Supplemental File 3. Determining probabilities and establishing a threshold probability for issuing advisories—an example at Buck Creek State Park, Ohio. The method described below was modified from Francy and Darner (1).

Two types of output may be produced by multiple linear regression models for determining bacterial water quality at recreational sites. The first is the predicted bacterial-indicator concentration. The second output—the probability that the single-sample maximum bathing-water standard (235 CFU/100 mL for *E. coli* at Ohio beaches) will be exceeded—was added because prediction intervals were shown to be fairly wide (2). This approach has been successfully applied to beaches that are part of the Ohio Nowcast at Great Lakes beaches (http://www.ohionowcast.info/). Predictive models applied through the Ohio Nowcast have provided more accurate predictions than the current method for assessing water quality (using the previous days' *E. coli* concentrations) (3).

The probability that the predicted value is greater than 235 CFU/100 mL is computed as the probability of Student's *t* being greater than *x,* with the degrees of freedom equaling the number of observations used in the regression minus the number of regression coefficients in the regression equation.

$x = (\log(235) - \hat{y}) / sep$

where
$\hat{y}$ is the regression estimate of the $\log_{10}$ *E. coli*, and
sep is the standard error of prediction of *y*.

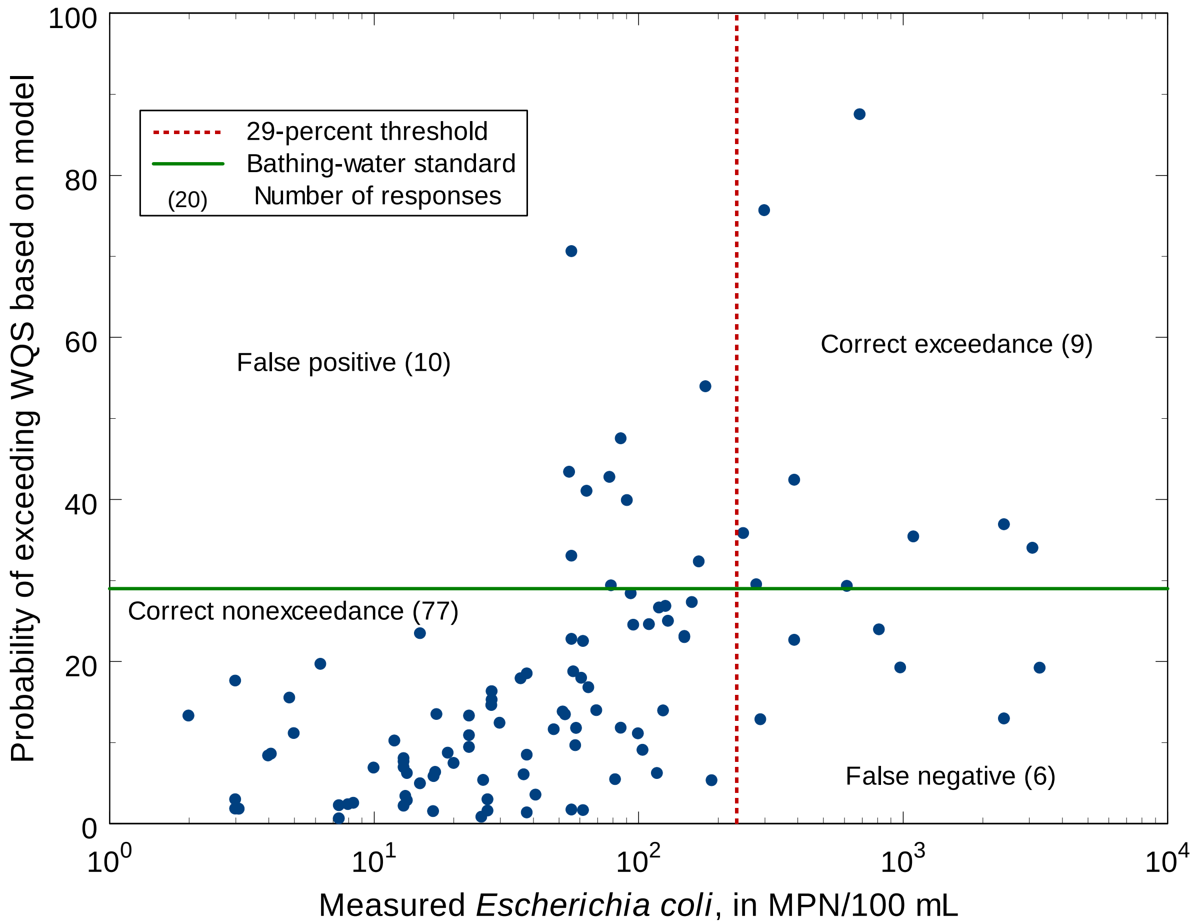
This approach was applied to models for inland lakes beaches in the current study. For each model, a probability associated with too great a risk to allow swimming is determined—this is called the threshold probability. Threshold probabilities are determined by taking the dataset used to develop the model (calibration dataset) and finding the probability that is a reasonable balance between achieving a high number of correct responses and a low number of false negative responses. Computed probabilities that are less than the threshold indicate that bacterial water quality is most likely acceptable for swimming. Computed probabilities equal to or greater than the threshold probability indicate that the water quality is most likely not acceptable and that a water-quality advisory may be needed.

The following example was done using Virtual Beach (version 2.2) (4) and the calibration data set from Buck Creek South 2010–11. The probability of exceeding the standard for each data point was output and a threshold probability was set. This concept can be best explained by examining the plot for the Buck Creek 2010–11 model with a 29-% threshold (see the plot below) and then explaining the process used to determine the 29-% threshold. The plot is divided into four quadrants by a vertical line through 235 CFU/100 mL on the x-axis and a horizontal line through the threshold probability of 29. The four quadrants are

- Correct nonexceedance (specificity). *E. coli* concentration met the standard (was less than 235 CFU/100 mL), and the predicted probability of exceedance was below the threshold. The specificity is the proportion of nonexceedances that are correctly predicted as being below the standard.

- False positive. *E. coli* concentration met the standard, but the predicted probability of exceedance was above the threshold.
- Correct exceedance (sensitivity). *E. coli* concentration exceeded the standard, and the predicted probability of exceedance was above the threshold. The sensitivity is the proportion of actual exceedances that are predicted correctly.
- False negative. *E. coli* concentration exceeded the standard, but the predicted probability of exceedance was below the threshold.

Our goals for good model performance are overall correct responses $\geq$ 80%, sensitivities $\geq$50%, and specificities $\geq$ 85%. By raising or lowering the horizontal line, one can determine the best threshold probability. This determination is somewhat subjective. Responses for different thresholds are listed in the table below the plot. In the example below, a threshold of 55 would have produced the highest number of correct responses (88, or 86.3%) but would also have produced 13 false negatives. False negative responses are especially troubling because the recreational water quality is determined to be acceptable when in fact the standard was exceeded. Thresholds between 40 and 50 do little to reduce the number of false negatives. Thresholds of 30 and 35, reduce the number false negatives, but still maintain sensitivities under 50%. Selecting a threshold of 29, maintains a high number of correct responses (86, or 84.3%), increases the sensitivity to 60%, and represents a compromise between false negative and false positive responses. Setting the threshold to a lower value than 29 increases the number of false positives without any further reduction to the numbers of false negatives.



Probability (%)	Total correct	False -	False +	Sensitivity (%)	Specificity (%)
55	88	13	1	13	99
50	87	13	2	13	98
45	86	13	3	13	97
40	84	12	6	20	93
35	86	9	7	40	92
30	85	8	9	47	90
29	86	6	10	60	89
28	85	6	11	60	87
25	82	6	14	60	84

FIG S1. Establishment of the threshold probability for 102 samples collected at Buck Creek State Park South, 2010–11.

References

1. **Francy DS, Darner RA**. 2006. Procedures for developing models to predict exceedance of recreational water-quality standards at coastal beaches. U.S. Geological Survey Techniques and Methods 6-B5. U.S. Geological Survey, Reston, VA. http://pubs.usgs.gov/tm/2006/tm6b5/.
2. **Francy DS, Darner RA**. 1998, Factors affecting *Escherichia coli* concentrations at Lake Erie public bathing beaches. U.S. Geological Survey Water-Resources Investigations Report 98-4241. U.S. Geological Survey, Reston, VA.
3. **Francy DS, Bertke EE, Darner RA**. 2009. Testing and refining the Ohio Nowcast at two Lake Erie beaches—2008. U.S. Geological Survey Open-File Report 2009-1066. U.S. Geological Survey, Reston, VA. http://pubs.usgs.gov/of/2009/1066/
4. **U.S. Environmental Protection Agency**. 2012. Exposure Assessment Models—Virtual Beach. Center for Exposure Assessment Modeling, U.S. Environmental Protection Agency, Athens, GA. http://www.epa.gov/ceampubl/swater/vb2/index.html.