TO: File: Russian River; Pathogen TMDL Development and Planning

FROM: Steve Butkus

DATE: July 25, 2013

SUBJECT: EVALUATION OF THE AVERAGING PERIOD FOR APPLICATION OF FECAL INDICATOR BACTERIA WATER QUALITY CRITERIA

The North Coast Regional Water Board staff are developing Russian River Total Maximum Daily Loads (TMDLs) for pathogen indicators to identify and control contamination impairing recreational water uses. Potential pathogen contamination has been identified in the lower and middle Russian River watershed leading to the placement of waters within these areas on the federal Clean Water Act Section 303(d) list of impaired waters. The contamination identified has been linked to impairment of the contact recreation (REC-1) and non-contact recreation (REC-2) designated beneficial uses. Health advisories for these waters have been published and posted by Sonoma County and the City of Santa Rosa authorities.

Regional and State Water Board staff have used fecal indicator bacteria (FIB) concentrations to assess the support of the REC-1 beneficial use. Criteria exist for FIB concentrations that indicate a potential health risk from exposure to pathogens in recreational waters (USEPA 2012). The bacteria do not pose a health risk, but are easier to measure then the actual pathogens that may pose a risk of illness. Since 2001, Regional water Board and the Sonoma County Water Agency have collected water samples to measure *Escherichia coli (E. coli*) and *Enterococcus* bacteria concentrations in the Russian River watershed to assess impairment to recreational uses.

The North Coast Water Quality Control Plan (Basin Plan) promulgates criteria (i.e. Water Quality Objectives (WQO) for bacteria concentrations that are protective of the REC-1 beneficial use. The Basin Plan narrative WQO states:

> *"The bacteriological quality of waters of the North Coast Region shall not be degraded beyond natural background levels."*

Regional Water Board staff used U.S. Environmental Protection Agency (USEPA) criteria for support of recreational uses was applied to evaluate the narrative WQO for bacteriological quality. The U.S. Environmental Protection Agency (USEPA) has recommended criteria for protection of human illness from swimming for both *E. coli* and *Enterococcus* bacteria concentrations (USEPA 2012; Table 1). The USEPA criteria consist of two numeric concentration thresholds to protect the recreation beneficial use: a geometric mean and the statistical threshold value (STV) of all samples collected over a 30-day period. No minimum sample size is suggested. The STV represents the 90th percentile of the data and is intended to be a value that should not be exceeded by more than 10 percent of the samples taken. The USEPA criteria are based on a 30-day averaging period "used in a static ***or*** rolling manner." Russian River FIB data were assessed and compared using both averaging period approaches.

Regional Water Board staff use USEPA criteria as an evaluation guideline for the narrative WQO criterion to assess impairment of REC-1 beneficial use. Water samples were collected at twenty-seven (27) locations within the Russian River watershed for analysis of *E. coli* and *Enterococcus* bacteria concentrations (Tables 2 & 3). The measured *E. coli* and *Enterococcus* bacteria concentrations were used to assess impairment of REC-1 beneficial use using both 30-day averaging approaches (static and rolling 30-day periods) recommended by the USEPA criteria. Discrete 30-day periods for the static geometric mean calculations were defined based on the Julian date of each year (i.e., 30-day period 1 for Julian days 1-30; 30-day period 2 for Julian days 31-60, etc.). No samples were excluded since none were collected on Julian days 361-365.

The median bacteria concentration values were used for replicate samples collected on the same day. The minimum or maximum analytical reporting limits were used for bacteria concentrations that were measured beyond those limits. Most often, the minimum reporting limit was <10 MPN/100mL and the maximum reporting limit was <24,196 MPN/100mL. These censored sample results were substituted with 10 MPN/100mL and 24,196 MPN/100mL, respectively, for both the rolling and static geometric mean calculations.

E. coli and *Enterococcus* bacteria concentrations were assessed at each specific sampling location using the USEPA criteria and Table 3.2 of the Water Quality Control Policy (Policy) for California's Clean Water Act Section 303(d) List (CSWRCB 2004). The Policy uses a binomial distribution for listing decisions that minimizes error based on sample size and number of samples exceeding the criteria. Assessment results for *E. coli* concentrations are presented in Table 2 and 3 for static and rolling 30-day averaging periods, respectively. Similar assessment results for *Enterococcus* bacteria concentrations are presented in Tables 4 and 5. Comparing these results shows that the USEPA criteria and Policy were exceeded at more locations due to high *Enterococcus* bacteria concentrations than due to *E. coli* bacteria concentrations (Table 6).

Comparison of the two different approaches of averaging periods for individual stream locations shows that five (5) more locations (18% of those assessed), do not meet the Policy when using the rolling averaging period as opposed to static 30-day periods (Table 7). Applying the Policy using static 30-day periods identified tweleve (12) locations out of twenty-seven (27) assessed locations (44%) meet the Policy for listing the stream reach. Using a rolling 30-day averaging period identified five (5) more locations that meet the listing Policy (Table 11). Of the twenty-seven (27) locations assessed, nearly two-thirds (62%) meet the Policy for listing.

Of those locations assessed, five (5) locations would be listed using the rolling 30-day averaging period, but would not be listed using a discrete 30-day period. The difference is due inclusion of a single sampling event in multiple averaging periods. For example, Table 8 shows the calculation of the geometric mean using both averaging methods for *Enterococcus* bacteria concentrations measured the months of June through September 2011 in Dutch Bill Creek at Main Street in Monte Rio. The rolling geometric mean identifies two days where the geometric mean criterion was exceeded, whereas the static 30-day period geometric mean identified no periods that exceeded the criterion. The rolling 30-day averaging period includes the high bacteria concentration measured on June 28, 2011 into two separate days with a recorded exceedance of the criterion. This approach violates the statistical assumption of independent samples required for the application of the binomial distribution of the Policy. Therefore, it is recommended that discrete 30-day averaging periods be applied when assessing bacteria concentrations to avoid listing a stream reach when it actually meets the Water Quality Objective.

FINDINGS

- Comparison of the two different approaches of averaging periods for individual stream locations shows that 18% more locations do not meet the Policy when using the rolling averaging period as opposed to discrete 30-day periods. Using a rolling 30-day averaging period identified five (5) more locations that meet the listing Policy.

- More locations are identified as impaired using a rolling 30-day averaging period due to inclusion of single sampling events with high bacteria concentrations into multiple averaging periods. The rolling 30-day averaging period violates the statistical assumption of independent samples required for the application of the binomial distribution of the Policy. Therefore, it is recommended that discrete 30-day averaging periods be applied when assessing bacteria concentrations to avoid listing a stream reach when it actually meets the Water Quality Objective.

CITATIONS

CSWRCB 2004. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List. California State Water Resources Control Board, Sacramento, CA.

USEPA 2012. 2012 Recreational Water Quality Criteria. Publication No. EPA 820-F-12-061. U.S. Environmental Protection Agency, Washington, DC.

TABLES

Table 1. Recreational Water Quality Criteria published by the U.S. Environmental Protection Agency (2012) for an estimated human illness rate of 36 illness per 1000 recreators.

Fecal Indicator Bacteria	Geometric Mean (cfu/100mL)	Statistical Threshold Value (cfu/100mL)
E. coli	126	140
Enterococcus	35	130

Table 2. Evaluations of measured *E. coli* bacteria concentrations with U.S. EPA (2012) criteria based on static 30-day averaging duration periods.

Location	Total Number of 30-day Periods Sampled	Number of Periods that Exceed Either the Geomean or STV	Meets §303(d) Policy for Listing
Russian River at Bridgehaven Station	12	2	No
Russian River at Camp Rose Beach	49	0	No
Russian River at Cloverdale River Park	9	0	No
Russian River at Casini Ranch Campground	12	0	No
Russian River at Commisky Station Rd	18	1	No
Russian River at Crocker Rd	4	0	No
Russian River at Diggers Bend	12	0	No
Russian River at Duncans Mills	12	0	No
Russian River at Forestville Access Beach	28	1	No
Russian River at Geyserville Bridge	12	1	No
Russian River at Hacienda Bridge	6	0	No
Russian River at Healdsburg Memorial Beach	55	2	No
Russian River at Hopland	6	0	No
Russian River at Jenner Boat Ramp	17	2	No
Russian River at Jimtown Bridge	23	0	No
Russian River at Johnsons Beach	49	0	No
Russian River at Monte Rio Beach	61	4	No
Russian River at Riverfront Park	18	0	No
Russian River at Steelhead Beach	52	1	No
Atascadero Creek at Green Valley Rd.	6	4	No
Dutch Bill Creek at Main St.	6	0	No
Foss Creek at Matheson St.	7	6	**Yes**
Green Valley Creek at Martinelli Rd.	6	3	No
Green Valley Creek at River Rd.	5	4	No
Laguna de Santa Rosa at Sebastopol Community Park	11	6	**Yes**
Santa Rosa Creek at Los Alamos Rd.	11	9	**Yes**
Santa Rosa Creek at Railroad St.	33	32	**Yes**

* inadequate sample size for§303(d) Policy decision on stream reach

Table 3. Evaluations of measured *E. coli* bacteria concentrations with U.S. EPA (2012) criteria based on rolling 30-day averaging duration periods.

Location	Total Number of Days Sampled	Number of Days that Exceed Either the Geomean or STV	Meets §303(d) Policy for Listing
Russian River at Bridgehaven Station	31	3	No
Russian River at Camp Rose Beach	208	0	No
Russian River at Cloverdale River Park	30	0	No
Russian River at Casini Ranch Campground	31	0	No
Russian River at Commisky Station Rd	61	1	No
Russian River at Crocker Road	24	0	No
Russian River at Diggers Bend	31	0	No
Russian River at Duncans Mills	31	0	No
Russian River at Forestville Access Beach	126	0	No
Russian River at Geyserville Bridge	41	8	**Yes**
Russian River at Hacienda Bridge	21	0	No
Russian River at Healdsburg Memorial Beach	210	2	No
Russian River at Hopland	21	0	No
Russian River at Jenner Boat Ramp	48	0	No
Russian River at Jimtown Bridge	95	0	No
Russian River at Johnsons Beach	198	5	No
Russian River at Monte Rio Beach	222	9	No
Russian River at Riverfront Park	52	0	No
Russian River at Steelhead Beach	200	1	No
Atascadero Creek at Green Valley Road	9	7	**Yes**
Dutch Bill Creek at Main St.	21	0	No
Foss Creek at Matheson St.	10	9	**Yes**
Green Valley Creek at Martinelli Road	20	7	**Yes**
Green Valley Creek at River Road	7	6	**Yes**
Laguna de Santa Rosa at Sebastopol Community Park	28	17	**Yes**
Santa Rosa Creek at Los Alamos Road	13	13	**Yes**
Santa Rosa Creek at Railroad Street	97	95	**Yes**

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Table 4. Evaluations of measured *Enterococcus* bacteria concentrations with U.S. EPA (2012) criteria based on static 30-day averaging duration periods.

Location	Total Number of 30-day Periods Sampled	Number of Periods that Exceed Either the Geomean or STV	Meets §303(d) Policy for Listing
Russian River at Bridgehaven Station	11	2	No
Russian River at Camp Rose Beach	35	6	**Yes**
Russian River at Cloverdale River Park	9	1	No
Russian River at Casini Ranch Campground	11	2	No
Russian River at Commisky Station Rd	18	7	**Yes**
Russian River at Crocker Rd	4	3	*
Russian River at Diggers Bend	11	3	No
Russian River at Duncans Mills	11	4	No
Russian River at Forestville Access Beach	28	0	No
Russian River at Geyserville Bridge	12	2	No
Russian River at Hacienda Bridge	6	0	No
Russian River at Healdsburg Memorial Beach	41	5	No
Russian River at Hopland	6	1	No
Russian River at Jenner Boat Ramp	17	6	**Yes**
Russian River at Jimtown Bridge	23	8	**Yes**
Russian River at Johnsons Beach	25	1	No
Russian River at Monte Rio Beach	46	9	No
Russian River at Riverfront Park	18	8	**Yes**
Russian River at Steelhead Beach	41	8	**Yes**
Atascadero Creek at Green Valley Rd.	5	3	No
Dutch Bill Creek at Main St.	6	2	No
Foss Creek at Matheson St.	5	5	**Yes**
Green Valley Creek at Martinelli Rd.	6	6	**Yes**
Green Valley Creek at River Rd.	5	4	**Yes**
Laguna de Santa Rosa at Sebastopol Community Park	11	9	**Yes**
Santa Rosa Creek at Los Alamos Rd.	9	9	**Yes**
Santa Rosa Creek at Railroad St.	28	25	**Yes**

Table 5. Evaluations of measured E*nterococcus* bacteria concentrations with U.S. EPA (2012) criteria based on rolling 30-day averaging duration periods.

Location	Total Number of 30-day Periods Sampled	Number of Periods that Exceed Either the Geomean or STV	Meets §303(d) Policy for Listing
Russian River at Bridgehaven Station	31	4	No
Russian River at Camp Rose Beach	163	39	**Yes**
Russian River at Cloverdale River Park	30	0	No
Russian River at Casini Ranch Campground	30	3	No
Russian River at Commisky Station Rd	63	21	**Yes**
Russian River at Crocker Rd	24	11	**Yes**
Russian River at Diggers Bend	28	4	No
Russian River at Duncans Mills	30	8	**Yes**
Russian River at Forestville Access Beach	127	0	No
Russian River at Geyserville Bridge	44	4	No
Russian River at Hacienda Bridge	20	0	No
Russian River at Healdsburg Memorial Beach	158	17	No
Russian River at Hopland	20	4	No
Russian River at Jenner Boat Ramp	48	15	**Yes**
Russian River at Jimtown Bridge	47	30	**Yes**
Russian River at Johnsons Beach	125	29	**Yes**
Russian River at Monte Rio Beach	175	22	No
Russian River at Riverfront Park	60	18	**Yes**
Russian River at Steelhead Beach	155	29	**Yes**
Atascadero Creek at Green Valley Rd.	8	6	**Yes**
Dutch Bill Creek at Main St.	21	6	**Yes**
Foss Creek at Matheson St.	8	8	**Yes**
Green Valley Creek at Martinelli Rd.	20	17	**Yes**
Green Valley Creek at River Rd.	7	6	**Yes**
Laguna de Santa Rosa at Sebastopol Community Park	28	26	**Yes**
Santa Rosa Creek at Los Alamos Rd.	11	11	**Yes**
Santa Rosa Creek at Railroad St.	77	61	**Yes**

Table 6. Comparison of averaging duration periods on Section 303(d) listing policy criteria for measured fecal indicator bacteria concentrations

Location	Meets §303(d) Policy for Listing			
	E. coli Bacteria Concentration		*Enterococcus* Bacteria Concentration	
	Static 30-day Periods	Rolling 30-day Periods	Static 30-day Periods	Rolling 30-day Periods
Russian River at Bridgehaven Station	No	No	No	No
Russian River at Camp Rose Beach	No	No	**Yes**	**Yes**
Russian River at Cloverdale River Park	No	No	No	No
Russian River at Casini Ranch Campground	No	No	No	No
Russian River at Commisky Station Rd	No	No	**Yes**	**Yes**
Russian River at Crocker Rd	No	No	*	**Yes**
Russian River at Diggers Bend	No	No	No	No
Russian River at Duncans Mills	No	No	No	**Yes**
Russian River at Forestville Access Beach	No	No	No	No
Russian River at Geyserville Bridge	No	**Yes**	No	No
Russian River at Hacienda Bridge	No	No	No	No
Russian River at Healdsburg Memorial Beach	No	No	No	No
Russian River at Hopland	No	No	No	No
Russian River at Jenner Boat Ramp	No	No	**Yes**	**Yes**
Russian River at Jimtown Bridge	No	No	**Yes**	**Yes**
Russian River at Johnsons Beach	No	No	No	**Yes**
Russian River at Monte Rio Beach	No	No	No	No
Russian River at Riverfront Park	No	No	**Yes**	**Yes**
Russian River at Steelhead Beach	No	No	**Yes**	**Yes**
Atascadero Creek at Green Valley Rd.	No	**Yes**	No	**Yes**
Dutch Bill Creek at Main St.	No	No	No	**Yes**
Foss Creek at Matheson St.	**Yes**	**Yes**	**Yes**	**Yes**
Green Valley Creek at Martinelli Rd.	No	**Yes**	**Yes**	**Yes**
Green Valley Creek at River Rd.	No	**Yes**	**Yes**	**Yes**
Laguna de Santa Rosa at Sebastopol Community Park	**Yes**	**Yes**	**Yes**	**Yes**
Santa Rosa Creek at Los Alamos Rd.	**Yes**	**Yes**	**Yes**	**Yes**
Santa Rosa Creek at Railroad St.	**Yes**	**Yes**	**Yes**	**Yes**

* inadequate sample size for§303(d) Policy decision on stream reach

Table 7. Comparison of averaging duration periods on Section 303(d) listing policy criteria for either measured *E. coli* or *Enterococcus* bacteria concentrations.

Location	Meets §303(d) Policy for Listing	
	Static 30-day Periods	**Rolling 30-day Periods**
Russian River at Bridgehaven Station	No	No
Russian River at Camp Rose Beach	**Yes**	**Yes**
Russian River at Cloverdale River Park	No	No
Russian River at Casini Ranch Campground	No	No
Russian River at Commisky Station Rd	**Yes**	**Yes**
Russian River at Crocker Rd	No	**Yes**
Russian River at Diggers Bend	No	No
Russian River at Duncans Mills	No	**Yes**
Russian River at Forestville Access Beach	No	No
Russian River at Geyserville Bridge	No	No
Russian River at Hacienda Bridge	No	No
Russian River at Healdsburg Memorial Beach	No	No
Russian River at Hopland	No	No
Russian River at Jenner Boat Ramp	**Yes**	**Yes**
Russian River at Jimtown Bridge	**Yes**	**Yes**
Russian River at Johnsons Beach	No	**Yes**
Russian River at Monte Rio Beach	No	No
Russian River at Riverfront Park	**Yes**	**Yes**
Russian River at Steelhead Beach	**Yes**	**Yes**
Atascadero Creek at Green Valley Rd.	No	**Yes**
Dutch Bill Creek at Main St.	No	**Yes**
Foss Creek at Matheson St.	**Yes**	**Yes**
Green Valley Creek at Martinelli Rd.	**Yes**	**Yes**
Green Valley Creek at River Rd.	**Yes**	**Yes**
Laguna de Santa Rosa at Sebastopol Community Park	**Yes**	**Yes**
Santa Rosa Creek at Los Alamos Rd.	**Yes**	**Yes**
Santa Rosa Creek at Railroad St.	**Yes**	**Yes**

* inadequate sample size for§303(d) Policy decision on stream reach

Table 8. Comparison of geometric mean calculation methods for *Enterococcus* bacteria concentrations measured in the months of June through September 2011 from Dutch Bill Creek at Main Street in Monte Rio. **Red** font indicates when the USEPA (2012) criterion was exceeded.

Date	*Enterococcus* Bacteria Concentration (MPN/100mL)	Rolling Geometric Mean (MPN/100mL)	Static 30-day Period Month Number	Static 30-day Period Geometric Mean (MPN/100mL)
6/2/2011	10	10	6	23
6/7/2011	30	17		
6/14/2011	10	14		
6/21/2011	10	13		
6/28/2011	195	23		
7/5/2011	86	**35**	7	24
7/12/2011	10	28		
7/19/2011	10	28		
7/26/2011	41	**37**		
8/2/2011	10	20	8	16
8/9/2011	10	13		
8/16/2011	10	13		
8/23/2011	74	20		
8/30/2011	10	15	9	9
9/6/2011	10	15		
9/13/2011	10	15		
9/20/2011	55	21		
9/27/2011	1	9		