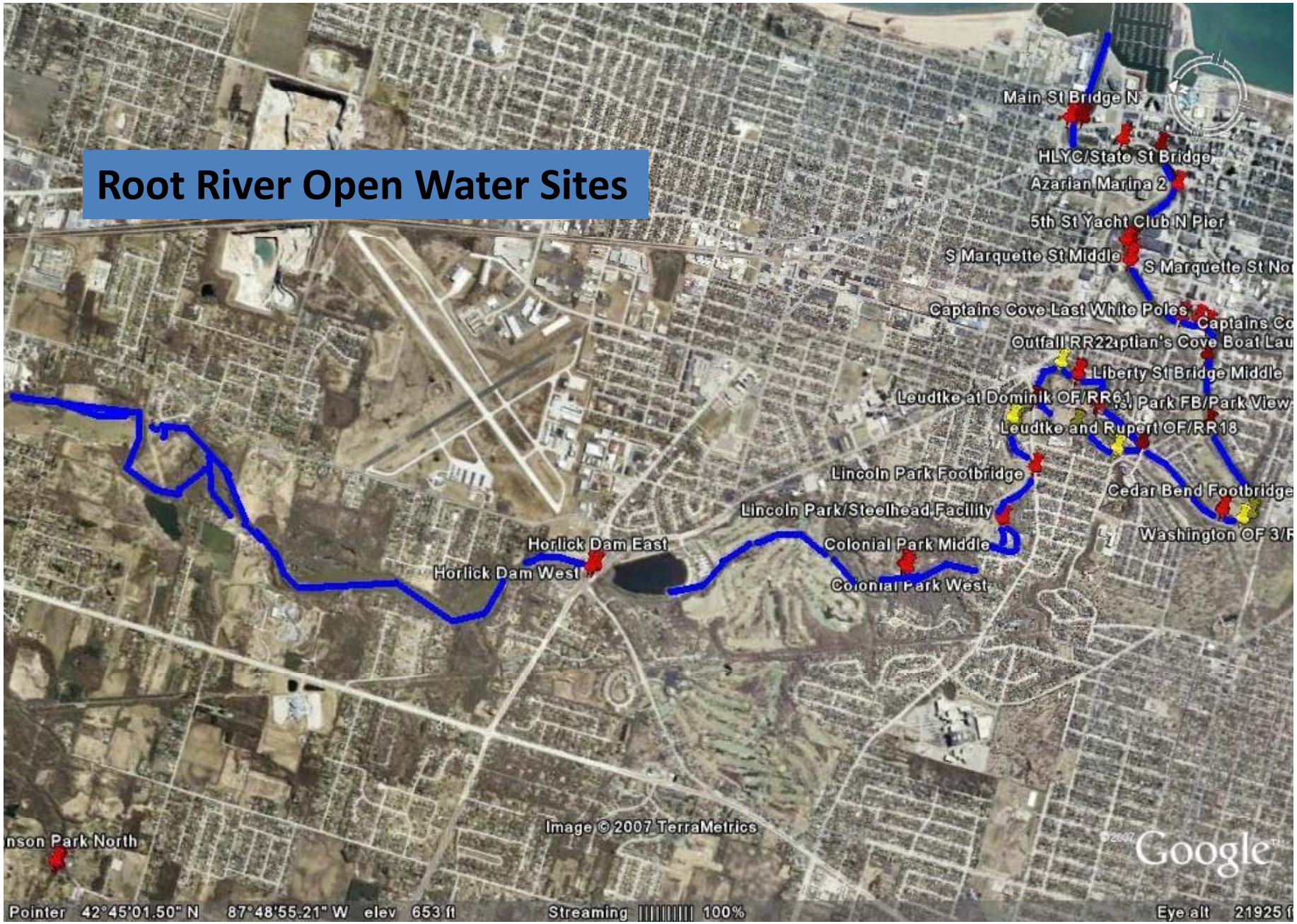
Purpose of Recent Studies

- Expand upon historic Root River monitoring conducted by the Racine Health Department
- Assemble a comprehensive database of water quality data which could be used as a baseline from which to gauge improvements
- Provide science to target remediation
- Link Root River water quality to coastal water quality
- Explore utility of predictive models

2007 Study Sites

- Johnson Park (3)
- Horlick Dam (3)
- Colonial Park (3)
- Lincoln Park (2)
- Spring St/Domanik (1)
- Island Park/Glen St (3)
- Horlick Dr/Liberty St (3)
- Parkview Dr (3)
- W. 6th St/Rupert (2)
- Riverside/Cedarbend (3)
- Clayton Park (1)
- Barbee Park (1)
- REC Center (3)
- S. Marquette St. (2)
- 5th St. YC/Azarian (2)
- Azarian – downstream (3)
- State St. Bridge (1)
- Main St. Bridge (3)
- Chartroom (1)

- Leudtke Ct/Domanik
- Leudtke Ct/Spring
- Glen St
- Rupert/Leudtke
- Washington Park (3)
- Water Street/Azarian (2)


Root River Open Water Sites
Main St Bridge N
HLYC/State St Bridge
Azarian Marina 2
5th St Yacht Club N Pier
S Marquette St Middle
Captains Cove Last White Poles
Outfall RR22
Liberty St Bridge Middle
Leudtke and Rupert OF/RR18
Lincoln Park Footbridge
Lincoln Park/Steelhead Facility
Cedar Bend Footbridge
Horlick Dam East
Horlick Dam West
Colonial Park Middle
Colonial Park West
Image © 2007 TerraMetrics
Google
Pointer 42°45'01.50" N 87°48'55.21" W elev 653 ft
Streaming 100%
Eye alt 21925 f


Storm Water Outfall Sites
Luedtke off Spring Outfall
Luedtke off Domanik Outfall
Racine Luthern Outfall
Water Street Outfall
Leudtke and Rupert Street Outfall
Racine, WI
Washington Outfall 3
Washington Outfall 1
Washington Oufall 2
Image © 2009 TerraMetrics
2776 ft
© 2009 Google
Imagery Date: Oct 11, 2007
42°43'37.90" N 87°47'41.08" W elev 599 ft
Eye alt 10877 ft

Additional Studies

- 2008 expanded Root River study
  - Seasonal variation
  - Educational component
  - DO
  - Phosphorous
  - Contribution from biofilms
- 2009 - 2010 predictive modeling study
  - Combine land use & coastal models

Results

- Turbidity
- *E. coli*
- Chemical markers
- Bacteroides
- Biofilms
- Basin Assessments
- Models

Turbidity (2008)

(Normal range ≤ 29 NTU above natural background levels):

- Of the 41 sites tested all but Clayton Park had turbidity levels exceeded 29 NTU at least once.

- The average number of elevated turbidity values associated with precipitation was 2 per site.

- Some sites had elevated turbidity without rainfall
  - –Johnson's Park
  - –Horlick Dam
  - –Colonial Park
  - –Lincoln Park at the DNR Steelhead Facility
  - –Spring St./Domanik Drive, Captain's Cove/REC
  - –W. Sixth St. – Middle
  - –Azarian Marina – sampling point #2

Turbidity as a Function of Location, by Group, Johnson's Park to the Mouth

Between Group Turbidity – 2007 and 2008			
2007		**2008**	
Group	**Mean Rank (NTU)**	**Group**	**Mean Rank (NTU)**
1	191.58	1	230.47
2	186.53	2	227.55
3	163.55	3	211.86
4	156.18	4	171.61
	p = 0.07		**p = 0.003**

Turbidity vs. Precipitation, 2007-2008						
	Coefficient of determinations [(R^2) left column] and correlation coefficients [(*r*) right column] for combined dry and wet weather data					
PPT	**Group 1 and 2**		**Group 3**		**Group 4**	
24 hr	0.12	0.11	0.56	0.47	0.56	0.75
48 hr	0.28	0.53	0.60	0.44	0.61	0.78

Turbidity vs. Flow Rate, 2007-2008			
	Group 1 and 2	**Group 3**	**Group 4**
R^2	0.65	0.90	0.90
r	0.81	0.95	0.95

Root River Average *E. coli* Densities (MPN/100 ml)		
SITE	**2004** **(Rainfall = 9.23”)**	**2007** **(Rainfall = 19.45”)**
Johnson Park (R1)	1518	483
Horlick Dam (R2)	1431	460
Cedar Bend (R3)	3705	815
Washington Park Storm Water Outfall (R4)	38,856	5469
Water Street Storm Water Outfall (R5)	18,020	4392
State Street Bridge (R6)	1372	840
Chartroom (R7)	1098	805

E. coli (2008)

(Normal range: depends on use, recommended up to 394 MPN/100 mL):

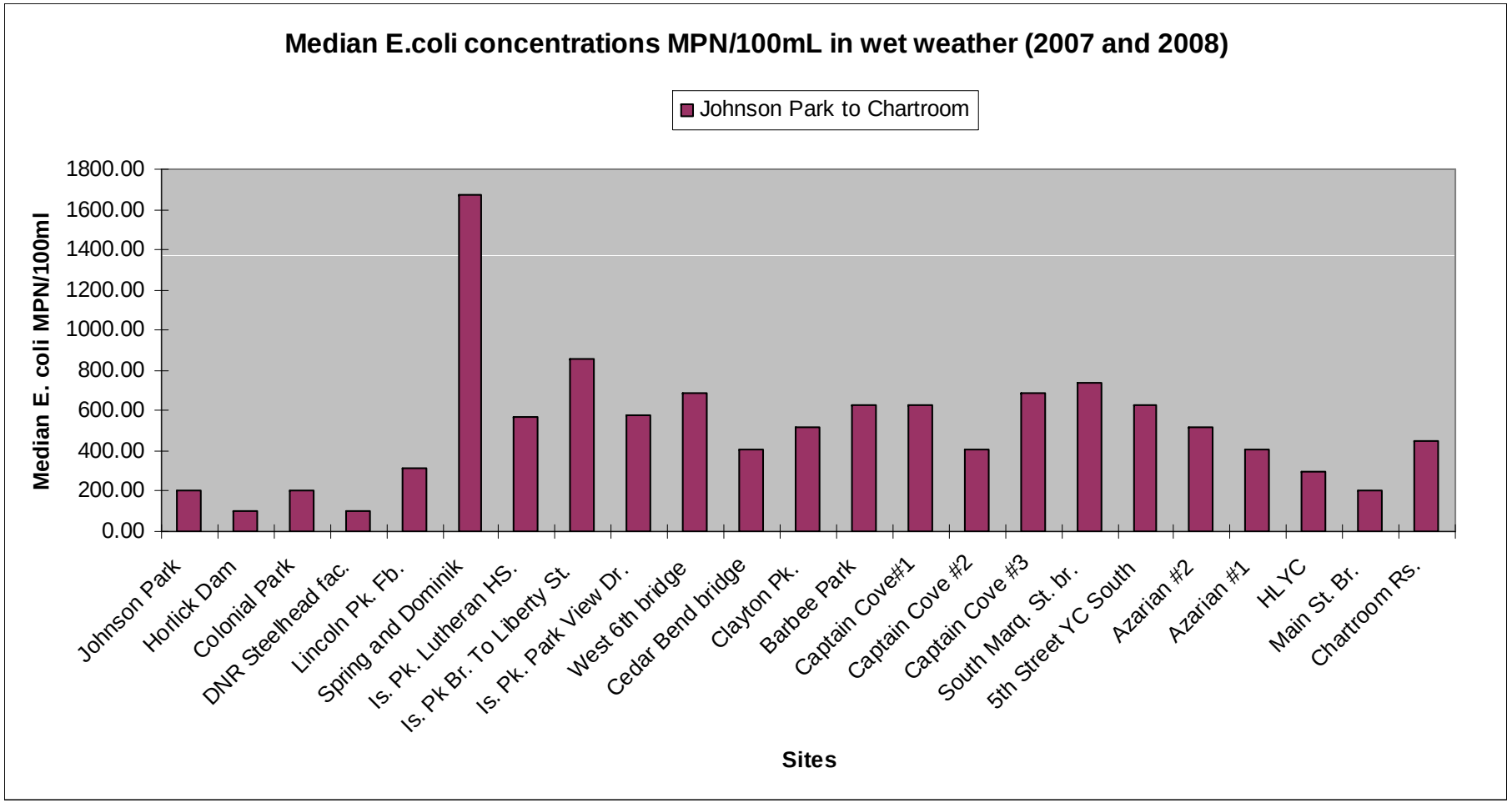
- All sites exhibited elevated *E. coli* levels after some rain events. For some sites this was exclusive
  - Colonial Park – east
  - Lincoln Park/Spring St.
  - Azarian Marina/#1
  - Harbor Light Yacht Club

- Most sites also had elevated *E. coli* levels in the absence of precipitation

- For two of the sampling sites there was little correlation between the sampling points (either bank, middle of stream, or both)
  - Island Park/Liberty Street
  - Island Park/Park View Drive

- *E. coli* values were generally correlated to turbidity except at the Island Park footbridge behind Lutheran High School (all three sites), Island Park footbridge to Park View Drive – East, and Island Park bridge to Liberty St. – East

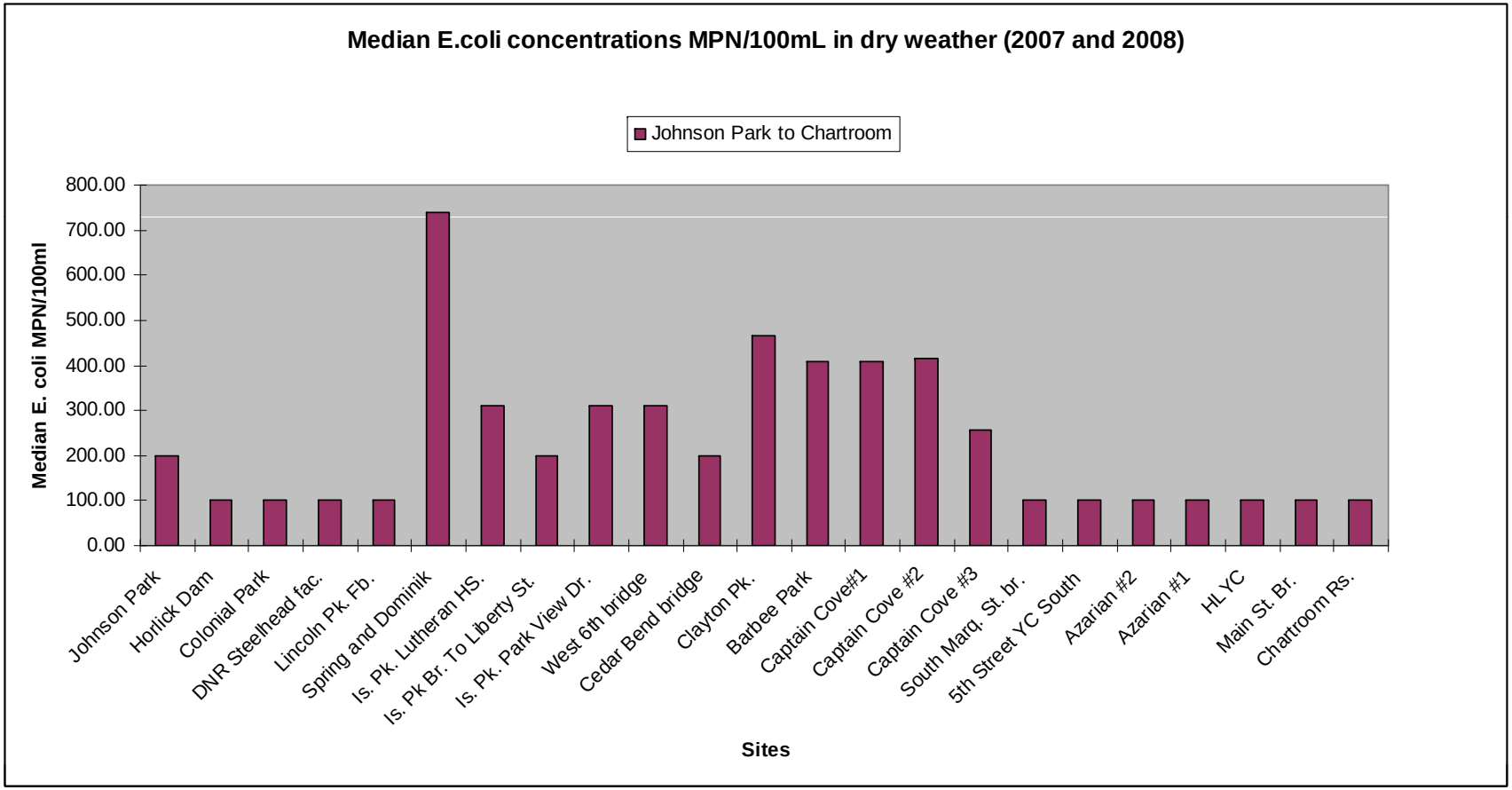
Wet weather *E. coli*



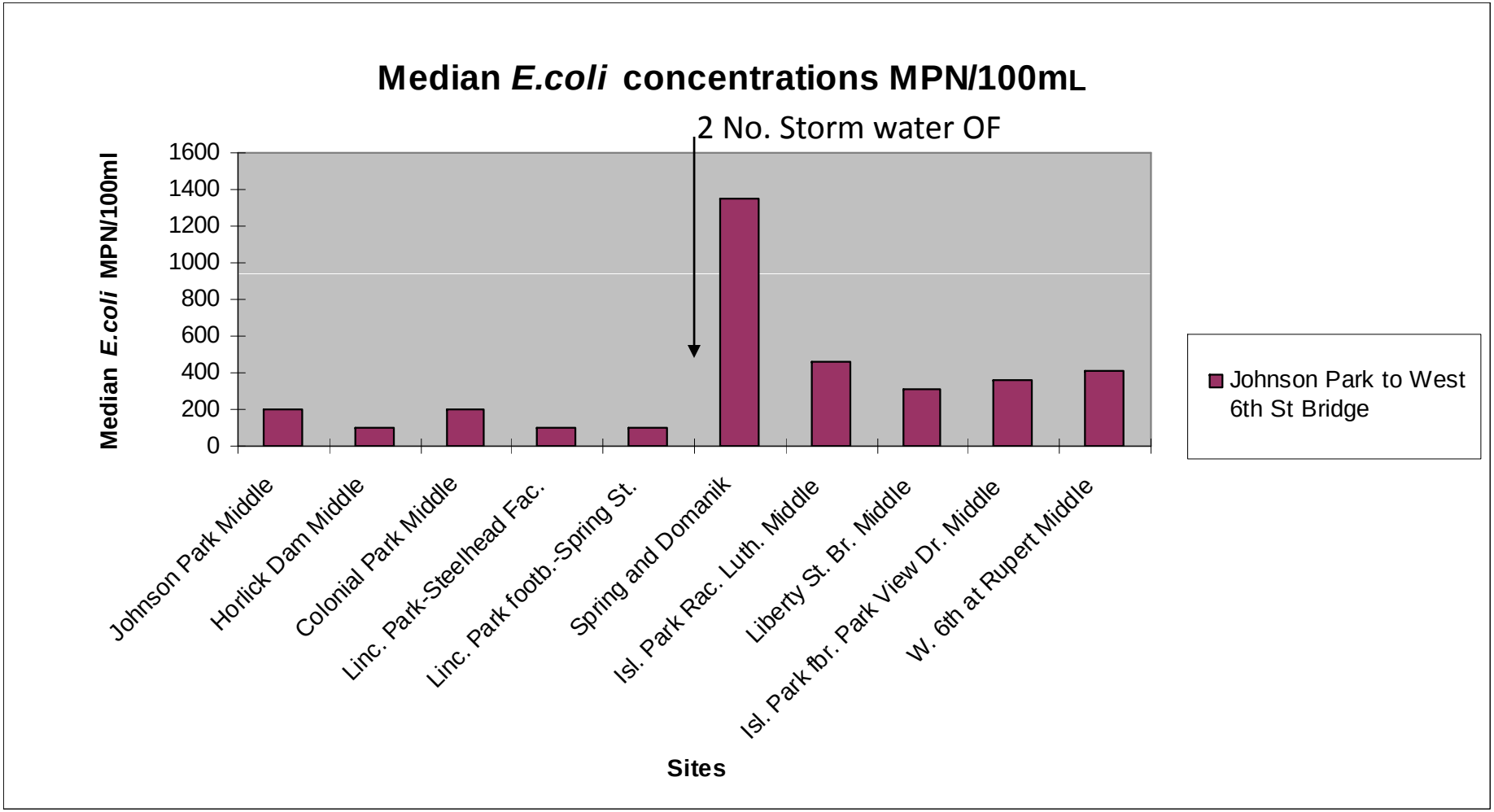
Occurrence of E. coli Spikes w/o Rain

- 6%: Main St. Bridge, Johnson Park, Chartroom, State St. Bridge, Lincoln Park/Steelhead, Azarian Marina/#2
- 6-19%: Horlick Dam, depending on sampling location
- 6-25%: W. 6th St., depending on sampling location
- 6-31%: Island Park/Liberty St., depending on sampling location
- 12.5%: Colonial Park – west, middle
- 12.5-19%: Marquette St., depending on sampling location
- 19%: Island Park/Park View Dr.
- 25%: Island Park/Lutheran HS
- 25-31%: 5th Street Yacht Club, depending on sampling location
- 31%: Clayton Park, Barbee Park, Spring St./Domanik Dr.
- 31 – 37.5%: Captain's Cove/REC, Cedarbend

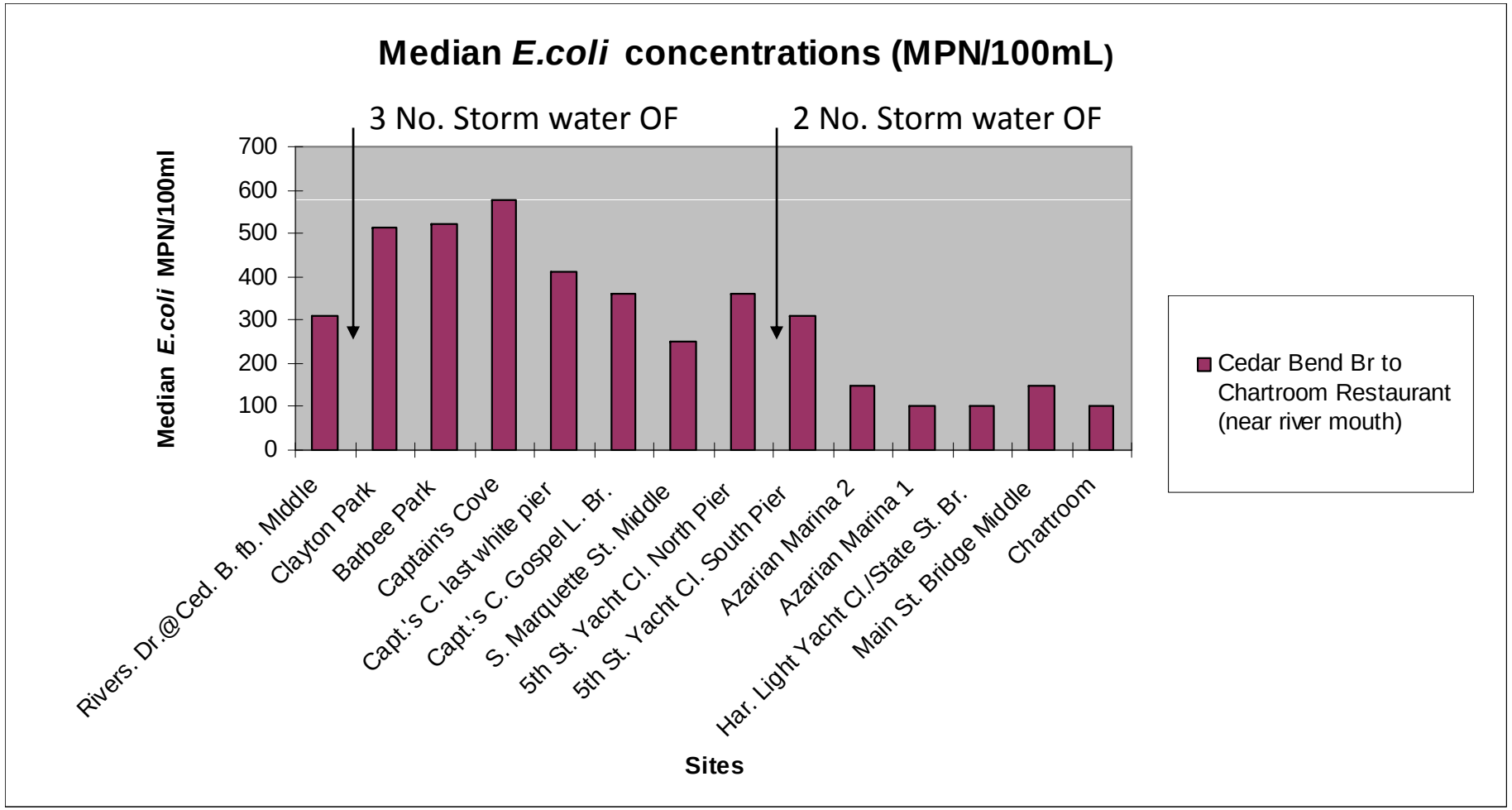
Dry Weather *E. coli*



Median *E. coli* concentrations from Johnson's Park to West 6th Street



Median *E. coli* concentrations from Cedarbend Bridge to mouth of Root River



Chemical Parameters

- **Detergents (Normal range: ≤ 0.50 mg/L):**
  Detergents were detected frequently (80 – 100% of sampling events) except at Washington Park Outfall #3 (RR37-c, 31%)

- **Total Residual Chlorine (Normal range: < 0.01 mg/L:**
  Total residual chlorine was detected in the Water Street Outfall (#RR36-1W, #RR36-2E) 25% of the time. Values ranged from 0.1 – 0.15 mg/L.

- **Copper (Normal range: ≤ 3.7 µg/L): None detected**

- **Total Phenols (Normal range: < 1.0 µg/L):**
  Washington Park Outfall #2, #RR37-b, had detectable phenols once (0.15 µg/L) but they were within acceptable limits.

Total Phosphorous (2008 – 2009)

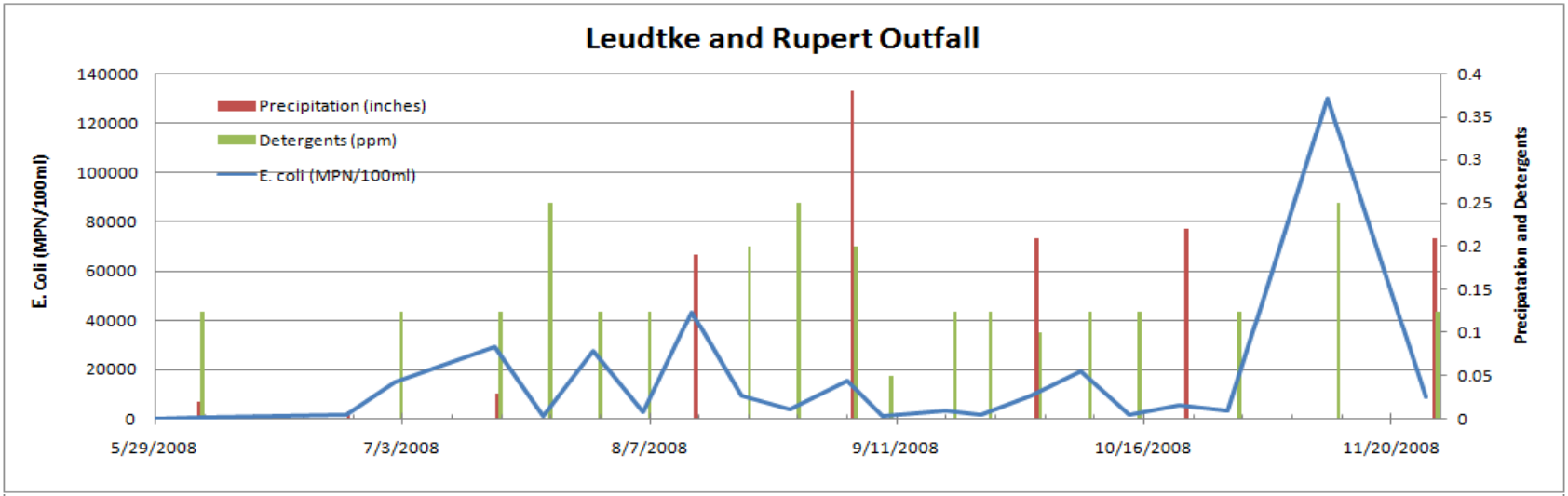
- Johnson Park
  - Mean: 0.12 mg/L
  - Range: 0.04 – 0.26 mg/L
- Colonial Park
  - Mean: 0.11 mg/L
  - Range: 0.03 – 0.19 mg/L
- Washington Park
  - Mean: 0.16 mg/L
  - Range: 0.04 – 0.37 mg/L

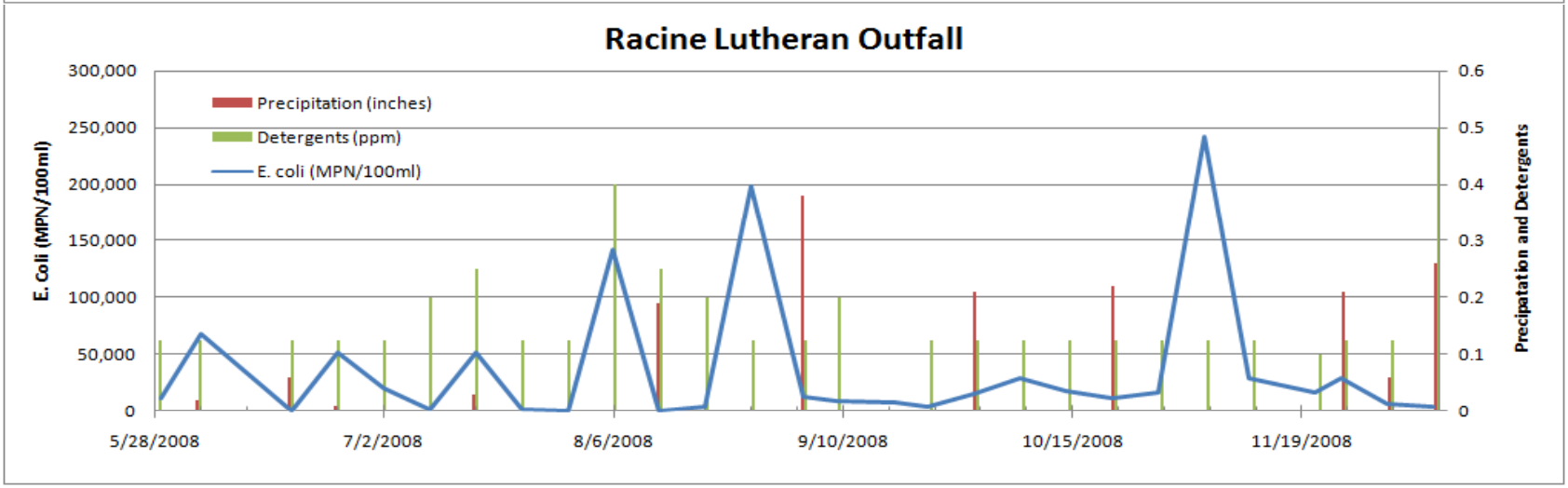
Dissolved Oxygen

Site Location & Description	Average (mg/L)		Range (mg/L)	
	2007-2008	2009	2007-2008	2009
Horlick Dam - West Bank	8.0	11.7	2.72 - 10.16	7.2 - 17.1
Johnson Park - North Bank	7.0	10.6	4.43 - 10.03	8.4 - 16.4
Colonial Park - West Bank	8.3	11.4	7.26 - 9.90	6.54 - 17.6
Lincoln Pk. - Steelhead Facility	8.0	11.3	7.01 - 9.14	7.2 - 17.6
Spring Street & Dominic Street	7.8	10.7	6.1 - 9.3	7.0 - 18.1
Isl. Pk. fb. Behind Rac. Luth. - West Bank	7.8	11.3	6.03 - 9.24	6.1 - 17.6
W. 6th St. at Rupert St. - West Bank	8.2	11.2	6.81 - 9.8	6.2 - 17.5
Isl. Pk. fb. To Park View Drive - West Bank	8.1	11.1	7.05 - 9.6	6.5 - 16.37
Liberty St. Bridge - West Bank	8.4	11.2	6.6 - 10.45	6.9 - 16.81
Riverside Dr. at Cedar Bend Fb. - East Bank	7.2	10.6	4.35 - 9.15	5.3 - 18.4
Clayton Park	8.3	10.5	4.57 - 10.91	6.1 - 17.9
Barbee Park	7.9	10.4	10.5 - 30.56	5.3 - 16.8
Captain's Cove	8.5	10.0	5.36 - 11.4	5.4 - 16.9
Captain's Cove - Last White Pier	8.7	9.7	5.36 - 12.59	5.3 - 15.7
Captain's Cove - Gospel Light Bridge	8.8	10.0	5.3 - 13.28	5.6 - 15.9
S. Marquette St. Bridge - North Bank	8.3	9.7	5.56 - 12.2	4.1 - 21.0
5th St. Yacht Club - North Pier	8.2	9.5	5.88 - 11.35	5.7 - 32.0
Chartroom	7.4	9.7	10.56 - 31.11	4.0 - 15.5
Azarian Marina 1	7.7	9.1	4.86 - 11.48	4.0 - 15.5
5th St. Yacht Club - South Pier	8.4	9.4	6.08 - 12.5	4.1 - 15.4

Summary of storm water outfall results using chemical and microbiological source tracking parameters (2008)

Outfall	Percent exceedance Total samples	Percent exceedance Dry weather	Mean *E. Coli* MPN/100 mL	Max *E. Coli* MPN/100 mL	Mean Chlorine (mg/L)	Mean Detergents (mg/L)
Glen Street	95	52	30,248	141,360	0.002	0.2
Water St. East	93	60	11,611	173,287	0.061	0.2
Leudtke/Domanik	93	52	25,212	241,917	0.006	0.2
Leudtke/Rupert	88	42	14,396	141,360	0.002	0.2
Water St. West	83	45	27,951	241,920	0.098	0.14



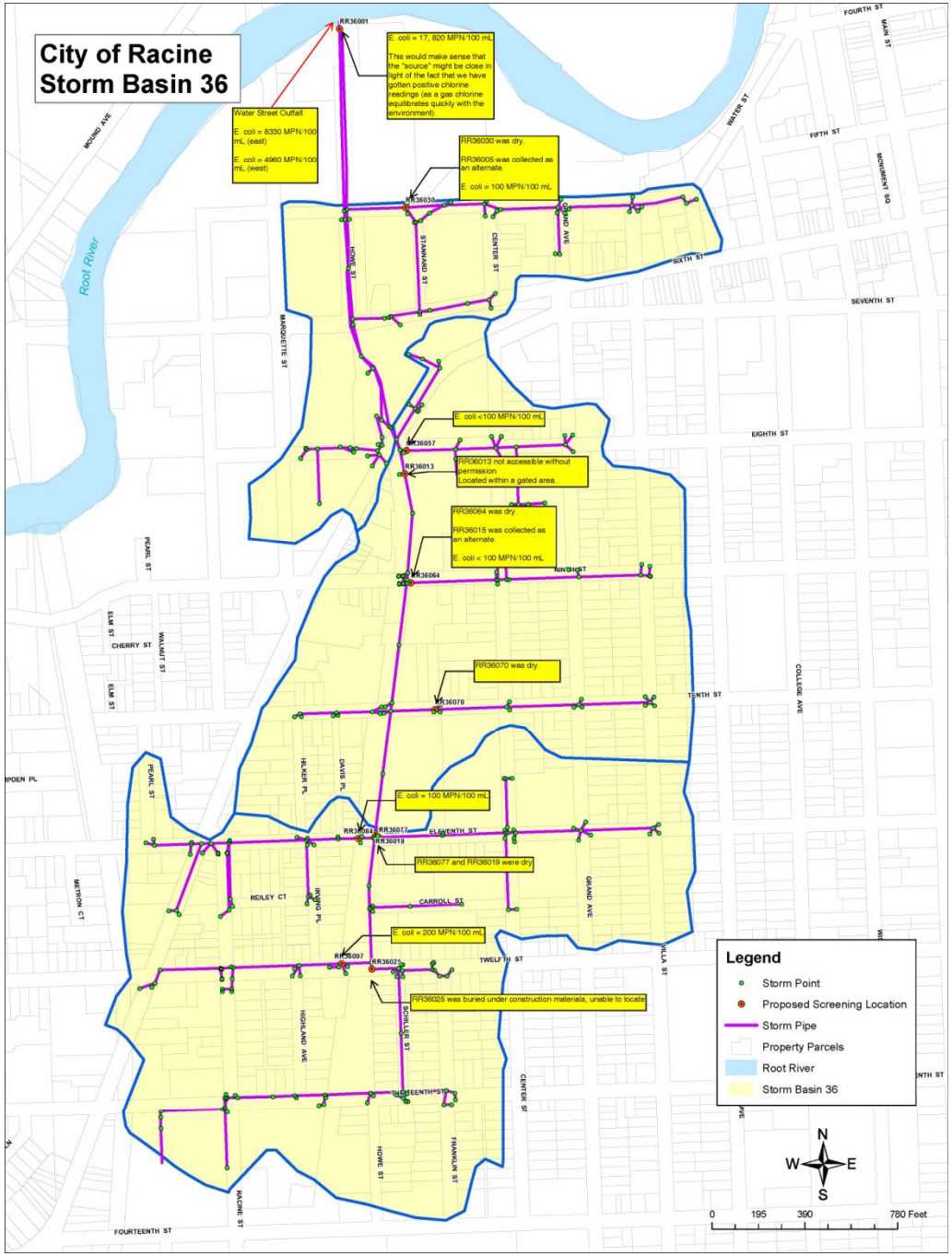


Location	Average *E.Coli* (MPN/100ml)	Average Dry Weather *E.Coli* (MPN/100ml)	Average Wet Weather *E. Coli* (MPN/100ml)	Average Detergent concentration (ppm)	Average Dry Weather Detergent Concentration (ppm)	Average Wet Weather Detergent Concentration (ppm)	n_{Dry}	n_{Wet}
Leudtke and Rupert	15200	15700	14300	0.12	0.14	0.08	14	8
Racine Luther Outfall	36200	44500	23400	0.16	0.15	0.18	17	11
Racine Luthern West	2100	1500	3100				18	11
Racine Luthern East	1500	600	3000				18	11

Bacteroides (2010)

Sample Date	EWS#	Site	Bacteroides Human	Bacteroides Human (CN/100ml)	Total Bacteroides (CN/100ml)	Ratio of Human Bacteroides/Total Bacteroides (%)
5/7/2010	1A	Horlick NW OF	Negative			
5/7/2010	2A	Horlick SW OF	Negative			
5/7/2010	3A	Horlick E OF	Negative			
5/7/2010	4A	Leudtke Off Spring	Negative			
5/7/2010	5A	Racine Lutheran OF	**Positive**	1,855	54,914	3.38%
5/8/2010	1A	Washington Park #2	**Positive**	7,020	67,023	10.47%
5/8/2010	2A	Washington Park #2	**Positive**	2,127	26,032	8.17%
5/8/2010	3A	Washington Park #3	Negative			
5/8/2010	4A	Water St OF W	Negative			
5/8/2010	5A	Water St OF E	Negative			
5/13/2010	IEB	Wetland Outflow	Negative			
5/13/2010	EOF	English St OF	**Positive**	74	20,022	0.37%
6/30/2010	1A	RR16002	**Positive**	4	12,232	0.03%
6/30/2010	2A	RR16005	Negative			
6/30/2010	3A	RR16007	**Positive**	39	17,661	0.22%
6/30/2010	4A	RR16009	**Weak**	7	3,589	0.19%
6/30/2010	5A	RR16012	**Weak**	30	2,375	1.27%
6/30/2010	6A	RR36004	Negative			
6/30/2010	7A	RR36005	**Positive**	386	29,433	1.31%
6/30/2010	8A	RR3601	Negative			
6/30/2010	9A	RR3602	Negative			

The ratio of human bacteroides to total bacteroides in raw sewage is ~2.2 to 8.0 (mean = 5.1) [Dr. Sandra McLellan, UWM WATER Institute]



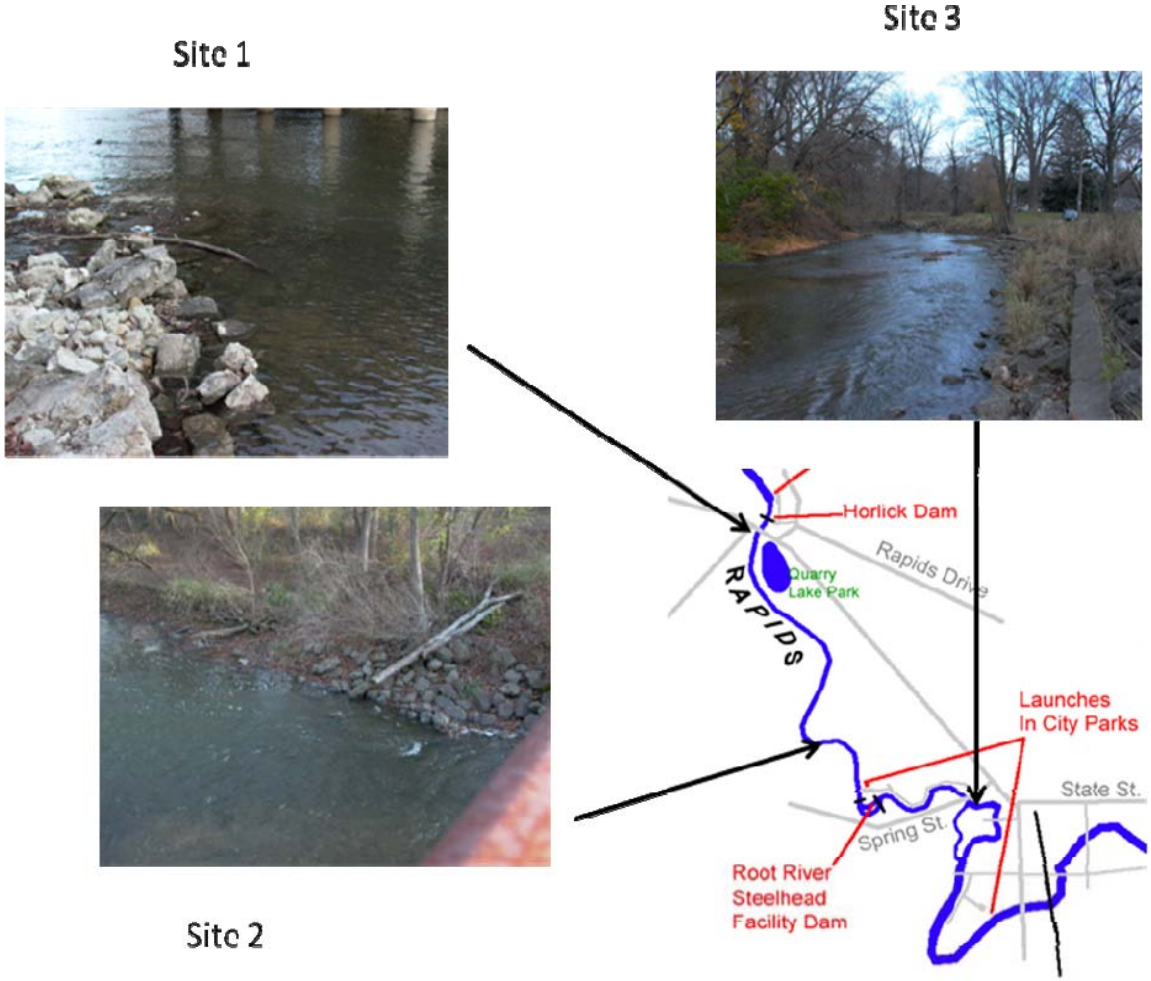
Basin Assessments

Looking for Telltale Evidence

***E. Coli* (MPN/100 ml):**

RR17003 = >241,920
RR17004 (west pipe) = 241,917
RR17002 (north pipe) = 2,780
RR17002 (west pipe) = 30,760
RR17005 = 30,760
Racine Lutheran Outfall = 77,010

Biofilm Assessment



Samples collected from the field demonstrated the presence of *E. coli* DNA in biofilms that developed on sterile surfaces placed in the river. The data from one of the outfalls also indicated the presence of *E. coli* DNA. However, the presence of the *E. coli* DNA in these samples could be from either live or dead cells. The data does suggest that biofilms in the Root River could be a reservoir of *E. coli*. However, more importantly, even though *E. coli* DNA was amplified, no Shiga toxin-producing bacteria were detected in any of the biofilm samples.

Conclusions

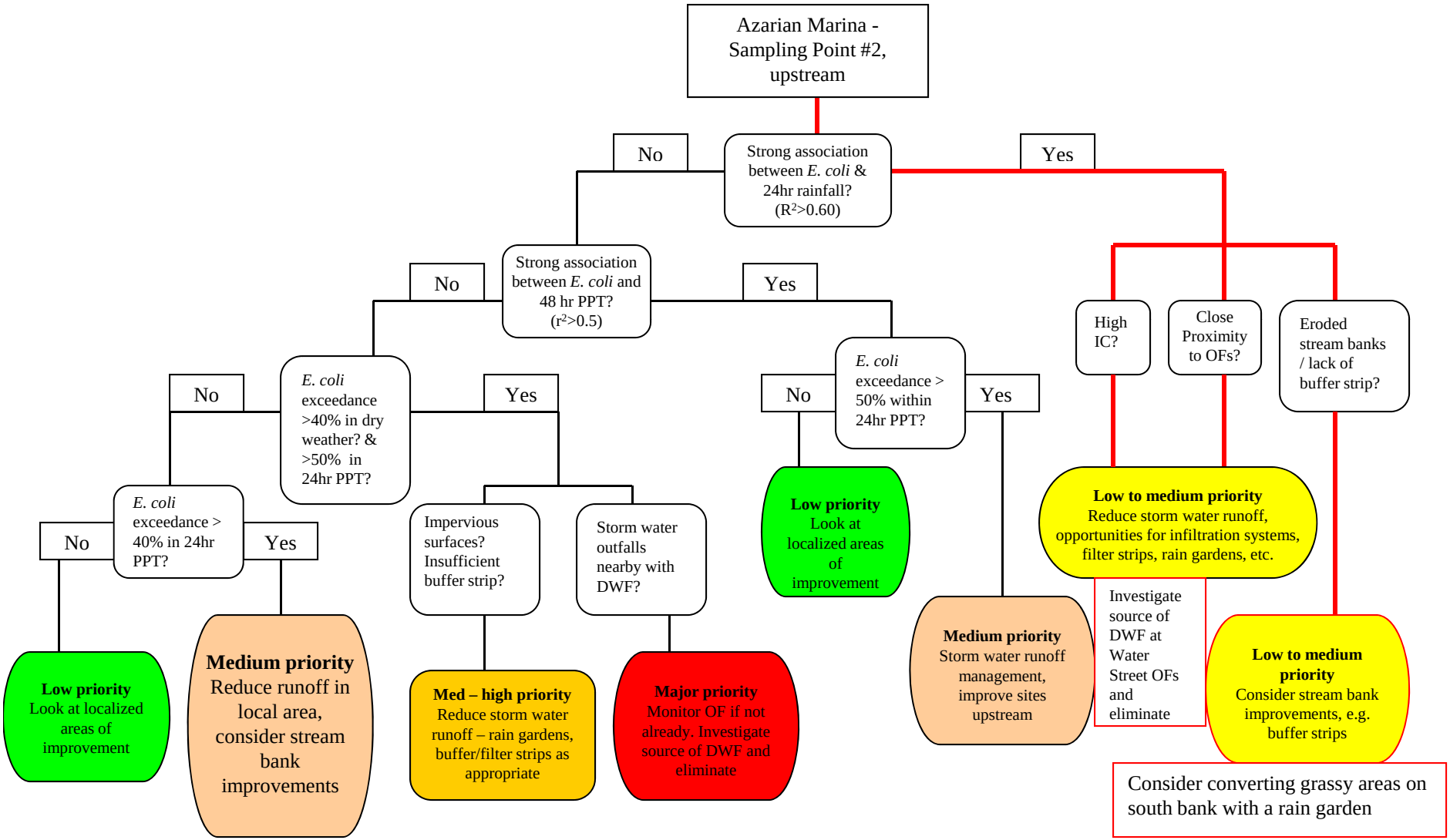
No statistical difference was noted between multiple sample points at any of the 11 sites for turbidity, specific conductance, and pH. This demonstrates that in terms of these parameters there is a relatively high level of dispersion of material within the river making cross-sectional sampling of little scientific value while driving up project costs.

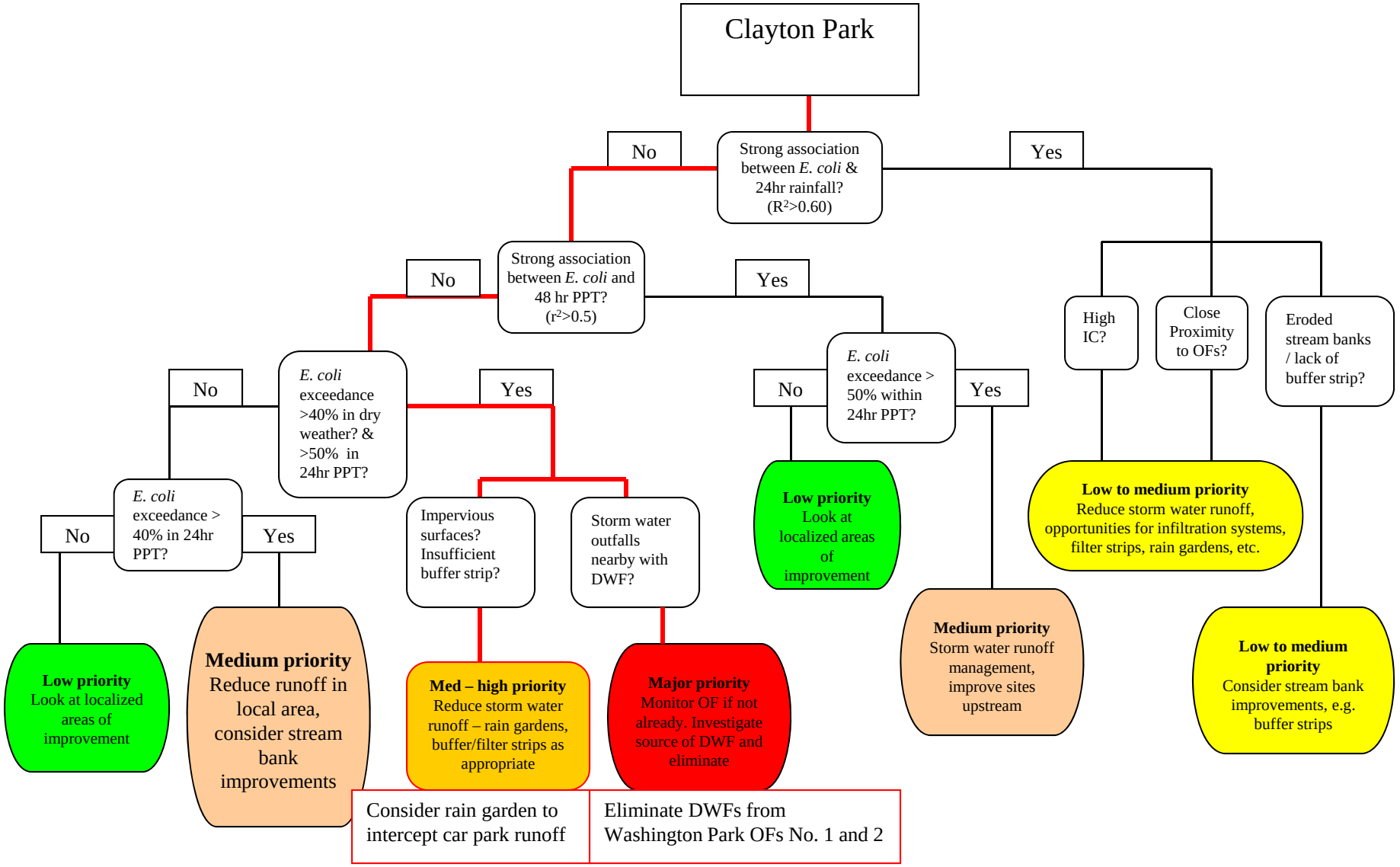
While there was no significant difference in seasonal mean *E. coli* density, with one exception, there was variation in the daily concentrations of this microbial indicator. This information is important as an additional source tracking tool since it may serve to pinpoint the actual locations where water quality exceeds acceptable standards, giving an indication of potential sources of pollution.

Conclusions

A number of associations were identified between environmental conditions, assessed chemical and microbial parameters, and physical characteristics (morphology, stream bank erosion, and presence/quality of infrastructure) along the Root River. These associations were consequently used in order to determine sources of pollution to the river and to develop a means of prioritising effective mitigation at individual sites along the river

The strength of association between *E. coli* concentrations and precipitation at a monitored site may be explained by the physical characteristics of the site and surrounding area. These characteristics may determine how the site responds to rainfall, including what deters or enhances runoff. Sites which exhibit different strengths of association to one another may lead to the identification of common pollution sources, factors which impact the level of association, and what incurs the variability between sites. Differences in association between 24 and 48 hour rainfall events may also be explained by the same physical characteristics.


Azarian Marina - Sampling Point #2, upstream
No
Strong association between E. coli & 24hr rainfall? (R²>0.60)
Yes
No
Strong association between E. coli and 48 hr PPT? (r²>0.5)
Yes
No
E. coli exceedance >40% in dry weather? & >50% in 24hr PPT?
Yes
No
E. coli exceedance > 50% within 24hr PPT?
Yes
High IC?
Close Proximity to OFs?
Eroded stream banks / lack of buffer strip?
No
E. coli exceedance > 40% in 24hr PPT?
Yes
Impervious surfaces? Insufficient buffer strip?
Storm water outfalls nearby with DWF?
Low priority Look at localized areas of improvement
Low priority Look at localized areas of improvement
Low to medium priority Reduce storm water runoff, opportunities for infiltration systems, filter strips, rain gardens, etc.
Medium priority Reduce runoff in local area, consider stream bank improvements
Med – high priority Reduce storm water runoff – rain gardens, buffer/filter strips as appropriate
Major priority Monitor OF if not already. Investigate source of DWF and eliminate
Medium priority Storm water runoff management, improve sites upstream
Investigate source of DWF at Water Street OFs and eliminate
Low to medium priority Consider stream bank improvements, e.g. buffer strips
Consider converting grassy areas on south bank with a rain garden


Clayton Park
No
Strong association between E. coli & 24hr rainfall? (R²>0.60)
Yes
No
Strong association between E. coli and 48 hr PPT? (r²>0.5)
Yes
High IC?
Close Proximity to OFs?
Eroded stream banks / lack of buffer strip?
No
E. coli exceedance >40% in dry weather? & >50% in 24hr PPT?
Yes
No
E. coli exceedance > 50% within 24hr PPT?
Yes
No
E. coli exceedance > 40% in 24hr PPT?
Yes
Impervious surfaces? Insufficient buffer strip?
Storm water outfalls nearby with DWF?
Low priority Look at localized areas of improvement
Low to medium priority Reduce storm water runoff, opportunities for infiltration systems, filter strips, rain gardens, etc.
Low priority Look at localized areas of improvement
Medium priority Reduce runoff in local area, consider stream bank improvements
Med – high priority Reduce storm water runoff – rain gardens, buffer/filter strips as appropriate
Major priority Monitor OF if not already. Investigate source of DWF and eliminate
Medium priority Storm water runoff management, improve sites upstream
Low to medium priority Consider stream bank improvements, e.g. buffer strips
Consider rain garden to intercept car park runoff
Eliminate DWFs from Washington Park OFs No. 1 and 2

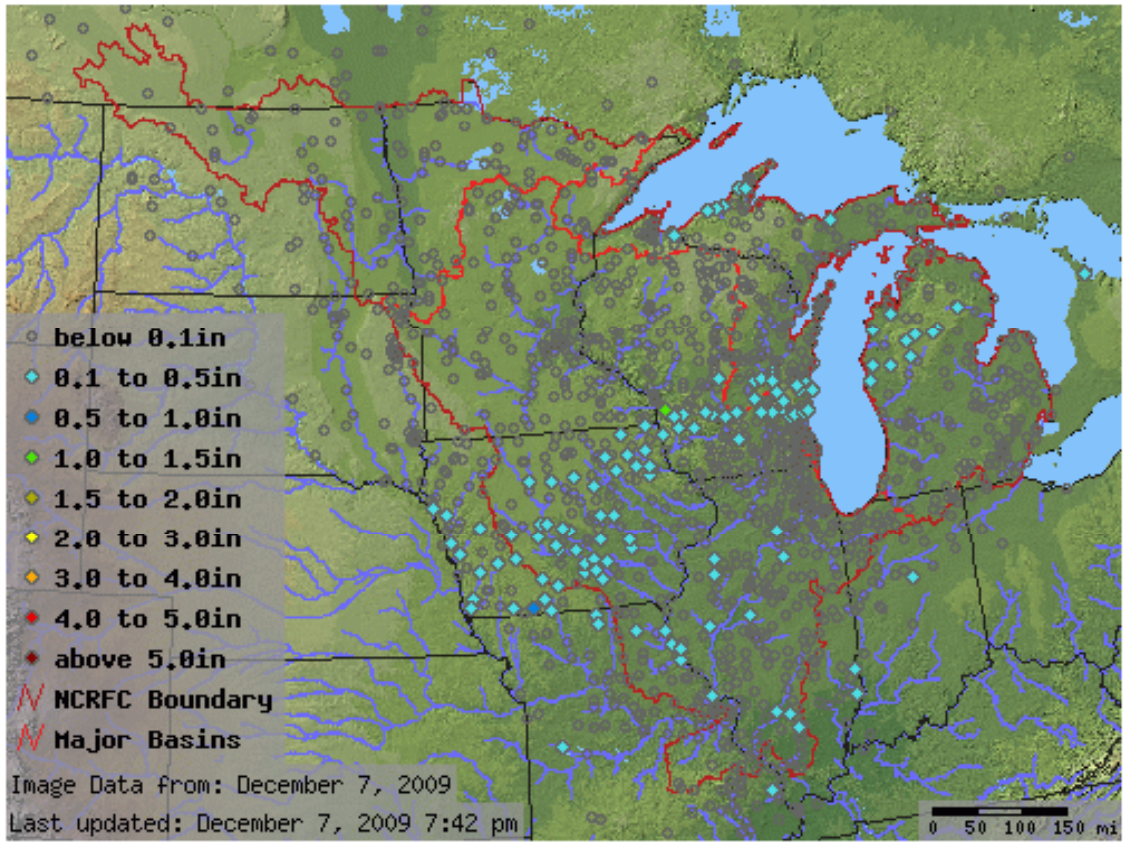
L-THIA

- Web-based Long-Term Hydrologic Impact Assessment system developed by Purdue University
- Predicts average annual impacts of alternative land use/ land management scenarios on:
    1. Direct runoff
    2. Eighteen different NPS pollutants
- Scalable: ~subdivisions to watersheds
- Anywhere in U.S.

“Real-Time” L-THIA

Today's Observed Gage Precipitation

Observations come from a variety of sources including automated sensors and cooperative observers using standard rain gages. Observations are 24-hour totals ending at 12Z (6am CST; 7am CDT). Canadian data included courtesy of *Environment Canada*.



- Based on real-time precipitation data from NOAA NWS
- Will estimate daily runoff, *E. coli*, and other NPS loadings
- Fed directly into North Beach model

Mitigation

- Watershed approach
  - Use Natural boundaries not manmade ones
- Base decisions on sound science
  - Strong scientific data, tools and techniques will enhance the process and aid in targeted remediation
- Public Involvement and Partnerships
  - Involving concerned individuals, agencies and organizations
  - Provide public education (kids & adults)
  - Communicate

Local Initiatives

- City of Racine
  - Stormwater outfall improvements
  - Streambank restoration
  - Streetscape improvements
    - Historic Sixth Street Association (HSSA)
- Root-Pike WIN
  - Rain garden initiative
- UW-Parkside
  - Expand urban environmental education and recreation
- River Alliance of Wisconsin
  - Comprehensive Root River Plan
  - Uses best elements of existing plans to ensure, among other key principles, that the water quality in the Root River is improved and the environment protected

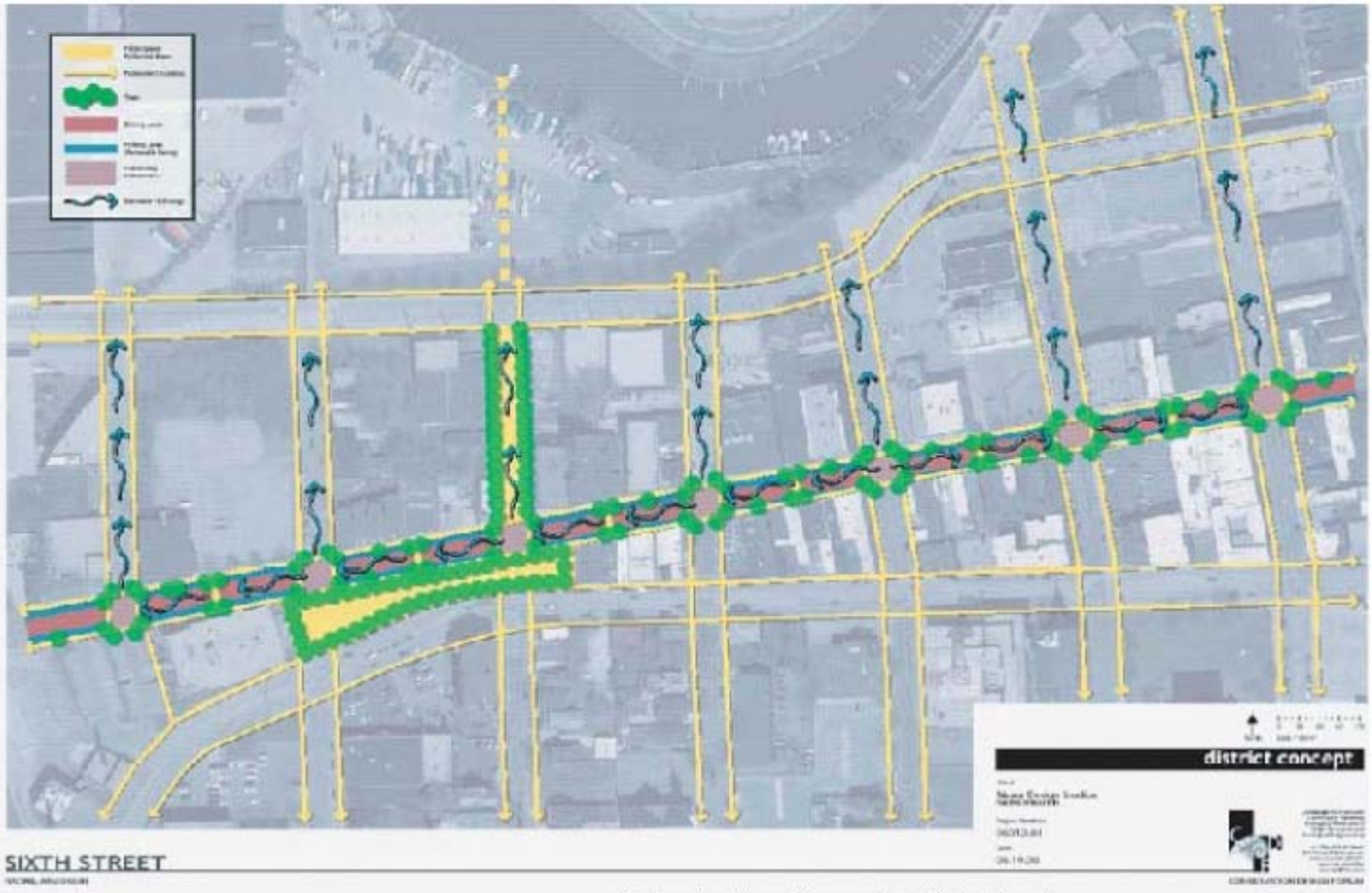
Municipal Infrastructure Improvements

- Televising and repairing cross connections
- Lining of storm sewers
- Lining of sanitary sewers
- Infestation prevention measures
- Retention basins
- Stenciling of storm drains
- Hang tags in residential areas
- Educational signage

Root River
Stream Bank Stabilization Projects

Island Park, 2005

Island Park, 2006



Rainwater flow diagram for Sixth Street

Sewer work in the 400 Block of Sixth Street

Root-Pike WIN/Sierra Club

Rain Garden, REC Center

Rain Barrel, REC Center

French Drain & Rain Garden

French Drain, REC Center

Lower Rain Garden, REC Center

Root River Environmental Education & Community Center (REC)

REC Center began in 2007 as a joint effort between the City of Racine and UW-Parkside

REC Goals

- Increase and improve environmental education opportunities available to the general public, PK-16 educators, and elementary, secondary, and postsecondary students.

- Foster and support interdisciplinary environmental research opportunities for PK-16 students and faculty and environmental organizations.

- Demonstrate innovative, ecologically sound residential and commercial products and business practices.

- Build awareness and appreciation for the Great Lakes ecosystem and connected watersheds.

Best Management Practices

- Riparian buffers
- Eliminate phosphorous fertilizers
- No dumping (anything) into the storm sewer system
- Install a rain garden
- Wash your car on the grass or at a car wash
- Direct your downspouts over the lawn
- Discourage wildlife like geese

River Alliance of WI

- “Back to the Root – An Urban River Revitalization Plan”
- Engage the Community - >100 participants
- Create a Sense of Place
- Stimulate Economic Growth
- Allow Public Access and Interaction
- Improve Water Quality
- Proposed river planning boundary

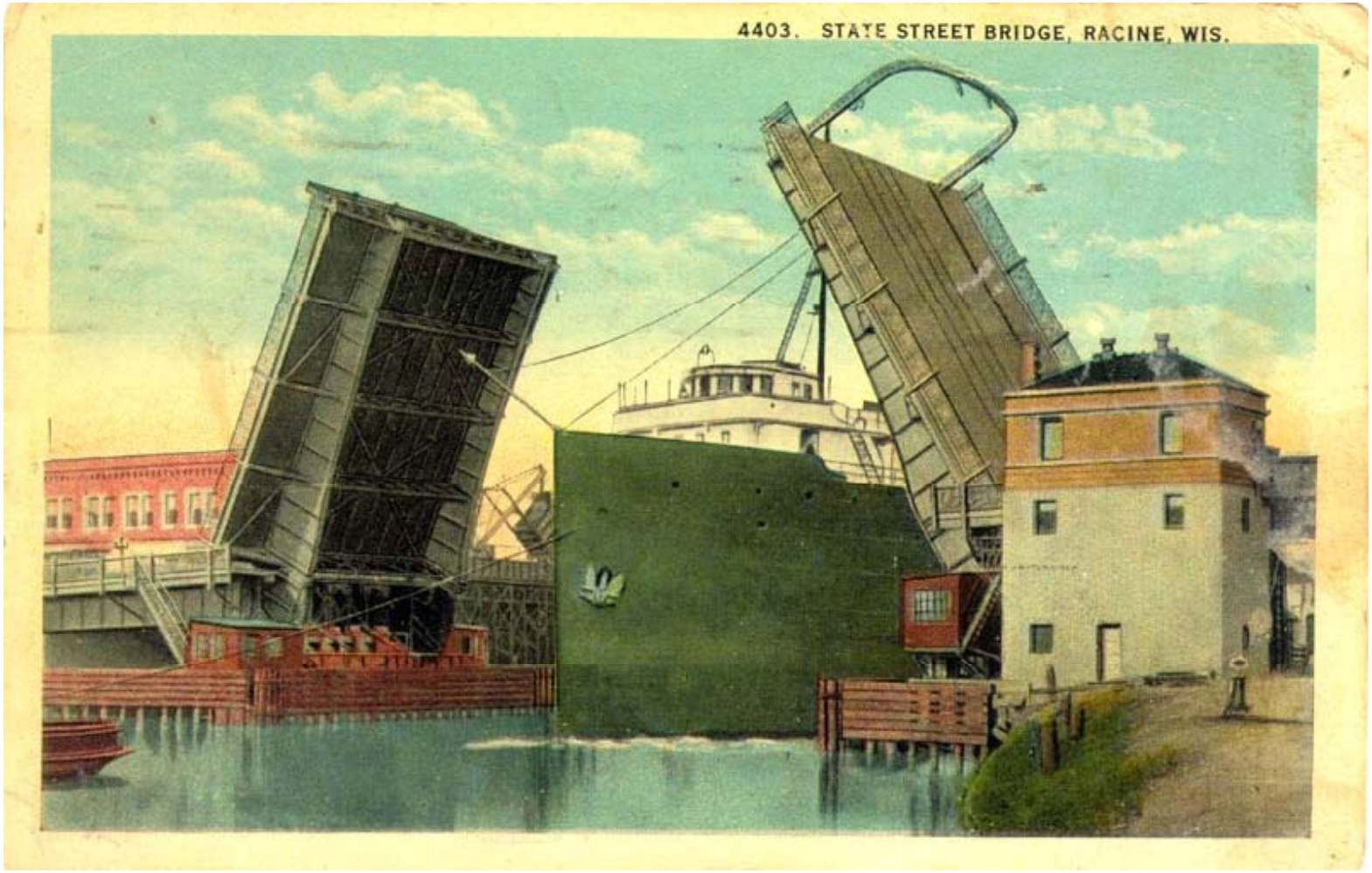
Testing Sustainability

- Has chemical, physical, & biological integrity been restored?

- Has it been maintained?

- Is the ecosystem resilient and stable?
  - Does the system remain intact when challenged?
  - Can it self-regulate internal & external stresses?
  - Has it evolved towards increasing complexity?

State Street Bridge c. 1924



Racine Heritage Museum/Todd Wallace

Thank you!

Sustainable Fisheries

Recreational Opportunities

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- Kirk Abbott, Tristan Begotka, and Stephan Kurdas
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- Susan Greenfield
  - Root-Pike WIN
- Dr. John Skalbeck
  - UW-Parkside