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 water contact recreation (REC-1) and non-contact water 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.

The Regional Water Board and the Sonoma County Water Agency have been collecting water samples for analysis of fecal indicator bacteria concentrations from various locations in the Russian River watershed. Recreational beneficial use criteria have been developed for measurements of bacteria concentrations to indicate a potential health risk from exposure to pathogens in surface waters. Most strains of fecal indicator bacteria do not directly pose a health risk to swimmers (i.e., primary contact recreators), but fecal indicator bacteria often co-occur with human pathogens and FIB concentrations are easier to measure than the actual pathogens that may pose a risk of illness. Over time, numerous measurements of fecal indicator bacteria concentrations have been made across the Russian River watershed to assess potential impairment to REC-1 and REC-2 beneficial uses.

The purpose of this memorandum is to assess the reductions needed in fecal indicator bacteria concentrations to support REC-1 and REC-2 uses at measurement locations in the Russian River watershed.
Recreational Beneficial Use Water Quality Criteria

The North Coast Water Quality Control Plan (Basin Plan) identifies REC-1 and REC-2 as existing beneficial uses in all surface waters of the Russian River watershed. Water Contact Recreation (REC-1) Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white-water activities, fishing, or use of natural hot springs. Non-Contact Water Recreation (REC-2) uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

The Basin Plan promulgates both narrative and numeric criteria (i.e. Water Quality Objectives (WQO)) for bacteria concentrations that are protective of the REC-1 and REC-2 beneficial uses.

The Basin Plan narrative Water Quality Objective states:
“\textit{The bacteriological quality of waters of the North Coast Region shall not be degraded beyond natural background levels.}”

The Basin Plan numeric Water Quality Objective states:
“\textit{In no case shall coliform concentrations in waters of the North Coast Region exceed the following: In waters designated for contact recreation (REC-1), the median fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed 50/100 ml, nor shall more than ten percent of total samples during any 30-day period exceed 400/100 ml.}”

Since 2001, fecal coliform bacteria concentrations have been routinely measured in the Russian River watershed. New analytical methods were developed and approved by the U.S. Environmental Protection Agency (USEPA) that measure \textit{E. coli} and \textit{Enterococcus} bacteria concentrations (IDEXX 2001). These analytical methods have been used for assessment of REC-1 in the Russian River since 2001. Therefore, the older fecal coliform bacteria concentration measurements were not assessed.

The USEPA (2012) recently published freshwater recreational beneficial use criteria based on \textit{E. coli} and \textit{Enterococcus} bacteria concentrations (Table 1). These criteria are based on the distribution of numerous bacteria concentration measurements collected over time and are not based on measurements made from single grab samples. The criteria were published in the U.S. Federal Register for both the geometric mean and the statistical threshold (STV) values. The geometric mean criterion is compared to the logarithmic average of the bacteria concentration distribution. The STV criterion is compared to the 90th percentile of the bacteria concentration distribution. The criteria are expressed as
colony forming units per 100 mL of samples. Colony forming units were assumed in this
assessment to be equivalent to the most probable number derived from the new analytical
methods approved by the USEPA.

Criteria were also published for two different levels of illness risk. The first level of risk (36
estimated illnesses per 1,000 recreators) is the same risk level applied with the previous
recreational criteria (USEPA 1986). The USEPA (1986) criteria recommendations
correspond to the level of risk associated with an estimated illness rate of the number of
highly credible gastrointestinal illnesses (HCGI) per 1,000 primary contact recreators. The
information developed for the 2012 criteria used a more comprehensive definition of GI
illness, referred to as NEEAR-GI (NGI). Because NGI is broader than HCGI (i.e., NGI includes
diarrhea without the requirement of fever), more illness cases were reported and
associated with recreation using the NGI definition of illness, at the same level of water
quality observed using the previous illness definition (i.e., HCGI). The USEPA (2012) also
recommends more protective criteria that correspond to an illness rate of 32 NGI per 1,000
primary contact recreators to “encourage an incremental improvement in water quality.”

Bacteria Concentration Measurements

Table 2 shows the Russian River watershed locations and dates where measurements of *E.
coli* and *Enterococcus* bacteria have been collected by the Regional Water Board and the
Sonoma County Water Agency. The sampling locations are also mapped in Figures 1
through 7. These data were assessed for the support and protection of REC-1 beneficial
use. A distribution size of five samples was selected as the minimum number of samples
needed to determine distribution characteristics based on minimum sample size
requirements identified in the USEPA (1976) recreation criteria. There are bacteria
concentrations measured at other locations in the Russian River watershed not shown on
Table 2 that were not assessed due to an inadequate sample size at the location.

Several of the analyses resulted in bacteria concentrations that were either below or above
the reporting limits of the analytical test. Measurements analyzed beyond the reporting
unit are called “censored” data (Helsel and Hirsch 2002). Estimates of summary statistics,
which best represent the entire distribution of data, both below and above the reporting
limit, are needed to accurately analyze environmental conditions. As such, unbiased
estimates of the censored data are needed to assess the variation in measured bacteria
concentrations. Regression on order statistics (ROS) was applied to estimate censored data
prior to use in assessments. ROS is based on the modified probability plotting (Helsel
1990). The approach fits a regression line to log transformed observation values beyond
the reporting limit against their standard scores. The regression line is used to estimate
the values of each censored value. The data are then transformed back to the measurement
unit. The fitted distribution was used only to extrapolate the measurement values below
the analytical reporting limit. These extrapolated values are not considered estimates for
specific samples, but are only used collectively to estimate distributional characteristics.
**Statistical Rollback Method**

The statistical rollback method (Ott 1995) describes a way to use the statistical characteristics of a bacteria concentration distribution to estimate future concentrations after abatement processes are applied to sources. The method relies on basic dispersion and dilution assumptions and their effect on the mean and standard deviation of the bacteria concentration distribution. The statistical rollback method provides a statistical estimate of the new bacteria concentration distribution after a reduction factor is applied. With the USEPA's two-part bacteria criteria (i.e., geometric mean and STV), protection of REC-1 beneficial use will be achieved only when both criteria are met. Therefore, the percent reduction needed to meet the REC-1 beneficial use will be determined from the most restrictive of the dual bacteria concentration criteria based on the location-specific bacteria concentration distribution.

The following are the assumptions associated with the statistical rollback method (Joy 2000):

1. If $Q = \text{the concentration of a contaminant at a source, and } D = \text{the dilution-diffusion factor, and } X = \text{the concentration of the contaminant at the monitoring site, then } X = Q*D.$
2. Successive random dilution and diffusion of a contaminant $Q$ in the environment often result in a lognormal distribution of the contaminant $X$ at a distant monitoring site.
3. The coefficient of variation (CV) of $Q$ is the same before and after applying a “rollback” (i.e., the CV in the post-control state will be the same as the CV in the pre-control state). The rollback factor $= r$, a reduction factor expressed as a decimal (i.e., a 70% reduction would be a rollback factor of 0.3). The random variable $Q$ represents a pre-control source output state and $rQ$ represents the post-control state.
4. If $D$ remains consistent in the pre-control and post-control states (long-term hydrological and climatic conditions remain unchanged), then $CV(Q)*CV(D)=CV(X)$, and $CV(X)$ will be the same before and after the rollback is applied.
5. If $X$ is multiplied by the rollback factor $r$, then the variance in the post-control state will be multiplied by $r^2$, and the post-control standard deviation will be multiplied by $r$.
6. If $X$ is multiplied by the rollback factor $r$, the quantiles of the concentration distribution will be scaled geometrically.
7. If any random variable is multiplied by a factor $r$, then its expected value and standard deviation also will be multiplied by $r$, and its CV will be unchanged.

Since, the statistical rollback method is a parametric approach, it requires additional assumptions are met with the bacteria concentration distribution. The data set must have independent samples, show linearity, and be distributed normally. The median bacteria concentration from replicate samples was used to address sample independence. Inadequate measurement data exist to test for serial autocorrelation, but it is not expected between daily samples. If fact, most measurements used in the assessment were collected more than a week apart.
The linearity and normality of the bacteria concentration distributions can be visually assessed for meeting parametric assumptions. Figures 8 through 117 present the bacteria concentration measurements at each assessed location in the Russian River watershed. The figures plot the bacteria concentration against the standard normal variate. The standard normal variate is a normally distributed random variable with expected value 0 and variance 1. Using the standard normal variate allows the distribution to be displayed linearly.

The measurements are compared to the best fit of normal and log-normal distributions derived from the measurements. At most locations, the bacteria concentrations fit a log-normal distribution better than a normal distribution. Those locations where the difference is not as apparent are represented by small sample sizes (Figures 94 and 95). A more normal distribution would be expected if a larger sample size was available, such as Figures 112 and 113. This assessment of the bacteria concentration distributions demonstrates that a logarithmic transformation of the measurements will provide a distribution that meets the parametric assumptions required of the statistical rollback method.

The new criteria (USEPA 21012) do not specify a minimum sample size needed for the averaging period. The USEPA (1976) criteria had specified a minimum of five samples needed to apply the criteria. Therefore, a single bacteria concentration measurement collected within a 30-day period would be used with both the geometric mean and the STV criteria. Small sample sizes are simply not representative of the actual distribution found with larger sample sizes.

USEPA (2012) recommends a 30-day averaging period to apply the recreational criteria. The short duration was recommended to “allow for the detection of transient fluctuations in water quality in a timely manner.” USEPA (2012) acknowledges that a longer duration averaging period would “improve the accuracy of the characterization of water quality.” Attainment of a longer duration bacteria concentration distribution that meets REC-1 criteria will assure that any particular 30-day averaging period would also likely achieve REC-1 criteria. Therefore, all the bacteria concentration measurements collected at any particular location were used for the statistical rollback method to improve the accuracy of the percent reduction estimates.

Figures 118 and 119 demonstrate the application of the statistical rollback method with bacteria concentration measurements collected in the Laguna de Santa Rosa. The figures compare the log-transformed bell-shaped distribution curve with the distribution linearized by the standard normal variate using measured *E. coli* bacteria concentrations. The figures show that a twenty-seven percent (27%) reduction in *E. coli* bacteria concentrations will be needed to achieve the geometric mean criterion of 126 MPN/100mL for an estimated risk of 36 illnesses per 1000 recreators. However, that reduction would not likely achieve the STV criterion based on the assumptions of the statistical rollback method. An eighty-nine percent (89%) reduction in *E. coli* bacteria concentration will be
needed to achieve the STV criterion of 410 MPN/100mL. Therefore, an eighty-nine percent (89%) reduction in the geometric mean is needed. Therefore, for the Laguna de Santa Rosa location, a target geometric mean of 18 MPN/100mL (an 89% reduction from the current geometric mean of 172 MPN/100mL) will be needed to meet both USEPA (2012) criteria for support of the REC-1 beneficial use.

Assessment Results

Tables 3 and 4 summarize whether the bacteria concentration measurements meet the USEPA (2012) criteria for each of the assessed locations in the Russian River watershed. All location in the Russian River met both criteria for \textit{E. coli} bacteria concentrations. However, most of the tributaries did not meet the criteria. Most of the locations on the Russian River also met the criteria for \textit{Enterococcus} bacteria concentration, except for five locations. Three of these locations are in the lower Russian River estuary. Again, most of the tributaries did not meet the criteria for \textit{Enterococcus} bacteria concentration.

Figures 120 through 229 show the distribution of bacteria concentrations, the USEPA (2012) criteria, and any percent reduction goals and criteria targets. Tables 5 and 6 present those locations where a bacteria concentration reduction is needed to meet the USEPA (2012) criteria. In most cases, a larger percent reduction is needed to meet the STV criterion as opposed to the geometric mean criteria. Only \textit{Enterococcus} bacteria measurements from the Russian River at Crocker Road needed a greater reduction to meet the geometric mean criterion than the STV criterion. This anomaly may be due to the limited sample size not truly representing the actual distribution of bacteria concentrations for that location.

Findings

Based on the assessment of \textit{E. coli} and \textit{Enterococcus} bacteria concentrations measured in the Russian River watershed and presented in this memorandum, Regional Water Board staff can make the following findings:

- All locations in the Russian River met the criteria for \textit{E. coli} bacteria concentrations.
- Most of the Russian River tributaries did not meet the criteria for \textit{E. coli} bacteria concentrations.
- Most of the locations on the Russian River met the criteria for \textit{Enterococcus} bacteria concentrations, except for five locations. Three of these locations are in the lower Russian River estuary.
- Most of the Russian River tributaries did not meet the criteria for \textit{Enterococcus} bacteria concentration.
- For most of the locations not meeting the criteria, a larger percent reduction is needed to meet the STV criterion as opposed to the geometric mean criteria.
CITATIONS


### TABLES

Table 1. Recreational Water Quality Criteria (USEPA 2012)

<table>
<thead>
<tr>
<th>Criteria Elements</th>
<th><strong>Recommendation 1</strong> Estimated Illness Rate 36 per 1,000 recreators</th>
<th><strong>Recommendation 2</strong> Estimated Illness Rate 32 per 1,000 recreators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fecal Indicator Bacteria</strong></td>
<td>Geometric Mean (cfu/100mL)</td>
<td>Statistical Threshold Value (cfu/100mL)</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>126</td>
<td>410</td>
</tr>
<tr>
<td><em>Enterococcus</em></td>
<td>35</td>
<td>130</td>
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</table>
Table 2. Available *E. coli* and *Enterococcus* Bacteria Concentration Measurements Assessed

<table>
<thead>
<tr>
<th>Location</th>
<th>Measurement Dates</th>
<th>Number of Measurements</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
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<tr>
<td><strong>Russian River</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jenner Boat Ramp</td>
<td>2009 - 2012</td>
<td>58</td>
<td>38.4494</td>
<td>-123.1156</td>
</tr>
<tr>
<td>Bridgehaven</td>
<td>2011 - 2012</td>
<td>31</td>
<td>38.4383</td>
<td>-123.0968</td>
</tr>
<tr>
<td>Duncans Mills</td>
<td>2011 - 2012</td>
<td>31</td>
<td>38.4541</td>
<td>-123.0495</td>
</tr>
<tr>
<td>Casini Ranch Campground</td>
<td>2011 - 2012</td>
<td>31</td>
<td>38.4653</td>
<td>-123.0490</td>
</tr>
<tr>
<td>Monte Rio Beach</td>
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<td>233</td>
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<td>-123.0094</td>
</tr>
<tr>
<td>Johnsons Beach</td>
<td>2002 - 2012</td>
<td>198</td>
<td>38.4994</td>
<td>-122.9982</td>
</tr>
<tr>
<td>Hacienda Bridge</td>
<td>2012</td>
<td>21</td>
<td>38.5081</td>
<td>-122.9279</td>
</tr>
<tr>
<td>Forestville Access Beach</td>
<td>2007 - 2012</td>
<td>126</td>
<td>38.5107</td>
<td>-122.9239</td>
</tr>
<tr>
<td>Steelhead Beach</td>
<td>2002 – 2012</td>
<td>200</td>
<td>38.5002</td>
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<tr>
<td>Riverfront Park</td>
<td>2011 - 2012</td>
<td>32</td>
<td>38.5166</td>
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<tr>
<td>Healdsburg Memorial Beach</td>
<td>2002 - 2012</td>
<td>210</td>
<td>38.6035</td>
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<tr>
<td>Camp Rose Beach</td>
<td>2002 - 2012</td>
<td>208</td>
<td>38.6136</td>
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</tr>
<tr>
<td>Digger Bend</td>
<td>2011 - 2012</td>
<td>31</td>
<td>38.6328</td>
<td>-122.8508</td>
</tr>
<tr>
<td>Jimpstown Bridge</td>
<td>2009 - 2012</td>
<td>95</td>
<td>38.6585</td>
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<tr>
<td>Geyserville Bridge</td>
<td>2009 - 2011</td>
<td>41</td>
<td>38.7128</td>
<td>-122.8954</td>
</tr>
<tr>
<td>Crocker Road</td>
<td>2012</td>
<td>24</td>
<td>38.8087</td>
<td>-123.0081</td>
</tr>
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<td>Cloverdale River Park</td>
<td>2009 - 2012</td>
<td>50</td>
<td>38.8232</td>
<td>-123.0095</td>
</tr>
<tr>
<td>Commisky Station Road</td>
<td>2009 - 2012</td>
<td>61</td>
<td>38.8874</td>
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<tr>
<td>Hopland</td>
<td>2012</td>
<td>21</td>
<td>38.9717</td>
<td>-123.1070</td>
</tr>
<tr>
<td><strong>Tributaries</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atascadero Creek at Green Valley Road</td>
<td>2002 - 2009</td>
<td>9</td>
<td>38.4445</td>
<td>-122.8770</td>
</tr>
<tr>
<td>Dutch Bill Creek at Main Street</td>
<td>2011</td>
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<td>-123.0090</td>
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<tr>
<td>Foss Creek at Matheson Street</td>
<td>2002 - 2009</td>
<td>10</td>
<td>38.6104</td>
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<tr>
<td>Green Valley Creek at Martinelli Road</td>
<td>2008 - 2011</td>
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<td>38.4788</td>
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</tr>
<tr>
<td>Laguna de Santa Rosa at Sebastopol Community Center</td>
<td>2008 - 2011</td>
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<td>38.4080</td>
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<td>Mark West Creek at Trenton-Healdsburg Road</td>
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<td>9</td>
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<td>Santa Rosa Creek at Highway 12</td>
<td>2001 - 2011</td>
<td>33</td>
<td>38.4571</td>
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</tr>
<tr>
<td>Santa Rosa Creek @ Railroad Street</td>
<td>2001 - 2012</td>
<td>97</td>
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</tr>
<tr>
<td>Santa Rosa Creek @ Wildwood Mountain Road*</td>
<td>2008 - 2009</td>
<td>6</td>
<td>38.4669</td>
<td>-122.6220</td>
</tr>
</tbody>
</table>

* only *Enterococcus* Bacteria concentration measurements are available
Table 3. Assessment of *E. coli* Bacteria Concentration Measurements with USEPA (2012) Criteria

<table>
<thead>
<tr>
<th>Location</th>
<th>Illness rate = 36/1000 recreators</th>
<th>Illness rate = 32/1000 recreators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meets Geomean &lt;= 126</td>
<td>Meets STV &lt;= 410</td>
</tr>
<tr>
<td></td>
<td>Meets Geomean &lt;= 100</td>
<td>Meets STV &lt;= 320</td>
</tr>
</tbody>
</table>

**Russian River**

- Jenner Boat Ramp                | Yes | Yes | Yes | Yes |
- Bridgehaven                      | Yes | Yes | Yes | Yes |
- Duncans Mills                    | Yes | Yes | Yes | Yes |
- Casini Ranch Campground          | Yes | Yes | Yes | Yes |
- Monte Rio Beach                  | Yes | Yes | Yes | Yes |
- Johnsons Beach                   | Yes | Yes | Yes | Yes |
- Hacienda Bridge                  | Yes | Yes | Yes | Yes |
- Forestville Access Beach         | Yes | Yes | Yes | Yes |
- Steelhead Beach                  | Yes | Yes | Yes | Yes |
- Riverfront Park                  | Yes | Yes | Yes | Yes |
- Healdsburg Memorial Beach        | Yes | Yes | Yes | Yes |
- Camp Rose Beach                  | Yes | Yes | Yes | Yes |
- Digger Bend                      | Yes | Yes | Yes | Yes |
- Jimtown Bridge                   | Yes | Yes | Yes | Yes |
- Geyserville Bridge               | Yes | Yes | Yes | Yes |
- Crocker Rd                       | Yes | Yes | Yes | Yes |
- Cloverdale River Park            | Yes | Yes | Yes | Yes |
- Commissky Station Rd             | Yes | Yes | Yes | Yes |
- Hopland                          | Yes | Yes | Yes | Yes |

**Tributaries**

- Atascadero Creek                | No  | No  | No  | No  |
- Dutch Bill Creek                | Yes | Yes | Yes | Yes |
- Foss Creek                      | No  | No  | No  | No  |
- Green Valley Creek              | Yes | No  | No  | No  |
- Laguna de Santa Rosa            | No  | No  | No  | No  |
- Mark West Creek                 | Yes | Yes | Yes | Yes |
- Santa Rosa Creek at Highway 12  | No  | No  | No  | No  |
- Santa Rosa Creek at Railroad Street | No  | No  | No  | No  |
Table 4. Assessment of *Enterococcus* Bacteria Concentration Measurements with USEPA (2012) Criteria

<table>
<thead>
<tr>
<th>Location</th>
<th>Illness rate = 36/1000 recreators</th>
<th>Illness rate = 32/1000 recreators</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Meets Geomean &lt;= 35</td>
<td>Meets STV &lt;= 130</td>
</tr>
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<td><strong>Russian River</strong></td>
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<td></td>
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<tr>
<td>Jenner Boat Ramp</td>
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<td>No</td>
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<td>Bridgehaven</td>
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<td>Duncans Mills</td>
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<td>Mark West Creek</td>
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<tr>
<td>Santa Rosa Creek at Highway 12</td>
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<tr>
<td>Santa Rosa Creek at Railroad Street</td>
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<td>No</td>
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<td>Santa Rosa Creek at Wildwood Mountain Road</td>
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Table 5. Percent Reductions needed to meet *E. coli* Bacteria Concentration Criteria

<table>
<thead>
<tr>
<th>Location</th>
<th>Percent Reduction Needed to Meet Criteria</th>
<th>Illness rate = 36/1000 recreators</th>
<th>Illness rate = 32/1000 recreators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geomean &lt;= 126</td>
<td>STV &lt;= 410</td>
<td>REC-1</td>
</tr>
<tr>
<td>Atascadero Creek at Green Valley Road</td>
<td>75%</td>
<td>89%</td>
<td>89%</td>
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<td></td>
<td></td>
<td>80%</td>
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<tr>
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<td>Location</td>
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<td>Illness rate = 32/1000 recreators</td>
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<td>Geomean &lt;= 35</td>
<td>STV &lt;= 130</td>
<td>REC-1</td>
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<tr>
<td>Russian River at Jenner Boat Ramp</td>
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<tr>
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<td>Russian River at Duncans Mills</td>
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<td>Santa Rosa Creek at Highway 12</td>
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<td>Santa Rosa Creek at Wildwood Mountain Road</td>
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FIGURES

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Figure 209. Comparison of *E. coli* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek to concentration targets for estimated 32 illnesses per 1,000 recreators
Figure 210. Comparison of *Enterococcus* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek to concentration targets for estimated 36 illnesses per 1,000 recreators.

Figure 211. Comparison of *Enterococcus* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek to concentration targets for estimated 32 illnesses per 1,000 recreators.
Figure 212. Comparison of *E. coli* bacteria concentration measurements collected at the Sebastopol Community Center in the Laguna de Santa Rosa to concentration targets for estimated 36 illnesses per 1,000 recreators

Figure 213. Comparison of *E. coli* bacteria concentration measurements collected at the Sebastopol Community Center in the Laguna de Santa Rosa to concentration targets for estimated 32 illnesses per 1,000 recreators
Figure 214. Comparison of *Enterococcus* bacteria concentration measurements collected at Sebastopol Community Center in the Laguna de Santa Rosa to concentration targets for estimated 36 illnesses per 1,000 recreators

Figure 215. Comparison of *Enterococcus* bacteria concentration measurements collected at Sebastopol Community Center in the Laguna de Santa Rosa to concentration targets for estimated 32 illnesses per 1,000 recreators
Figure 216. Comparison of *E. coli* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek to concentration targets for estimated 36 illnesses per 1,000 recreators.

Figure 217. Comparison of *E. coli* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek to concentration targets for estimated 32 illnesses per 1,000 recreators.
Figure 218. Comparison of *Enterococcus* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

Figure 219. Comparison of *Enterococcus* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek to concentration targets for estimated 32 illnesses per 1,000 recreators
Figure 220. Comparison of *E. coli* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

Figure 221. Comparison of *E. coli* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators
Figure 222. Comparison of *Enterococcus* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

Figure 223. Comparison of *Enterococcus* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators
Figure 224. Comparison of *E. coli* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

Figure 225. Comparison of *E. coli* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators
Figure 226. Comparison of *Enterococcus* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

Figure 227. Comparison of *Enterococcus* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators
Figure 228. Comparison of Enterococcus bacteria concentration measurements collected at Wildwood Mountain Road in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

Figure 229. Comparison of Enterococcus bacteria concentration measurements collected at Wildwood Mountain Road in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators