Chapter 3
Bacteria

List of Figures

List of Tables

INTRODUCTION

The bacteria total maximum daily load (TMDL) for the Molalla-Pudding Subbasin has been developed within hydrologic units 1709000901 (Abiqua Creek/Pudding River), 1709000902 (Butte Creek/Pudding River), 1709000903 (Rock Creek/Pudding River), 1709000904 (Senecal/Mill Creek), 1709000905 (Upper Molalla River), and 1709000906 (Lower Molalla River), which collectively comprise the entire Molalla-Pudding Subbasin. The TMDL addresses segments of the following streams identified as water quality limited on the 303(d) list: Pudding River, Zollner Creek, Silver Creek, West Fork Little Pudding River, and the Molalla River. Required TMDL components from OAR 340-042-0040 are listed in Table 3- 1.

Table 3- 1: Molalla-Pudding Subbasin Bacteria TMDL Components.

Name & Location **OAR 340-042-0040(4)(a)**	Perennial and intermittent streams within the Molalla-Pudding Subbasin, Hydrologic Unit Codes (HUCs) 170900901, 170900902, 170900903, 170900904, 170900905, and 170900906.
Pollutant Identification **OAR 340-042-0040(4)(b)**	Pollutants: Human pathogens from various sources. *E. coli* is currently used as an indicator of human pathogens in Oregon's water quality standard and in this TMDL. Before 1996, fecal coliform bacteria were used as an indicator of human pathogens.
Water Quality Standards and Beneficial Uses **OAR 340-042-0040(4)(c)** **OAR 340-041-0009(1)(a)(A)** **OAR 340-041-0009(1)(a)(B)**	Water Quality Standards OAR 340, Division 41 provides numeric and narrative bacteria criteria: (1) Numeric Criteria: Organisms of the *E. coli* group commonly associated with fecal sources (MPN or equivalent membrane filtration using a representative number of samples) may not exceed the criteria described in subparagraph (a) of this paragraph: (a) Freshwaters and Estuarine Waters Other than Shellfish Growing Waters: (A) A 30-day log mean of 126 E. coli organisms per 100 ml, based on a minimum of five (5) samples; (B) No single sample shall exceed 406 E. coli organisms per 100 ml. Beneficial Uses Water contact recreation is the most sensitive beneficial use to bacteria pollution in the Molalla-Pudding Subbasin.
TMDL **Loading Capacity** **OAR 340-042-0040(4)(d)** **Excess Load** **OAR 340-042-0040(4)(e)** **Sources or Source Categories** **OAR 340-042-0040(4)(f)**	*Loading Capacity:* The loading capacity is expressed as a flow-based load of *E. coli* bacteria organisms per day that will correspond to a logarithmic mean of 126 *E. coli* organisms per 100 ml under all flow conditions, thereby protecting beneficial uses. Excess Load: The difference between the current pollutant load and the loading capacity of a waterbody. Excess load was calculated for five flow intervals across all flow conditions. Current pollutant load was estimated by the logarithmic mean of bacteria counts measured in all samples collected within a flow interval. Sources or Source Categories: There are multiple point and nonpoint sources during runoff and non-runoff events, including urban storm water discharge, wastewater treatment plant discharge, confined animal feeding operations (CAFOs), faulty septic systems, and agricultural run-off.
Wasteload Allocations **OAR 340-042-0040(4)(g)** **Load Alloacations OAR 340-042-0040(4)(h)** **Surrogate Measures** **OAR 340-042-0040(5)(b)**	*Wasteload Allocations (Point Sources)*: Wasteload allocations for wastewater treatment plants are expressed as loads of *E. coli* bacteria organisms per day equivalent to a concentration no more than the logarithmic mean criterion of the bacteria standard with no single sample exceeding 406 organisms/100 mL. Wasteload allocations for confined animal feeding operations (CAFOs) are zero (no discharge of bacteria allowed). *Load Allocations (Nonpoint Sources)*: Load allocations are expressed by a surrogate measure of percent reduction necessary to meet the numeric criteria (both the logarithmic mean and single sample criteria) and as a load of *E. coli* organisms per day equivalent to the difference between the loading capacity and the sum of the wasteload allocations and reserve capacity. The percent load reduction for the listed waterbodies ranges from 75 to 87% during summer months (June 1 – September 30) and 70 to 92% in fall-winter-spring months (October 1 – May 31). Load allocations applicable to municipal stormwater permits are expressed as a 86% percent reduction assigned to urban land use. *Surrogate Measure for Load Allocations* Load allocations are in terms of percent reduction needed to achieve both the logarithmic and single sample numeric criteria. This translates load allocations into more applicable measures of performance.
Margins of Safety **OAR 340-042-0040(4)(i)**	*Margins of Safety* are applied as conservative assumptions in the development and interpretation of the load duration curve. The margin of safety for this TMDL is implicit.
Seasonal Variation **OAR 340-042-0040(4)(j)**	In the Molalla-Pudding subbasin, violations of the bacteria criteria occur throughout the year and under all observed flow conditions. Individual reaches are water quality listed only for certain

	seasons: Pudding River, West Fork Little Pudding River, and Molalla River in fall/winter/spring; Silver Creek in summer, and Zollner Creek year-round. Wasteload allocations apply year-round. Load allocations, expressed by a surrogate measure of percent reductions apply year-round, but where sufficient data were available to distinguish season difference, seasonal percent reductions (June 1 – September 30 and October 1 – May 31) apply. This TMDL allows all listed waterbodies to meet water quality standards during all seasons.
Reserve Capacity OAR 340-042-0040(4)(k)	No reserve capacity is allotted at this time. Future point sources will be required to meet water quality criteria prior to discharge. Additional non point source contribution, such as from land development, may not cause total loading to exceed the loading capacity.
Water Quality Management Plan OAR 340-042-0040(4)(l)	The Water Quality Management Plan provides the framework of management strategies to attain and maintain water quality standards. The framework is designed to work with detailed plans and analyses provided in sector-specific or source-specific implementation plans.
Standards Attainment & Reasonable Assurance OAR 340-042-0040(4)(l) & (j)	Implementation of pollutant load reductions and limitations in the point source and non point source sectors will result in water quality standards attainment. Standards Attainment and Reasonable Assurance are addressed in the WQMP.

NAME AND LOCATION OF WATERBODIES LISTED FOR BACTERIA

The Pudding River (RM 0 to 35.4), Silver Creek (RM 0 – 5.9), Zollner Creek (0 to 7.8), and the West Fork of the Little Pudding River (RM 0 to 5.1) are listed on Oregon's 2004 303(d) List, which includes listings from previous years, for exceeding the bacteria water quality criteria (Table 3- 2 and Figure 3- 1). The Molalla River (RM 0 to 25) and Pudding River (RM 0 to 35.4) were listed on the 2002 303(d) list for bacteria violations in fall/winter/spring and summer, respectively, but were removed from the 2004/2006 303(d) list based on additional data collection. DEQ's data review for this TMDL found that bacteria violations could still occur during fall/winter/spring and summer on the Molalla and Pudding Rivers, respectively, so TMDLs were completed. Bacteria listings before 2002 were based on exceedance of the fecal coliform standard, the indicator of bacterial contamination DEQ used until 1996. In 1996, DEQ adopted a bacteria criteria based on the indicator species *Escherichia coli (E. coli)*.

Zollner Creek is listed year-round for bacteria standard violations. Silver Creek is listed only for the summer months (June – September). The West Fork Little Pudding bacteria 303(d) listing applies in the fall, winter, and spring months (October – May).

Table 3- 2: Molalla-Pudding Subbasin 1998, 2002, and 2004 303(d) Bacteria Listings.
A 1998 listing for Pudding River (River Mile 0 to 35.4) for fecal coliform in fall/winter/spring is not included because the 2004-06 listing for *E. coli* applies to the same reach and season.

Water Body	Listed River Mile	Parameter	Season	Criteria
Pudding River	0 to 35.4	E Coli	Fall/Winter/Spring	Log mean of 126 organisms per 100 ml, no single sample >406
Pudding River	0 to 35.4	Fecal coliform	Summer	Log mean of 200, No more than 10% > 400
Silver Creek	0 to 5.9	Fecal Coliform	Summer	Log mean of 200, No more than 10% > 400
West Fork Little Pudding River	0 to 5.1	E Coli	Fall/Winter/Spring	Log mean of 126 organisms per 100 ml, no single sample >406
Zollner Creek	0 to 7.8	Fecal Coliform	Fall/Winter/Spring	Log mean of 200, No more than 10% > 400
Zollner Creek	0 to 7.8	Fecal Coliform	Summer	Log mean of 200, No more than 10% > 400
Molalla River	0 to 25	Fecal Coliform	Fall/Winter/Spring	Log mean of 200, No more than 10% > 400

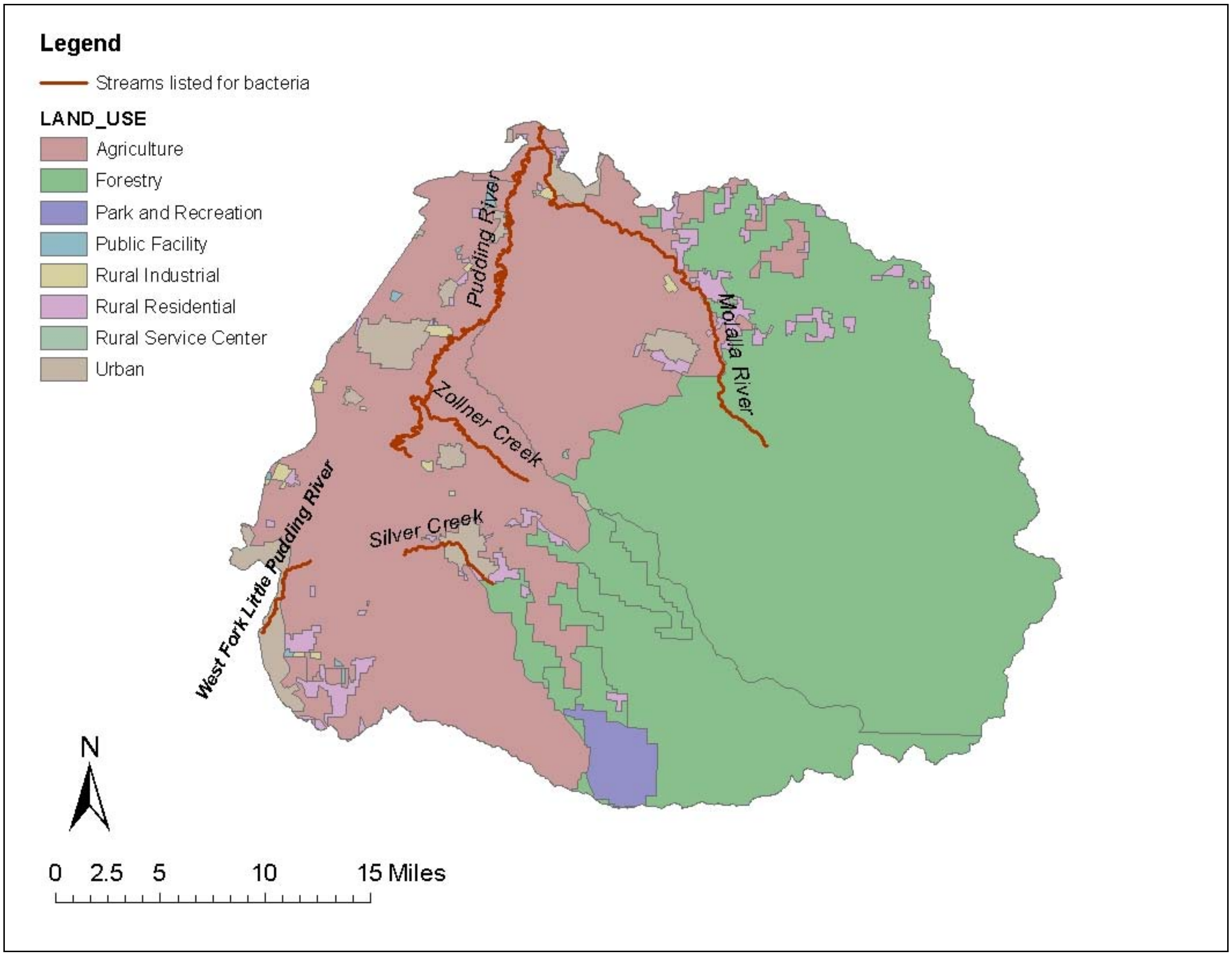

Figure 3- 1: Bacteria 303(d) Listed Streams and Major Land Use Types in the Molalla-Pudding Subbasin. Generalized zoning coverage originates with Oregon Dept. of Land Conservation and development. Coverage is from data collected from 1983 – 1986 and was digitized off 1:100,000 scale USGS maps.

POLLUTANT IDENTIFICATION

The pollutants addressed by this TMDL are the human pathogens indicated by the presence of *E. coli* bacteria. Before 1996, ODEQ used fecal coliform and enterococci as the bacteria indicator species to represent water quality pollution from pathogens. In 1996, Oregon adopted *E. coli*, a subset of fecal coliform, as the indicator species of bacteria pollution. For this bacteria TMDL, DEQ converted fecal coliform bacteria concentrations to equivalent *E. coli* concentrations so larger data sets would be available for statistical analysis (Cude, 2005).

WATER QUALITY STANDARDS AND BENEFICIAL USE IDENTIFICATION

Water contact recreation is the most sensitive beneficial use to bacterial contamination in the Molalla-Pudding subbasin. Untreated sewage, pet waste, wildlife waste, or livestock waste released into the water can expose swimmers and other recreational users to bacteria and their associated pathogens. Children, the elderly, and people with weakened immune systems are most likely to develop illnesses or infections after swimming in polluted water. The most common illness associated with swimming in water polluted by excessive bacteria is gastroenteritis. In highly polluted water, swimmers may occasionally be exposed to more serious diseases like dysentery, hepatitis, cholera, and typhoid fever. Most of these diseases are associated with ingestion of polluted water, although some illnesses can be transmitted through wounds exposed to water. This TMDL targets bacteria counts that are protective of the most sensitive beneficial use, water contact recreation.

This TMDL targets the *E. coli* criteria that DEQ adopted in January 1996. Because waterbodies were listed in the Molalla-Pudding Subbasin based on criteria effective before January 1996, Table 3- 3 also lists the bacteria criteria that applied before January 1996. These earlier listings based on other indicators are addressed in this TMDL with limitations of *E. coli* as the numeric objective.

Table 3- 3: Prior and current bacteria criteria applicable in the Molalla-Pudding Subbasin.

Beneficial Use	Bacteria Criteria
Water Contact Recreation	Prior to July 1995: • a log mean of 200 fecal coliform per 100 milliliters (ml) based on a minimum of 5 samples in a 30-day period with no more than 10% of the samples in the 30-day period exceeding 400 per 100 ml. July 1995 to January 1996: • a log mean of 33 enterococci per 100 ml based on no fewer than 5 samples collected in a period of 30 days • no single sample should exceed 61 enterococci per 100 ml. **Effective January 1996 to present: OAR 340-041-0009(1)(a)(A) & (B)** Freshwaters and Estuarine Waters other than shellfish growing waters: • a 30-day log mean of 126 *E. coli* organisms per 100 ml, based on a minimum of five samples; • no single sample may exceed 406 *E. coli* organisms per 100 ml.

LOADING CAPACITY

The 30-day log mean of 126 *E. coli* organisms per 100 milliliters criterion was used as the target concentration in this TMDL for determining the loading capacity for streams in the Molalla-Pudding subbasin This criterion most directly relates to illness rates[1] and potential adverse effects on the beneficial use of water contact recreation. The loading capacity of a stream can be calculated with Equation 1 or illustrated with a load duration curve. The technical basis for development of load duration curves is included in Appendix F, but generally, the load duration curve illustrates pollutant loading across a range of stream flows. Historical stream flow data is used to estimate the likelihood that a certain flow would be exceeded – the exceedance probability. For example, low flows have a high exceedance probability and high flows have a low exceedance probability. In Figure 3- 2 through Figure 3- 5, the loading capacity is represented by the log mean 126 criterion curve. Figure 3- 2 through Figure 3- 5 illustrate the loading capacity for each of the four streams listed in the Molalla-Pudding basin for which sufficient data were available to develop load duration curves. DEQ assumes the loading capacity for West Fork Little Pudding River, which did not have sufficient data available to construct a load duration curve, would be similar to Zollner Creek based on having a similar drainage area.

Table 3- 4 lists the flow based loading capacity for each of the four listed streams. The loading capacity was calculated for each of the five flow intervals in Table 3- 4 by Equation 1. With one exception, loading capacity was calculated for each flow interval using the lowest flow rate (highest exceedance probability) in the interval to allow for the most conservative estimate of loading capacity. For example, the loading capacity for the flow range of 40 to 60% exceedance probability was calculated based on stream flow at

[1] From Implementation Guidance for Ambient Water Quality Criteria for Bacteria (USEPA, EPA-823-B-02-003, May 2002 Draft, pg 7):

“For the purpose of analysis, the data collected at each of these sites were grouped into one paired data point consisting of an averaged illness rate and a geometric mean of the observed water quality. These data points were plotted to determine the relationships between illness rates and average water quality (expressed as a geometric mean). The resulting linear regression equations were used to calculate recommended geometric mean values at specific levels of protection (e.g., 8 illnesses per thousand). Using a generalized standard deviation of the data collected to develop the relationships and assuming a log normal distribution, various percentiles of the upper ranges of these distributions were calculated and presented as single sample maximum values.

USEPA recognizes that the single sample maximum values in the 1986 criteria document are described as “upper confidence levels,” however, the statistical equations used to calculate these values were those used to calculate percentile values. While the resultant maximum values would more appropriately be called 75th percentile values, 82nd percentile values, etc., this document will continue to use the historical term “confidence levels” to describe these values to avoid confusion.”

60% exceedance probability. For the lowest flow interval, an exceedance probability of 99%, instead of 100%, was used to calculate the loading capacity.

The loading capacity of any stream for which a load duration curve was not constructed would be the load at a particular stream flow that would result in a logarithmic average of sample bacteria concentrations equal to 126 *E. coli* bacteria counts/100 mL. In this way, a loading capacity applies to all the water bodies in the Molalla-Pudding subbasin. Application of the loading capacity at the subbasin scale protects water contact recreation throughout the Molalla-Pudding Subbasin.

$$LoadingCapacity(\frac{organisms}{day}) = 126\frac{organisms}{100mL} * Q\frac{ft^3}{s} * 283.2\frac{100mL}{ft^3} * 86400\frac{s}{day}$$ Equation 1

Table 3- 4: Flow based loading capacity for bacteria listed streams in the Molalla Pudding Subbasin.

Stream	**Highest Flows** 0 - 10% Exceedance Probability (*E. coli* counts/day)	**High Flows** 10 - 40% Exceedance Probability (*E. coli* counts/day)	**Transitional Flows** 40 - 60% Exceedance Probability (*E. coli* counts/day)	**Low Flows** 60 – 90% Exceedance Probability (*E. coli* counts/day)	**Lowest Flows** 90 - 100% Exceedance Probability (*E. coli* counts/day)
Pudding River	1.0783×10^{13}	2.8898×10^{12}	1.1738×10^{12}	1.5096×10^{11}	3.3889×10^{10}
Zollner Creek	1.9717×10^{11}	2.4339×10^{10}	7.3940×10^{9}	1.0167×10^{9}	1.8485×10^{8}
Silver Creek	1.3683×10^{12}	4.8986×10^{11}	2.4261×10^{11}	5.8536×10^{10}	1.6329×10^{10}
Molalla River	8.2875×10^{12}	2.8652×10^{12}	1.2601×10^{12}	2.3723×10^{11}	1.2940×10^{11}

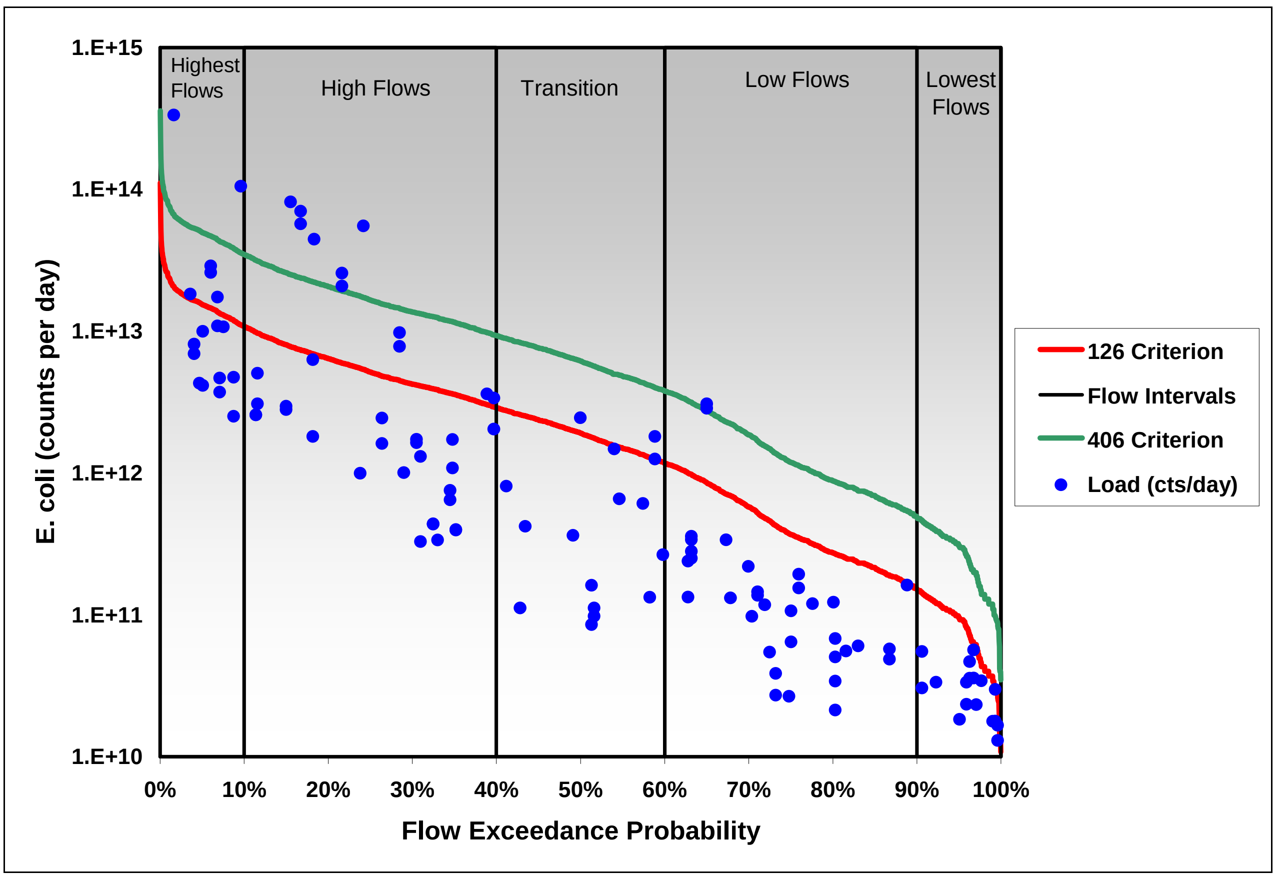

Figure 3- 2: Load duration curve for Pudding River at Highway 99E, river mile 7.3.
Samples shown collected between 1973 and 2006. USGS Gage Pudding River at Aurora.

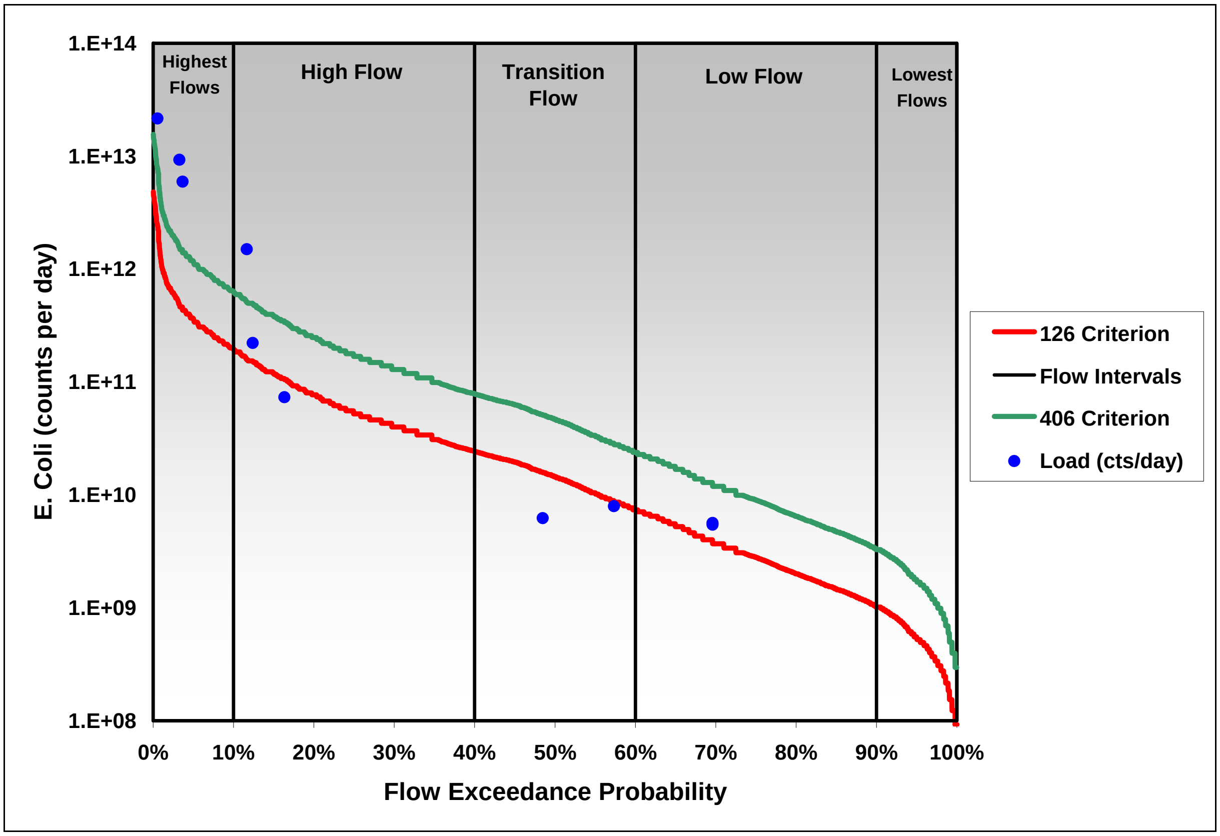

Figure 3- 3: Load duration curve for Zollner Creek at Monitor McKee Road. Samples shown collected between 2004 and 2006. USGS Gage Zollner Creek near Mt. Angel.

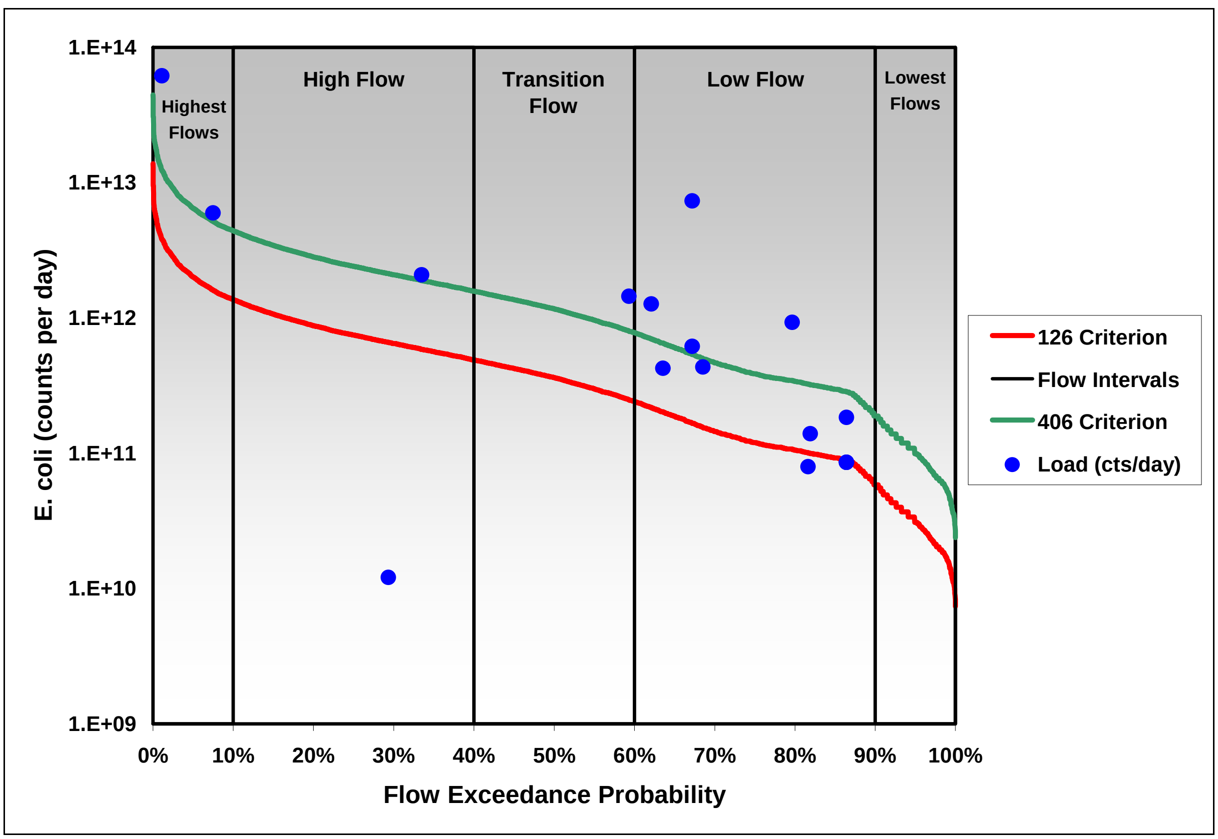

Figure 3- 4: Load duration curve for Silver Creek at Brush Creek Road.
Samples shown collected between 1969 – 1993. USGS gage Silver Creek at Silverton.

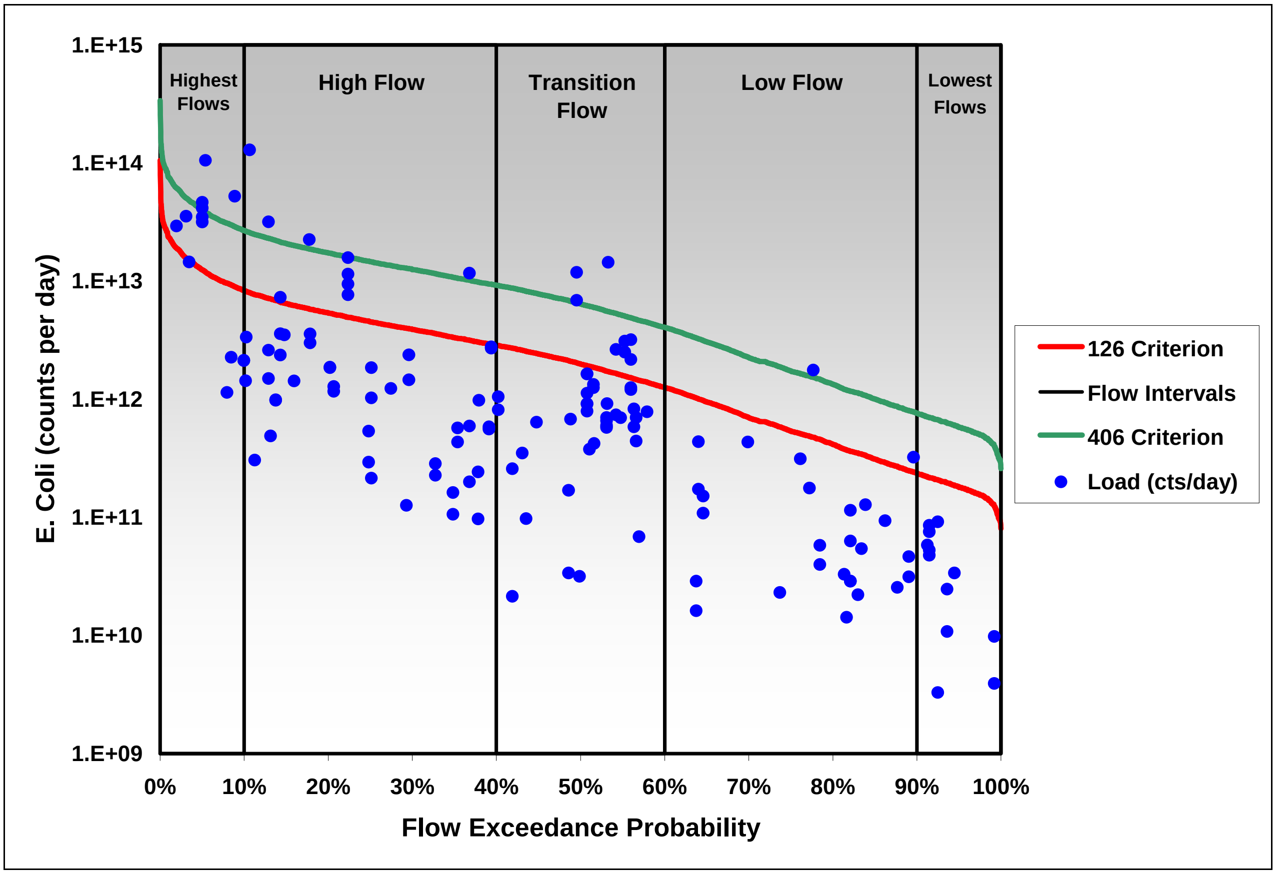

Figure 3- 5: Load duration curve for Molalla River at Knights Bridge Road.
Samples shown collected between 1968 – 2006. USGS gage Molalla River near Canby.

EXCESS LOAD

Excess load is the difference between the current pollutant load to a waterbody and the loading capacity of that waterbody. Load capacity for all streams in the Molalla-Pudding subbasin, previously presented, was calculated based on attainment of the 126 log mean criterion across all flow regimes.

To estimate current pollutant load, sample data was thinned to samples collected after January 1, 1989. Samples collected in the subbasin before 1989 were collected in the late 1960s and early 1970s and may not represent effects from current land use, wastewater treatment, and population. For four sites with sufficient data to construct load duration curves, current pollutant load was then estimated by calculating the 75th percentile of the load within each flow interval. Representing current pollutant load by the 75th percentile of loads in a flow interval is a more conservative estimate than using the log mean. The difference between the loading capacity and the estimated current pollutant load is an explicit excess load. Table 3.5 and Table 3- 6 present the current pollutant load and excess load in each of the four listed streams for which load duration curves were developed.

Additionally, excess load across the subbasin can be represented by the percent reduction necessary to meet water quality standards, both the log mean criterion and the single sample criterion. DEQ used a surrogate measure (i.e. percent reduction), explained in the load allocations section of this chapter, as a more practical expression of load allocations. The bacteria load equivalent to the percent reduction that substitutes for a load allocation is an implicit excess load. At present, there is no indication that point source discharges are violating the terms of their NPDES permits (refer to Existing Sources section), which would result in a contribution to excess load.

Table 3- 5: Current Load for bacteria listed streams in Molalla-Pudding Subbasin.
Based on the 75th percentile of data collected after January 1, 1989.

Stream	**Highest Flows** 0 - 10% Exceedance Probability (*E. coli* counts/day)	**High Flows** 10 - 40% Exceedance Probability (*E. coli* counts/day)	**Transitional Flows** 40 - 60% Exceedance Probability (*E. coli* counts/day)	**Low Flows** 60 – 90% Exceedance Probability (*E. coli* counts/day)	**Lowest Flows** 90 - 100% Exceedance Probability (*E. coli* counts/day)
Pudding River	1.5772×10^{13}	5.9845×10^{12}	9.1868×10^{11}	2.1930×10^{11}	3.5683×10^{10}
Zollner Creek	1.5419×10^{13}	8.6090×10^{11}	7.5151×10^{9}	5.5895×10^{9}	
Silver Creek	1.2111×10^{10}		1.4467×10^{12}	4.3161×10^{11}	
Molalla River	4.2673×10^{13}	2.8311×10^{12}	1.2538×10^{12}	1.2100×10^{11}	6.3957×10^{10}

Table 3- 6: Excess Load for bacteria listed streams in the Molalla-Pudding Subbasin.
NA = not applicable, no excess load based on available data.

Stream	**Highest Flows** 0 - 10% Exceedance Probability (*E. coli* counts/day)	**High Flows** 10 - 40% Exceedance Probability (*E. coli* counts/day)	**Transitional Flows** 40 - 60% Exceedance Probability (*E. coli* counts/day)	**Low Flows** 60 – 90% Exceedance Probability (*E. coli* counts/day)	**Lowest Flows** 90 - 100% Exceedance Probability (*E. coli* counts/day)
Pudding River	4.9888×10^{12}	3.0947×10^{12}	NA	6.8341×10^{10}	1.7937×10^{9}
Zollner Creek	1.5222×10^{13}	8.3656×10^{11}	1.2108×10^{8}	4.5728×10^{9}	
Silver Creek	NA		1.2041×10^{12}	3.7307×10^{11}	
Molalla River	3.4385×10^{13}	NA	NA	NA	NA

SEASONAL VARIATION

DEQ prepared wasteload allocations and load allocations that are protective year-round based on analysis of seasonal variation in instream bacteria concentrations. While bacteria listings are distinguished only as summer (June 1 to September 30) or fall-winter-spring (October 1 to May 31), DEQ reviewed bacteria concentrations and their relationship to stream flow quantity and precipitation, as well as season.

Wasteload allocations and load allocations are described in detail in those sections of this chapter. Wasteload allocations to point sources apply year-round, even in streams listed for bacteria only in the summer season, because wasteload allocations are the equivalent of the concentration limits in discharge permits. DEQ used a surrogate measure for load allocations, percent reduction in bacteria load, explained in the load allocations section of this chapter. Load allocations for particular compliance points apply June 1 – September 30 or October 1 – May 31, with higher percent reductions usually required October 1 – May 31. If sufficient bacteria or stream flow data were not available to distinguish seasonal differences, DEQ applied year-round load allocations by land use.

OBSERVATIONS FROM SEASONAL ANALYSIS

Several techniques were used to evaluate relationships among bacteria concentrations, season, stream flow, and precipitation. Those analyses are included in Appendix G. In the following summary, “winter” generally means between October 1 and May 31. “Summer” means June 1 – September 30. The observations from the seasonal analysis are:

- Criteria exceedances on the mainstem Pudding River are more common and larger in the winter months, corresponding with higher stream flows and precipitation. Still, criteria exceedances occur across a range of stream flow conditions, including the summer months of June – September and under dry conditions (defined as less than 0.15 in. precipitation in previous 24 hours). Refer to Figures G-2 though G-6, and G-16.

- Differences among quarterly medians of bacteria concentrations measured at a site decreases with distance upstream on the Pudding River. Refer to Figures G-4 – G-6.

- In the lower Pudding River, data collected in the first quarter (January – March) have the greatest median concentration (Figure G-4). In the middle Pudding River (river mile 21), data collected in the third quarter (July – September) have the greatest median concentration (Figure G-5).

- The summer variability of bacteria concentrations (as measured by the interquartile range) is similar among sites with larger data sets on the Pudding River, those located between river miles 26 and 5 (Figures G-1 through G-3).

- Bacteria concentrations measured in Zollner Creek do not differ with season as much as do concentrations in the mainstem Pudding River. Consistent criteria exceedances occur throughout the year, across all flow conditions, and under both wet and dry conditions (Figures G-7, G-19, and G-20).

- Third (July – September) and fourth quarter (October – December) median concentrations of data collected in Silver Creek are similar. Too few samples have been collected between October and May on Silver Creek to evaluate differences in between summer and winter concentrations (Figures G-8 and G-21).

- More frequent and greater magnitude exceedances occur in the winter months, with higher stream flows and precipitation, at sites on the Molalla River (Figures G-11 and G-23). The greatest median concentration in a data set from a site on the lower Molalla River occurs in the first quarter, January – March (Figure G-13). Bacteria concentrations in most samples collected at the same site under low flow and dry conditions are well below the log mean criteria (Figure G-23).

EXISTING DATA REVIEW

This section presents a summary of the data used in the bacteria TMDL analyses. The data summary is intended characterize the data sets, in particular showing the magnitude and quantity of bacteria criteria exceedances at particular sites. For this overview, DEQ reviewed all data available, including data collected up to 30 years ago. Figure 3- 6 indicates the location of sites for which bacteria data were available for analysis in addition to general land use surrounding the sample sites. Data identified as “summer” were collected between June 1 and September 30. Data identified as “winter” or “fall/winter/spring” were collected between October 1 and May 31.

For comparison to the bacteria criteria, DEQ calculated a logarithmic mean (log mean) of the data at several sites located on the Pudding and Molalla Rivers and Zollner and Silver Creeks. The log mean is the arithmetic mean of the base 10 logarithms of each sample result in the data set. A log mean is a measure of central tendency useful in summarizing highly skewed data, such as bacteria concentrations. The log mean numeric bacteria criterion is based on the concentrations measured in five samples collected within a 30-day period. While the samples reviewed in the following section were not necessarily collected within a 30 day time period, the log mean of a data set is still a useful approximation of deviation from the 30-day log mean criterion of 126 counts/100 mL. One exceedance of the 406 counts/100 mL bacteria criterion constitutes a violation, though water quality listing is generally decided by at least 10% of samples exceeding the 406 count/100 mL criterion. Bold faced numbers in the summary tables in this section indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion. In the tables in this section units are counts of *E. coli* per 100 mL, with fecal coliform counts converted to *E. coli* equivalents via Cude, 2005.

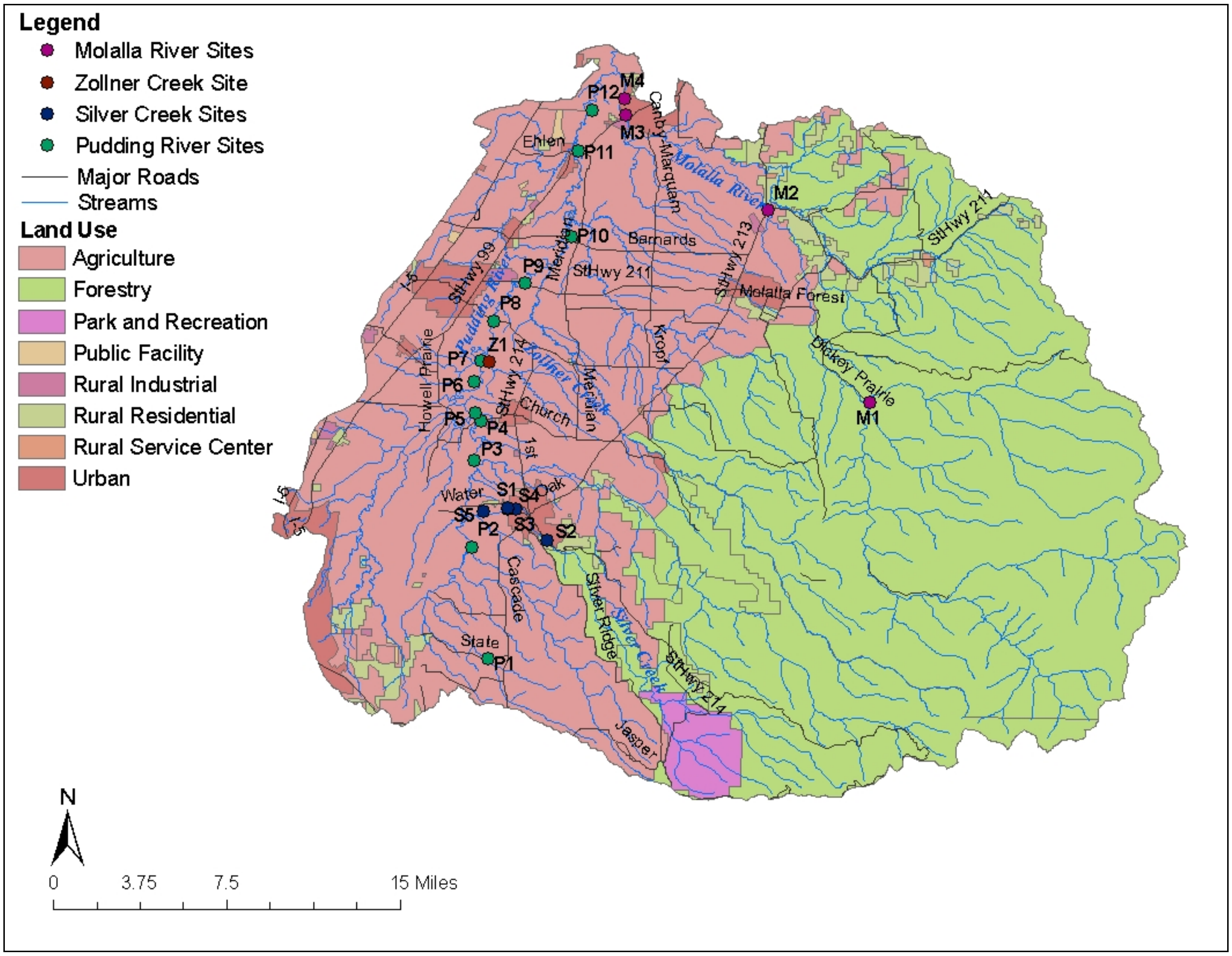

Figure 3- 6: Bacteria sample locations and general land use in the Molalla-Pudding subbasin.

Pudding River, including Zollner and Silver Creeks

The Pudding River was listed as water quality limited on the 1998 303(d) list based on fecal coliform bacteria in the fall/winter/spring exceeding the criteria. More than 20% of fall/winter/spring samples exceeded the fecal coliform standard of 400 organisms per 100 mL. At that time, the Pudding River was also listed for fecal coliform violations during the summer season from its mouth to river mile 35.4. In 2004, the listing was updated to reflect the change in the bacteria criteria as well as additional data collection. On the 2004 list, the Pudding River was listed for *E. coli* violations only during the fall/winter/spring season with more than 10% of samples exceeding the 406 organisms criterion. Additional data collection showed that the Pudding River met bacteria criteria, both log mean and discrete sample, during the summer season. However, DEQ's data review for this TMDL indicated bacteria violations may still occur during summer months at some locations on the Pudding River, and for that reason, a TMDL was completed for the Pudding River for both summer and fall/winter/spring seasons.

Table 3- 7 summarizes basic statistics of the year-round data sets from several Pudding River sampling locations indicated in Figure 3- 6. The statistics are calculated from DEQ data collected between 1969 and 2006, with approximately 60% of the data collected before 1996. The log mean of data collected from four sites exceeds the log mean criterion of 126 counts/100 mL (bold font numbers the following tables). The concentrations measured at those four sites, as well as two others, exceed the 406 counts/100 mL criterion more than 10% of the time.

Table 3- 8 and Table 3 – 9 summarize Pudding River bacteria data from summer and winter seasons, respectively. Relatively few exceedances of the 406 counts/100 mL criterion occur in the summer months, though exceedances of the 126 counts/100 mL criterion have been recorded in summer months. The log mean of data measured at the lowest site on the river with a large summer data set (Pudding River at Hwy.

99E) does not exceed the 126 counts/100 mL or 406 counts/100 mL criterion in the summer. Criteria exceedances are more common and larger in the winter months, with data measured at most sites exceeding the 406 counts/100 mL criterion more than 10% of the time.

Table 3- 7: Summary of year-round bacteria data collected from Pudding River sites.
Units are counts of *E. coli* per 100 mL. n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	Site # in Fig. 3.6	n	Log mean	Median	75th Quartile	90th Quantile	% > 406	Data Period
58	Pudding R. at Doefler Rd.	P1	3	83	41	345	345	0	1969 - 1973
51	Pudding R. d/s Drift Cr.	P2	8	**182**	128	605	921	**38**	2004 - 2006
44	Pudding R. at Nusom Rd.	P3	4	115	131	177	177	0	1989
41	Pudding R. at Saratoga Rd.	P4	9	105	120	177	272	0	2004 - 2006
37.6	Pudding R. at Mt. Angel-Brooks Rd.	P5	8	**211**	173	437	2033	**25**	1969 - 1987
31.6	Pudding R. at Dominic Rd.	P6	5	49	65	75	85	0	1989
30.2	Pudding R. at Monitor-Mckee Rd.	P7	3	**163**	889	889	889	**67**	1989
25.5	Pudding R. at Hwy. 214	P8	44	121	127	353	889	**18**	1969 - 1994
21	Pudding R. at Hwy. 211	P9	186	82	65	177	543	**14**	1969 - 2006
16.4	Pudding R. at Bernard Rd.	P10	42	120	130	264	353	7	1989 - 1997
7.3	Pudding R. at Hwy. 99E	P11	249	61	50	132	353	9	1973 - 2006
4.4	Pudding R. at Arndt Rd.	P12	20	**326**	345	468	5207	**35**	1969- 1975

Table 3- 8: Summary of summer (June 1 – September 30) bacteria data collected from Pudding River sites.
Units are counts of *E. coli* per 100 mL. n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	n	Log mean	Median	75th Quartile	90th Quantile	% > 406
37.6	Pudding R. at Mt. Angel-Brooks Rd.	4	**128**	142	303	345	0
31.6	Pudding R. at Dominic Rd.	3	41	29	85	85	0
30.2	Pudding R. at Monitor-Mckee Rd.	3	**163**	889	889	889	**67**
25.5	Pudding R. at Hwy. 214	17	107	77	349	565	**12**
21	Pudding R. at Hwy. 211	58	86	66	177	353	7
16.4	Pudding R. at Bernard Rd.	14	**131**	177	185	308	0
7.3	Pudding R. at Hwy. 99E	91	38	31	66	123	0
4.4	Pudding R. at Arndt Rd.	8	**142**	261	345	345	0

Table 3- 9: Summary of winter (October 1 – May 31) bacteria data collected from Pudding River sites.
Units are counts of *E. coli* per 100 mL.   n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	n	Log mean	Median	75th Quartile	90th Quantile	% > 406
58	Pudding R. at Doefler Rd.	3	83	41	345	345	0
51	Pudding R. d/s Drift Cr.	8	**182**	128	605	921	**38**
41	Pudding R. at Saratoga Rd.	9	105	120	177	272	0
37.6	Pudding R. at Mt. Angel-Brooks Rd.	4	**349**	318	1642	2033	**50**
25.5	Pudding R. at Hwy. 214	27	**131**	177	385	889	**22**
21	Pudding R. at Hwy. 211	128	81	65	179	614	**17**
16.4	Pudding R. at Bernard Rd.	28	114	108	353	465	**11**
7.3	Pudding R. at Hwy. 99E	158	80	54	231	737	**14**
4.4	Pudding R. at Arndt Rd.	12	**568**	468	1646	6094	**58**

Zollner Creek

Zollner Creek is listed year-round based on the fecal coliform standard in effect at the time of listing and year-round statistics are summarized in Table 3- 10. Fifty percent of summer samples and more than 80% of winter samples exceed either the log mean 126 *E. coli* criterion or the single sample 406 *E. coli* criterion. Exceedances of the 406 counts/100 mL criterion occur more frequently in the winter months, as do the greatest absolute concentrations.

Table 3- 10: Summary of Zollner Creek bacteria data.
Units are counts of *E. coli* per 100 mL.   n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

Station	Number Observations	Log mean	Median	75th Quartile	90th Quantile	%>406	Data Period
Zollner Creek at Monitor-McKee Rd. (year-round)	54	**429**	577	889	1323	**52**	1989 - 2006
Zollner Creek at Monitor-McKee Rd. (summer)	16	**299**	264	353	1323	**19**	1989 - 2006
Zollner Creek at Monitor-McKee Rd. (winter)	38	**500**	889	889	1323	**66**	1989 - 2006

Silver Creek

Silver Creek is listed for summer months based on the fecal coliform standard in effect at the time of listing. More than 30% of samples exceed one of the current numeric *E.coli* criteria, the log mean or single sample criteria. DEQ also made use of data collected by the Marion SWCD between 2002 and 2006. Table 3 – 11 through Table 3- 13 summarize those combined data. Though all sample sets are small, samples collected upstream of the city of Silverton indicate few criteria exceedances. Dilution from the wastewater treatment plant discharge (dry weather design flow is 3.5 million gallons/day) may influence the bacteria concentrations in Silver Creek – the 75th and 90th percentiles of the few samples collected downstream of the treatment plant indicate lower bacteria concentrations that those collected upstream by differences exceeding 0.5 logarithm (base 10).

The greatest bacteria counts, in all seasons, were measured at the site furthest downstream, at Brush Creek Rd.. This sampling site is located upstream of Brush Creek, which accepts discharge from Oregon Garden wetlands that treat a portion of the Silverton WWTP discharge. The Marion SWCD collected 22 samples from Brush Creek between 2002 and 2006. The median *E. coli* count from analysis of those samples ranges from 53 to 59, depending on how the data is grouped seasonally. Four exceedances of the 126 counts/100 mL occurred, all except one in October (280 – 1990 counts/100 mL) and one in June (306 counts/100 mL).

Table 3- 11: Summary of year-round bacteria data collected by DEQ and Marion SWCD at Silver Creek sites.
Units are counts of *E. coli* per 100 mL. n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	Site # in Fig. 3.6	n	Log mean	Median	75th Quartile	90th Quantile	% > 406	Data Period
5.2	Silver Cr. at 1336 S water St.	S1	7	27	29	58	79	0	2003 - 2004
5.1	Silver Cr. Upstream Silverton	S2	5	49	41	105	169	0	1969 – 1973, 1992
2.95	Silver Cr. 100 ft. u/s STP outfall	S3	14	**193**	181	698	1323	**36**	1992 - 2004
2.9	Silver Cr. 100 ft. d/s STP outfall	S4	14	**133**	170	192	846	7	1992 - 2006
1.3	Silver Cr. at Brush Cr. Rd.	S5	17	**289**	345	736	2738	**41**	1969 - 1993

Table 3- 12: Summary of Silver Creek summer (June 1 – September 30) bacteria data collected by DEQ and Marion SWCD.
Units are counts of *E. coli* per 100 mL. n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	n	Log mean	Median	75th Quartile	90th Quantile	% > 406
5.2	Silver Cr. at 1336 S water St.	7	27	29	58	79	0
2.95	Silver Cr. 100 ft. u/s STP outfall	10	**210**	181	644	1323	**30**
2.9	Silver Cr. 100 ft. d/s STP outfall	10	**156**	174	192	1211	10
1.3	Silver Cr. at Brush Cr. Rd.	10	**379**	264	774	5092	**40**

Table 3- 13: Summary of Silver Creek winter (October 1 – May 31) bacteria data collected by DEQ and Marion SWCD.
Units are counts of *E. coli* per 100 mL n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	n	Log mean	Median	75th Quartile	90th Quantile	% > 406
2.95	Silver Cr. 100 ft. u/s STP outfall	4	**158**	263	1115	1323	**50**
2.9	Silver Cr. 100 ft. d/s STP outfall	4	91	116	320	370	0
1.3	Silver Cr. at Brush Cr. Rd.	7	**195**	353	468	2033	**43**

West Fork Little Pudding River

The West Fork of the Little Pudding River was also listed in 2004 based on a 20% exceedance of the 406 E. coli standard (City of Salem data). DEQ did not include a site on the West Fork of the Little Pudding River in its TMDL development survey (the stream was listed after field work for the TMDL was completed), but includes this stream in the allocations section of this TMDL.

Molalla River
The Molalla River was included on the 1998 303(d) list for fall-winter-spring violation of the fecal coliform standard, and was kept on the 2002 list. Additional data collection completed before the 2004/2006 303(d) list release indicated that the Molalla River did not violate the current *E. coli* criteria. DEQ analyzed the Molalla River bacteria data, and completed a TMDL for three reasons:

- Past bacteria concentrations measured during high flow seasons (maximum 1,100 counts/100 mL fecal coliform) suggested sporadic but significant criteria exceedances are possible.
- The resulting bacteria reduction targets could be used in planning for growth and development in the watershed.
- A new point source with potential to contribute bacteria, the Molalla Wastewater Treatment Plant, began discharging to the Molalla River in January 2007.

DEQ reviewed seasonal patterns at the three sites with the largest data sets. The Molalla River at Knights Bridge Road site (river mile 2.8) has been the DEQ ambient sampling station since 1991. Since 1969, this site, as well at the Molalla River at Canby site (Highway 99E, river mile 3.8) have been sampled at least several times per year. Fewer sample results (<10 collected between 1979 and 2001) were available from a site several miles upstream, Molalla River at Highway 213 (river mile 24). Table 3- 14 through Table 3 – 16 summarize the year-round, winter, and summer data, respectively, collected from the Molalla River sites. DEQ also included in Table 3- 14 statistics from four samples collected between December 2004 and June 2005 from a site generally reflecting only forestry land use, Molalla River upstream of the North Fork Molalla River (river mile 25). The data summaries indicate more frequent and greater magnitude violations in the winter months (October – May). DEQ has recorded few bacteria violations on the Molalla River in the summer months.

Table 3- 14: Summary of year-round bacteria data collected by DEQ at Molalla River sites.
Units are counts of E. coli per 100 mL. n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	Site # in Figure 3.6	n	Log mean	Median	75th Quartile	90th Quantile	% >406	Data Period
25	Molalla River u/s N. Fk. Molalla River	M1	4	9	17	19	19	0	2004 - 2005
24.1	Molalla River at Highway 213	M2	11	43	41	**133**	**348**	0	2004 - 2006
3.8	Molalla River at Canby (Highway 99E)	M3	81	34	29	65	**177**	1	1979 - 1991
2.8	Molalla River at Knights Bridge Rd.	M4	155	37	37	77	**313**	8	1968 - 2006

Table 3- 15: Summary of winter (October 1 – May 31) bacteria data collected by DEQ at Molalla River sites.
Units are counts of *E. coli* per 100 mL. n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	n	Log mean	Median	75th Quartile	90th Quantile	% > 406
24.1	Molalla River at Highway 213	9	49	57	**163**	**387**	0
3.8	Molalla River at Canby (Highway 99E)	46	43	29	**177**	**336**	2
2.8	Molalla River at Knights Bridge Rd.	102	35	31	78	**424**	**11**

Table 3- 16: Summary of summer (June 1 – September 30) bacteria data collected by DEQ at Molalla River sites. Units are counts of *E. coli* per 100 mL. n = number of samples. For comparison purposes only, bold faced numbers indicate an exceedance of either the log mean criterion or that more than 10% of samples exceed the discrete sample criterion.

River Mile	Site	n	Log mean	Median	75th Quartile	90th Quantile	% > 406
3.8	Molalla River at Canby (Highway 99E)	35	25	24	63	82	0
2.8	Molalla River at Knights Bridge Rd.	53	38	48	76	**145**	2

EXISTING SOURCES OF BACTERIA

Bacteria reach surface waters from a variety of point and nonpoint sources, during both precipitation driven run-off events and non run-off dry weather periods. The following sections describe many likely sources of bacteria, but this source assessment is not exhaustive. Watershed managers from the designated management agencies must conduct further investigations of watershed-specific bacteria sources in order to develop an effective strategy for bacteria control.

NONPOINT SOURCES OF BACTERIA

Urban and agricultural runoff, rural residential runoff, and seepage from failing septic systems, all may carry bacteria and are potential nonpoint bacteria sources in the Molalla-Pudding Subbasin. Stormwater that flows over paved surfaces and agricultural land can carry waste material from pets, wildlife, and livestock. The urban area is small relative to agricultural land in the subbasin, mostly comprising the cities and larger towns of Woodburn, Mt. Angel, Silverton, Canby, and Molalla. Nearby large urban areas include Salem, Keizer, and Wilsonville, though they contribute only a small portion of their runoff to the Molalla-Pudding subbasin. Smaller developed areas in the subbasin include Hubbard, Gervais, Aurora, Brooks, Barlow, Colton, Scotts Mills and a portion of Donald. Rural residential areas are ubiquitous in the Pudding River portion of the subbasin and the lower portion of the Molalla River watershed.

Urban

Urban runoff sources of bacteria are multiple and may include Illegal dumping of sanitary waste, failing septic systems, and sanitary sewer overflows in addition to pet, wildlife, and other animal waste. Though some sources of bacteria to stormwater, such as birds and other wildlife, may be naturally-occurring, the paths that bacteria from these sources take and the time it takes to reach a nearby stream are often greatly shortened by modern stormwater conveyance systems. None of the cities or town located entirely within the in the Molalla-Pudding subbasin have Municipal Separate Storm Sewer System (MS4) NPDES permits that address stormwater runoff from urban areas. DEQ permits stormwater from the cities of Salem and Keizer through MS4 permits, and a portion of the stormwater from these cities is discharged in the Molalla-Pudding subbasin. MS4 permitted stormwater is treated as a nonpoint source in this TMDL and as a source receives a load allocation expressed as a percent reduction of bacterial load.

Non-runoff non-point sources of urban bacteria may include sanitary sewer cross connections and illicit discharge of sanitary waste from septic vacuum trucks and recreational vehicles. A small scale discharge, such as a single residential cross connection, may not have a significant effect during runoff events or when stream flows are high, but can cause water quality criteria violations during the summer months in smaller streams. Direct deposition of pet waste into streams can cause water quality criteria violations during low flow conditions.

DEQ has issued approximately 75 construction and industrial stormwater permits. Facilities and properties covered by a construction or industrial stormwater permit are not provided an allocation of bacteria load. Holders of construction and industrial stormwater stormwater permits should assure that best management practices are followed that are sufficient to prevent sediment (potentially carrying bacteria) from entering surface water.

Rural Residential
Rural runoff may contain bacteria from the same sources as urban runoff. Additional potential sources are "hobby" farms, horse pastures, ranchettes or small acreages and man-made instream ponds that attract wildlife. The density of septic systems is often relatively high in rural areas, especially on the fringe of urban areas, with unknown failure rates.

Septic systems fail in a variety of ways and may contribute to water quality problems under both storm and non-storm conditions. Some systems only fail when the soil is saturated or when winter storms raise the local water table. Other systems fail year round and contribute bacteria to low-flowing streams capable of less dilution. Homes in areas that are not served by city sewer systems treat domestic wastes with septic systems. Older septic systems may have a higher failing rate due to their age and the design criteria in place at the time. Older systems are present in rural areas of the subbasin.

Agricultural
The primary source of bacteria in agricultural runoff is animal waste. Livestock wastes from animals in confinement areas are stored for later application to the land. Wastes are also deposited by livestock to pasture areas near streams, as well as directly into streams. Depending on landscape conditions, proximity to streams, and overland flow rates, animal wastes can find their way to surface waters.

POINT SOURCES OF BACTERIA

DEQ issues National Pollutant Discharge Elimination System (NPDES) permits to facilities that may be sources of bacteria, referred to here as point sources. There are nine permitted wastewater treatment plants or facilities that discharge to streams in the subbasin (Table 3 - 17and Figure 3 - 7). Two year-round discharging facilities, Woodburn and Silverton Wastewater Treatment Plants (WWTPs), send a portion of their treated effluent to irrigation or to wetlands in the summer months. JLR, Inc./Bruce Pac also currently land applies all treated wastewater between May and October. NPDES permits limit bacteria concentrations in effluent to the numeric water quality criteria at the point of discharge without benefit of dilution by receiving waters. DEQ reviewed the past 10 years of discharge monitoring reports (DMRs) for the permitted facilities, or the period of discharge if the facility has been discharging for less than 10 years. The summary of compliance history in Table 3 - 18indicates only sporadic, usually single occurrence, violations of the bacteria criteria at a few of the facilities. The lack of any bacteria violations in the past five years indicates that situations that led to earlier violations were corrected.

Other permitted sources are a food processor (Norpac, Inc) and circuit board manufacturer (Sunstone Circuits) that are not likely or permitted to contribute bacterial contamination through their discharge. DEQ has also issued approximately seven general NPDES permits in the Molalla-Pudding subbasin for filter backwash (from drinking water treatment facilities), washwater (from a car lot), and treated groundwater (petroleum cleanup sites). DEQ treats these generally permitted sources as unlikely or insignificant sources of bacteria to surface water in the subbasin and does not assign wasteload allocations.

There are 43 permitted Confined Animal Feeding Operations (CAFOs) distributed throughout the Molalla-Pudding Subbasin (Figure 3- 7). CAFOs are facilities that feed animals in confinement for specified periods of time prior to selling the animals. There are 31 dairies, four mink facilities, six swine lots, one chicken lot, and one goat facility in the subbasin. Part of normal CAFO facility operation is to manage the accumulated manure. The facilities are regulated as point sources under a general NPDES permit issued by ODEQ and administered by Oregon Department of Agriculture (ODA). Under the terms of these permits, no discharge is allowed from areas of animal confinement, manure management or storage. DEQ is aware of one CAFO in the subbasin that has been issued two Notices of Noncompliance and at which corrective actions are ongoing at the time of this writing.

Table 3- 17: Individual NPDES Permits that limit bacteria discharge in the Molalla-Pudding subbasin.

Facility Name	Permit Type	Permit Description	Receiving Stream	River Mile
Molalla WWTP	NPDES-DOM-Da	Sewage disposal; less that 1 MGD with lagoons.	Molalla River	~ 20
Silverton WWTP	NPDES-DOM-C1a	Sewage disposal; 5 MGD or more, less than 10 MGD	Silver Creek	2.4
Woodburn WWTP	NPDES-DOM-C1a	Sewage disposal; 5 MGD or more, less than 10 MGD	Pudding River and Mill Creek	21.4
Aurora WWTP	NPDES-DOM-Db	Sewage disposal; less that 1 MGD with lagoons.	Pudding River	8.8
Gervais WWTP	NPDES-DOM-Db	Sewage disposal; less that 1 MGD with lagoons.	Pudding River	31.2
Mt. Angel WWTP	NPDES-DOM-Da	Sewage – less than 1 MGD	Pudding River	34
Hubbard WWTP	NPDES-DOM-Da	Sewage – less than 1 MGD	Mill Creek	5.3
Lakewood Homeowners, Inc.	NPDES-DOM-Da	Sewage – less than 1 MGD	Mill Creek	3.9
JLR, Inc./ Bruce Pac	NPDES-IW-B05	Food/beverage processing - Large and complex. Flow greater than or equal to 1 MGD for 180 days/year or more. Discharge combines domestic sewage, treated with a separate process.	Pudding River	27.0

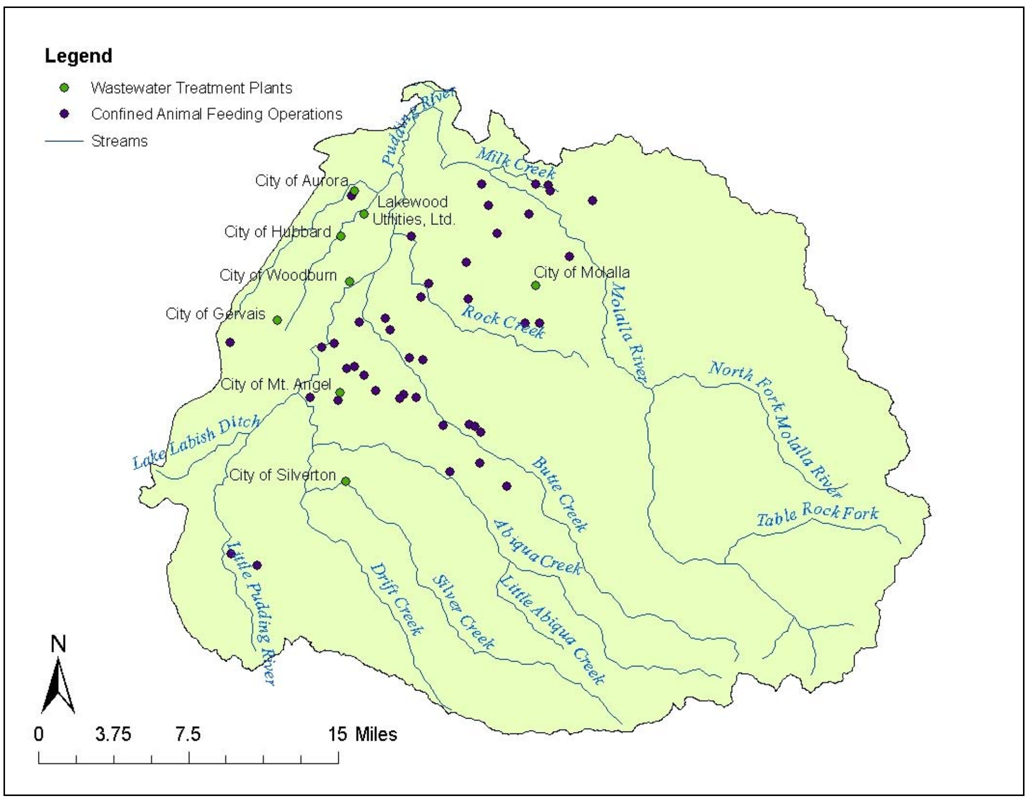

Figure 3- 7: Locations of CAFOS and permitted wastewater treatment plants in the Molalla-Pudding basin.

Table 3- 18: Point sources of bacteria in Molalla-Pudding subbasin with design flow and compliance history summary. Recent discharge monitoring report (DMR) review comprised approximately the past 10 years or the time period the facility has discharged if less than 10 years.

Facility Name	Period of discharge	Average Design flow (wet)	Average Design flow (dry)	Comment/violations
Molalla WWTP	Nov. 1 – April 30	1.92	1*	Discharge limited by a dilution equation** No recent violations -- multiple non *E. coli* violations in former discharge to Bear Creek[2]
Silverton WWTP	Year round	4.6 MGD (monthly average)	3.5 MGD (monthly average)	~55% of June – Sept. discharge goes to OR Garden wetlands and eventually Brush Creek. 1/17/99 Fecal coliform violation: 775 cfu/100 mL.
Woodburn WWTP	Year round	4.5	5.037	~65% of May – Oct discharge goes to irrigate poplar farm no recent violations
Aurora WWTP	Nov. 1 – April 30	0.37	0.08	6/11/02 1,600 total coliform/100 mL
Gervais WWTP	Nov. 1 – April 30	0.49	0.22	11/1998 676 *E. coli* colonies/100 mL
Mt. Angel WWTP	Nov. 1 – April 30	1.32	0.56	No recent violations
Hubbard WWTP	Year round	0.39	0.34	No recent violations
Lakewood Homeowners, Inc.	Nov. 1 – April 30	0.08	0.05	7/6/00 and 8/15/00 >2,419 and 488 *E. coli* colonies/100 mL
JLR, Inc./Bruce Pac	Year round***	0.5	0.5	No recent violations

*Average Dry Weather Design flow for Molalla WWTP if 0.79 MGD, but it is not practical for them to discharge at less than 1.0 MGD. **Dilution equation =(64% of flow at Canby gauge (cfs))/DR_{do}. where DR_{do} is dilution ratio necessary to maintain required dissolved oxygen in stream after effluent mixing. DR_{do} = 481.42 x (0.64 x measured stream flow at Canby)$^{-0.2765}$. ***JLR, Inc/Bruce Pac currently land applies treated wastewater in the summer months.

ALLOCATIONS

WASTELOAD ALLOCATIONS

Wasteload allocations (WLA) for point sources vary with effluent flow. The wasteload allocations are based on effluent limits equal to or less than numeric bacteria criteria at the end of the discharge pipe, as required by NPDES permits. DEQ estimated potential loading based on the dry or wet weather design flows from the treatment plant and assuming the point sources discharge at the 126 log mean criterion (Table 3- 19). Estimated bacteria loads from WWTPs are relatively small and if controlled at the end of the pipe will not contribute to violations of water quality standards. Permitted sources are also required to disinfect their effluent, and dechlorinate if chorine is used as the disinfectant.

Permitted point sources must monitor *E. coli* concentrations weekly and report those concentrations monthly to DEQ. Generally, as shown in the last column of Table 3- 19, the sources' treatment processes remove *E. coli* to a greater extent than the permit requires. The last column of Table 3- 19 is presented only to compare *E. coli* counts in an average of recent effluent measurements with the water quality criteria. The average concentration of *E. coli* in the sources' effluent in Table 3- 19 is based on a review of approximately the last five years of monthly reports (or as long as the facility has been discharging if less than 5 years).

[2] City of Molalla WWTP discharged to Bear Creek, a tributary to the Pudding River, until November 2006, when the discharge location was moved to the Molalla River. Between 1999 and 2006, approximately 100 violations of the dilution factor for Bear Creek, total suspended solids, and biochemical oxygen demand occurred.

Confined animal feeding operations are not allowed to discharge wastes from specific areas covered by the general NPDES permit. CAFOs are allocated a zero load of *E. coli* in runoff from regulated portions of the operations, such as confinement, storage, or concentration areas.

Table 3- 19: Wasteload Allocations for Wastewater Treatment Plants (WWTP) and Confined Animal Feeding Operations
Estimate of wet and dry weather loads are based on meeting the 126 log mean criteria.

Facility Name	**Logarithmic Mean Limit (*E. coli* counts/100 mL)**	**Single Sample Limit (*E.coli* counts/ 100 mL *i*)**	**Average Wet Weather Flow (MGD)**	**Average Dry Weather Flow (MGD)**	**Estimate of Wet Weather WLA (counts/day)**	**Estimate of Dry Weather WLA (counts/day)**	**Average Monthly Maximum --recent reported *E. coli* concentrations (counts/100 mL) (For comparison purposes only. Not a WLA)**
Molalla WWTP	126	406	1.92	1	9.15×10^{9}	4.77×10^{9}	<2
Silverton WWTP	126	406	4.6 MGD (monthly average)	2.5 MGD (monthly average)	2.19×10^{10}	1.19×10^{10}	69
Woodburn WWTP	126	406	4.5	5.037	2.14×10^{10}	2.40×10^{10}	99
Aurora WWTP	126	406	0.37	0.08	1.76×10^{9}	3.82×10^{8}	99
Gervais WWTP	126	406	0.49	0.22	2.34×10^{9}	1.05×10^{9}	3
Mt. Angel WWTP	126	406	1.32	0.56	6.29×10^{9}	2.67×10^{9}	90
Hubbard WWTP	126	406	0.39	0.34	6.29×10^{9}	1.62×10^{9}	76
Lakewood Homeowners, Inc.	126	406	0.08	0.05	3.82×10^{8}	2.37×10^{8}	8
JLR, Inc./Bruce Pac	126	406	0.5	0.5	9.15×10^{9}	4.77×10^{9}	72
Confined Animal Feeding Operations (CAFO)	0	0			0	0	NA

LOAD ALLOCATIONS

Load allocations have been developed for nonpoint sources in the subbasin to ensure that both bacteria numeric water quality criteria are met, the log mean criterion as well as the discrete sample criterion. Load allocations have been quantified and expressed by a surrogate measure that will be more practical to implement. Unless otherwise specified with a surrogate measure applicable during a particular time period, load allocations apply year-round to all streams in the subbasin. Details of the applications of load allocations are expanded in the Surrogate Measures discussion in this section.

Quantified Load Allocations

A quantified load allocation may be calculated with Equation 2 for a loading capacity applicable to a particular flow condition. Once the Wasteload Allocations (WLA), Reserve Capacity (RC) and Margin of Safety (MOS) have been defined, the load allocation is the remainder of the loading capacity after the sum of these three terms (WLA, RC, and MOS) have been subtracted. Loading capacity for each of five flow intervals was previously calculated, and the loading capacity for the transitional flow interval (40 – 60 % exceedance probability -- EP) is shown in Table 3- 20. No reserve capacity is allotted and the MOS is implicit, as further explained in the Reserve Capacity and Margin of Safety sections of this chapter. The load allocation for each stream with sufficient data to perform this calculation is listed in Table 3- 20.

$$\text{Loading capacity} = LA + WLA + RC + MOS \qquad \text{Equation 2}$$

Table 3- 20: Summary of Explicit Load Allocations in units of *E. coli* organisms/day.

Stream and Point Sources	WLA (wet weather)	Load Allocation	Load Capacity (40 – 60% EP)
Pudding River			
Woodburn WWTP	2.14×10^{10}		
JLR, Inc./Bruce Pac	9.15×10^{9}		
Aurora WWTP	1.76×10^{9}		
Gervais WWTP	2.34×10^{9}		
Mt. Angel WWTP	6.29×10^{9}		
Hubbard WWTP	6.29×10^{9}		
Lakewood WWTP	3.82×10^{8}		
Total Pudding River	4.32×10^{10}	1.13×10^{12}	1.17×10^{12}
Silver Creek (Silverton WWTP)	2.19×10^{10}	2.20×10^{11}	2.42×10^{11}
Molalla River (Molalla WWTP)	9.15×10^{9}	1.25×10^{12}	1.26×10^{12}
Zollner Creek	0	7.39×10^{9}	7.39×10^{9}

Surrogate Measures

The Molalla-Pudding Subbasin bacteria TMDL allocates "*other appropriate measures*" (or surrogate measures) as provided under USEPA regulations [40 CFR 130.2(i)]. The surrogate measure translates load allocations into more applicable measure of performance than a mass/time load. Load allocations are expressed as percent reduction in in-stream bacteria concentrations needed to achieve both log mean and single sample numeric criteria for protection of recreational contact. Stream specific percent reductions are determined for each 303(d) listed stream (Pudding River, Molalla River, Zollner Creek, W. Fork Little Pudding, and Silver Creek) and apply to their tributaries, as well. Percent reductions by land use apply to all other watersheds in the subbasin lacking sufficient data to calculate stream-specific percent reductions.

In the following discussion, DEQ refers to some locations as compliance points. These compliance points are not necessarily near the mouths of streams, but are locations where sufficient data have been collected to calculate a percent reduction needed to meet water quality standards. Figures and tables with these compliance points indicate the river mile at which they are located.

In some cases, percent reductions are specified by seasons, defined as summer (June 1 to September 30) and winter or fall-winter-spring (October 1 to May 31). While the driver for bacteria exceedances appears to be stream flow and/or precipitation, generally these hydrologic characteristics correlate with the summer or fall-winter-spring periods, as defined. A percent reduction based on dates will also be more practical to implement than percent reductions based on streamflow percent exceedance.

Percent reductions were calculated based on samples collected after January 1, 1989. Samples collected in the subbasin before 1989 generally were collected in the late 1960s and early 1970s and may not reflect recent and current land uses, land management, wastewater treatment, and population. The percent reduction was calculated by reducing the post-1989 data so that the 75th percentile of the data did not exceed the log mean criteria and no one sample exceeded the discrete sample criterion of 406 *E. coli* organisms/100 mL. Reducing the 75th percentile of the data did not always achieve the single sample criterion. In those cases, a greater percent reduction was required.

Pudding River

Percent reduction necessary to meet water quality standards in both the summer (June 1 – September 30) and winter (October 1 – May 31) periods in the Pudding River are based on data collected from two different sites. The Pudding River at 99E (river mile 7.3) site had higher and more frequent exceedances at higher flows corresponding with fall, winter and, spring months (October 1 – May 31). The Pudding River at Highway 211 (river mile 21) site had higher and more frequent exceedances at lower flows, often corresponding with summer months, defined June 1 – September 30. The percent reductions in both seasons apply to the entire length of the Pudding River and tributaries entering the Pudding River (except those tributaries with their own percent reductions, e.g. Zollner, Silver, and W. Fk. Little Pudding), even those upstream of the listed portion of the Pudding River (RM 35.4), because data analysis reveals exceedances of the log mean bacteria criterion upstream of the listing.

The percent reduction in in-stream bacteria concentrations necessary to meet the log-mean and single sample criteria for the summer period (June 1 – September 30) in the Pudding River is presented in Figure 3- 8. The compliance point is the Pudding River at Highway 211 (river mile 21), the site requiring the largest reductions at low flows, typically corresponding with summer months of June – September.. The reduction required is 75%. Applying this reduction to the bacteria concentrations from samples collected in the summer months reduces in the 75th percentile of samples from this site to the 126 log mean criterion, and no single sample exceeds the 406 criterion (Table 3- 21).

The percent reduction in in-stream bacteria concentrations necessary to meet the log-mean and single sample criteria for the winter period in the Pudding River is presented in Figure 3- 9. The compliance point is the Pudding River at Highway 99E, the site requiring the largest reductions at high flows, more typical of fall-winter-spring months, October – May. DEQ calculated the necessary reduction to reduce the 75th percentile during high flow regimes to the log mean criterion, but this was not sufficient to meet the single sample criterion of no sample exceeding 406 counts/100 mL. The required reduction to meet both the single sample and log mean criteria is 70% (Table 3- 22).

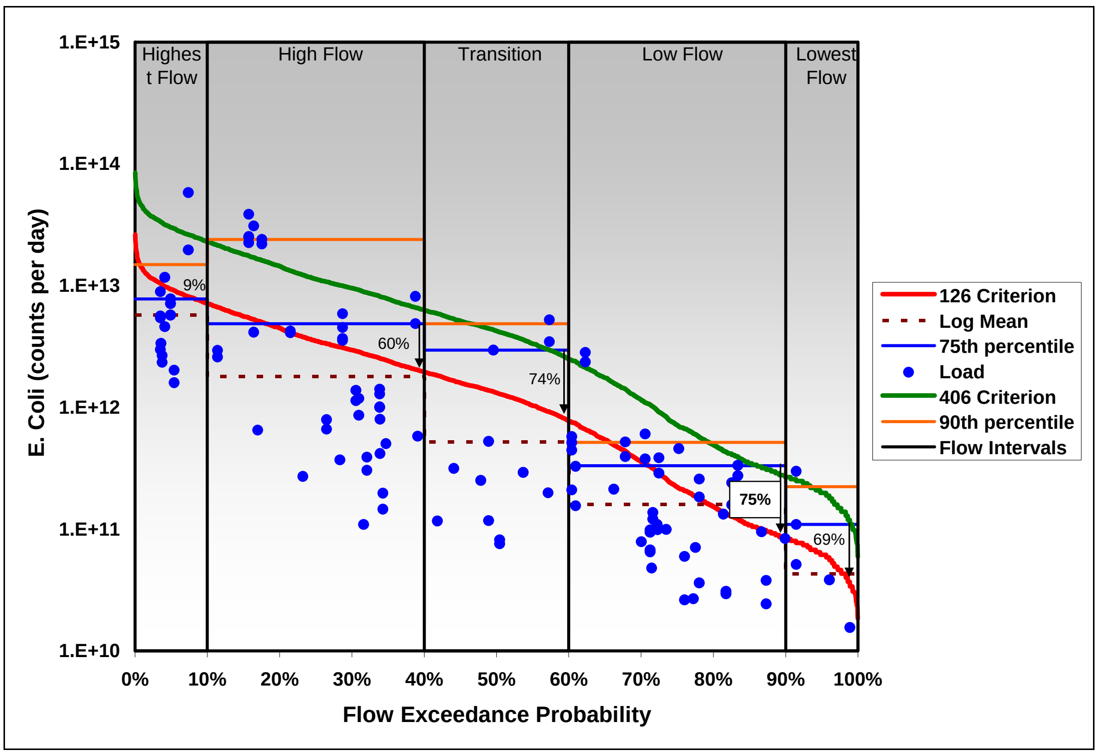

Figure 3- 8: Required percent reduction to meet bacteria criteria at Pudding River at Highway 211, river mile 21. A 75% reduction is necessary to meet numeric bacteria criteria, based on 1990 – 2006 data. Reductions are based on the 75th percentile of the data if that is sufficient to meet both the log mean and single sample criteria. The 90th percentile in the figure is for illustrative purposes. Percent reduction applies to entire length of Pudding River and tributaries, June 1 – September 30.

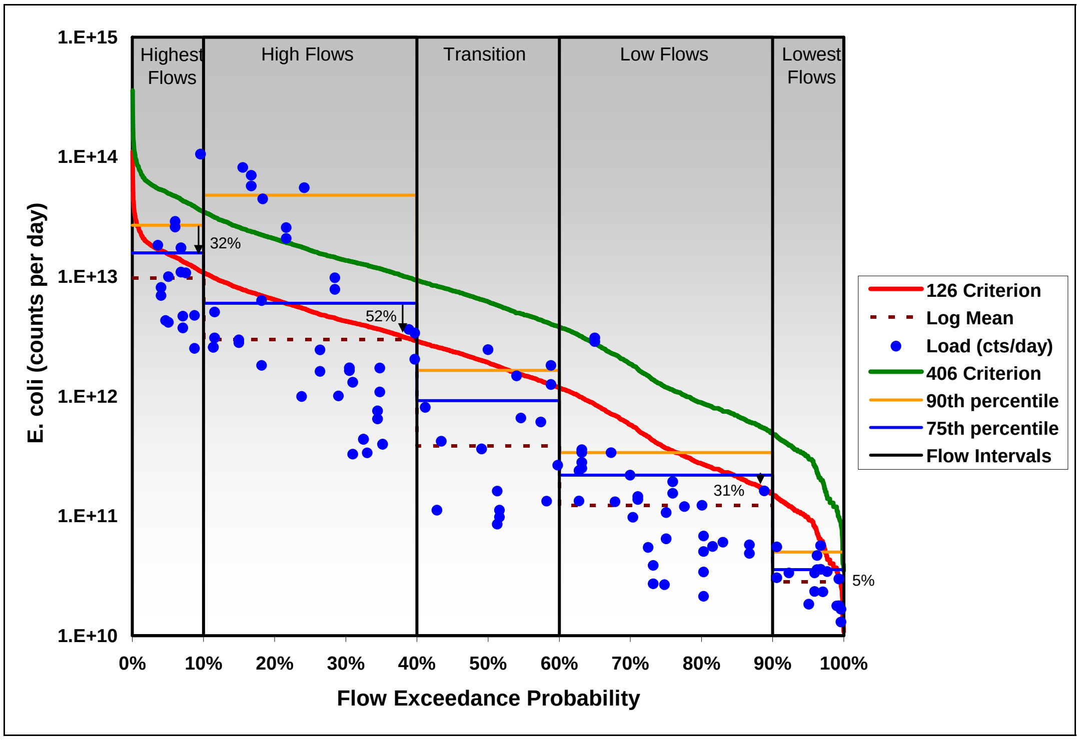

Figure 3- 9: Required percent reduction to meet bacteria criteria at Pudding River at 99E, river mile 7.3. A 52% reduction would meet the log mean bacteria criterion, but not the single sample criterion. .A 70% reduction is necessary to meet both numeric criteria, based on 1990 – 2006 data. Reductions are based on the 75th percentile of the data if that is sufficient to meet both the log mean and single sample criteria. The 90th percentile in the figure is for illustrative purposes. Percent reduction applies to entire length of Pudding River and tributaries, October 1 – May 31.

Zollner Creek Watershed

Figure 3- 10 depicts the reductions necessary for Zollner Creek at Monitor McKee Road to attain compliance with the 126 log mean standard and single sample criterion. Since the sample set available with coincident flow measurement is small (10 samples), DEQ reviewed all the concentrations measured at Monitor McKee road after 1989 and based the reductions on the concentration duration curve rather than the load duration curve. A reduction of 87% would be necessary between June 1 and September 30, coinciding with transitional to low flows. The required winter time reduction, which applies October 1 – May 31, when higher flow is typical, would be 92%. These percent reductions are listed in Table 3- 21 and Table 3- 22 .

West Fork Little Pudding

DEQ assigns the West Fork Little Pudding River the same fall-winter-spring (October 1 – May 31) reduction target (92%) as Zollner Creek, given the Little Pudding's similarly small watershed and predominantly agricultural land use. DEQ assigns this conservative target because sufficient data were not available to calculate a reduction particular to the West Fork Little Pudding. This reduction target does not apply to the MS4 stormwater contribution to this watershed. The portion of the Little Pudding watershed drained by the West Fork Little Pudding has a higher percentage of urban and rural residential land use than the remainder of the Little Pudding watershed and contributes stormwater from the City of Salem system (MS4). The MS4 reduction target for the City of Salem MS4 contribution is 86%, as explained further at the end of this section.

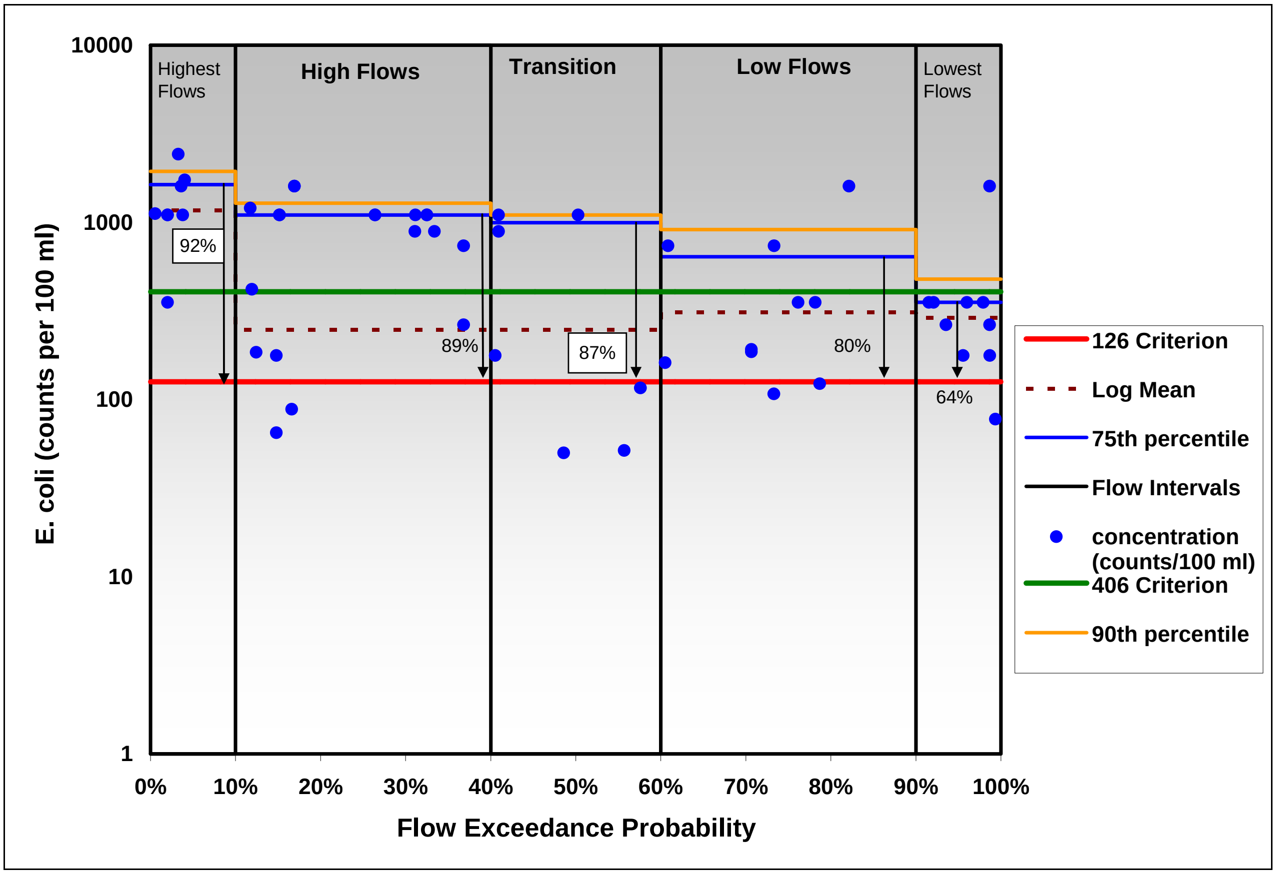

Figure 3- 10: Required percent reduction to meet bacteria criteria in Zollner Creek, river mile 0.3. Reductions of 92% (October 1 – May 31) and 87% (June 1 – September 30) are necessary to meet numeric bacteria criteria, based on 1989 – 2006 data. Reductions are based on the 75th percentile of the data if that is sufficient to meet both the log mean and single sample criteria. The 90th percentile in the figure is for illustrative purposes.

Silver Creek

Figure 3- 11 depicts the reductions necessary for Silver Creek at Brush Creek Road to attain compliance with the 126 log mean criterion and the single sample criterion Few Silver Creek data were collected in the winter months that correspond with high and transition flows. Winter data were collected in the late 1960s and early 1970s, but may not be representative of current land use and population in the watershed. After calculating the required percent reduction from the load duration curve, DEQ applied the reduction to all data collected in or after 1989 at the Brush Creek Road site as well as two sites downstream of river mile 3. The percent reduction from the load duration curve (86%) allows both the log mean and single sample criteria to be met at each of these three sites (Table 3- 21 and Table 3- 22). To be protective, the reduction target applies year round even though Silver Creek is not bacteria listed for fall-winter-spring. Few data are available from fall-winter-spring months, but recent data (1993 – 2004) collected from Silver Creek at river mile 2.5 shows exceedances of both the log mean and single sample criteria in the fall-winter-spring period.

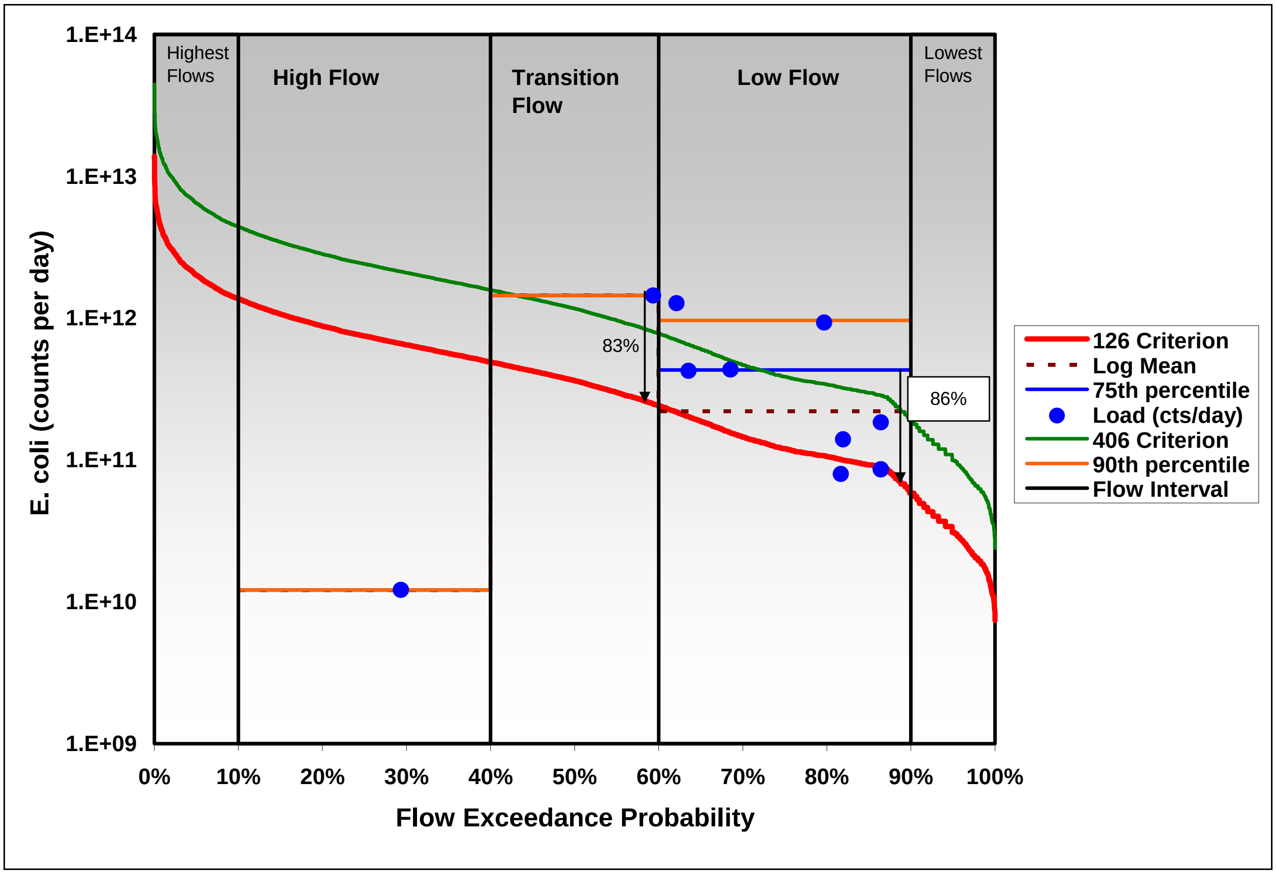

Figure 3- 11: Load duration curve and percentiles based on 1989 – 1993 data collected at Silver Creek at Brush Creek Road, river mile 1.3.
An 86% reduction year round is necessary to meet water quality standards. Reductions are based on the 75th percentile of the data if that is sufficient to meet both the log mean and single sample criteria. The 90th percentile in the figure is for illustrative purposes.

Molalla River

For the Molalla River, the load allocations apply from the confluence with the North Fork (river mile 25) downstream to the mouth. Data collected from the Molalla River upstream of North Fork, though limited, do not indicate that bacteria exceedances or violation of the water quality standard have occurred or are likely to occur. The land use upstream of the North Fork Molalla is predominantly forestry, and forestry does not receive an allocation based on available data that indicate forestry does not contribute to the excess load of bacteria in the Molalla-Pudding subbasin.

DEQ provides a percent reduction to the fall-winter-spring period (October 1 – May 31) on the Molalla River. Figure 3- 12 shows that the 75th percentile in all flow intervals except the highest are well below the log mean criterion. A 81% load reduction, applicable between October 1 and May 31 will allow both the log mean criterion and single sample criterion to be met on all samples collected after 1989 in the months October – May (Table 3- 22).

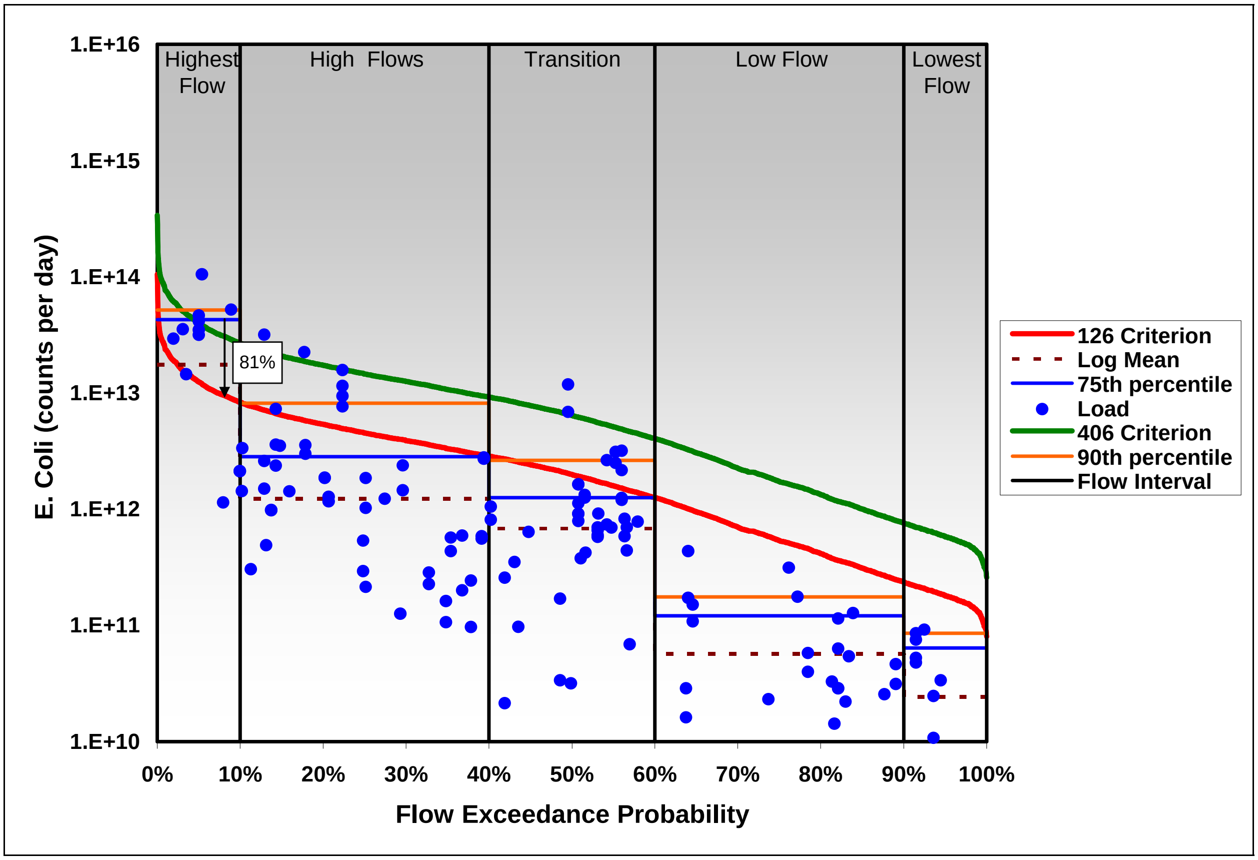

Figure 3- 12: Bacteria load reductions necessary to meet compliance during winter months at Molalla River at Knights Bridge Road, river mile 2.8.
An 81% reduction is required October 1 – May 31 to meet water quality standards. Reductions are based on the 75th percentile of the data if that is sufficient to meet both the log mean and single sample criteria. The 90th percentile in the figure is for illustrative purposes.

Table 3- 21: Compliance with bacteria criteria after reductions applied, June 1 – September 30.

Compliance Points	**Sample Size**	**Sample years: June - September**	**Percent reduction**	**Log mean (June – Sept) *E. coli* counts/100 mL**	**>406 E. coli counts/ 100 mL**	**Land Use**
Pudding R. at Hwy. 211 (river mile 21)	35	1989 - 2006	75	22	0	58% agriculture 34% forestry 5% urban 3% rural residential (<1% rural industrial)
Zollner Creek at Monitor McKee Rd. (river mile 0.3)	16	1989 - 2006	87	40	0	99 % agriculture <1 % urban <1% rural residential
Silver Creek (3 sites d/s river mile 3)	29	1989 - 2006	86	29	0	76% forestry/park 18% agriculture 5% urban 3% rural residential

Table 3- 22: Compliance with bacteria criteria after reductions applied, October 1 – May 31.

Compliance Points	Sample Size	Sample years: October - May	Percent reduction	Log mean (Oct – May)	>406	Land Use
Pudding R. at 99E (river mile 7.3)	85	1989 - 2006	70	17	0	58% agriculture 34% forestry 5% urban 3% rural residential (<1% rural industrial)
Zollner Creek at Monitor McKee Rd. (river mile 0.3)	38	1989 - 2006	92	43	0	99 % agriculture <1 % urban <1% rural residential
Silver Creek (3 sites d/s river mile 3)	17	1989 - 2006	86	8	0	76% forestry/park 18% agriculture 5% urban 3% rural residential
West Fk. Little Pudding R.			92			77% agriculture 12% urban 8% rural residential 2% rural industrial/ public facility
Molalla River at Knights Bridge Road (river mile 2.8)	92	1989 - 2006	81	6	0	83% forestry 13% agriculture 3% public facility 1% urban

Allocations by Land Use

The percent reductions in Table 3- 21 and Table 3- 22 are stream specific and apply to all land uses on that stream except forestry. For streams in the rest of the subbasin that do not have specific compliance points, percent reductions are allocated by land use. This application of allocations throughout the subbasin allows newly discovered sources of bacteria to be addressed by the current TMDL rather than requiring additional TMDL development in the future.

Overall the land use in the Molalla Pudding Subbasin breaks down to 40% agriculture, 53% forestry and parks, 3% urban, 3% rural residential, and 1% rural industrial and public facilities (Table 3- 23). Land use distribution differs significantly between the Pudding River and Molalla River portions of the subbasin, the Molalla watershed having a larger percentage forestry and the Pudding watershed, a larger percentage of agriculture. Bacteria concentrations measured at forestry dominated sites do not indicate that forestry contributes significantly to exceedances of the bacteria criteria. With the percentage of the land in forestry land use set aside, the remaining land uses in each watershed distribute as shown in Table 3- 24.

The load allocations that apply subbasin-wide where a specific stream allocation does not apply are listed in Table 3- 25. Since Zollner Creek land use is nearly exclusively agriculture, the Zollner Creek percent reduction is used to set the allocation for agricultural land use. The urban land use allocation is based on the percent reduction for Silver Creek because that watershed has a higher ratio of urban to agricultural land than other watersheds.[3] Allocations to the MS4 sources are identical to those assigned to urban land use. The W. Fk. Little Pudding River appears to be the only watershed that receives MS4-permitted discharge. Forestry land use does not receive an allocation/percent reduction because data do not indicate that forestry is a significant bacteria source.

Table 3- 23: Percentage land use distribution in the Molalla-Pudding Subbasin.

Land Use	Subbasin	Pudding Watershed	Molalla Watershed
Forestry (and Parks)	53	34	83
Agriculture	40	58	13
Urban	3	5	1
Rural Residential	3	2	3
Rural Industrial	1	1	<1

[3] excepting the Little Pudding watershed, although percent reductions were not calculated directly for the Little Pudding.

Table 3- 24: Percentage land use distribution other than forestry in the Molalla-Pudding Subbasin

Land Use	Pudding Watershed (minus forestry land)	Molalla Watershed (minus forestry land)
Agriculture	89	75
Urban	7	6
Rural Residential	3	18
Rural Industrial	1	1

Table 3- 25: Percent reductions that apply by land use within the Molalla-Pudding Subbasin, where specific percent reductions were not assigned.

Land Use	Percent Reduction (summer)	Percent Reduction (Fall-winter-spring)
Agriculture (including rural residential and industrial)	87	92
Urban	86	86
MS4	86	86
Forestry	0	0

MARGINS OF SAFETY

The margin of safety applied to the bacteria TMDL for the Molalla-Pudding subbasin is implicit in several conservative assumptions:

- Loading capacity was calculated from load duration curves based on lowest flow (highest exceedance probability) within each flow interval
- Current pollutant load estimate was based on the 75the percentile of loads calculated from recent concentration data
- The percent reductions that serve as load allocations are based on reducing the 75th percentile of data, rather than the log mean, to meet the log mean criteria.
- Percent reductions would reduce all current in-stream concentrations below the single sample criterion of 406 *E.coli* organisms/100 mL as well as well below the log mean criterion of 126 *E.coli* organisms/100 mL.
- Wasteload allocations allows for point sources to discharge at water quality criteria when records indicate that permitted facilities are currently discharging well below permit concentration limits.

RESERVE CAPACITY

No reserve capacity is allotted at this time for bacteria in Molalla-Pudding Subbasin waterbodies. Future permitted sources or increases to existing sources of bacteria will be required to meet the water quality criteria of 126 *E. coli* counts/100 ml as a log mean and no sample greater than 406 *E. coli* counts/100ml, the single sample criterion. Any additional non point source could not cause bacteria loading to exceed the loading capacity.

REFERENCES

Aroner, E.R. 1997. WQHydro – Water Quality/Hydrology Graphics/Analysis System – Environmental Data Analysis Technical Appendix. WQHydro Consulting, Portland, Oregon, 223 pp.

Cleland, B. 2002. TMDL Development from the “Bottom Up” – Part II: Duration Curves and Wet-Weather Assessments. Unpublished Manuscript.

Cleland, B. 2002. TMDL Development from the “Bottom Up” – Part III: Using Duration Curves to Connect the Pieces. Unpublished Manuscript.

Cude, Curtis G. 2005. Accommodating Change of Bacterial Indicators in Long Term Water Quality Datasets. Journal of the American Water Resources Association (JAWRA) 41(1):47-54.

Helsel, D.R. and Hirsch, R.M. 2002. Statistical Methods in Water Resources, U.S. Geological Survey.

ODEQ. 1995. 1992-1994 Water Quality Standards Review. Portland, OR.