TO: File: Russian River; TMDL Development and Planning

FROM: Steve Butkus

DATE: November 7, 2013

SUBJECT: FECAL INDICATOR BACTERIA CONCENTRATION REDUCTIONS NEEDED TO MEET 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 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:

> *"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:

> *"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 *E. coli* and *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 *E. coli* and *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 90^{th} 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 = the concentration of a contaminant at a source, and D = the dilution-diffusion factor, and X = 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 samples 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 *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 *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 *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 *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 *E. coli* and *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 *E coli* bacteria concentrations.
- Most of the Russian River tributaries did not meet the criteria for *E coli* bacteria concentrations.
- Most of the locations on the Russian River met the criteria for *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 *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

Helsel, D.R. 1990. Less Than Obvious: Statistical Treatment of Data Below the Detection Limit. *Environmental Science and Technology* 24(12): 1766-1774.

Helsel, D.R. and R. M. Hirsch, 2002. Statistical Methods in Water Resources Techniques of Water Resources Investigations, Book 4, chapter A3. U.S. Geological Survey, Reston, VA.

IDEXX. 2001. Colilert® and Enterolert® Test Pack Procedures IDEXX Laboratories, Inc., Westbrook, Maine. (http://www.idexx.com/view/xhtml/en_us/water/water-microbiology.jsf).

Joy, J. 2000. Lower Nooksack River Basin Bacteria Total Maximum Daily Load Evaluation. Publication No. 00-03-006. Washington State Dept. of Ecology, Olympia, WA.

Ott, W., 1995. Environmental Statistics and Data Analysis. Lewis Publishers, New York, NY.

USEPA 1976. Quality Criteria for Water. U.S. Environmental Protection Agency: Washington, DC.

USEPA 1986. Ambient Water Quality Criteria for Bacteria – 1986. Publication No. EPA440/5-84-002. U.S. Environmental Protection Agency: Washington, DC.

USEPA 2012. Recreational Water Quality Criteria. Publication No. EPA 820-F-12-058. U.S. Environmental Protection Agency, Washington, DC.

TABLES

Table 1. Recreational Water Quality Criteria (USEPA 2012)

Criteria Elements	**Recommendation 1** Estimated Illness Rate 36 per 1,000 recreators		**Recommendation 2** Estimated Illness Rate 32 per 1,000 recreators	
Fecal Indicator Bacteria	Geometric Mean (cfu/100mL)	Statistical Threshold Value (cfu/100mL)	Geometric Mean (cfu/100mL)	Statistical Threshold Value (cfu/100mL)
E. coli	126	410	100	320
Enterococcus	35	130	30	110

Table 2. Available *E. coli* and *Enterococcus* Bacteria Concentration Measurements Assessed

Location	Measurement Dates	Number of Measurements	Latitude	Longitude
Russian River				
Jenner Boat Ramp	2009 - 2012	58	38.4494	-123.1156
Bridgehaven	2011 - 2012	31	38.4383	-123.0968
Duncans Mills	2011 - 2012	31	38.4541	-123.0495
Casini Ranch Campground	2011 - 2012	31	38.4653	-123.0490
Monte Rio Beach	2002 – 2012	233	38.4663	-123.0094
Johnsons Beach	2002 - 2012	198	38.4994	-122.9982
Hacienda Bridge	2012	21	38.5081	-122.9279
Forestville Access Beach	2007 - 2012	126	38.5107	-122.9239
Steelhead Beach	2002 – 2012	200	38.5002	-122.8995
Riverfront Park	2011 - 2012	32	38.5166	-122.8640
Healdsburg Memorial Beach	2002 - 2012	210	38.6035	-122.8598
Camp Rose Beach	2002 - 2012	208	38.6136	-122.8312
Digger Bend	2011 - 2012	31	38.6328	-122.8508
Jimtown Bridge	2009 - 2012	95	38.6585	-122.8295
Geyserville Bridge	2009 - 2011	41	38.7128	-122.8954
Crocker Road	2012	24	38.8087	-123.0081
Cloverdale River Park	2009 - 2012	50	38.8232	-123.0095
Commisky Station Road	2009 - 2012	61	38.8874	-123.0544
Hopland	2012	21	38.9717	-123.1070
Tributaries				
Atascadero Creek at Green Valley Road	2002 - 2009	9	38.4445	-122.8770
Dutch Bill Creek at Main Street	2011	21	38.4650	-123.0090
Foss Creek at Matheson Street	2002 - 2009	10	38.6104	-122.8716
Green Valley Creek at Martinelli Road	2008 - 2011	27	38.4788	-122.9084
Laguna de Santa Rosa at Sebastopol Community Center	2008 - 2011	28	38.4080	-122.8182
Mark West Creek at Trenton-Healdsburg Road	2012	9	38.4939	-122.8530
Santa Rosa Creek at Highway 12	2001 - 2011	33	38.4571	-122.6309
Santa Rosa Creek @ Railroad Street	2001 - 2012	97	38.4348	-122.7191
Santa Rosa Creek @ Wildwood Mountain Road*	2008 - 2009	6	38.4669	-122.6220

* only *Enterococcus* Bacteria concentration measurements are available

Table 3. Assessment of *E. coli* Bacteria Concentration Measurements with USEPA (2012) Criteria

Location	Illness rate = 36/1000 recreators		Illness rate = 32/1000 recreators	
	Meets Geomean <= 126	Meets STV <= 410	Meets Geomean <= 100	Meets STV <= 320
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
Commisky 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

Location	Illness rate = 36/1000 recreators		Illness rate = 32/1000 recreators	
	Meets Geomean <= 35	Meets STV <= 130	Meets Geomean <= 30	Meets STV <= 110
Russian River				
Jenner Boat Ramp	Yes	**No**	Yes	**No**
Bridgehaven	Yes	**No**	Yes	**No**
Duncans Mills	Yes	**No**	Yes	**No**
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	**No**	Yes	**No**
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 Road	**No**	Yes	**No**	**No**
Cloverdale River Park	Yes	Yes	Yes	Yes
Commisky Station Road	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	**No**	**No**	**No**	**No**
Laguna de Santa Rosa	**No**	**No**	**No**	**No**
Mark West Creek	**No**	**No**	**No**	**No**
Santa Rosa Creek at Highway 12	**No**	**No**	**No**	**No**
Santa Rosa Creek at Railroad Street	**No**	**No**	**No**	**No**
Santa Rosa Creek at Wildwood Mountain Road	**No**	**No**	**No**	**No**

Table 5. Percent Reductions needed to meet *E. coli* Bacteria Concentration Criteria

Location	**Percent Reduction Needed to Meet Criteria**					
	Illness rate = 36/1000 recreators			**Illness rate = 32/1000 recreators**		
	Geomean <= 126	**STV <= 410**	**REC-1**	**Geomean <= 100**	**STV <= 320**	**REC-1**
Atascadero Creek at Green Valley Road	75%	89%	89%	80%	91%	91%
Foss Creek at Matheson Street	96%	99%	99%	97%	99%	99%
Green Valley Creek at Martinelli Road	0%	34%	34%	12%	49%	49%
Laguna de Santa Rosa at Sebastopol Community Center	27%	89%	89%	42%	92%	92%
Santa Rosa Creek at Highway 12	49%	56%	56%	60%	66%	66%
Santa Rosa Creek at Railroad Street	74%	79%	79%	79%	84%	84%

Table 6. Percent Reductions needed to meet *Enterococus* Bacteria Concentration Criteria

Location	**Illness rate = 36/1000 recreators**			**Illness rate = 32/1000 recreators**		
	Geomean <= 35	**STV <= 130**	**REC-1**	**Geomean <= 30**	**STV <= 110**	**REC-1**
Russian River at Jenner Boat Ramp	0%	11%	11%	0%	25%	25%
Russian River at Bridgehaven	0%	24%	24%	0%	36%	36%
Russian River at Duncans Mills	0%	3%	3%	0%	18%	18%
Russian River at Riverfront Park	0%	41%	41%	0%	50%	50%
Russian River at Crocker Road	24%	8%	24%	35%	22%	35%
Atascadero Creek at Green Valley Road	91%	98%	98%	92%	98%	98%
Foss Creek at Matheson Street	96%	97%	97%	97%	97%	97%
Green Valley Creek at Martinelli Road	72%	91%	91%	76%	93%	93%
Laguna de Santa Rosa at Sebastopol Community Center	75%	91%	91%	78%	92%	92%
Mark West Creek at Trenton-Healdsburg Road	86%	90%	90%	88%	92%	92%
Santa Rosa Creek at Highway 12	68%	74%	74%	72%	78%	78%
Santa Rosa Creek at Railroad Street	73%	89%	89%	77%	90%	90%
Santa Rosa Creek at Wildwood Mountain Road	73%	73%	73%	77%	78%	78%

FIGURES

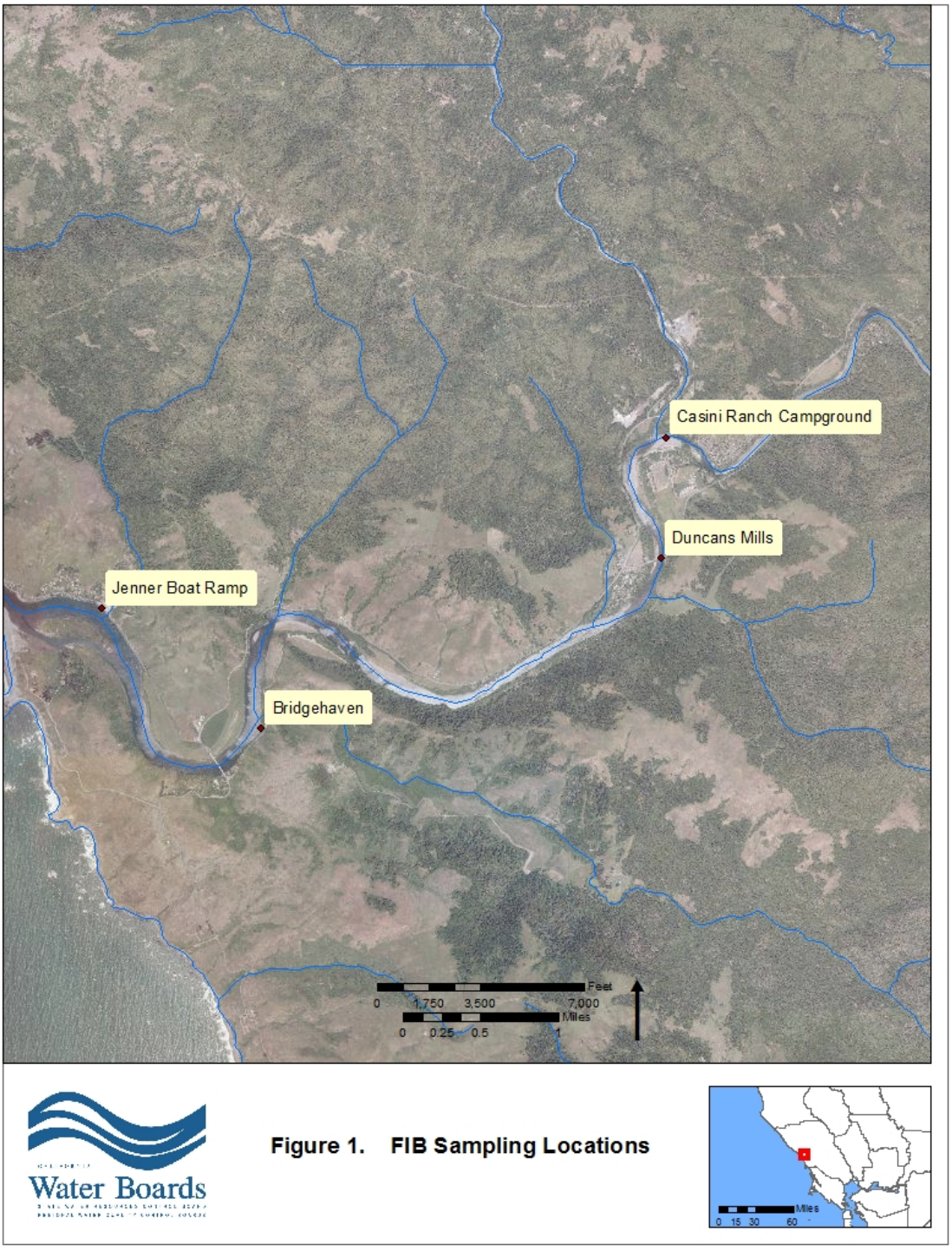

Figure 1. Locations Assessed for REC-1 Beneficial Use in the Russian River Watershed

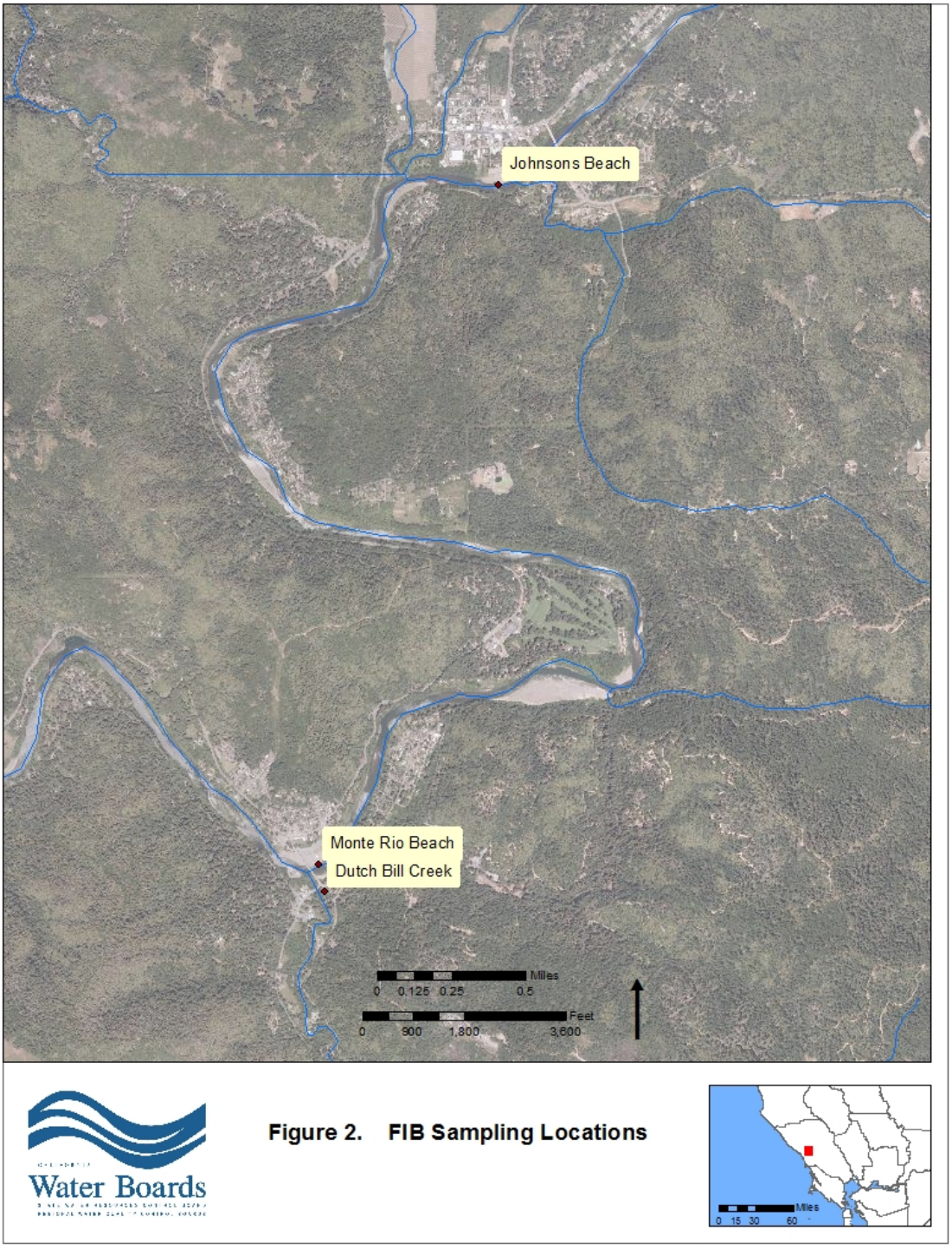

Figure 2. Locations Assessed for REC-1 Beneficial Use in the Russian River Watershed

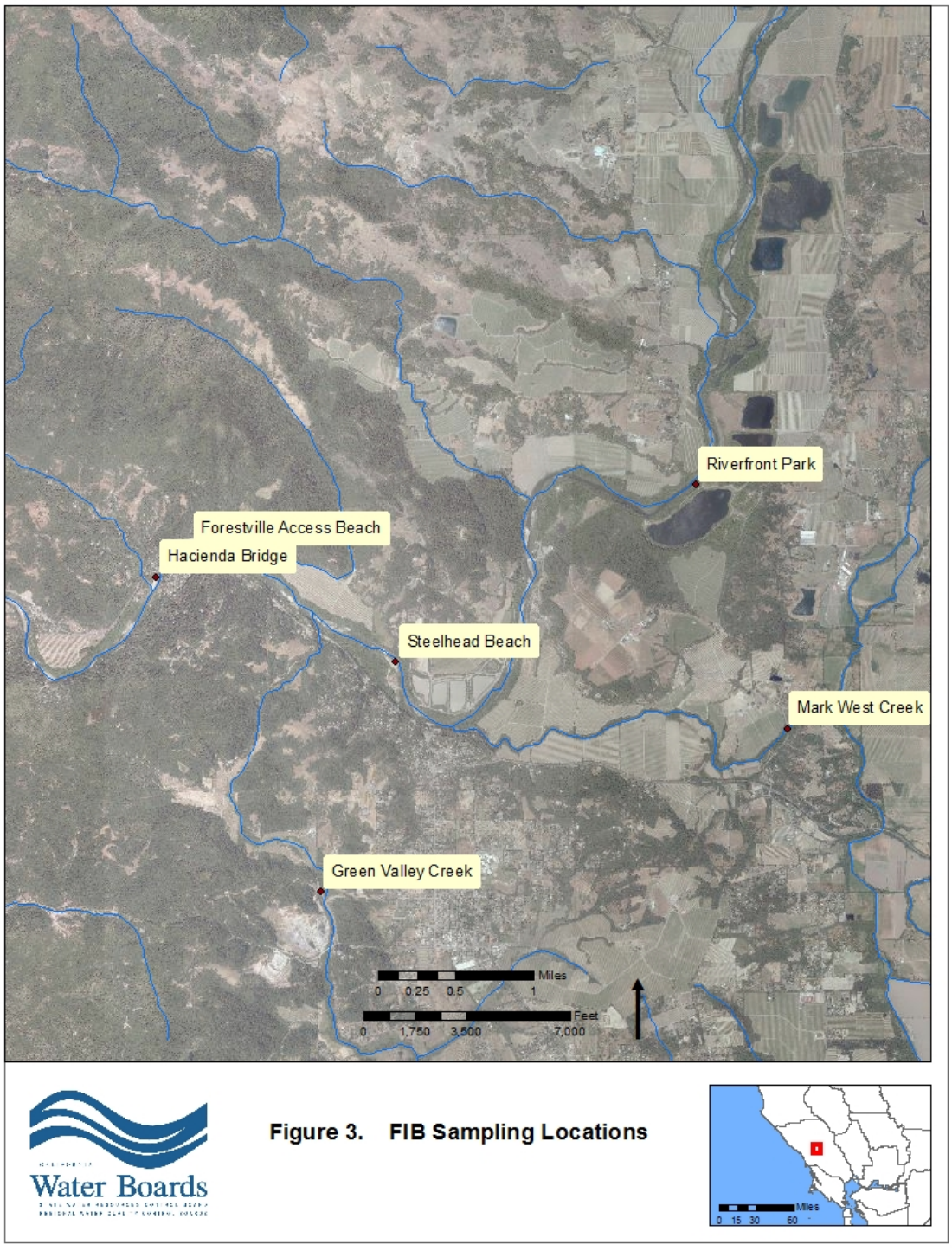

Figure 3. Locations Assessed for REC-1 Beneficial Use in the Russian River Watershed

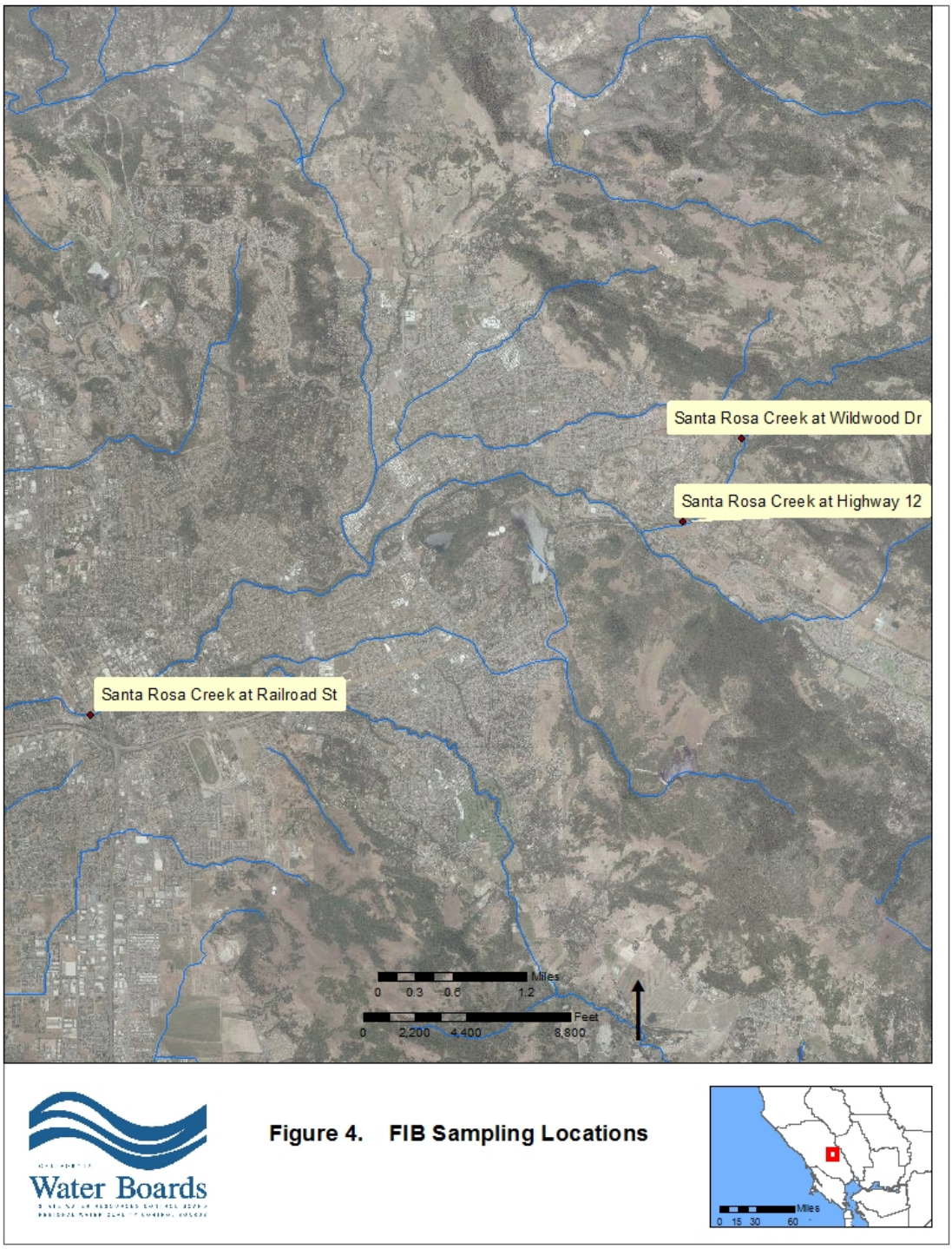

Figure 4. Locations Assessed for REC-1 Beneficial Use in the Russian River Watershed

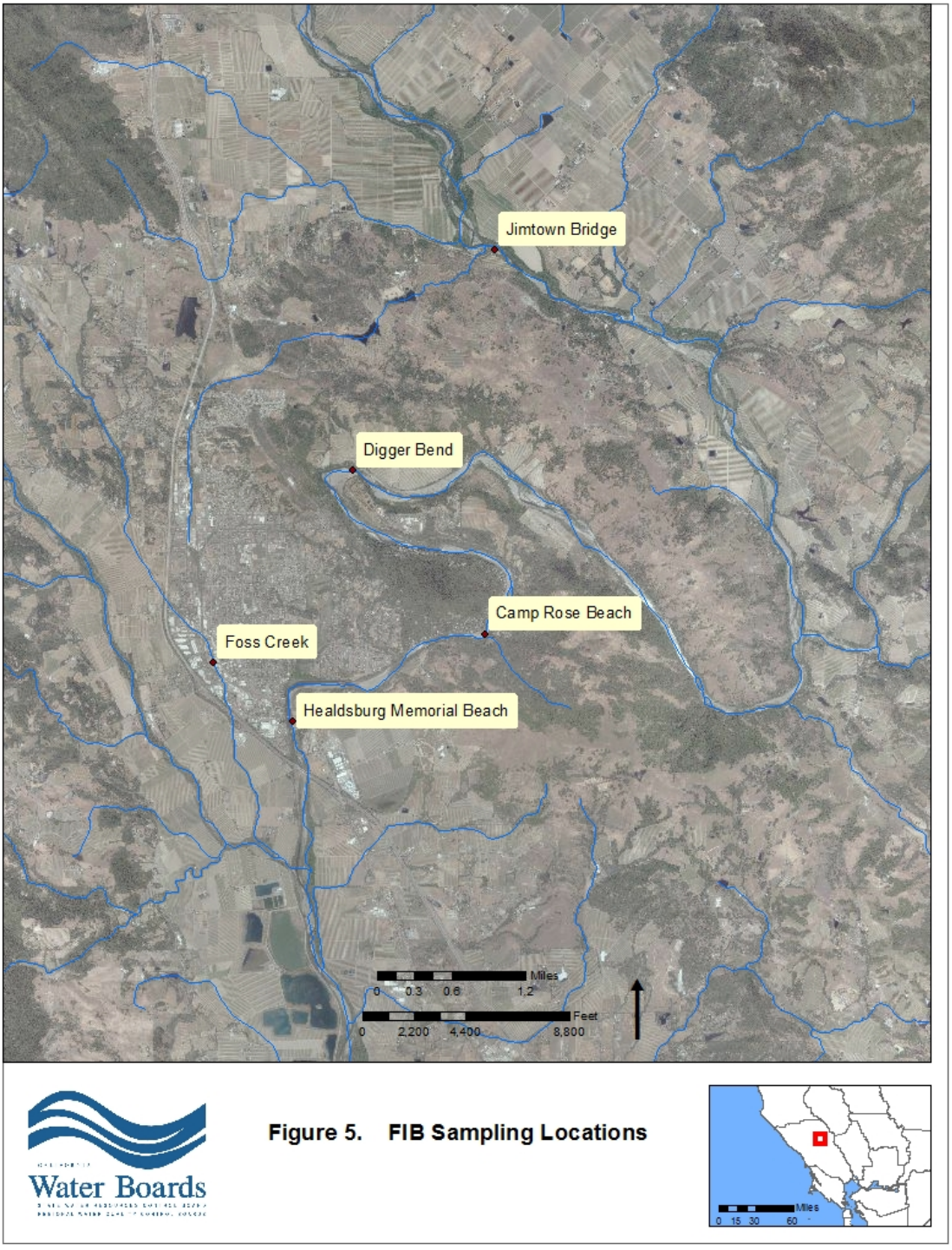

Figure 5. Locations Assessed for REC-1 Beneficial Use in the Russian River Watershed

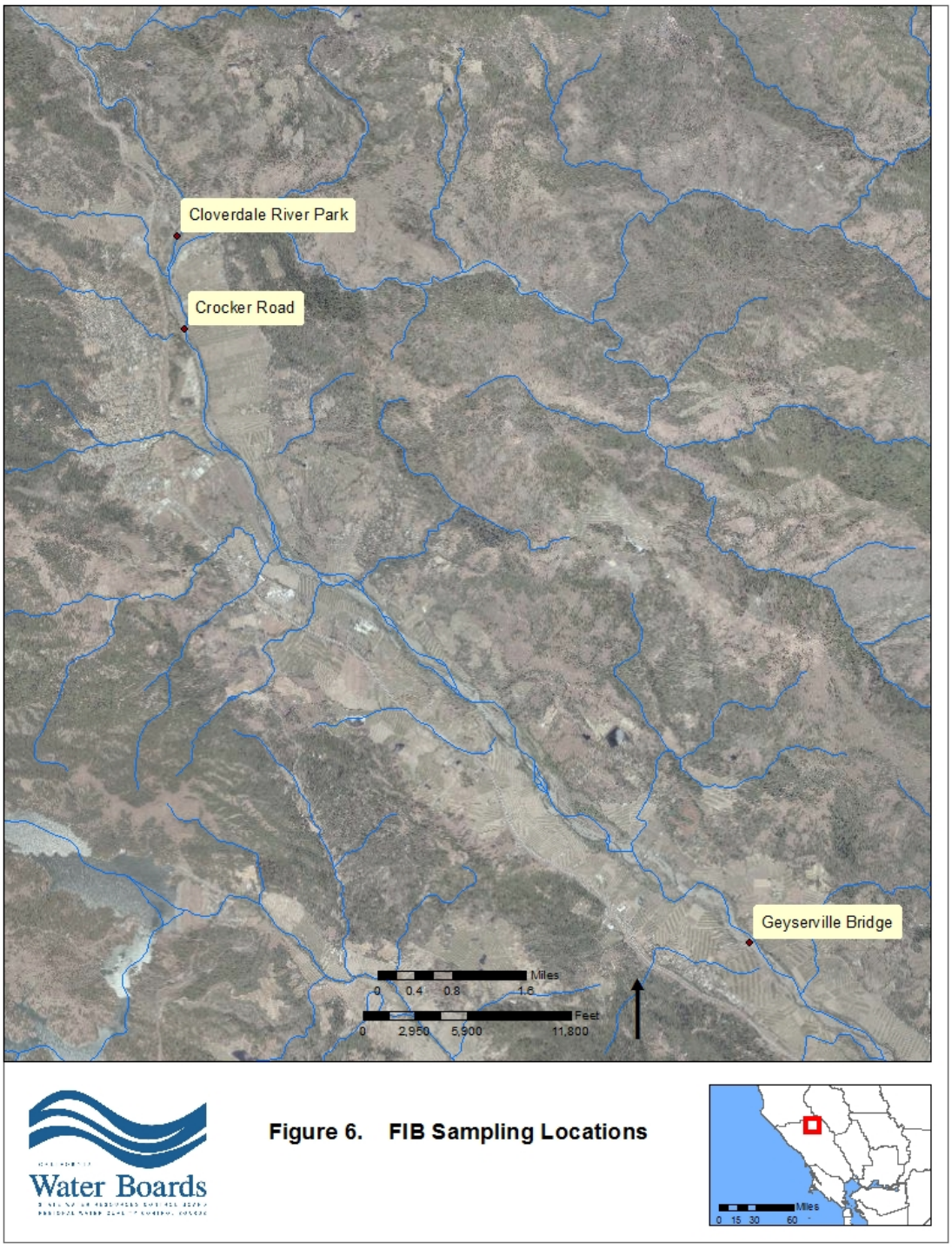

Figure 6. Locations Assessed for REC-1 Beneficial Use in the Russian River Watershed

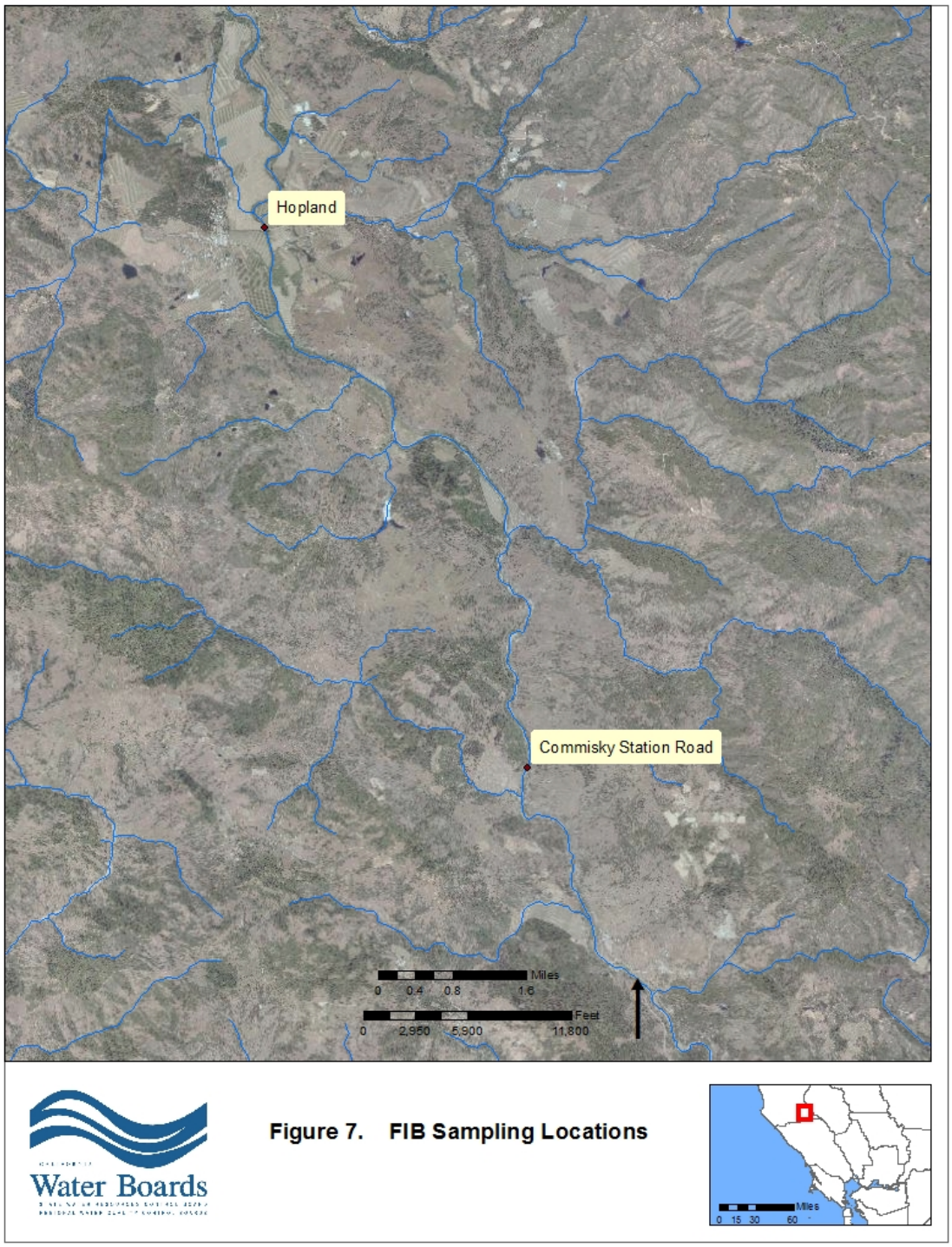

Figure 7. Locations Assessed for REC-1 Beneficial Use in the Russian River Watershed

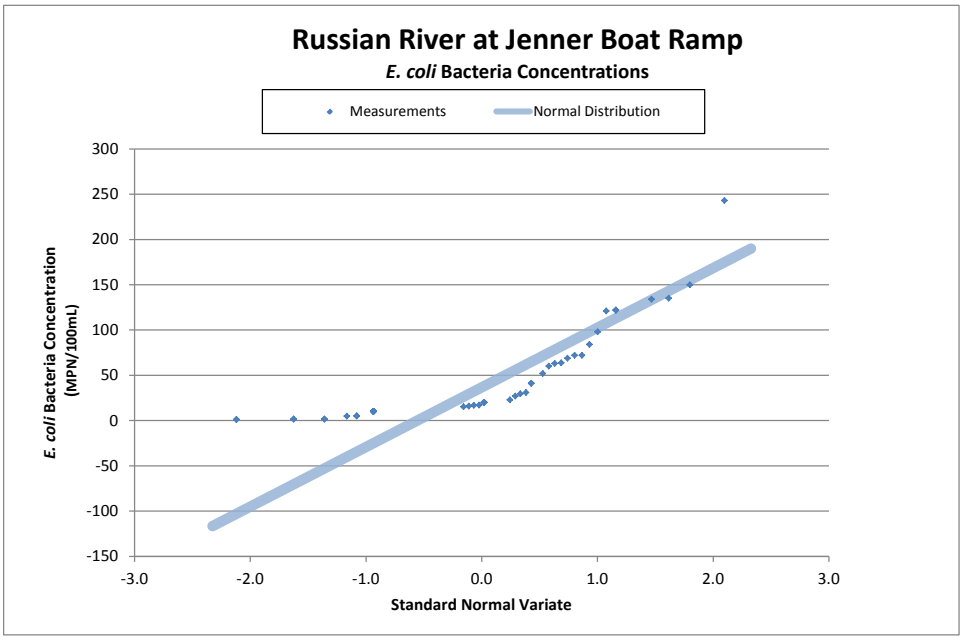

Figure 8. Normal distribution compared to E. coli bacteria concentration measurements collected at the Jenner boat ramp in the Russian River

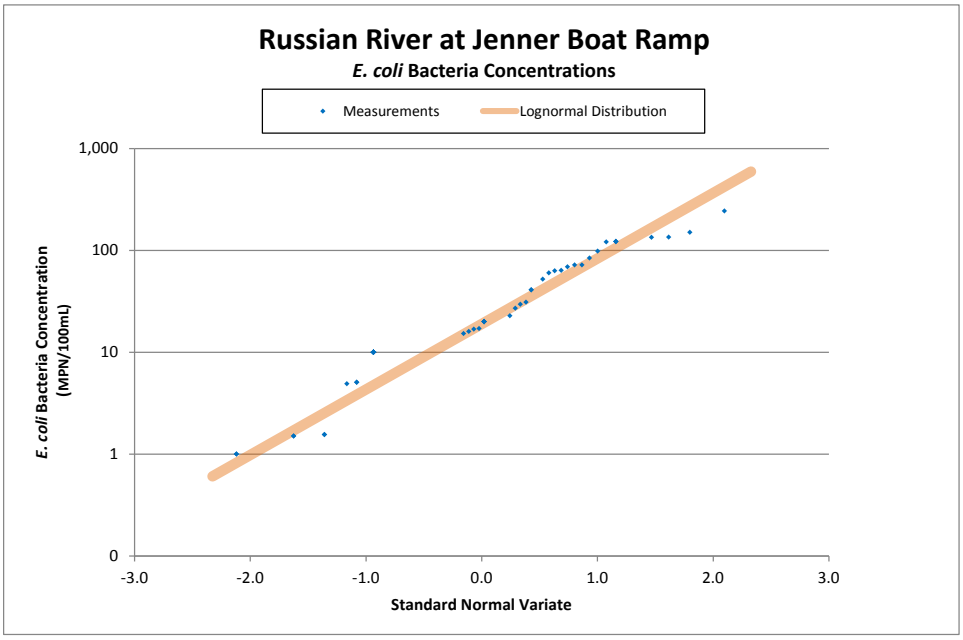

Figure 9. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at the Jenner boat ramp in the Russian River

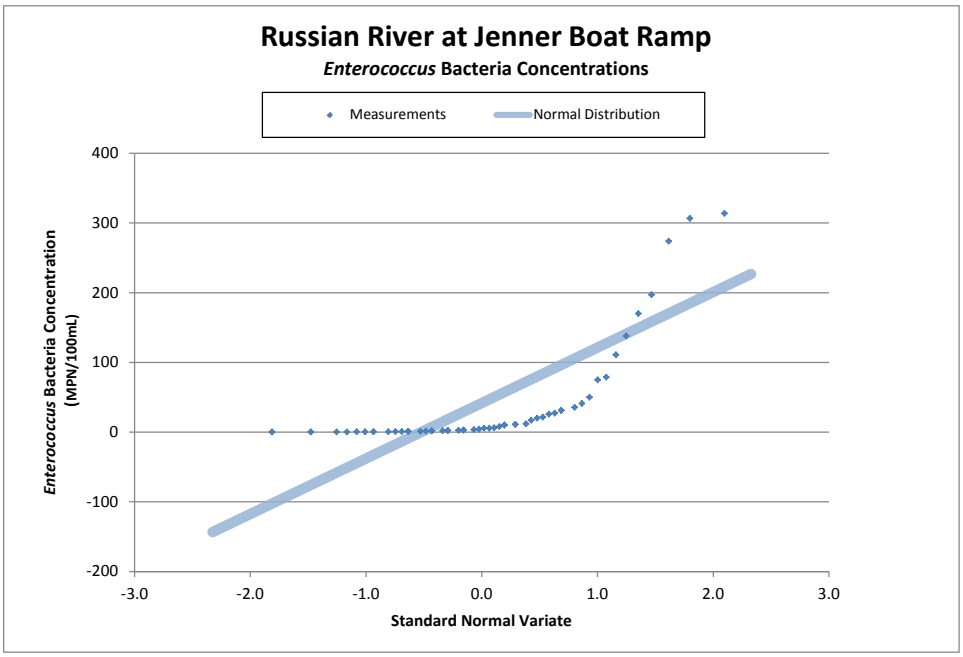

Figure 10. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at the Jenner boat ramp in the Russian River

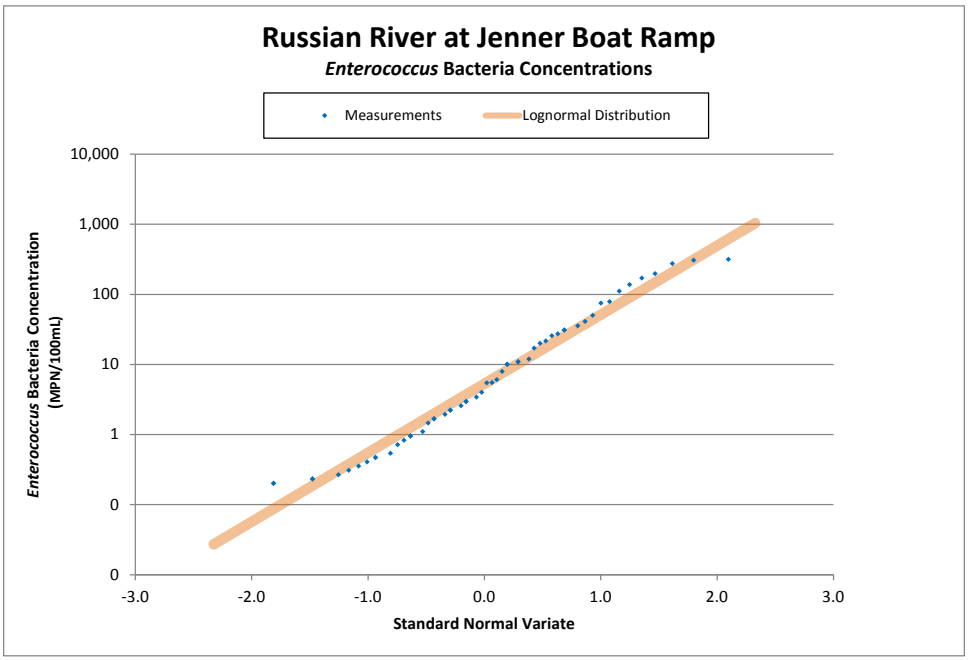

Figure 11. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at the Jenner boat ramp in the Russian River

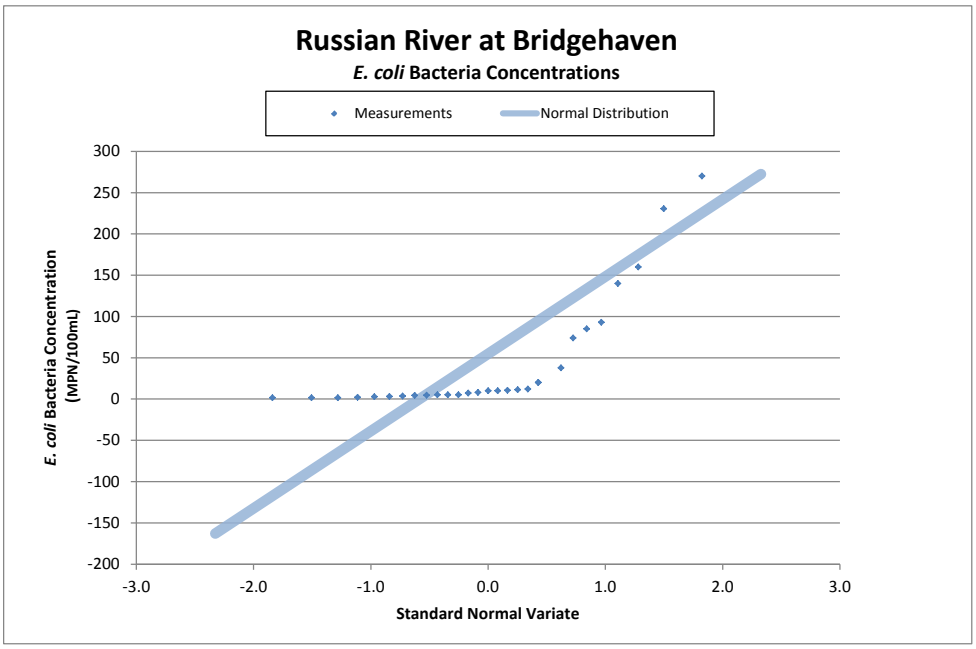

Figure 12. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Bridgehaven in the Russian River

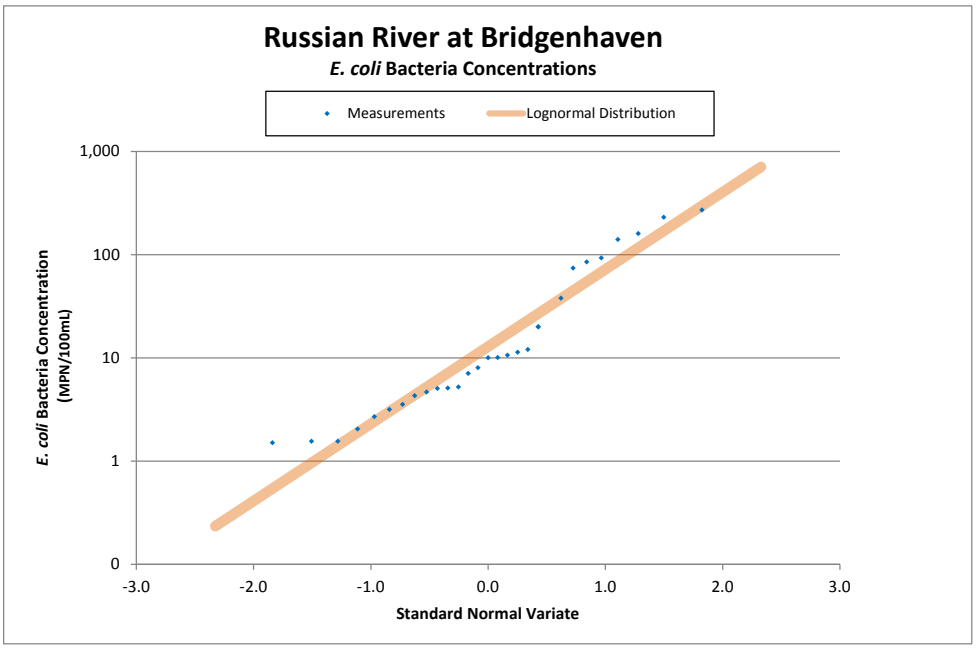

Figure 13. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Bridgehaven in the Russian River

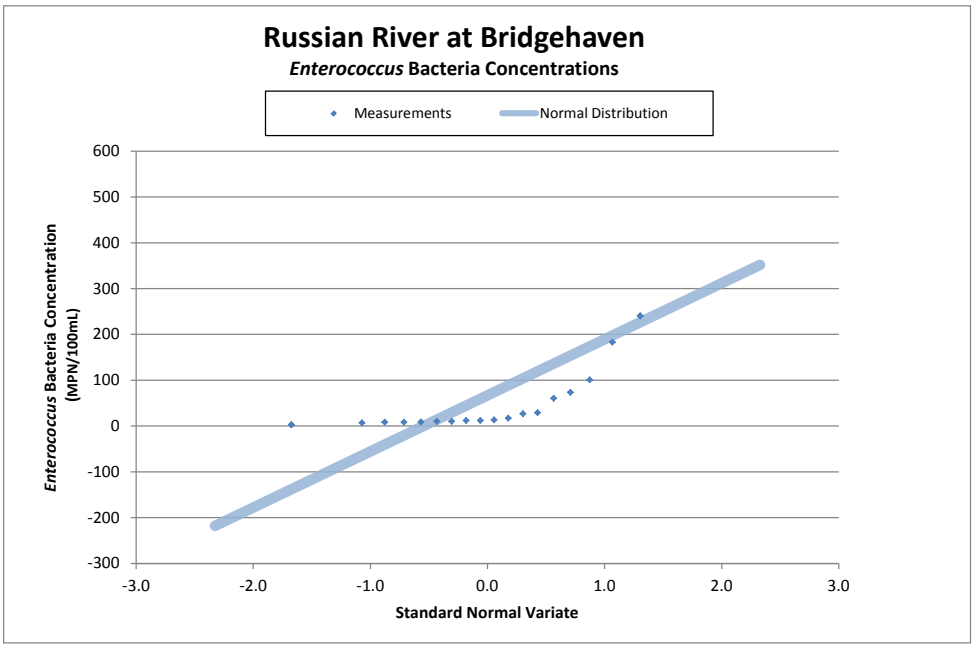

Figure 14. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Bridgehaven in the Russian River

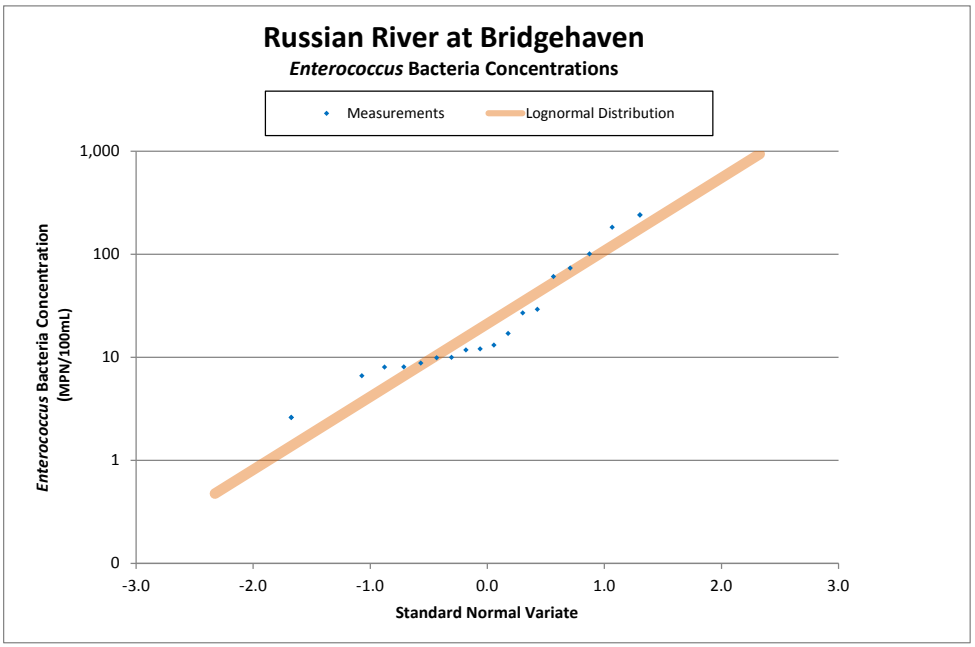

Figure 15. log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Bridgehaven in the Russian River

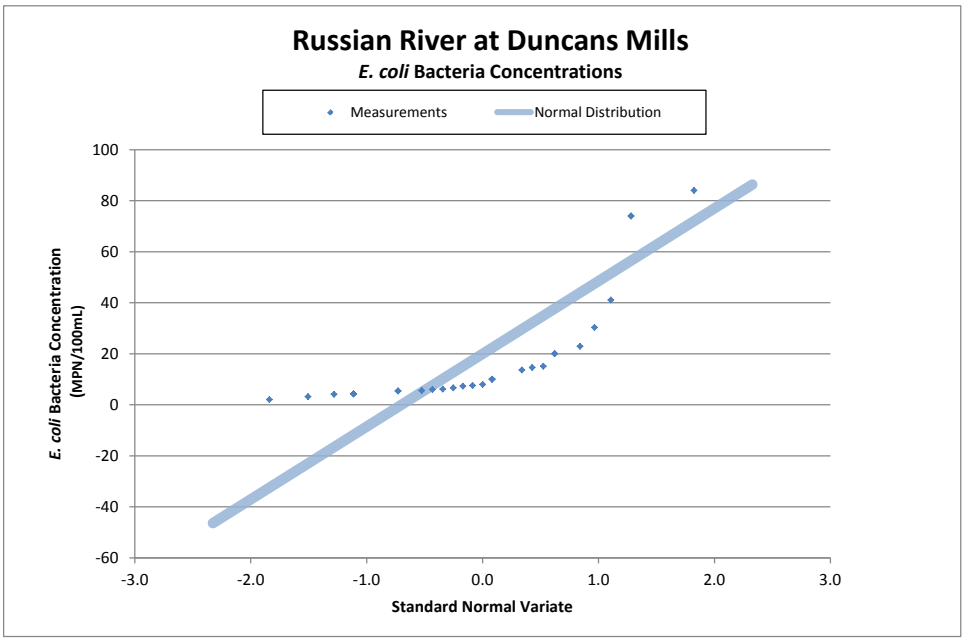

Figure 16. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Duncans Mills in the Russian River

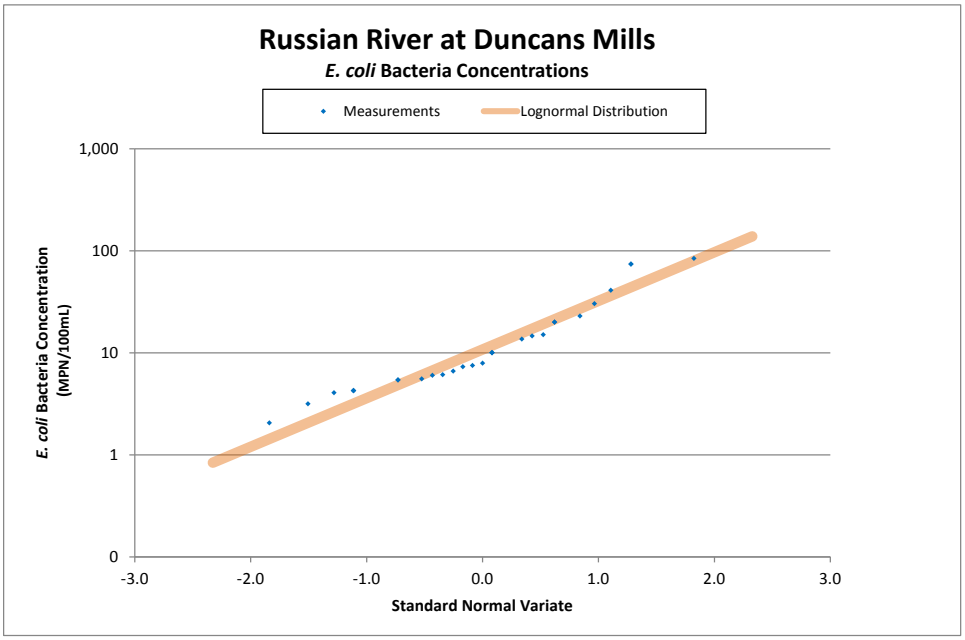

Figure 17. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Duncans Mills in the Russian River

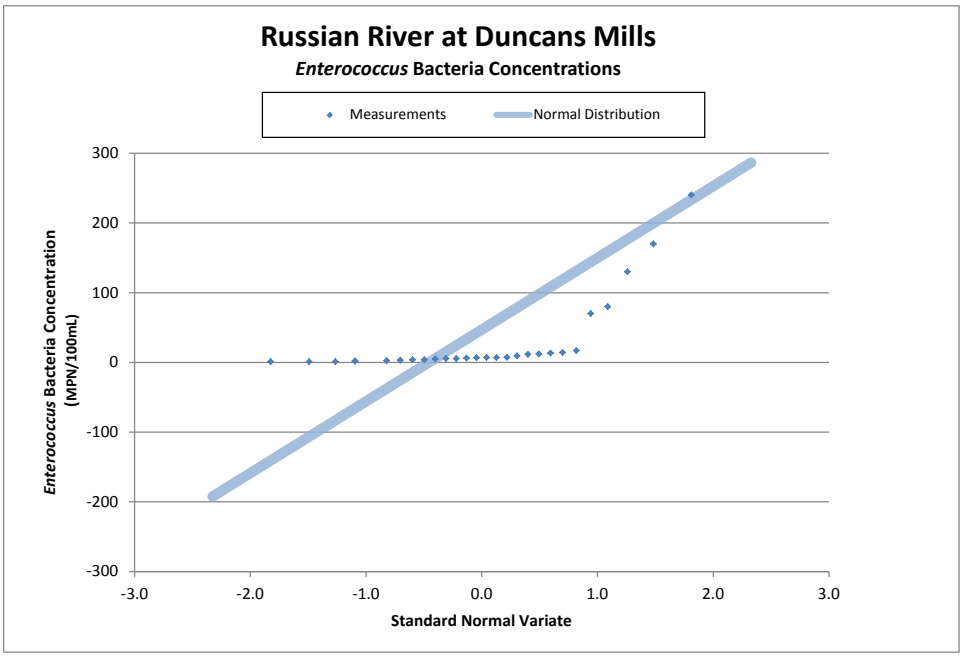

Figure 18. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Duncans Mills in the Russian River

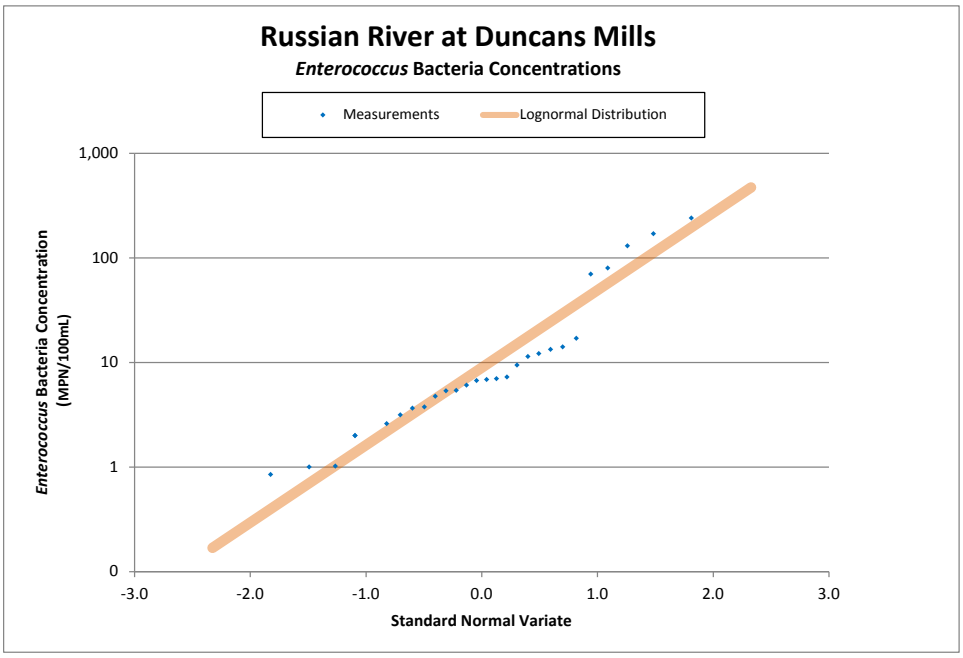

Figure 19. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Duncans Mills in the Russian River

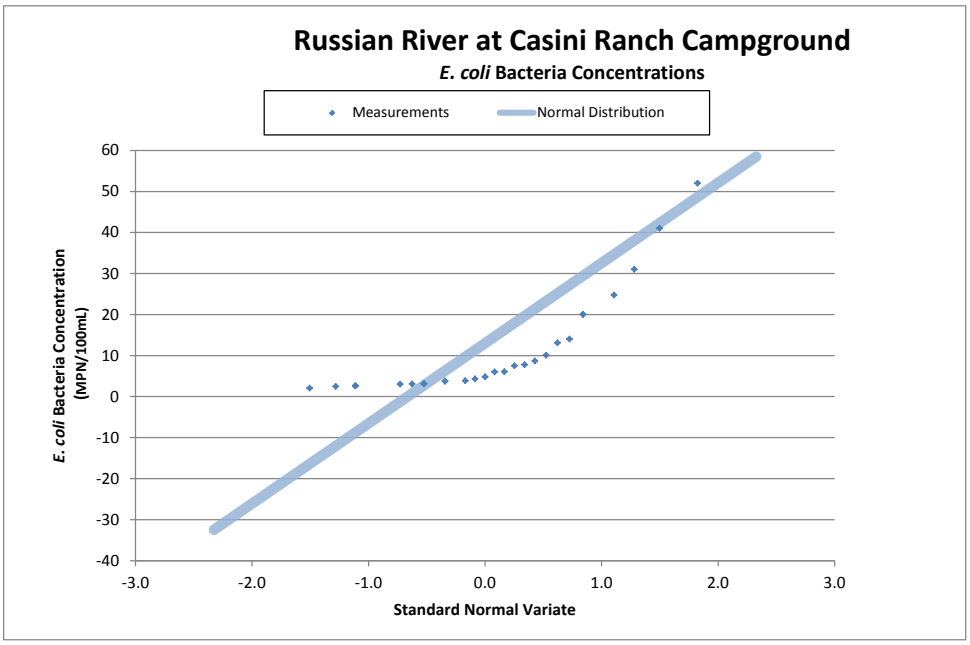

Figure 20. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Casini Ranch campground in the Russian River

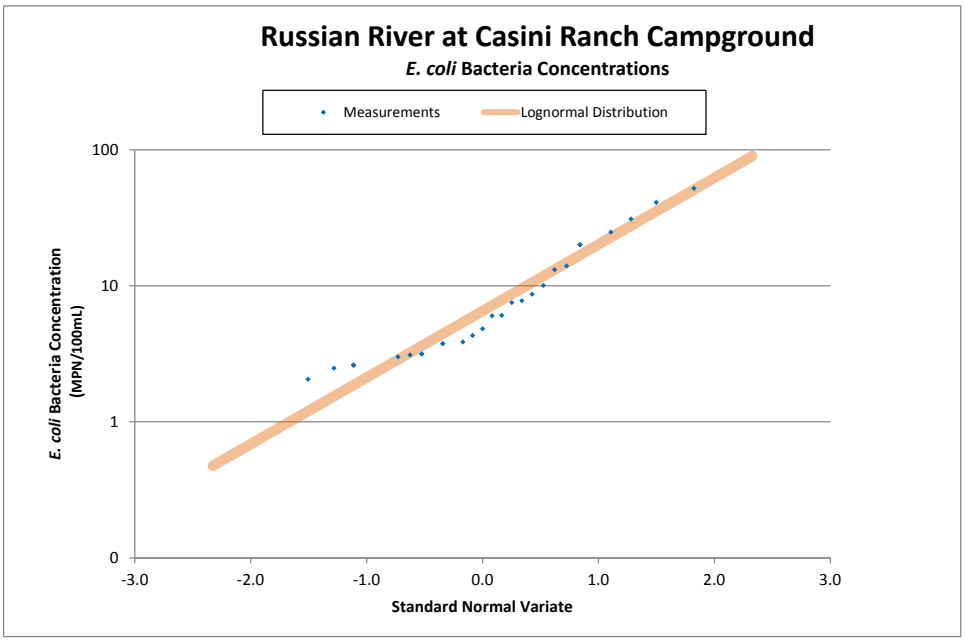

Figure 21. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Casini Ranch campground in the Russian River

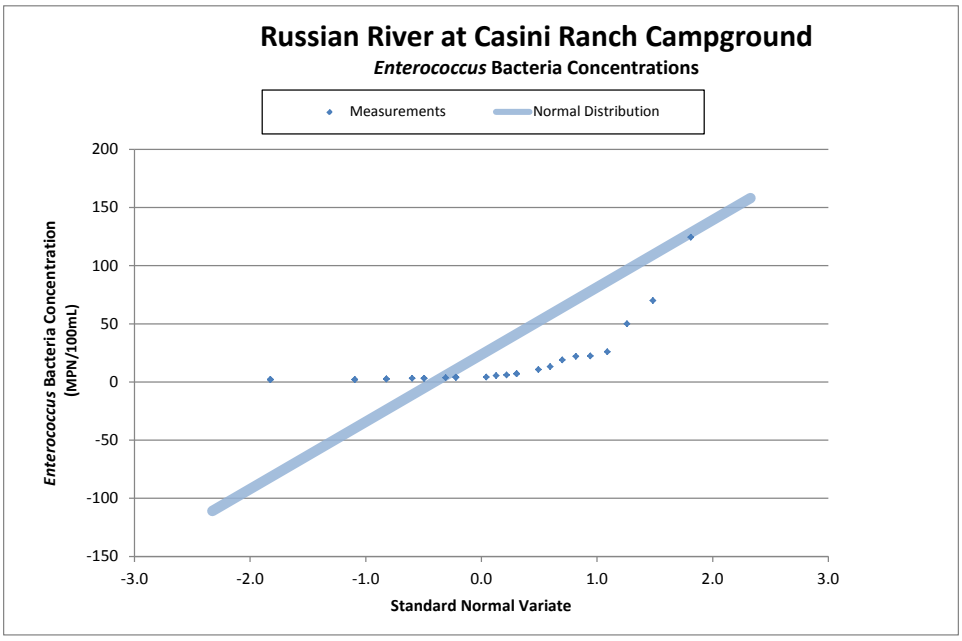

Figure 22. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Casini Ranch Campground in the Russian River

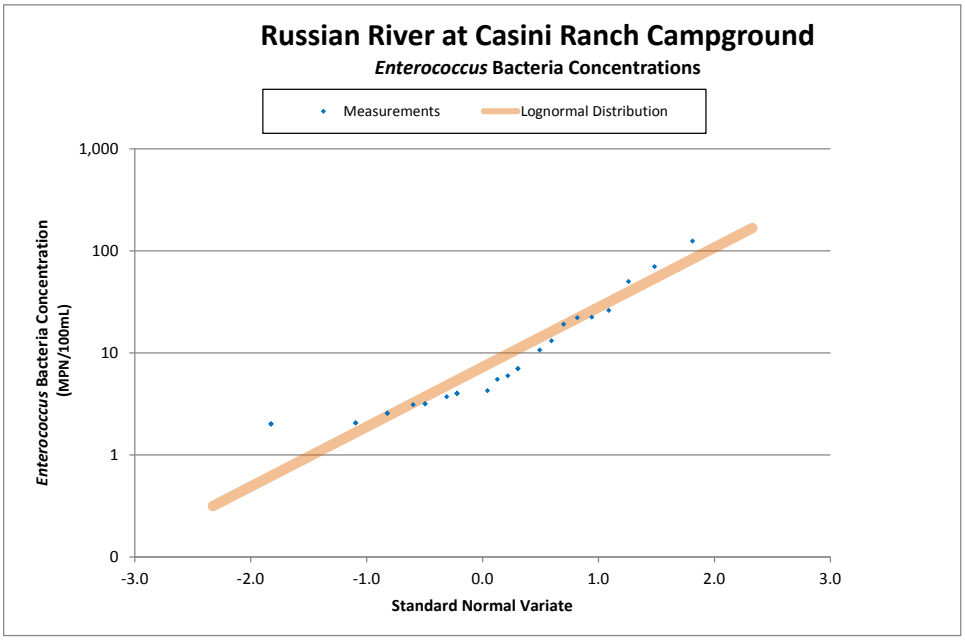

Figure 23. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Casini Ranch Campground in the Russian River

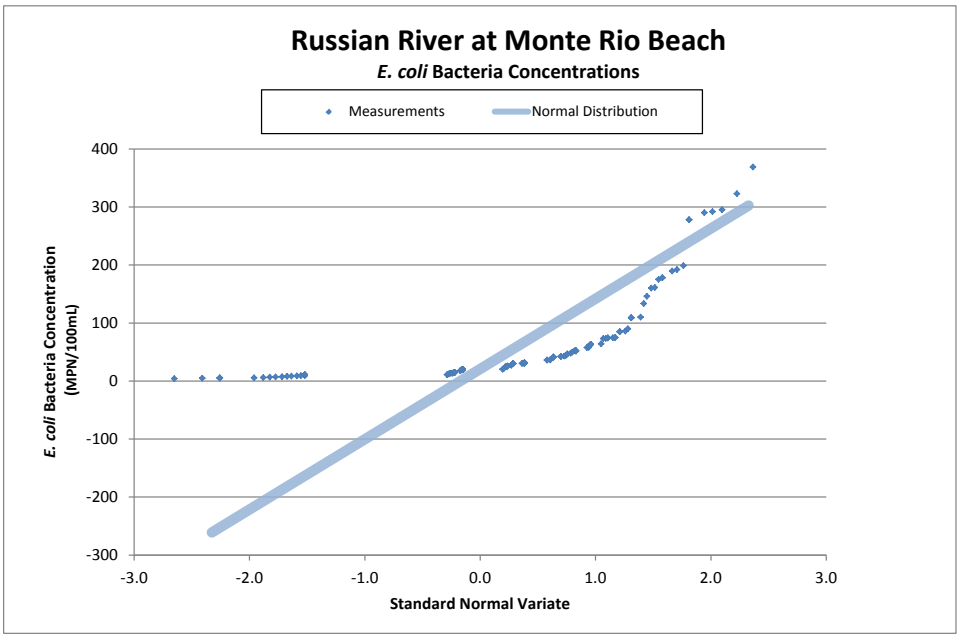

Figure 24. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Monte Rio Beach in the Russian River

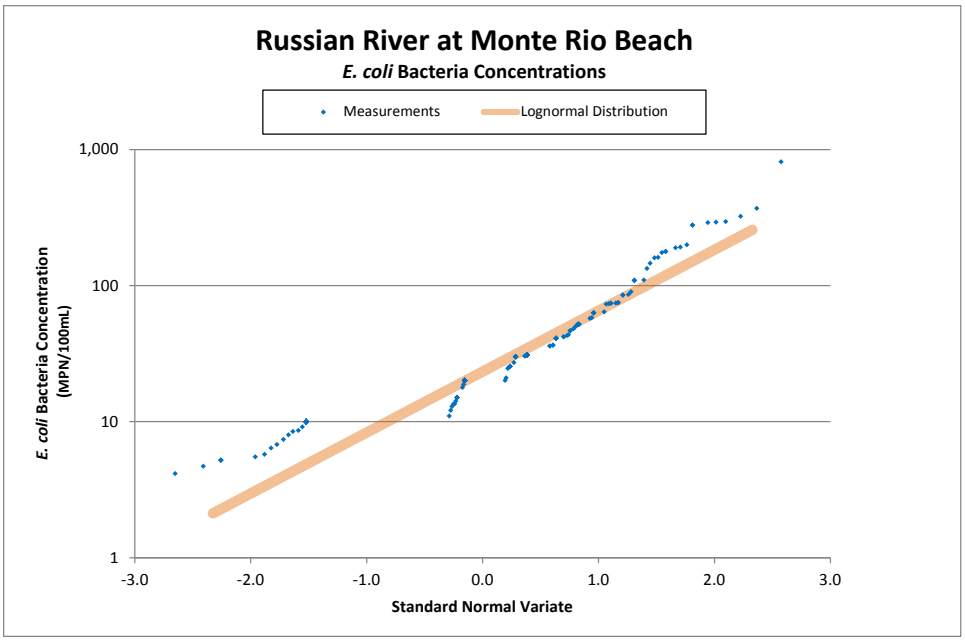

Figure 25. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Monte Rio Beach in the Russian River

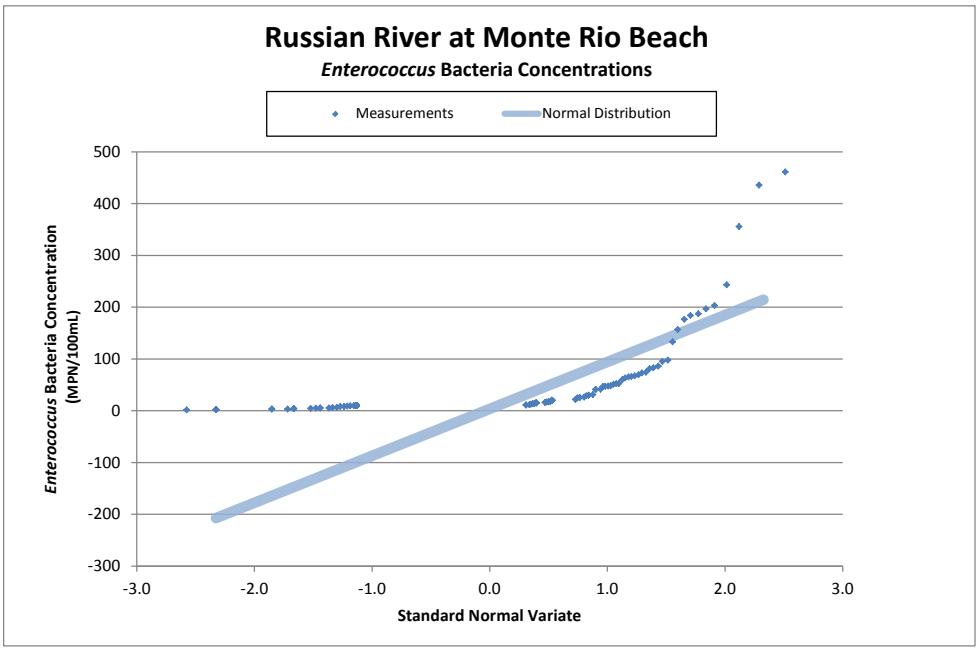

Figure 26. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Monte Rio Beach in the Russian River

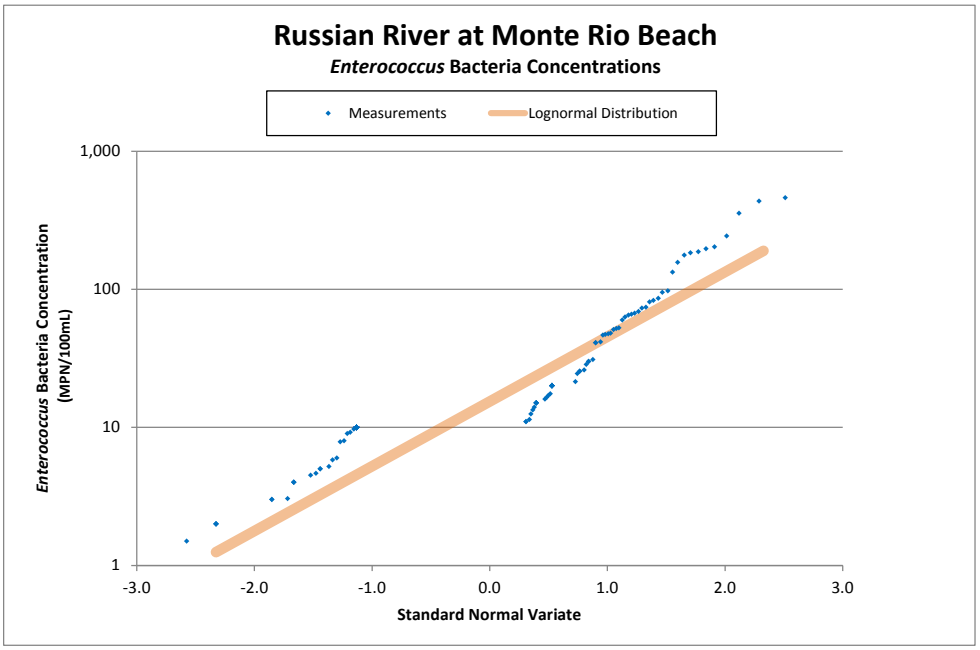

Figure 27. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Monte Rio Beach in the Russian River

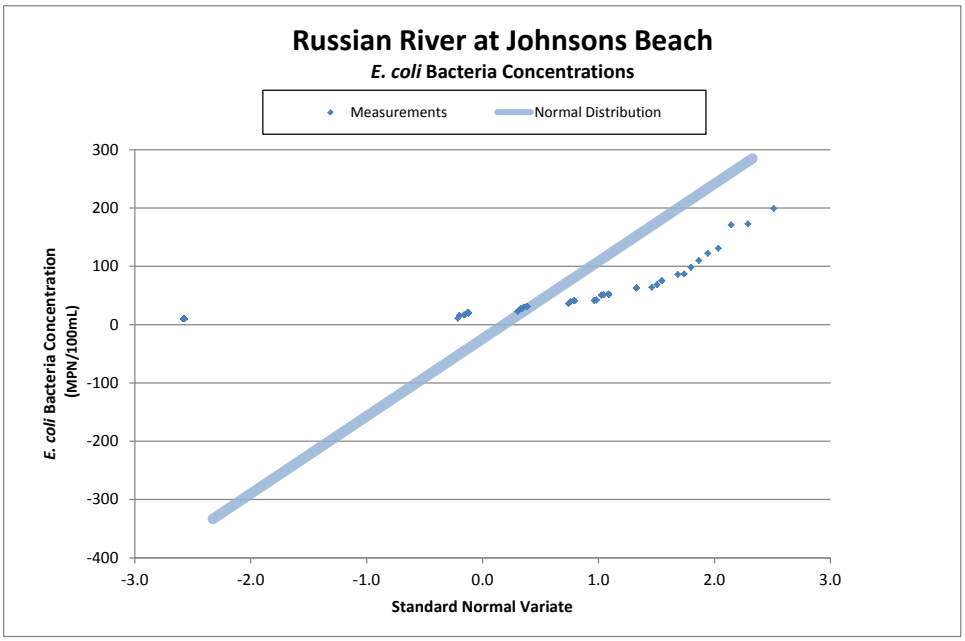

Figure 28. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Johnsons Beach in the Russian River

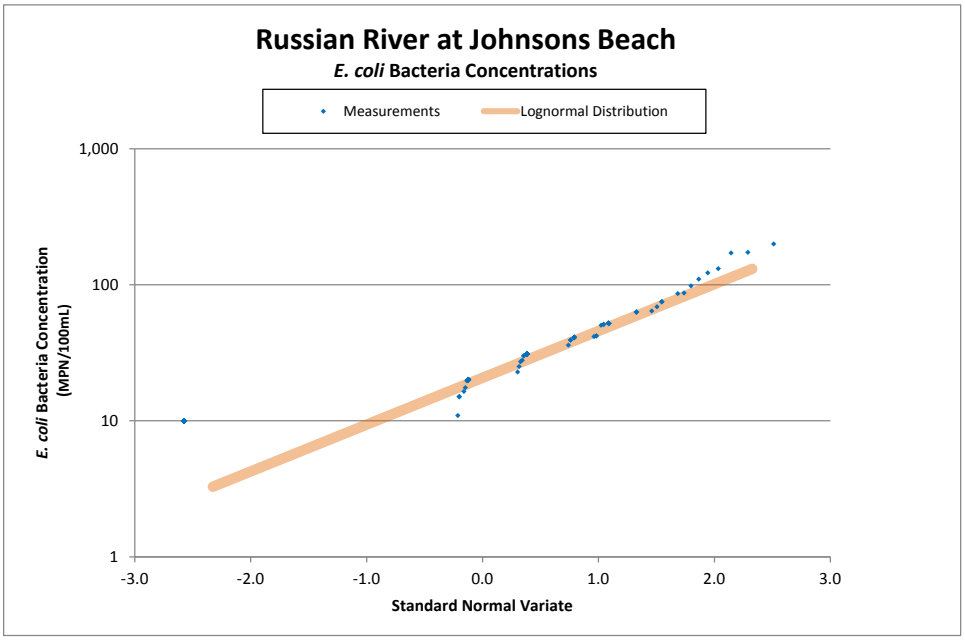

Figure 29. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Johnsons Beach in the Russian River

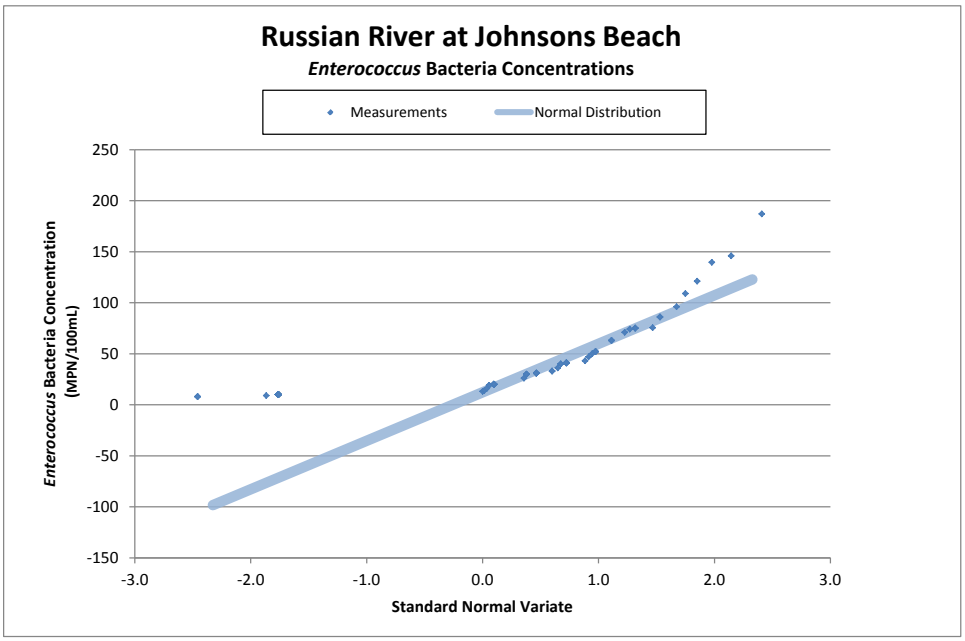

Figure 30. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Johnsons Beach in the Russian River

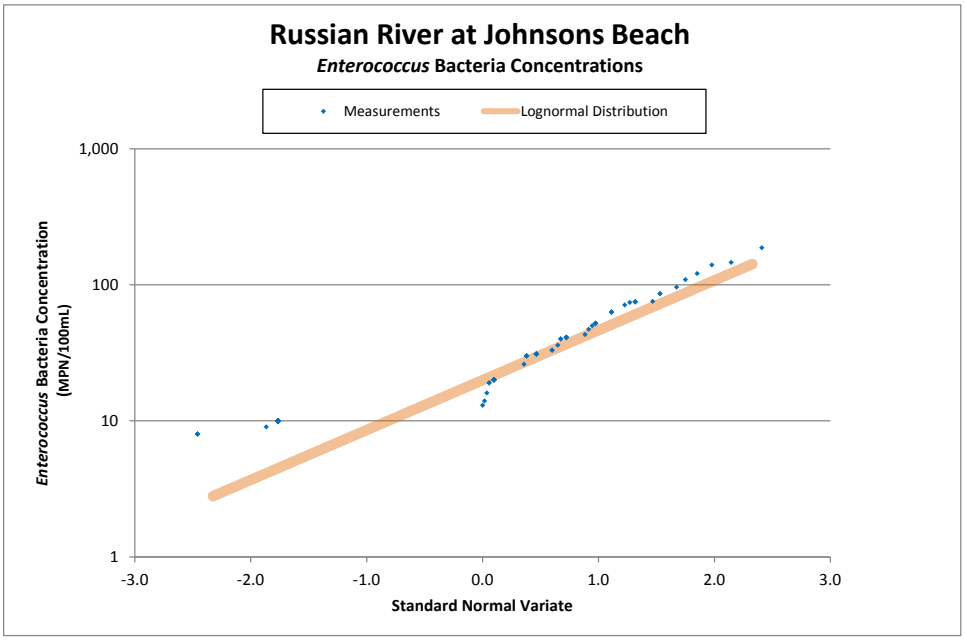

Figure 31. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Johnsons Beach in the Russian River

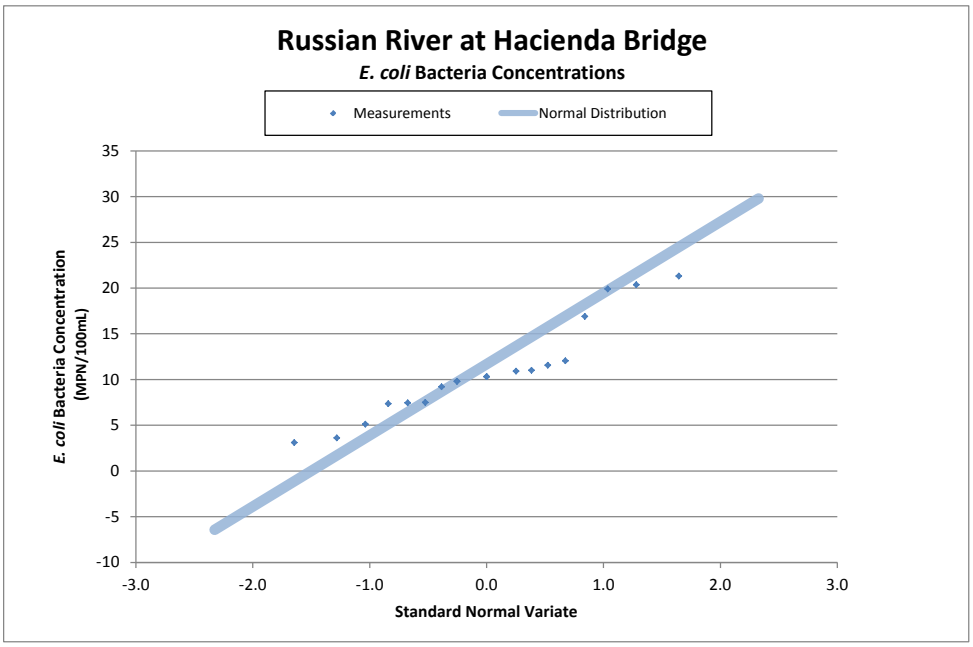

Figure 32. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Hacienda Bridge in the Russian River

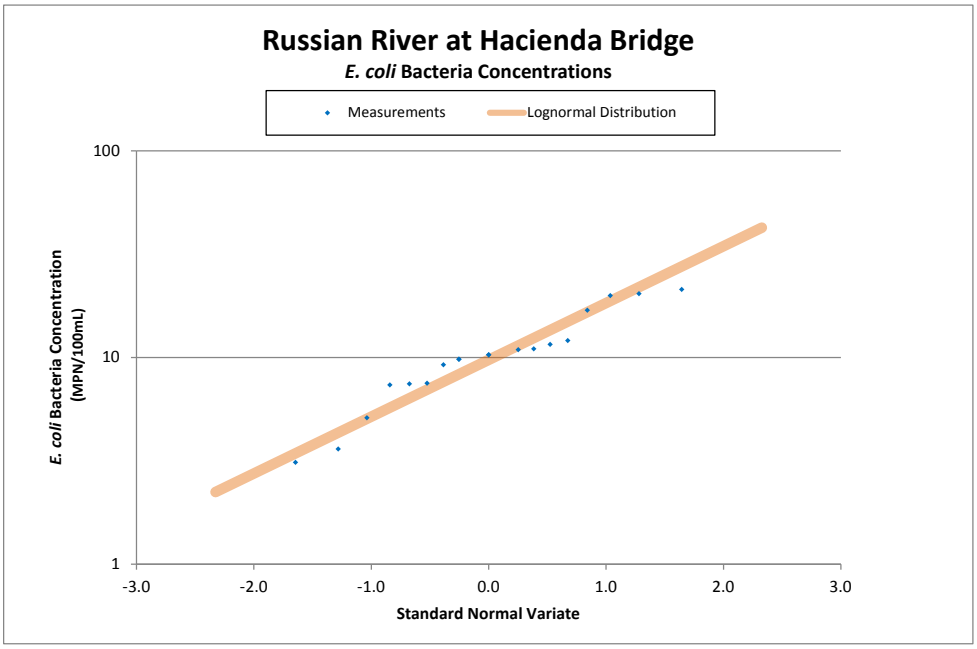

Figure 33. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Hacienda Bridge in the Russian River

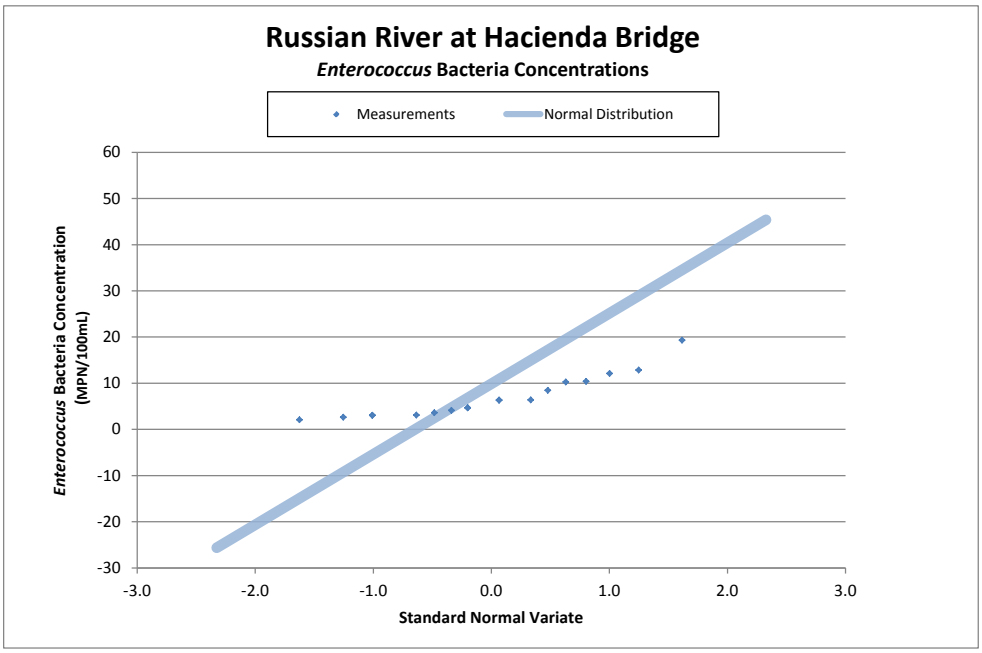

Figure 34. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Hacienda Bridge in the Russian River

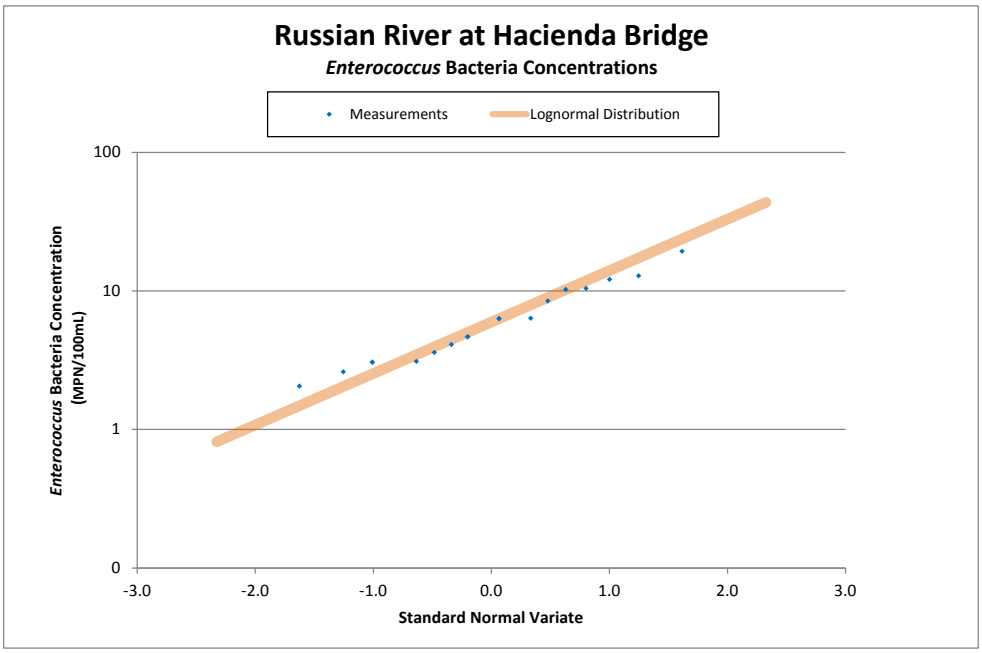

Figure 35. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Hacienda Bridge in the Russian River

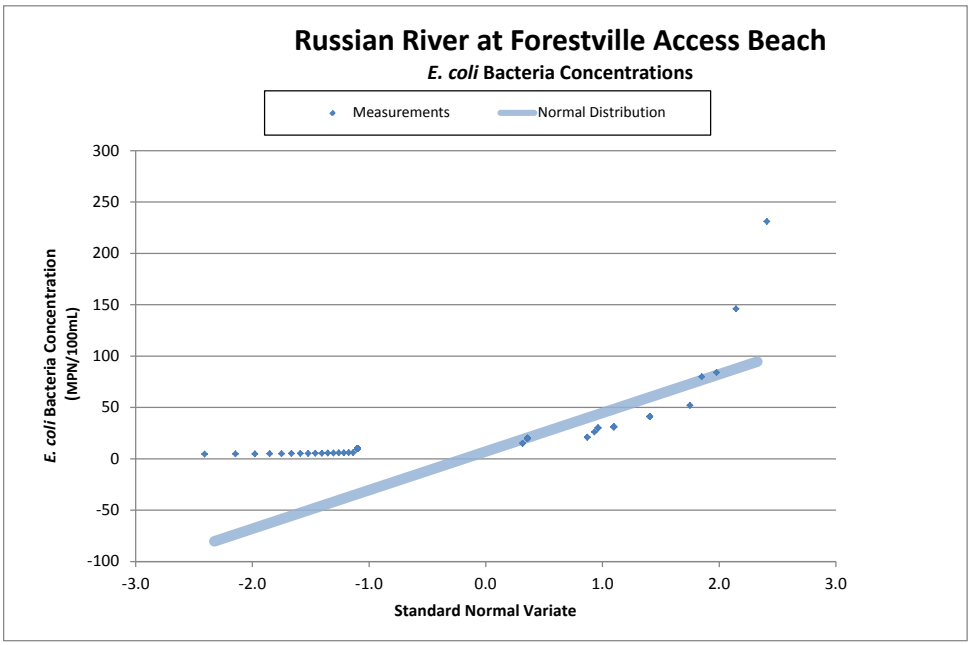

Figure 36. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Forestville Access Beach in the Russian River

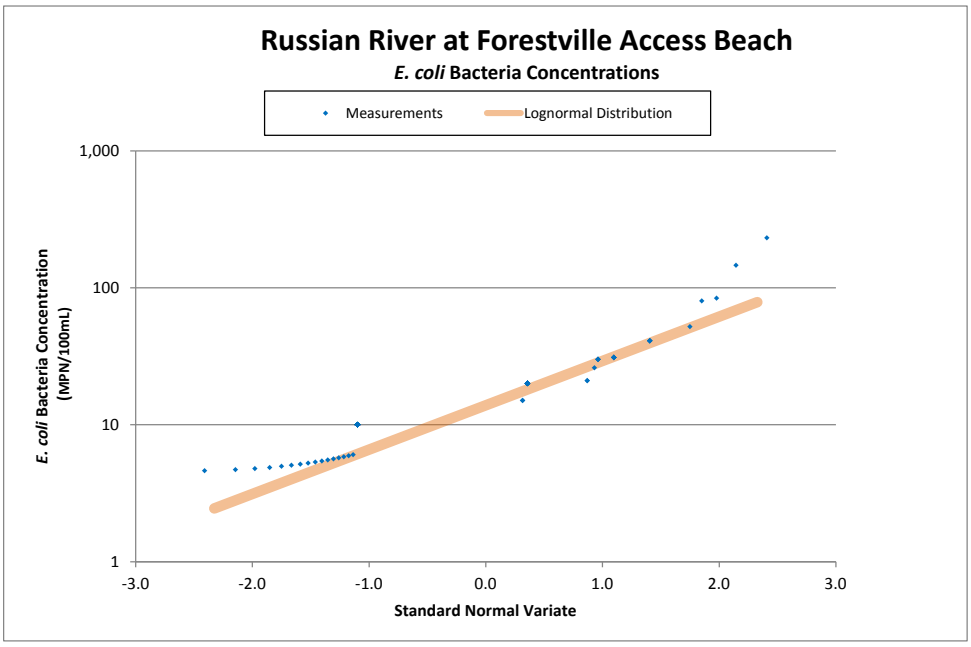

Figure 37. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Forestville Access Beach in the Russian River

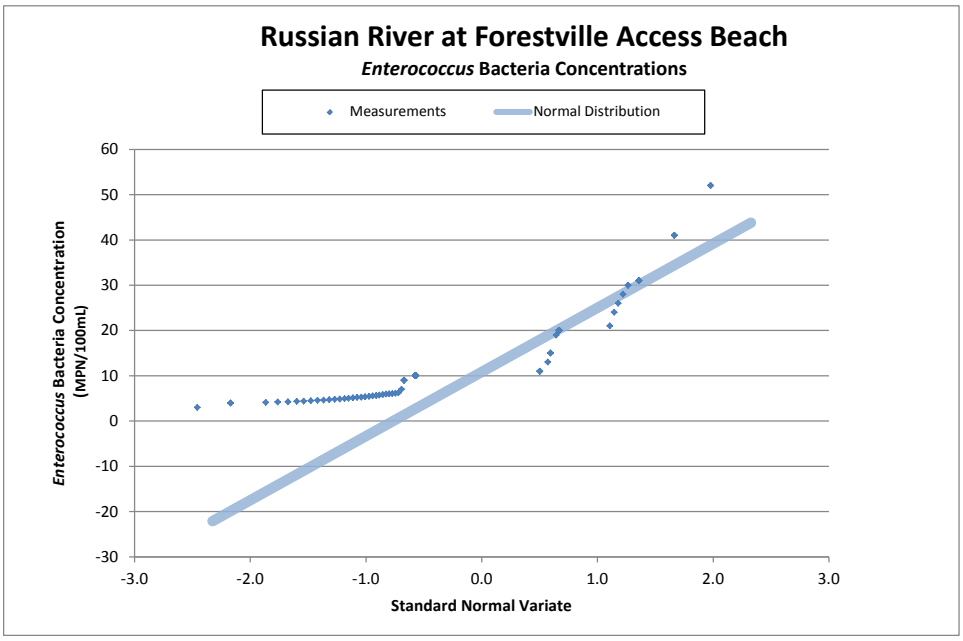

Figure 38. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Forestville Access Beach in the Russian River

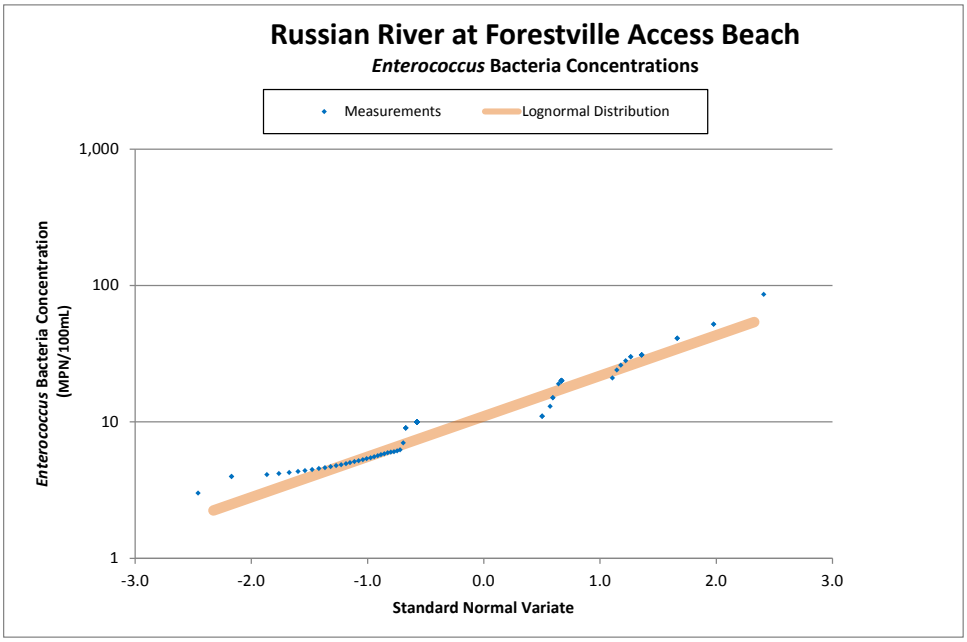

Figure 39. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Forestville Access Beach in the Russian River

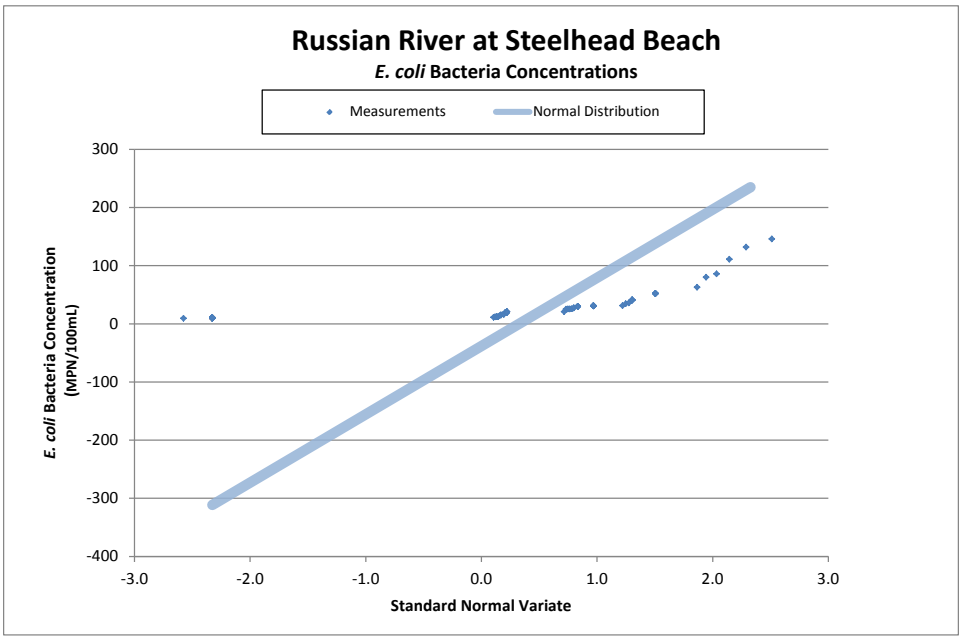

Figure 40. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Steelhead Beach in the Russian River

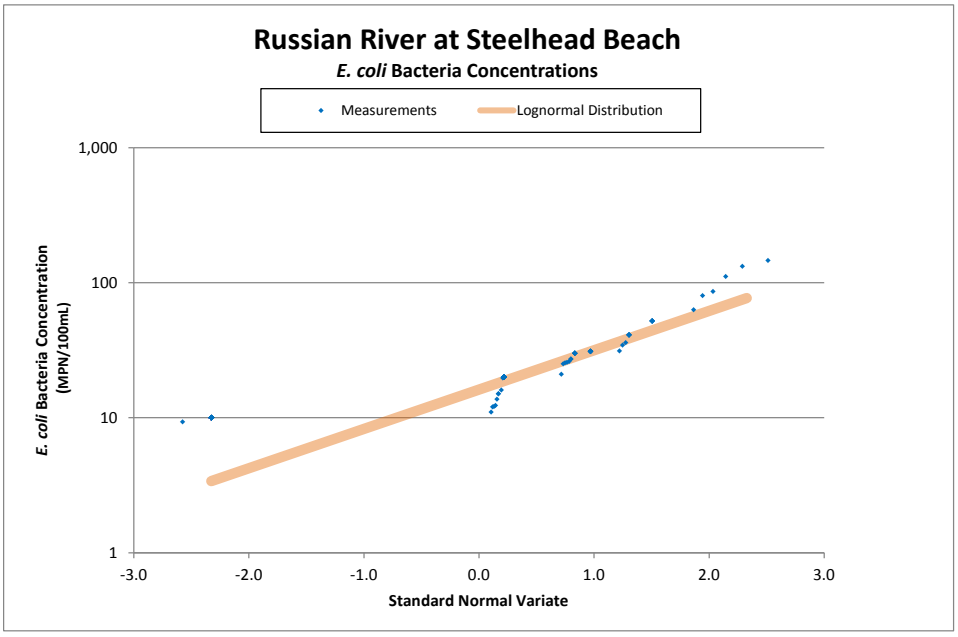

Figure 41. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Steelhead Beach in the Russian River

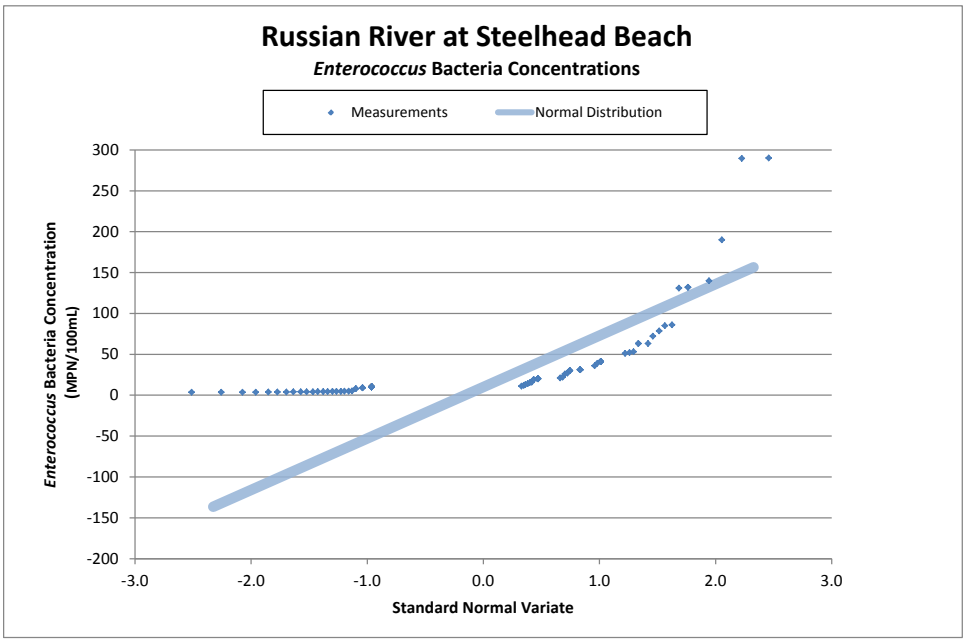

Figure 42. Normal distribution compared to E*nterococcus* bacteria concentration measurements collected at Steelhead Beach in the Russian River

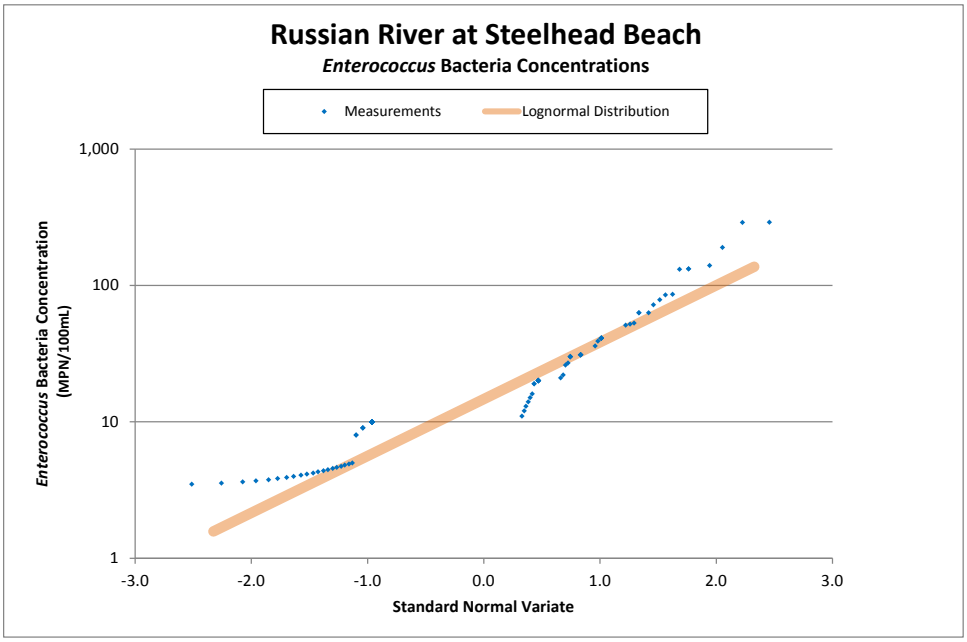

Figure 43. Log-normal distribution compared to E*nterococcus* bacteria concentration measurements collected at Steelhead Beach in the Russian River

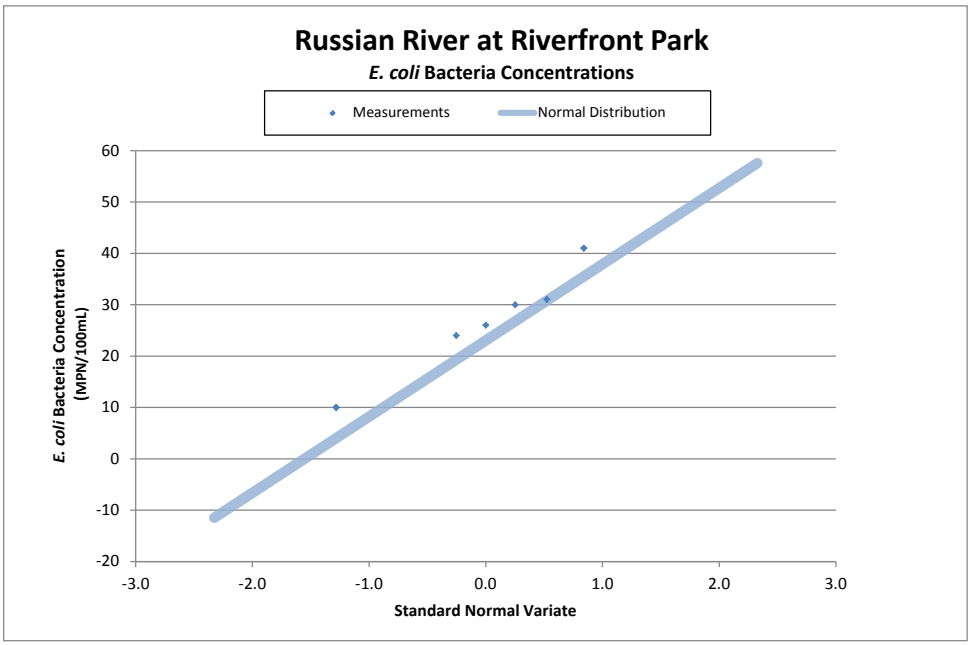

Figure 44. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Riverfront Park in the Russian River

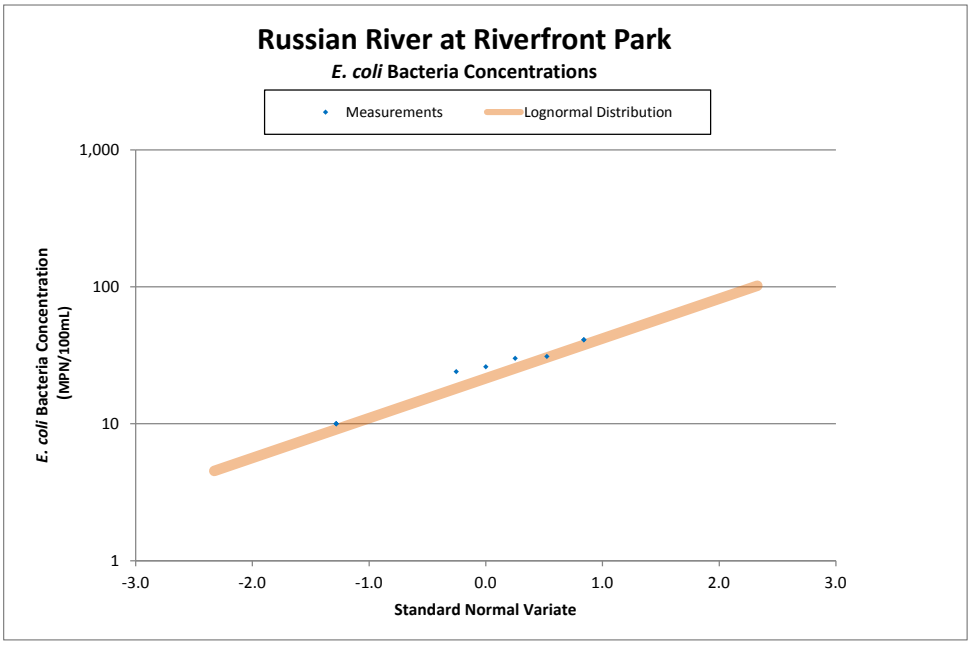

Figure 45. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Riverfront Park in the Russian River

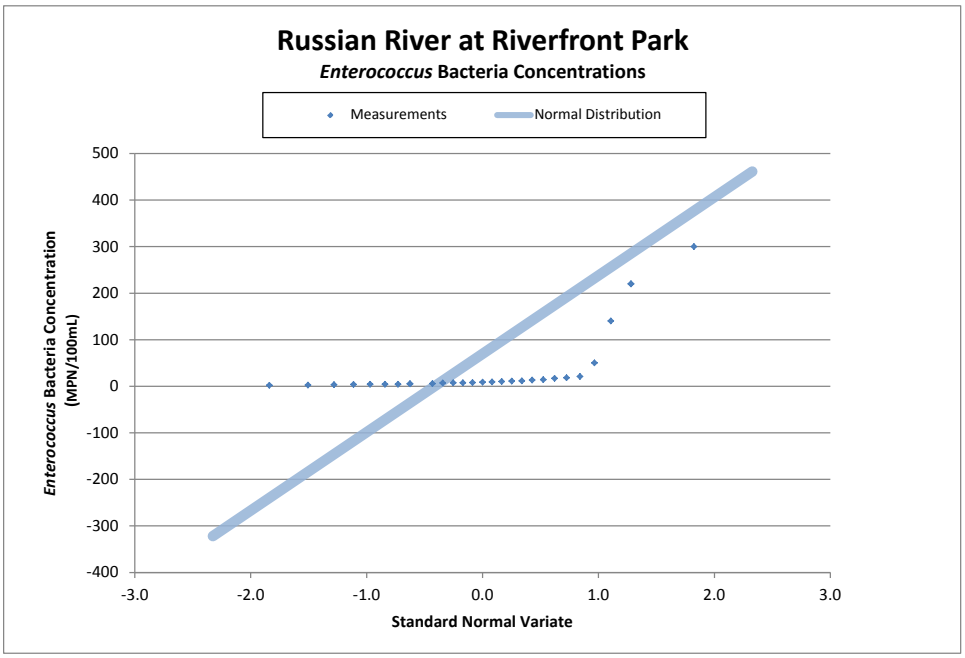

Figure 46. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Riverfront Park in the Russian River

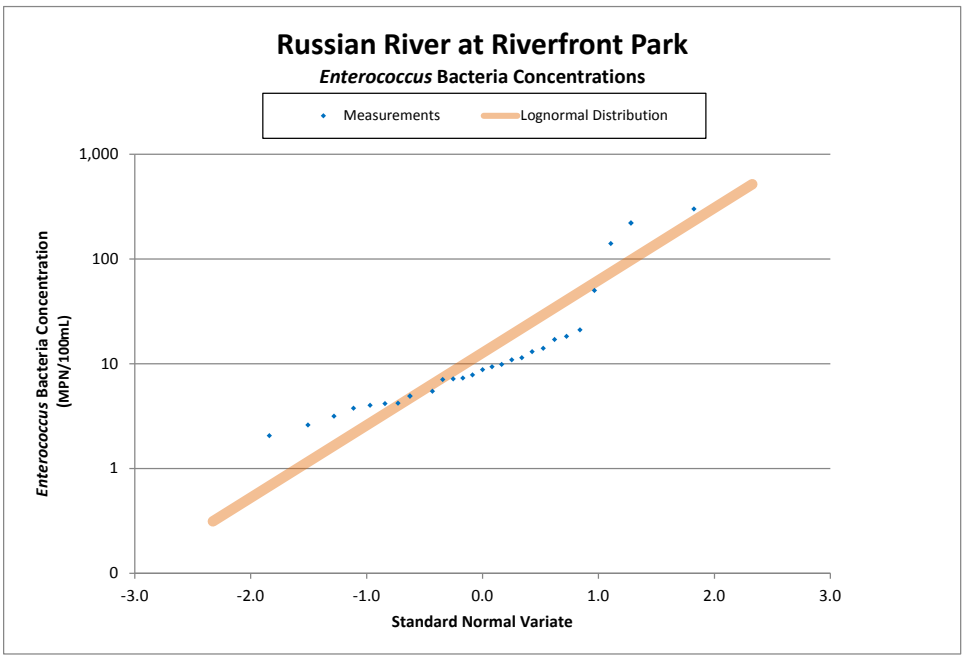

Figure 47. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Riverfront Park in the Russian River

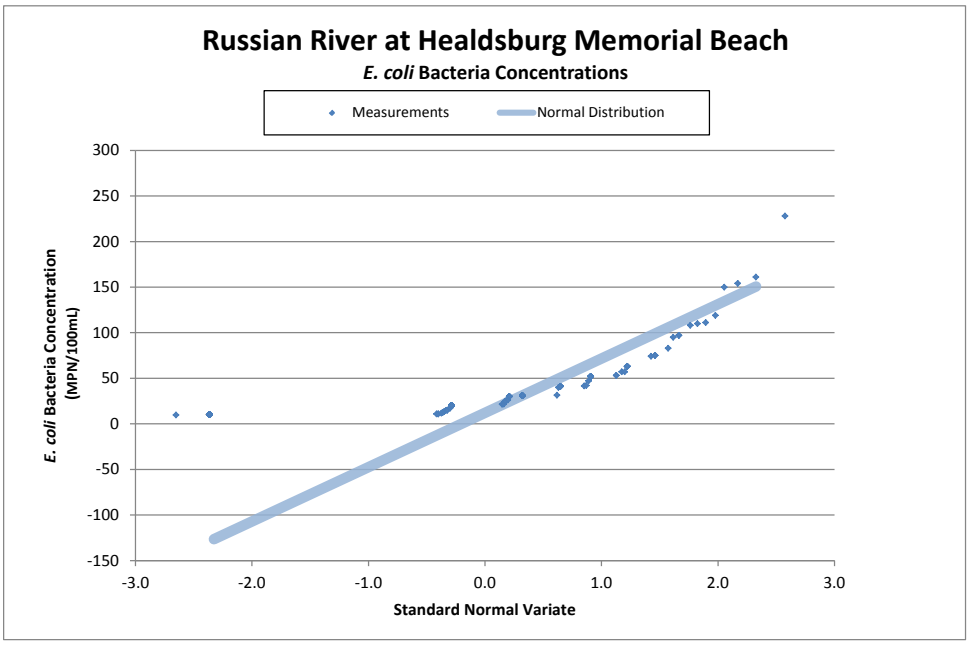

Figure 48. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Healdsburg Memorial Beach in the Russian River

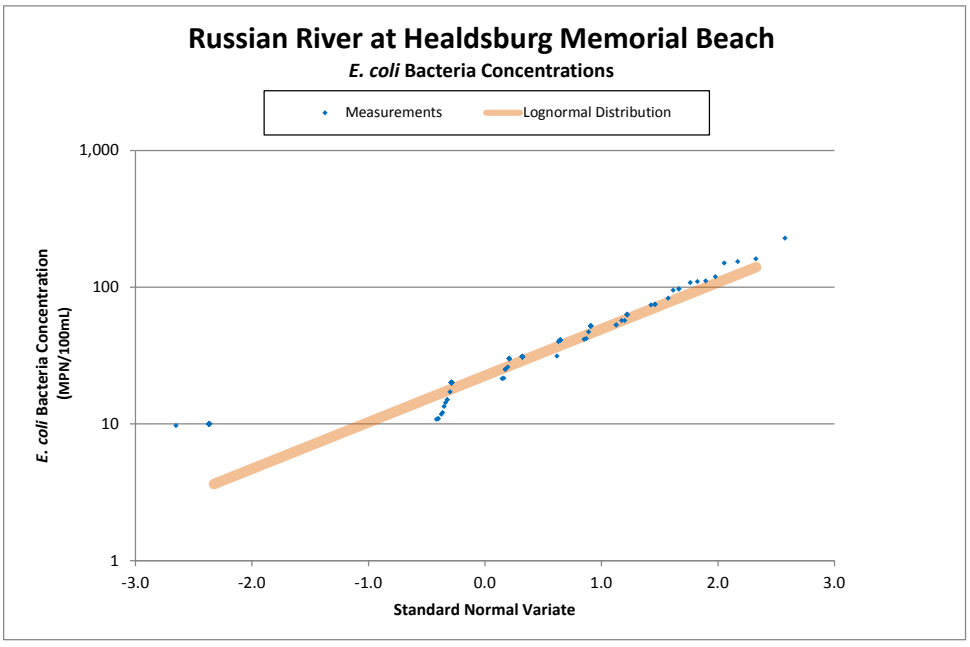

Figure 49. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Healdsburg Memorial Beach in the Russian River

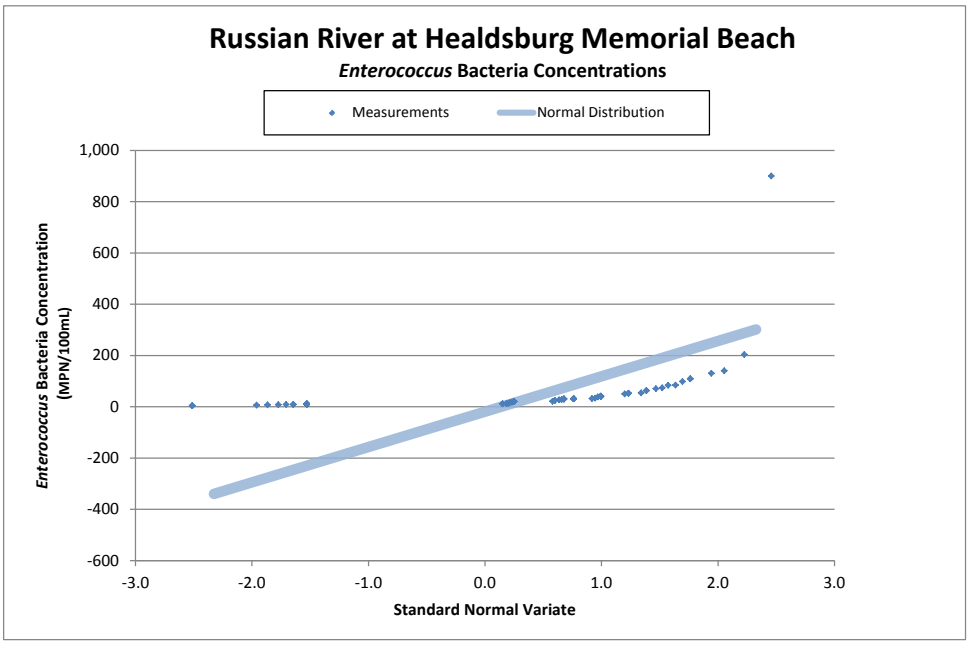

Figure 50. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Healdsburg Memorial Beach in the Russian River

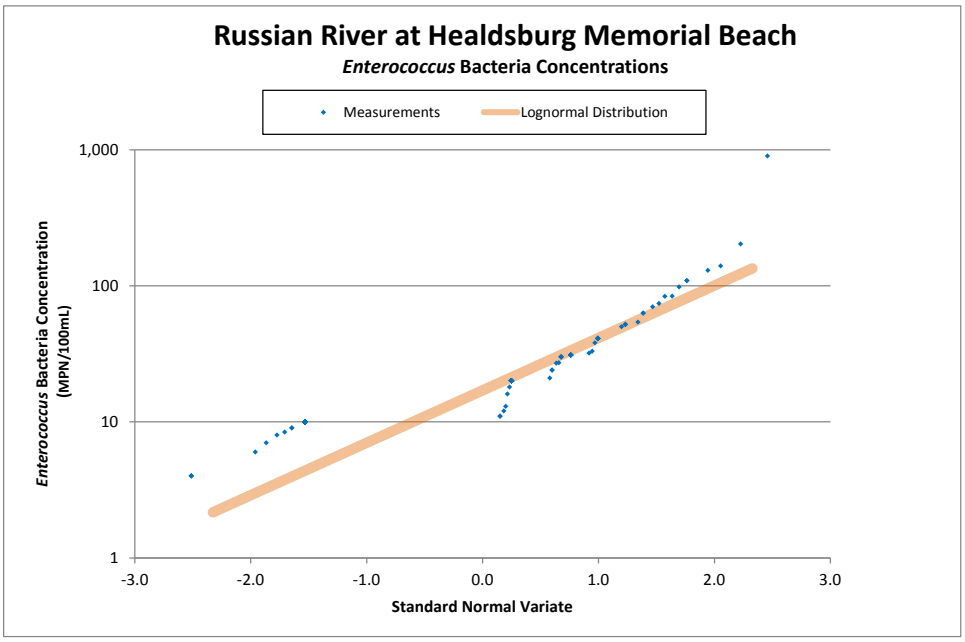

Figure 51. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Healdsburg Memorial Beach in the Russian River

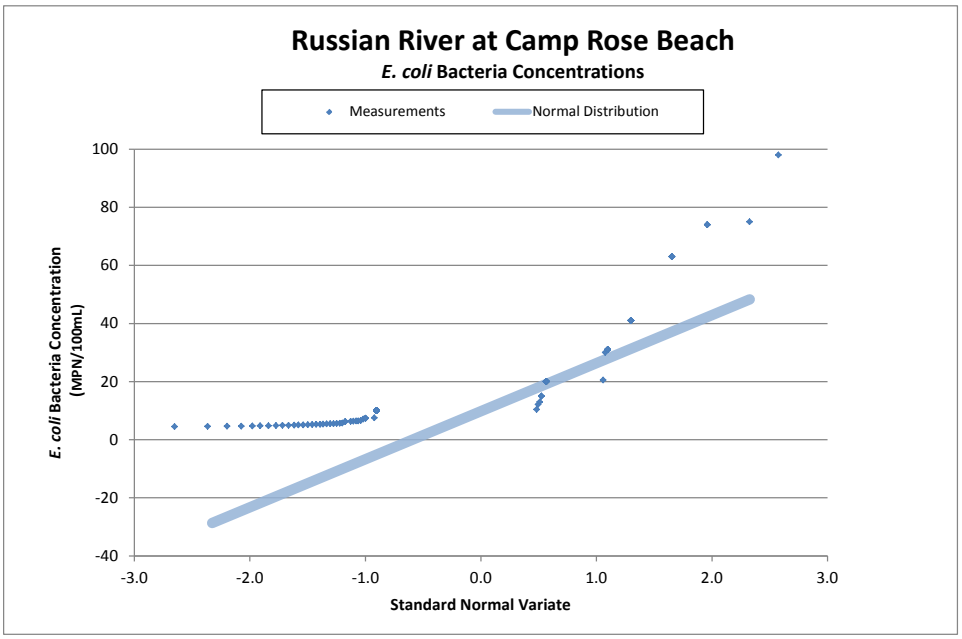

Figure 52. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Camp Rose Beach in the Russian River

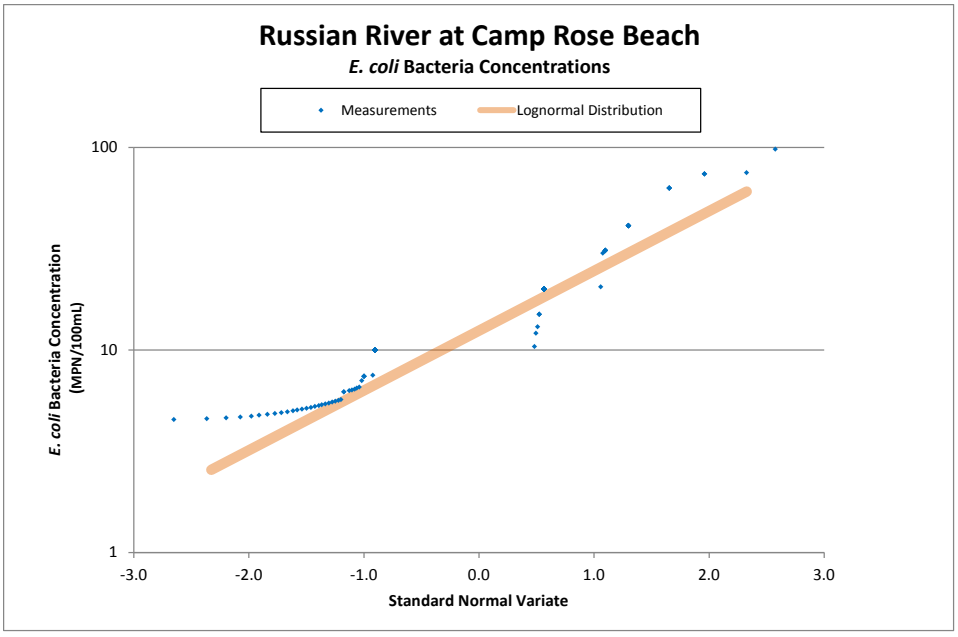

Figure 53. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Camp Rose Beach in the Russian River

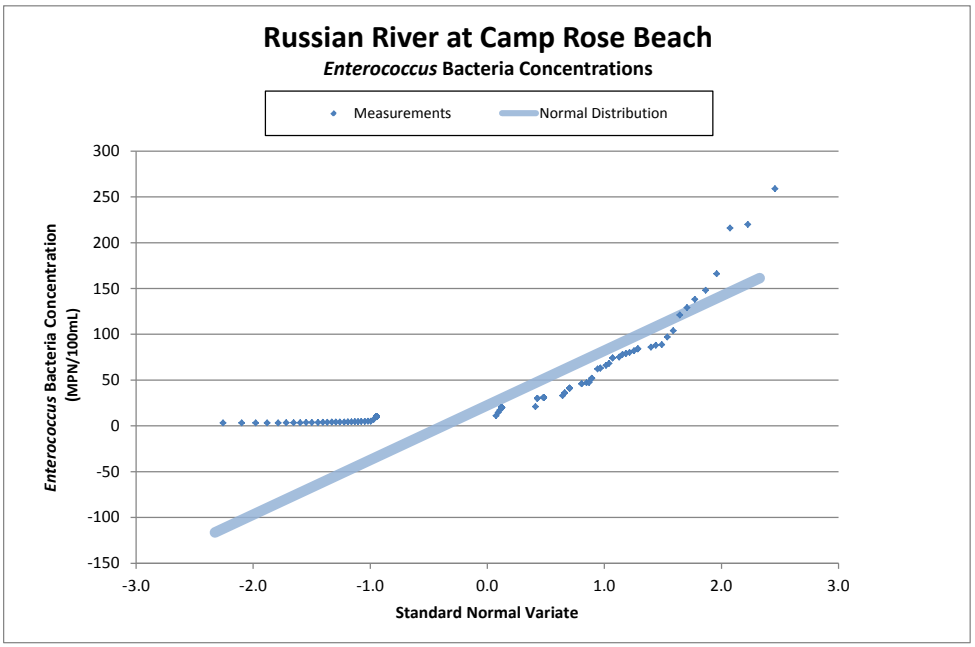

Figure 54. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Camp Rose Beach in the Russian River

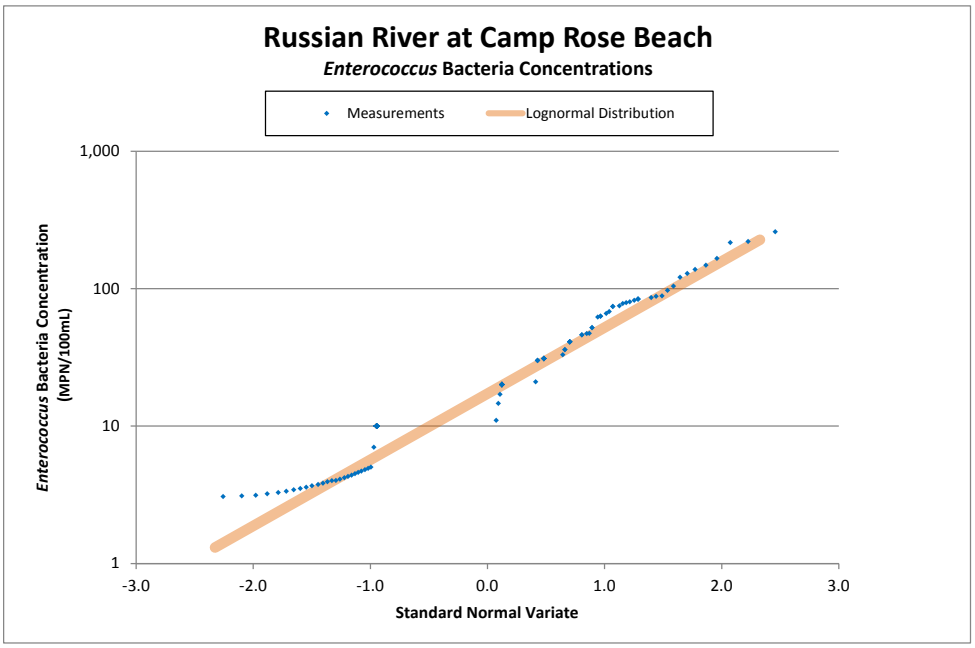

Figure 55. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Camp Rose Beach in the Russian River

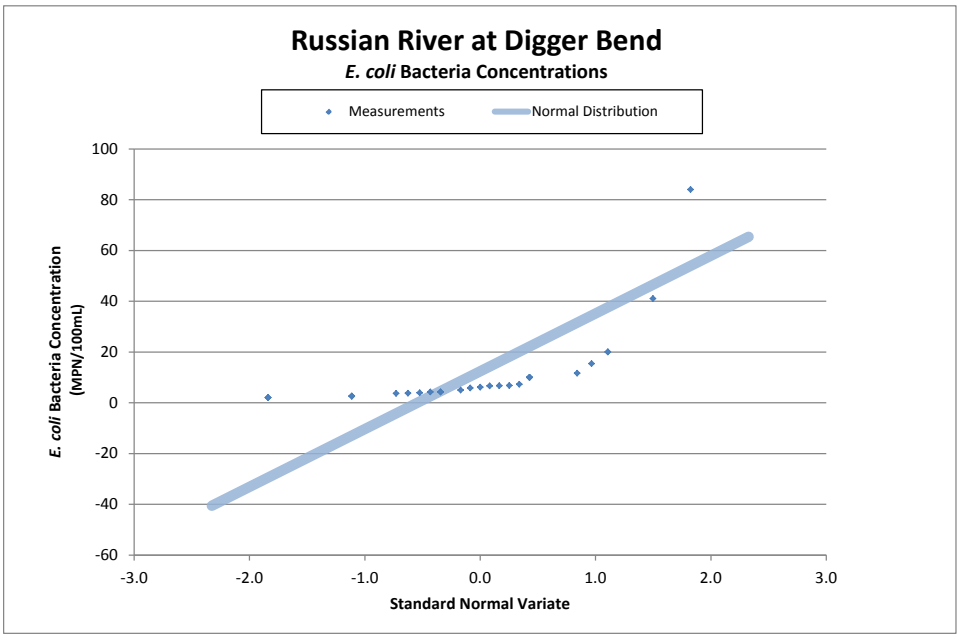

Figure 56. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Digger Bend in the Russian River

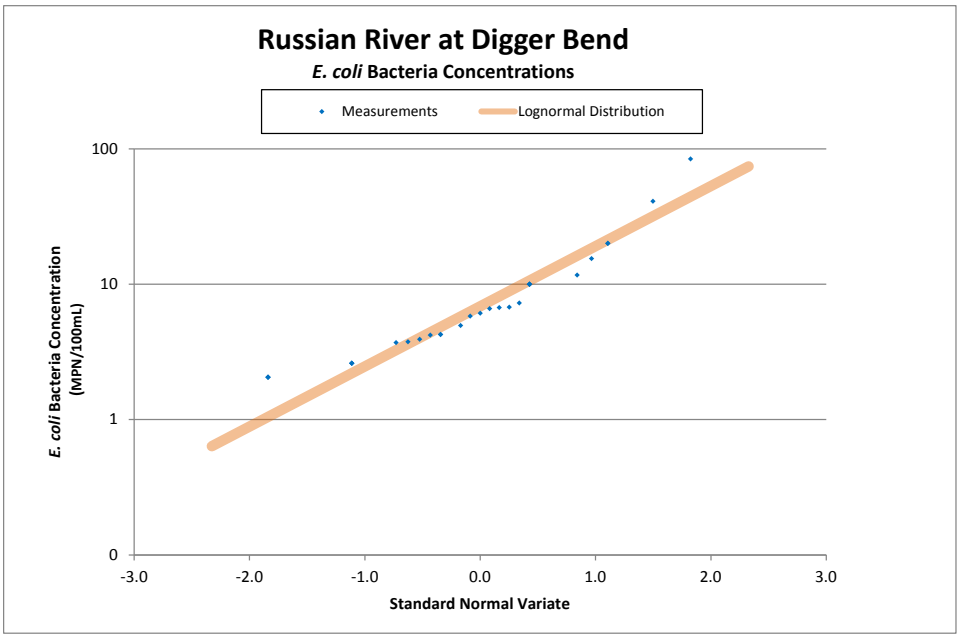

Figure 57. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Digger Bend in the Russian River

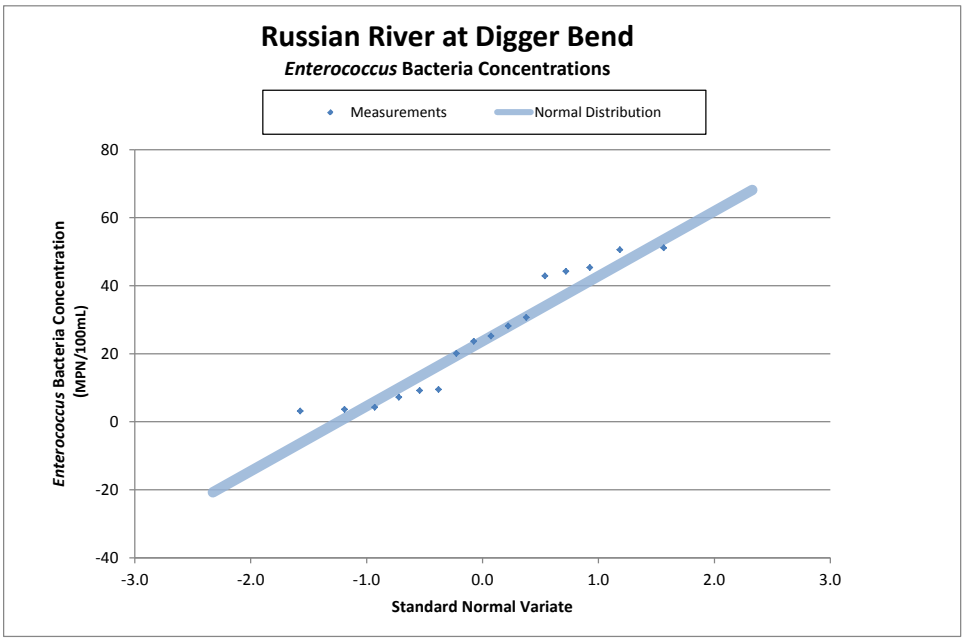

Figure 58. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Digger Bend in the Russian River

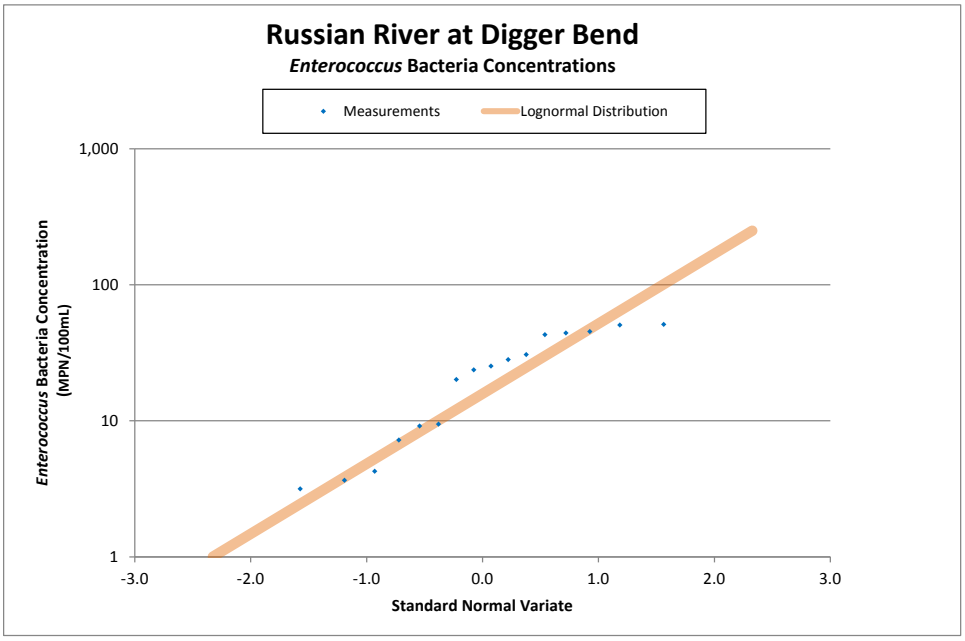

Figure 59. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Digger Bend in the Russian River

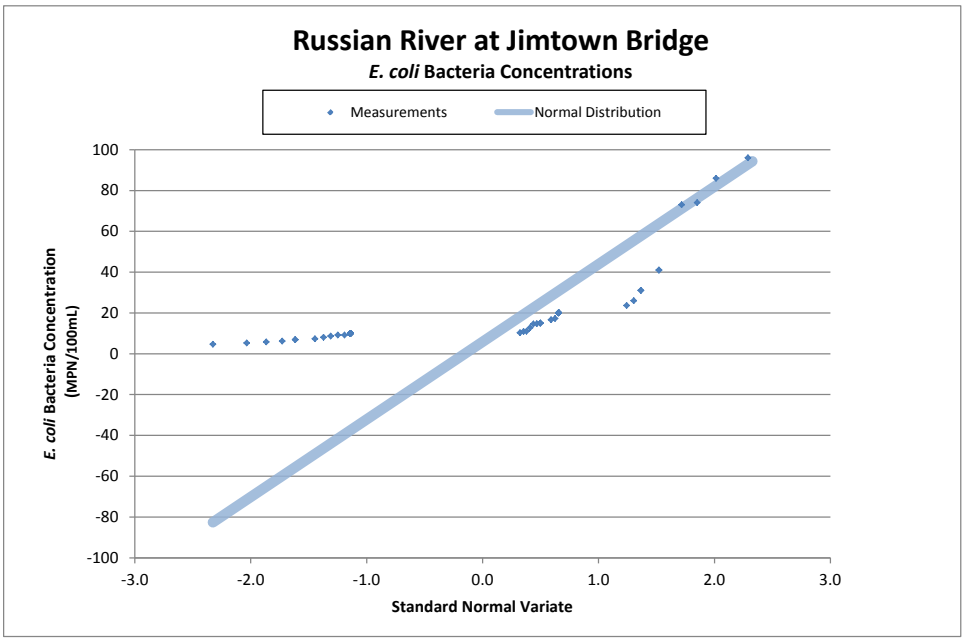

Figure 60. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Jimtown bridge in the Russian River

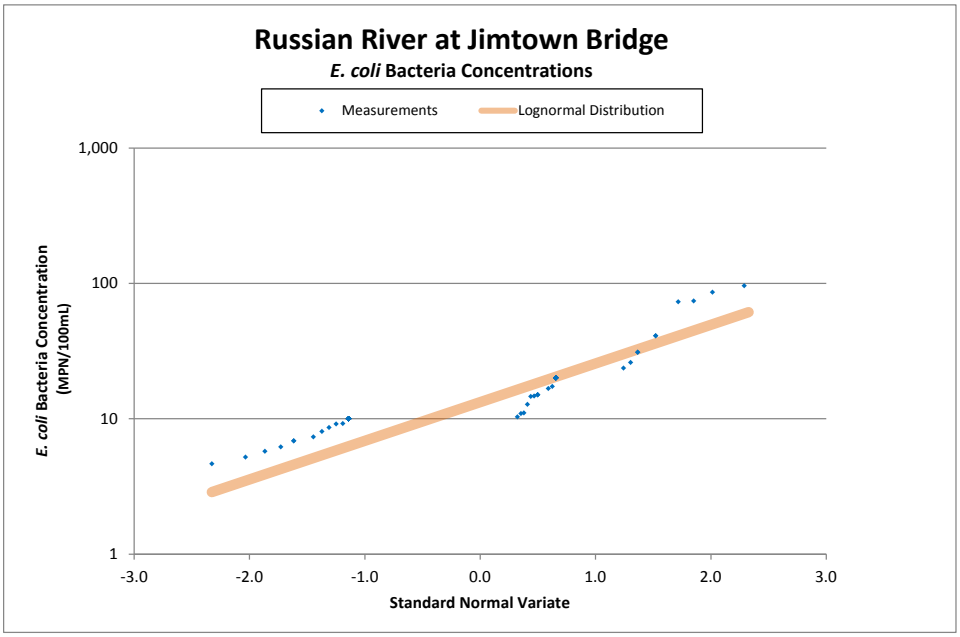

Figure 61. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Jimtown bridge in the Russian River

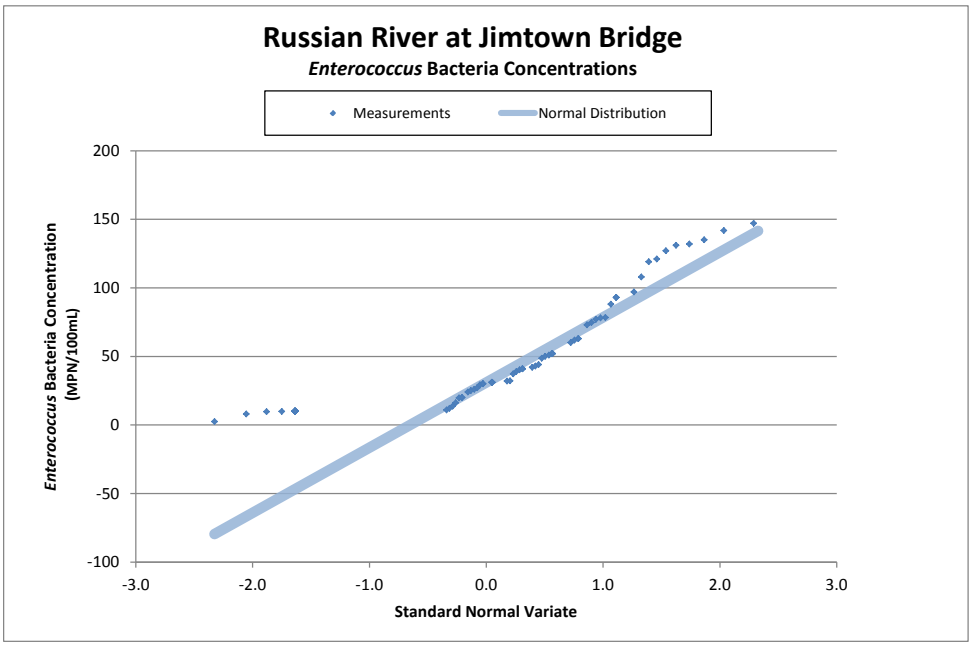

Figure 62. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Jimtown bridge in the Russian River

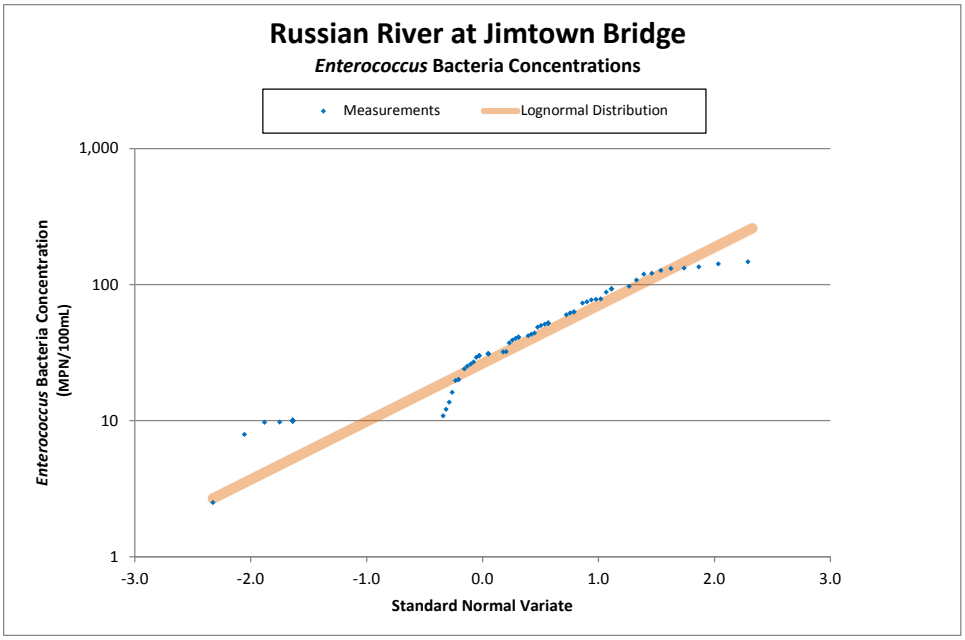

Figure 63. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Jimtown bridge in the Russian River

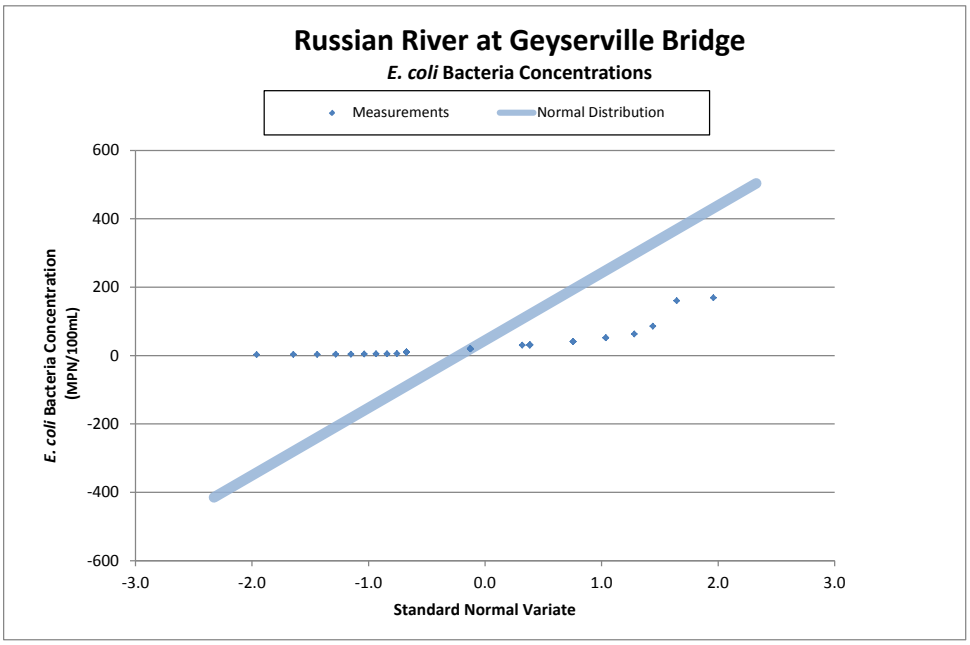

Figure 64. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Geyserville Bridge in the Russian River

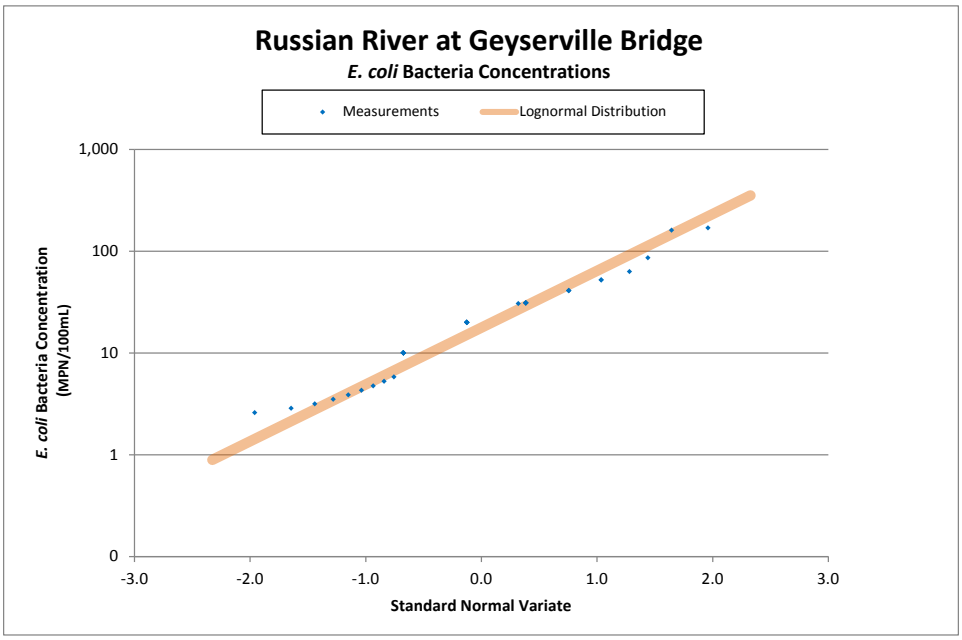

Figure 65. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Geyserville Bridge in the Russian River

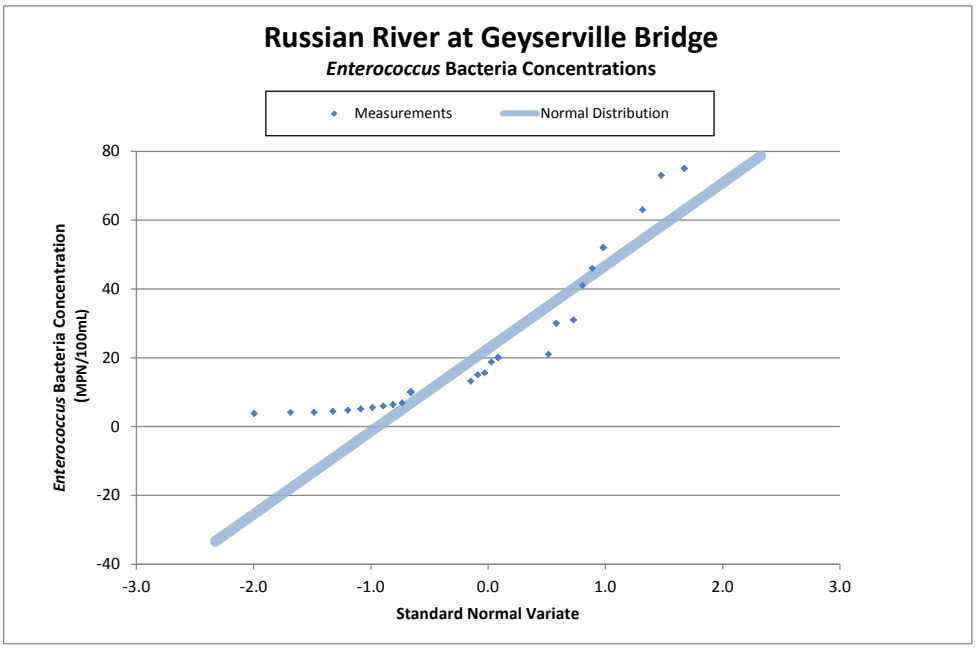

Figure 66. Normal distribution compared to *Enterocccus* bacteria concentration measurements collected at Geyserville Bridge in the Russian River

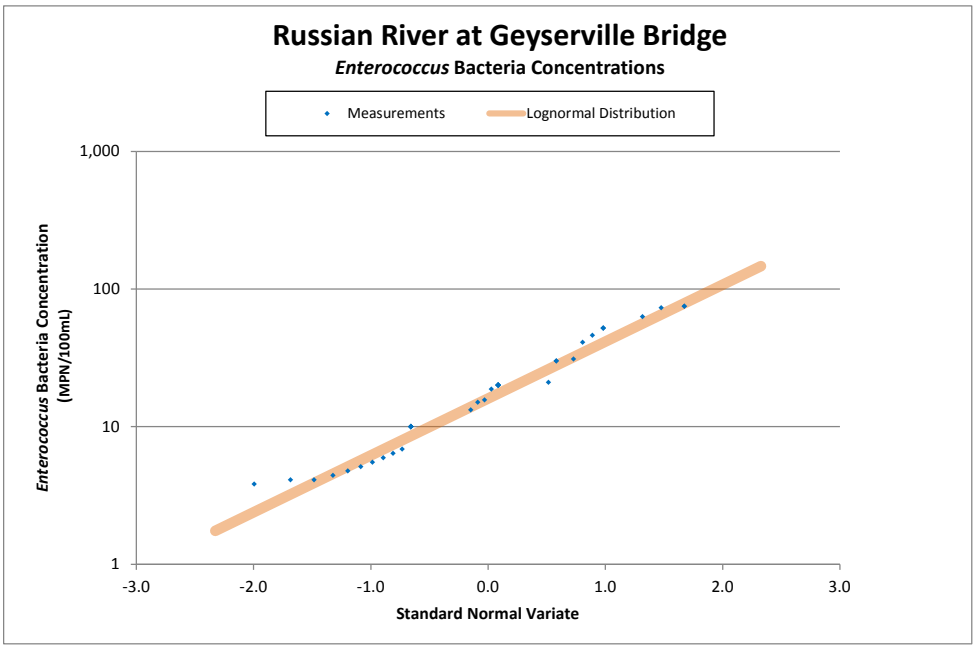

Figure 67. Log-normal distribution compared to *Enterocccus* bacteria concentration measurements collected at Geyserville Bridge in the Russian River

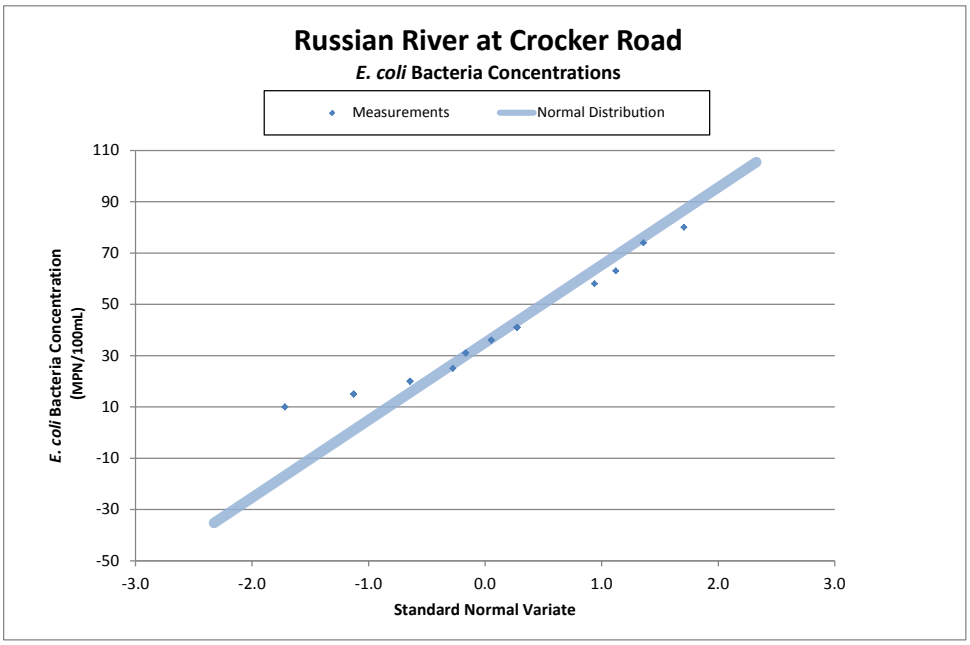

Figure 68. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Crocker Road in the Russian River

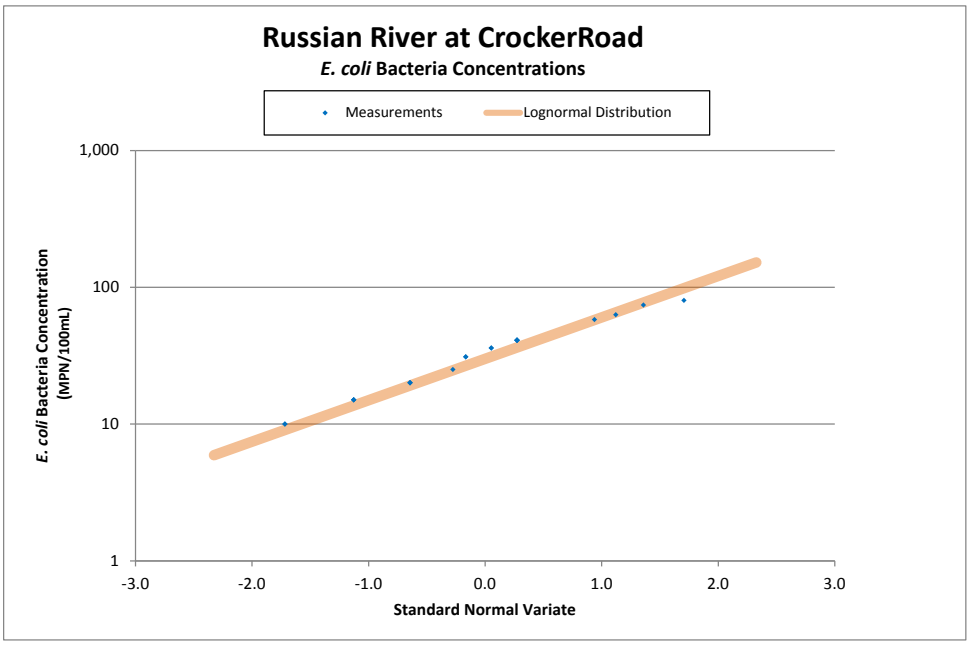

Figure 69. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Crocker Road in the Russian River

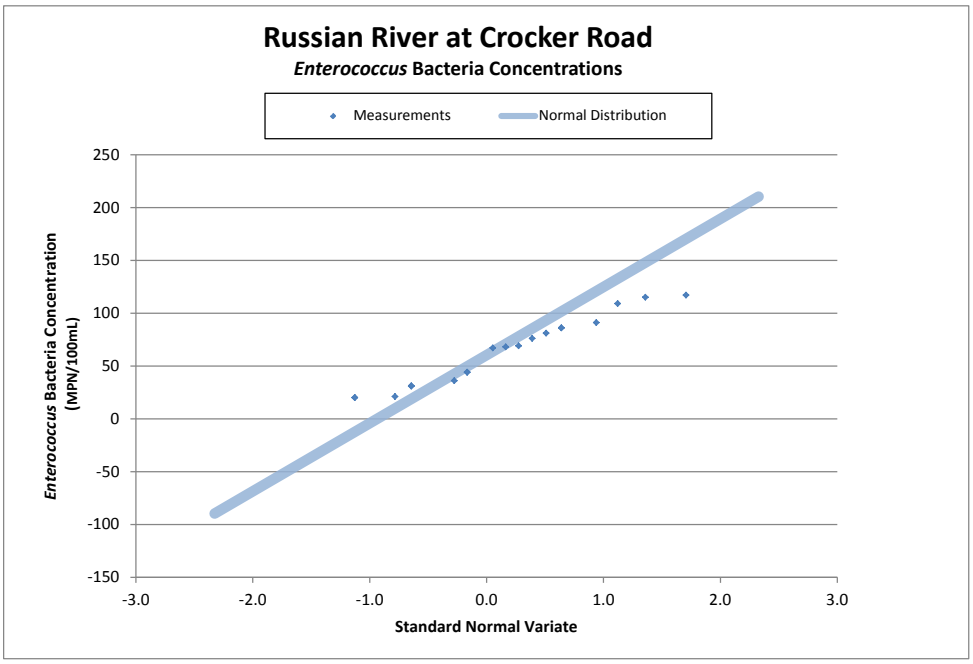

Figure 70. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Crocker Station Road in the Russian River

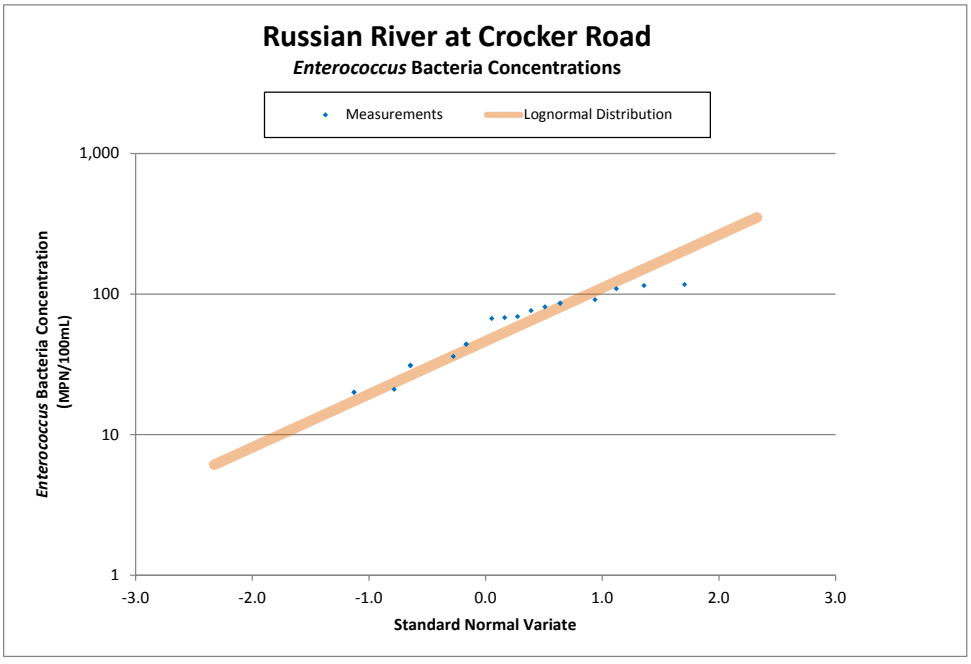

Figure 71. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Crocker Station Road in the Russian River

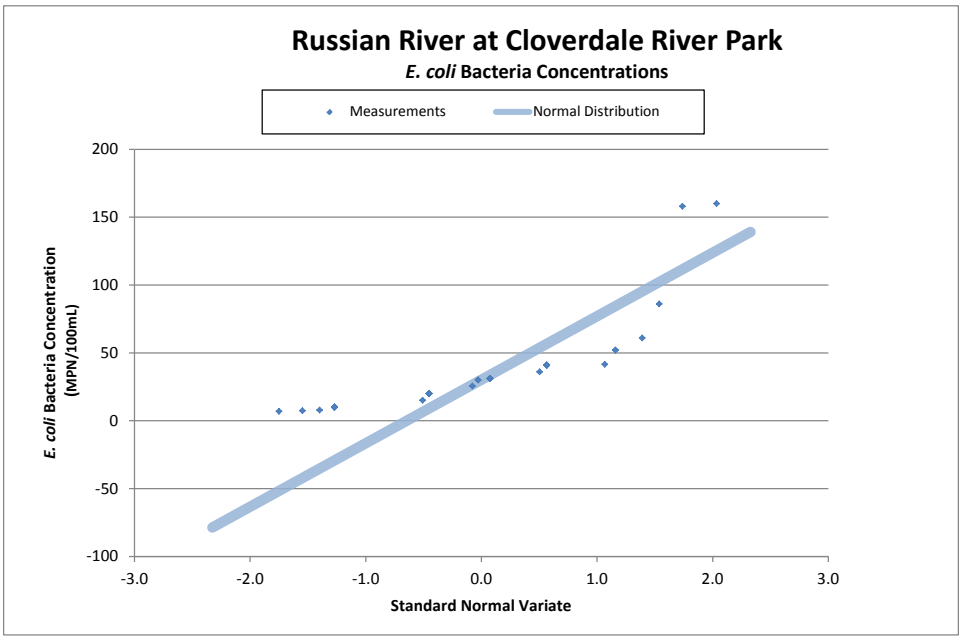

Figure 72. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Cloverdale River Park in the Russian River

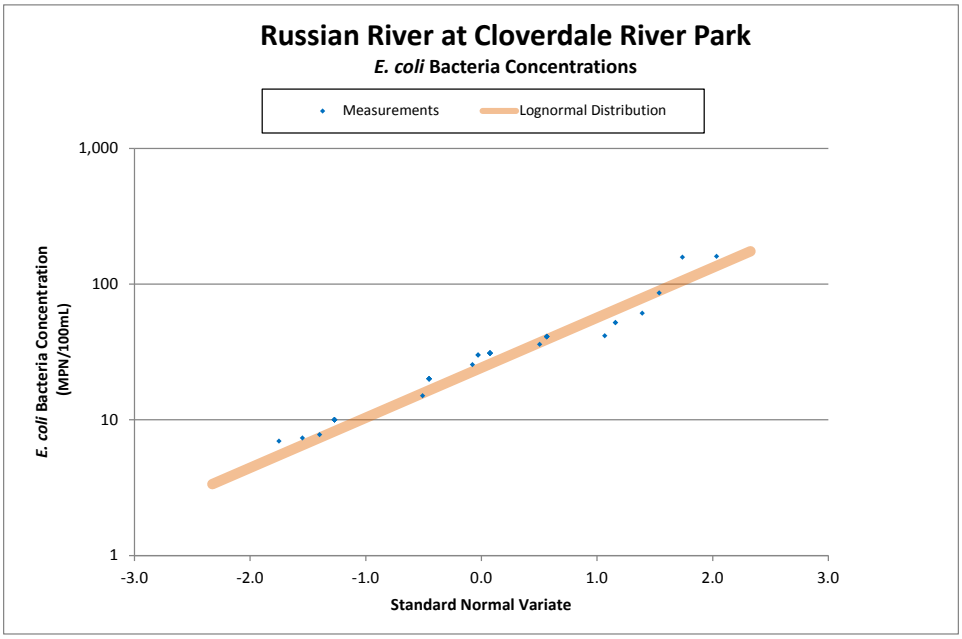

Figure 73. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Cloverdale River Park in the Russian River

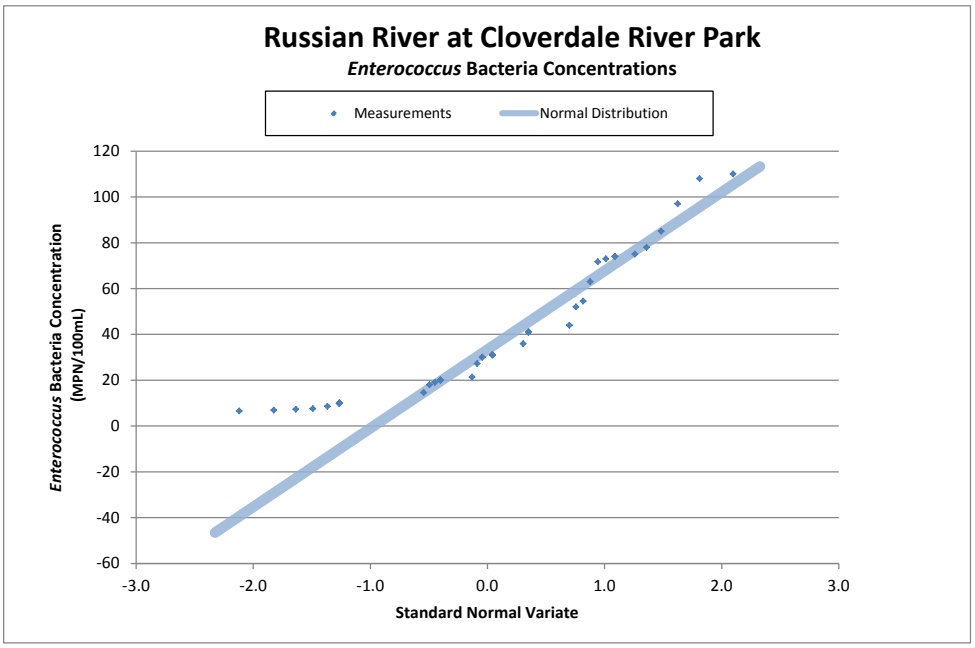

Figure 74. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Cloverdale River Park in the Russian River

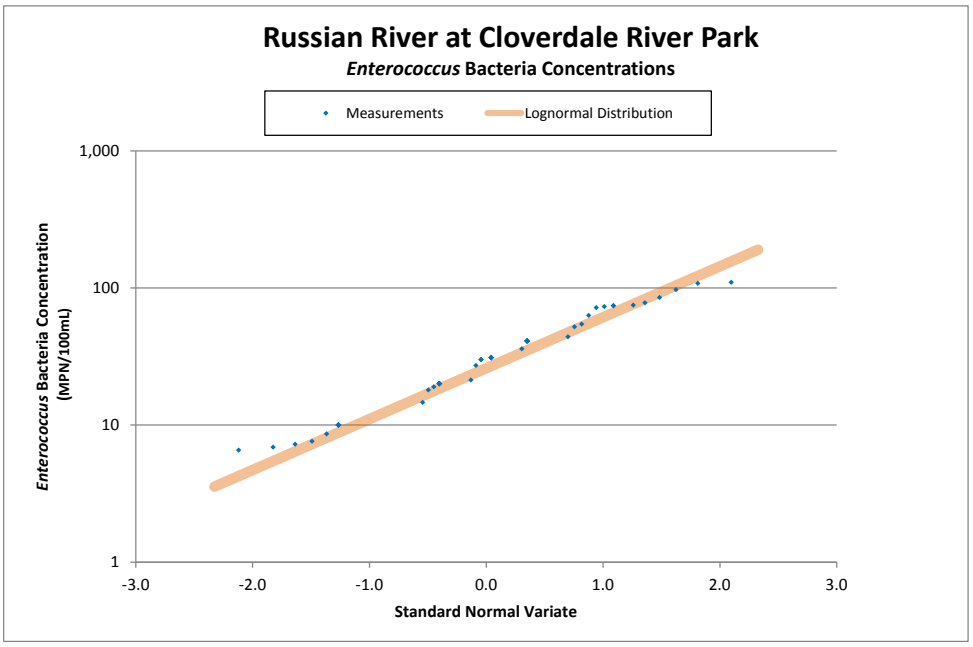

Figure 75. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Cloverdale River Park in the Russian River

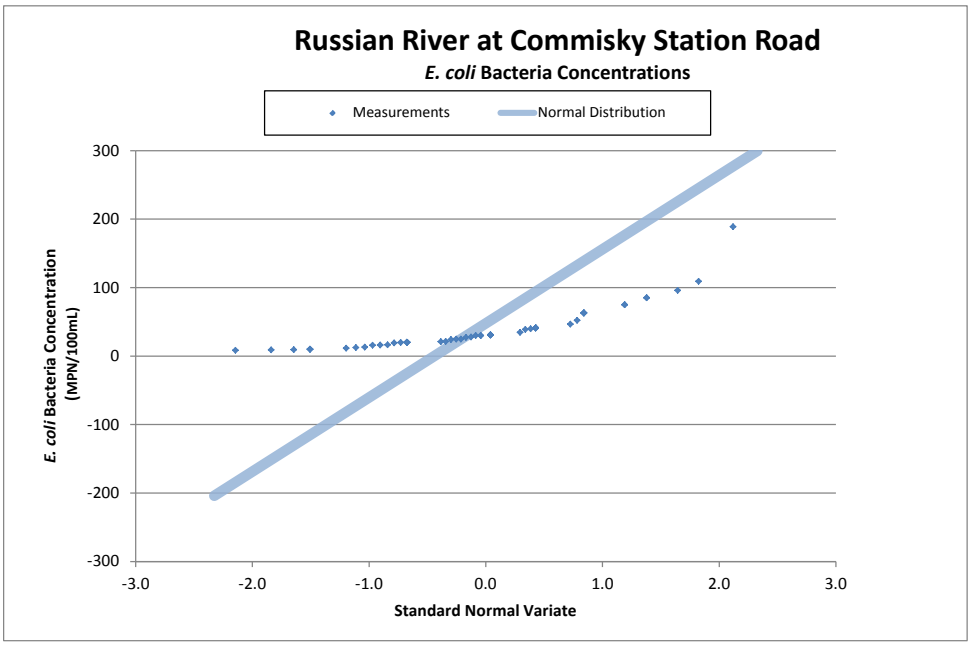

Figure 76. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Commisky Station Road in the Russian River

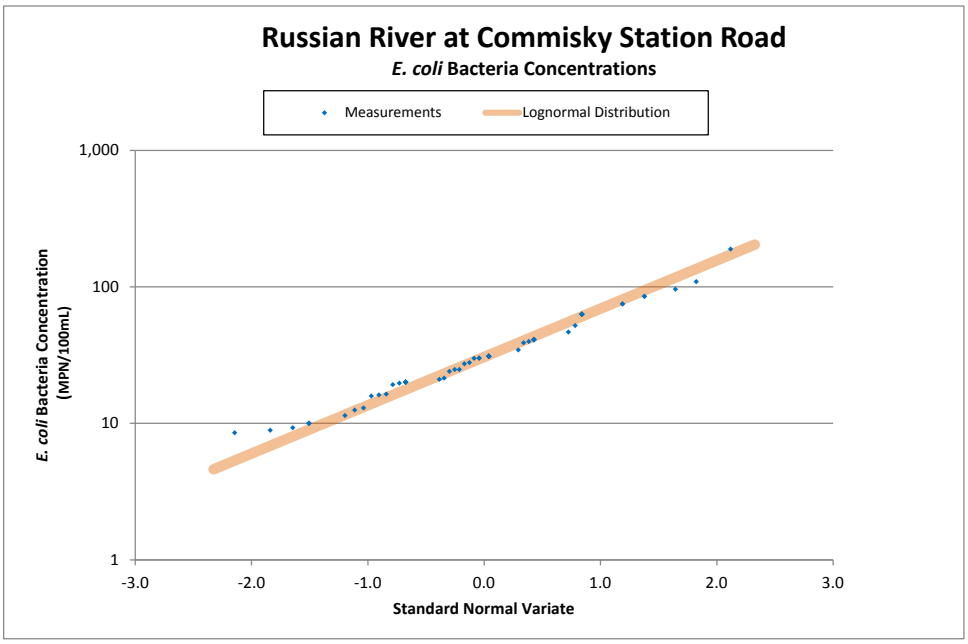

Figure 77. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Commisky Station Road in the Russian River

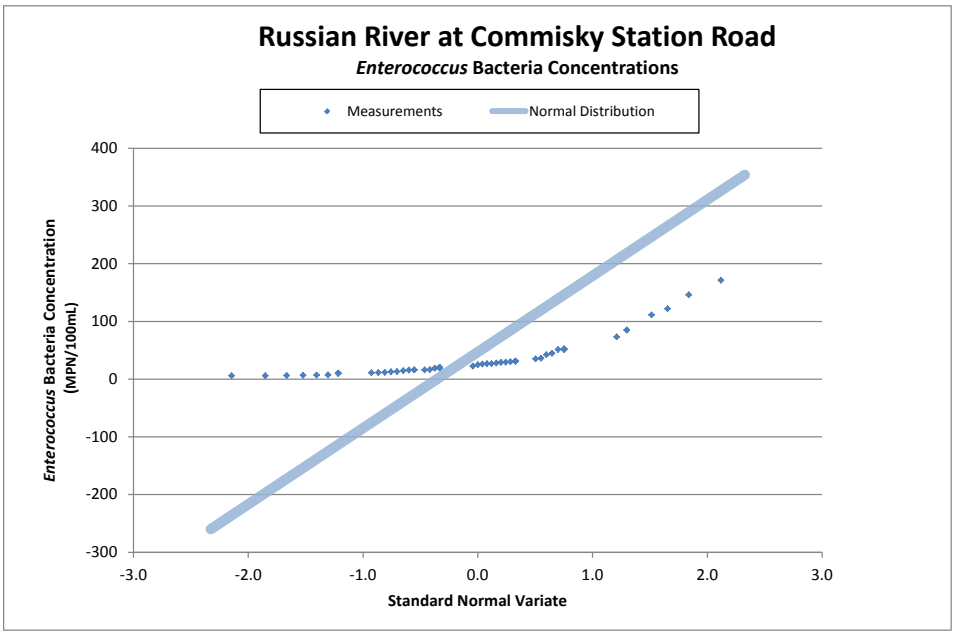

Figure 78. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Commisky Station Road in the Russian River

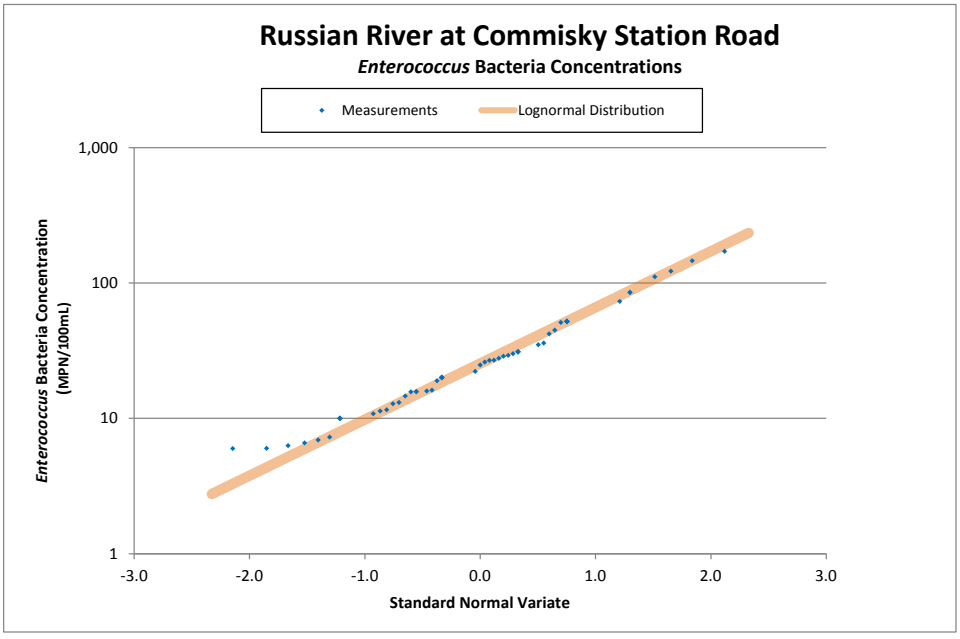

Figure 79. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Commisky Station Road in the Russian River

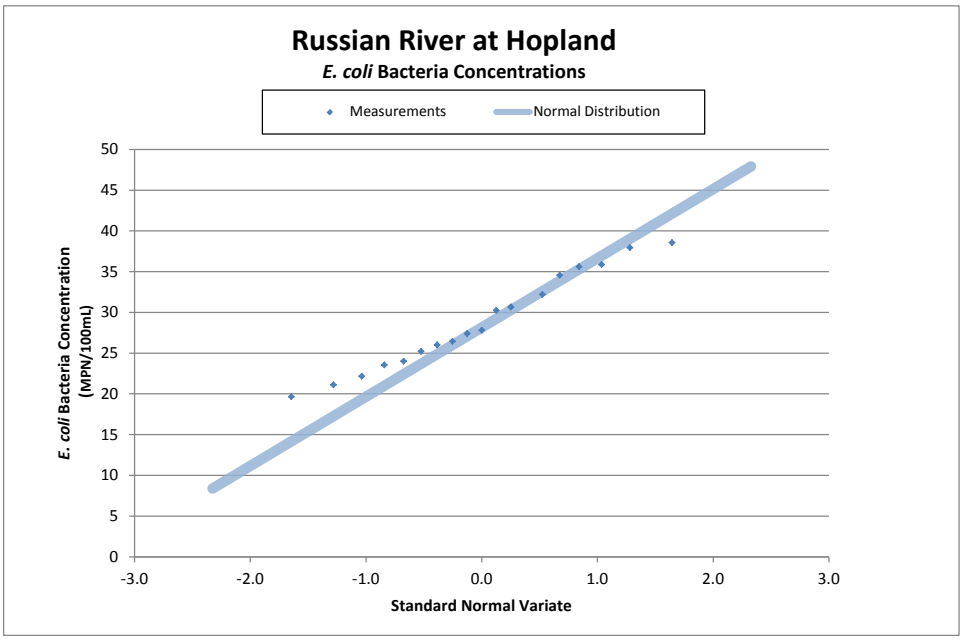

Figure 80. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Hopland in the Russian River

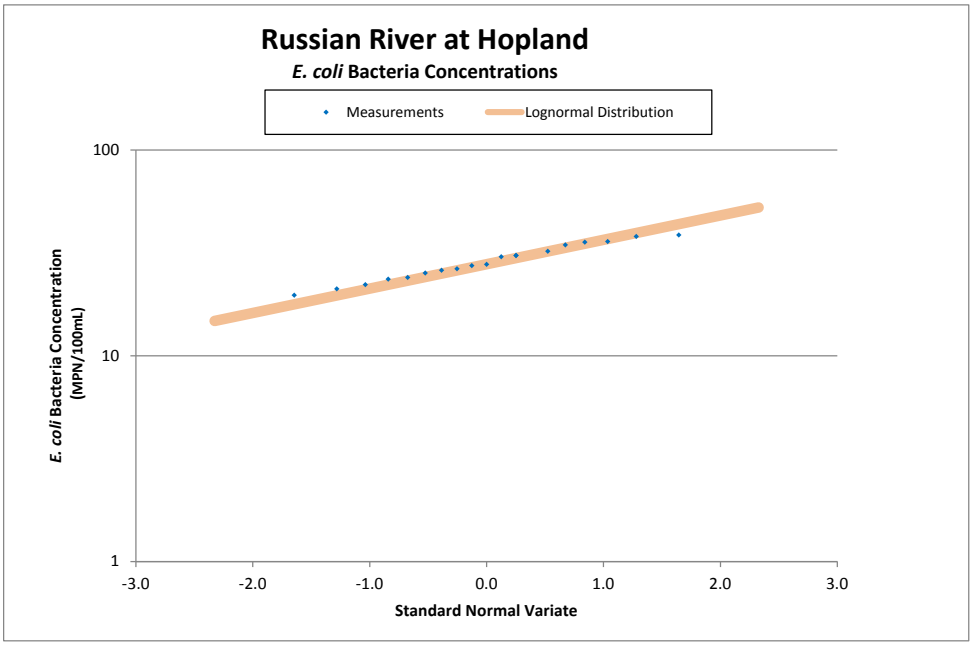

Figure 81. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Hopland in the Russian River

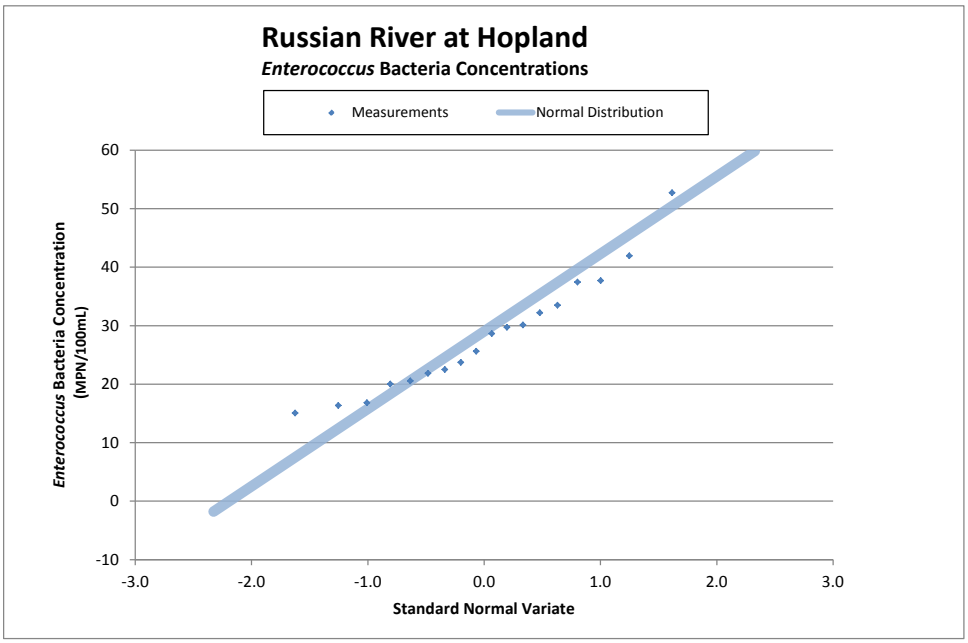

Figure 82. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Hopland in the Russian River

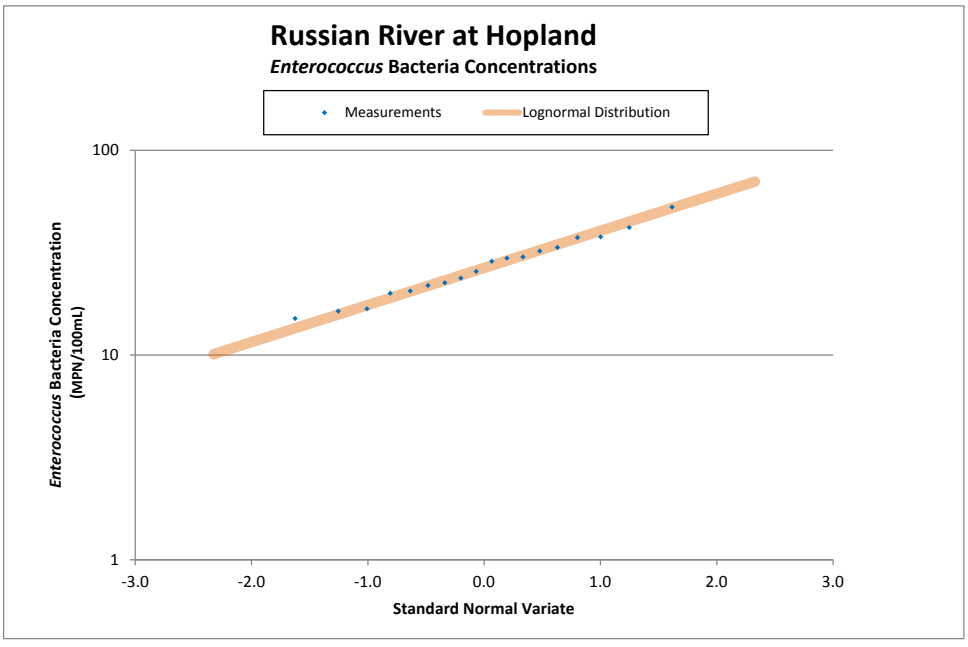

Figure 83. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Hopland in the Russian River

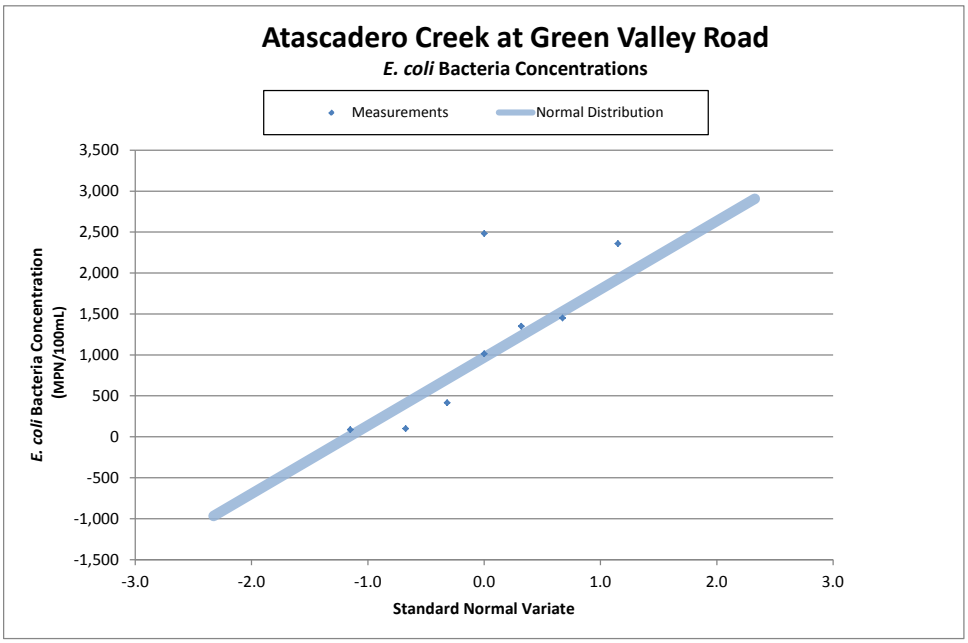

Figure 84. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Green Valley Road in Atascadero Creek

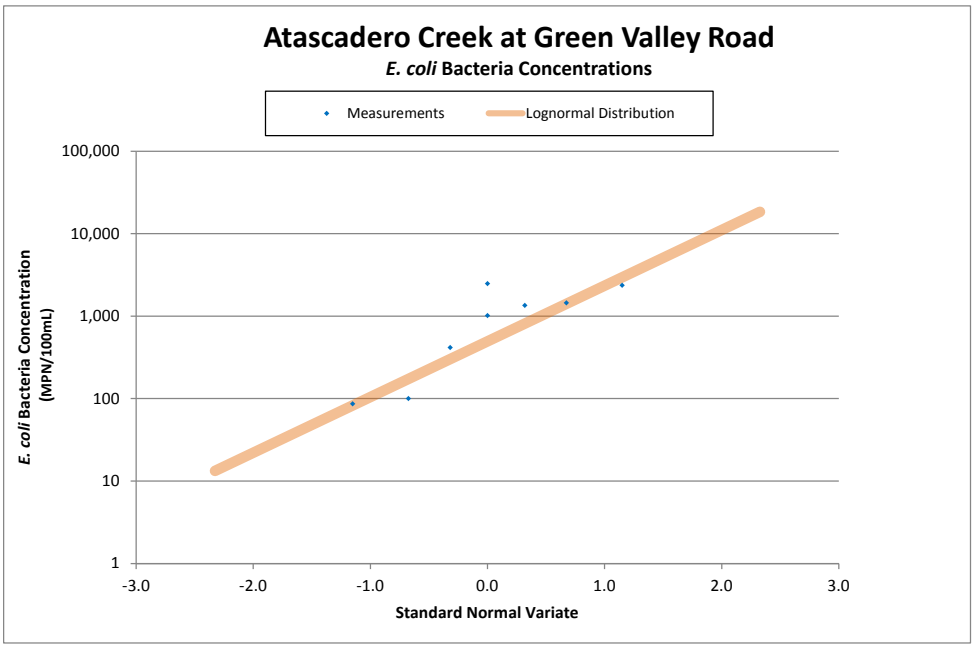

Figure 85. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Green Valley Road in Atascadero Creek

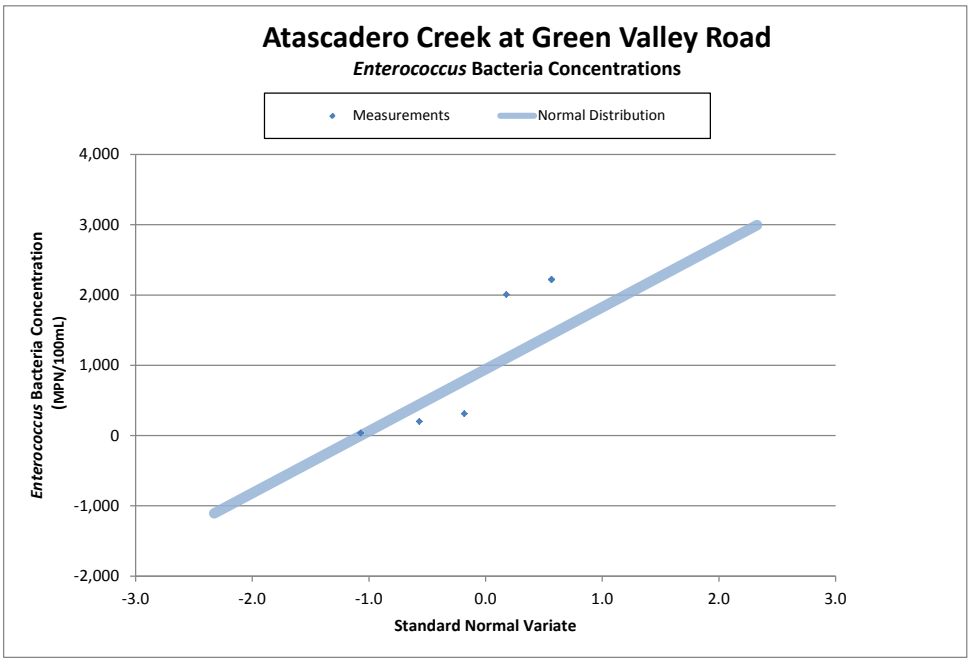

Figure 86. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Green Valley Road in Atascadero Creek

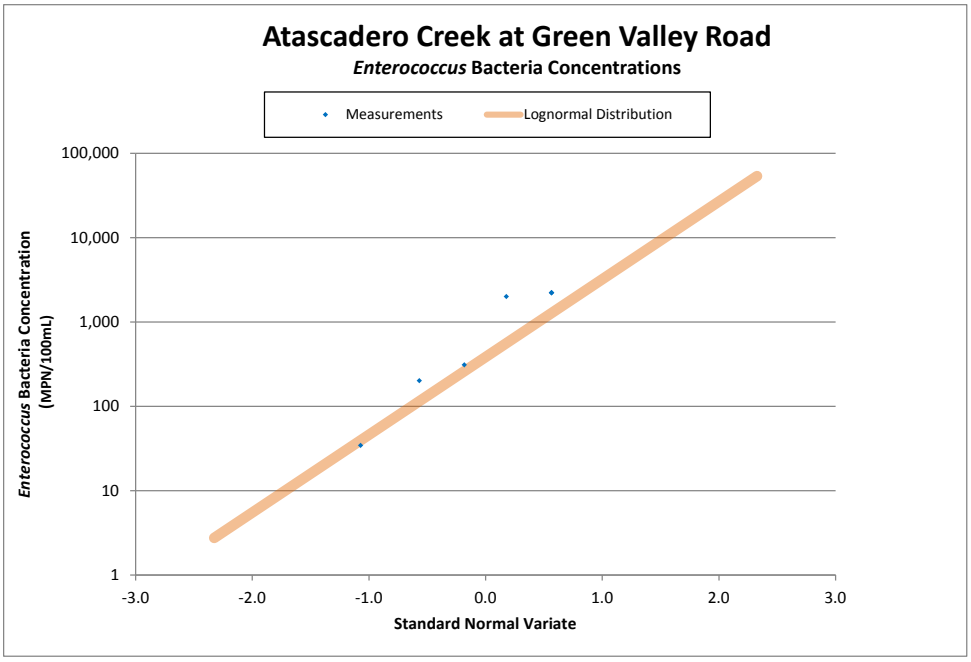

Figure 87. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Green Valley Road in Atascadero Creek

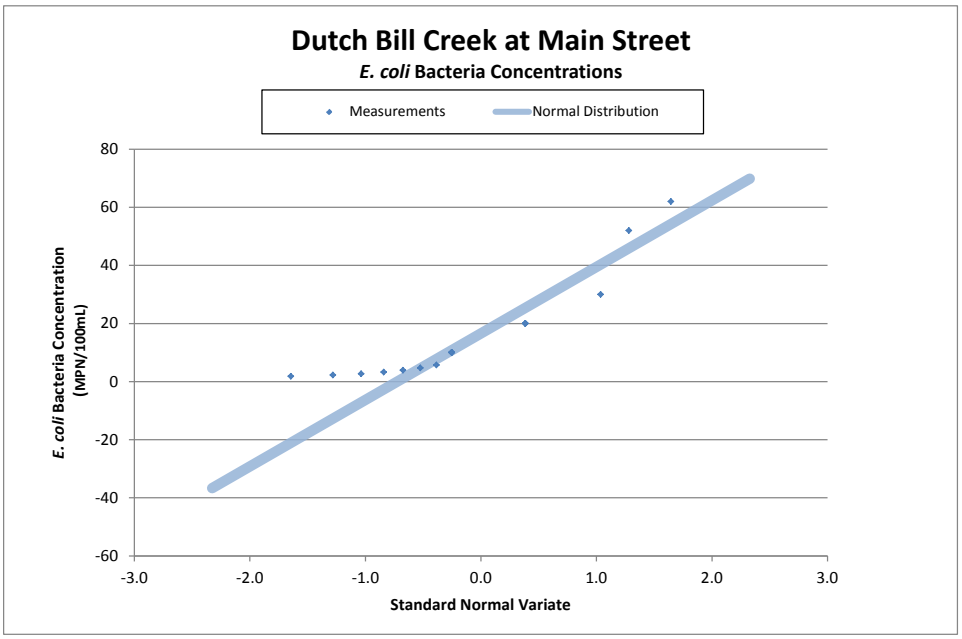

Figure 88. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Main Street in Dutch Bill Creek

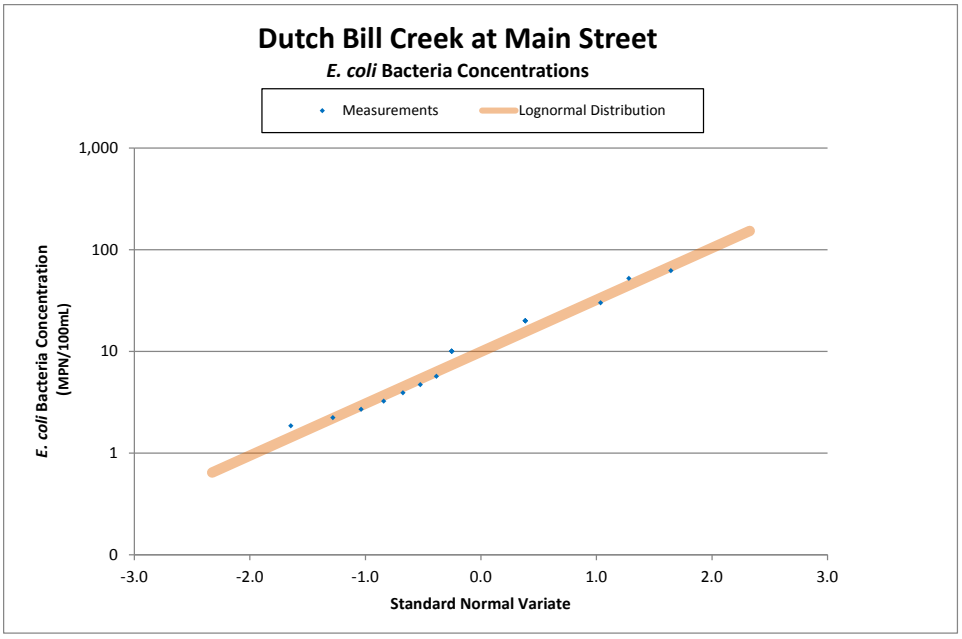

Figure 89. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Main Street in Dutch Bill Creek

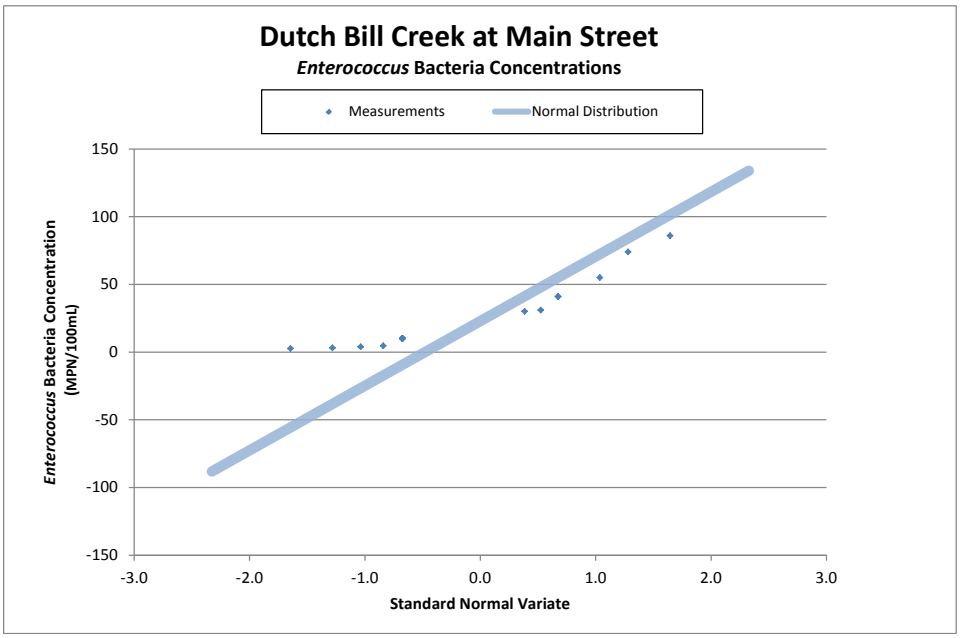

Figure 90. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Main Street in Dutch Bill Creek

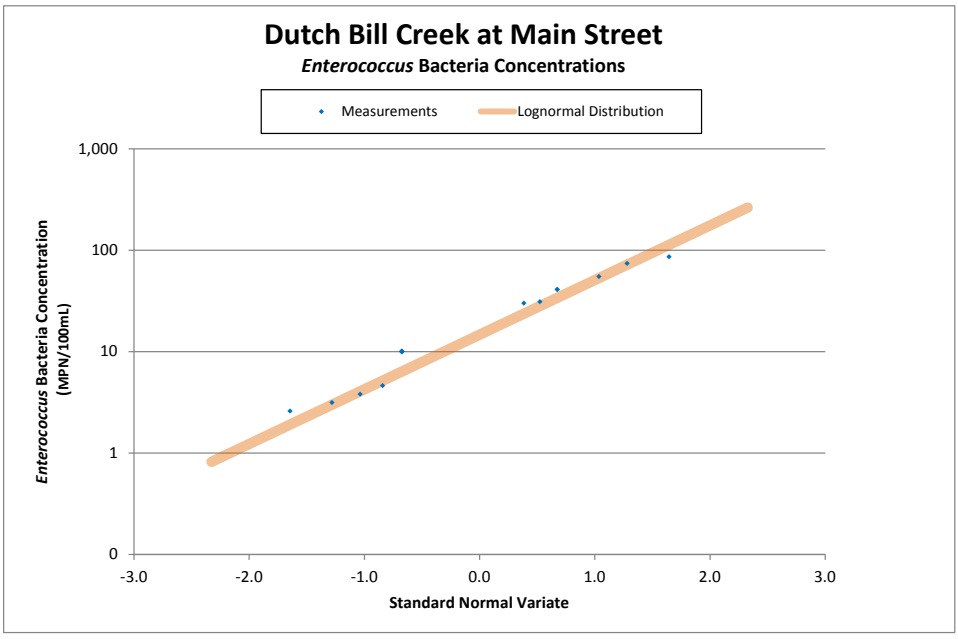

Figure 91. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Main Street in Dutch Bill Creek

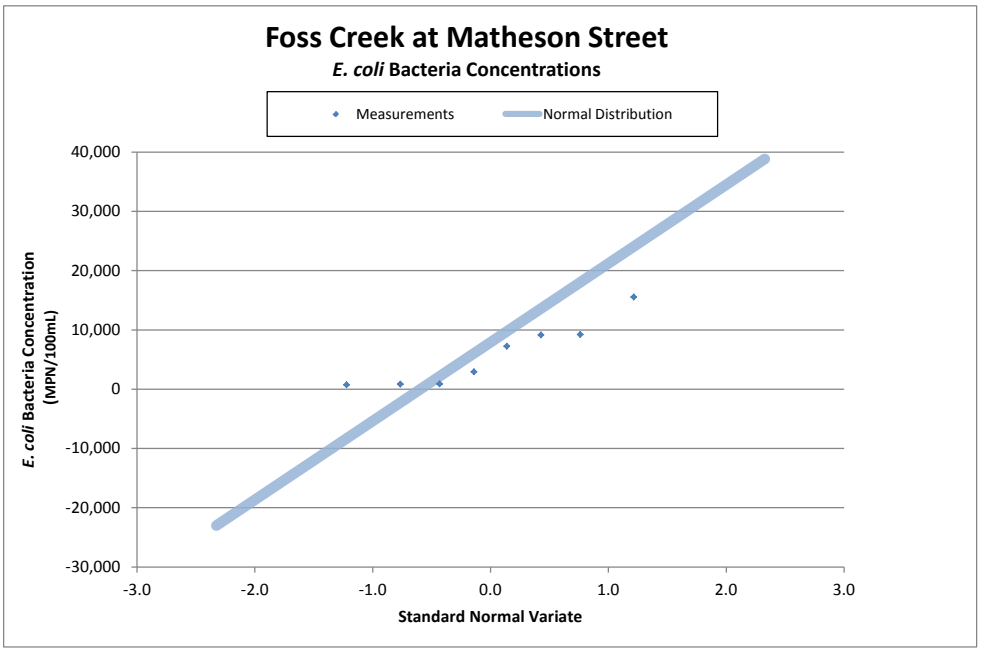

Figure 92. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Matheson Street in Foss Creek

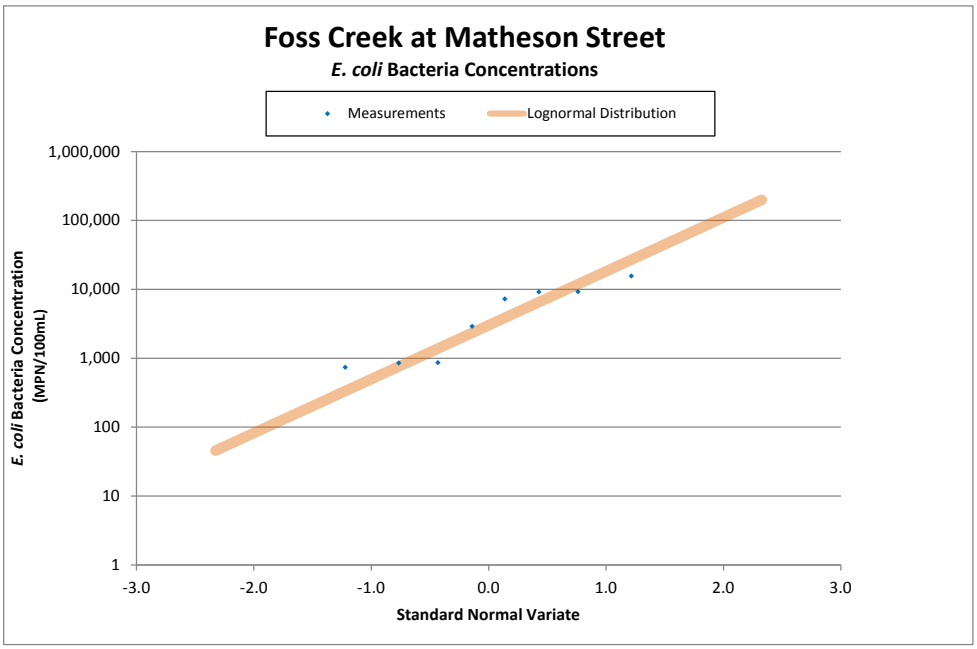

Figure 93. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Matheson Street in Foss Creek

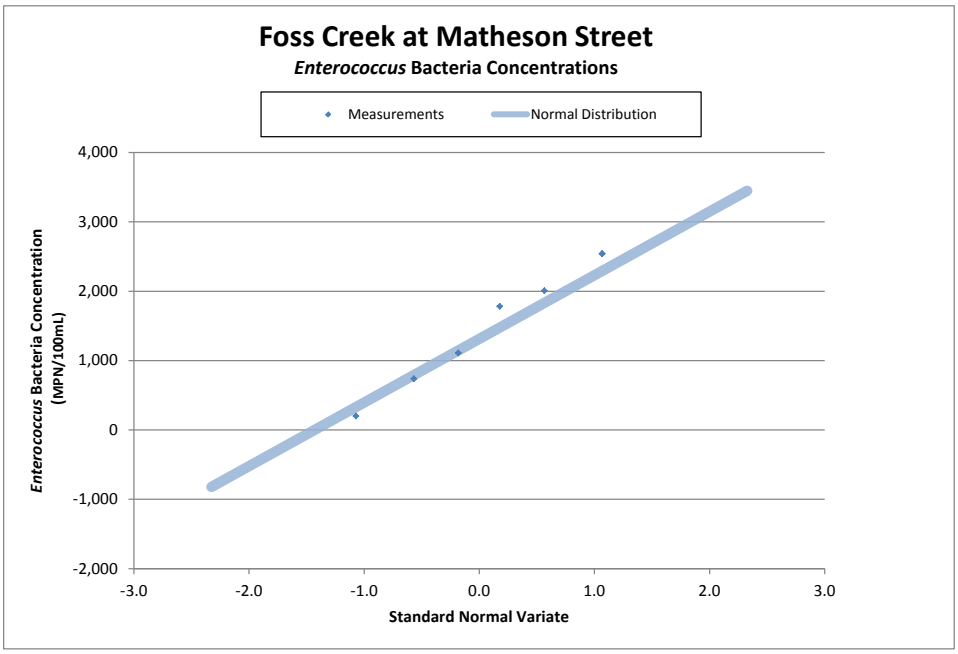

Figure 94. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Matheson Street in Foss Creek

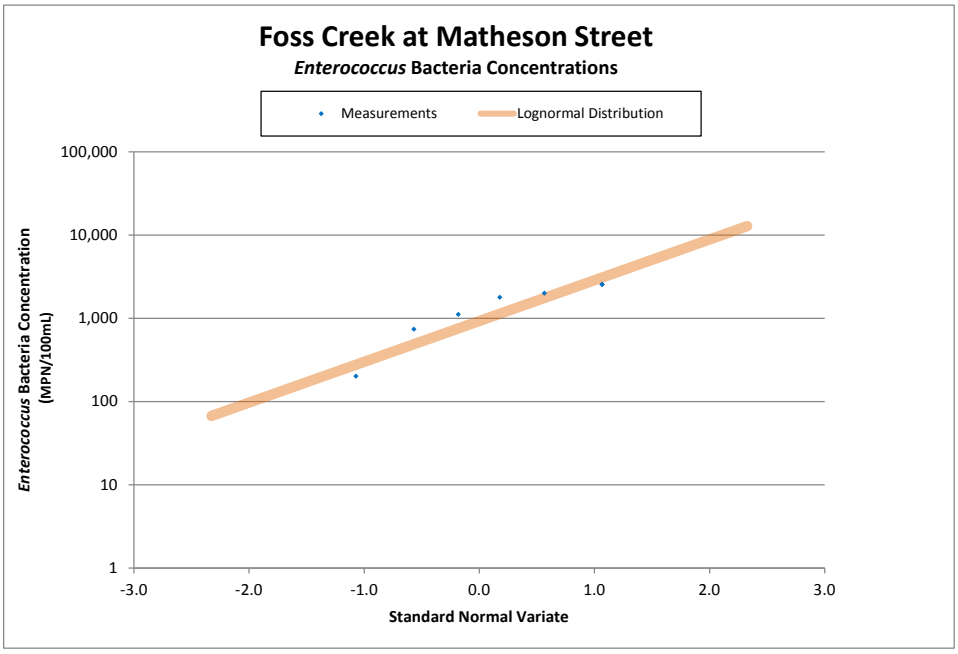

Figure 95. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Matheson Street in Foss Creek

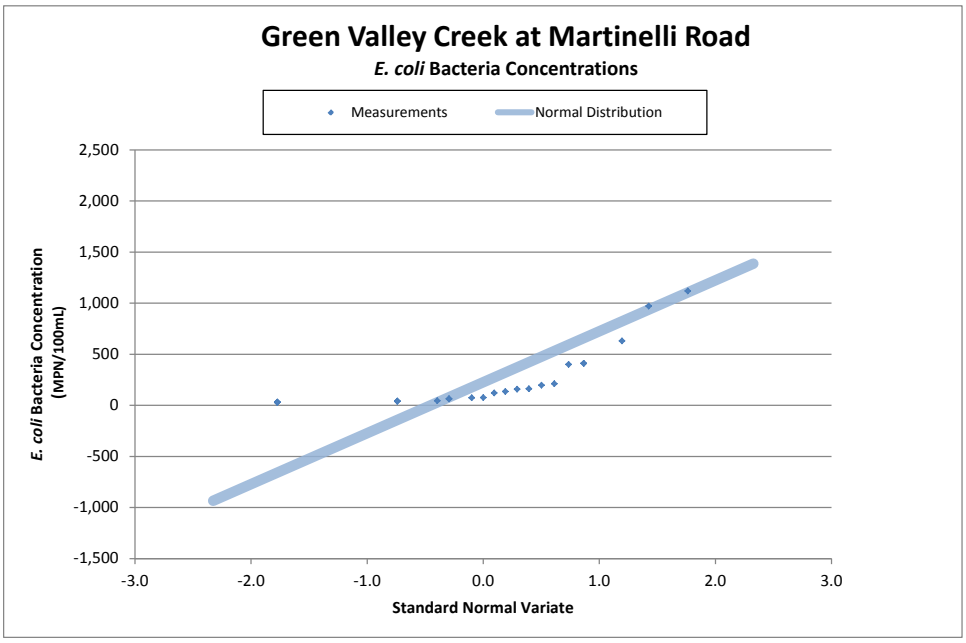

Figure 96. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek

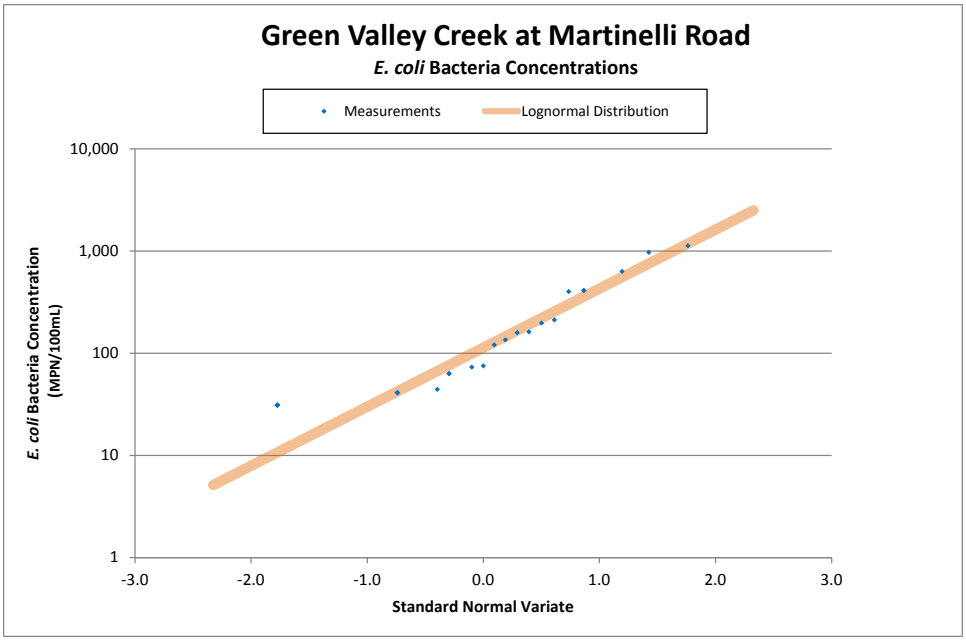

Figure 97. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek

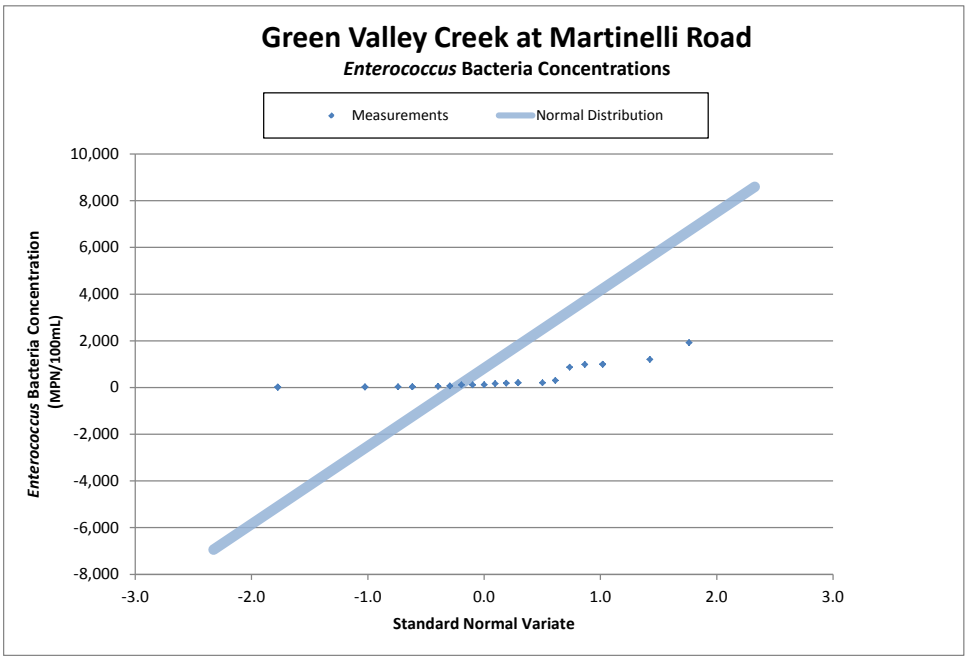

Figure 98. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek

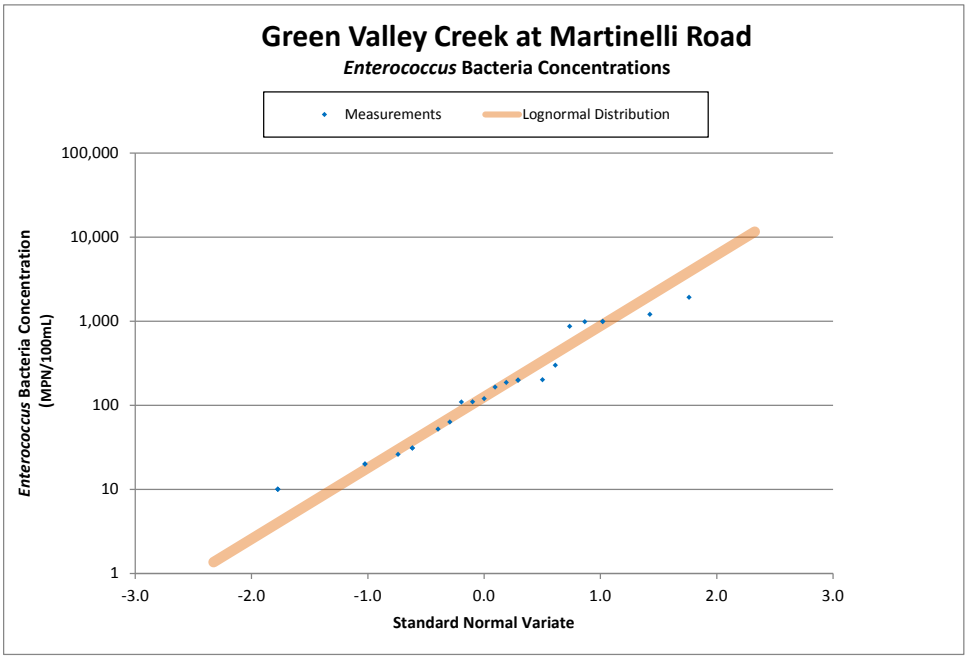

Figure 99. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek

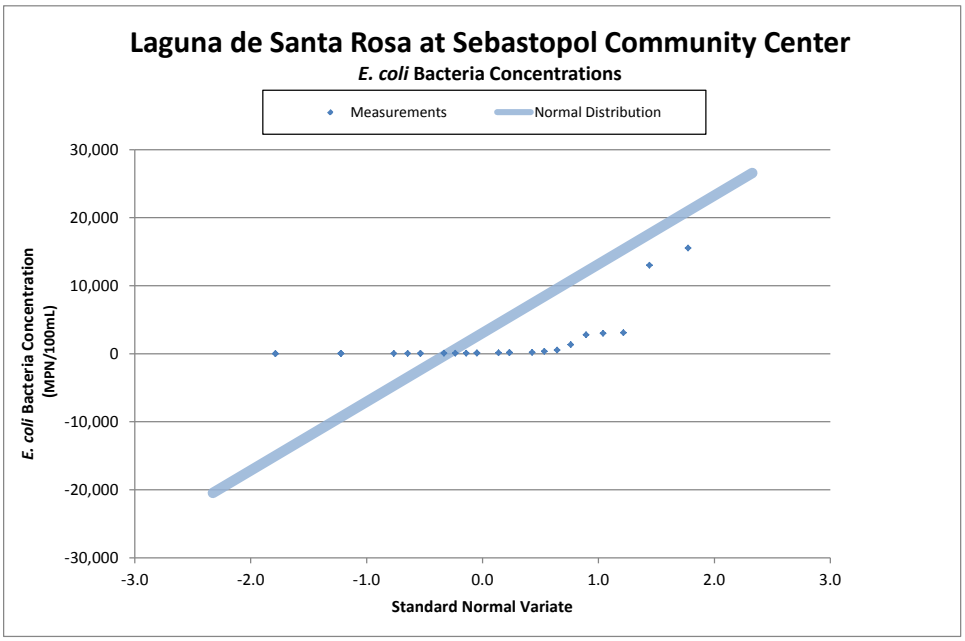

Figure 100. Normal distribution compared to *E. coli* bacteria concentration measurements collected at the Sebastopol Community Center in the Laguna de Santa Rosa

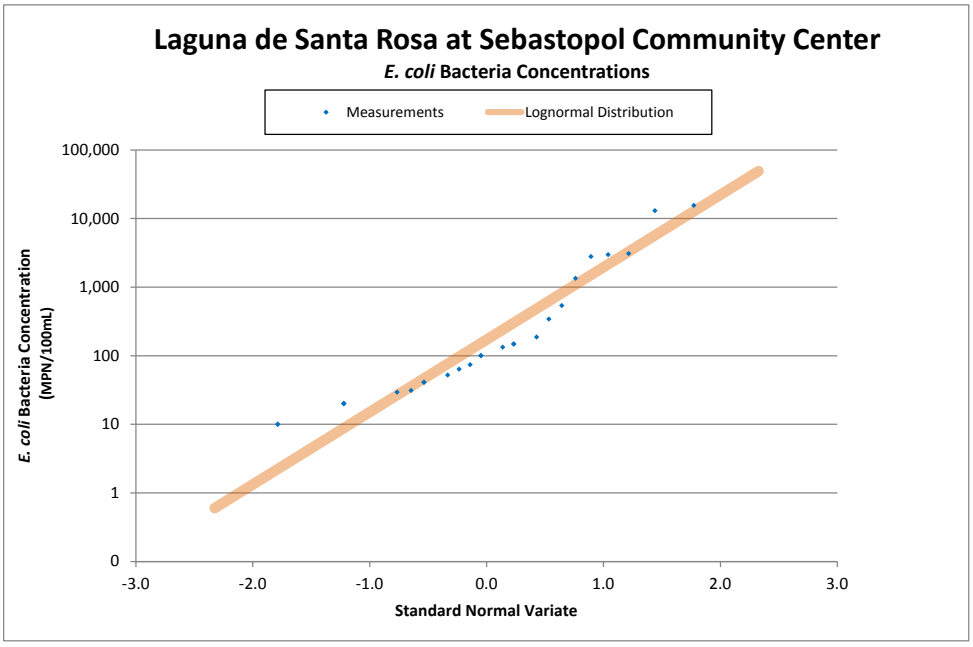

Figure 101. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at the Sebastopol Community Center in the Laguna de Santa Rosa

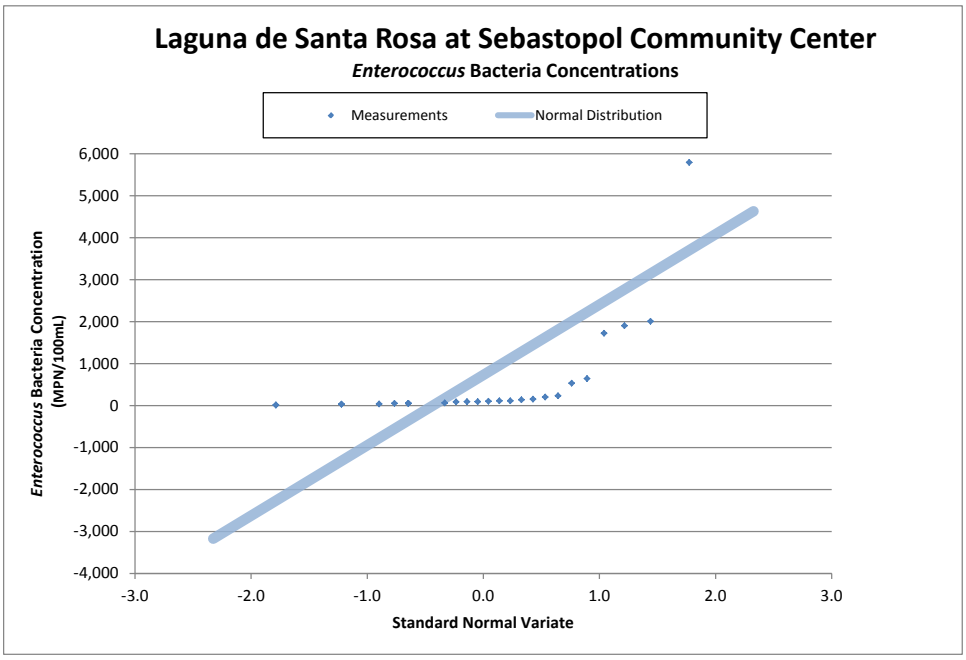

Figure 102. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at the Sebastopol Community Center in the Laguna de Santa Rosa

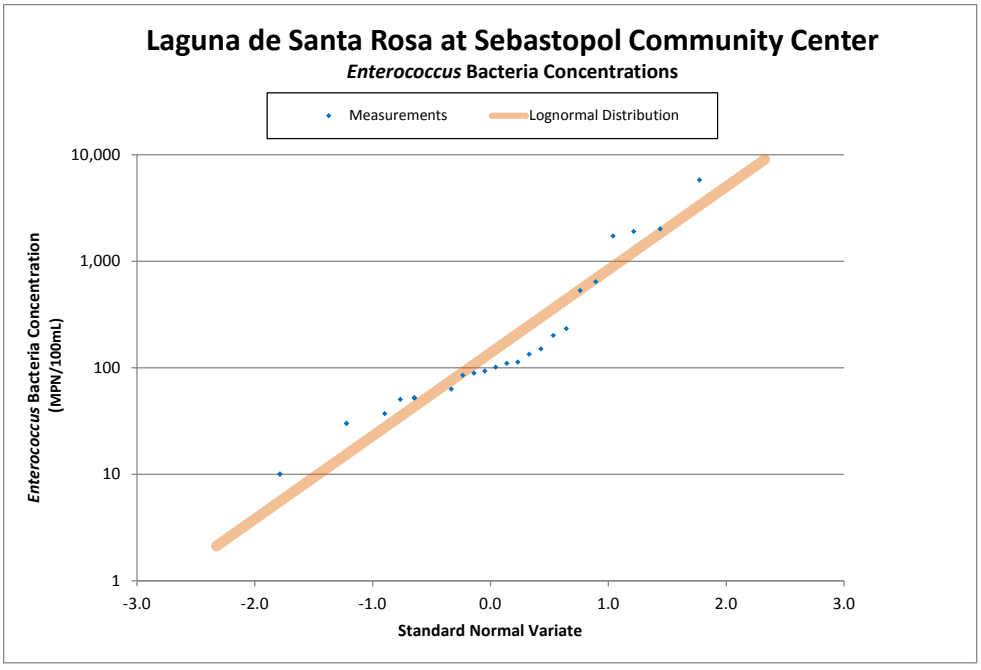

Figure 103. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at the Sebastopol Community Center in the Laguna de Santa Rosa

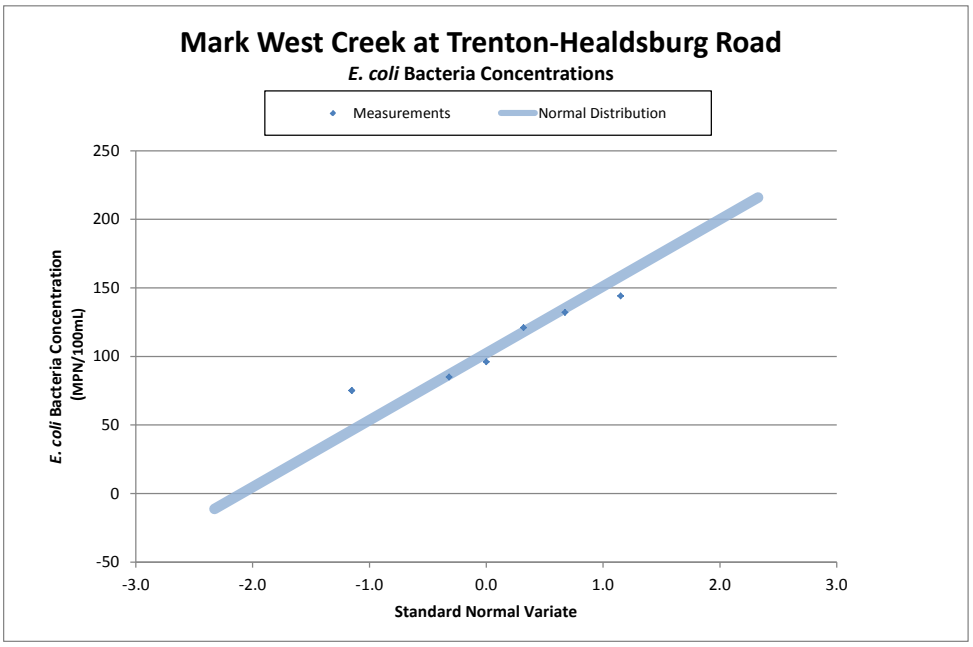

Figure 104. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek

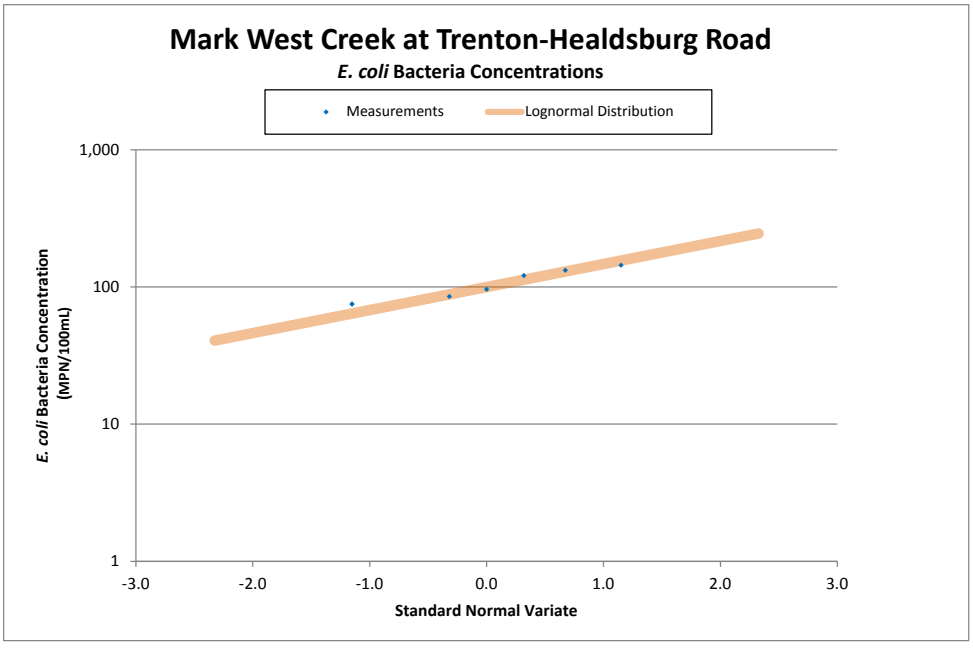

Figure 105. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek

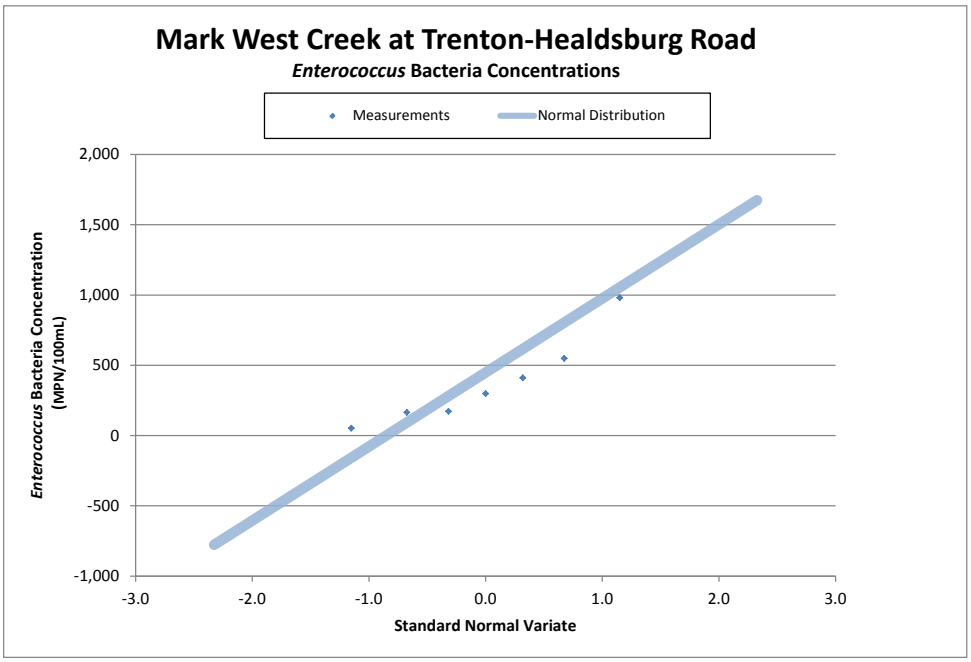

Figure 106. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek

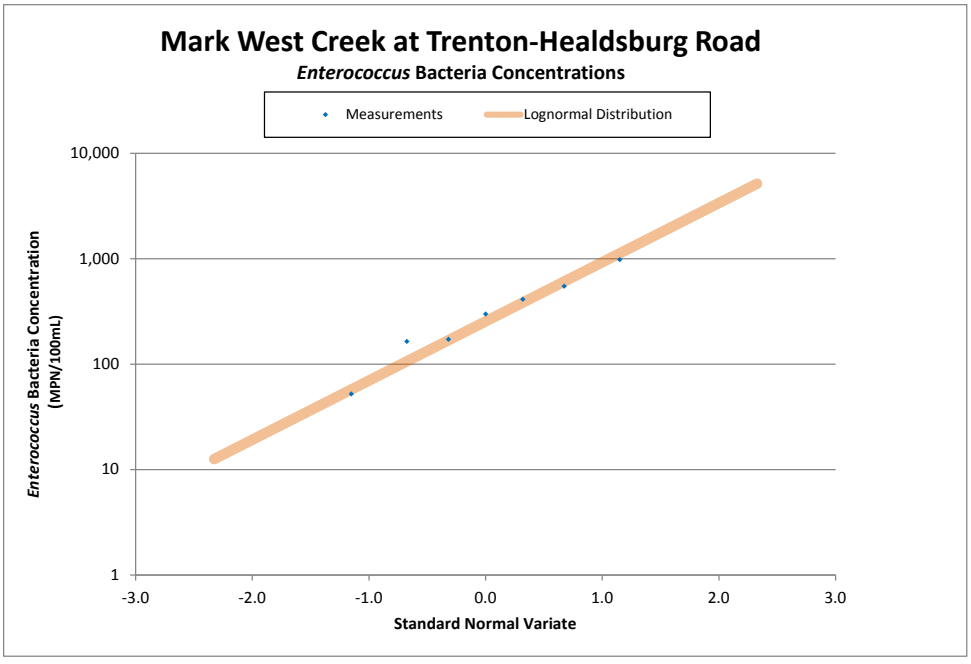

Figure 107. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek

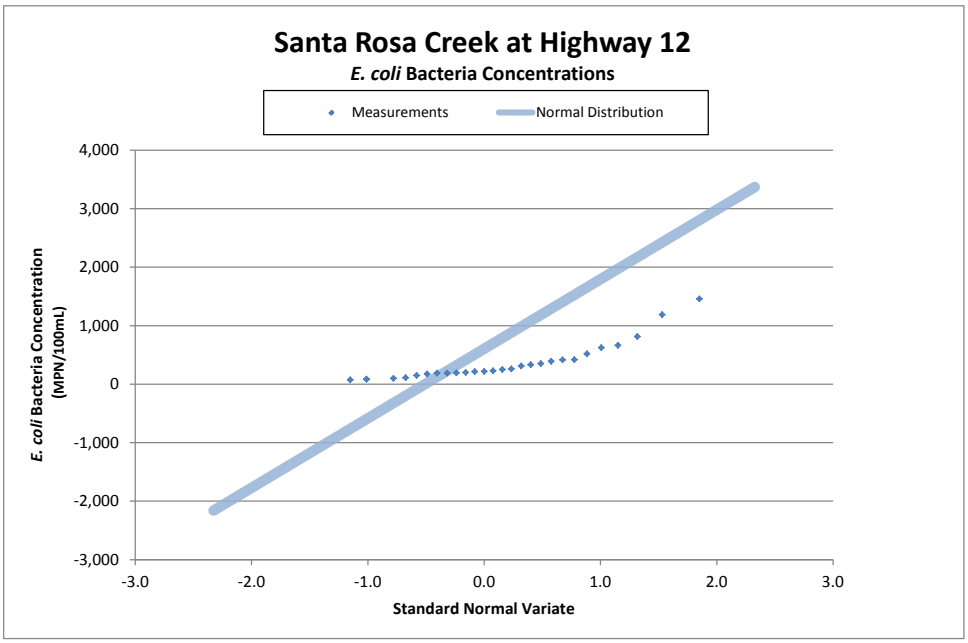

Figure 108. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek

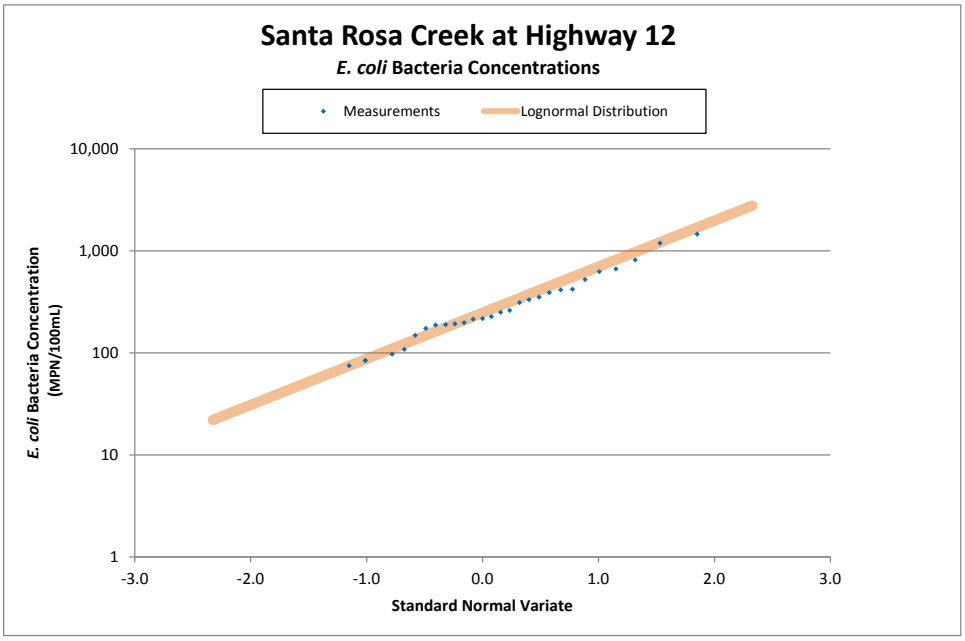

Figure 109. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek

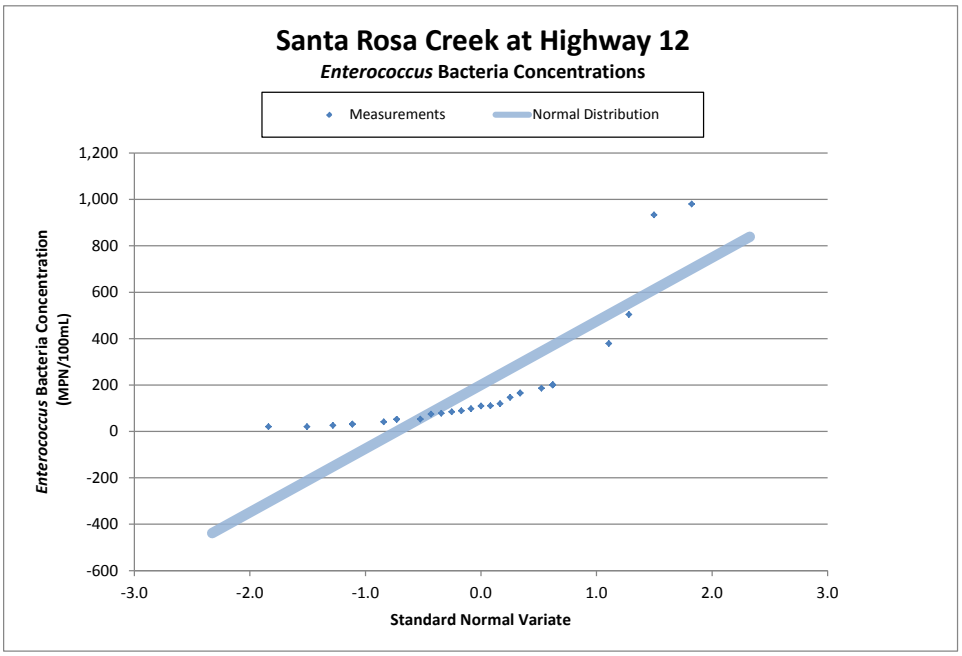

Figure 110. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek

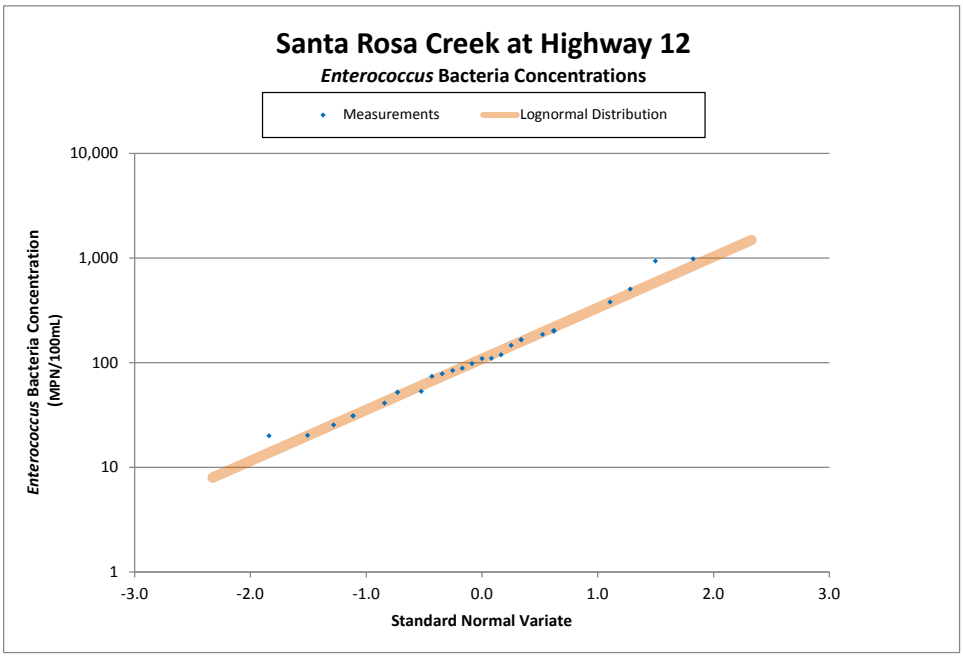

Figure 111. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek

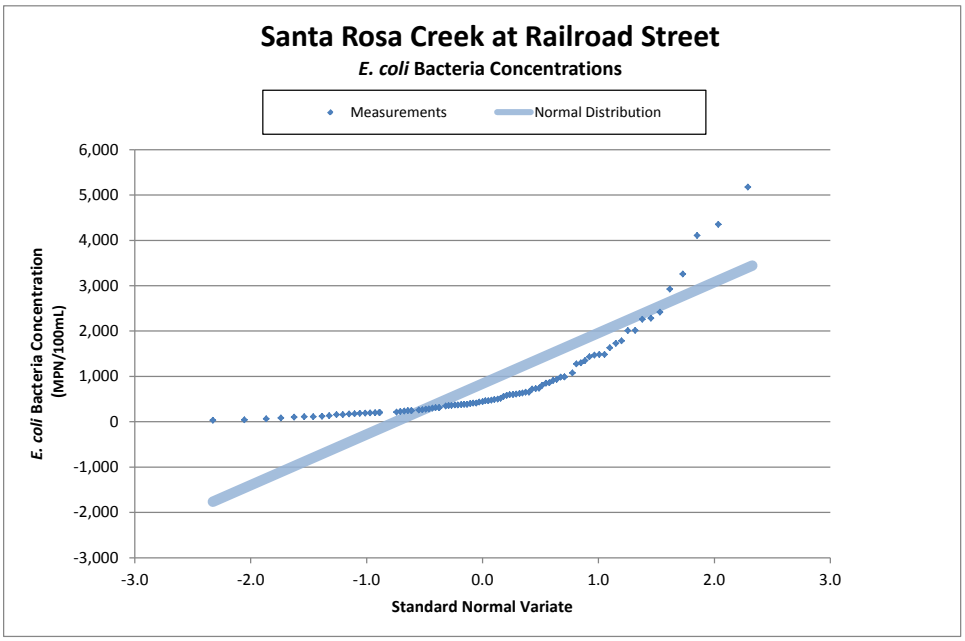

Figure 112. Normal distribution compared to *E. coli* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek

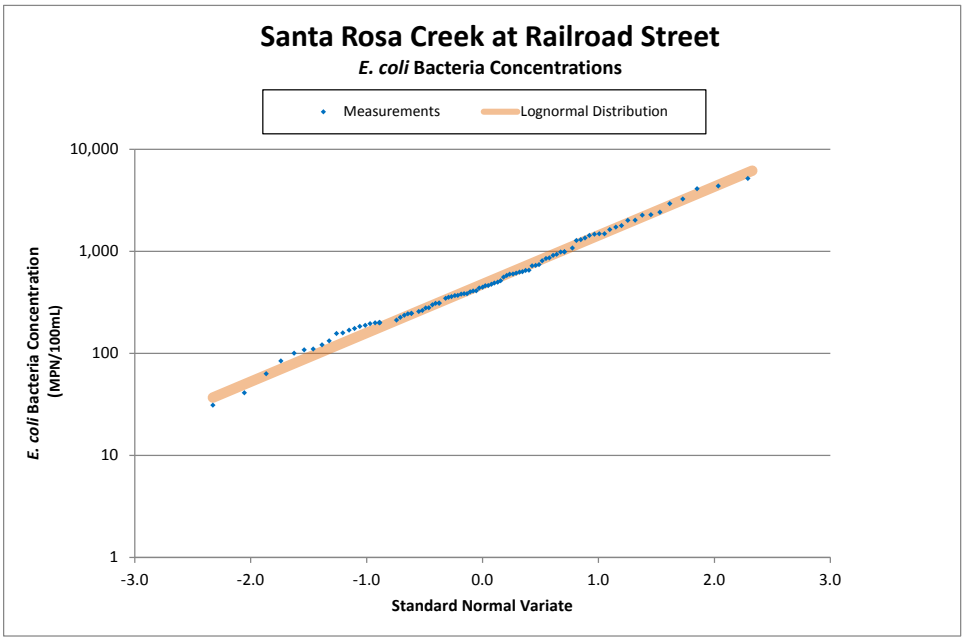

Figure 113. Log-normal distribution compared to *E. coli* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek

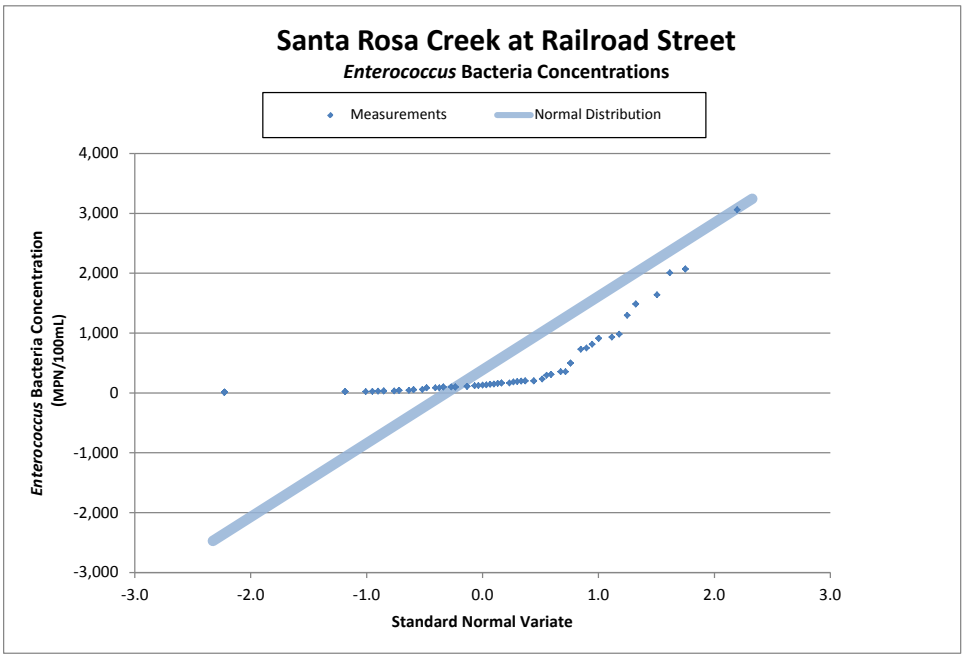

Figure 114. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek

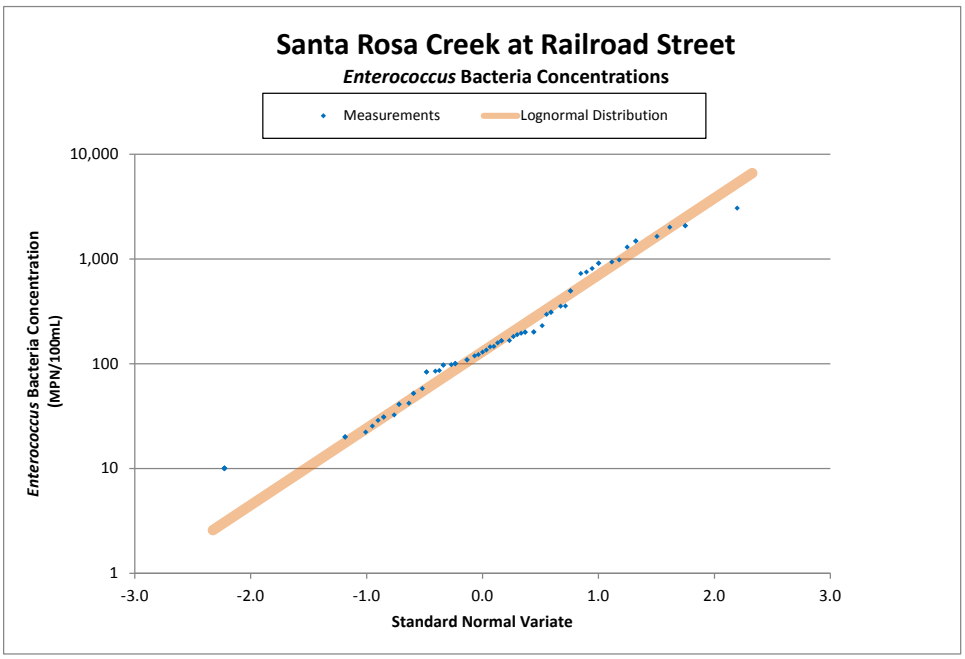

Figure 115. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek

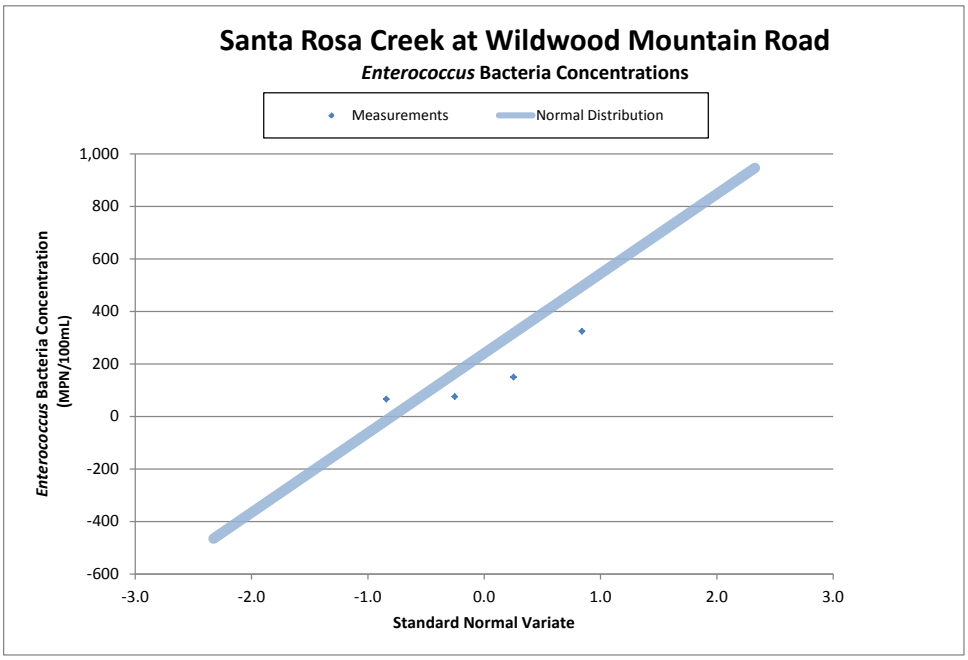

Figure 116. Normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Wildwood Mountain Road in Santa Rosa Creek

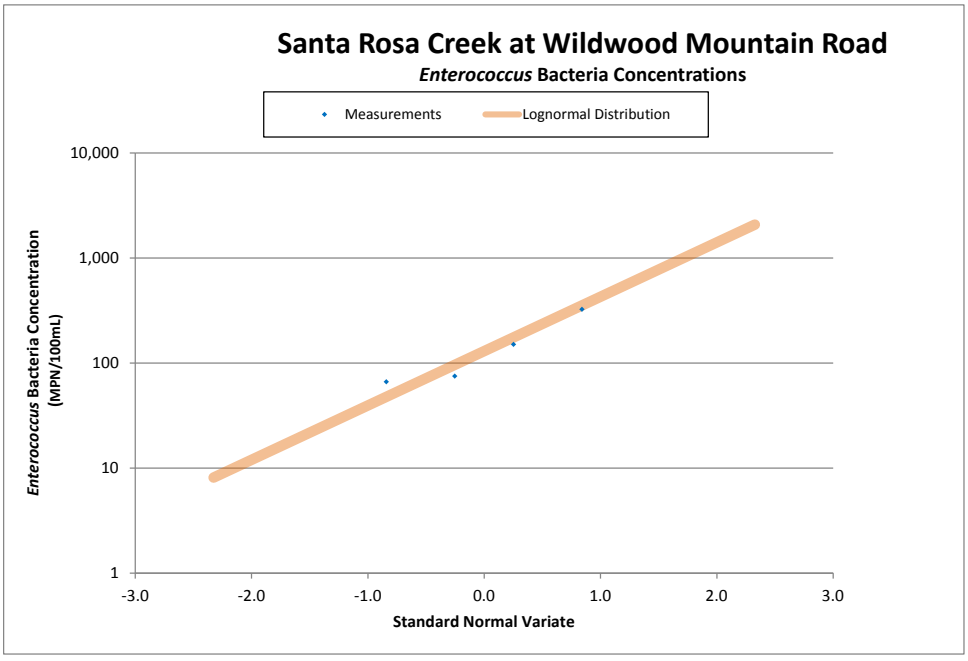

Figure 117. Log-normal distribution compared to *Enterococcus* bacteria concentration measurements collected at Wildwood Mountain Road in Santa Rosa Creek

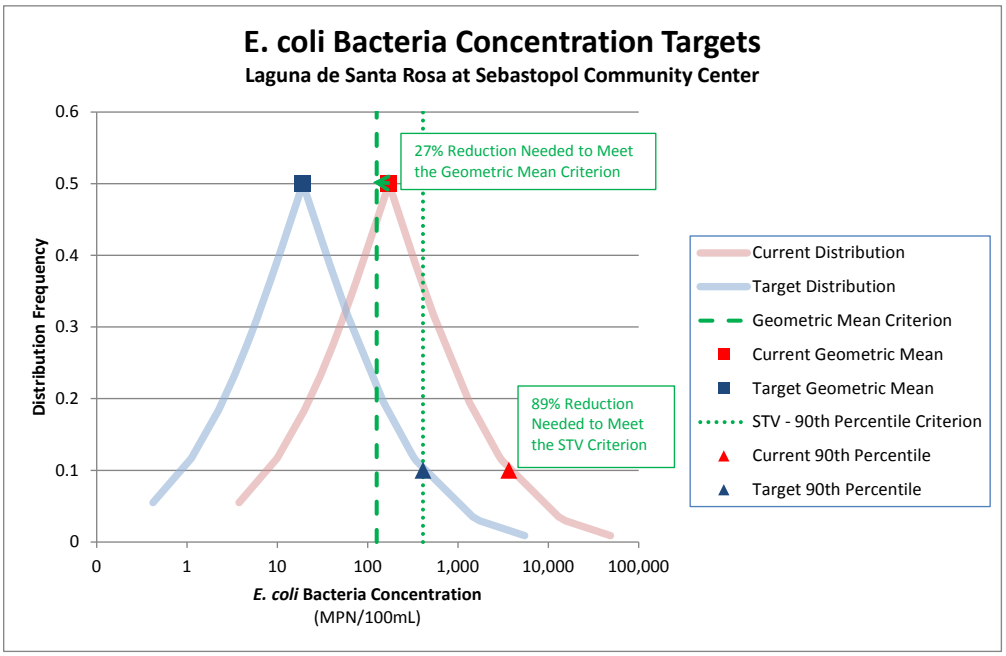

Figure 118. Statistical Rollback Method applied to a distribution of E. coli bacteria concentration measurements collected in the Laguna de Santa Rosa at Sebastopol Community Center

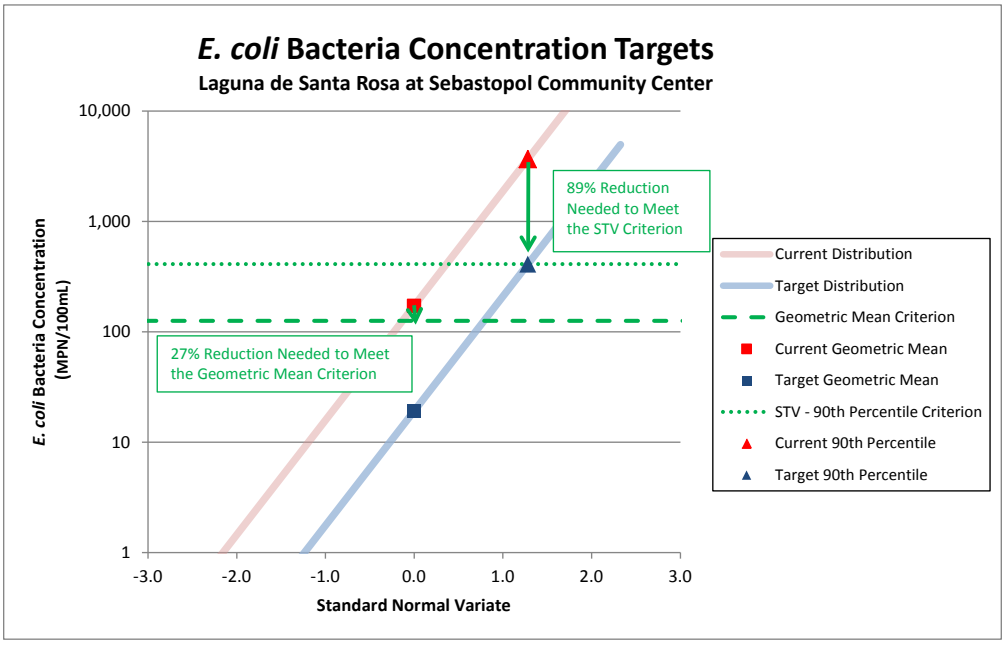

Figure 119. Statistical Rollback Method applied to a standardized distribution of E. coli bacteria concentration measurements collected in the Laguna de Santa Rosa at Sebastopol Community Center

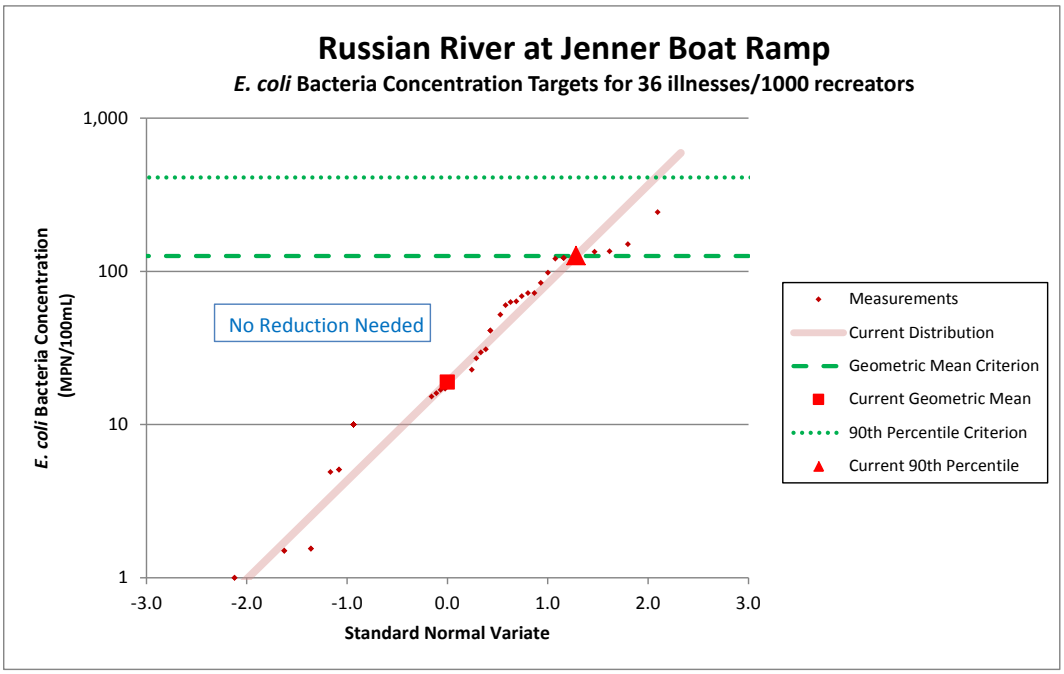

Figure 120. Comparison of *E. coli* bacteria concentration measurements collected at the Jenner boat ramp in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

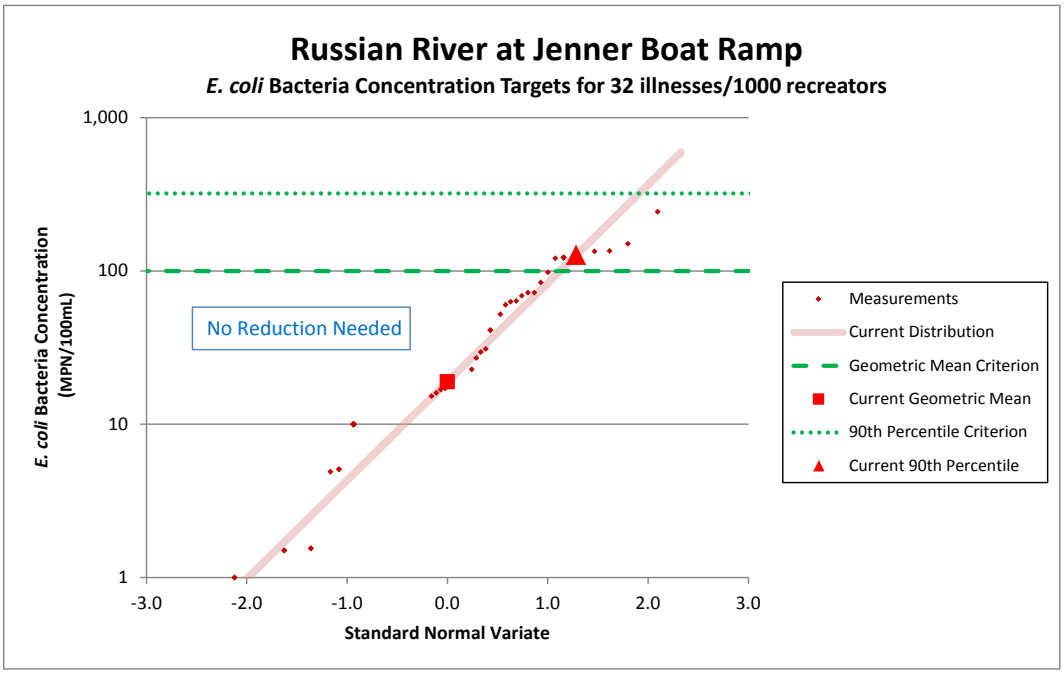

Figure 121. Comparison of *E. coli* bacteria concentration measurements collected at the Jenner boat ramp in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

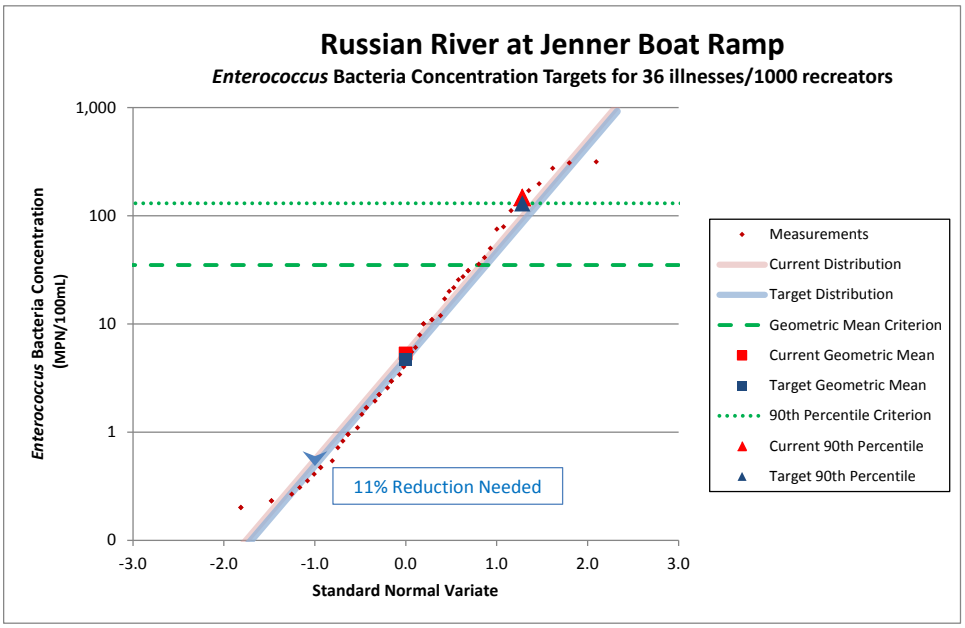

Figure 122. Comparison of *Enterococcus* bacteria concentration measurements collected at the Jenner boat ramp in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

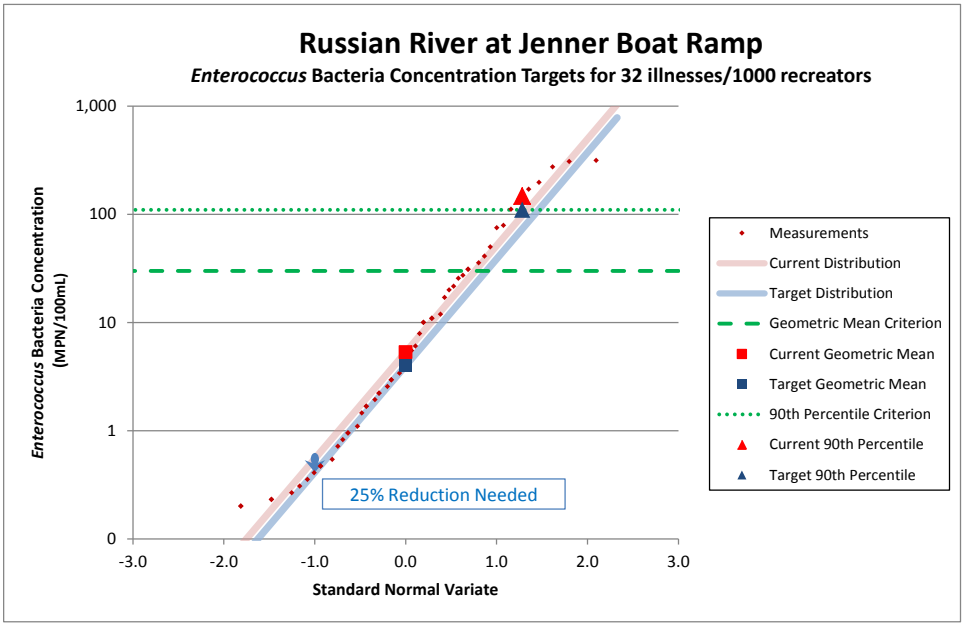

Figure 123. Comparison of *Enterococcus* bacteria concentration measurements collected at the Jenner boat ramp in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

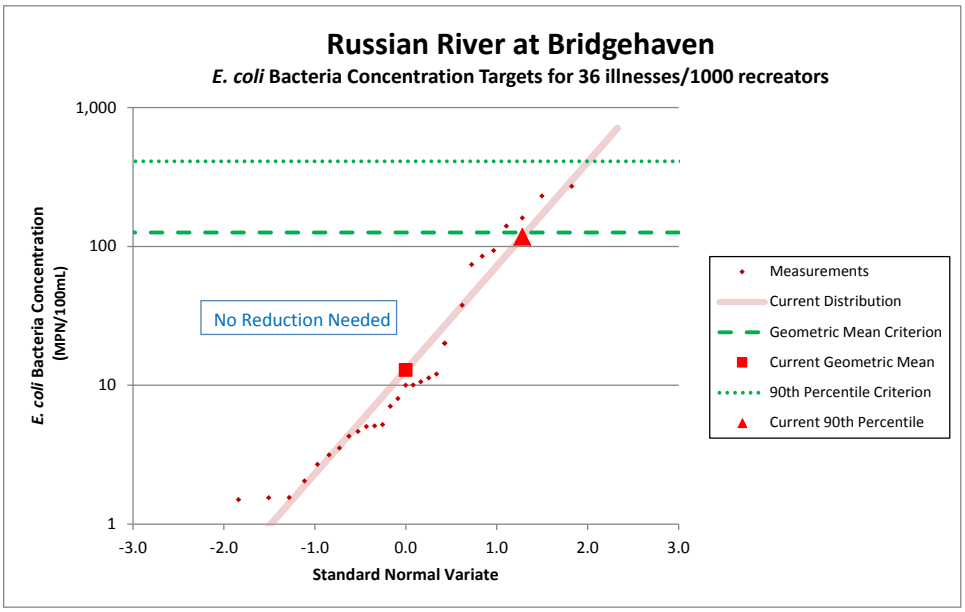

Figure 124. Comparison of *E. coli* bacteria concentration measurements collected at Bridgehaven in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

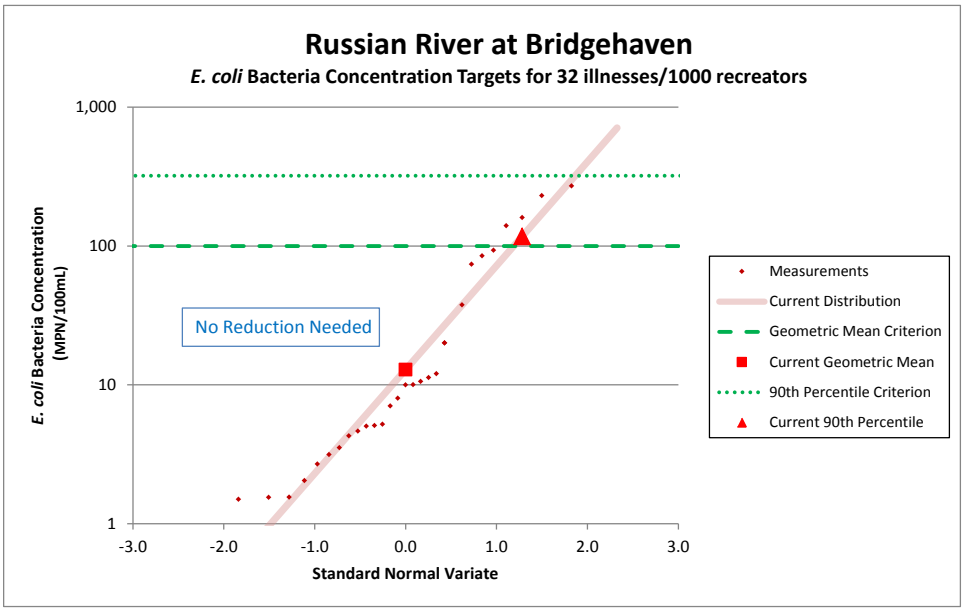

Figure 125. Comparison of *E. coli* bacteria concentration measurements collected at Bridgehaven in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

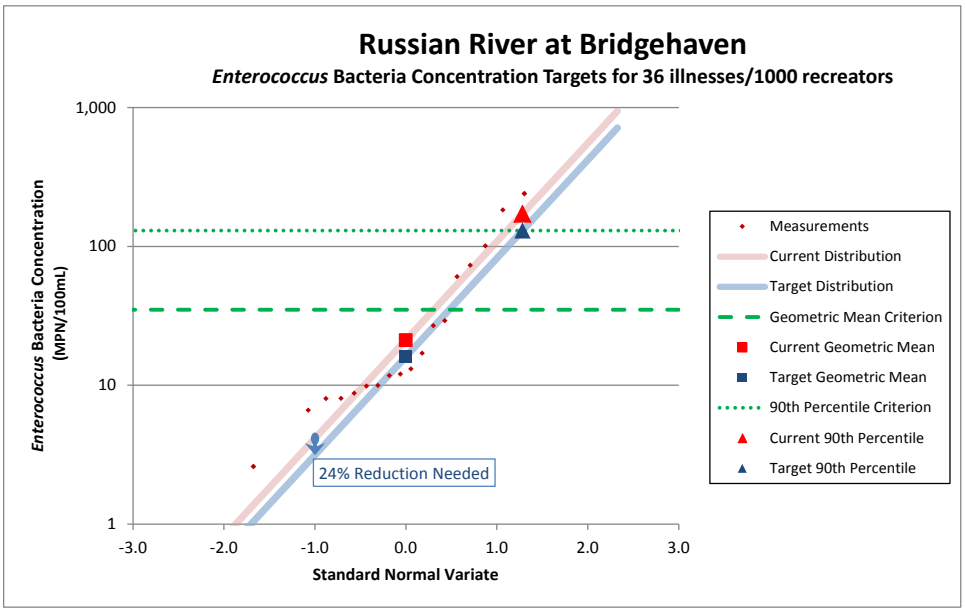

Figure 126. Comparison of *Enterococcus* bacteria concentration measurements collected at Bridgehaven in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

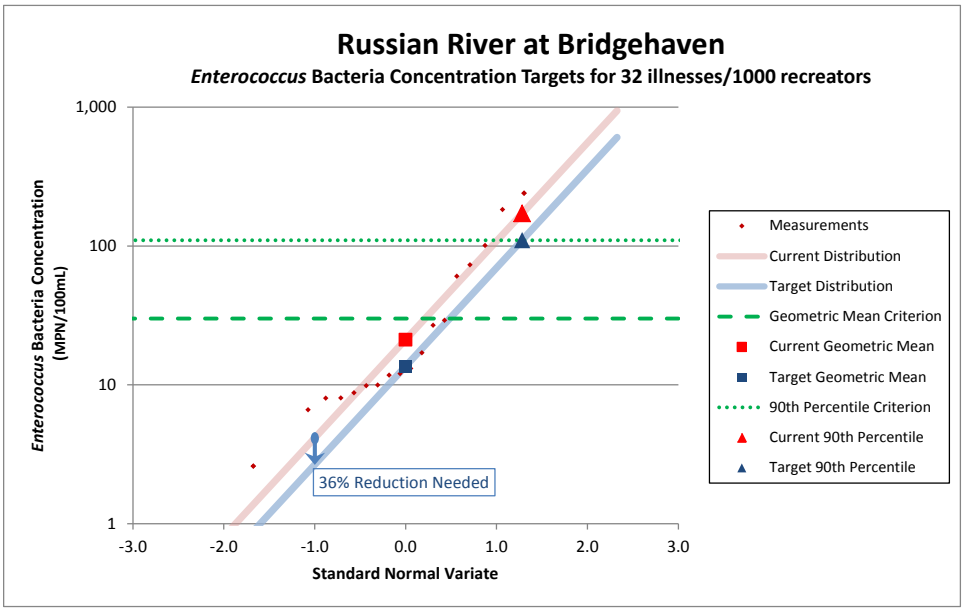

Figure 127. Comparison of *Enterococcus* bacteria concentration measurements collected at Bridgehaven in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

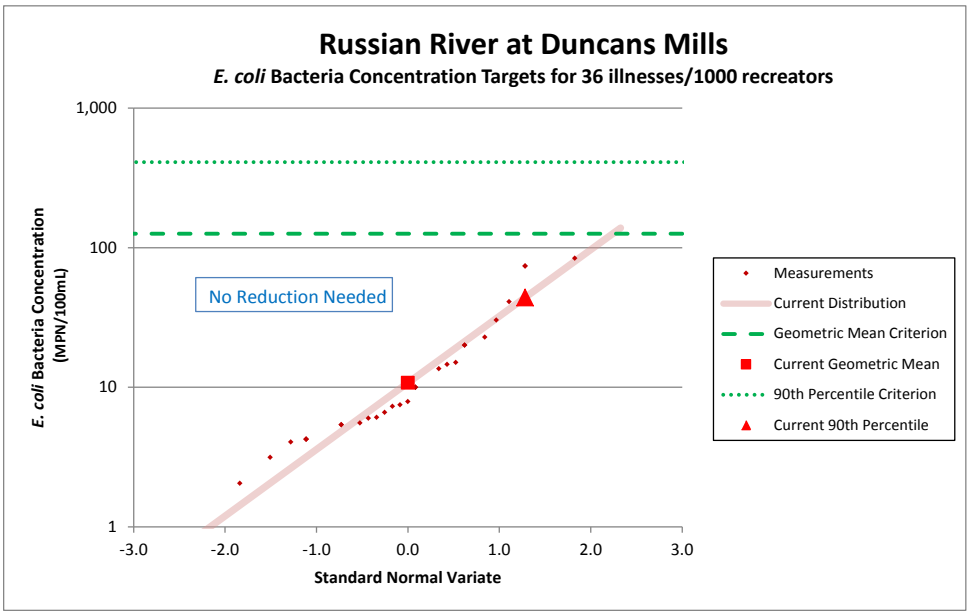

Figure 128. Comparison of *E. coli* bacteria concentration measurements collected at Duncans Mills in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

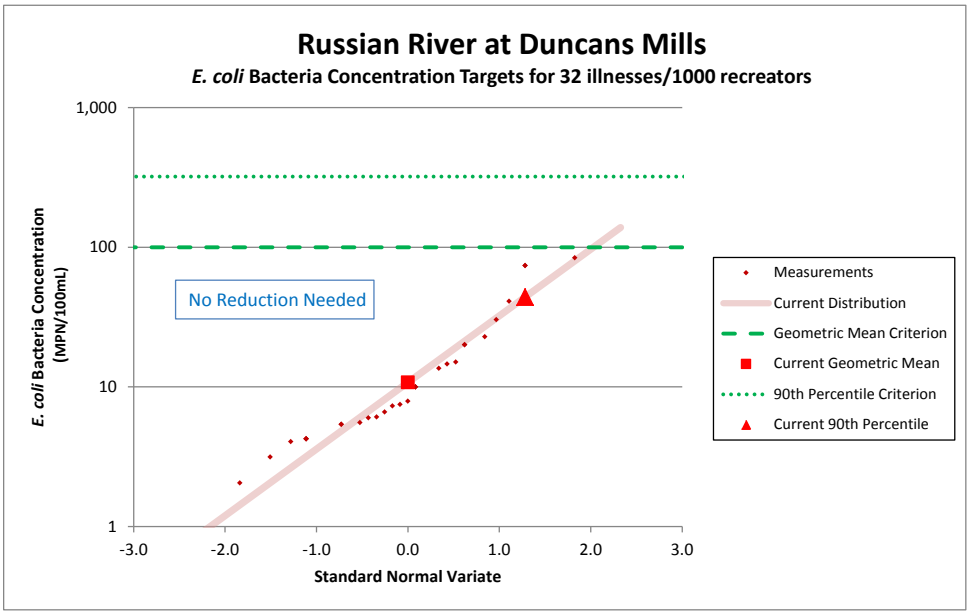

Figure 129. Comparison of *E. coli* bacteria concentration measurements collected at Duncans Mills in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

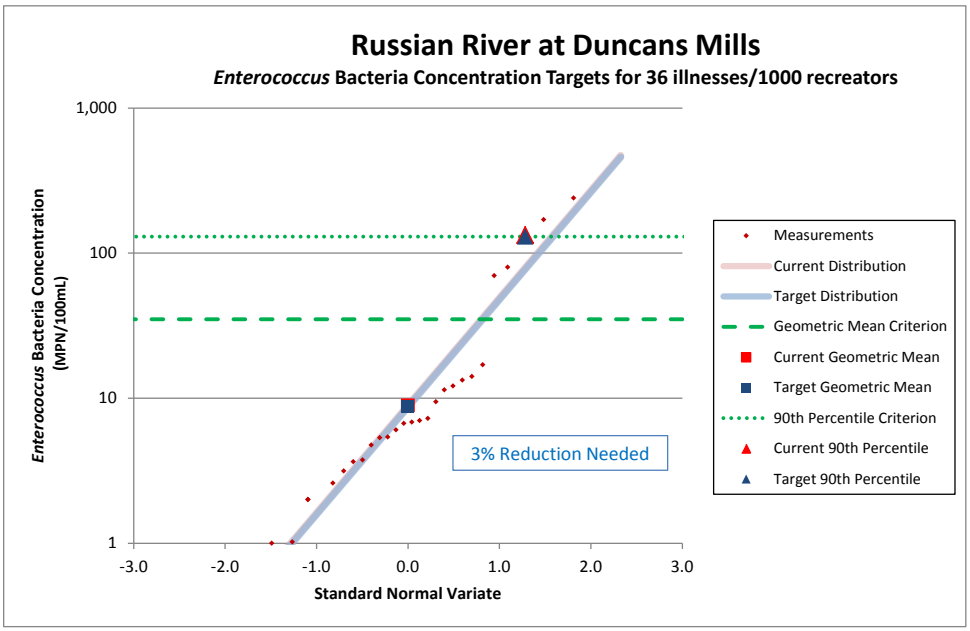

Figure 130. Comparison of *Enterococcus* bacteria concentration measurements collected at Duncans Mills in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

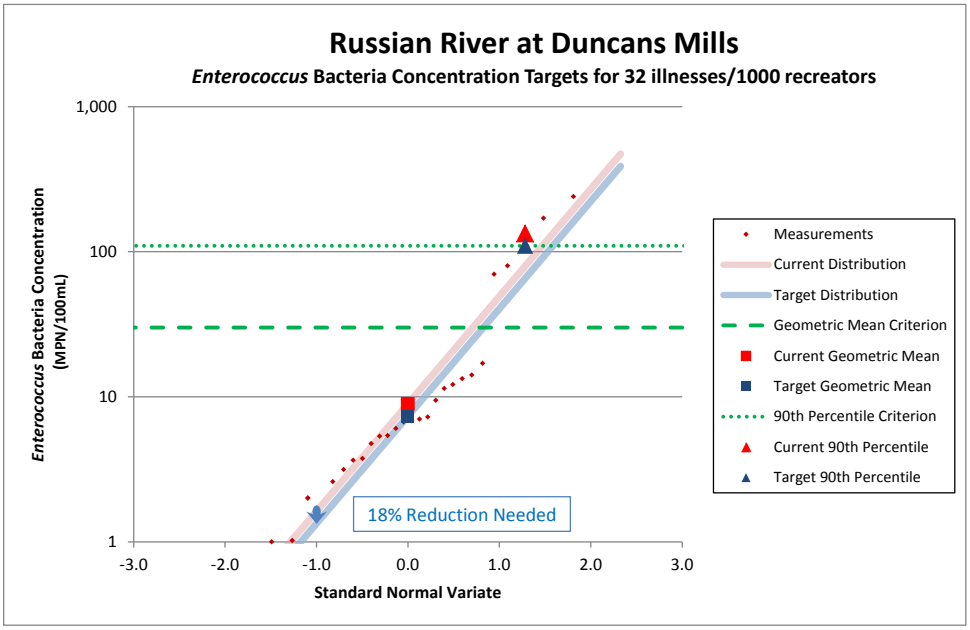

Figure 131. Comparison of *Enterococcus* bacteria concentration measurements collected at Duncans Mills in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

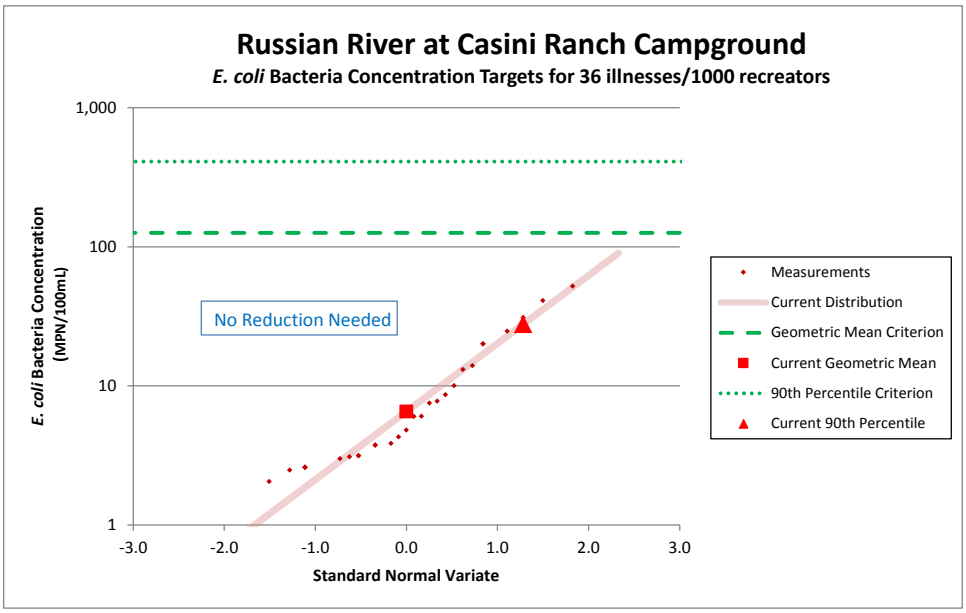

Figure 132. Comparison of *E. coli* bacteria concentration measurements collected at the Casini ranch Campground in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

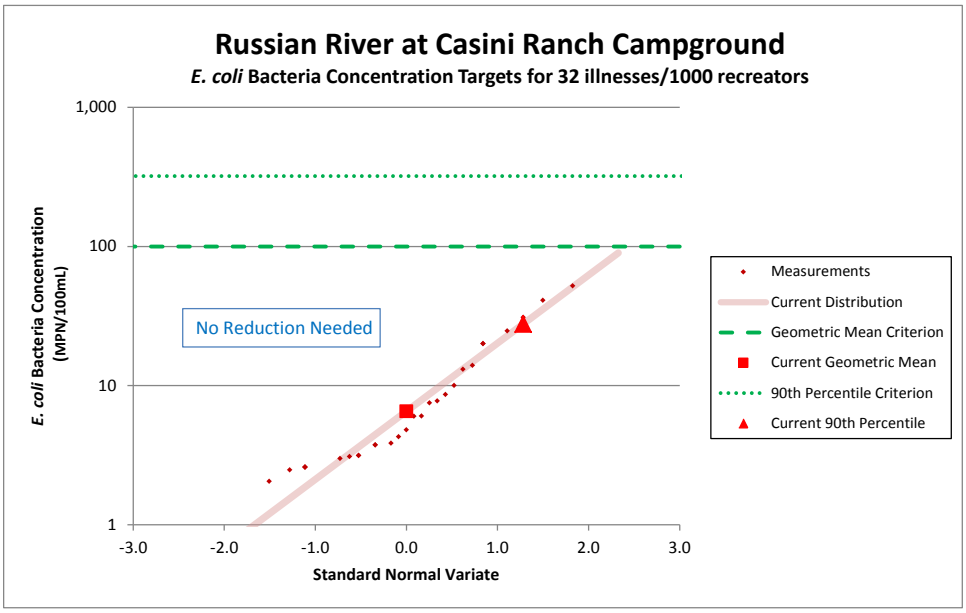

Figure 133. Comparison of *E. coli* bacteria concentration measurements collected at the Casini ranch Campground in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

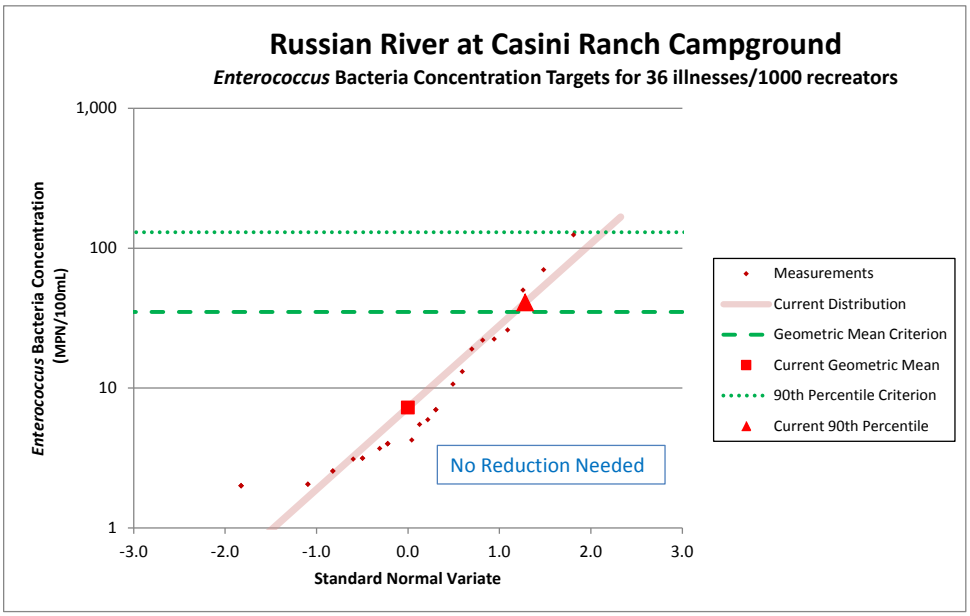

Figure 134. Comparison of *Enterococcus* bacteria concentration measurements collected at the Casini Ranch Campground in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

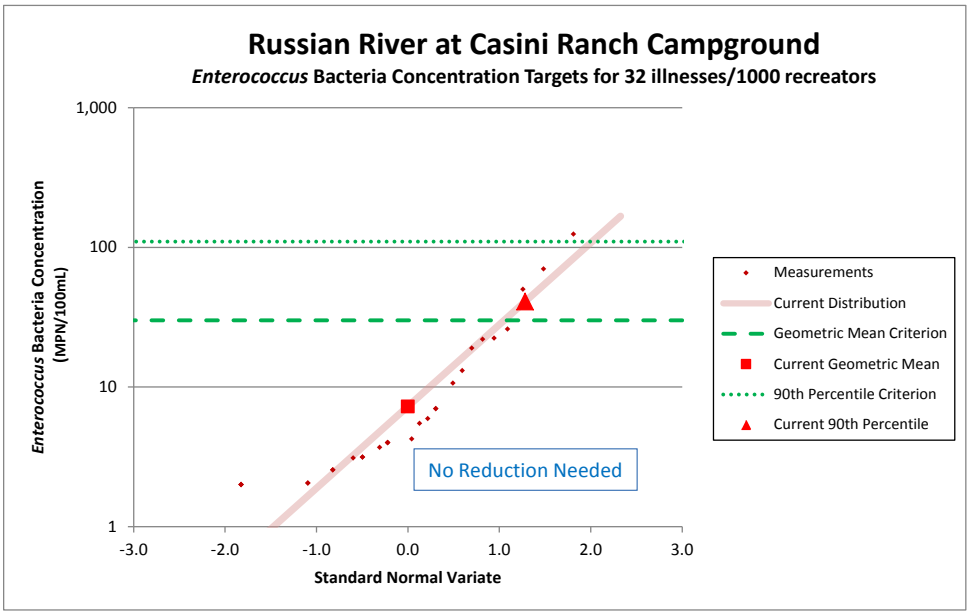

Figure 135. Comparison of *Enterococcus* bacteria concentration measurements collected at the Casini Ranch Campground in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

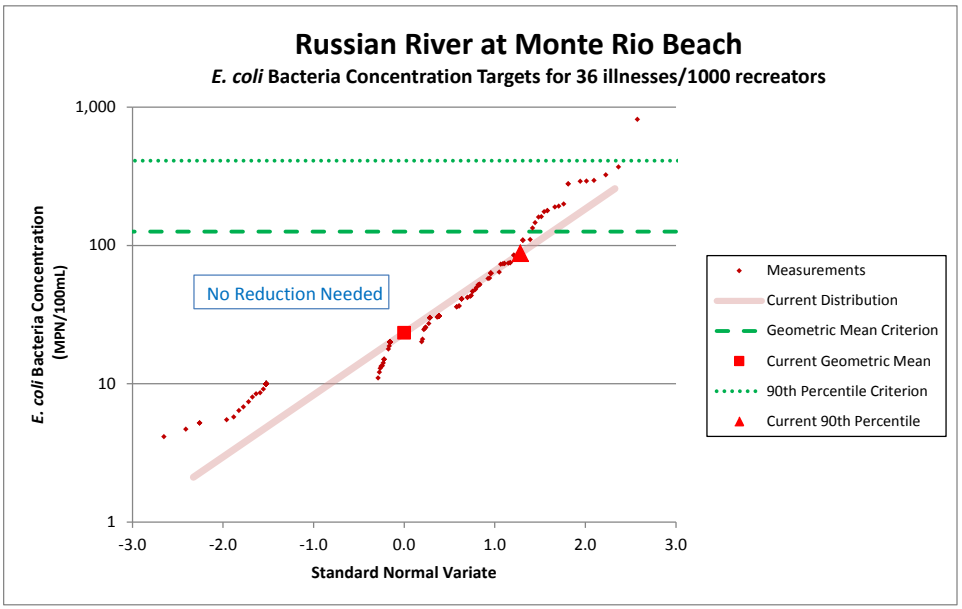

Figure 136. Comparison of *E. coli* bacteria concentration measurements collected at Monte Rio Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

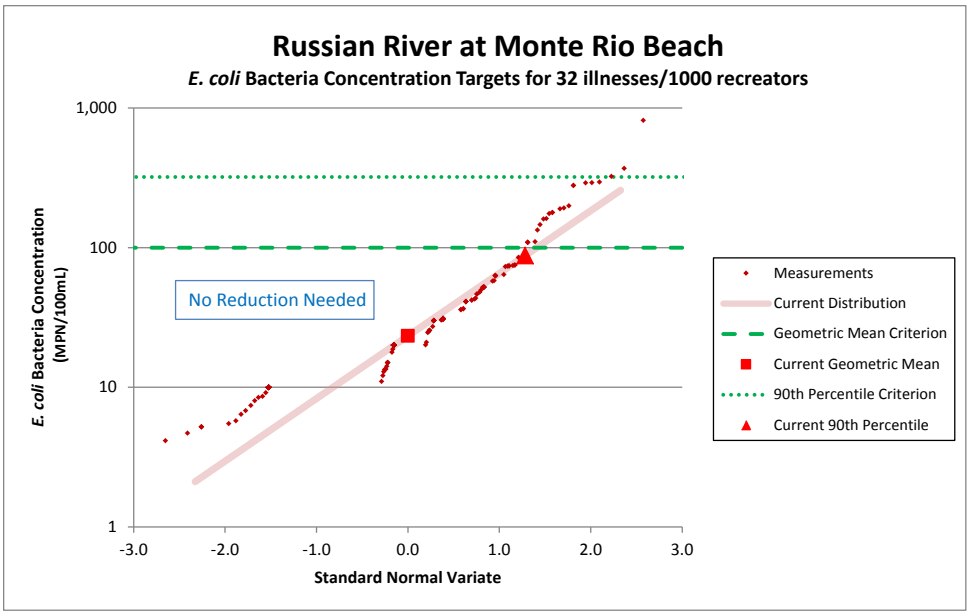

Figure 137. Comparison of *E. coli* bacteria concentration measurements collected at Monte Rio Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

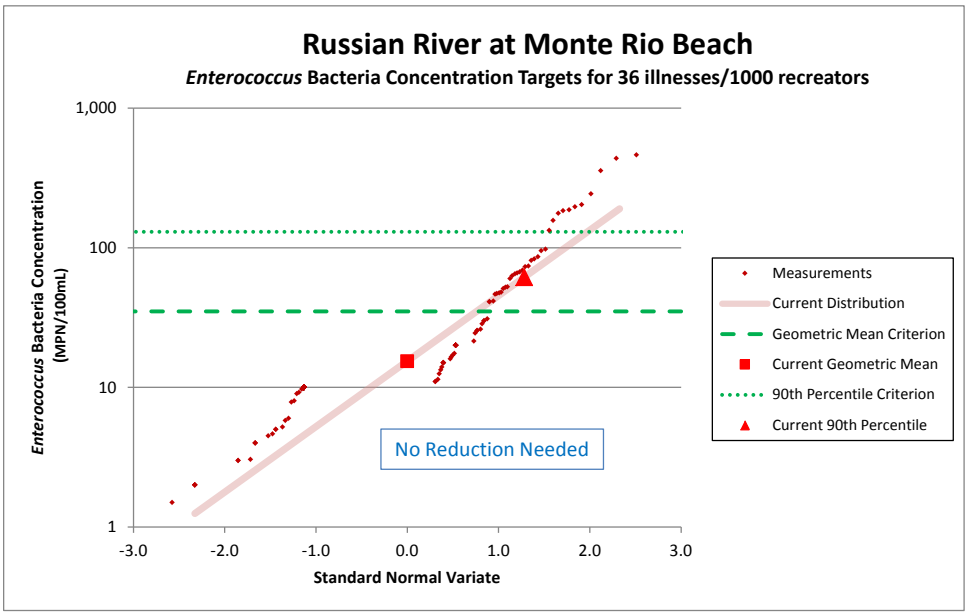

Figure 138. Comparison of *Enterococcus* bacteria concentration measurements collected at Monte Rio Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

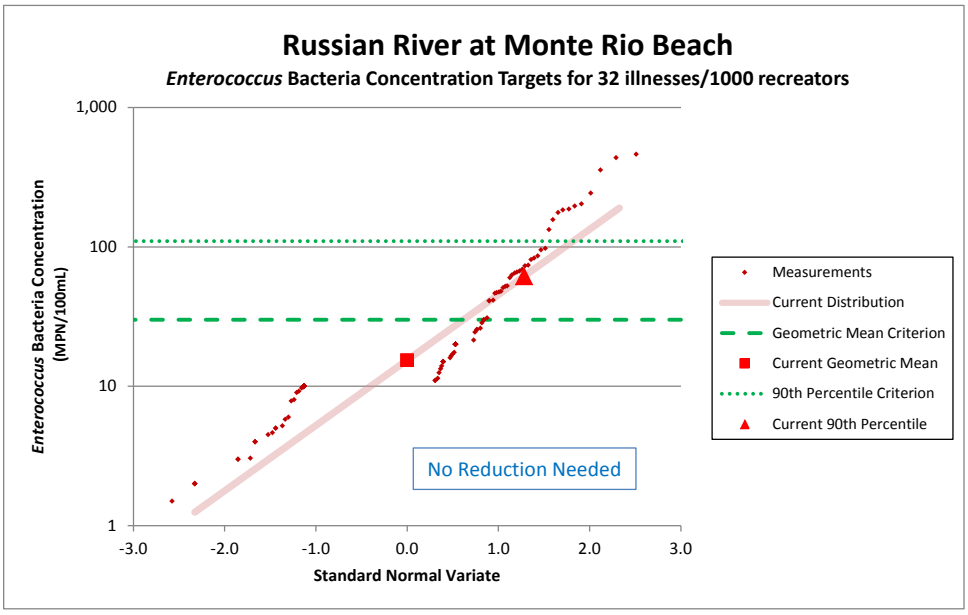

Figure 139. Comparison of *Enterococcus* bacteria concentration measurements collected at Monte Rio Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

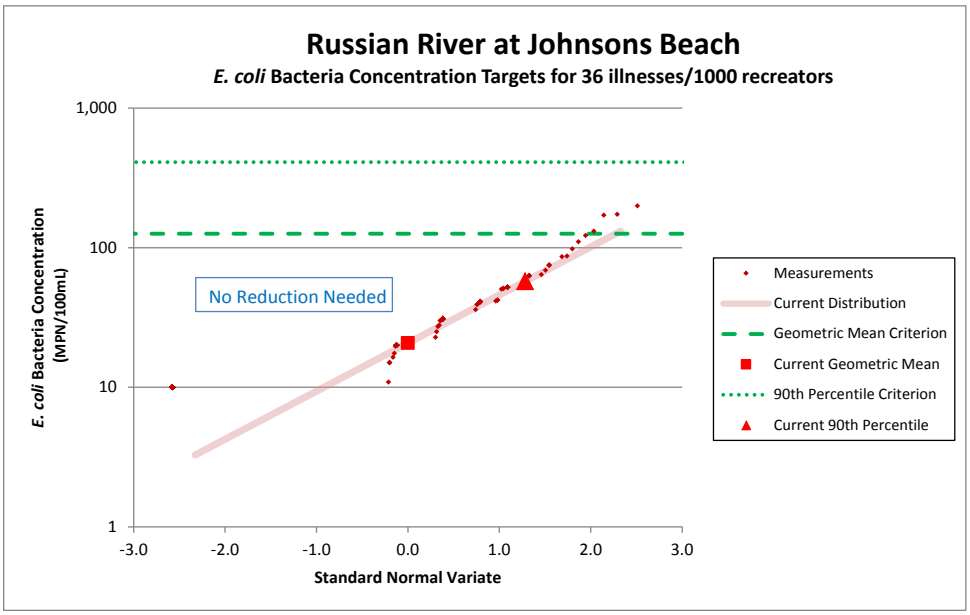

Figure 140. Comparison of *E. coli* bacteria concentration measurements collected at Johnsons Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

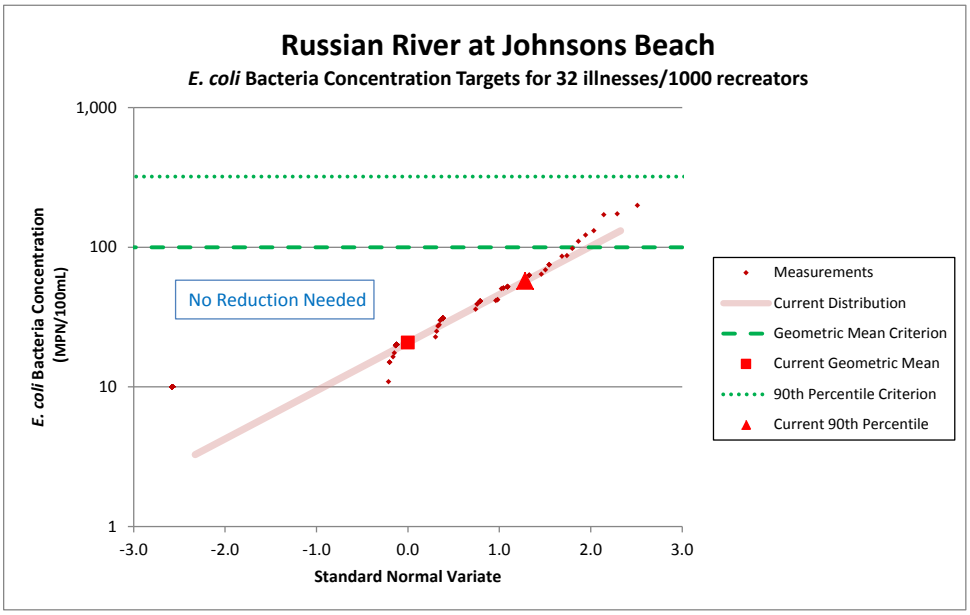

Figure 141. Comparison of *E. coli* bacteria concentration measurements collected at Johnsons Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

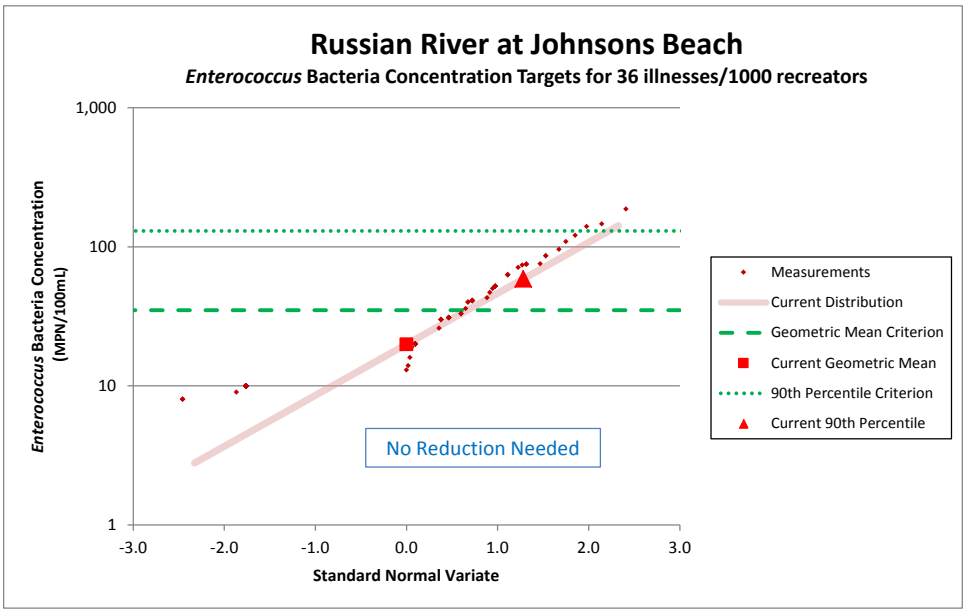

Figure 142. Comparison of *Enterococcus* bacteria concentration measurements collected at Johnsons Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

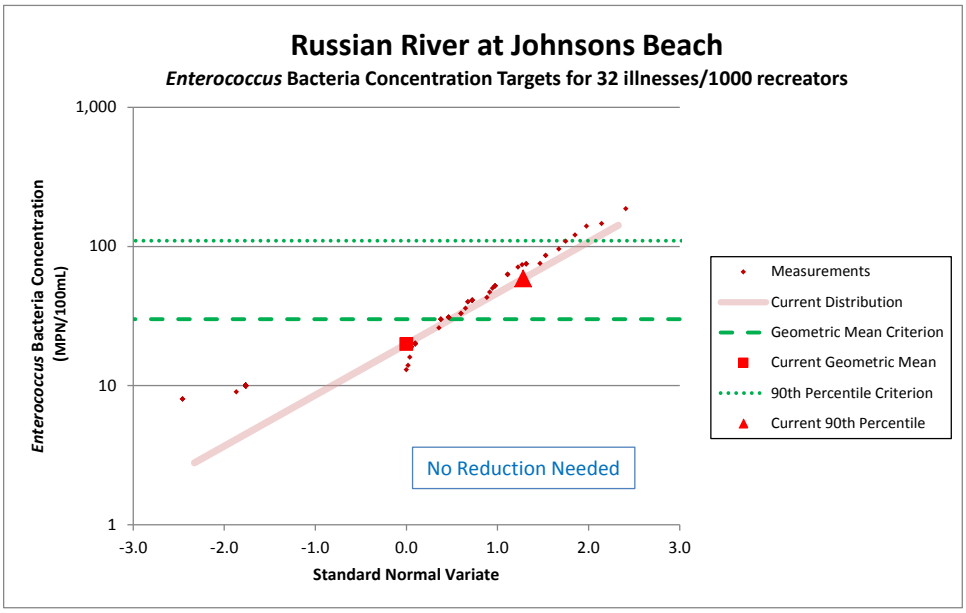

Figure 143. Comparison of *Enterococcus* bacteria concentration measurements collected at Johnsons Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

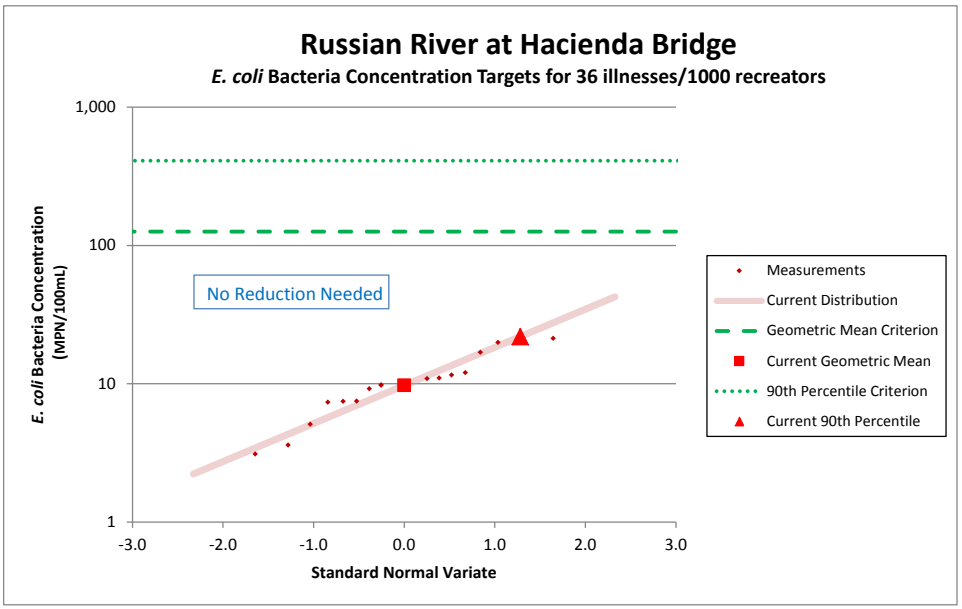

Figure 144. Comparison of *E. coli* bacteria concentration measurements collected at the Hacienda Bridge in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

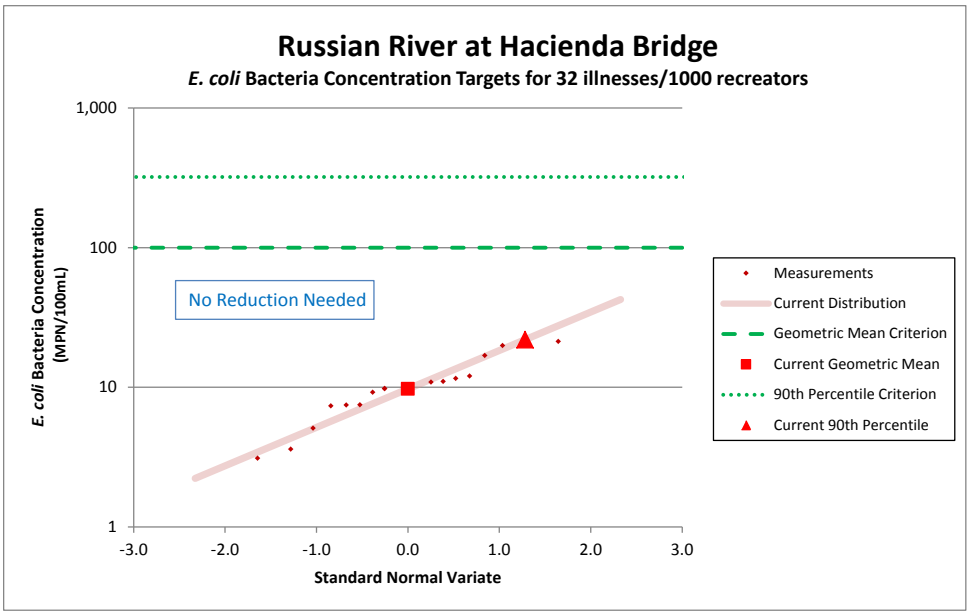

Figure 145. Comparison of *E. coli* bacteria concentration measurements collected at the Hacienda Bridge in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

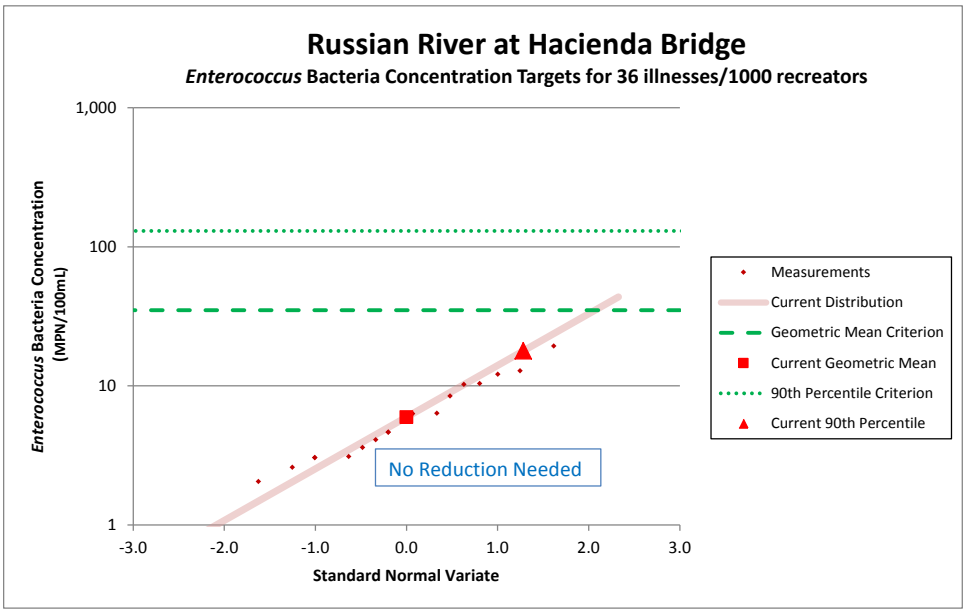

Figure 146. Comparison of *Enterococcus* bacteria concentration measurements collected at the Hacienda Bridge in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

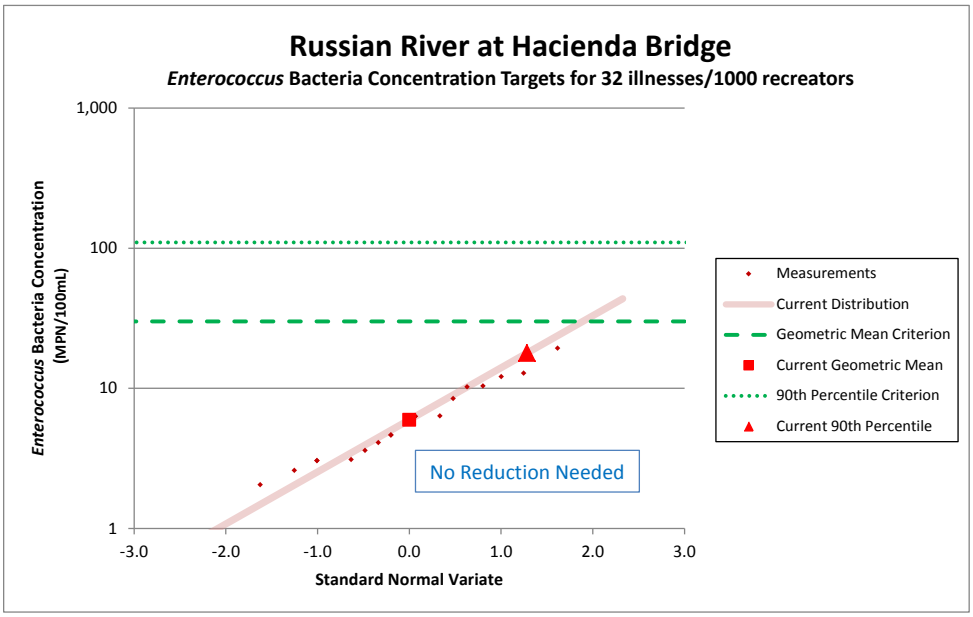

Figure 147. Comparison of *Enterococcus* bacteria concentration measurements collected at the Hacienda Bridge in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

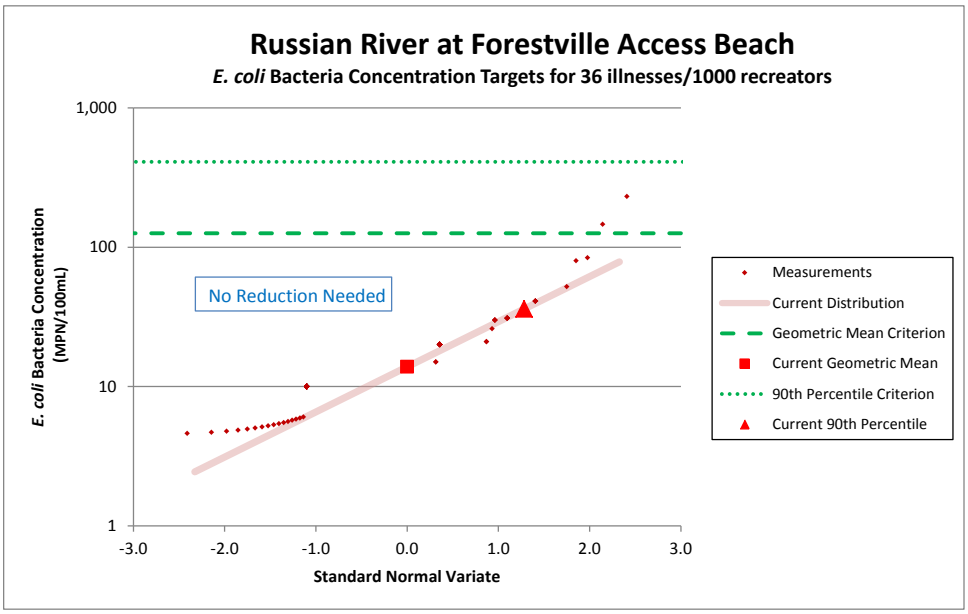

Figure 148. Comparison of *E. coli* bacteria concentration measurements collected at Forestville Access Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

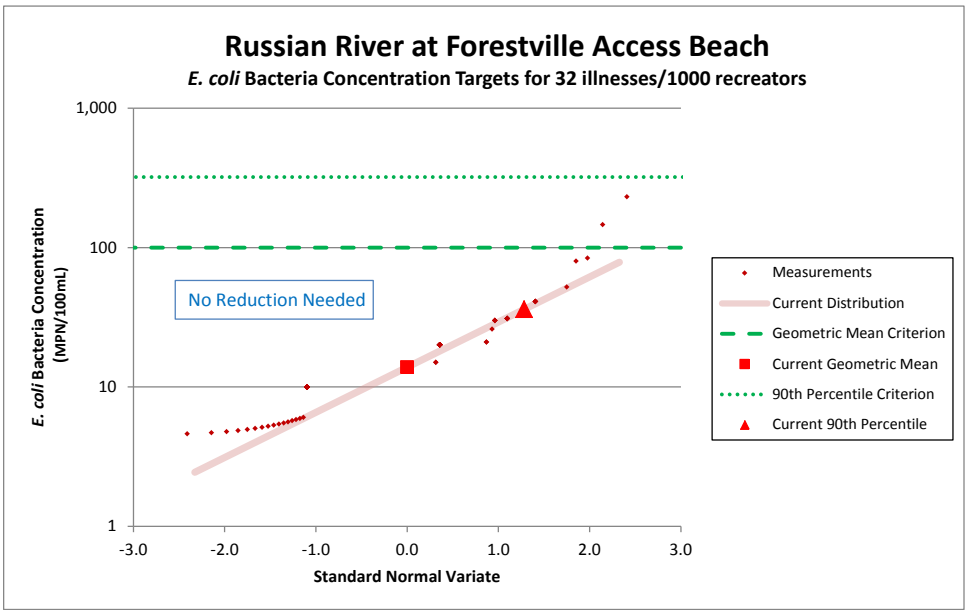

Figure 149. Comparison of *E. coli* bacteria concentration measurements collected at Forestville Access Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

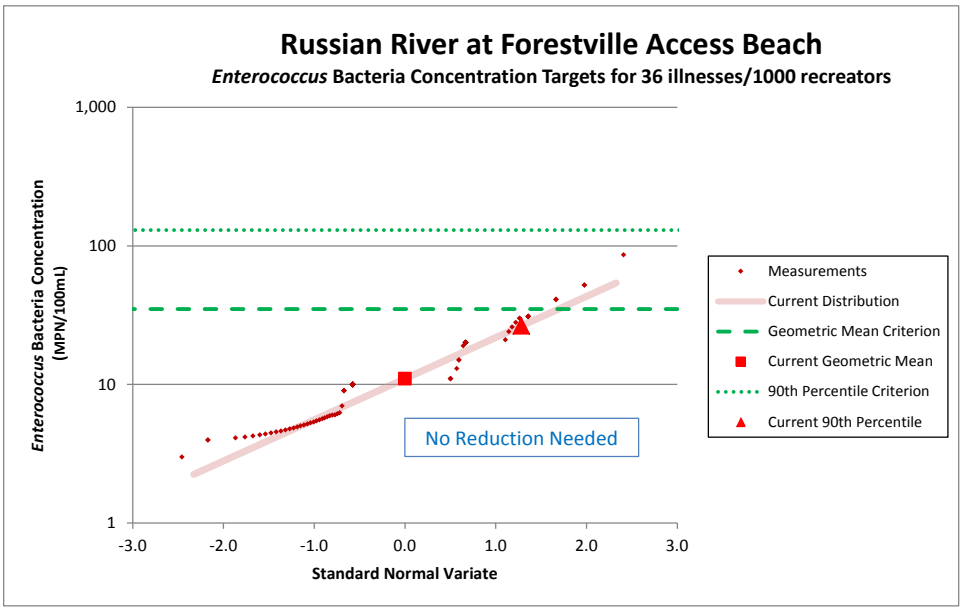

Figure 150. Comparison of *Enterococcus* bacteria concentration measurements collected at Forestville Access Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

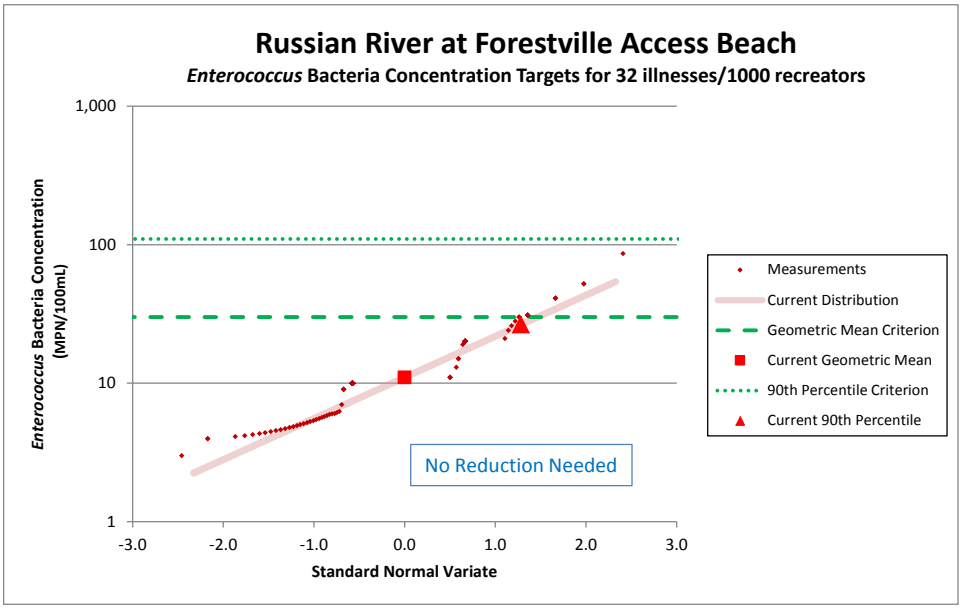

Figure 151. Comparison of *Enterococcus* bacteria concentration measurements collected at Forestville Access Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

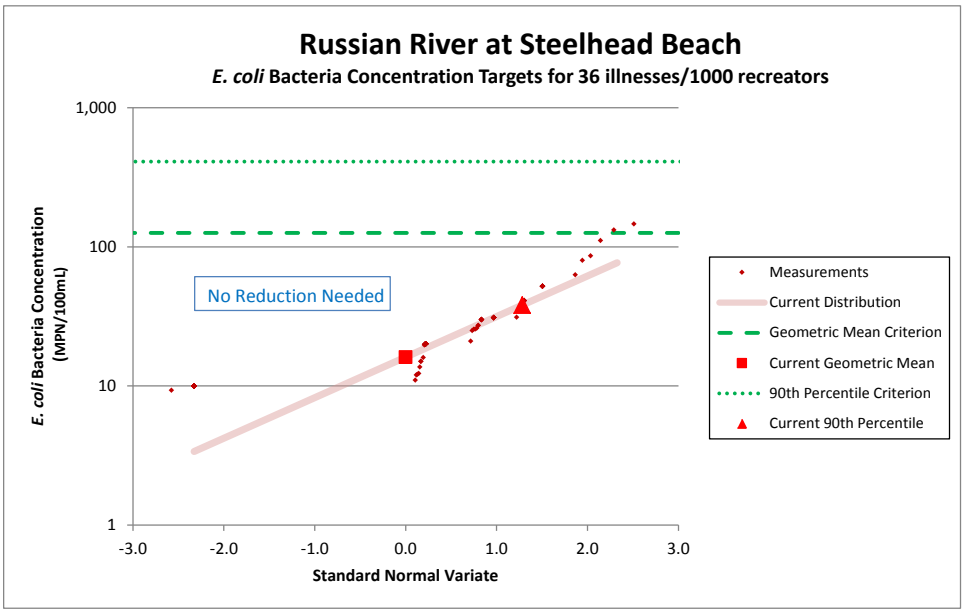

Figure 152. Comparison of *E. coli* bacteria concentration measurements collected at Steelhead Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

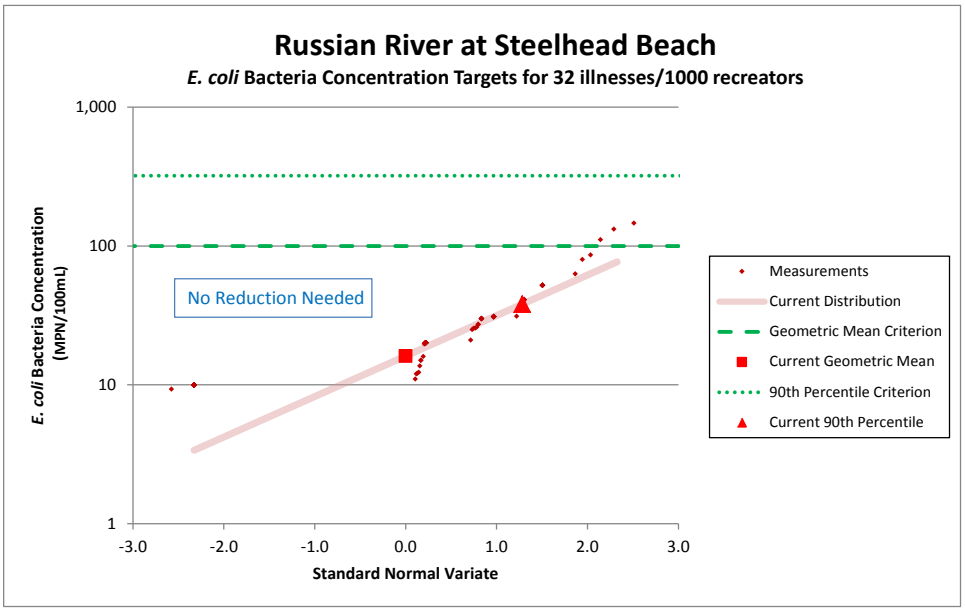

Figure 153. Comparison of *E. coli* bacteria concentration measurements collected at Steelhead Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

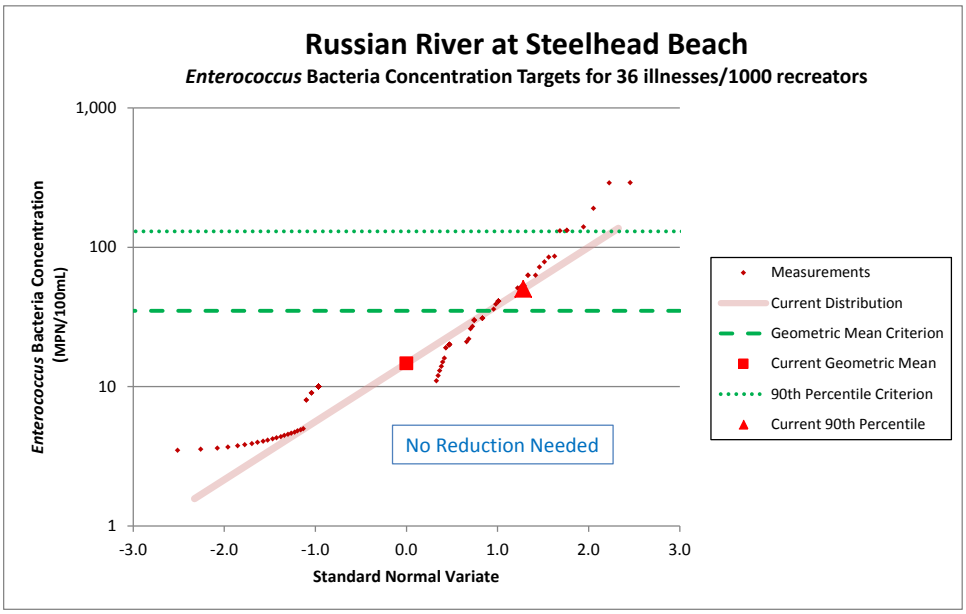

Figure 154. Comparison of *Enterococcus* bacteria concentration measurements collected at Steelhead Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

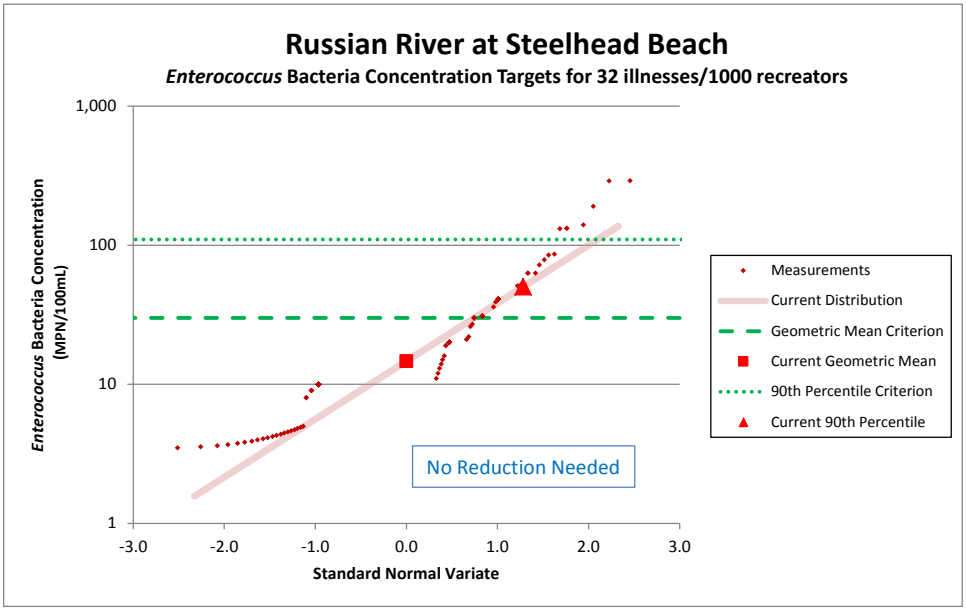

Figure 155. Comparison of *Enterococcus* bacteria concentration measurements collected at Steelhead Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

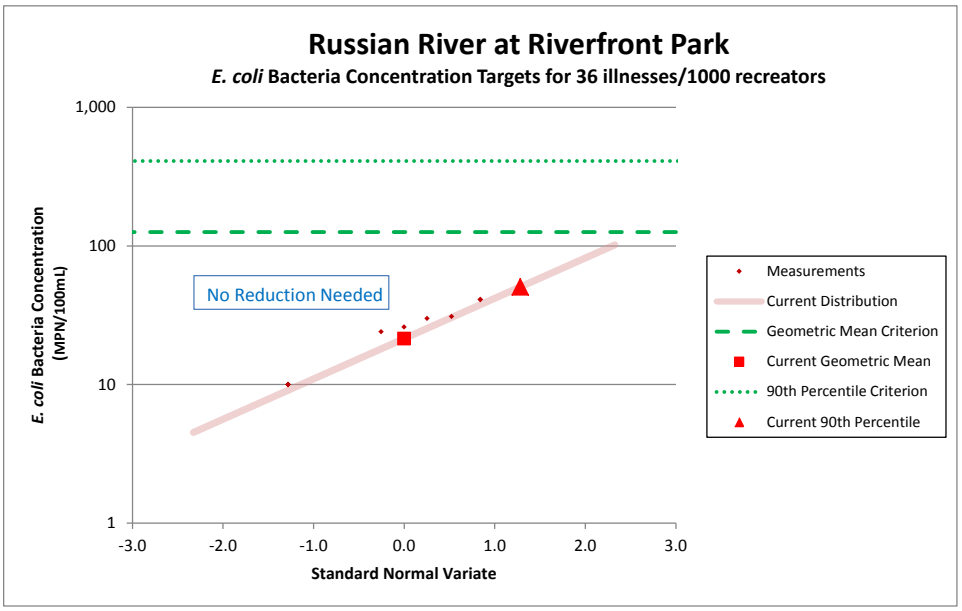

Figure 156. Comparison of *E. coli* bacteria concentration measurements collected at Riverfront Park in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

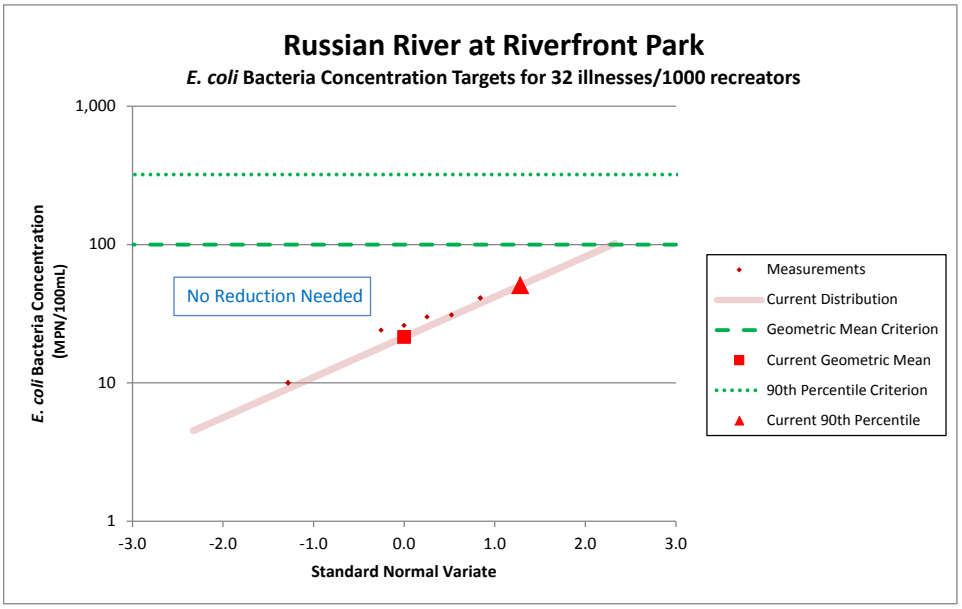

Figure 157. Comparison of *E. coli* bacteria concentration measurements collected at Riverfront Park in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

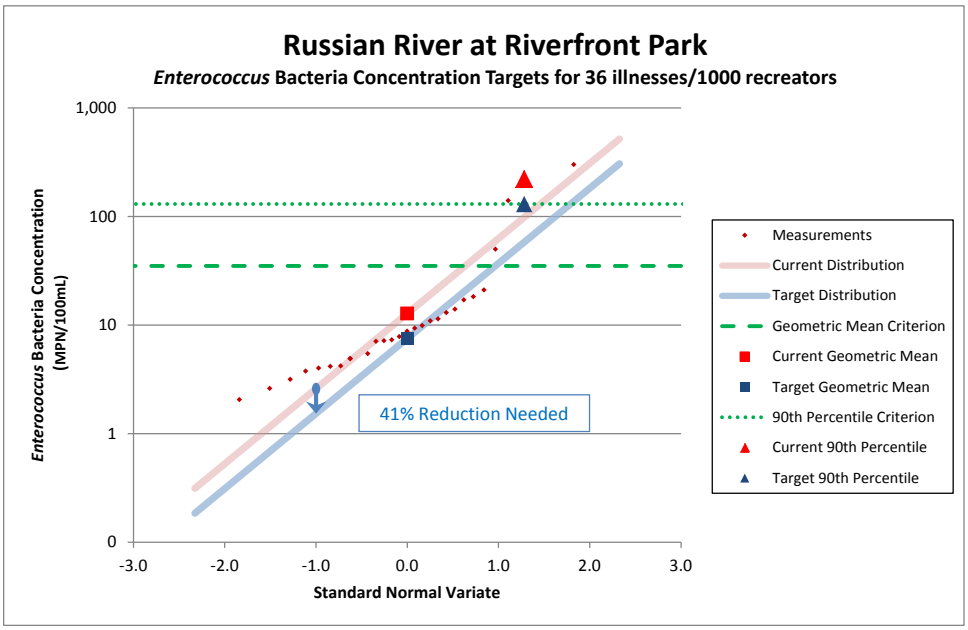

Figure 158. Comparison of *Enterococcus* bacteria concentration measurements collected at Riverfront Park in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

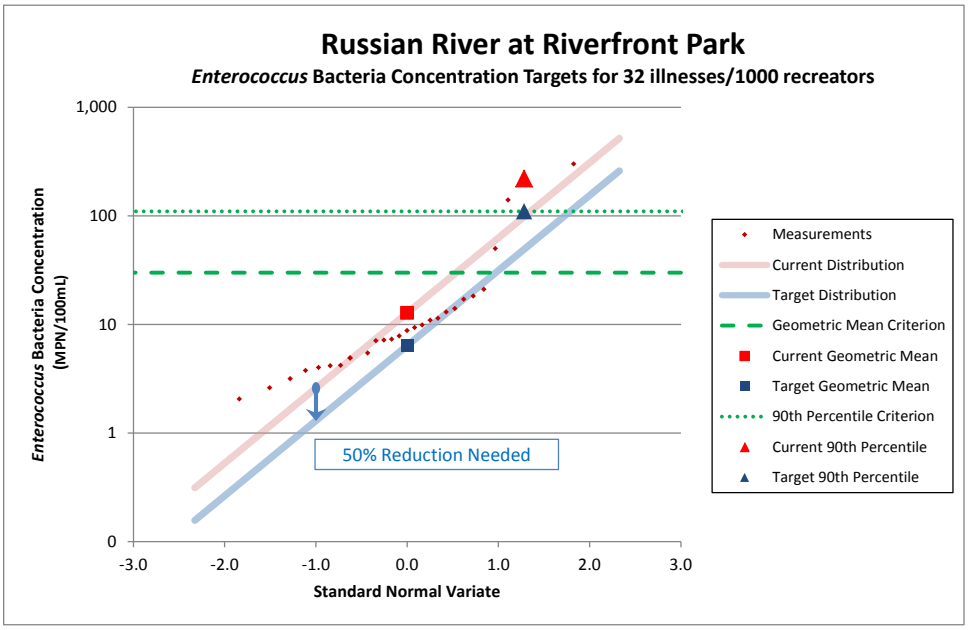

Figure 159. Comparison of *Enterococcus* bacteria concentration measurements collected at Riverfront Park in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

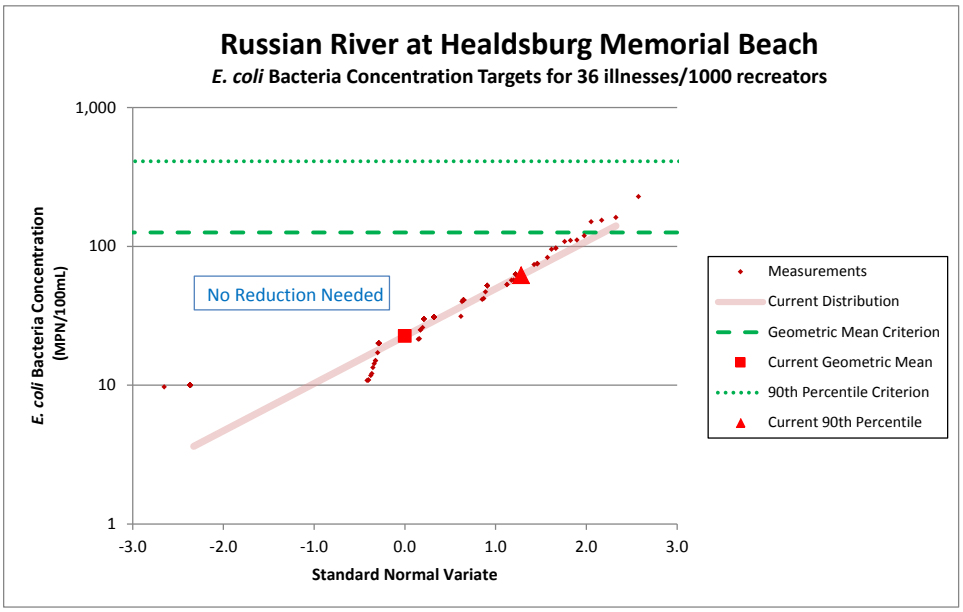

Figure 160. Comparison of *E. coli* bacteria concentration measurements collected at Healdsburg-Memorial Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

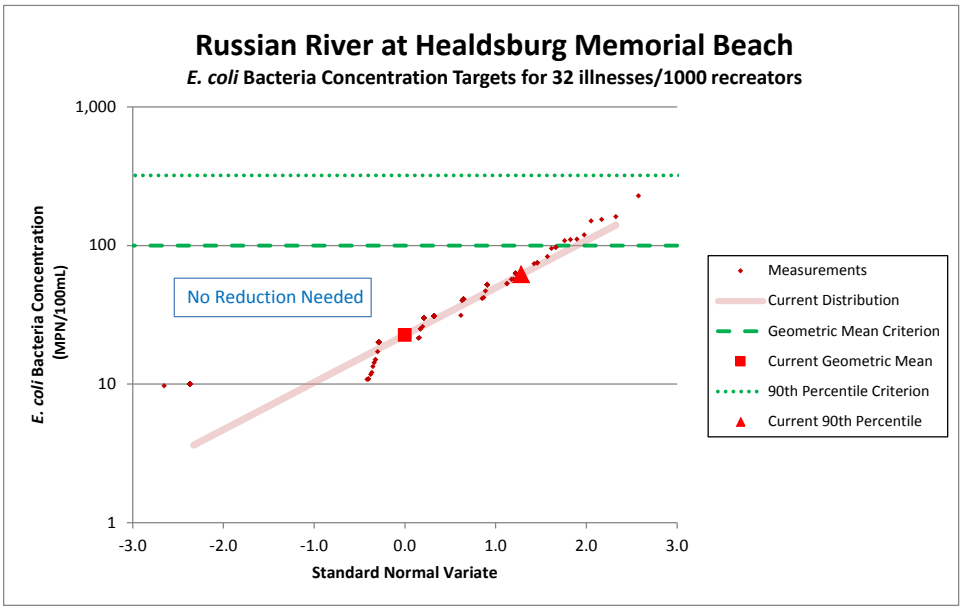

Figure 161. Comparison of *E. coli* bacteria concentration measurements collected at Healdsburg-Memorial Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

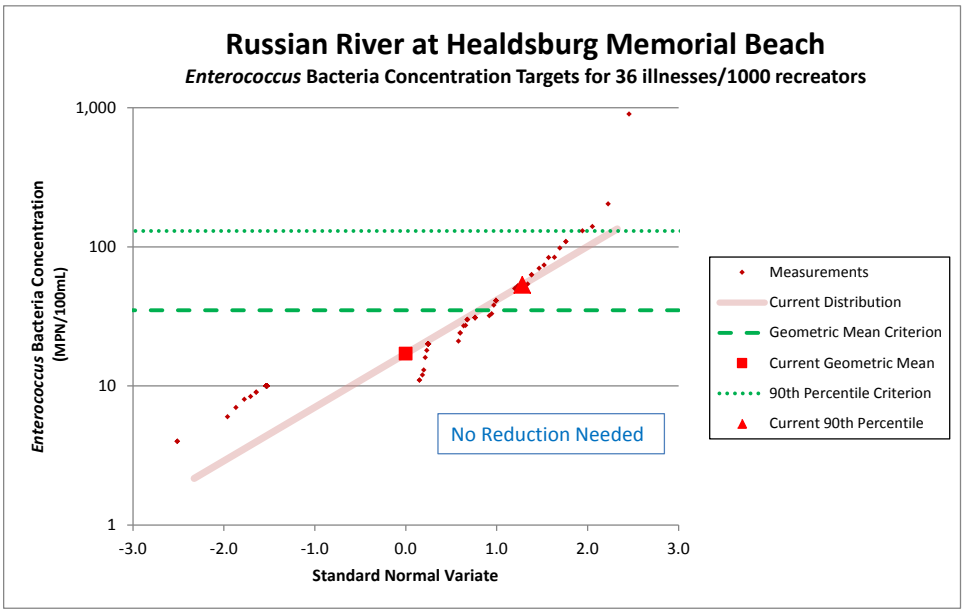

Figure 162. Comparison of *Enterococcus* bacteria concentration measurements collected at Healdsburg Memorial Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

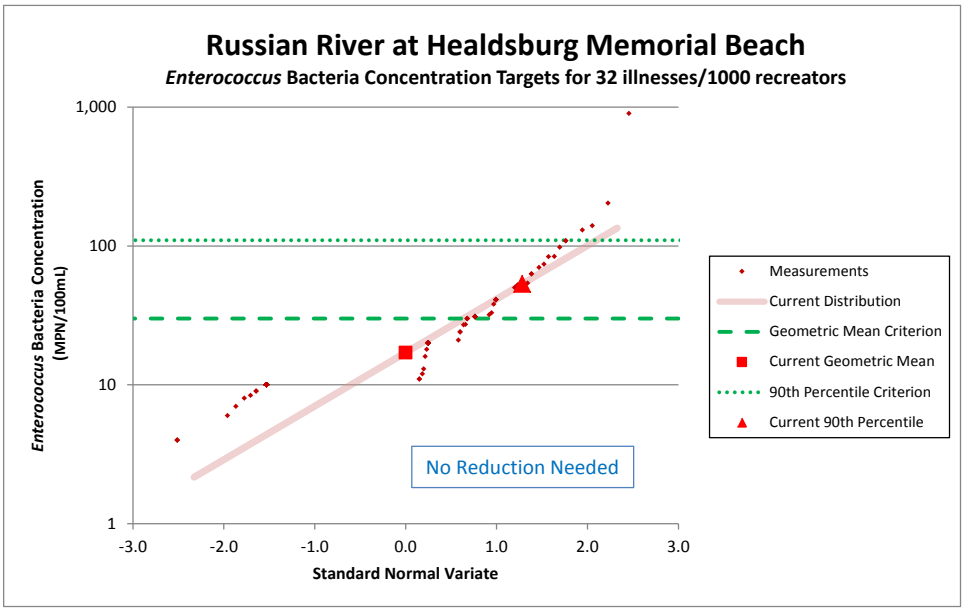

Figure 163. Comparison of *Enterococcus* bacteria concentration measurements collected at Healdsburg Memorial Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

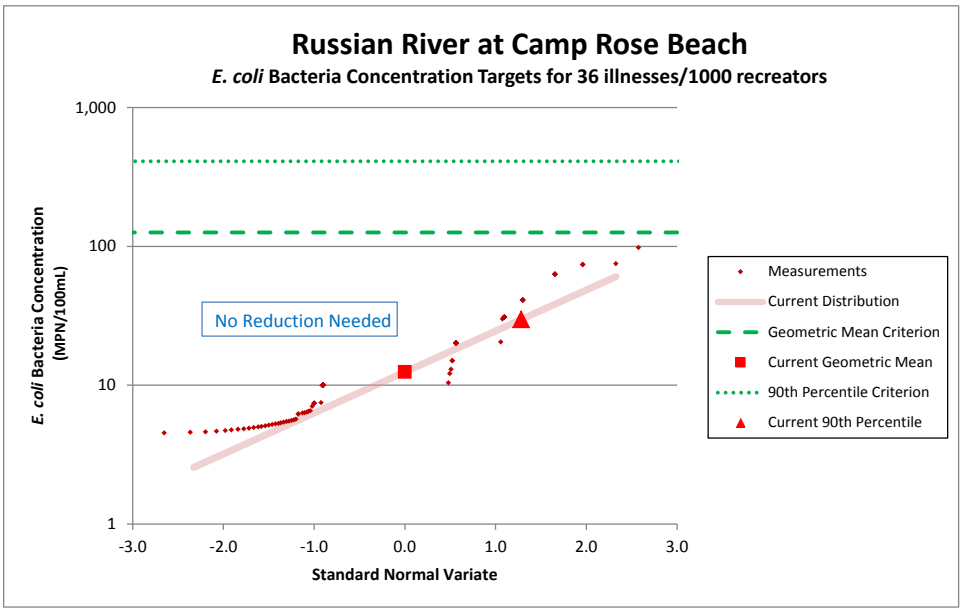

Figure 164. Comparison of *E. coli* bacteria concentration measurements collected at Camp Rose Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

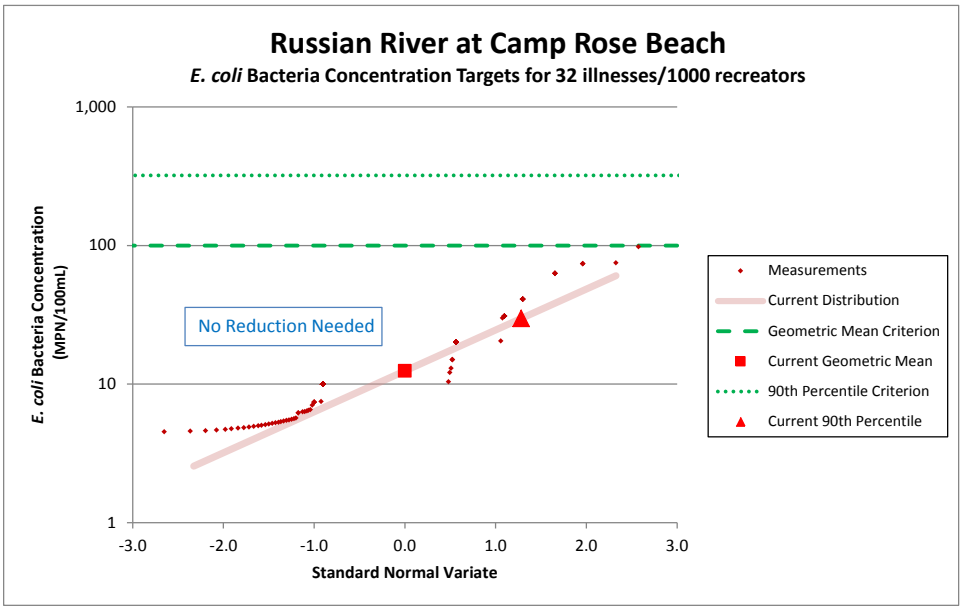

Figure 165. Comparison of *E. coli* bacteria concentration measurements collected at Camp Rose Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

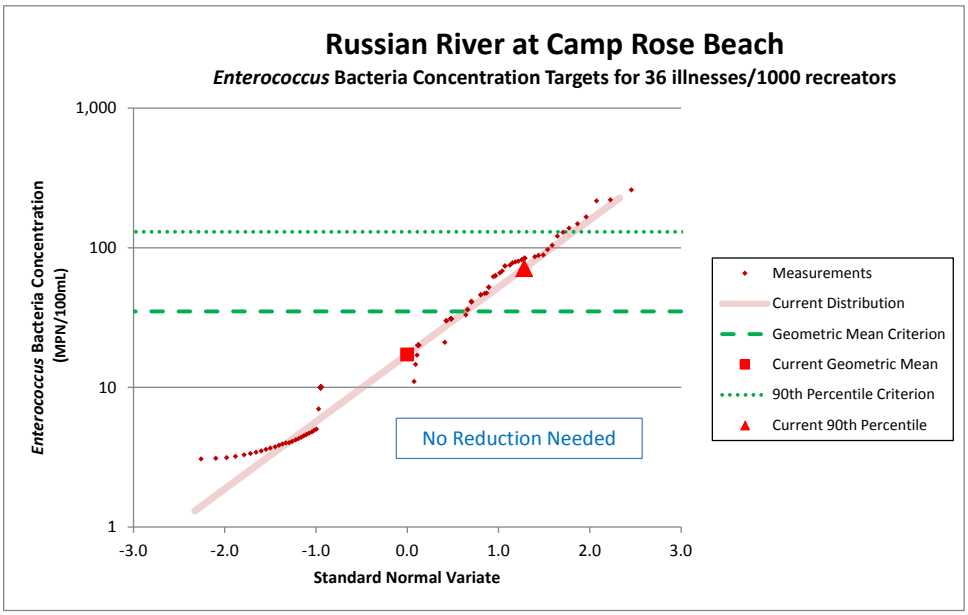

Figure 166. Comparison of *Enterococcus* bacteria concentration measurements collected at Camp Rose Beach in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

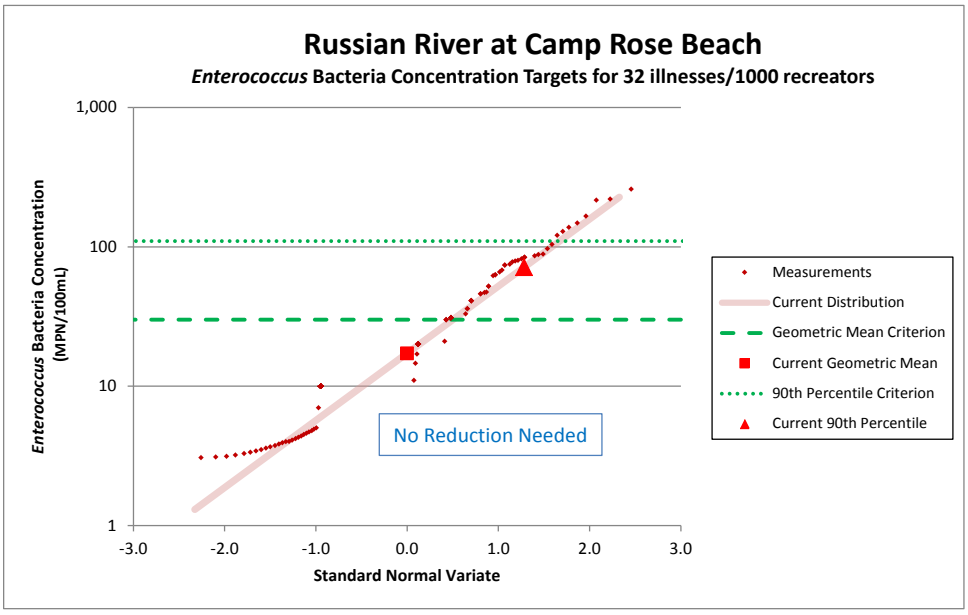

Figure 167. Comparison of *Enterococcus* bacteria concentration measurements collected at Camp Rose Beach in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

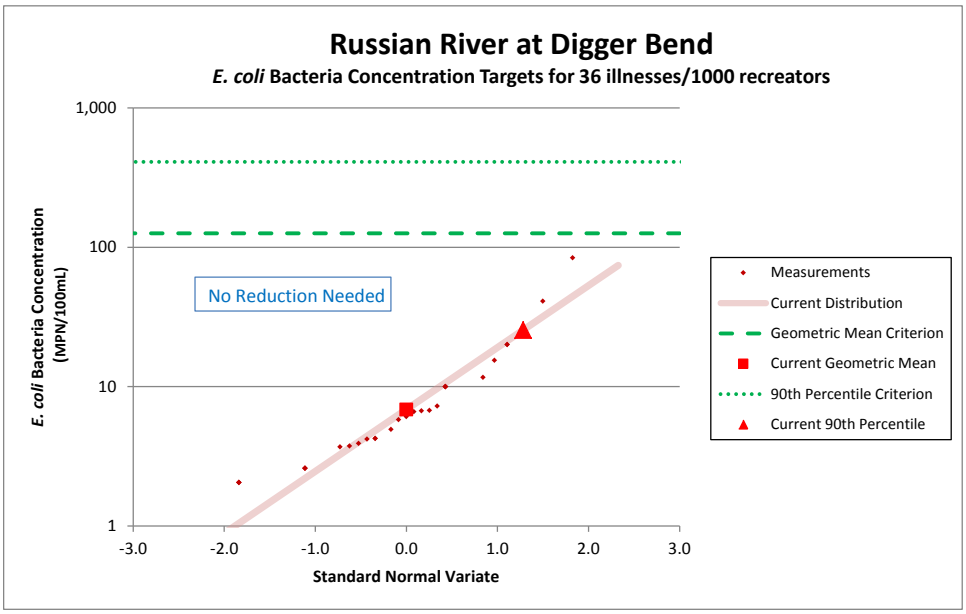

Figure 168. Comparison of *E. coli* bacteria concentration measurements collected at Digger Bend in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

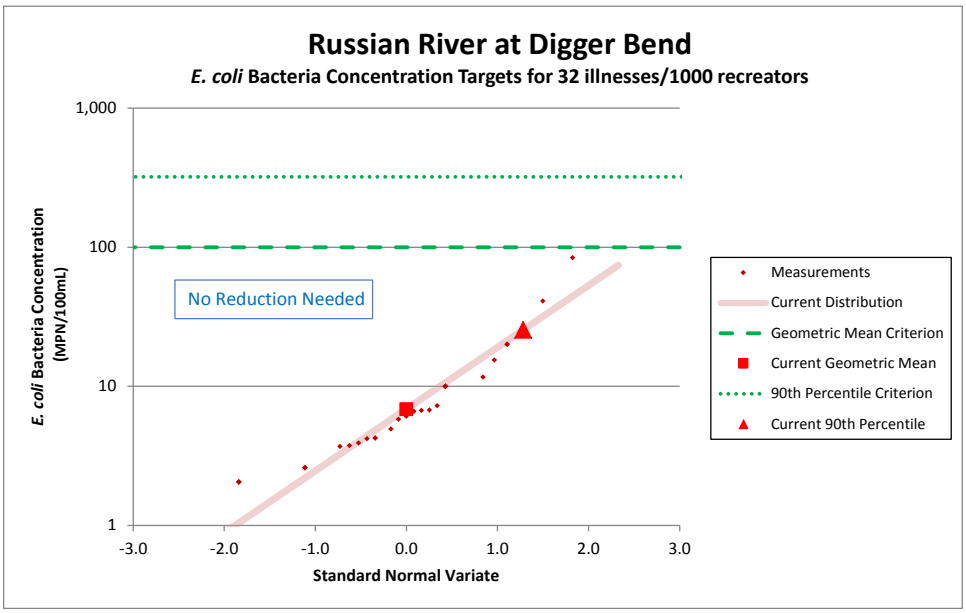

Figure 169. Comparison of *E. coli* bacteria concentration measurements collected at Digger Bend in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

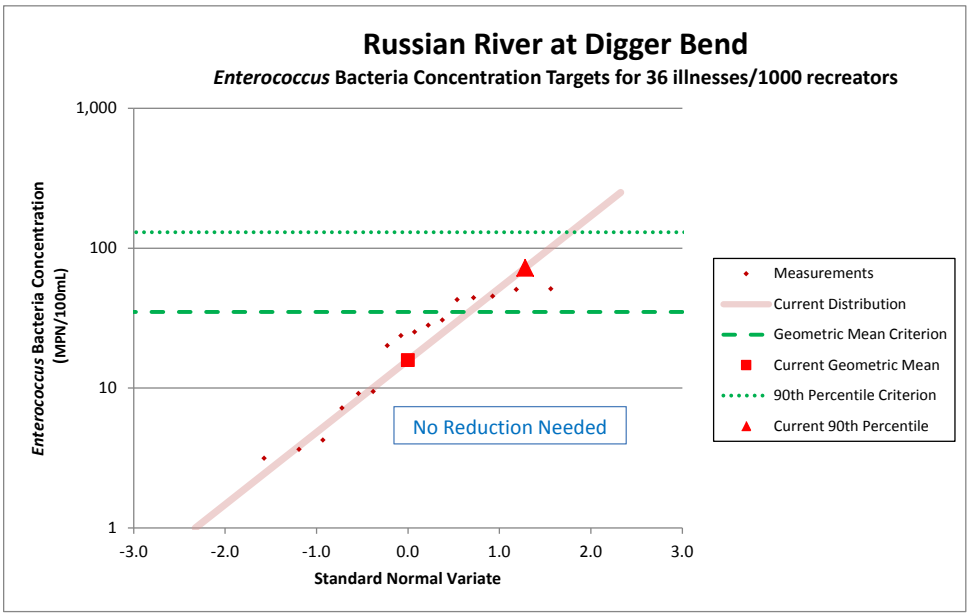

Figure 170. Comparison of *Enterococcus* bacteria concentration measurements collected at Digger Bend in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

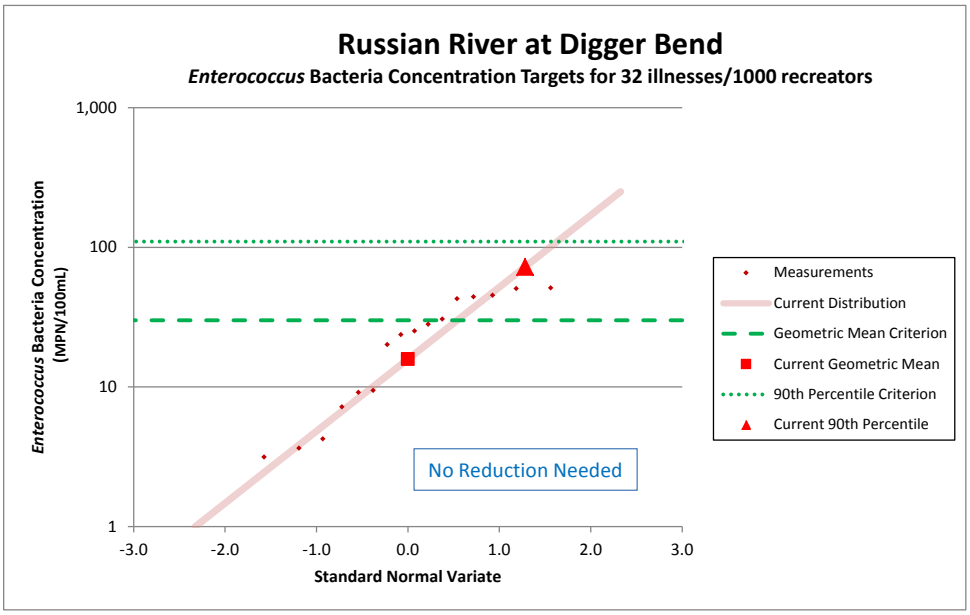

Figure 171. Comparison of *Enterococcus* bacteria concentration measurements collected at Digger Bend in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

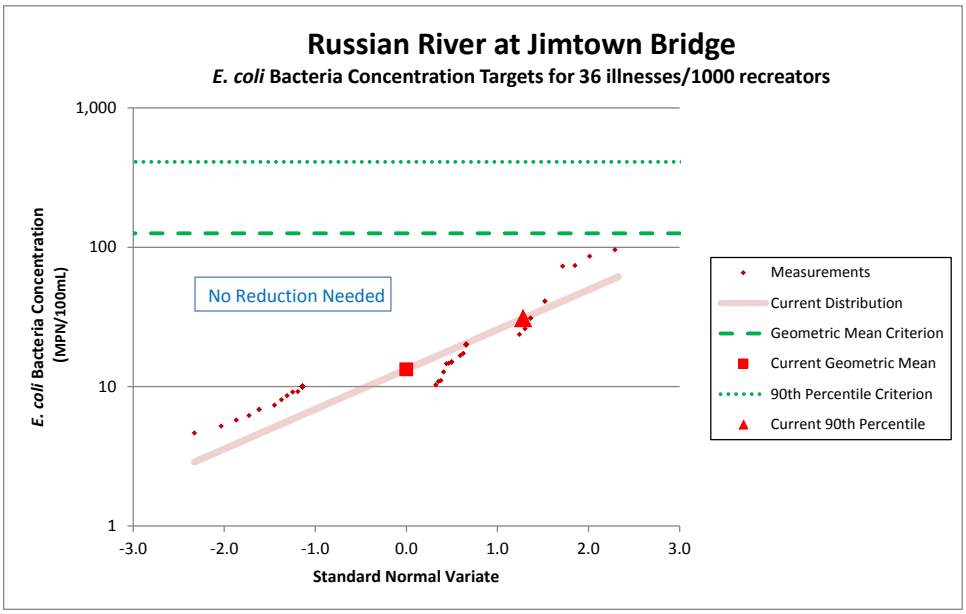

Figure 172. Comparison of *E. coli* bacteria concentration measurements collected at the Jimtown Bridge in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

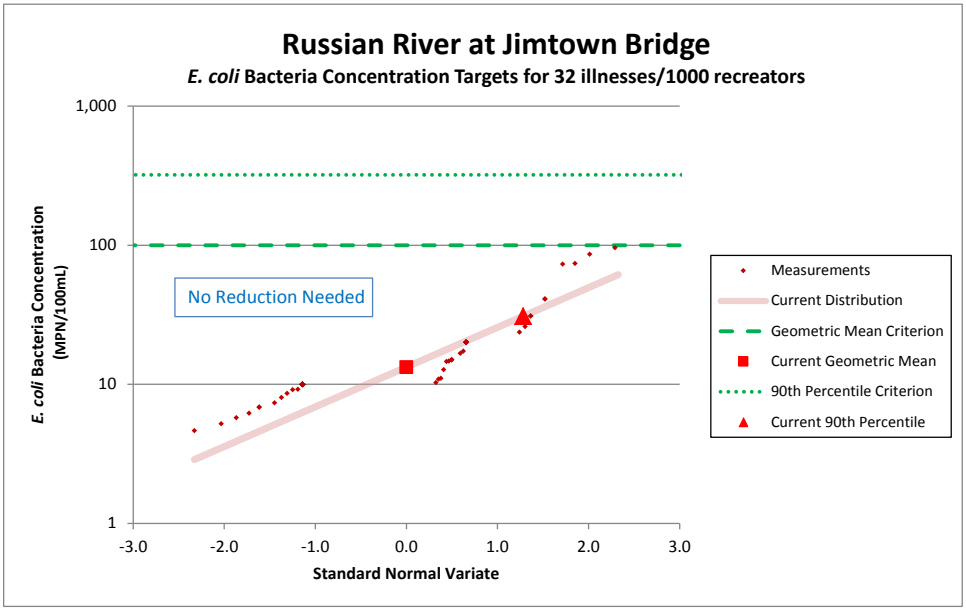

Figure 173. Comparison of *E. coli* bacteria concentration measurements collected at the Jimtown Bridge in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

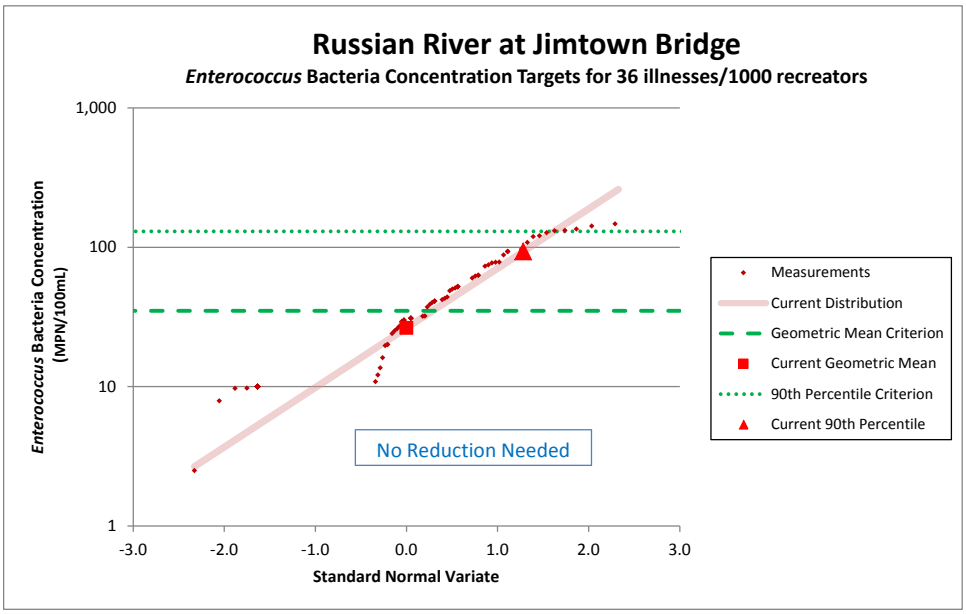

Figure 174. Comparison of *Enterococcus* bacteria concentration measurements collected at the Jimtown Bridge in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

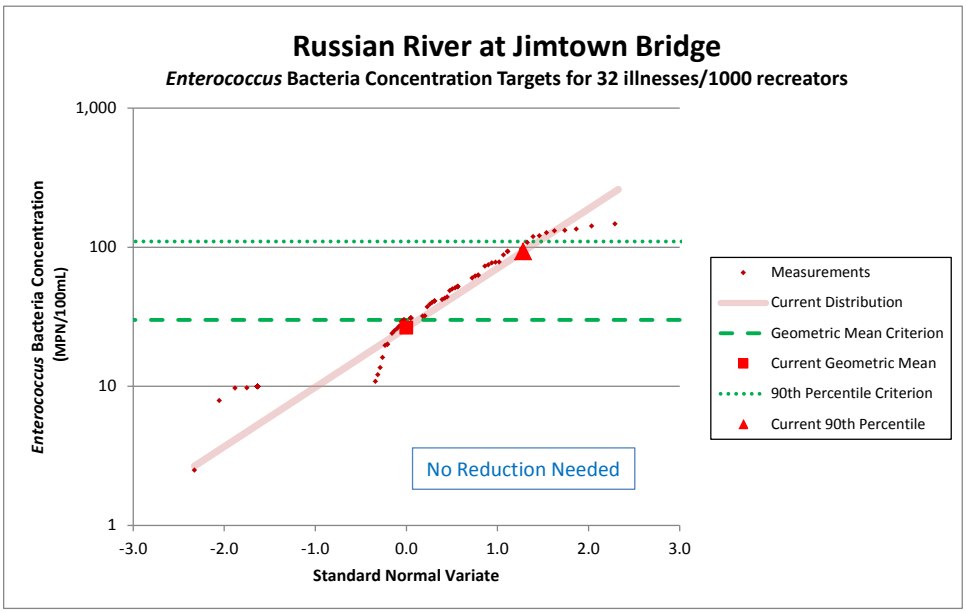

Figure 175. Comparison of *Enterococcus* bacteria concentration measurements collected at the Jimtown Bridge in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

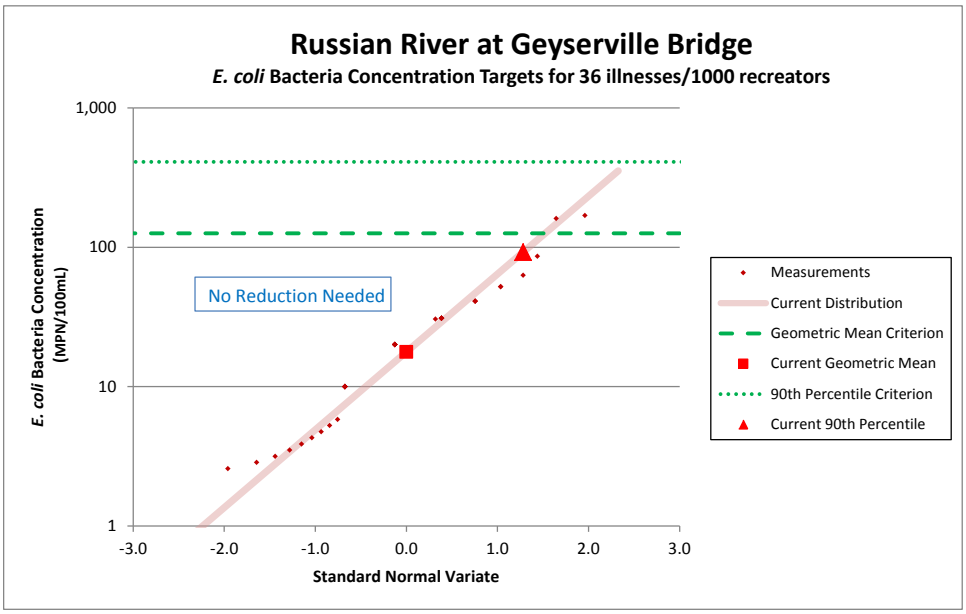

Figure 176. Comparison of *E. coli* bacteria concentration measurements collected at the Geyserville Bridge in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

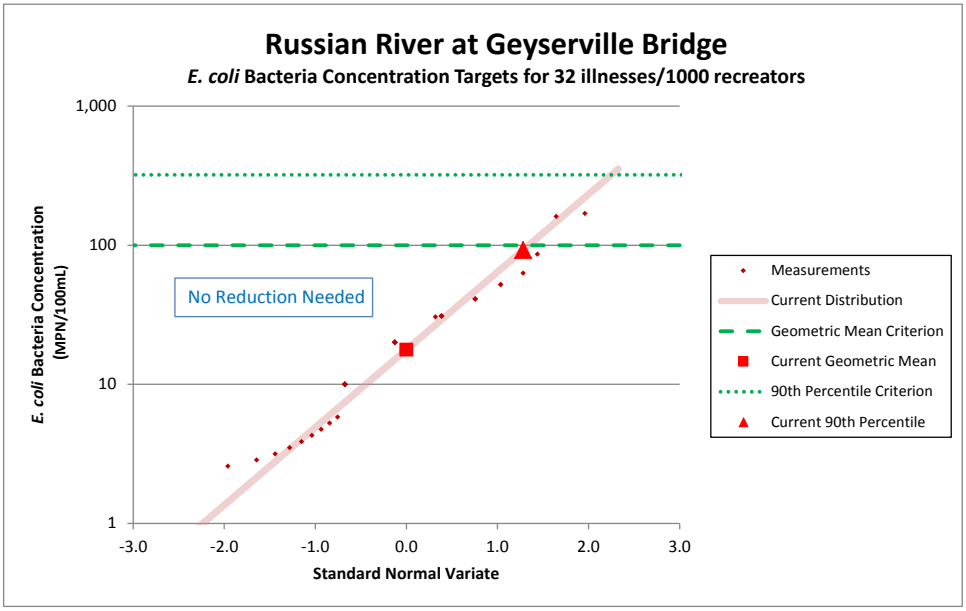

Figure 177. Comparison of *E. coli* bacteria concentration measurements collected at the Geyserville Bridge in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

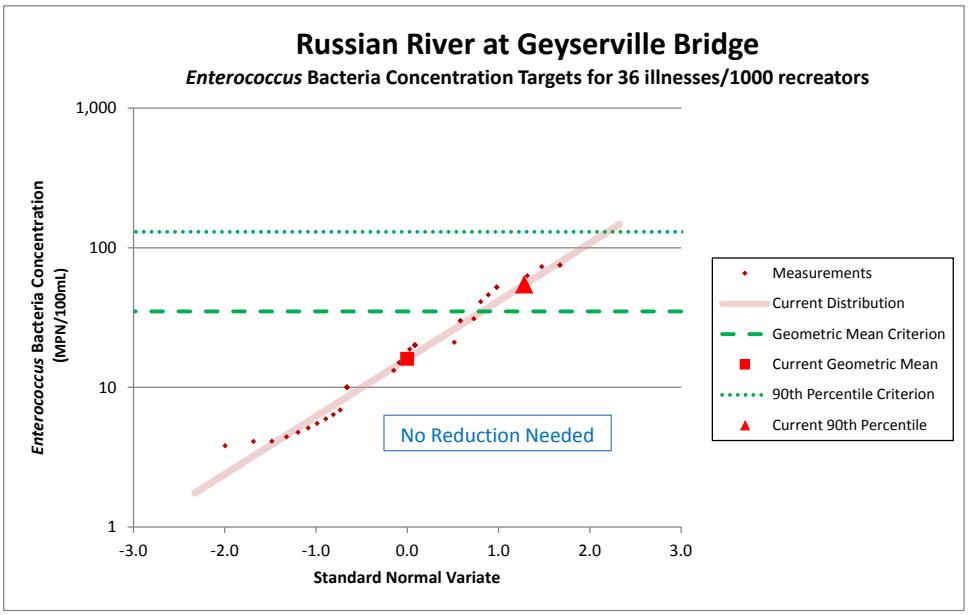

Figure 178. Comparison of *Enterococcus* bacteria concentration measurements collected at the Geyserville Bridge in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

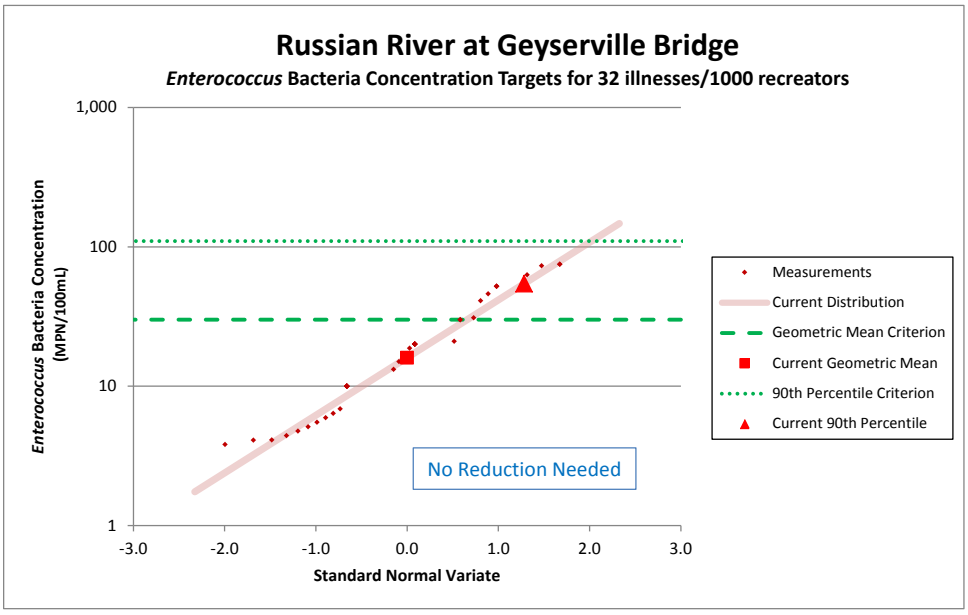

Figure 179. Comparison of *Enterococcus* bacteria concentration measurements collected at the Geyserville Bridge in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

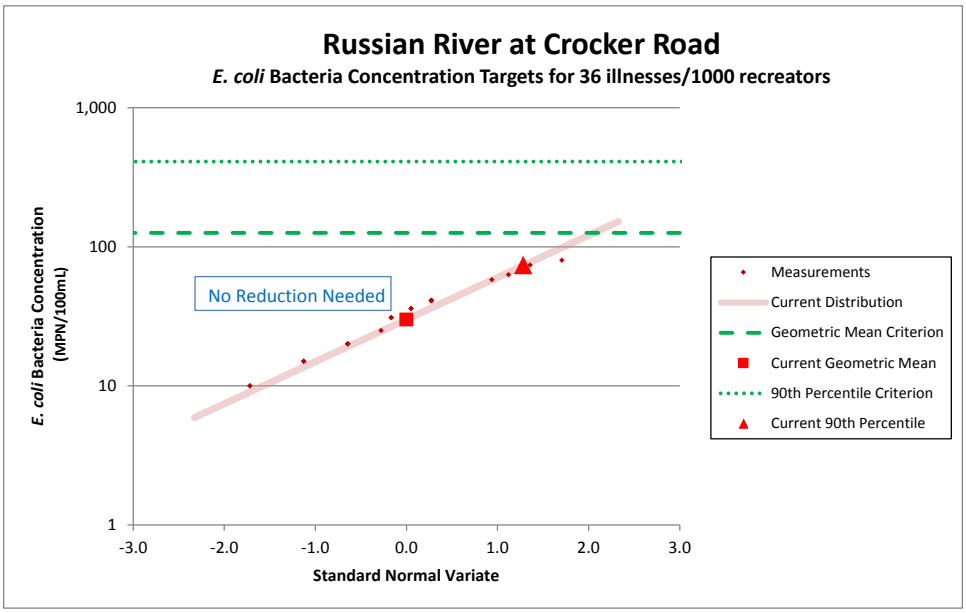

Figure 180. Comparison of *E. coli* bacteria concentration measurements collected at Crocker Road in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

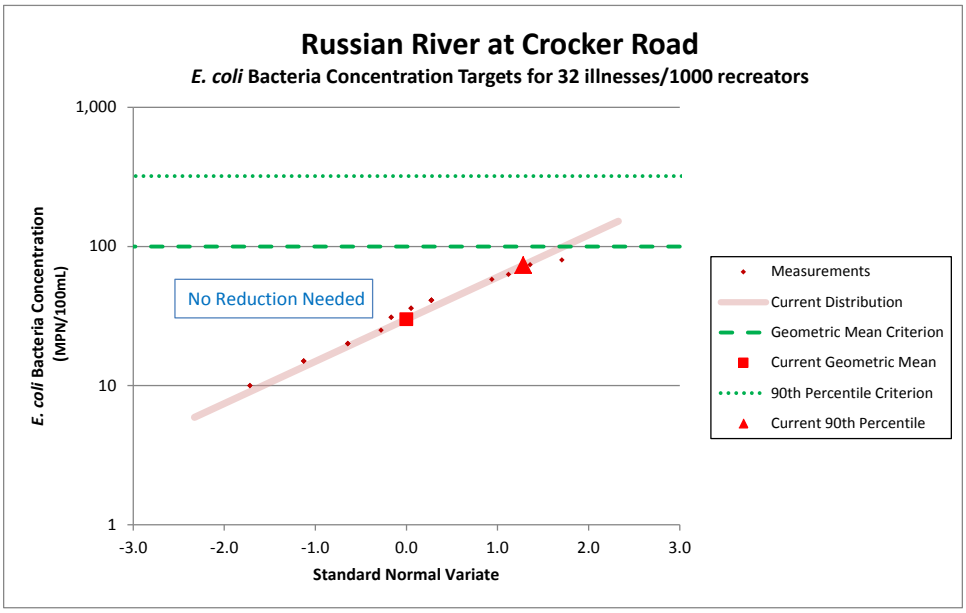

Figure 181. Comparison of *E. coli* bacteria concentration measurements collected at Crocker Road in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

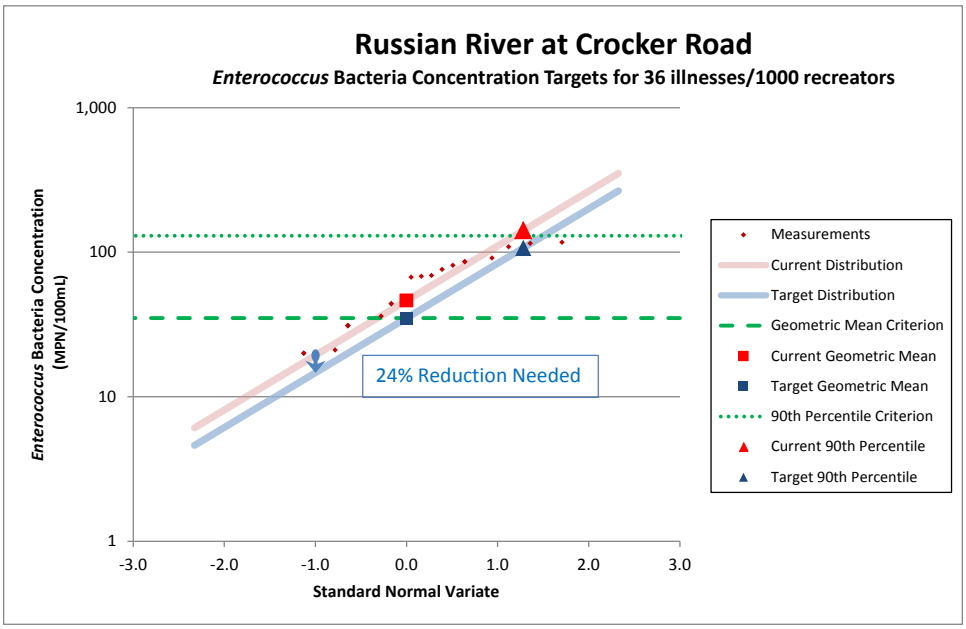

Figure 182. Comparison of *Enterococcus* bacteria concentration measurements collected at Crocker Road in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

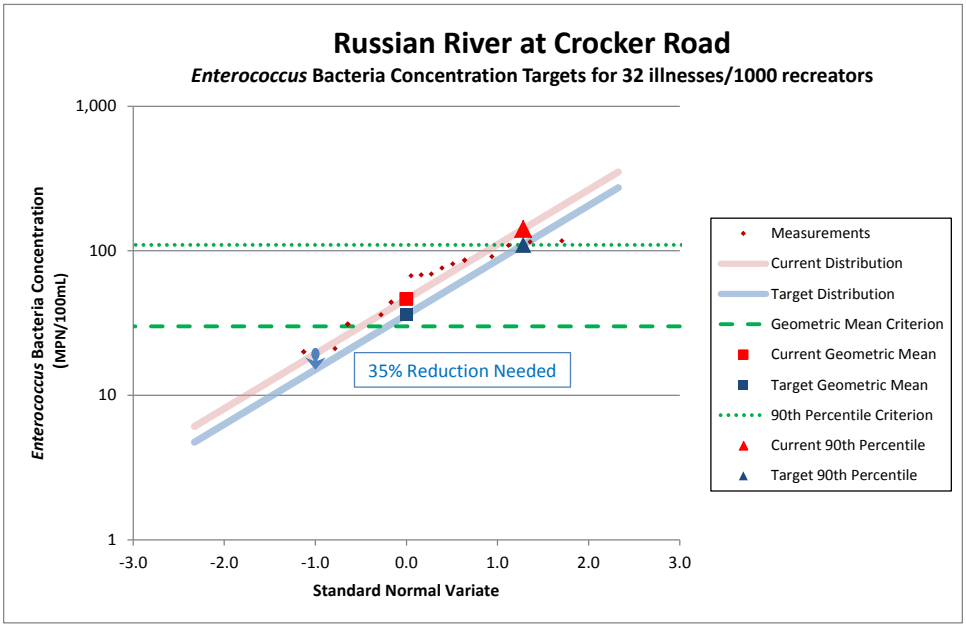

Figure 183. Comparison of *Enterococcus* bacteria concentration measurements collected at Crocker Road in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

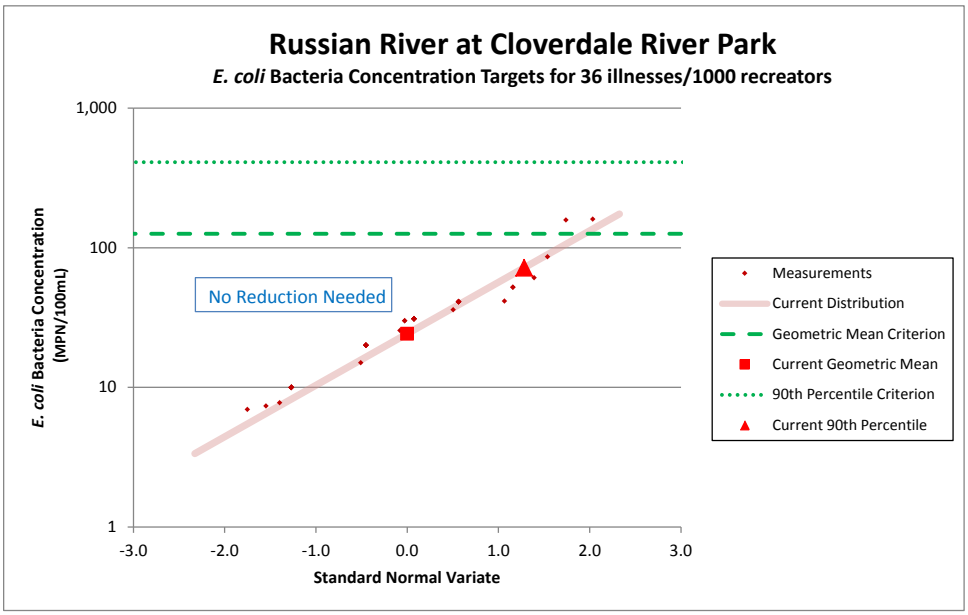

Figure 184. Comparison of *E. coli* bacteria concentration measurements collected at Cloverdale River park in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

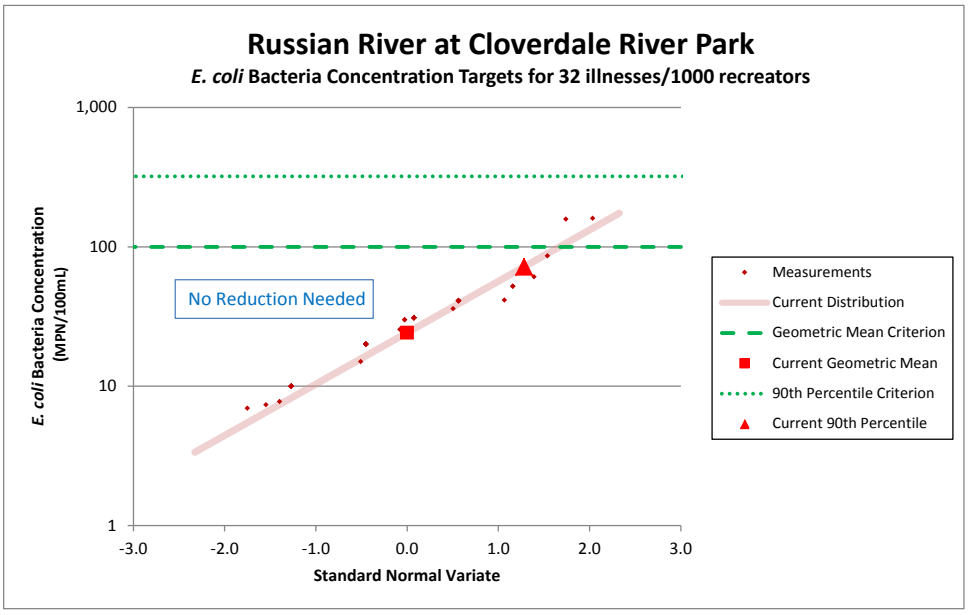

Figure 185. Comparison of *E. coli* bacteria concentration measurements collected at Cloverdale River park in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

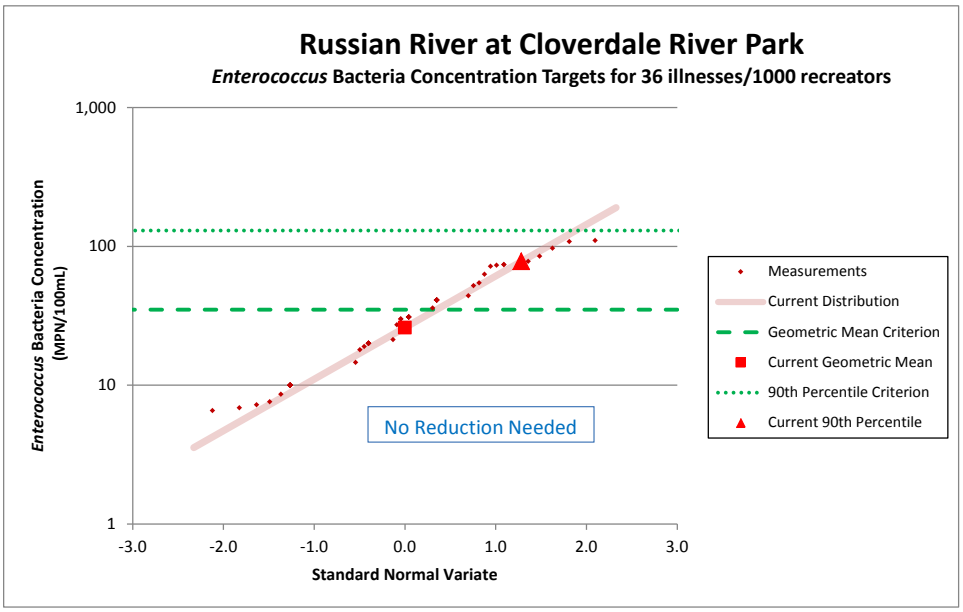

Figure 186. Comparison of *Enterococcus* bacteria concentration measurements collected at Cloverdale River park in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

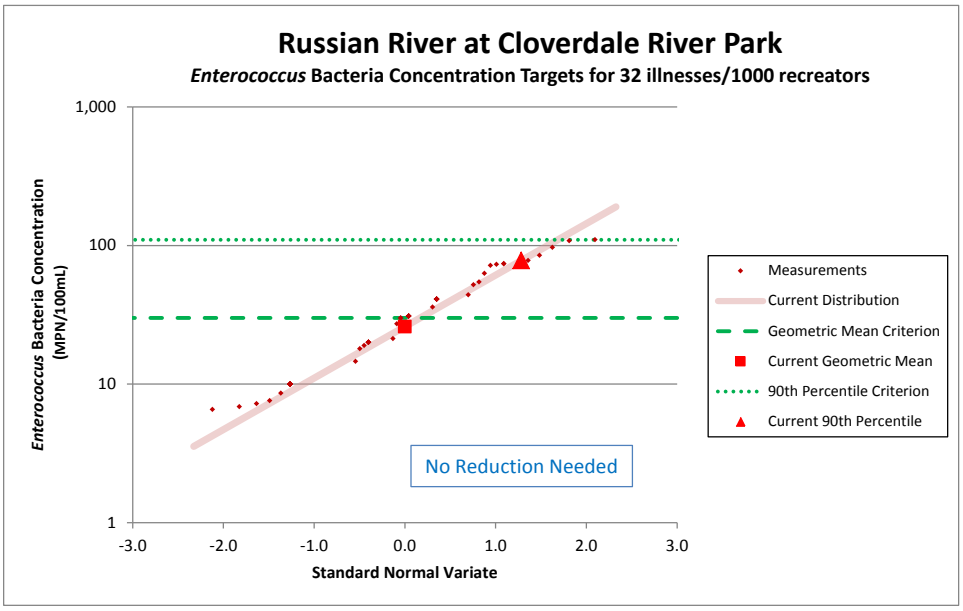

Figure 187. Comparison of *Enterococcus* bacteria concentration measurements collected at Cloverdale River park in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

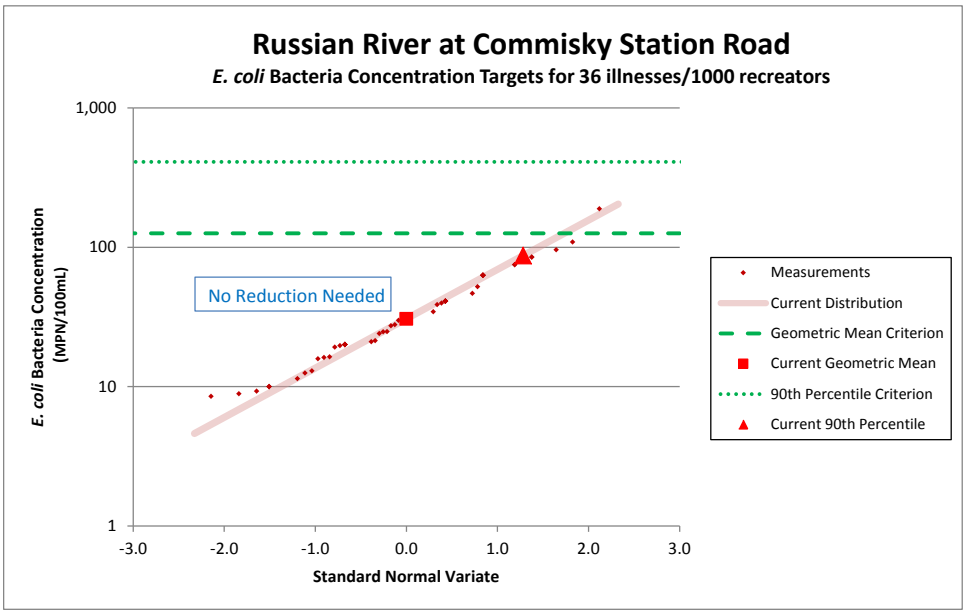

Figure 188. Comparison of *E. coli* bacteria concentration measurements collected at Commisky Station Road in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

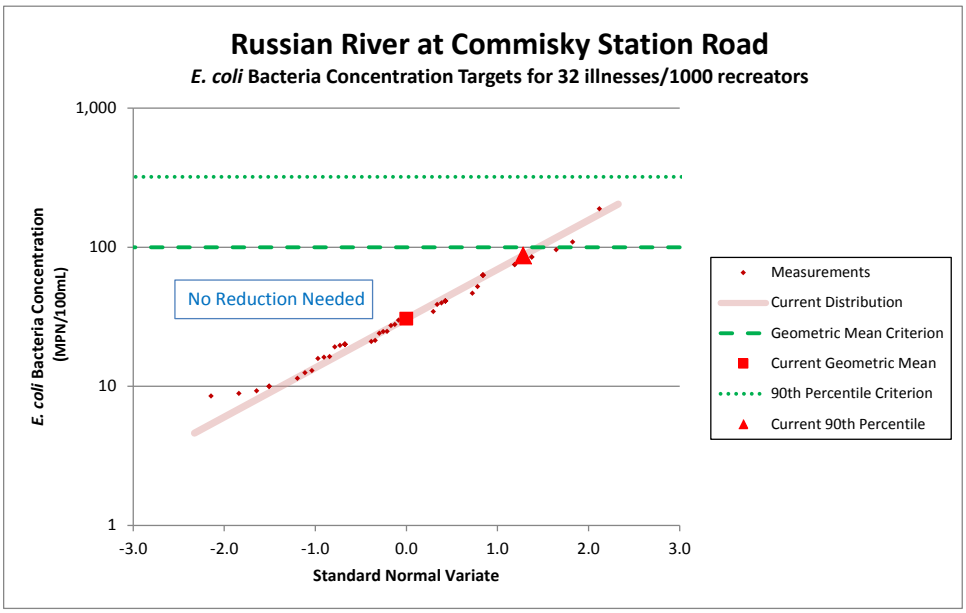

Figure 189. Comparison of *E. coli* bacteria concentration measurements collected at Commisky Station Road in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

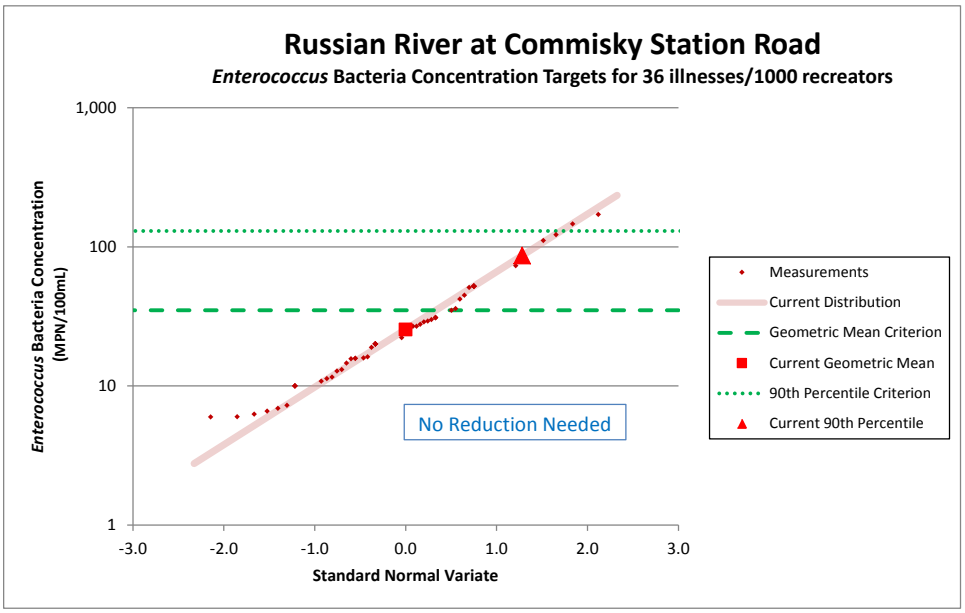

Figure 190. Comparison of *Enterococcus* bacteria concentration measurements collected at Commisky Station Road in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

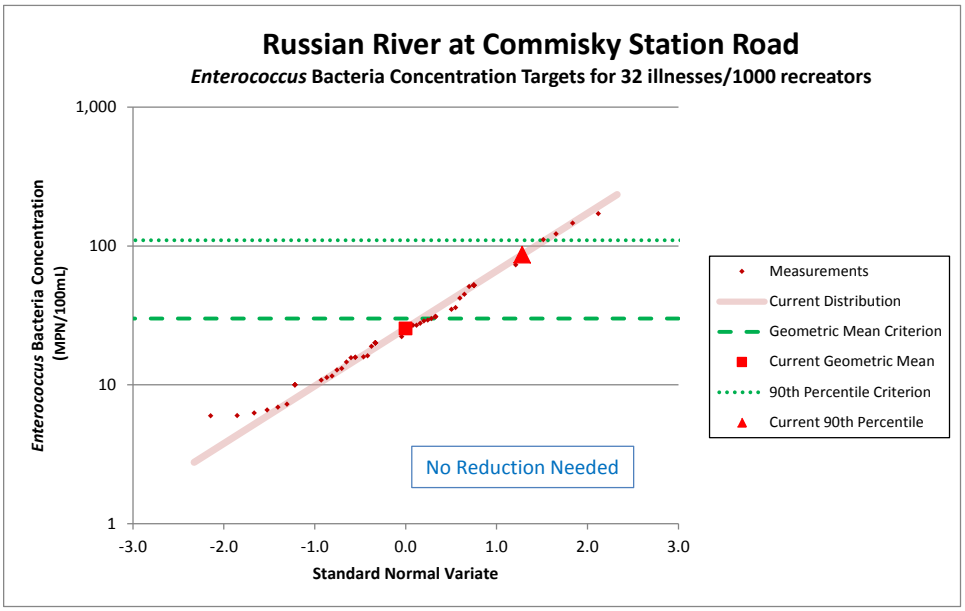

Figure 191. Comparison of *Enterococcus* bacteria concentration measurements collected at Commisky Station Road in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

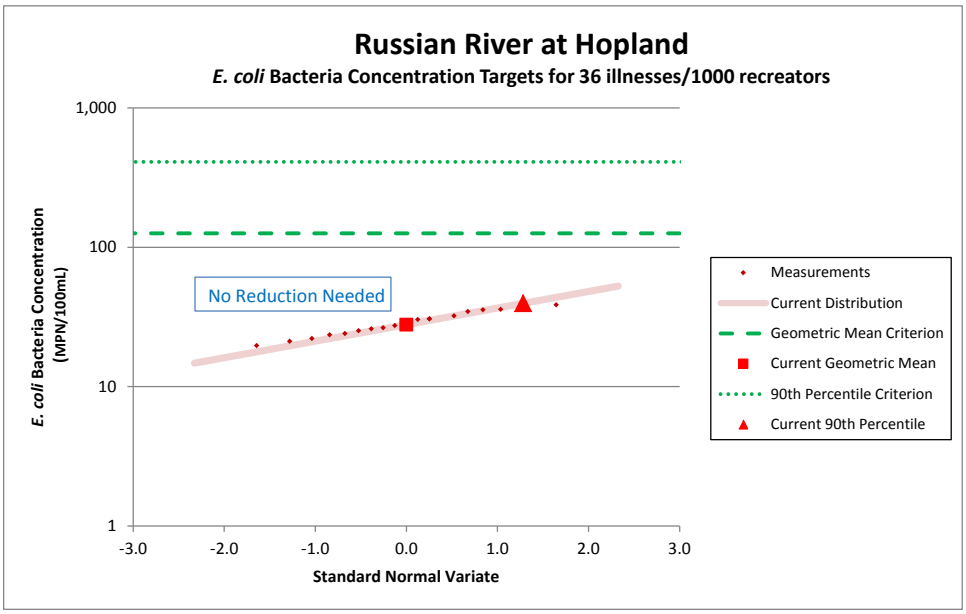

Figure 192. Comparison of *E. coli* bacteria concentration measurements collected at Hopland in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

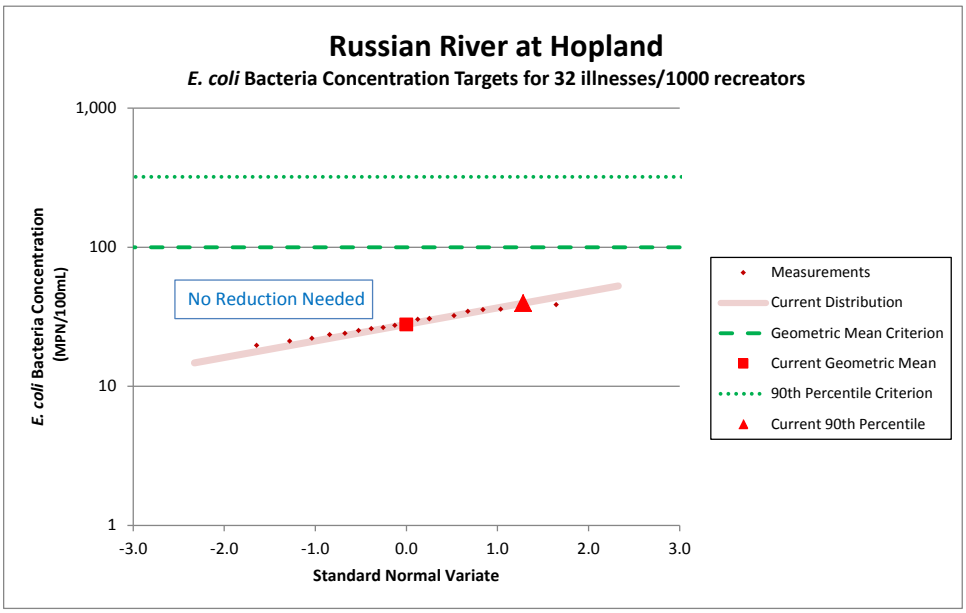

Figure 193. Comparison of *E. coli* bacteria concentration measurements collected at Hopland in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

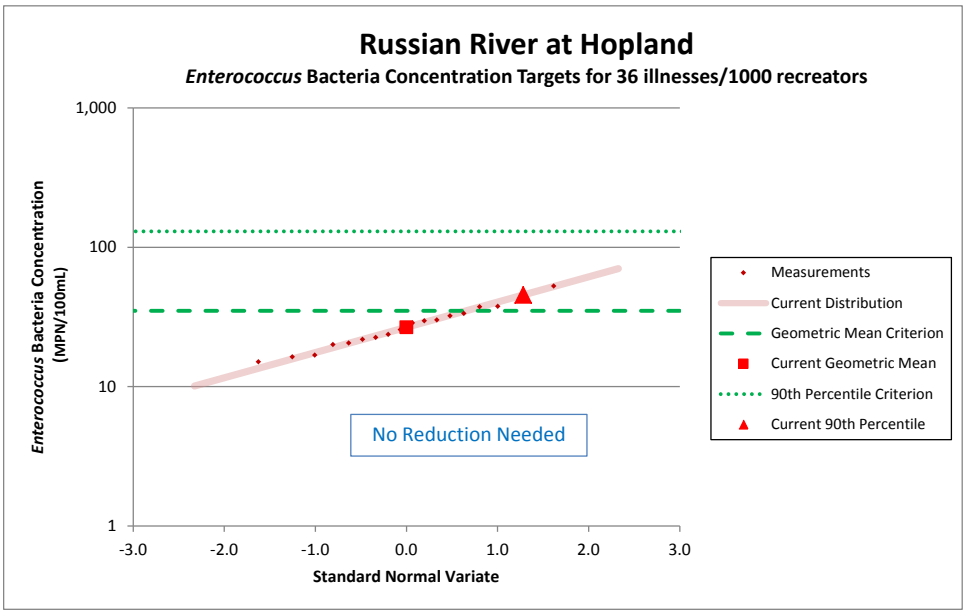

Figure 194. Comparison of *Enterococcus* bacteria concentration measurements collected at Hopland in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

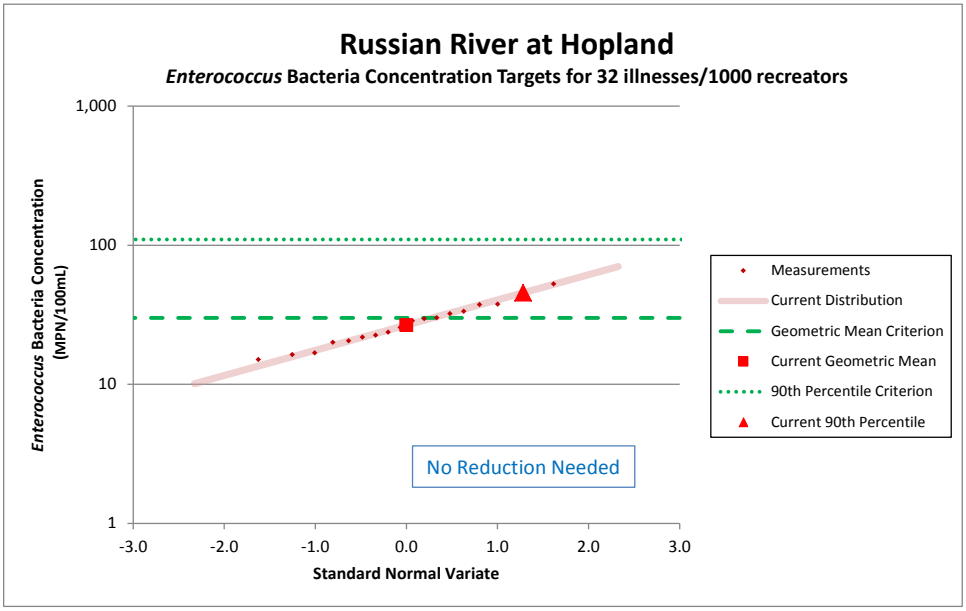

Figure 195. Comparison of *Enterococcus* bacteria concentration measurements collected at Hopland in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

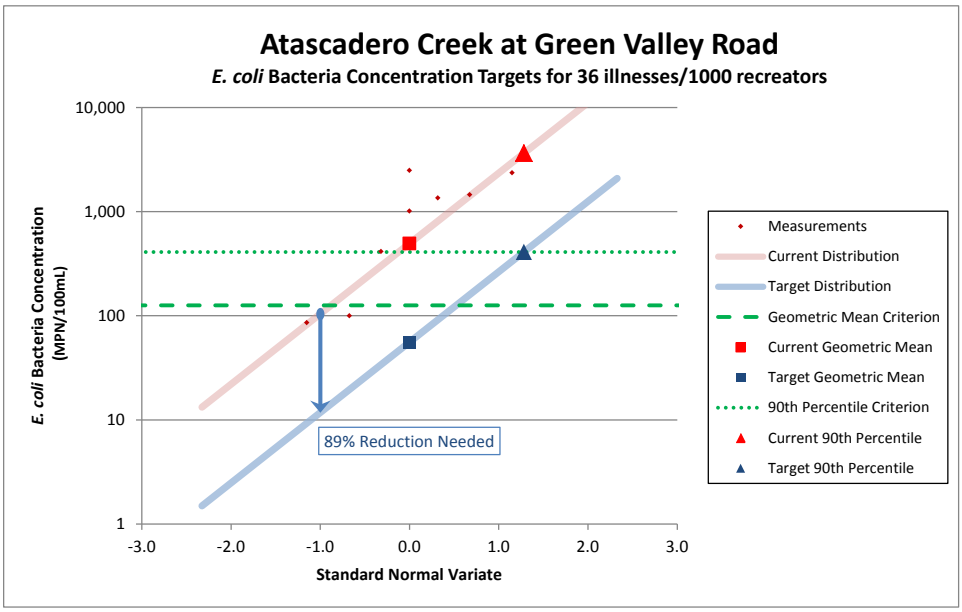

Figure 196. Comparison of *E. coli* bacteria concentration measurements collected at Green Valley Road in Atascadero Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

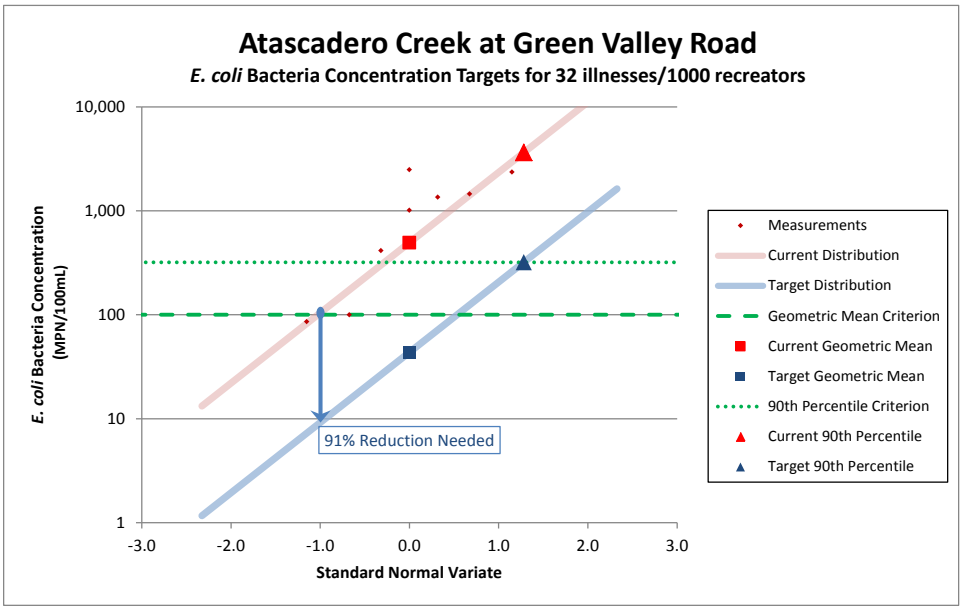

Figure 197. Comparison of *E. coli* bacteria concentration measurements collected at Green Valley Road in Atascadero Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

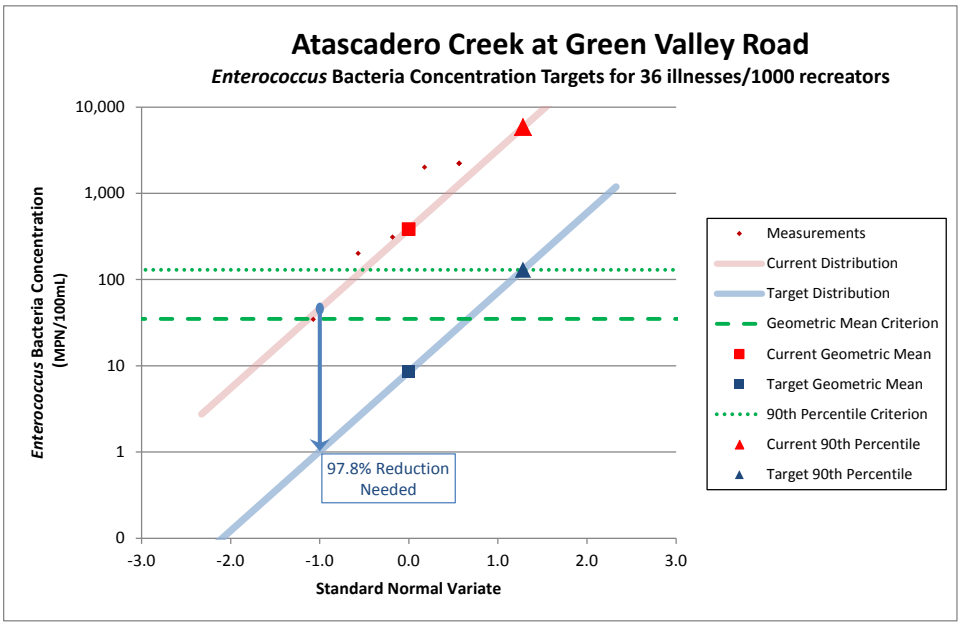

Figure 198. Comparison of *Enterococcus* bacteria concentration measurements collected at Green Valley Road in Atascadero Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

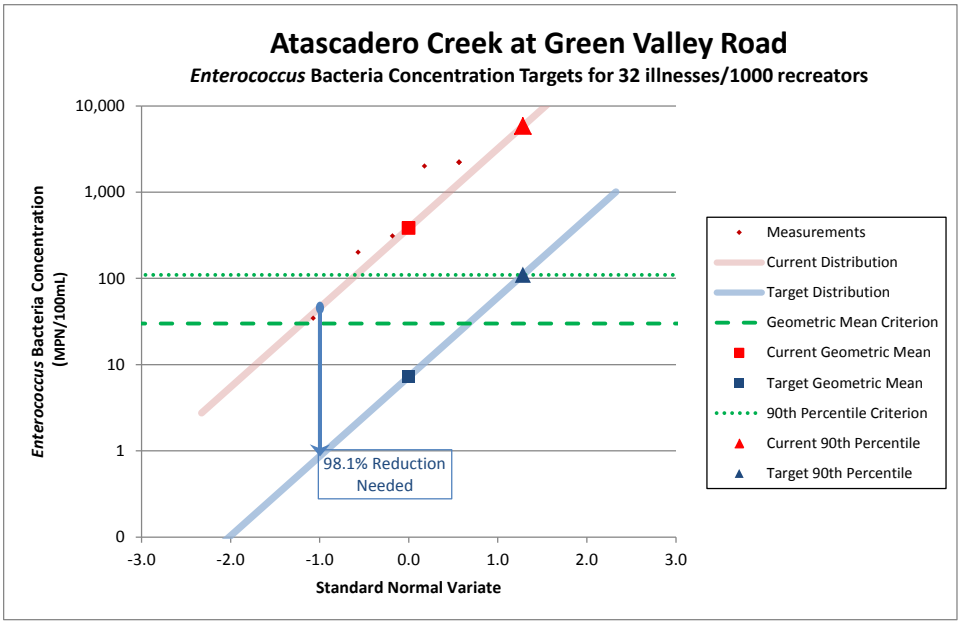

Figure 199. Comparison of *Enterococcus* bacteria concentration measurements collected at Green Valley Road in Atascadero Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

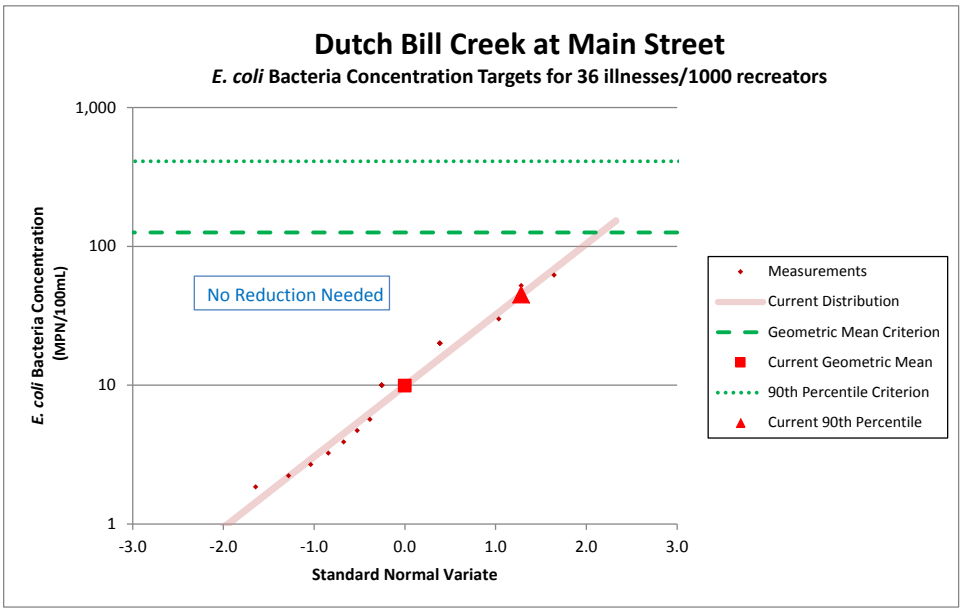

Figure 200. Comparison of *E. coli* bacteria concentration measurements collected at Main Street in Dutch Bill Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

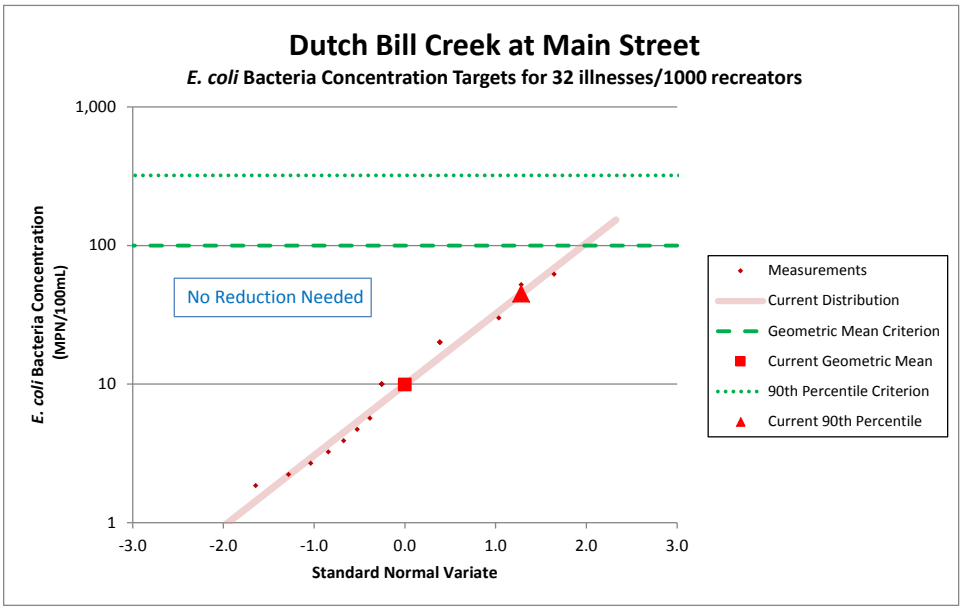

Figure 201. Comparison of *E. coli* bacteria concentration measurements collected at Main Street in Dutch Bill Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

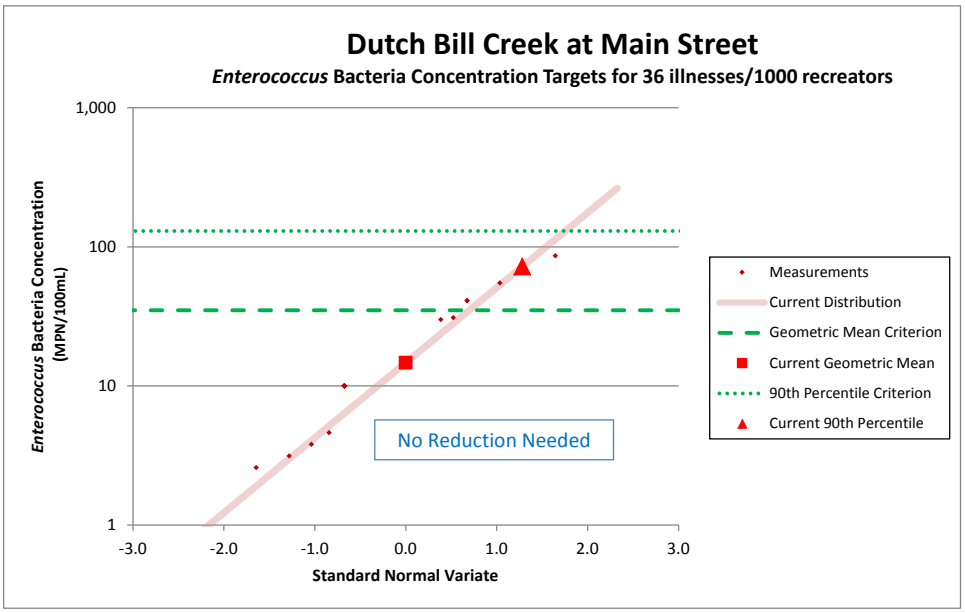

Figure 202. Comparison of *Enterococcus* bacteria concentration measurements collected at Main Street in Dutch Bill Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

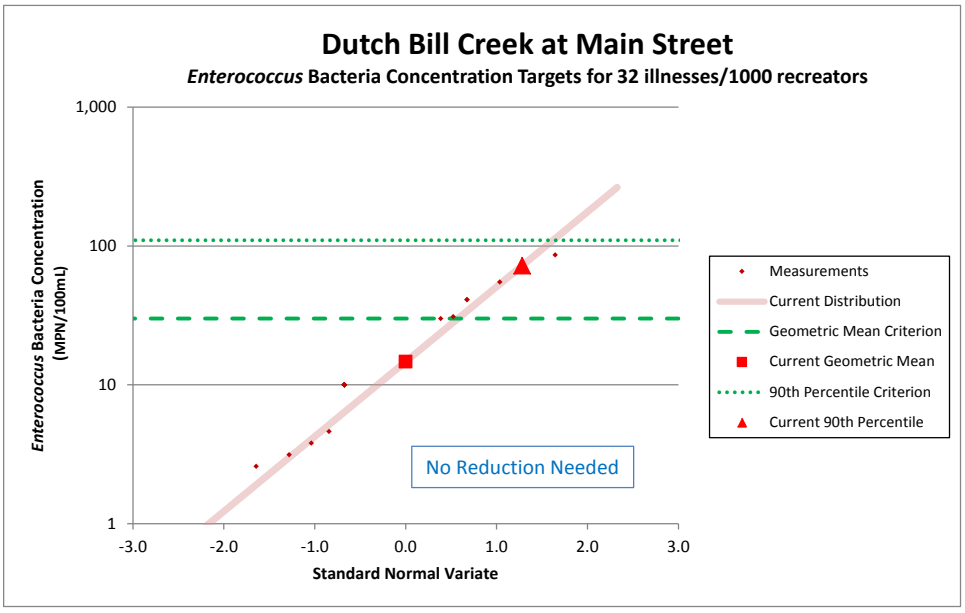

Figure 203. Comparison of *Enterococcus* bacteria concentration measurements collected at Main Street in Dutch Bill Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

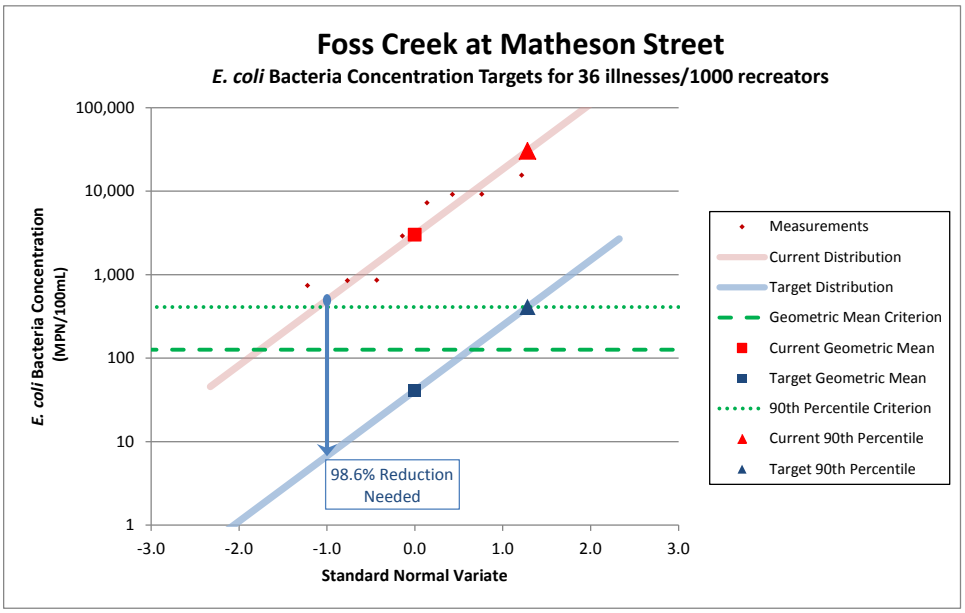

Figure 204. Comparison of *E. coli* bacteria concentration measurements collected at Matheson Street in Foss Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

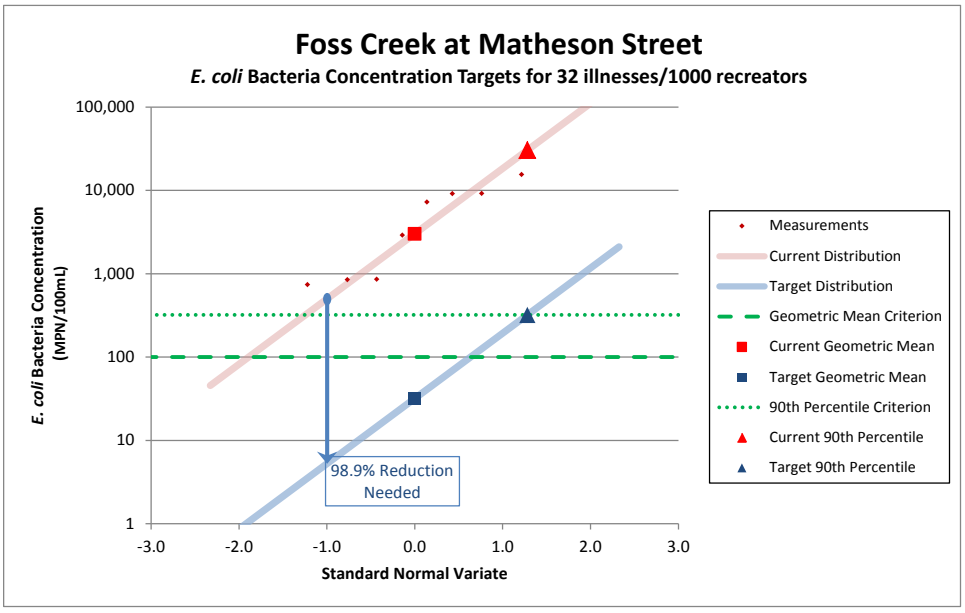

Figure 205. Comparison of *E. coli* bacteria concentration measurements collected at Matheson Street in Foss Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

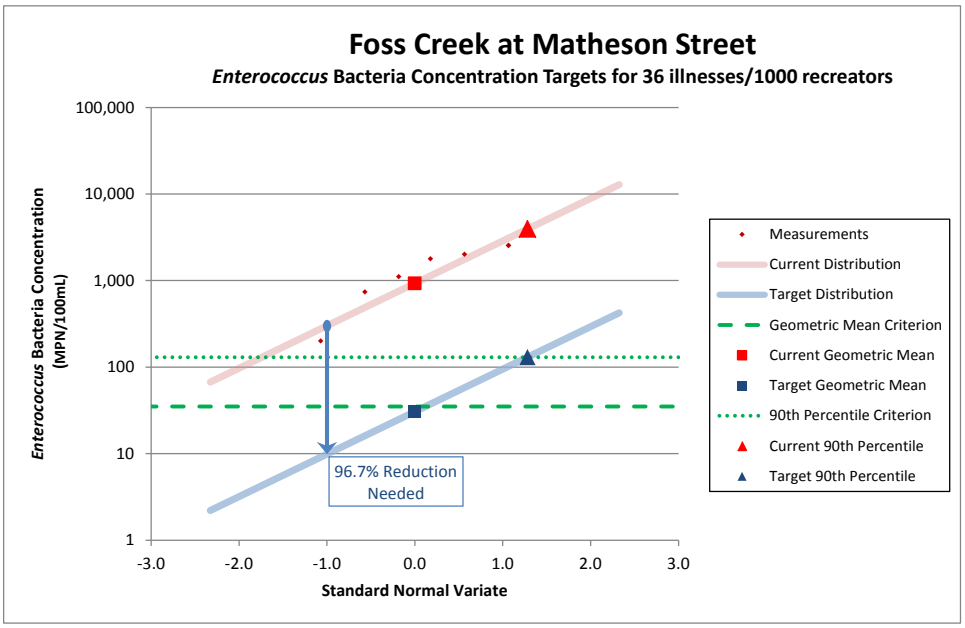

Figure 206. Comparison of *Enterococcus* bacteria concentration measurements collected at Matheson Street in Foss Creek in the Russian River to concentration targets for estimated 36 illnesses per 1,000 recreators

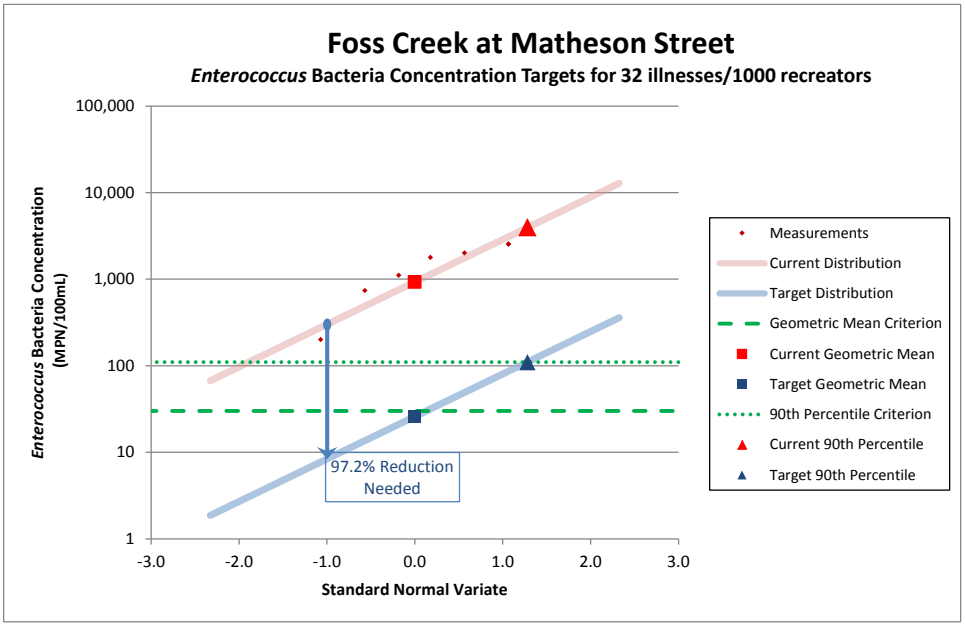

Figure 207. Comparison of *Enterococcus* bacteria concentration measurements collected at Matheson Street in Foss Creek in the Russian River to concentration targets for estimated 32 illnesses per 1,000 recreators

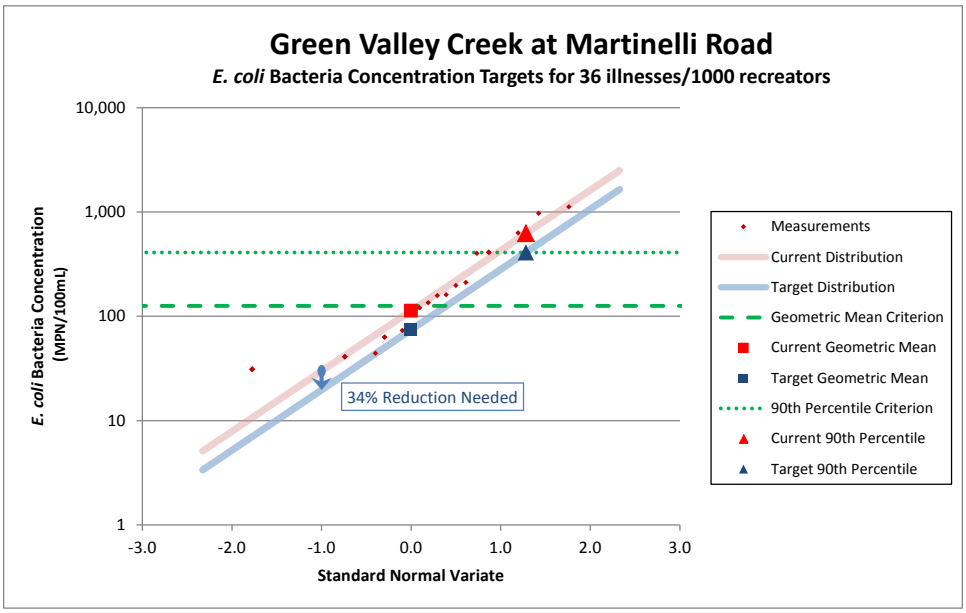

Figure 208. Comparison of *E. coli* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

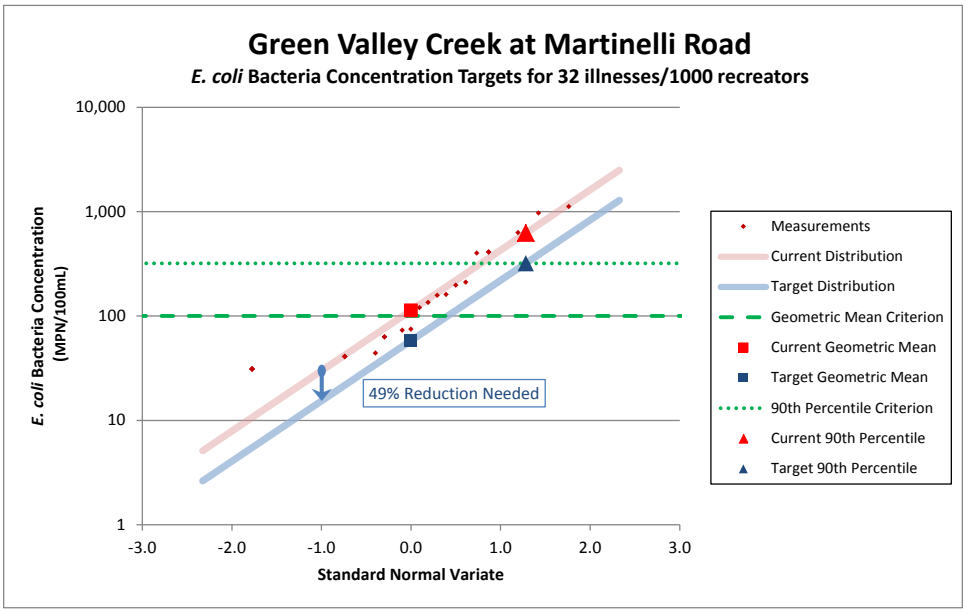

Figure 209. Comparison of *E. coli* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

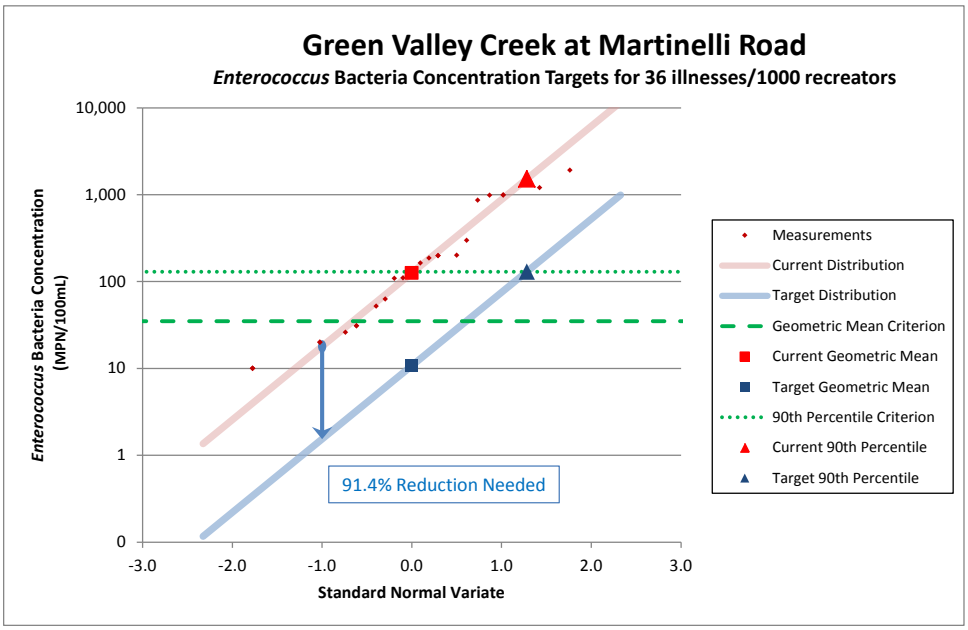

Figure 210. Comparison of *Enterococcus* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

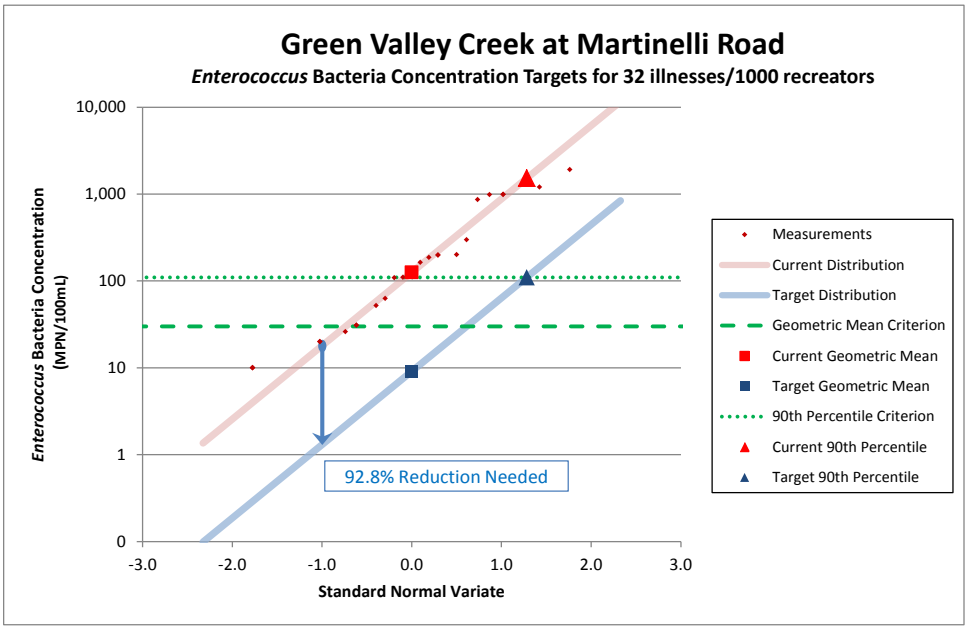

Figure 211. Comparison of *Enterococcus* bacteria concentration measurements collected at Martinelli Road in Green Valley Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

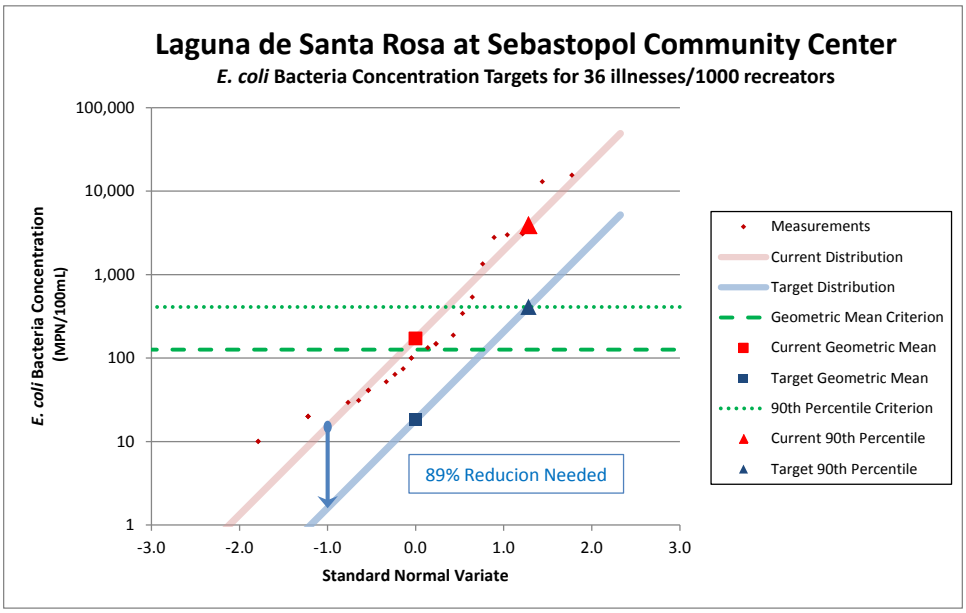

Figure 212. Comparison of *E. coli* bacteria concentration measurements collected at the Sebastopol Community Center in the Laguna de Santa Rosa to concentration targets for estimated 36 illnesses per 1,000 recreators

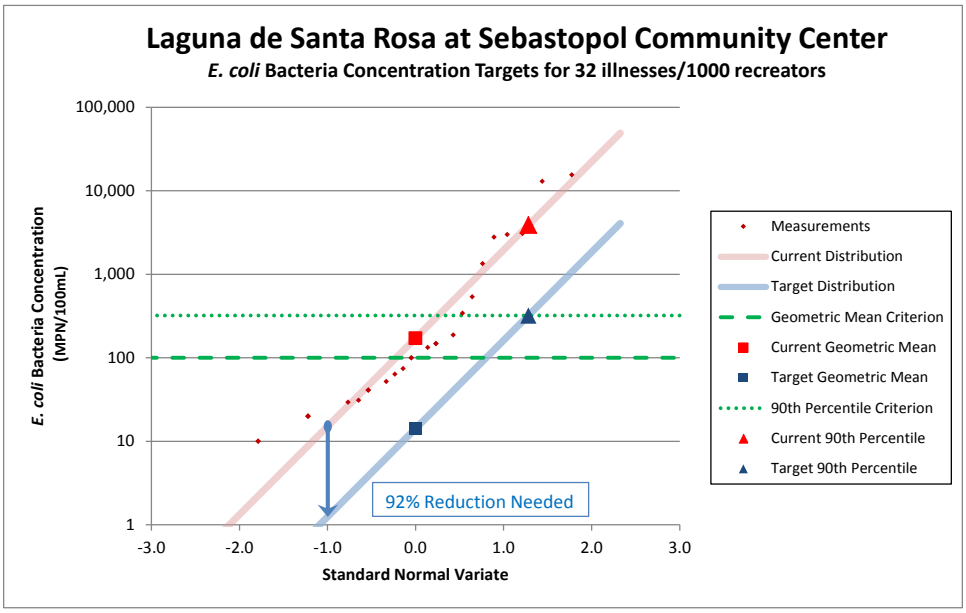

Figure 213. Comparison of *E. coli* bacteria concentration measurements collected at the Sebastopol Community Center in the Laguna de Santa Rosa to concentration targets for estimated 32 illnesses per 1,000 recreators

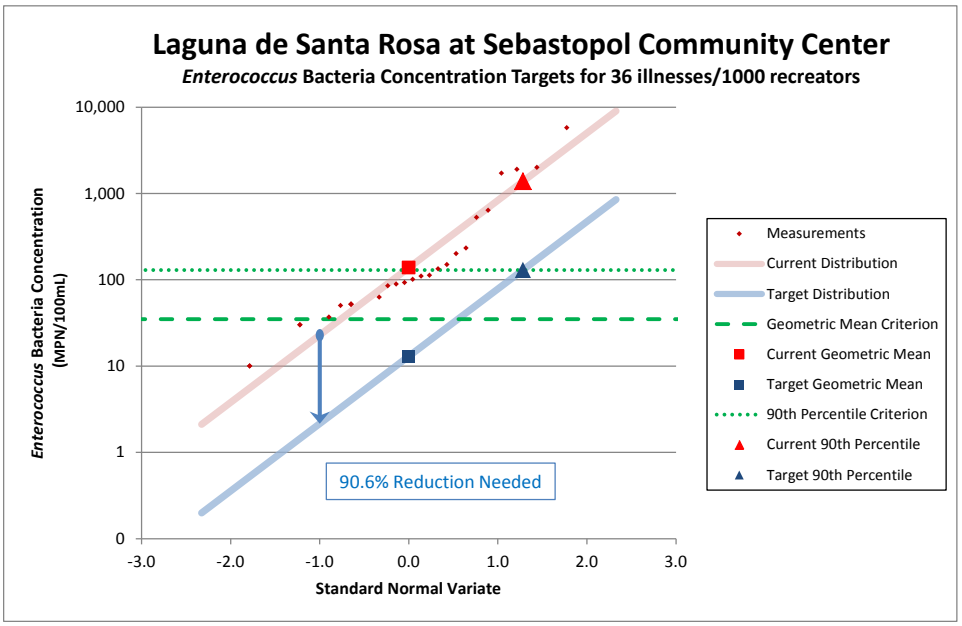

Figure 214. Comparison of *Enterococcus* bacteria concentration measurements collected at Sebastopol Community Center in the Laguna de Santa Rosa to concentration targets for estimated 36 illnesses per 1,000 recreators

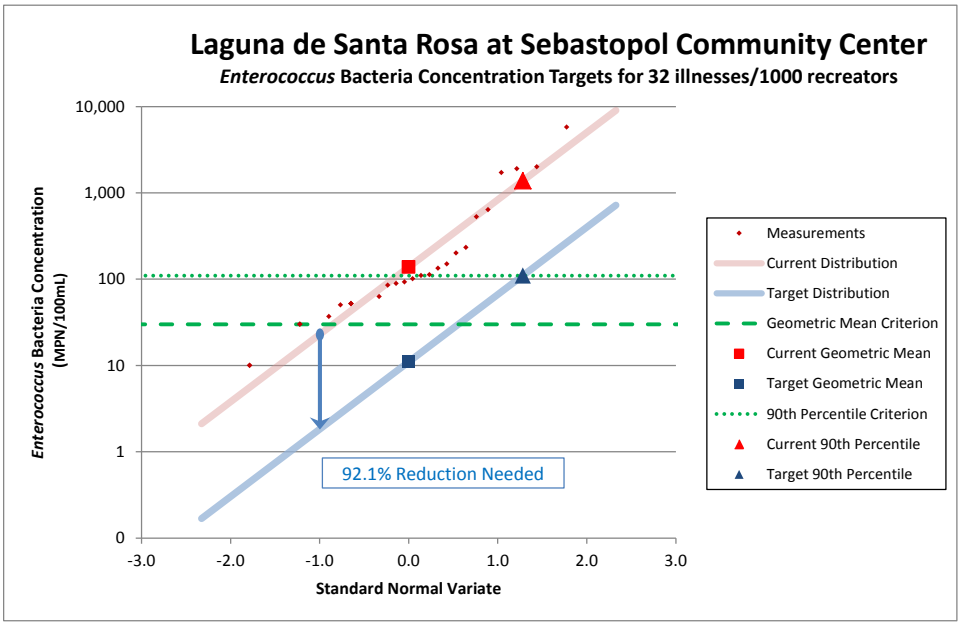

Figure 215. Comparison of *Enterococcus* bacteria concentration measurements collected at Sebastopol Community Center in the Laguna de Santa Rosa to concentration targets for estimated 32 illnesses per 1,000 recreators

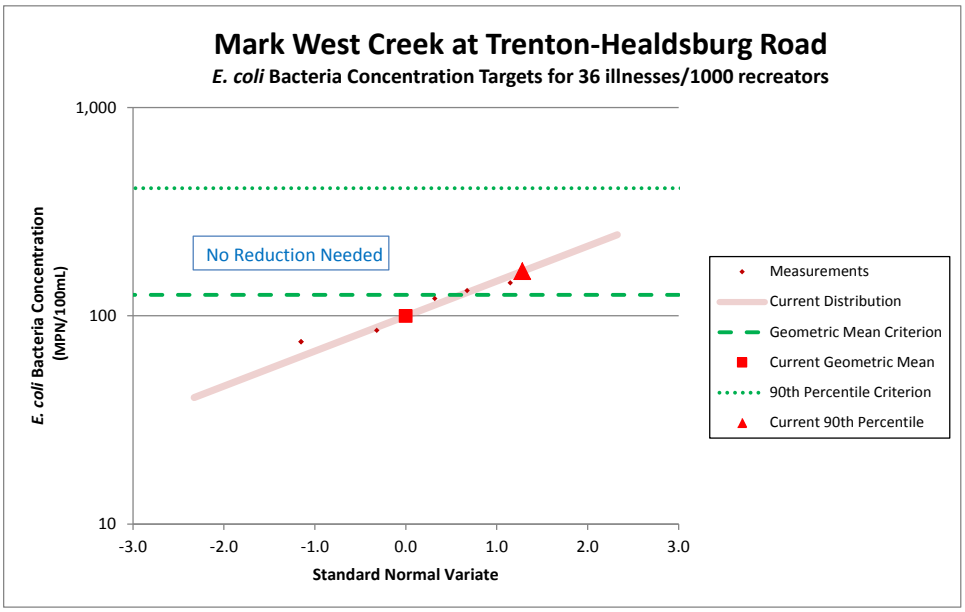

Figure 216. Comparison of *E. coli* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

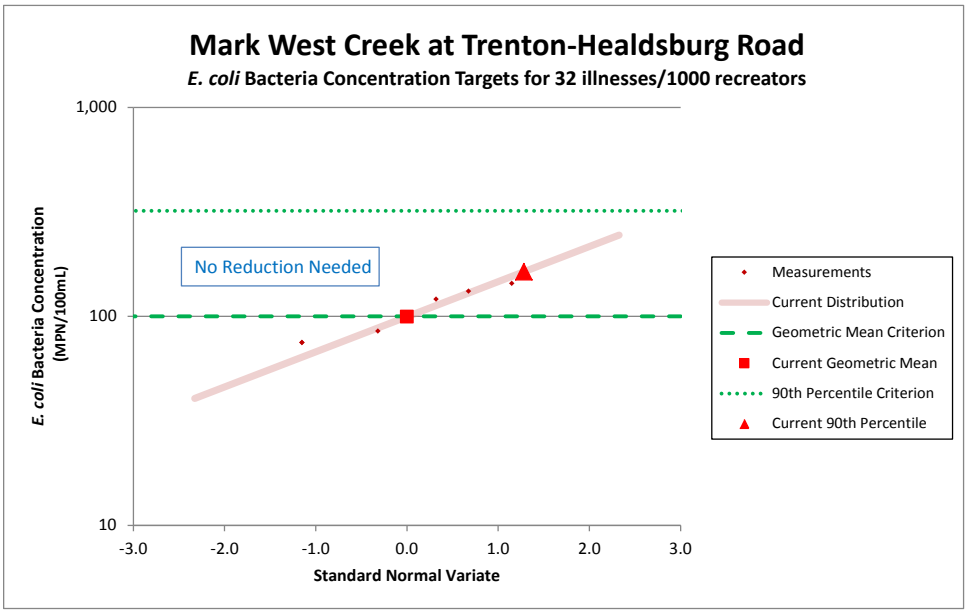

Figure 217. Comparison of *E. coli* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

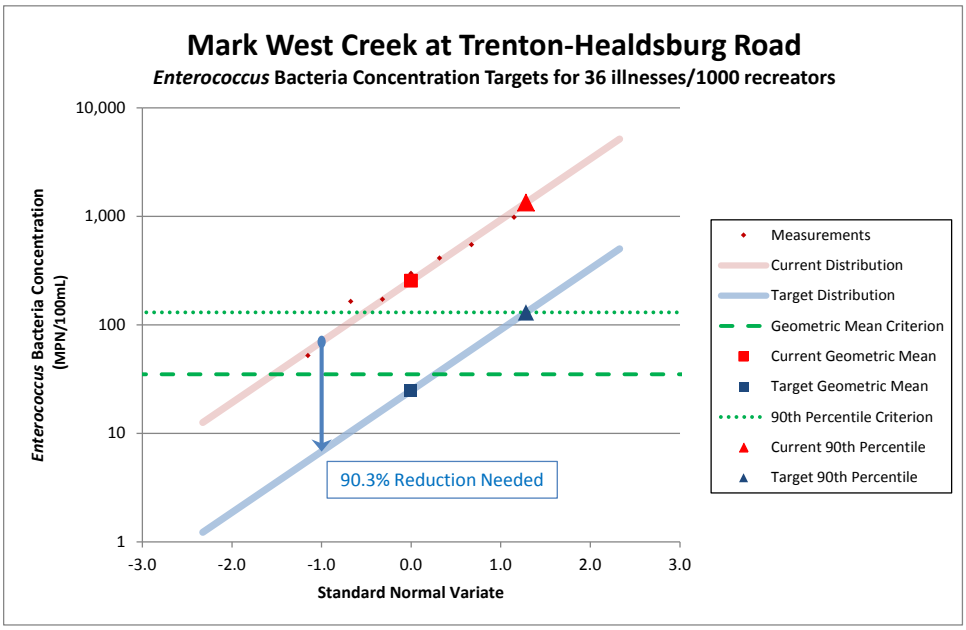

Figure 218. Comparison of *Enterococcus* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

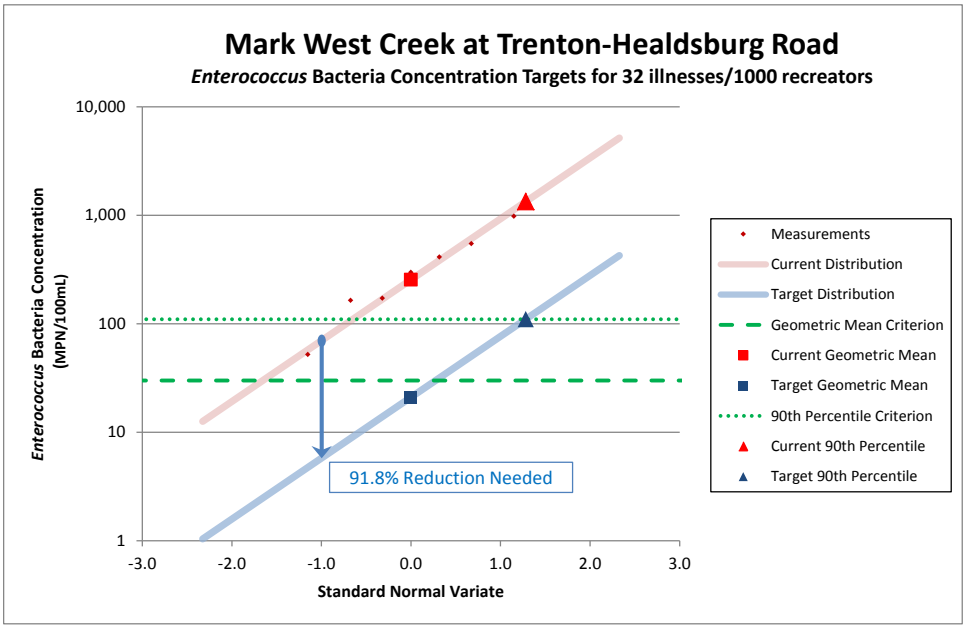

Figure 219. Comparison of *Enterococcus* bacteria concentration measurements collected at Trenton-Healdsburg Road in Mark West Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

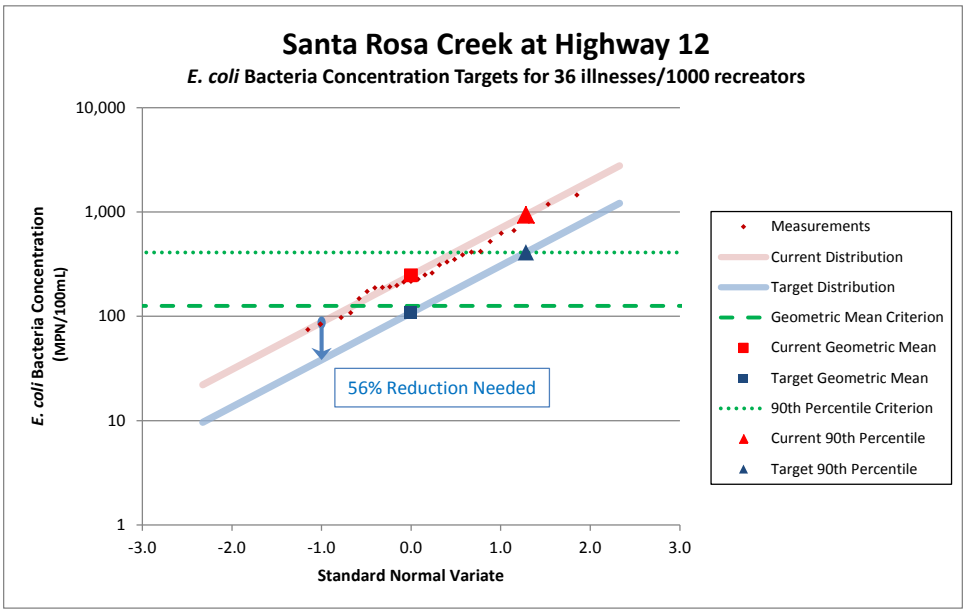

Figure 220. Comparison of *E. coli* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

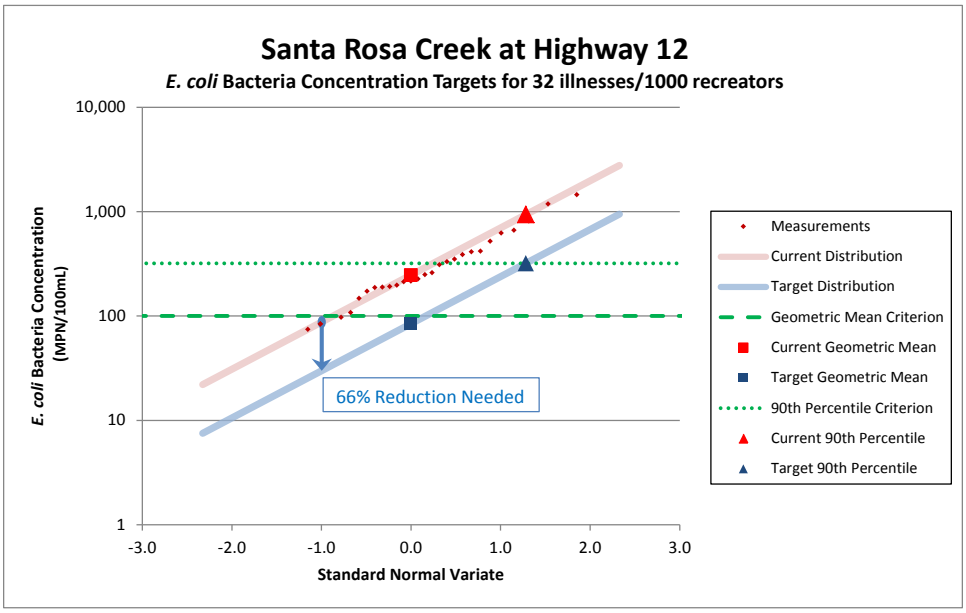

Figure 221. Comparison of *E. coli* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

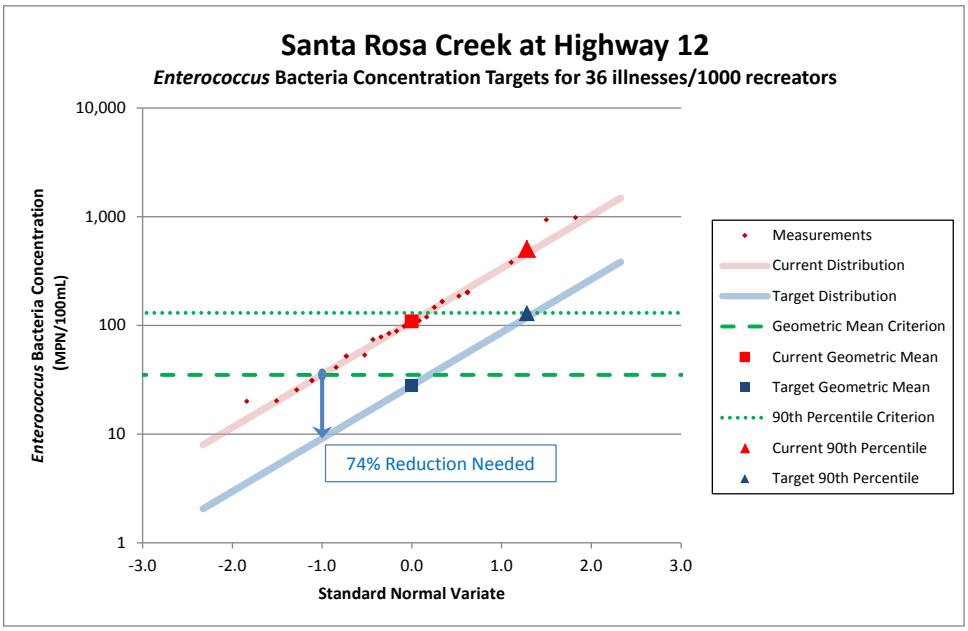

Figure 222. Comparison of *Enterococcus* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

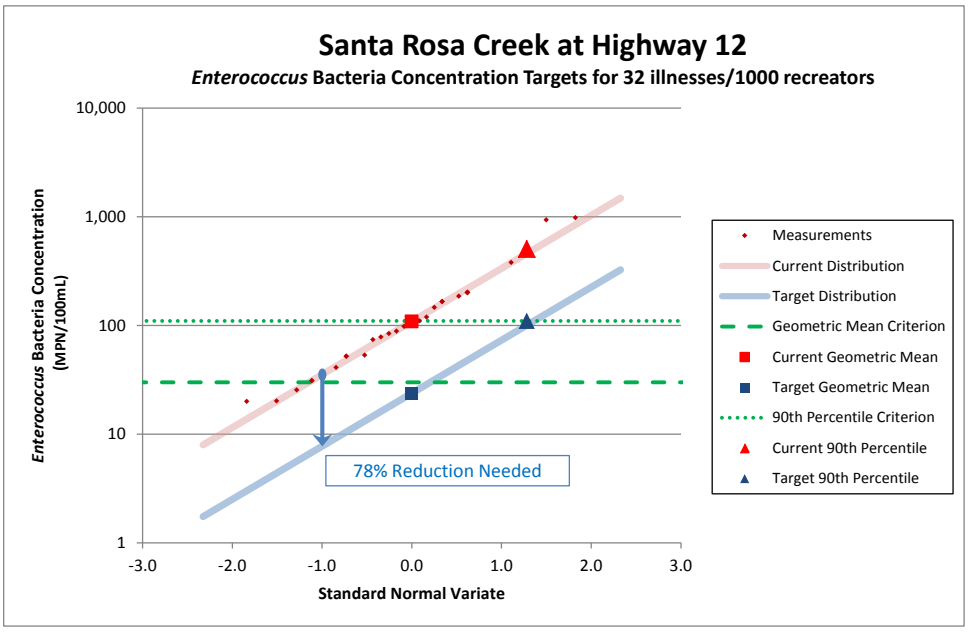

Figure 223. Comparison of *Enterococcus* bacteria concentration measurements collected at Highway 12 in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

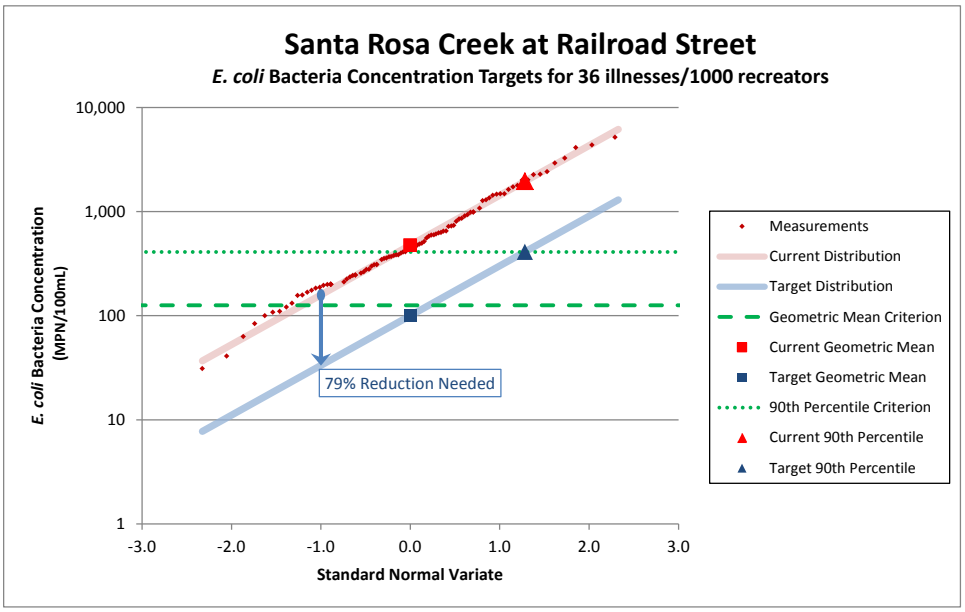

Figure 224. Comparison of *E. coli* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

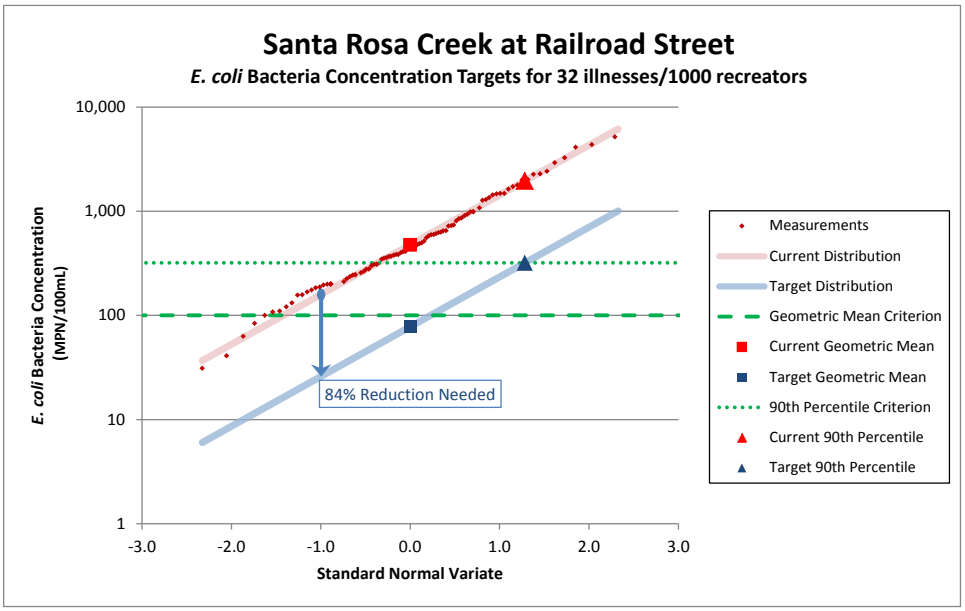

Figure 225. Comparison of *E. coli* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

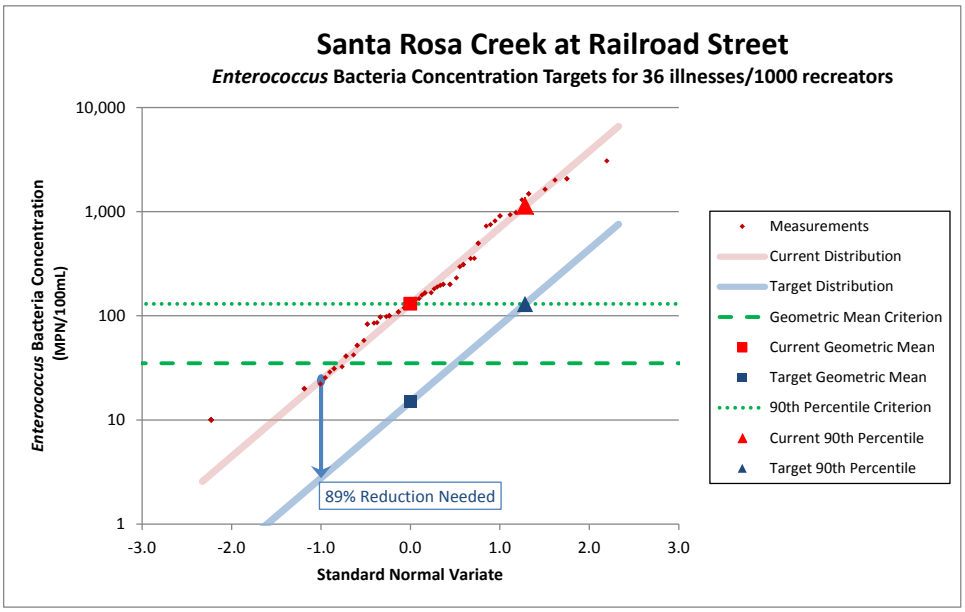

Figure 226. Comparison of *Enterococcus* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

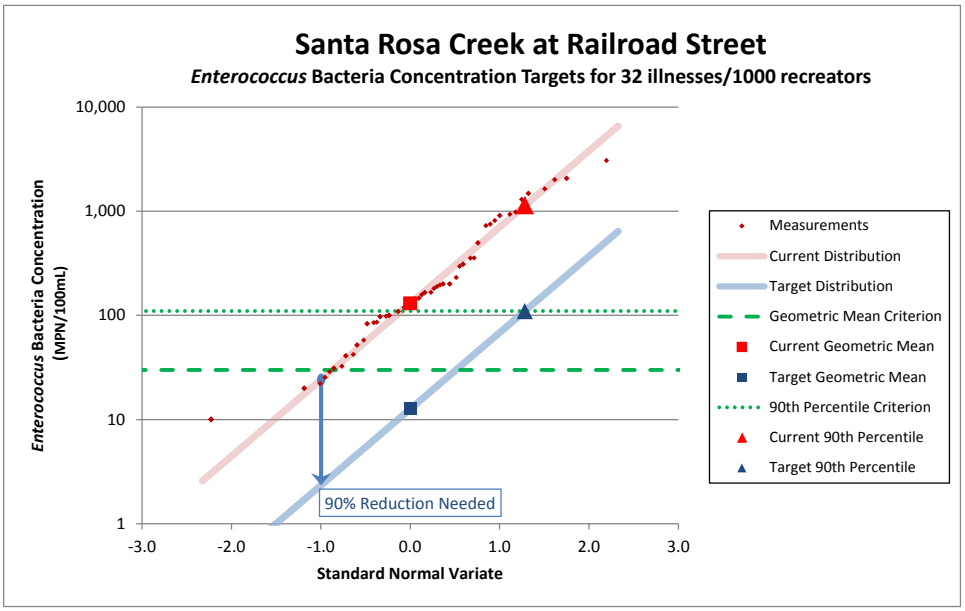

Figure 227. Comparison of *Enterococcus* bacteria concentration measurements collected at Railroad Street in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators

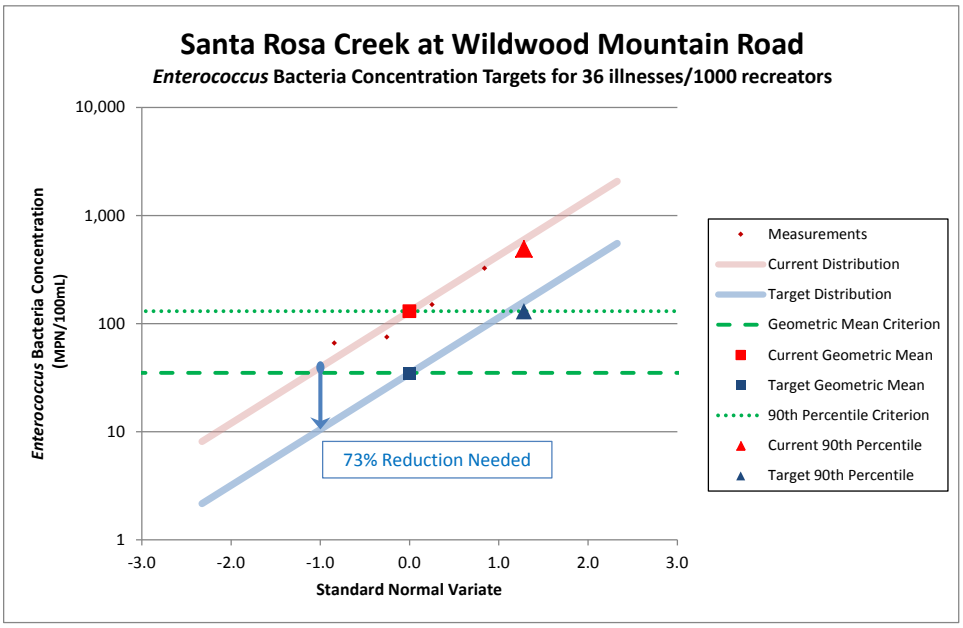

Figure 228. Comparison of *Enterococcus* bacteria concentration measurements collected at Wildwood Mountain Road in Santa Rosa Creek to concentration targets for estimated 36 illnesses per 1,000 recreators

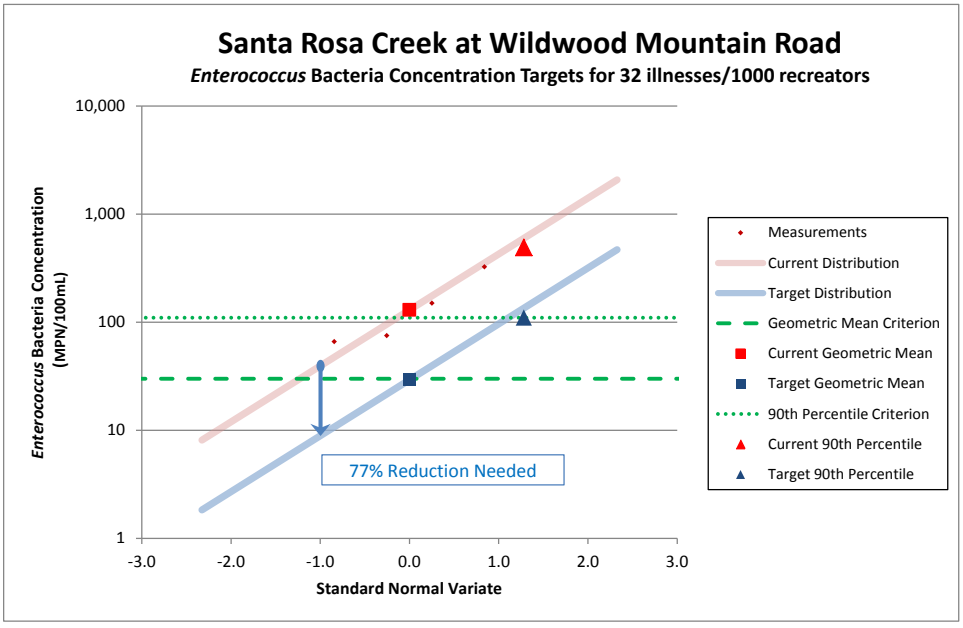

Figure 229. Comparison of *Enterococcus* bacteria concentration measurements collected at Wildwood Mountain Road in Santa Rosa Creek to concentration targets for estimated 32 illnesses per 1,000 recreators