GRDA's Bacteria Management Plan for Designated Swimming Areas in the Grand River Watershed

Background

Fecal Indicator Bacteria

Monitoring of fecal indicator bacteria (FIB) has long been used to protect users of recreational waters. Since the development of the *EPA's Ambient Water Quality Criteria for Bacteria* in 1986, the bacteria *E. coli* and enterococci have been monitored and used for Recreation Water Quality Criteria (RWQC) and Standards throughout the U.S. (including Oklahoma) because they are typically good predictors of gastrointestinal (GI) illness. These bacteria are usually not the cause of these GI illnesses, but rather are pathogen indicators because they "indicate the potential for human infectious disease."

Problem and need

Following reports of illness at Grand Lake State Park (formerly Bernice State Park) after Memorial Day weekend (2014) members of the GRDA Water Quality Research Lab responded by collecting and analyzing samples along the beach and swimming area. These samples indicated high levels of contamination for FIBs using chromogenic substrate tests (i.e., Colisure and Enterolert). Subsequently the beach was closed after thorough consultation with our fellow resource agencies.

Figure 1. Sampling locations at Grand Lake State Park.

Following these initial test results GRDA increased its monitoring efforts by sampling three sites along the beach (Figure 1) at least twice a week and at times daily samples were collected during periods in June and July (2014). Subsequently, *E. coli* levels fell below state Water Quality Standards (WQS; Table 1; see below) on 6/20/2014 and remained there throughout the rest of the recreational season (Figure 2). However, Enterococci values remained high throughout the summer (Figure 2) and exceeded WQS until 11/19/2014. Although WQS do not mandate the closure of beaches or swimming areas with fecal contamination, the beach remained closed throughout the remainder of the recreational season in accordance with recommendations from the ongoing consultation with state agency partners and out of an abundance of caution for health and public safety.

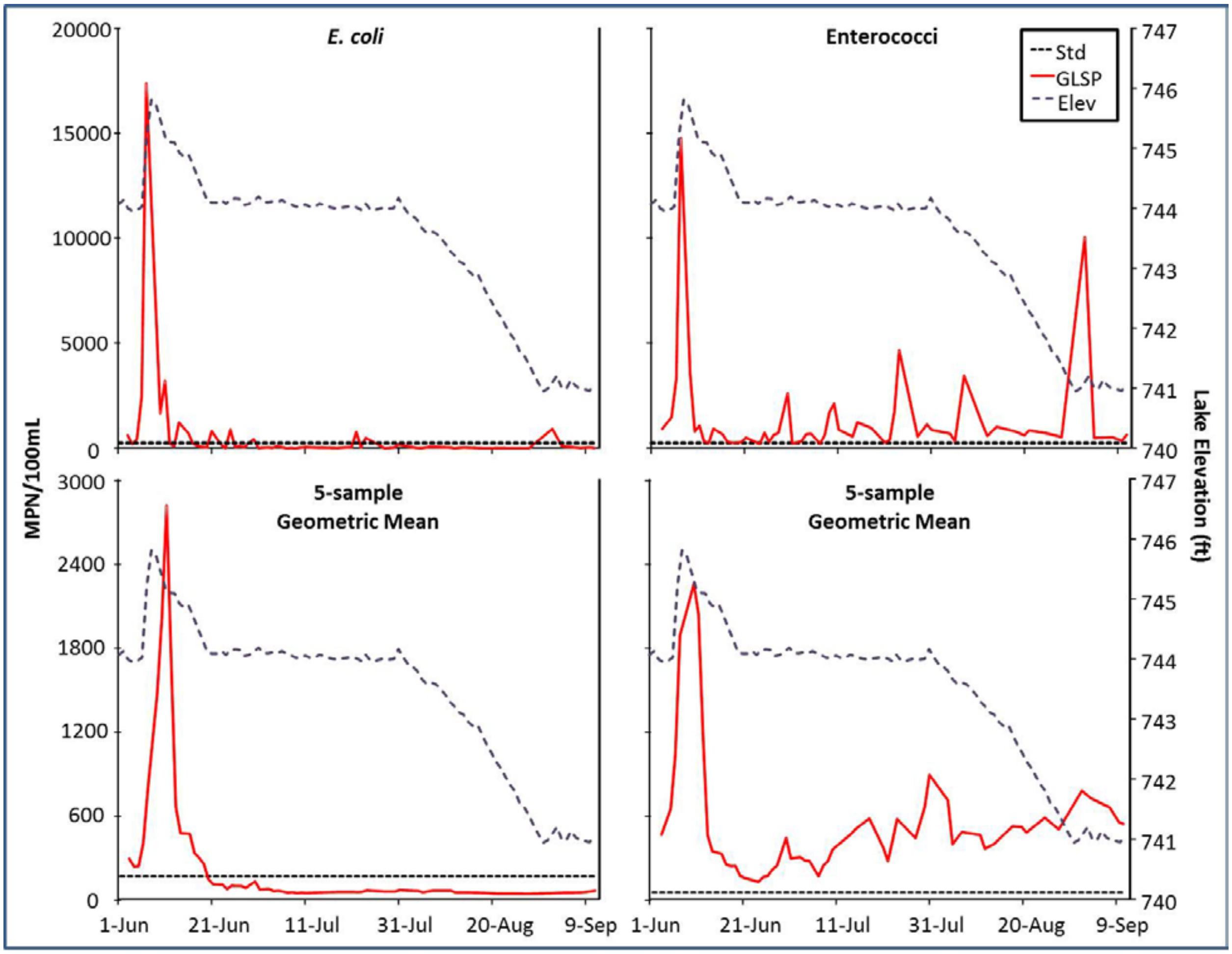


Figure 2. FIB data for samples taken from Grand Lake State Park during the Recreational season of 2014 (red line; GLSP). Lake elevation data are also shown (purple dashed line). The WQS are also included (black dashed line). The left hand column depicts *E. coli* data and the right hand column depicts Enterococci data. The top row depicts raw data and the bottom row depicts 5-sample geometric means. Both representations are included for means of comparison with the WQS listed in Table 1.

In an attempt to better understand the potential source of contamination and assess the risk to health and public safety, water was sampled on two dates in June (grab samples on 6/5/2014 from sites BSP2 and BSP3 and on 6/10/2014 from site BSP3) for genetic microbial source tracking (MST; samples were sent to Microbial Insights for analyses). MST in general is using the detection of different, more specific groups of indicator organisms or other more specific chemical or organic markers than typical FIBs to identify the host or environment (i.e., the source) that likely caused fecal contamination. It is also possible to directly monitor human pathogens, however it is often not practical as these pathogens if present are usually in very low numbers and often have a very low infectious dose. In the case of genetic MST different specific genetic markers are used to target known sequences of bacterial DNA that are specific to species or groups of bacteria that are specific to a given source. GRDA chose to assess the water samples with a variety of markers, but specifically chose to assess human and ruminant (in particular cows) sources, as these sources pose the greatest risk to health and public safety. For instance, the samples collected on 6/5/2014 was assessed for markers that would indicate fecal contamination from Canada goose (2 markers), cow (2 markers), gull, human (3 markers), and a general marker for fecal contamination (*Bacteroidetes*). Results for the general marker indicated fecal contamination (Table 1). There were also detections for Human and Canada goose as sources. However, for each of these sources results yielded conflicting results with detects for only 1 of 3 possible markers for human sources, and 1 of 2 markers for Canada goose (data from markers without detections not shown). Furthermore, of these detections one of two samples for humans was below the quantifiable limit of the method (from BSP2) and both samples were also below quantifiable limits (Table 1). The sample from 6/10/2014 was assessed using the same markers and also with genetic markers for *Enterococcus* spp. and *E. coli*. Additionally, for comparison purposes, Canada goose feces was also analyzed. These samples showed similar results to those from 6/5/2014 as detections of Canada goose were again at detection limits for the water sample, however there were no detections of human feces.

Table 1. Results from FIB testing and MST for June samples. One sample each was taken from BSP2 and BSP3 on 6/5/14 and One sample was taken from BSP3 on 6/10/14. Data from two samples taken on 6/5/14 are presented as an average.

Sample Date	Total Coliforms IDEXX Colisure (MPN/100mL)	*E. Coli* IDEXX Colisure (MPN/100mL)	*E. coli* TECOLI (cells/mL)	*Enterococcus* IDEXX Enterolert (MPN/100mL)	*Enterococcus* TENT (cells/mL)	*Bacteroid-etes* GenBac (cells/mL)	Human HF183 (cells/mL)	Canada goose CG Bact1 (cells/mL)
6/5/14	1.8×10^3	4.3×10^2	NA	1.3×10^3	NA	3.2×10^2	1.6×10^1*	5.0×10^{-1} (J)
6/10/14	3.9×10^3	1.6×10^3	9.2×10^1	6.5×10^2	5.0×10^1	1.2×10^3	ND	4.0×10^{-1} (J)

NA =Not Analyzed; ND = Not Detected; *Indicates that one of 2 samples was below practical quantification limit; (J) estimated quantity between practical quantification limit and lower quantification limit.

Because of this apparent contradiction showing little known source material from the sources examined in MST (Table 1) and the discrepancy between the 2 FIB indicators (i.e., low *E.* coli vs. high Enterococci; Figure 2) we attempted to discern if it was possible that a residual population of Enterococci were residing on the beach. In July, we sampled both the sediment (on 7/7/2014), which showed very high levels of both *E. coli* and Enterococci. We also conducted a third round of MST on 7/31/14 using the company Source Molecular. In an attempt to gain more certainty in our results we took multiple samples from sites BSP2 and BSP3 during a rain event to increase our chances of detecting any sources washing in to the beach. We tested for 2 human markers, a general avian marker, and a general ruminant marker. Despite using genetic markers spanning a greater breadth of sources we were unable to detect any fresh sources of fecal contamination (Table 2). However, Enterococci numbers remained high. We also sampled along an ephemeral creek that runs into Grand Lake State Park during the same rain event. Although we found high levels of both FIBs in the creek, levels of *E. coli* had dissipated downstream at the creek's mouth.

Table 2. Results from FIB testing and MST for July samples. Three replicate samples were taken from both BSP2 and BSP3.

Sample Date	Total Coliforms IDEXX Colisure (MPN/100mL)	*E. Coli* IDEXX Colisure (MPN/100mL)	*Enterococcus* IDEXX Enterolert (MPN/100mL)	Human HF183 HumM2 (cells/mL)	Ruminant Rum2Bac (cells/mL)	Bird Helio-bacter GFD (cells/mL)
7/31/14	3.0×10^3	1.7×10^2	7.4×10^2	ND	ND	ND

ND = Not detected

Figure 3. Spirogyra algal mats present along the beach at Grand Lake State Park.

Additionally, we sent some of our chromogenic substrate tests (samples taken on 8/12) to determine if there could be potential for false positives associated with Enterococci in our chromogenic substrate tests. Tests from all three sites had members of non-enterococcal bacteria growing in them (both *Chromobacterium haemolyticum*, *Lactococcus garvieae* were identified at all three sites). Only at BSP 3 were there any *Enterococcus* species identified (*E. casseliflavus*), however, this species is not commonly associated with feces. All of the bacteria identified are commonly associated with soil, freshwater, and/or aquatic vegetation. This suggests that the large presence of *Spirogyra* algal mats present at the beach (Figure 3) may have been harboring bacteria that can cause false positives associated with chromogenic substrate tests. False positives and detection of *Enterococcus* species that are not associated with feces have also been found in other research investigating FIB contamination (U.S. EPA 2014a & references therein). Thus, we also sampled those algal mats on three consecutive days in August (8/18/2014 – 8/20/2014). High levels of Enterococci were found at all three sites (among the highest seen during our sampling), but levels were variable between days, but no *E. coli* was found at the site.

This situation illustrates the need for further guidelines if the possibility exists to conduct more thorough investigations in fecal contamination. It demonstrates the possibility for conflicting results originating from FIB culturing and MST methodologies. Furthermore, it illustrates the possibility for these tests to be confounded by natural conditions. Although culturing methods are well established and in many cases are all that is possible, recent advances in MST have shown that it is possible to further investigate fecal contamination beyond the capabilities of these tests. MST can also allow a further assessment of risk beyond what is possible from culturing methodologies. Therefore, GRDA is proposing to provide additional guidelines for body contact in designated swimming areas and parks in cases where bacteria sources can be ascertained to better assess and manage risks to health and public safety.

Objective

The objective of this document is to provide additional guidelines for body contact in the designated swimming areas and parks in cases where bacteria sources can be ascertained to further protect and assess risk to health and public safety.

GRDA’s water quality monitoring and state standards for body contact in designated swimming areas

GRDA’s Water Quality Monitoring:

The goal of the GRDA Water Quality Monitoring Program is to collect and maintain a baseline water quality database for the waters of the Grand River. These data allow GRDA to make informed management decisions regarding human health and safety and watershed and water quality improvement initiatives. Furthermore, this database allows GRDA to understand the complex feedback relationships between the ecosystem processes impacting water quality, beneficial uses, and threats to health and public safety. Currently, GRDA has functioned in the capacity and actively investigates any reports of illness, impairments, or perceived declines in water quality.

State Standards for Body Contact

Recommendations for beach closures have been based strictly on the Oklahoma Water Quality Standards, which were adopted based on the EPA 1986 Ambient Water Quality Criteria for Bacteria (Table 3; OWRB 2013). These standards are based on an estimated health risk of 8 out of 1000 swimmers contracting a Highly Credible Gastrointestinal Illness (HCGI), which is equivalent to 36 out of 1000 swimmers contracting an NEEAR-Gastrointestinal illness (NGI). HCGI is defined as “any one of the following unmistakable or combinations of symptoms [within eight to ten days of swimming]: (1) vomiting (2) diarrhea with fever or a disabling condition (remained home, remained in bed or sought medical advice because of symptoms), (3) stomachache or nausea accompanied by a fever.” NGI is derived from EPA’s NEEAR epidemiological studies and includes any of the following [within ten to 12 days after swimming]: (a) diarrhea (three or more loose stools in a 24 hour period), (b) vomiting, (c) nausea and stomachache, or (d) nausea or stomachache and impact on daily activity” (U.S. EPA 2010). Essentially this definition is more inclusive in a longer time window and removes the requirement of a fever, which may not present with viral gastroenteritis.

Table 3. Oklahoma WQS for Primary Body Contact Recreation

Fecal Indicator Bacteria	5-sample geometric mean (CFU or MPN/100mL)	75% one-sided confidence level for lakes and high use waterbodies (CFU or MPN/100mL)	90% one-sided confidence level for all other beneficial use areas (CFU or MPN/100mL)
E. coli	126	235	406
Enterococci	33	61	108

Proposed guidelines for body contact in cases where state standards are exceeded and microbial source tracking is available

Rationale for proposed guidelines

The RWQC, recommended by U.S. EPA, are derived from studies of beaches effected by human sources, primarily point-source pollution and effluent from wastewater treatment plants. However, the state of the science is much less clear about the relationships between GI illness and FIB concentrations from non-point sources and other sources of fecal contamination and contribution. It is problematic if the relationship between FIBs and pathogens are decoupled because then they are no longer effective proxies for predicting pathogen concentrations and health risk. FIBs are only reliable indicators of health risk if the source of fecal contamination is equivalent in pathogenicity to human sources (in particular treated sewage effluent). Furthermore, using FIBs as pathogen indicators is only reliable if the bacteria are associated with the same sources as the pathogens. Indeed, the EPA has acknowledged these possibilities exist in the most recent issuance of their RWQC (U.S. EPA 2012a) and the Site-Specific Alternative Criteria Technical Support Materials for Alternative Indicators and Methods (U.S. EPA 2014a, U.S. EPA 2014b). Because advancements have been made in both monitoring methods (including genetic methods) and criteria since the 1986 recommendations the EPA has also provided Technical Support Materials (TSM) for use by states if they want to consider using new or alternative methods to develop site-specific water quality criteria (EPA 2014b). Thus, evaluating and developing equivalent WQS associated with genetic testing (as has been done for Enterococci; U.S. EPA 2012a) may improve the accuracy of determining threats to health and public safety (U.S. EPA 2014a). Furthermore, these provisions have been added by the EPA in order to use scientifically defensible methods for site-specific recommendations so long as they are protective of the sites designated uses (U.S. EPA 2014a & b). Therefore, in order to deal with these new challenges in understanding health risks and the ability to use advanced tools in the management of fecal contamination GRDA is proposing to modify our current practices by employing some of the methods in the TSM for the purposes of collecting information and to better inform decision making with regards to recommendations for body contact in designated swimming areas.

These new provisions and guidelines issued by the EPA could have affected the previously mentioned situation at Grand Lake State Park. Both *E. coli* and Enterococci were detected in the genetic source tracking conducted on the 6/10/14. At the time of testing Enterococci appeared to be above the state WQS. However, a retrospective look at the results from the genetic testing indicated that the values detected for Enterococci were equivalent to values that would actually be below standard according to the recent release of the Recreational Water Quality Criteria (U.S. EPA 2012a[1]). Taken into context with the results showing prolonged detections of Enterococci (Figure 2) and the possibility for false positives associated with the above mentioned algal mats these results further suggest that the perceived threat to health and public safety may have been overestimated. Furthermore, the results from the genetic testing further demonstrate the power of using genetic testing in potentially providing a better estimate

[1] The EPA currently has not released equivalent values for genetic testing for *E. coli.*

of FIB contamination. Finally, the results from the various MST samplings, FIB monitoring, and GRDA's survey of the site (e.g., creek and sediment sampling) could potentially have been used towards constructing a Quantitative Microbial Risk Assessment (QMRA) using known relationships of reference pathogens and health risk (see Soller et al. 2010 and Table 4 for examples) that could have aided in making management decisions that would be protective of health and public safety.

Proposed Guidelines

GRDA will continue to actively investigate any reports of illness associated with designated swimming areas in its waters along with its continued monitoring of heavy-use coves in accordance with its shoreline management plan. In the event of a detection of FIB contamination GRDA will attempt to follow the steps outlined in this section to better assess risk to health and public safety and to determine and manage (if possible) the source(s) of the fecal contamination. Any values presented in this section with regards to its recommendations to the Oklahoma Tourism and Recreation Department for beach closures and advisories on GRDA lakes are based upon the EPA RWQC 2012, the Oklahoma WQS, and the recommendations for body contact and recreational use developed by the interagency working group convened to develop guidelines for body contact and recreational use for the Oklahoma River (the only other document of this kind existing statewide). Because the Oklahoma WQS values are all based on a culturing methodology for determining the amount of contamination, genetic quantification[2] may also be used as an alternative method for quantification (e.g., *Enterococcus* spp. as measured genetically by qPCR – EPA Method 1611; U.S. EPA 2012b) so long as there are established relationships between the qPCR values that are equivalent to the Oklahoma WQS (i.e., U.S. EPA 2012b).

Table 4. Examples of relative health risk from different sources of fecal contamination determined using Quantitative Microbial Risk Assessment. Adapted from: Soller et al. 2010.

	Median Relative Risk[1]	
	Enterococci (35 CFU/100mL)	***E. coli* (126 CFU/100mL)**
2012 RWQC health goal	0.036	0.036
Source of fecal contamination		
Effluent	0.31	0.30
Raw Sewage	0.0065	0.0081
Bovine	0.36	0.028
Porcine	0.0005	0.007
Poultry (chicken)	0.0005	0.00002
Waterfowl (gulls)	0.00007	0.0002

[1] Assumes direct deposition and that the prevalence of infection in each of the sources and the proportion of human-infection pathogenic strains from is as reported in the literature (Soller et al. 2010, Table 2).

[2] Specifically including both qPCR and ddPCR. GRDA is currently implementing ddPCR into its FIB monitoring and assessment. ddPCR provides similar data to qPCR, but is more advanced and provides more precise results. GRDA is collaborating with the Southern California coastal Water Research Project (SCCWRP) in developing their lab and implementing this technique into their monitoring for FIB. SCCWRP is currently developing numerous methods for genetic MST and is considered a leader in MST.

As a result, we propose to utilize the following steps to assess risk to health and public safety:

Step 1. Initial recommendation following the detection of FIB contamination (Table 2)

- **"Green" – Unrestricted access** – at or below the WQS for geometric mean if 5 samples within a given 30 day period are available with no sample exceeding the 75% one-sided confidence level and/or at or below the single sample 75% one-sided confidence level if fewer than 5 samples are available

- **"Yellow" – Information and education materials available to users for risk communication** – at or below the WQS geometric mean if 5 samples are available within a given 30 day period with one or more samples exceeding the 75% one-sided confidence level and no sample exceeding 90% one-sided confidence level and/or between the single sample 75% one-sided confidence level and the 90% one-sided confidence if fewer than 5 samples are available

- **"Red" – No primary recreational body contact activity** – above the WQS geometric mean if 5 samples are available within a given 30 day period or above the single sample 90% one-sided confidence if fewer than 5 samples are available

Table 4. Basis for initial recommendation following the detection of FIB contamination

Fecal Indicator Bacteria (CFU or MPN/100mL)	5-sample geometric mean[1] No exceedances	Fewer than 5 samples (75% OSCI[2])	5-sample geometric mean 1 or more exceedances	Fewer than 5 samples (75% OSCI ≤sample ≤90%OSCI)	5-sample geometric mean	Fewer than 5 samples (≥90%OSCI)
E. coli	≤126	≤235	≤126	235 ≤ X ≤ 406	≥126	406
Enterococci	≤33	≤61	≤33	61 ≤ X ≤ 108	≥33	108

1. within a 30 day sampling period; 2. OSCI: One sided confidence interval

Step 2. (If Yellow or Red) Determination of possible sources

- Conduct Microbial Source Tracking (MST) – using molecular methods to determine sources and amount of contamination from said source. Numerous markers and methods exist in the literature. There are also many labs that offer this as a purchasable service.

- Sanitary Survey – a collection of information about a site and its surrounding watershed for information on physical conditions and features, potential pollution sources, land use, onsite wastewater treatment systems, etc… that could influence water quality (see Appendix B).

Step 3. Risk assessment and recommendation adjustment

- If humans are detected as a source of fecal contamination then no adjustment to the previous recommendation is required.

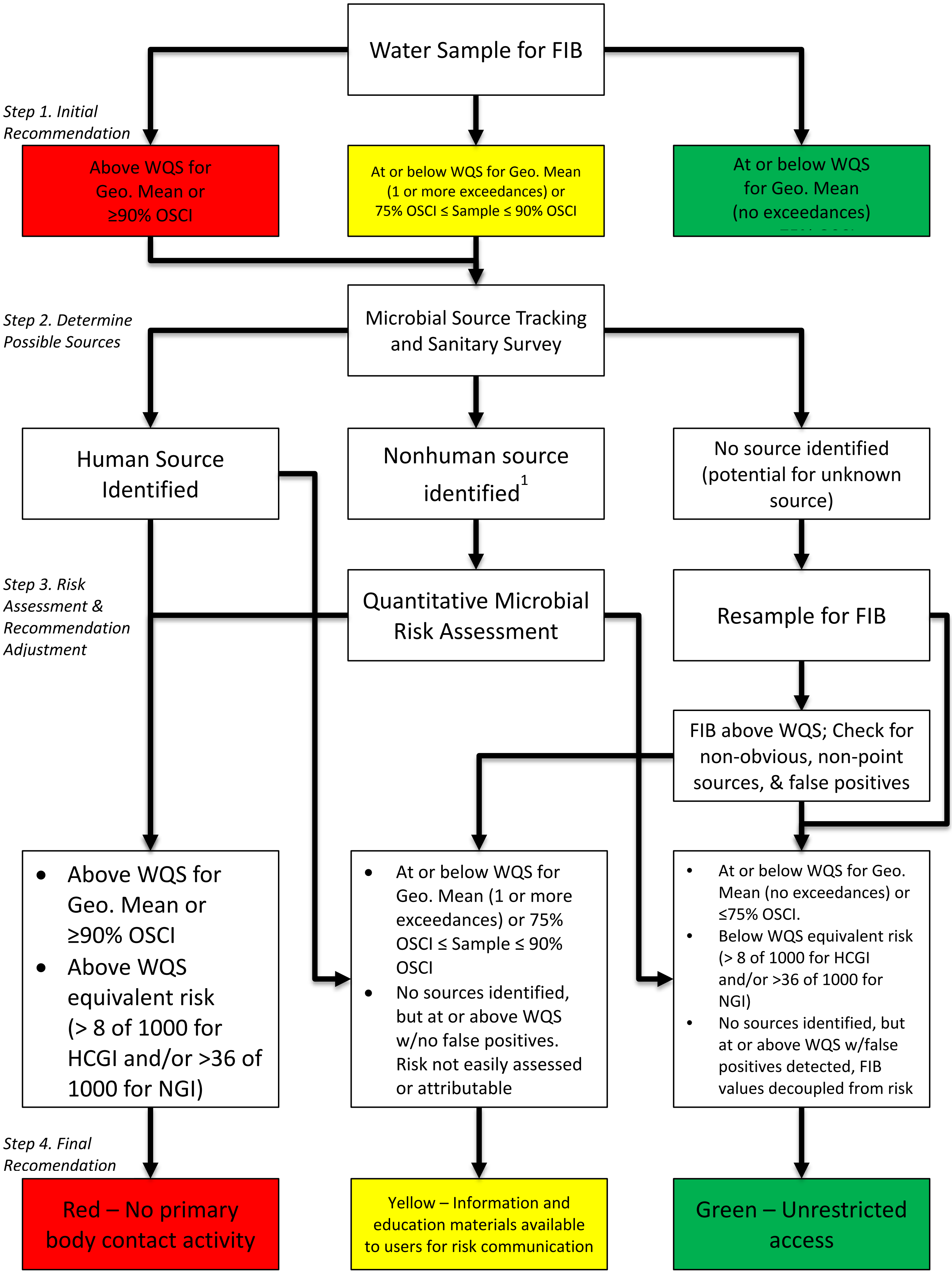
- If other sources are detected conduct a QMRA (see Soller et al. 2010, and U.S. EPA 2010b and references therein for more information). QMRA a way to estimate human GI illness risk associated with recreation at freshwater beaches contaminated by non-human fecal sources based on known reference pathogens. QMRA is a good complement to epidemiology studies where epidemiology data are not readily available, do not apply, or are impractical to collect. QMRAs use FIB monitoring data, known pathogen/source/FIB relationships, and the amount of water ingested to determine pathogen dose and probability of infection multiplied by a morbidity factor to produce a probability of illness.

    - Results of the QMRA will determine recommendation
    - If risk < 8 of 1000 for HCGI and/or <36 of 1000 recommend "Green"
    - If risk > 8 of 1000 for HCGI and/or >36 of 1000 recommend "Red"

- If no obvious sources identified in sanitary survey/MST resample for FIB contamination (use weight of evidence to show no fecal contamination)
    - If contamination absent or below Oklahoma WQS change recommendation to "Green"
    - If present and above standard then look for non-obvious, non-point sources, and check for false positives
        - If no other sources can be found but contamination persists recommend "Yellow" with continued monitoring
        - If false positives detected and contamination persists recommend "Green"

Step 4. Final Recommendation and Management/Continued Monitoring

- If "Green" no additional monitoring after 5 samples within a given 30 day period sampling and a determination below the geometric mean for Oklahoma WQS
- If "Yellow" monitor until either:
    - 5 FIB samples within a given 30 day period fall below the Oklahoma WQS for geometric mean
    - End of the recreation season (September 30th)
    - False positives are found
- If "Red" monitor until either:
    - Sources of fecal contamination are removed, ameliorated, or can no longer be detected for 5 samples and/or 5 FIB samples fall below the Oklahoma WQS for geometric mean within a given 30 day period
    - End of the recreation season (September 30th)
    - False positives are found



[1] Examples of current possible genetic markers for use in genetic MST: human, general ruminant, general avian, cow, chicken, horse, dog, pig, sheep, gull, Elk, Canada geese, *E. coli*, and *Enterococcus*.

Acronynms

CFU	Colony Forming Unit
ddPCR	Droplet Digital Polymerase Chain Reaction
EPA	Environmental Protection Agency
GRDA	Grand River Dam AuthorityO
HCGI	Highly Credible Gastrointestinal Illness
FIB	Fecal Indicator Bacteria
MPN	Minimum Problem Number
MST	Microbial Source Tracking
NEEAR	National Epidemiological and Environmental Assessment of Recreational Water
NGI	NEEAR Gastrointestinal Illness
OMRA	Quantitative Microbial Risk Assessment
OWRB	Oklahoma Water Resources Board
qPCR	Quantitative Polymerase Chain Reaction
RWQC	Recreational Water Quality Criteria
SCCWRP	Southern California Coastal Water Research Project
TSM	Technical Support Materials
U.S.	United States
WQS	Water Quality Standards

Appendix A

References

Oklahoma Water Resources Board. 2014. Oklahoma's Water Quality Standards. Title 785, Chapter 45. Available at: http://www.owrb.ok.gov/util/rules/pdf_rul/current/Ch45.pdf

U.S. EPA 1986. EPA's Ambient Water Quality Criteria for Bacteria – 1986. U.S. Environmental Protection Agency: Washington, DC. EPA440/5-84-002. Available at: http://water.epa.gov/scitech/swguidance/standards/upload/2001_10_12_criteria_ambientwqc_bacteria1986.pdf

U.S. EPA 2010a. Report on 2009 National Epidemiologic and Environmental Assessment of 61 Recreational Water Epidemiology Studies (NEEAR 2010 - Surfside & Boquerón). EPA-600-R-10-168. Available at: http://www.epa.gov/neear/files/Report2009v5_508comp.pdf

U.S. EPA 2010. Quantitative Microbial Risk Assessment to Estimate Illness in Fresh water Impacted by Agricultural Animal Sources of Fecal Contamination. EPA 822-R-10-005. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/P4-QMRA-508.pdf

U.S.EPA 2012a. Recreational Water Quality Criteria. EPA 820-F-12-058. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/RWQC2012.pdf

U.S. EPA 2012b. Method 1611: Enterococci in Water by TaqMan Quantitative Polymerase Chain Reaction. Available at: http://water.epa.gov/scitech/methods/cwa/bioindicators/upload/Method-1611-Enterococci-in-Water-by-TaqMan-Quantitative-Polymerase-Chain-Reaction-qPCR-Assay.pdf

U.S. EPA 2014a. Overview of Technical Support Materials: A Guide to the Site-Specific Alternative Recreational Criteria TSM Documents. EPA-820-R-14-010. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/Overview-of-Technical-Support-Materials-A-Guide-to-the-Site-Specific-Alternative-Recreational-Criteria-TSM-Documents.pdf

U.S. EPA 2014b. Site-Specific Alternative Criteria Technical Support Materials for Alternative Indicators and Methods. EPA-820-R-14-011. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/Site-Specific-Alternative-Recreational-Criteria-Technical-Support-Materials-For-Alternative-Indicators-and-Methods.pdf

Soller, J.A., Schoen, M.E., Bartrand, T., Ravenscroft, J., Wade, T.J. 2010. Estimated human health risks from exposure to recreational waters impacted by human and non-human sources of faecal contamination. Water Research 44: 4674-4691

Appendix B.

Example Sanitary Survey. Taken from EPA Technical Resources about Beaches. Great Lakes Beach Sanitary Survey. Available at: http://www2.epa.gov/beach-tech/great-lakes-beach-sanitary-survey

GREAT LAKES BEACHES ROUTINE ON-SITE SANITARY SURVEY

Name of Beach:	Date and Time of Survey:
Beach ID:	Surveyor Name(s):
Sampling Station(s)/ID:	Surveyor Affiliation:
STORET Organizational ID:	

PART I – GENERAL BEACH CONDITIONS

Air Temperature: __________ °C or °F | Wind: Speed (mph) ______________
Direction (e.g., E or 90°) ____________ (From which direction the wind is coming)

Rainfall: ☐ <24 hours ☐ <48 hours ☐ <72 ☐ >72 hours since last rain event and inches or cm rainfall measured

Rain Intensity: ☐ Misting ☐ Light Rain ☐ Steady Rain ☐ Heavy Rain ☐ Other

Weather Conditions:

Sky Condition	☐ Sunny	☐ Mostly Sunny	☐ Partly Sunny	☐ Mostly Cloudy	☐ Cloudy
Amount of cloud coverage	No Clouds	1/8 to 2/8	3/8 to 1/2	5/8 to 7/8	Total Coverage

Wave Intensity: ☐ Calm ☐ Normal ☐ Rough Wave Height: ____________ ft ☐ Estimated or Actual

Longshore current speed and direction (cm/sec, S or 180°):

Comments/Observations

PART II – WATER QUALITY

Bacteria Samples Collected (list samples collected from beach water and potential pollution sources, if applicable—see Part IV)

Sample Point	Sample #	Parameter (*E. coli*, enterococci, etc.)	Comments:

Water Temperature: ____________ °C or °F Change in Color? ☐ yes ☐ no If yes, describe ______________

Odor: ☐ None ☐ Septic ☐ Algae Sulfur ☐ Other ______ ☐

Turbidity: ☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque or NTU:

Comments/Observations

PART III – BATHER LOAD

Total number of people in the water: ______________ Total number of people out of the water: ______________

Total number of people at the beach: ______________

List of Activities Seen (optional):

Type of Activity				
Number of People				

Comments/Observations

PART IV – POTENTIAL POLLUTION SOURCES

Sources of Discharge:

Type	River(s)	Pond(s)	Wetland(s)	Outfall(s)	Other (specify):
Name(s) of Source(s)					
Amount (H, M, L)					
Flow Rate (M/sec)					
Volume					
Characteristics					

Did you collect any bacteria samples from the sources listed in the table above? ☐ yes ☐ no

If "Yes", did you list the samples in the table in Part II, Water Quality? ☐ yes ☐ no

Floatables present: ☐ yes ☐ no Please circle the following floatables if found:

Type	Street litter	Food-related litter	Medical items	Sewage-related	Building materials	Fishing related	Household waste	Other:
Example	Cigarette filters	Food packing, beverage containers	Syringes	Condoms, tampons	Pieces of wood, siding	Fishing line, nets, lures	Household trash, plastic bags	

Amount of Beach Debris/Litter on Beach: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Type of Debris/Litter Found (please circle)

Type	Street litter	Food-related litter	Medical items	Sewage-related	Building materials	Fishing related	Household waste	Tar	Oil/ Grease	Other:
Example	Cigarette filters	Food packing, beverage containers	Syringes	Condoms, tampons	Pieces of wood, siding	Fishing line, nets, lures	Household trash, plastic bags	Tar balls	Oil slick	

Amount of Algae in Nearshore Water: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Amount of Algae on Beach: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Circle the types of algae found

Type	Periphyton	Globular	Free floating	Other
Description	Attached to rocks, stringy	Blobs of floating materials	No obvious mass of materials	Please describe

Circle the color of algae found

Light green	Bright green	Dark green	Yellow	Brown	Other

Presence of Wildlife and Domestic Animals

Type	Geese	Gulls	Dogs	Other (specify)
Number				

List the number of each species of bird found dead on the beach

Type	Common loons	Herring gulls	Ring-billed gulls	Double crested cormorants	Long-tailed ducks	White-winged scoter	Horned grebes	Red-necked grebes	Other
Number found dead									

Number of dead fish found on the beach: ______________

Comments/Observations (continue on back if necessary):