Who Pooped in our Water? Lessons Learned Using Microbial Biomarker Methods

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Charlotte-Mecklenburg Storm Water Services

Charlotte-Mecklenburg

Fecal Coliform Total Maximum Daily Load for the
Irwin, McAlpine, Little Sugar and Sugar Creek Watersheds,
Mecklenburg County

Final
February 2002

Catawba River Basin

Prepared by:

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of Environmental Protection
Water Quality Section
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(704) 336-5500

NC Department of Environment and
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Division of Water Quality
Water Quality Section – Planning Branch
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Fecal Coliform Total Maximum Daily Load for the McKee and Clear Creek Watersheds, Mecklenburg and Cabarrus Counties, North Carolina

Final Report
June 2003
(Approved August 2003)

Yadkin River Basin

Prepared by:
NC Department of Environment and
Natural Resources
Division of Water Quality
Water Quality Section – Planning Branch
1617 Mail Service Center
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(919) 733-5083

Through assistance from:
TMDL Modeling and Support Section
EPA, Region 4, Atlanta, GA

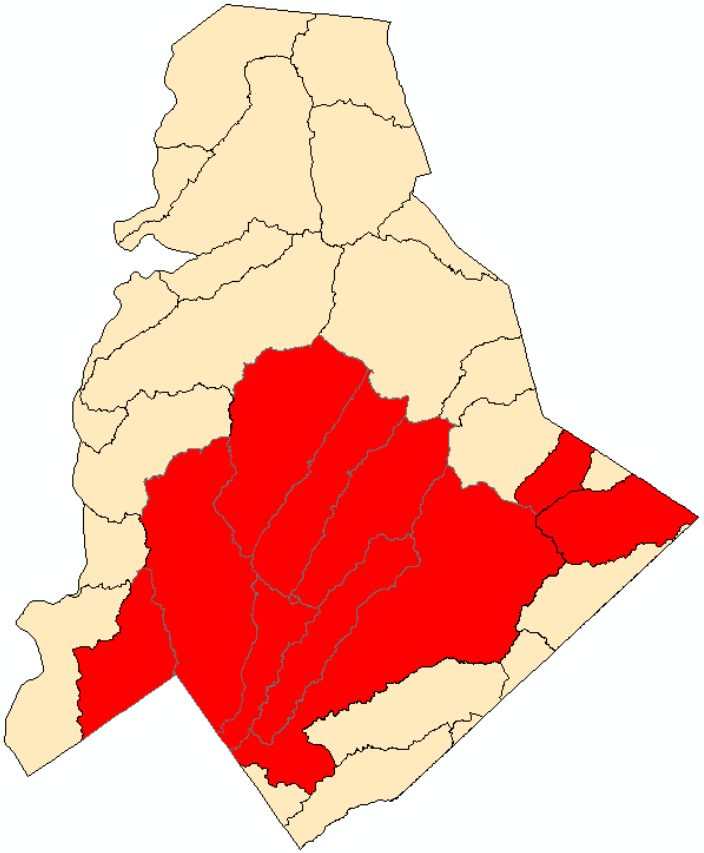
Total Maximum Daily Load – Steele Creek
(Hydrologic Unit Code 030501030108)
Stations CW-009, CW-011, CW-203
Fecal Coliform Bacteria

May 2007
Bureau of Water

D H E C
PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

SCDHEC Technical Report Number: 010-07

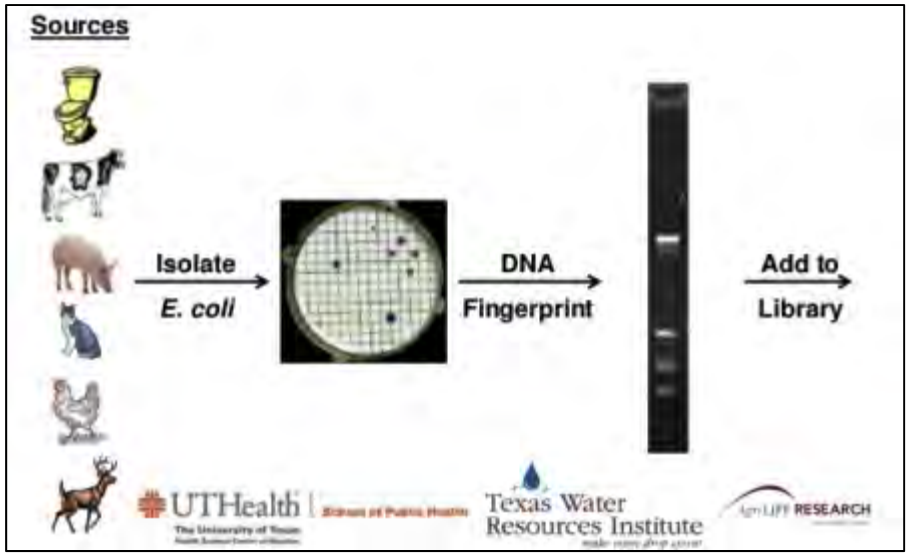
Fecal TMDL Watersheds

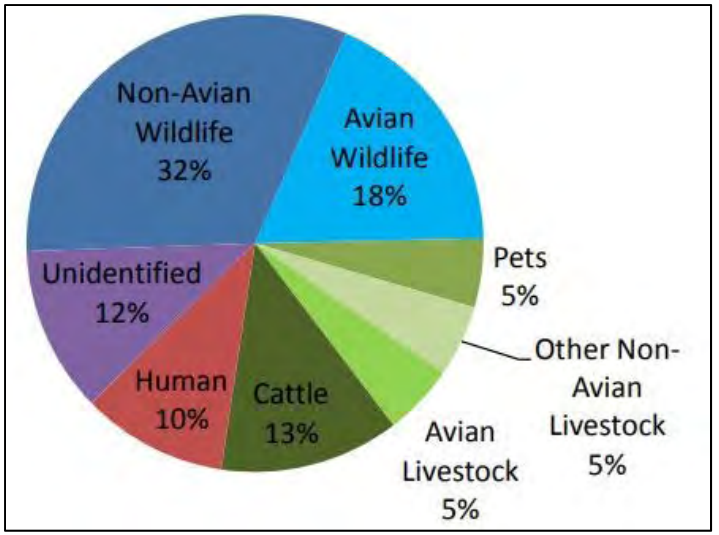


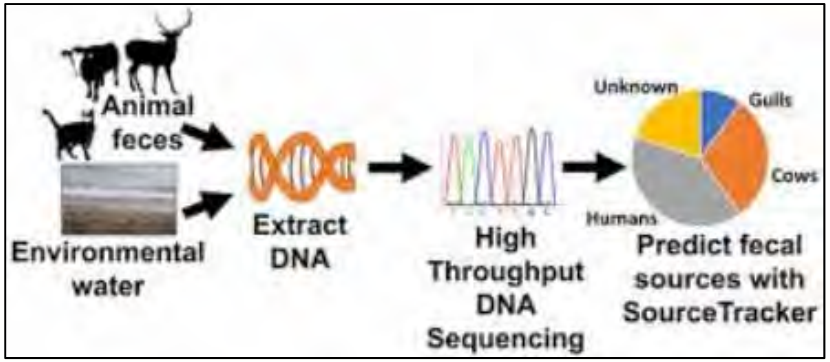
Microbial Source Tracking

Methods used to identify and quantify the extent to which different source species are contributing to the microbial contamination in a water body.

Library-Based Methods







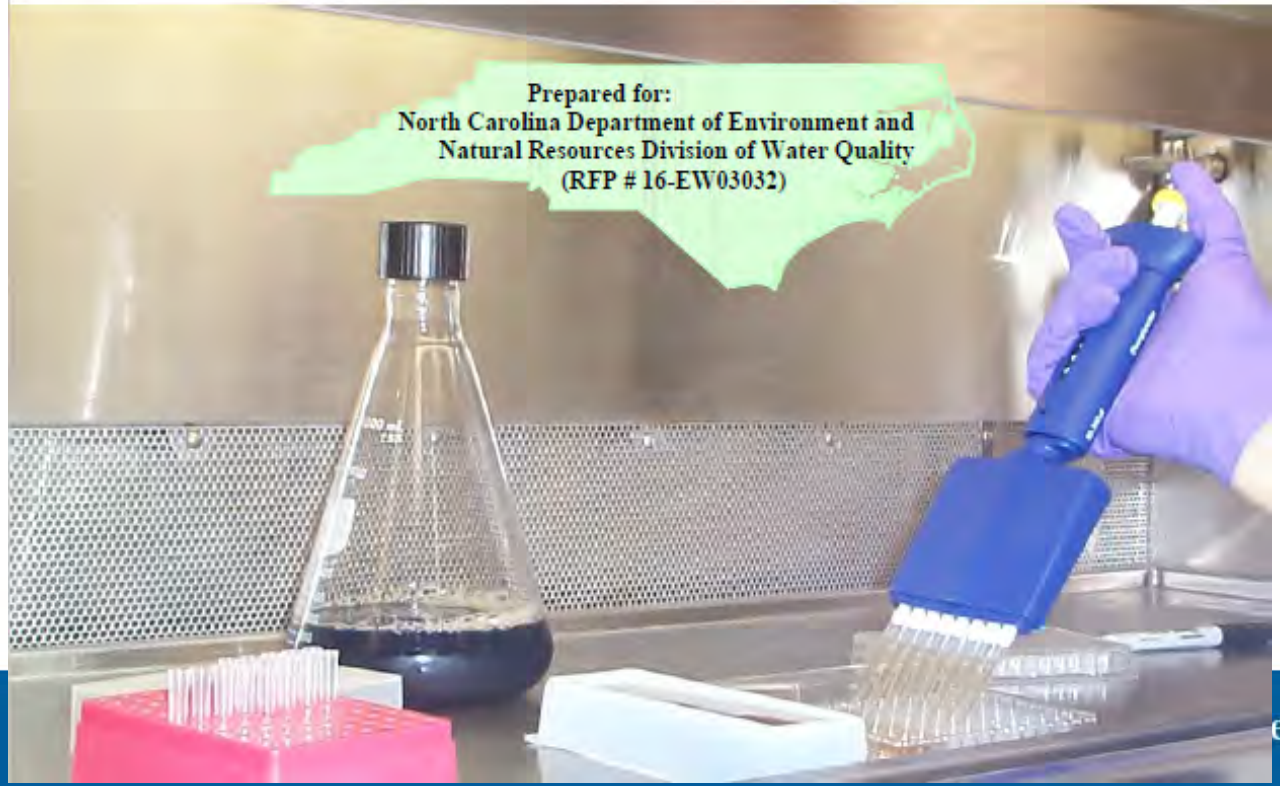
2005 Study for TMDL

Pathogen Source Assessment

for

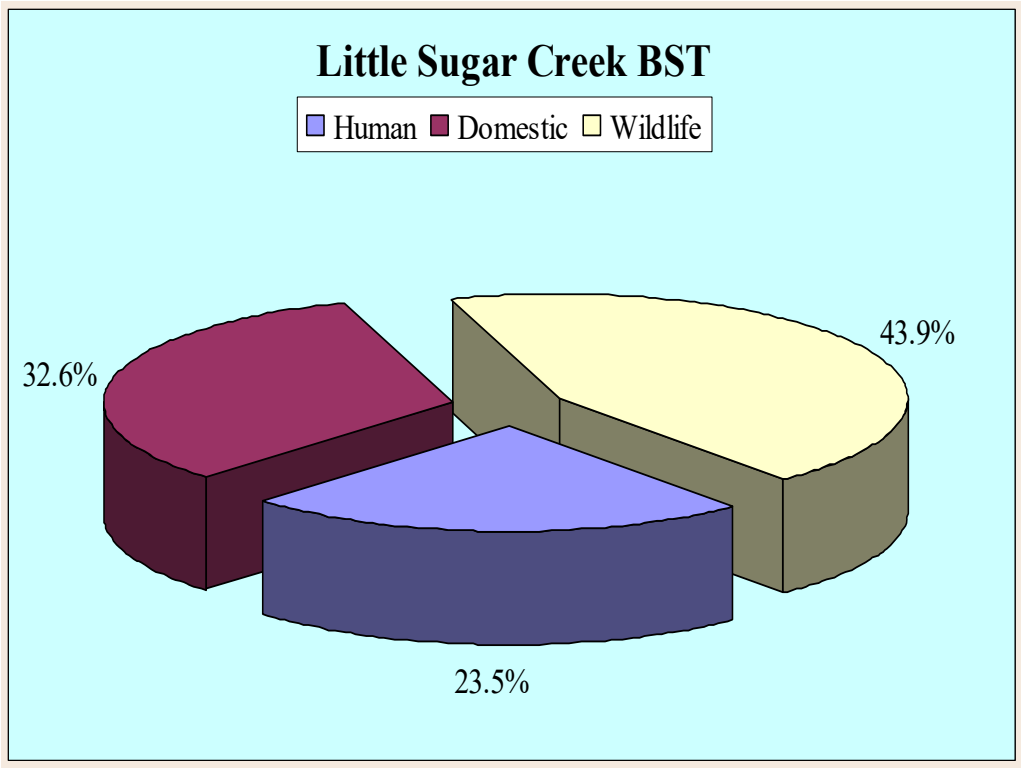
TMDL Development and Implementation in

North Carolina Piedmont and Coastal Plain Watersheds



2005 Source Tracking Study

- Antibiotic Resistance Analysis (ARA)
- Develop library of known fecal sources
- Isolate colonies
- Subject “isolates” to antibiotics
- Identify source-related patterns
- Compare to patterns in water samples



Library-Dependent Methods

Challenges & Limitations

- Time & investment required for library development
- Geographic variability
- Traits that are assayed show considerable overlap among species
- High rate of false positives
- Pie charts inaccurate

Stewart Creek, 2013-2014

- Flooding
- High Fecal
- Equity concerns
- Stewart Creek Environmental Association
- Does the City or County care?
- What are they going to do about this?

Where is it coming from?

- Is it human or just pet waste?
- New Molecular Source Tracking Methods
  - Species specific molecular biomarkers
  - Biomarker quantification
  - No library needed
  - Less geographic variability

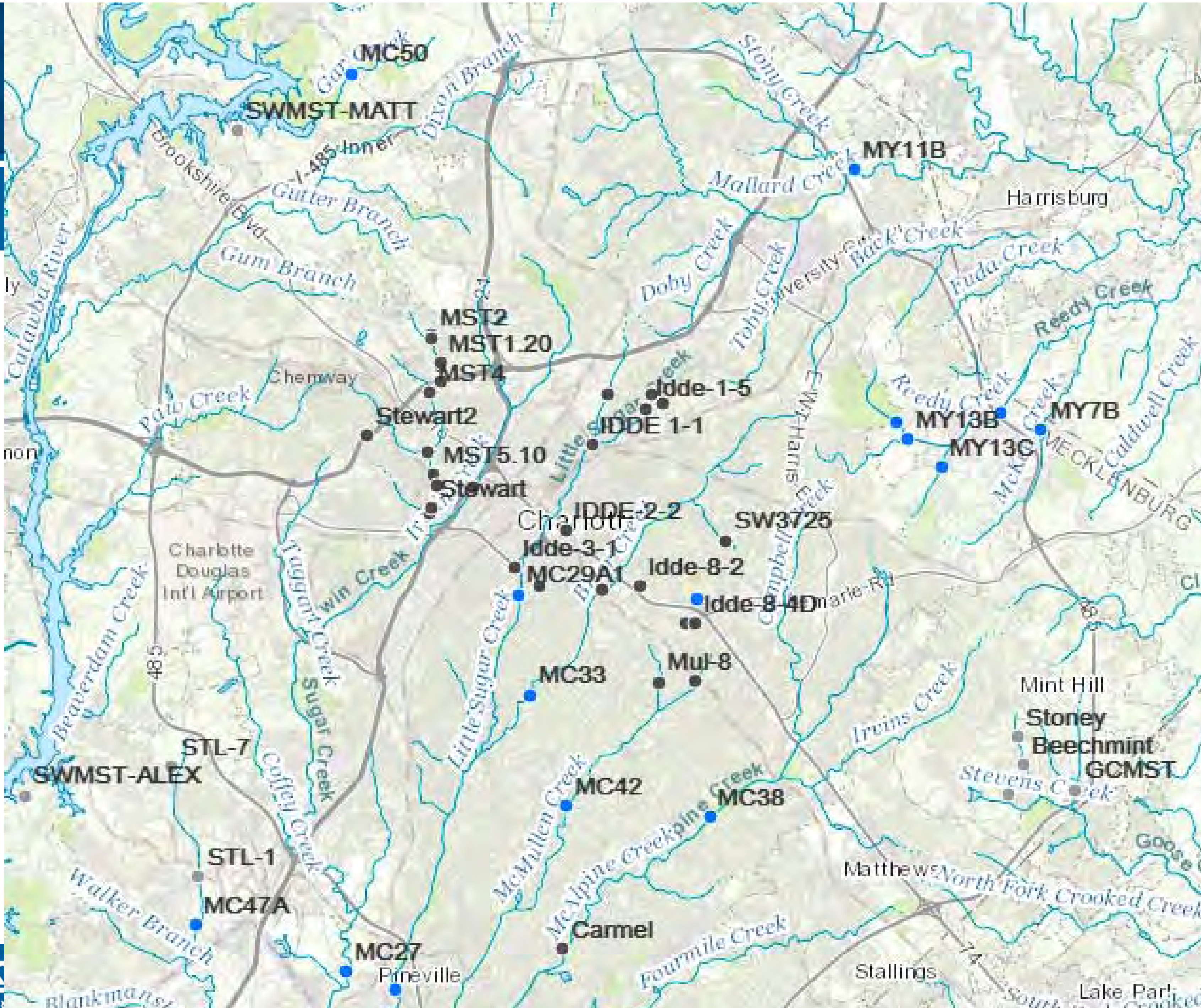
MST monitoring 2014-2017

- Fecal, E. coli, and Enterococcus collected alongside MST samples
- Stewart Creek
- Stream walks (samples >1,000 CFU/100mL)
- Fixed interval sites with high fecal numbers
- IDDE sites with high fecal
- Watersheds with fecal TMDL

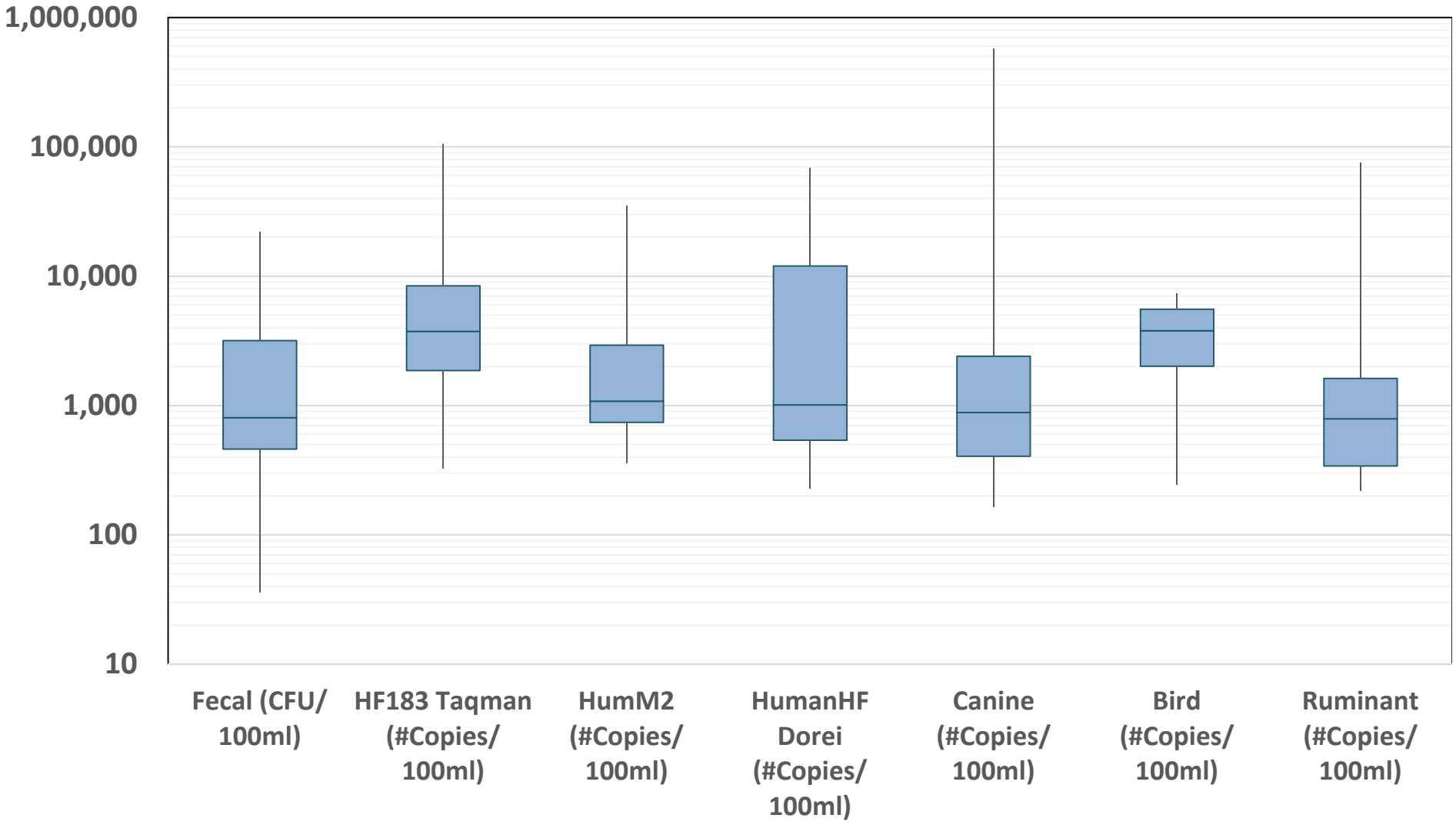
MST monitoring

- 57 sites sampled
- Storm & ambient
  - Stewart Creek
  - Reedy Creek
- Ambient only
  - TMDL
  - FIM
  - IDDE

- Most sites sampled only once/condition (screening)
- Biomarkers - Human, canine, bird, ruminant, beaver


MC50
SWMST-MATT
MY11B
Harrisburg
Mallard Creek
Stony Creek
Dixon Branch
Brookshire Blvd
I-485 Inner
Gutter Branch
Gum Branch
Catawba River
Doby Creek
Toby Creek
Back Creek
Rocky River
Reedy Creek
MST2
MST1.20
MST4
Chemway
Paw Creek
Stewart2
Idde-1-5
IDDE 1-1
MY13B
MY7B
MY13C
MST5.10
Stewart
Little Sugar Creek
Irwin Creek
Charlotte
IDDE-2-2
SW3725
MECKLENBURG
Caldwell Creek
Charlotte Douglas Int'l Airport
Idde-3-1
MC29A1
Idde-8-2
Idde-8-4D
Campbell Creek
Taggart Creek
Twin Creek
Beaverdam Creek
485
Mul-8
MC33
Mint Hill
Stoney
Beechmint
GCMST
Irvins Creek
Sugar Creek
Coffey Creek
STL-7
SWMST-ALEX
MC42
MC38
McMullen Creek
McAlpine Creek
Stevens Creek
Goose Creek
STL-1
Walker Branch
MC47A
Matthews
North Fork Crooked Creek
Carmel
MC27
Pineville
Fourmile Creek
Stallings
Lake Park
South Fork Crooked Creek

Fecal Coliform & Biomarker Ranges All Data



Human Biomarkers

- 2014 – HF183 & HumM2
- 2015 – HF183 only
- 2016 & 2017 – HF Dorei

	Site	Date	Fecal (CFU/ 100ml)	HF183 Taqman (#Copies/ 100ml)	HumM2 (#Copies/ 100ml)
Ambient	MST3	1/2/2014	450	10,900	4,060
	MST5	1/2/2014	160	2,160	740
	MST6	1/2/2014	200	665	780
	MST7	1/2/2014	160	10,500	2,150
	MST8	1/2/2014	1,500	95,300	35,300
	MST9	1/2/2014	150	11,300	2,930
	MST10	1/2/2014	520	673	-
Storm	MST3	1/10/2014	3,000	6,220	2,810
	MST5	1/10/2014	1,200	5,180	728
	MST6	1/10/2014	2,700	trace	618
	MST7	1/10/2014	2,000	2,570	1,040
	MST8	1/10/2014	3,800	56,500	12,500
	MST9	1/10/2014	940	4,410	1,080
	MST10	1/10/2014	3,700	1,020	357

HF183 routinely 3 times HumM2

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HF183 routinely 3 times HumM2

	Site	Fecal (CFU/ 100ml)	HF183 Taqman (#Copies/ 100ml)	Canine (#Copies/ 100ml)	Bird (#Copies/ 100ml)
Ambient	MST3	450	10,900	ND	ND
	MST5	160	2,160	ND	ND
	MST6	200	665	359	ND
	MST7	160	10,500	ND	ND
	MST8	1,500	95,300	ND	ND
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Fecal Coliform increases during wet weather but human biomarker decreases and no other biomarkers are detected.

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Makes sense

	Site	Fecal (CFU/ 100ml)	HF183 Taqman (#Copies/ 100ml)	Canine (#Copies/ 100ml)	Bird (#Copies/ 100ml)
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	MST9	940	4,410	ND	ND
	MST10	3,700	1,020	ND	ND

Low fecal during dry but several biomarkers detected. During wet, fecal increases but no biomarkers were detected.

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	MST9	940	4,410	ND	ND
	MST10	3,700	1,020	ND	ND

Fecal higher in wet compared to dry, human higher in dry vs wet, no other biomarker contributions.

Non-human data examples

Site	Date	Fecal (CFU/ 100ml)	HumanHF Dorei (#Copies/ 100ml)	Canine (#Copies/ 100ml)	Bird (#Copies/ 100ml)
Fairington	6/28/2017	10,800	228	6,010	trace

Site	Date	Fecal (CFU/ 100ml)	HumanHF Dorei (#Copies/ 100ml)	Canine (#Copies/ 100ml)	Ruminant (#Copies/ 100ml)
MC50	5/25/2016	1,000	trace	trace	1,530

Summary of Results

	HF183 Taqman	HumM2	HumanHF Dorei	Canine	Bird	Ruminant	Beaver
Total samples	67	22	29	82	84	59	29
% not detected	18%	41%	10%	32%	55%	63%	62%
% trace	6%	0%	34%	27%	43%	15%	28%
Total % quantified	76%	59%	55%	41%	2%	22%	10%
Max (#Copies/100mL)	106,000	35,300	68,300	573,000	7,320	75,100	3,180
Avg (#Copies/100mL)	8,840	2,959	11,175	11,301	158	1,802	295

Summary of Results

	HF183 Taqman	HumM2	HumanHF Dorei	Canine	Bird	Ruminant	Beaver
Total samples	67	22	29	82	84	59	29
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Total % quantified	76%	59%	55%	41%	2%	22%	10%
Max (#Copies/100mL)	106,000	35,300	68,300	573,000	7,320	75,100	3,180
Mean (#Copies/100mL)	8,840	2,959	11,175	11,301	158	1,802	295

Actions taken

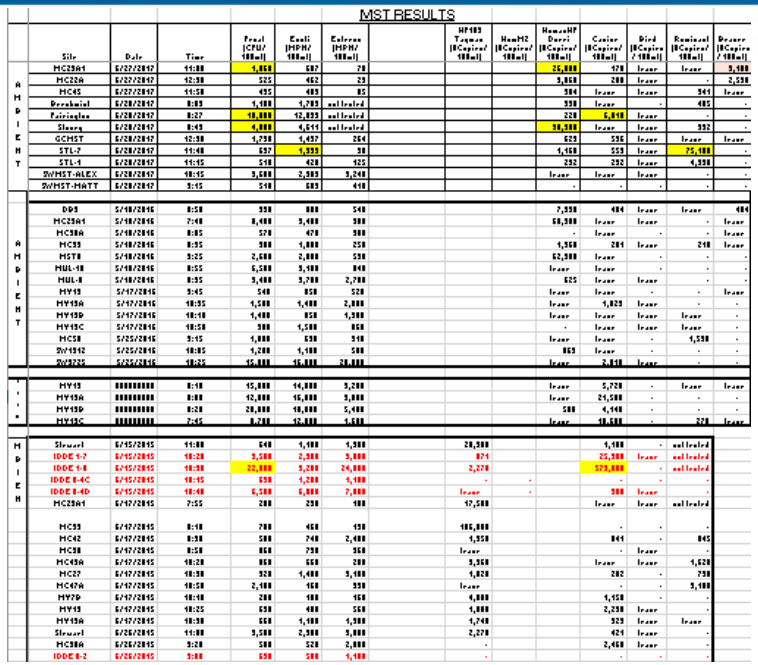
- Stewart Creek
  - Human influence was demonstrated
  - Fecal and HF183 used to prioritize sewer investigations
  - Pet waste information targeted to areas with high canine biomarkers

Questions

- Significance of different human biomarkers?
- Trace?
- Relationship between biomarkers & FIB #?
- What can we conclude so far?
- How should we proceed with future monitoring?

Review of data by expert

- All MST data
- FIB
- pH
- Turbidity
- Rainfall
- Temperature
- Monitoring location descriptions
- Map



Sensitivity & Specificity

- Sensitivity - likelihood of biomarker X being detected in fecal samples from species X

- Specificity/Cross reactivity - likelihood of detecting biomarker X in fecal samples from species Y or Z

Sensitivity & Specificity

- HF183 – very sensitive and specific
- DogBac – low sensitivity and specificity
  - Detected in deer, human, and goose feces
- Rum2Bac – low sensitivity and specificity
  - Detected in bird, human, and dog feces

Main observation

- HF183 results are dependable and indicate significant human contributions at multiple locations

Limitations

- Inadequate information from the lab
  - Couldn't interpret "trace"
  - Unclear why different human biomarkers were used
  - Insufficient assessment of sensitivity and specificity
- Low number of samples per location and condition

Recommendations

- Focus on human sources – most closely related to human illness
  - HF183
  - Other methods – viral
- Collect at least 10 wet & 10 dry samples per location
- Non-human biomarkers – avoid or test for sensitivity and specificity using 10 fecal samples each for human, dog, ruminant, bird

Lessons Learned

- New and experimental monitoring – involve experts who can help develop monitoring plan and interpret results
- Up front - try to understand meaning of results and how to interpret
  - What is high?
  - What is trace?
  - What is good vs bad?
- Understand strengths and weaknesses

Fecal Coliform Next Steps?

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It  s!

Next Steps

- Future use of MST TBD
- Charlotte Water lab biomarker development
- Follow development of the science as biomarkers improve and new methods are developed

Questions?

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