PURPOSE
AND APPLICATION
OF THE
DECISION SUPPORT TOOL

Why is a decision-support tool needed to help with fecal coliform BMAPs ?

- Florida currently has water quality criteria for fecal coliforms (e.g., no more than 10% of samples should exceed 400 CFU/100 mL), and is developing TMDLs and BMAPs for WBIDs that aren't meeting those criteria
- Coliform bacteria have been used as indicators of potential fecal contamination of water since the late 1800s. (Originally for detecting contamination of water by untreated or minimally-treated sewage.)
- In tropical and sub-tropical areas, fecal coliforms and other bacterial indicators can grow in soils and on vegetation, producing "false-positive" criterion exceedances that aren't correlated with elevated human health risk
- They can also produce "false-negative" results – e.g., pathogenic viruses and protozoa (*Giardia* or *Cryptosporidium*) can survive longer than fecal coliforms in surface waters, producing human health risk without elevated indicator levels

How does this tool help ?

- Provides a framework for interpreting and responding to concentrations of fecal coliforms and other indicators observed in ambient monitoring programs
- Helps managers prioritize WBIDs and areas within WBIDs for investigation and follow-up action
- Based on conceptual approaches currently used by the World Health Organization (WHO 2003) and recommended by the National Research Council (NRC 2004)
- For communicating results to elected officials and the public, allows the use of a simple “stoplight” (green/yellow/red) graphical approach, similar to one used in Tampa Bay area to provide annual tracking of water quality conditions and attainment of water quality goals

How should managers address technical limitations of fecal coliforms and other bacterial indicators, and protect public health?

- WHO (2000, 2003) recommends use of “Annapolis protocol”, which combines bacterial indicator counts with on-site assessments of potential pathogen sources

- NRC (2004) recommends Annapolis protocol and a “phased monitoring approach” to help identify and address pathogen sources

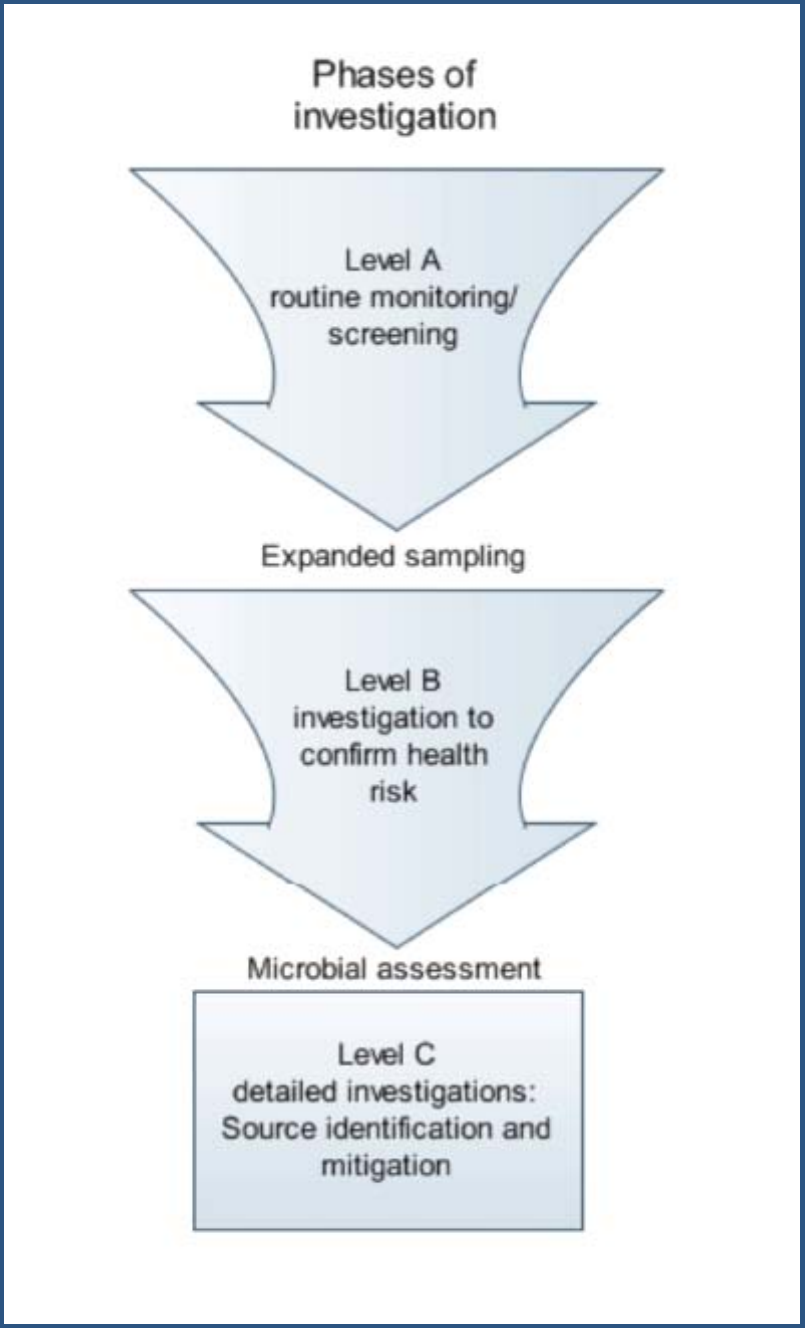
“Annapolis protocol” (WHO 2003) conceptual overview

Bacterial Indicator Concentrations
(based on monitoring data)

Estimated Health Risk

Phased monitoring approach

Recommended by NRC (2004) to help maximize cost-effectiveness of microbial monitoring and MST



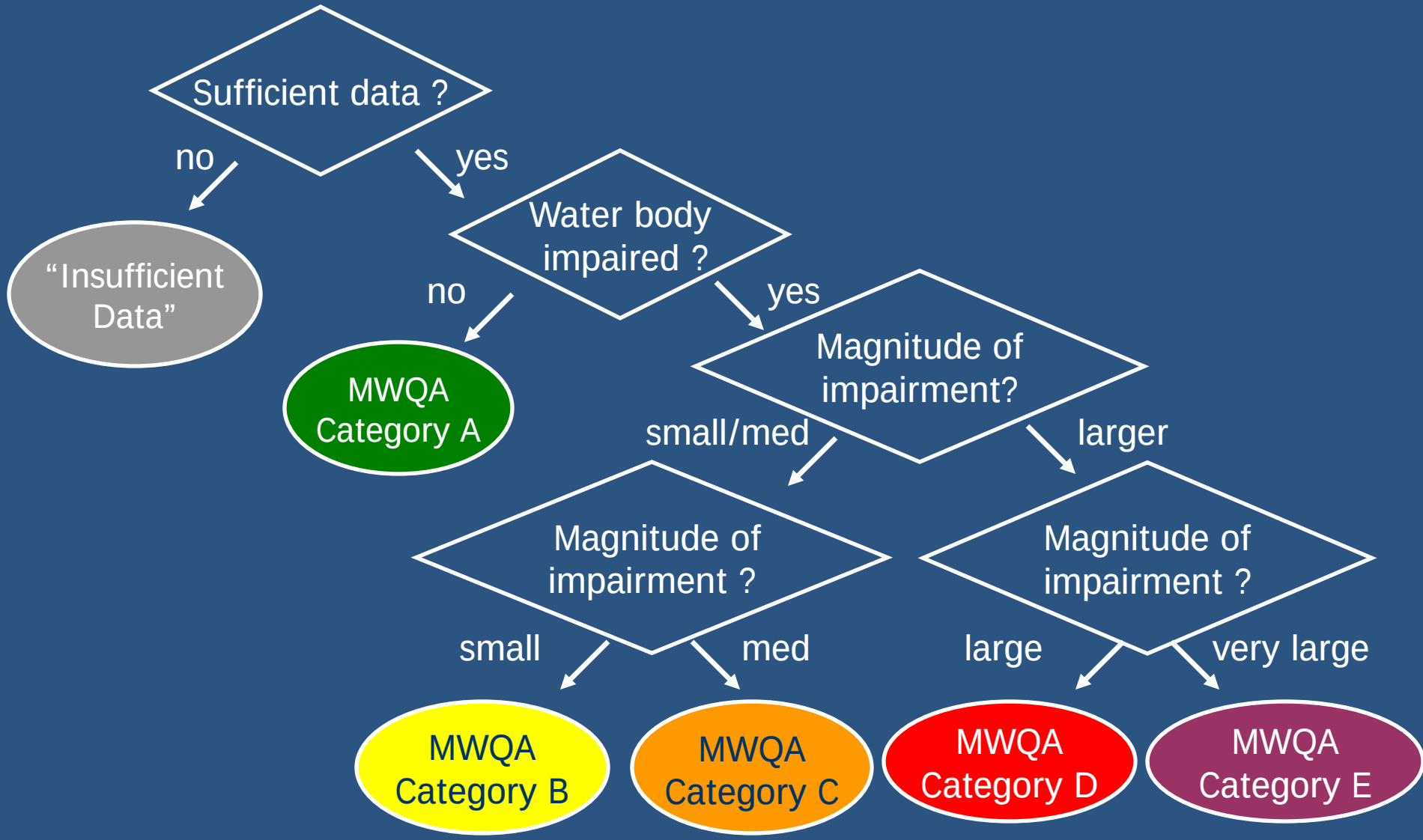
How to incorporate these ideas into fecal coliform TMDLs and BMAPs ?

- Use monitoring data (e.g., fecal coliform concentrations) as a screening tool, to help identify and prioritize sites for management attention
- Use information from “contaminant source surveys” (CSS) to supplement the bacterial data
- Use “Annapolis protocol” approach to combine the information and guide management responses

Step 1

- Characterize microbial water quality conditions within each WBID, based on fecal coliform concentrations observed in the available monitoring data

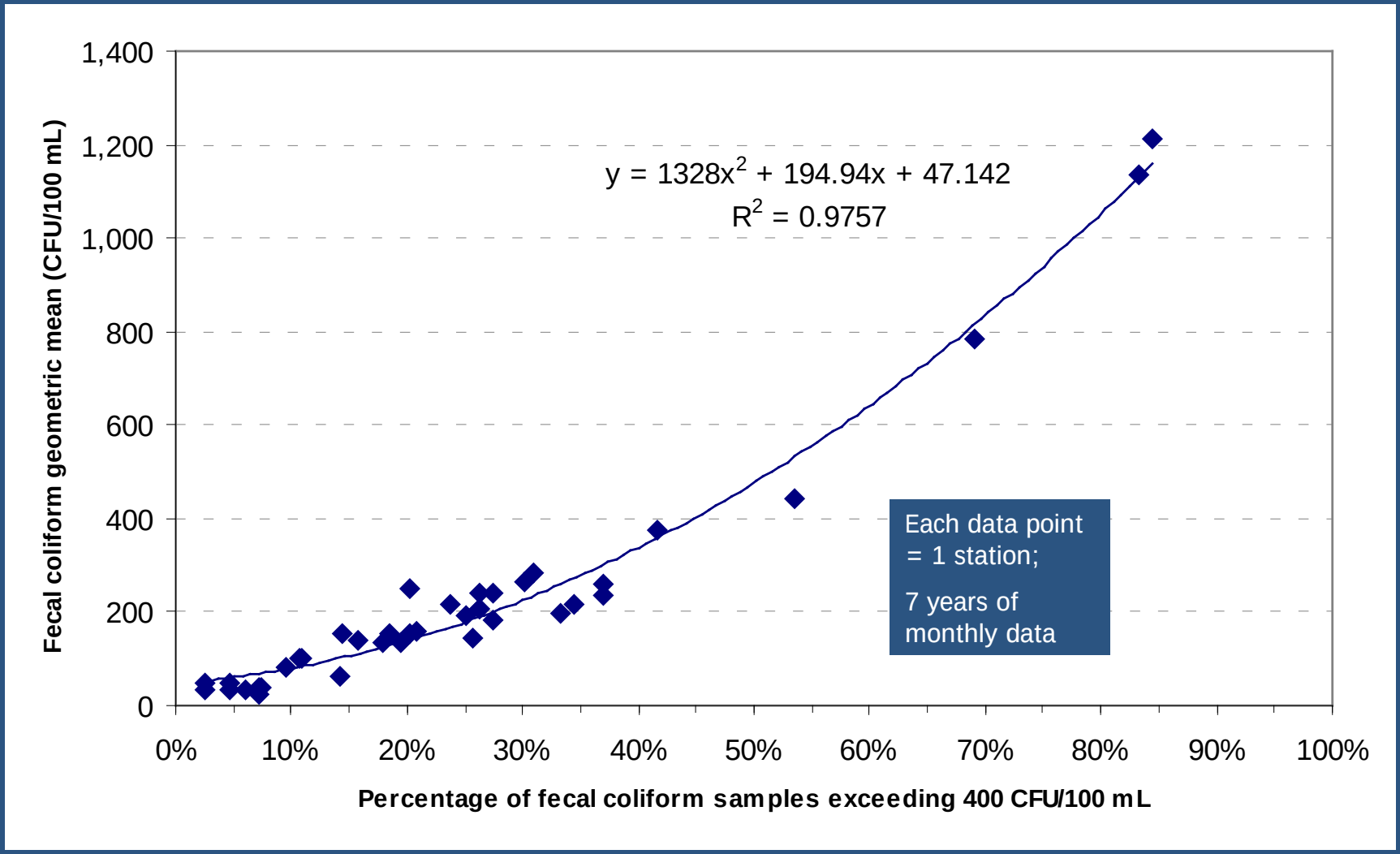
Decision Tree to Define Microbial Water Quality Assessment (MWQA) Categories Using Fecal Coliform Data)



How to Make the Decision Tree Quantitative ?

- Incorporate potential human health risk
- Incorporate information on frequency of exceedances of State water quality criterion (400 CFU/100 mL)
- Incorporate binomial test used by Florida DEP to determine statistical significance of criterion exceedances

Geometric mean fecal coliform counts vs. exceedances of 400 CFU criterion (EPC data)



Geometric mean enterococci counts vs. exceedances of 400 CFU criterion (EPC data)

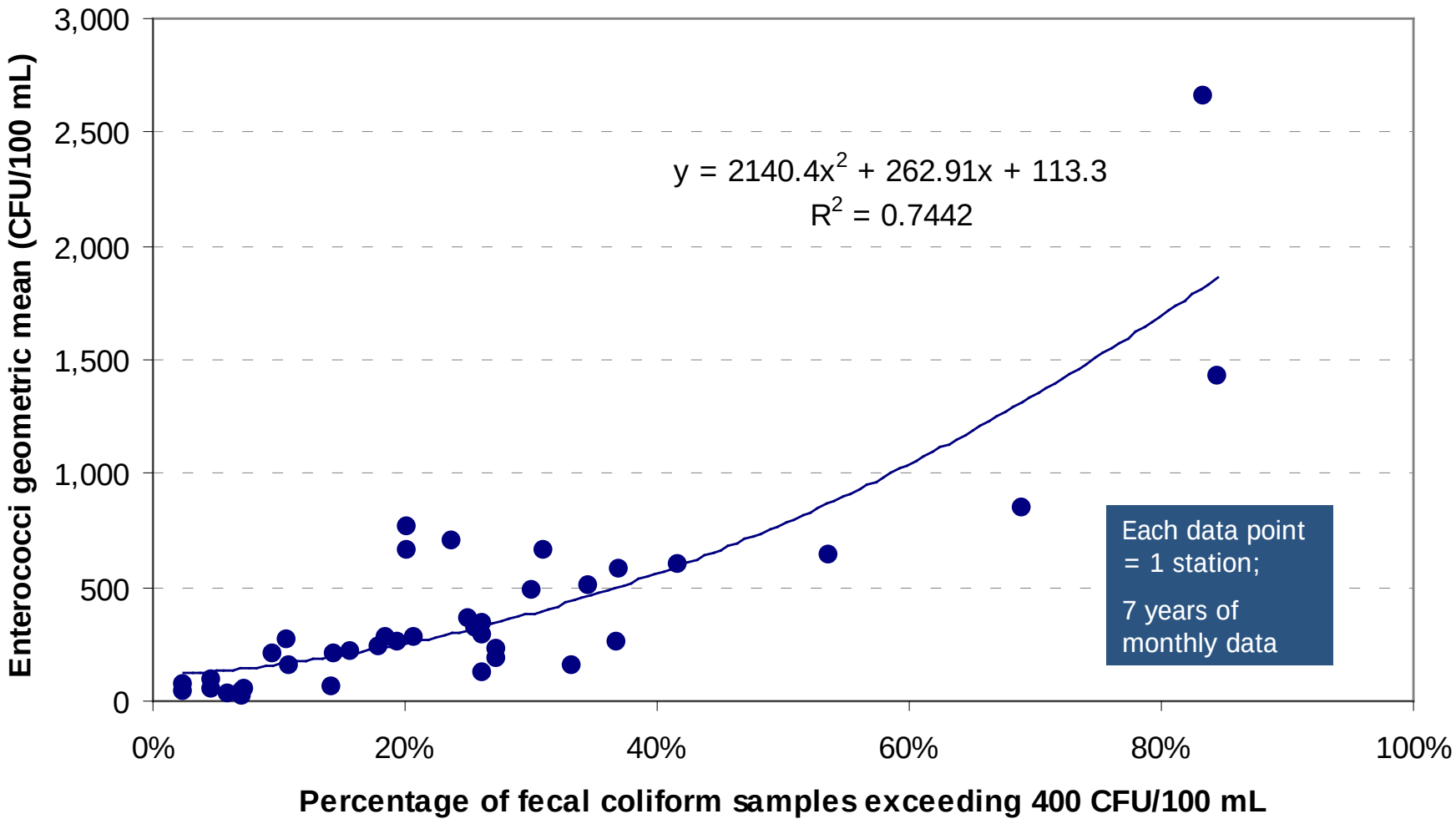
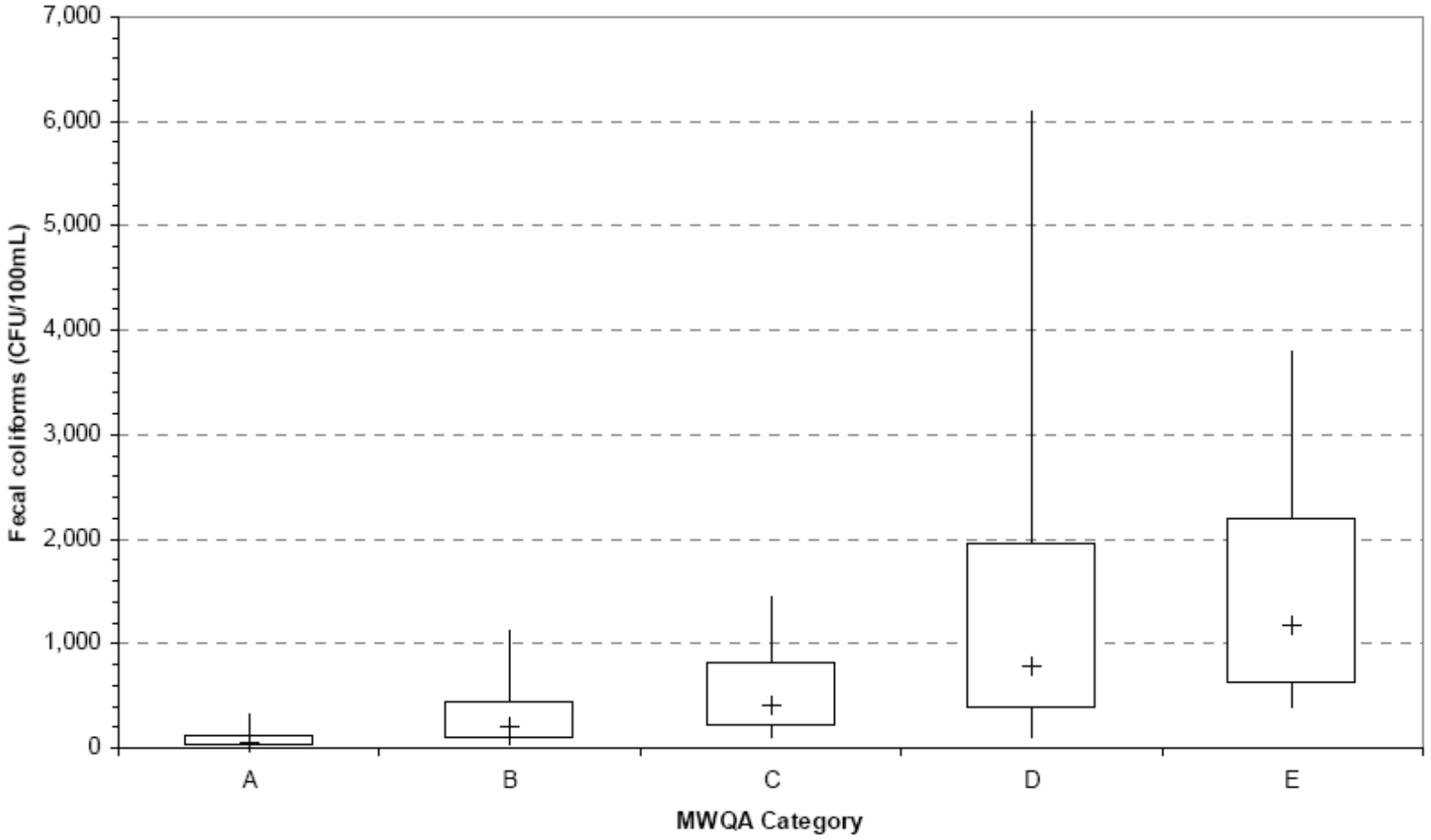


Table 6. Proposed microbial water quality assessment (MWQA) categories, based on the percentage of samples exceeding the State's 400 CFU/100 mL fecal coliform criterion. "Break points" separating the MWQA categories are at exceedance frequencies of 10%, 30%, 50% and 75%.

MWQA Category	Break Point (percentage of samples exceeding the 400 CFU/100 mL fecal coliform criterion)	Range of exceedance frequencies (percentage of samples exceeding the 400 CFU/100 mL fecal coliform criterion) included in category
A	≤ 10%	0% to 10%
B	> 10%	>10% to 30%
C	> 30%	>30% to 50%
D	> 50%	>50% to 75%
E	> 75%	>75% to 100%

fecal coliform concentrations in MWQA categories A through E
(EPC data, 2001 - 2007)



enterococci concentrations in MWQA categories A through E
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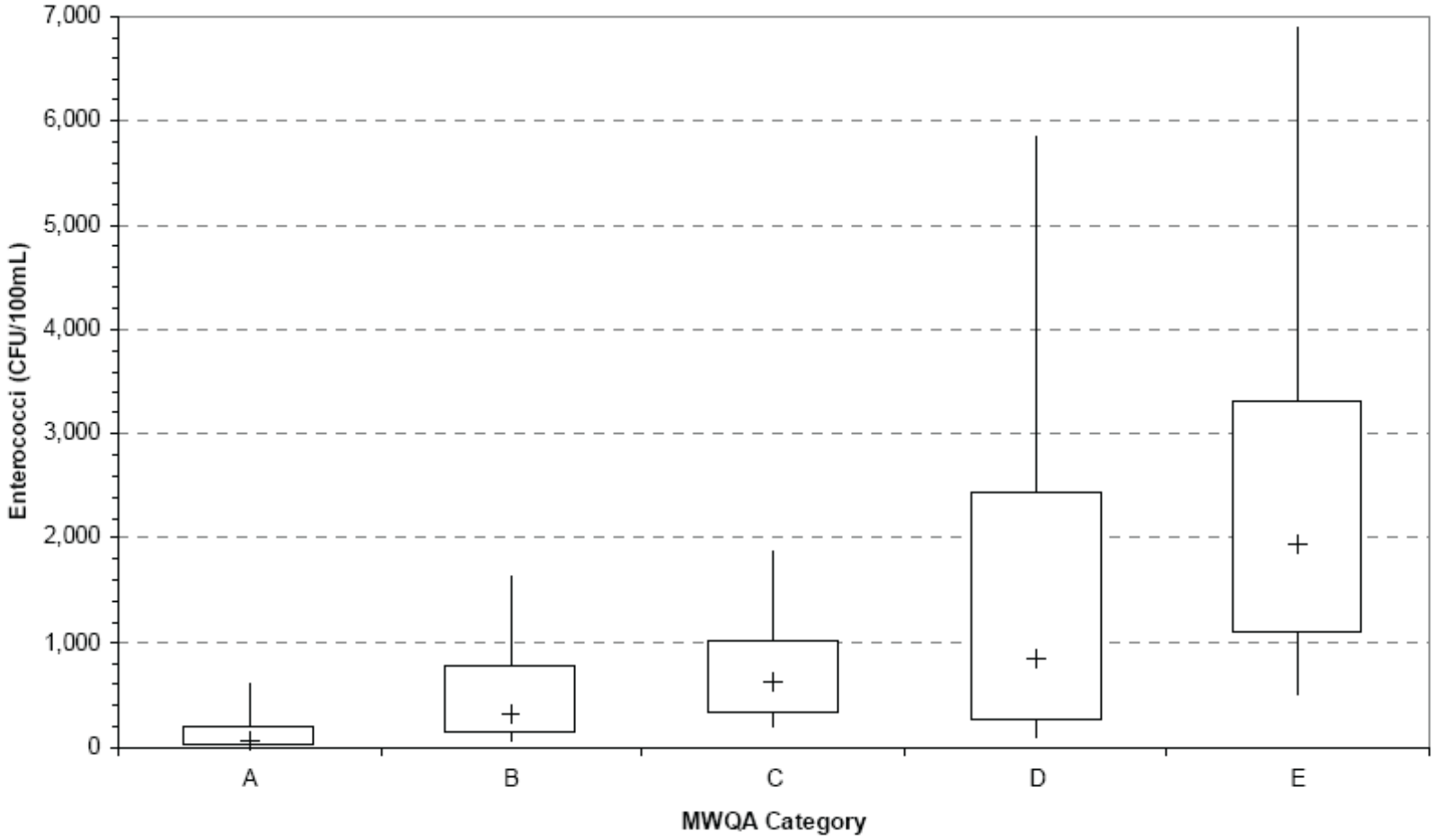


Bacteria levels and potential human health risk

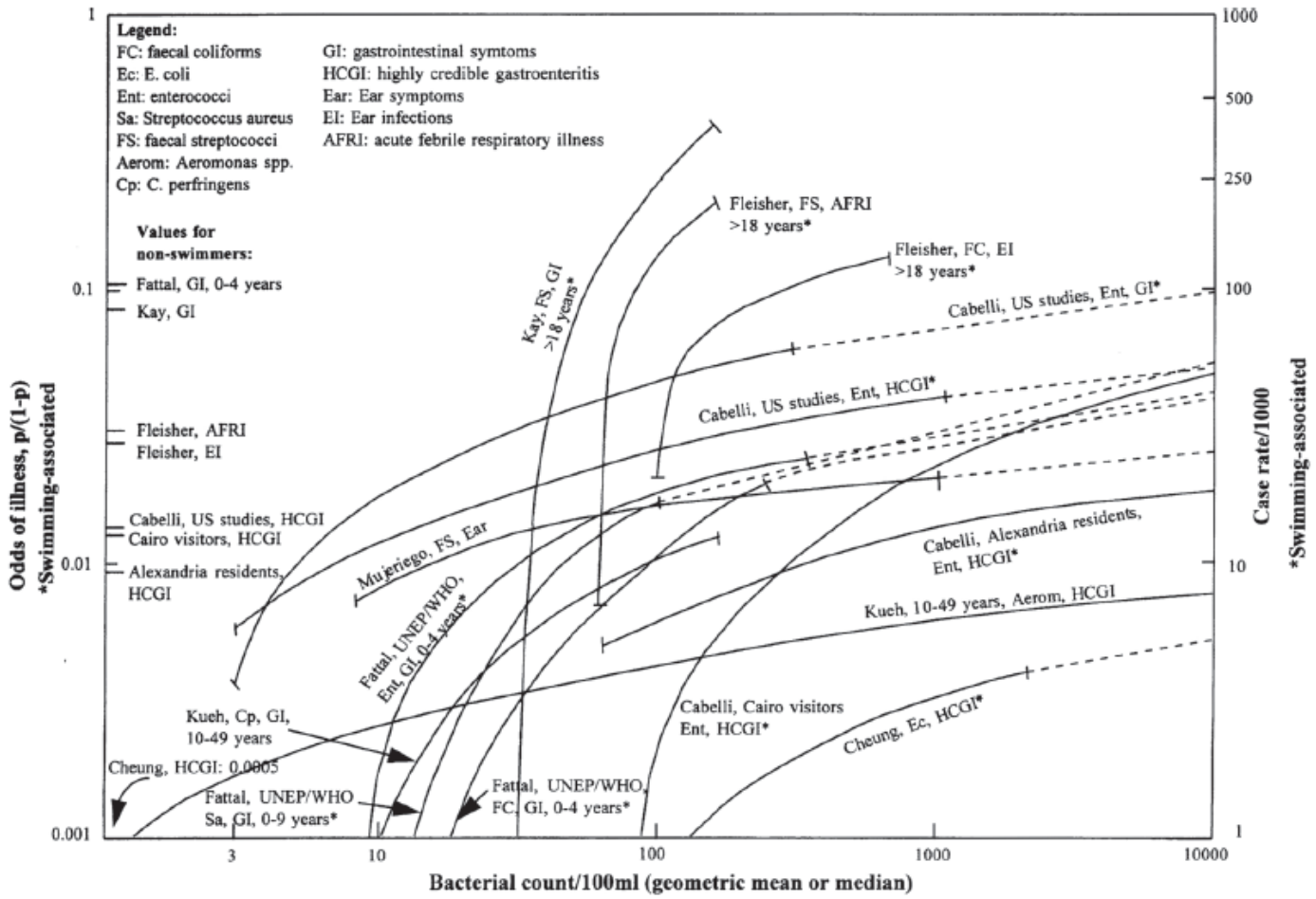
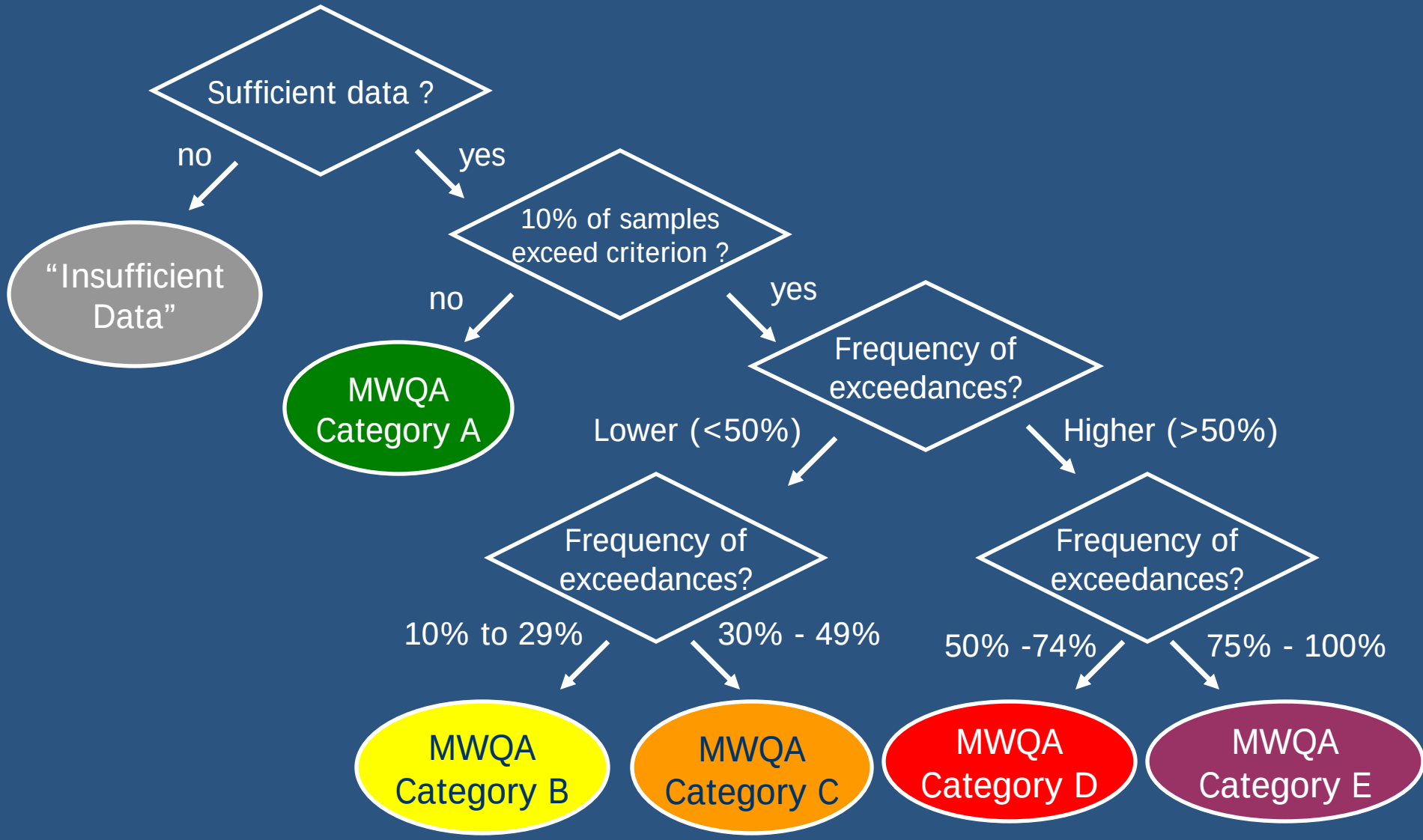


FIGURE 2-2 Relationships of risks of illness in swimmers to the microbial quality of water—fresh recreational waters. Note: Solid lines indicate actual data from original studies whereas dashed lines are extrapolations of data by Prüss (1998) or Pike (1991). SOURCE: Reprinted, with permission, from Prüss, 1998 © Oxford University Press.

Decision Tree to Define Microbial Water Quality Assessment (MWQA) Categories Based on Exceedances of 400 CFU/100 mL Fecal Coliform Criterion



Step 2

- Add information from contaminant source surveys (CSS) and, when available, MST
- Classify sites based on the likelihood of fecal contamination that would pose human health risks, using CSS assessment categories and MST data

CSS assessment categories (likelihood of fecal contamination posing human health risks)

- **Very Low**: No visual evidence of potential sources of human pathogens; natural environment; no or minimal anthropogenic land uses; wildlife present (any density)
- **Low**: Low density agricultural and residential sources, including pets, livestock (without direct access to surface waters), or poultry operations; residences on septic systems
- **Moderate**: Urban stormwater sources (including pet waste) present; well-functioning wastewater infrastructure (both sewer and septic); episodic/low volume sanitary sewer overflows (SSOs) reaching surface waters; moderate-density livestock with little direct access to surface waters; Class A residual and/or septage spreading areas may be present
- **High**: Major stormwater outfalls present; history of failing wastewater infrastructure (central sewer or onsite systems); episodic or chronic/high volume SSOs reaching surface waters; concentrated livestock without direct access to surface waters; residual/septage spreading (Class B)
- **Very High**: Current failing wastewater infrastructure; chronic/high volume SSOs reaching surface waters; concentrated livestock with direct access to surface waters; evidence of direct sewage inputs (e.g., confirmed illicit discharges)

Classification matrix ("Annapolis protocol") approach

		MWQA group (based on binomial assessment of frequency of 400 CFU/100 mL fecal coliform exceedances)					
		A (≤ 10%)	B (>10% - 30%)	C (>30% - 50%)	D (>50% - 75%)	E (>75%)	Exceptional Circumstances (e.g., sewer line break) [c]
Contaminant source survey (CSS) assessment category (likelihood of fecal contamination posing human health risks)	1. Very Low	A1	B1	C1[a]	D1[a]	E1[a]	Immediate Action
	2. Low	A2[b]	B2	C2	D2[a]	E2[a]	
	3. Moderate	A3[b]	B3	C3	D3	E3	
	4. High	A4[b]	B4[b]	C4	D4	E4	
	5. Very High	A5[b]	B5[b]	C5[b]	D5	E5	
	Exceptional Circumstances (e.g., sewer line break) [c]	Immediate Action					

Notes:

a) These outcomes imply that the CSS may be providing an overly optimistic rating of water quality, or the fecal coliform sources in the area may be relatively low-risk or primarily environmental (e.g., wildlife, sediments, soils, vegetation), and the cause(s) of the discrepancy should be verified.

b) These outcomes imply that the fecal coliform indicator may be providing an overly optimistic MWQA rating, or the CSS may be providing an overly negative assessment, and the cause(s) of the discrepancy should be verified.

c) As explained by WHO (2003), exceptional circumstances involve acute situations known to be associated with higher public health risks, such as sewer line breaks and other SSOs that contaminate surface waters, which require immediate remedial action.

Phased CSS Investigation Levels

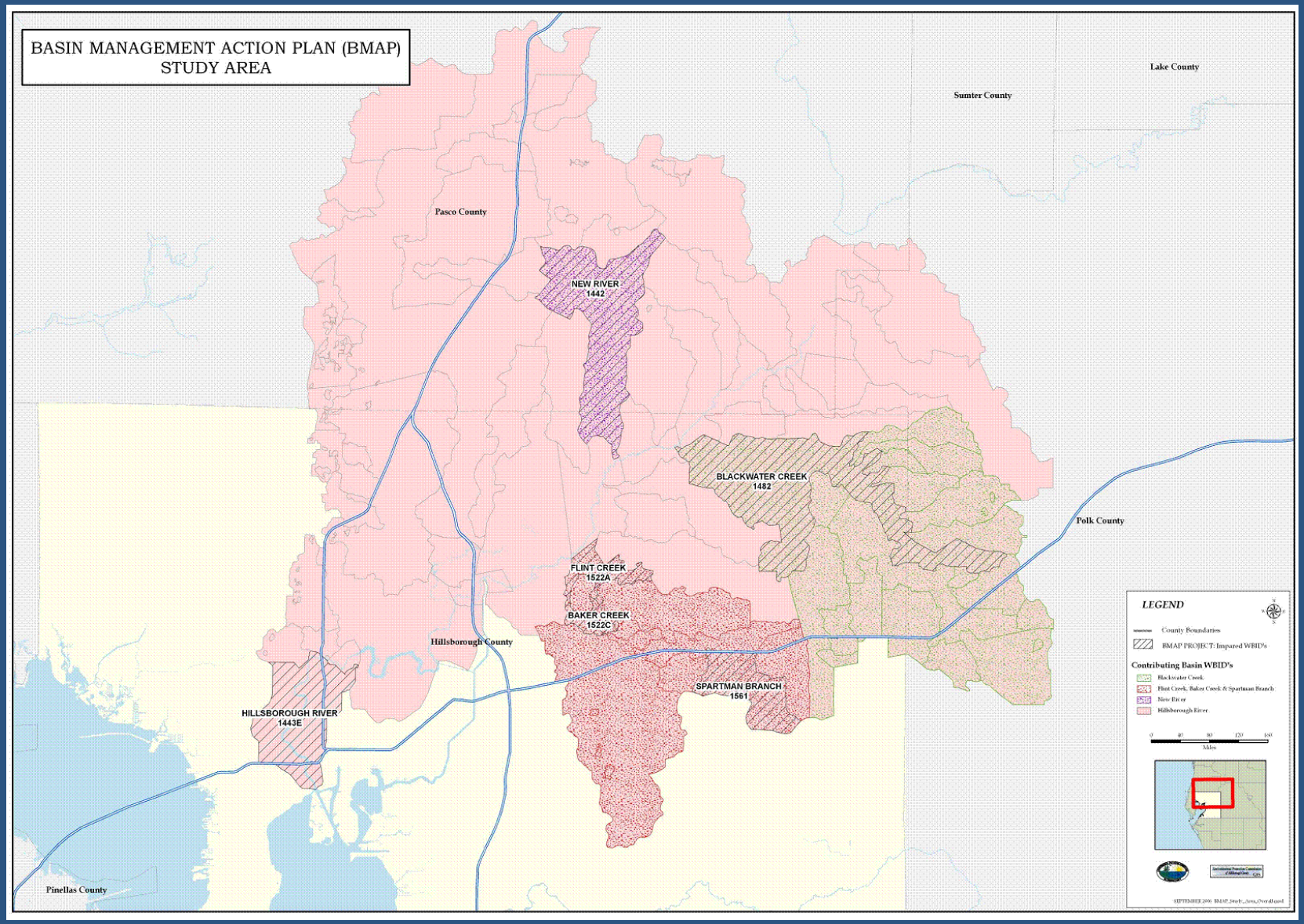
- **Phase 1** – basic (screening-level) water quality and land use analyses, and boots-on-the-ground source evaluation. (Applied automatically to MWQA Group B, and to Group A if needed.)
- **Phase 2** – adds more intensive indicator monitoring and CSS. (Applied automatically to MWQA Group C, and to Group A or B if needed.)
- **Phase 3** – adds appropriate source tracking (MST) tools, as necessary. (Applied automatically to MWQA groups D and E, and to others if needed.)

Track and report outcomes annually to the public and elected officials (using the color-coded classification matrix)

Allows water quality conditions to be tracked over time and across monitoring locations

	Monitoring Location			
Year	1	2	3	4
2004	D4	A1	B1	C3
2005	C4	B1	B1	C3
2006	D4	B1	C1	B3
2007	C3	A1	B1	B2
2008	C3	A1	A1	B2

An application to 6 pilot WBIDs
(In the Hillsborough River portion of the Tampa Bay watershed)



Using the classification matrix to prioritize WBIDs (and sites within WBIDs) for management action

				Human Fecal MST Markers		Ruminant Fecal MST Marker	
Sub-Basin	WBID	Monitoring Location	Classi-fication Matrix Outcome	No. Sampling Dates	% Dates Marker(s) Detected	No. Sampling Dates	% Dates Marker Detected
Lower Hillsborough River	1443E	DHR4A	D5	5	100 %	5	20 %
		HR3	D4	5	80 %	5	20 %
		DHR5	D4	2	50 %	2	0 %
		DHR8	D3	4	50 %	4	0 %
		HR2	C4	3	67 %	3	0 %
		HR4	C4	3	67 %	3	0 %
		DHR7	C3	5	60 %	5	60 %
		DHR6	C3	3	33 %	3	0 %
		HR1 REF	B3	3	100 %	8	0 %
		HR5	B3	5	60 %	5	0 %
		DHR10	A4	1	100 %	1	0 %
Blackwater Creek	1482	BW3	D4	4	75 %	1	0 %
		BW2	D4	3	67 %	3	100 %
		DBW4	A3	1	100 %	1	0 %
		BW5A	A3	2	50 %	2	0 %
		BW1 REF	A2	7	43 %	6	17 %
Baker Creek	1552C	BK2	D3	6	67 %	6	67 %
		BK1	C3	7	57 %	7	29 %
		BK3	C2	2	50 %	2	0 %
		BK4	A4	1	100 %	1	0 %
		BK5	A3	2	100 %	2	0 %
Flint Creek	1552A	FL2	C2	6	50 %	6	0 %
		FL1	C2	5	20 %	5	0 %
		FL3	A3	6	33 %	6	0 %
Spartman Branch	1561	SB1	D3	6	17 %	6	0 %
		SB2	D2	5	20 %	6	0 %
		DSB3	C2	2	0 %	2	50 %
		SB3	B2	4	25 %	4	0 %
New River	1442	NR2	C3	7	29 %	7	29 %
		NR1	C2	2	0 %	2	50 %
		NR3	C2	2	0 %	2	50 %

Using the detailed CSS information to suggest management actions for specific sites within a WBID (LHR examples)

Sub-Basin	WBID	Monitoring Location	Classification Matrix Outcome	Fecal Source(s) of Concern	% of Sampling Dates Markers Detected	Most Probable Source Categories and Recommended Management Actions
Lower Hillsborough River	1443E	DHR4A	D5	Human	100 %	Septic and possibly sanitary sewer; confirm and address specific source locations and provide public outreach explaining potential presence of health risk at site
		HR3	D4	Human	80 %	Septic and sanitary sewer; confirm and address specific source locations and provide public outreach explaining potential presence of health risk at site
		DHR8	D4	Human	50 %	Multiple sources suspected; identify and address specific source locations; provide public outreach explaining potential presence of health risk at site
		DHR5	D3	Human	50 %	Multiple sources suspected; identify and address specific source locations; provide public outreach explaining potential presence of health risk at site
		HR2	C4	Human	67 %	Sanitary sewer and stormwater; identify and address specific source location(s)
		HR4	C4	Human	67 %	Sanitary sewer and stormwater; identify and address specific source location(s)
		DHR7	C3	Human	60 %	Multiple sources suspected; identify and address specific source locations
		DHR6	C3	Human	33 %	Unknown; identify and address specific source location(s)
		HR1 REF	B3	Human	100 %	Homeless camp, sanitary sewer and possibly stormwater; confirm and address specific source locations
		HR5	B3	Human	60 %	Sanitary sewer; confirm and address specific source locations
		DHR10	A4	Human	100 %	Multiple sources suspected; identify and address specific source locations

This conceptual approach can also be used to prioritize sites for more intensive investigation, at a county-wide (or larger) scale...

Initial county-wide site prioritization

(using MWQA scores based on fecal coliform data from EPC of Hillsborough County monitoring stations; 2001-2007 data)

Location	Sta. No.	No. Samples (N)	% >400 CFU/ 100 mL ($\hat{P}$)	MWQA category	Geometric mean fecal coli. (CFU/ 100 mL)	Geometric mean enterococci (CFU/ 100 mL)
Turkey Creek at SR 60	111	77	84%	E	1,212.0	1,426.0
Bullfrog Creek at Symmes Rd	132	78	83%	E	1,134.8	2,658.9
Sweetwater Creek at Hillsborough Ave	104	84	69%	D	786.4	849.9
Delaney Creek at 36th Ave	138	84	54%	C	443.3	642.2
Delaney Creek at US 41	133	84	42%	C	376.7	596.8
Little Manatee River at CR 579	140	84	31%	B	283.6	664.9
English Creek at SR 60	154	83	30%	B	266.6	487.7
Mill Creek at I-4	149	81	37%	B	258.0	578.7
Little Manatee River at US 301	113	84	20%	B	250.8	664.0
Rocky Creek at Hillsborough Ave	103	84	26%	B	242.6	285.2
Hillsborough River at Sligh Ave	152	84	27%	B	239.8	182.8
Bullfrog Creek at US 41	144	84	37%	B	233.7	254.7
Little Manatee River at CR 674	129	84	24%	B	218.5	704.0
Baker Creek at Thonotosassa Rd	107	84	35%	B	216.5	508.7
Hillsborough River at Rowlett Pk	105	84	26%	B	208.7	127.7
Rocky Creek at Waters Ave	141	84	26%	B	205.8	343.4
Hillsborough River at Columbus Ave	137	84	33%	B	195.5	153.7
Flint Creek at US 301	148	84	25%	B	191.2	359.8
Double Branch Creek at Hillsborough Ave	101	84	27%	B	185.1	222.6
Blackwater Creek at SR 39	143	82	21%	B	156.9	284.2
Trout Creek at CR 581	145	65	18%	B	152.9	281.8
Sweetwater Creek at Anderson Rd	142	84	20%	B	152.2	764.8
Turkey Creek at Durant Rd	151	82	26%	B	142.0	322.6
Alafia River South Prong at Bethlehem Rd	139	83	16%	B	138.8	215.7
Alafia River at Bell Shoals Rd	114	84	18%	B	136.4	240.7
Cypress Creek at CR 581	120	72	19%	B	132.9	261.9
Alafia River at US 301	153	83	14%	A	152.7	209.7
Hillsborough River at US 301	108	83	11%	A	101.7	159.4
Alafia River North Prong ab confluence	115	84	11%	A	100.4	267.3
Alafia River South Prong ab confluence	116	84	10%	A	80.6	207.3
Channel A at Hillsborough Ave	102	84	14%	A	63.2	63.1
L. Thonotosassa at Flint Creek	118	82	2%	A	46.8	68.5
Hillsborough River at Fowler Ave	106	84	5%	A	46.6	96.4
TBC at Fowler Ave	146	82	7%	A	40.5	51.0
Palm River at US 41	109	84	7%	A	39.1	36.4
Little Manatee River at US 41	112	84	5%	A	34.6	55.1
L. Thonotosassa middle	135	82	2%	A	32.9	41.7
TBC at MLK Blvd	147	84	6%	A	31.9	31.0
Palm River at SR 60	110	84	7%	A	25.4	21.8

This is an initial application of the "Annapolis protocol" approach in Florida

Some issues not yet addressed are:

- How to deal with tidal / estuarine sites ?
  - *fecal coliform die-off in estuarine waters may affect site ratings in tidal streams and rivers*
  - *a different set of MWQA categories may be needed*
- How to deal with Class I and Class II waters ?
  - *different MWQA categories probably necessary*
  - *additional indicators (e.g., Crypto, Giardia) may also be needed*

Summary of support-tool application

- Within WBIDs, assign each long-term monitoring site to an MWQA category (A through E), based on exceedance frequency of the 400 CFU/100 mL fecal coliform criterion
- Also assign each site to an initial CSS category (1 through 5)
- Use classification matrix to prioritize WBIDs (and multiple sites within WBIDs, if applicable) for follow-up work, based on initial MWQA and CSS categories.
- Apply phased monitoring approach to identify potential hot spots within WBIDs and investigate their fecal contamination sources. Revise the initial MWQA and CSS categories, if necessary, based on results of this step.
- Correct fecal contamination sources that pose human health risk, as they are identified
- Continue monitoring, and provide annual report documenting changes in MWQA and CSS scores that occur over time in response to management actions

Benefits of the approach

- Can be used as a screening tool to prioritize bacterial impairments at the station and WBID levels, based on the level of impairment
  - Enables targeting of efforts to identify and address sources, resulting in a significant saving of time and money
- Uses a phased approach for identifying sources, based on the level of impairment and estimated likelihood of human health risk
  - Increases efficiency and effectiveness in identifying sources, resulting in a significant saving of time and money
- Encourages active stakeholder involvement in identifying potential sources
  - Helps to coordinate and leverage available resources in the identification of sources, and assist in building consensus on addressing sources
- Can be used to evaluate the “sufficiency of effort” of the projects identified in the BMAP to restore water quality
  - Helps ensure that projects identified in BMAP can be expected to address the impairment and in the most effective way
  - Helps reduce the possibility of 3rd party challenges to the BMAP

Thanks !

Questions ?

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Some additional reading…

- National Research Council (NRC). 2004. Indicators for waterborne pathogens. National Academy Press, Washington, DC
- Rose, J.B., and others. 2001. Healthy beaches Tampa Bay: Microbiological monitoring of water quality conditions and public health impacts. Tampa Bay Estuary Program Technical Report #03-01. TBEP. St. Petersburg, FL
- U.S. Environmental Protection Agency (U.S. EPA). 2007. Report of the experts scientific workshop on critical research needs for the development of new or revised recreational water criteria. EPA 823-R-07-006. Washington, DC
- World Health Organization (WHO). 2003. Guidelines for Safe Recreational Water Environments. Volume 1. Coastal and Fresh Waters. WHO, Geneva, Switzerland