APPENDIX B

Stormwater Pollutant Loads Modeling

Introduction

The Tualatin Subbasin Total Maximum Daily Load (TMDL) prepared by the Oregon Department of Environmental Quality in August 2001 includes waste load allocations (WLAs) for total phosphorus (TP), settleable volatile solids (SVS), and bacteria for municipal separate sewer system (MS4) discharges, including those within the jurisdiction of Clean Water Services (the District). Settles volatile solids were defined in the TMDL as an indicator of sediment oxygen demanding substances in relation to the dissolved oxygen TMDL. As allowed for in the TMDL, the District has used total suspended solids (TSS) as a surrogate for SVS. The District’s watershed-based National Pollutant Discharge Elimination System (NPDES) permit renewal application requires the evaluation of progress towards reducing TMDL pollutant loads “through the use of performance measures and pollutant load benchmarks developed and listed in the SWMP” (Stormwater Management Plan). The Watershed-based NPDES permit renewal application also requires an updated estimate of annual storm water pollutant loads for the original pollutants of concern listed in Part 2 of the application.

This appendix describes the TMDL and the annual stormwater pollutant loads modeling conducted for the permit renewal application.

Stormwater Pollutant Loads Model

The TMDL allocations to MS4s within the District’s jurisdiction are goals that are to be attained over time, without consideration for what the baseline, current, or future conditions actually were, are, or will be. As discussed later in this appendix, DEQ’s analyses did not attempt to account for actual pollutant concentrations (referred to below as event mean concentrations, EMCs) or any best management practices (BMPs) already in place. In order to evaluate potential benchmarks, it is necessary to estimate baseline conditions (i.e., actual pollutant concentrations prior to implementation of BMPs), and current conditions (with actual EMCs and BMPs currently in place). As a result, the District needed a tool such as PLOAD to estimate these various conditions.

PLOAD Model

PLOAD is a Geographic Information System (GIS) watershed pollutant loading model that also accounts directly for BMPs. It is a planning level model that was originally developed by CH2M HILL and was incorporated as one of a number of water quality/watershed models within the U.S. Environmental Protection Agency’s (EPA’s) BASINS framework. CH2M HILL recently modified PLOAD for the Oregon Association of Clean Water Agencies
(ACWA). The modifications included upgrading to ArcGIS Version 9.0 and adding new modules that: (1) allow use of effluent quality from a BMP in addition to percent pollutant reduction and (2) account for flow reduction that occurs with some BMPs. This version of the PLOAD model is licensed to ACWA for use by eligible member agencies such as the District. The District has used this version of the PLOAD model for the TMDL and the annual stormwater pollutant load modeling.

PLOAD uses the EPA Simple Method, which is commonly used for estimating pollutant loads for urban/suburban land uses. Two equations are required to calculate the loads for each specified pollutant type when using the Simple Method. First, the runoff coefficient for each land use type must be derived with the following equation:

$$R_{vu} = 0.05 + (0.009 \times I_u)$$

where

- $R_{vu}$ = Runoff coefficient for land use type $u$, inches runoff/inches rain
- $I_u$ = Percent Imperviousness

Percent imperviousness is extracted from an impervious factor lookup table (spreadsheet). The pollutant loads are then calculated with the following equation:

$$L_P = \sum u \left( P \times P_j \times R_{eu} \times C_u \times A_u \times \left[\frac{2.72}{12}\right]\right)$$

where

- $L_P$ = Total pollutant load for all land use types in watershed, $u$, lb/time step
- $P$ = Precipitation, inches/time step
- $P_j$ = Ratio of storms producing runoff (default = 0.9, but the user can enter appropriate number based on local storm and climatic information)
- $R_{eu}$ = Runoff coefficient for land use type $u$, inches runoff/inches rain
- $C_u$ = Event Mean Concentration for land use type $u$, milligrams/liter
- $A_u$ = Area of land use type $u$, acres (PLOAD allows the use of GIS files that are either in meters or in feet. PLOAD converts areas from square meters or square feet to acres prior to using the information in the above equation.)
- 12 = conversion factor to convert inches to feet
- 2.72 = conversion factor from mg/L and acre-feet to pounds

Note: The above equations and conversion factors are utilized for most parameters and yield a result measured in pounds/time step. Since bacteria are generally measured in counts/time step, the equation and conversion factors below are utilized:

2 Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Schueler, July 1987 Equation 1.2 on page 1.11.
3 Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Schueler, July 1987 Equation 1.1 on page 1.10.
\[ L_P = \sum u \left( P \times P_j \times R_{vu} \times C_{u} \times A_{u} \times \left[\frac{12334700}{12}\right]\right) \]

where

- \( L_P \) = Total pollutant load for all land use types in watershed, \( u \), counts/time step
- \( C_{u} \) = Event Mean Concentration for land use type \( u \), counts/100 mL
- 12 = conversion factor to convert inches to feet
- 12334700 = conversion factor from counts/100 mL and acre-feet to counts

The precipitation and storm ratio values are entered by the PLOAD user interactively. The loading rates are derived from a user-specified EMC lookup table (spreadsheet), while the land use areas are interpreted from the land use and watershed GIS data.

BMPs serve to reduce pollutant loads and PLOAD has an option to calculate loads based on the remedial effects of the various BMP types. BMP types may be represented as either area (polygon) or site (point) features, but the approach for both is similar. After the raw pollutant loads are calculated using the simple method, PLOAD recalculates the pollutant loads to reflect BMP removals. The model user specifies BMP effectiveness values for each BMP type and pollutant in a lookup table (spreadsheet). The BMP locations and watershed areas are derived from the BMP and watershed GIS data. Equations for BMP removals and the two special ACWA modules (BMP effluent concentration and BMP flow reduction) are not presented here but can be found in the ACWA PLOAD User’s Manual reference above.

PLOAD output includes pollutant load (or bacteria counts) per event, load (or bacteria counts) per acre per event, runoff volume, and spatially averaged pollutant concentration. This output is provided for each discrete watershed or sub-watershed delineated by the user.

**PLOAD Model Use**

The following information is necessary to run the PLOAD model and calculate pollutant loads:

**GIS files:** Watershed Boundaries, Land Uses, and BMPs (location, type, and drainage area).

**Lookup Tables:** Impervious Areas, Land use based median EMCs, effluent concentrations associated with non-structural BMPs and structural BMPs.

The following sections describe the GIS files and lookup tables that were used as inputs to the PLOAD model.
GIS Files

The 2001 Tualatin TMDL divides the Tualatin Basin into six sub-watersheds (Upper, Gales, Dairy, Rock, Middle, and Lower). Pollutant loads and/or percent reduction requirements are assigned to each sub-watershed. To calculate pollutant loads on a sub-watershed basis, the Tualatin Basin GIS file was divided into six TMDL sub-watersheds as shown in Figure 1.

![Tualatin River TMDL Sub-watersheds](image)

**FIGURE 1**
Tualatin River TMDL Sub-watersheds

For each sub-watershed, the portion that is served by the District along with the land use for that area was applied as shown in Figure 2. The land use files, which were obtained from Metro, did not assign a land use to roads. As discussed below, the effective impervious area determination accounted for roads within each polygon area. Since roads were already
incorporated into the impervious area calculations, a separate land use category was not necessary. Therefore, the District incorporated roads into the adjacent land uses.

Figure 2
Rock Creek Sub-watershed with Land Uses within the District Service Area

Note that the Upper Tualatin sub-watershed is outside the urban growth boundary and Metro’s land use data do not extend into this sub-watershed. So, land-use-based GIS files could not be developed for the Upper Tualatin sub-watershed. Such files are not needed for this analysis because the District did not receive MS4 WLAs for the Upper Tualatin sub-watershed.

A GIS point file was developed for the structural BMPs in each sub-watershed. Along with the location of the structural BMPs, information regarding the structural BMP type and drainage area is necessary for PLOAD to calculate resulting loads. The District gathered the necessary information to enable it to use most of the structural BMPs that have been installed over the past 15 years. However, there are BMPs for which one or more pieces of information are not readily available. This represents a relatively small percentage (~10 percent) of the total number of structural BMPs. The District will continue to obtain data to fill in these data gaps and include them in future stormwater pollutant loading evaluations. The following figure shows the structural BMPs in the Rock Creek sub-watershed:
FIGURE 3
Rock Creek Sub-watershed with Land Uses and Structural BMPs within the District Service Area

Lookup Tables
The following lookup tables were developed for use with the PLOAD model:

- Impervious Area
- Land use based median EMCs
- Non-structural BMP effluent concentrations
- Structural BMP effluent concentrations
- Flow reduction associated with structural BMPs (used for the TMDL pollutant load calculations but not for the annual stormwater pollutant load estimates)

Impervious Area
The effective impervious area (EIA) was used to define the imperviousness associated with various land uses. The EIA is different than the total impervious area (TIA) in that it takes into account the hydraulic “connectedness” of the surface water drainage system. The EIA values were developed as part of the District’s Watersheds 2000 study. Pacific Water Resources, Inc., which was one of the consultants that developed the EIA values for the
District’ Watersheds 2000 study, provided documentation on the procedures used to develop the EIA values. Their memorandum is attached to this document. The District expects to update these values periodically to ensure that they remain current.

EIA polygons were developed based on drainage patterns; these polygons typically encompassed multiple land uses. Based on information regarding the land use, roads, surface water drainage system, riparian corridor/green space, and other information, a unique EIA value was assigned to each polygon. Since there are hundreds of polygons with corresponding EIA areas, it is cumbersome to use. An aggregate area-weighted average based on the predominant land use in each polygon was determined. Using this procedure, EIA values were calculated for each predominant land use category (i.e., single family residential, commercial, industrial, etc.).

**Land-Use-Based EMCs**

Using the 1990-1996 ACWA stormwater data, median values for pollutants of concern were calculated. These values are slightly different than the statistics presented in the *Analysis of Oregon Runoff Water Quality Monitoring Data Collected from 1990–1996* report (1997 ACWA Report) prepared by Woodward Clyde. This is because the 1997 ACWA report used geometric means to represent medians. The District used medians to calculate stormwater pollutant loads because the MS4 WLAs for phosphorus are derived from summer medians (see Table 47 in the TMDL report).

**TABLE 1**

Land-Use-Based Median EMCs
From ACWA Data: 1990–1996

<table>
<thead>
<tr>
<th>Land Use Categories</th>
<th>TP (mg/L)</th>
<th>TSS (mg/L)</th>
<th>E. coli Bacteria* (#/100 mL)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>0.21</td>
<td>38</td>
<td>1800</td>
<td>ACWA Site Median Concentrations</td>
</tr>
<tr>
<td>Multi-family</td>
<td>0.21</td>
<td>38</td>
<td>1800</td>
<td>Equal to ACWA Residential</td>
</tr>
<tr>
<td>Commercial</td>
<td>0.25</td>
<td>55</td>
<td>1900</td>
<td>ACWA Site Median Concentrations</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.55</td>
<td>91</td>
<td>800</td>
<td>ACWA Site Median Concentrations</td>
</tr>
<tr>
<td>No Exposure Industrial</td>
<td>0.25</td>
<td>55</td>
<td>800**</td>
<td>Equal to ACWA Commercial except for bacteria</td>
</tr>
<tr>
<td>Multi-use</td>
<td>0.23</td>
<td>47</td>
<td>1850</td>
<td>Average of Residential and Commercial</td>
</tr>
<tr>
<td>Public Open Space</td>
<td>0.17</td>
<td>16</td>
<td>1100</td>
<td>ACWA Site Median Concentrations</td>
</tr>
<tr>
<td>Vacant</td>
<td>0.17</td>
<td>16</td>
<td>1100</td>
<td>Assumed to be equal to Open Space</td>
</tr>
<tr>
<td>Rural</td>
<td>0.17</td>
<td>16</td>
<td>1100</td>
<td>Assumed to be equal to Open Space</td>
</tr>
</tbody>
</table>

* E. *coli* bacteria values were calculated using the following relationship: *E. coli* = 0.81*fecal coliform.
The residential EMC data include multi-family dwellings. Therefore, the residential data were also used to represent the EMCs for the multi-family land use category. As noted above, roads were not assigned a separate category. The acreage associated with roads was incorporated into adjacent land uses. This is a reasonable approach because: (1) the EIA area determinations already account for roads in each polygon, and (2) EMC data include runoff from roads. For example, residential and multi-family EMC data include runoff from adjacent roadways; similarly other land use categories typically include runoff from adjacent roadways. Therefore, it is appropriate to incorporate roads into the adjacent land uses.

“No exposure industrial” is a new category that has been developed to separate traditional industrial activities from activities that are classified as industrial by their Standard Industrial Classification (SIC) code but do not have any exposure to stormwater. This includes industries such as high-tech manufacturing areas where industrial activities are conducted inside buildings. The District’s Source Control Section verifies industrial stormwater “no exposure” findings and maintains a database of such facilities. Since these facilities do not have stormwater exposure to industrial activities, it is appropriate to handle them as commercial facilities which would include structures such as office buildings. However, the bacteria levels for this category are expected to be lower than bacteria levels found in the commercial land use category. Therefore, the bacteria levels in the industrial category were also used for the “no exposure industrial” category.

The ACWA data for the “public open space” category were also used to represent rural land uses. This is because rural lands within the District service area do not constitute heavy agricultural use; they typically represent wooded land, large acreage lots, hobby farms, etc.

Most of the bacteria data in the 1990-1996 ACWA database were fecal coliform bacteria. This was because fecal coliform was the bacteria standard during most of the time period when the data were collected. In 1996, DEQ adopted an E. coli bacteria standard and municipalities are currently monitoring for this parameter. Since there were limited E. coli data in the 1990-1996 database, paired E. coli and fecal coliform data from the District and the City of Portland were used to develop a ratio. This ratio was used to calculate E. coli bacteria values from the fecal coliform dataset.

Best Management Practices

Two categories of BMPs were considered in calculating storm water pollutant loads: structural and non-structural. Structural BMPs are the physical structures that are used to treat stormwater runoff; a GIS point file was developed that contains information regarding structural BMPs (location, area served, and type). Non-structural BMPs include operation and maintenance (O&M) practices (e.g., street sweeping, catch basin cleaning, and illicit discharge prevention) and public education programs.

There are few or no literature data to assess the cumulative effect of O&M practices and public education programs. Most studies tend to evaluate the effectiveness of a single type of O&M practice such as street sweeping or catch basin cleaning. Furthermore, there is little or no information regarding the effectiveness of public education programs in reducing pollutant loads. Using the sum of literature removal efficiencies for each O&M program being implemented may overestimate the effectiveness of non-structural BMPs.
To gauge the effectiveness of non-structural BMPs, the land use data in the original ACWA study (1993-1996) were compared with more recent data. Since non-structural practices were in their infancy when the data for the original ACWA study were gathered, a comparison of the two land use data sets provides a method to estimate the effectiveness of non-structural BMPs. Recent land-use-based data from Clean Water Services and Portland for phosphorus and TSS were pooled and compared with the original ACWA land use data. A reduction percent based on this comparison was applied to the land use concentrations from the original ACWA study. This approach was presumed to capture the cumulative effect of all non-structural management practices being implemented in a watershed. No reductions were assumed for bacteria because there are few or no data regarding the effectiveness of non-structural management practices in reducing bacteria levels. The commonly employed non-structural BMPs were not designed to reduce bacteria in stormwater.

Table 2 presents a comparison of phosphorus and TSS concentrations based on 25 percent and 40 percent reduction, respectively, from the land use based median EMC levels presented in Table 1. These percent reductions were used as being indicative of the effectiveness of non-structural management practices. Overall, this approach provides a conservative (i.e., protective) approach because the percent-reduction-derived values are usually higher than measured influent values.

<table>
<thead>
<tr>
<th>Land Use Categories</th>
<th>Total Phosphorus</th>
<th>Total Suspended Solids</th>
<th>Source of Recent Land Use Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conc. Based on 25% Reduction of Table 1 Values (land-use-based EMCs)</td>
<td>Recent Land Use Data</td>
<td>Conc. Based on 40% Reduction of Table 1 Values (land-use-based EMCs)</td>
</tr>
<tr>
<td>Residential</td>
<td>0.16 mg/L</td>
<td>0.15 mg/L</td>
<td>23 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>District data; TSS value is average of median District residential data</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>0.19 mg/L</td>
<td>0.19 mg/L</td>
<td>33 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PDX data</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>0.41 mg/L</td>
<td>0.38 mg/L</td>
<td>55 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PDX data; this may be higher than industrial sites in the District area, which has very little traditional industrial areas</td>
<td></td>
</tr>
<tr>
<td>Multi-use</td>
<td>0.17 mg/L</td>
<td>0.17 mg/L</td>
<td>28 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average of Residential and Commercial</td>
<td></td>
</tr>
<tr>
<td>Public Open Space</td>
<td>0.13 mg/L</td>
<td>0.07 mg/L</td>
<td>10 mg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Best of PDX sites</td>
<td></td>
</tr>
</tbody>
</table>
The following table presents BMP type, the number of BMPs in the District’s database, along with BMP effluent concentrations and flow reduction percentages that are indicative of the performance of the structural BMP.

### TABLE 3
Structural BMP Type, Number, and Effectiveness (median effluent concentrations)

<table>
<thead>
<tr>
<th>Description</th>
<th># in District Database</th>
<th>TP (mg/L)*</th>
<th>TSS (mg/L)*</th>
<th>Percent Flow Reduction*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructed Wetland</td>
<td>9</td>
<td>0.08</td>
<td>7</td>
<td>5%</td>
</tr>
<tr>
<td>Wet Pond</td>
<td>139</td>
<td>0.14</td>
<td>16</td>
<td>7%</td>
</tr>
<tr>
<td>Extended Dry Pond</td>
<td>513</td>
<td>0.14</td>
<td>16</td>
<td>30%</td>
</tr>
<tr>
<td>Compost Filter Facility</td>
<td>67</td>
<td>0.12</td>
<td>13</td>
<td>0%</td>
</tr>
<tr>
<td>Swale</td>
<td>668</td>
<td>0.13</td>
<td>13</td>
<td>38%</td>
</tr>
<tr>
<td>Retention Basin</td>
<td>21</td>
<td>0.14</td>
<td>16</td>
<td>7%</td>
</tr>
<tr>
<td>Unknown</td>
<td>130**</td>
<td>0.14</td>
<td>16</td>
<td>5%</td>
</tr>
</tbody>
</table>

*ACWA Committee Recommendations

**The “unknown” BMP type lists BMPs that were installed but were not classified into a specific category. Where possible and as information becomes available, the District has been re-classifying these BMPs into one of the other types.

The BMP effluent concentrations and flow reduction percentages are primarily based on information compiled by an ACWA Committee that reviewed BMP performance data from several sources. The ACWA Committee’s recommendations are presented in a document titled *Storm Water BMP Effectiveness Report* (May 9, 2005). For phosphorus and TSS, the effluent concentrations for swales were based on District data (and not the ACWA Committee’s report) because the national data considered in developing the EMCs were above the land-use-based EMC values presented in Table 1. The wet pond effluent data for phosphorus and TSS were used as being representative for extended dry ponds also; this is because most of the District ponds are wet, vegetated ponds, even though the BMP database lists them as dry ponds.

### Stormwater Pollutant Load Modeling Results for TMDL Parameters

Baseline loads were calculated using the GIS watershed/land use file, the EIA data, and the land-use based median EMC values presented in Table 1. The baseline loads represent pollutant loads without non-structural and structural BMPs.

Current loads were calculated using the same GIS watershed/land use file and impervious data used to calculate the baseline loads. The land-use-based EMC values were reduced by
the percentages presented in Table 2 to reflect effectiveness of non-structural management practices. A GIS point file that contains information about the structural BMPs was also used. The flow reduction percentages and BMP effluent concentrations presented in Table 3 were used to account for the effectiveness of structural BMPs.

**PLOAD Model Runs: Bacteria**

The model runs for bacteria in the 2001 Tualatin TMDL were based on a typical summer and typical winter storm. The summer design storm was 0.11 inch (in 24 hours) and the winter design storm was 1.96 inches (in 96 hours).

Average bacteria concentrations based on the contributions from the various land uses in a sub-watershed (i.e., spatially averaged bacteria concentrations) and MS4 WLAs for bacteria (i.e., summer and winter TMDL concentrations) are presented Figure 4. The TMDL explicitly provides that bacteria concentrations may be used to assess monitoring data and provide targets for runoff quality. Note that while the bacteria load resulting from the summer and winter storms would be different, the spatially averaged concentrations will be the same. This is because seasonally adjusted land-use-based EMCs were not available.

![Stormwater Pollutant Load Modeling Results for Bacteria and TMDL WLAs](image)

**FIGURE 4**

*Stormwater Bacteria Concentrations in Tualatin Sub-basins*

The results show that bacteria counts (without accounting for dilution or decay as allowed in the TMDL) in all sub-watersheds, except Rock Creek, meet the TMDL concentrations for summer and winter design storm conditions. The Rock Creek sub-watershed does not meet TMDL bacteria concentrations during the winter.
As discussed below in this appendix, DEQ’s bacteria TMDL accounted for decay during overland runoff. It also accounted for both base flow dilution and further decay instream to the mouth of each sub-watershed. PLOAD does not account for any decay or base flow dilution. However, the importance of decay and dilution can be determined with the spreadsheets DEQ used to determine MS4 WLAs that included instream decay and dilution (e.g., see spreadsheet named “winter wlas w dma boundaries and new decay.xls” circa January 2001). The spreadsheet for the Rock Creek sub-watershed predicts that the bacteria concentration at the mouth is 520 cts/100 mL when instream decay and dilution are turned off. When instream decay and dilution are turned on, the concentration at the mouth is 117 cts/100 mL (a decrease by a factor of 4.4). If this factor were applied to the Rock Creek concentration predicted by PLOAD, it is apparent that the average bacteria concentration in winter also would comply with the TMDL concentration. The DEQ spreadsheet does not account for overland runoff decay effects, which are accounted for in their Access model. If this were considered here, it would further reduce the PLOAD-predicted value.

Even though the results show bacteria goals established by the TMDL are mostly being met in the District’s portion of the Tualatin watershed, the District is aware that bacteria levels are an issue in the watershed. The District is continuing to implement capital projects and management activities to reduce bacteria loads. The District has recently completed a DNA “fingerprinting” program to determine the sources of bacterial pollution at various locations in the Tualatin watershed. The results of the program are being used to develop targeted management practices to further reduce bacterial pollution.

**PLOAD Model Runs: Phosphorus**

Baseline and current pollutant loads were calculated using a cumulative rainfall of 8.2 inches during the TMDL period (May–October) with 83 percent of the rainfall resulting in runoff. These are consistent with the rainfall intensities and durations used in the 2001 Tualatin TMDL.

The resulting total phosphorus loads for each sub-watershed (except for the Upper Tualatin) along with the cumulative phosphorus load are presented in Figure 5. Using the City of Portland’s statistical analysis of land use based concentration data, an upper and lower confidence interval has been added to the total phosphorus load predictions (represented by the “whiskers” on the bar graph). For phosphorus, a confidence interval of ±50% was used for the pollutant load predictions. The results represent the District’s best estimate of the general range of variability with regards to the total phosphorus pollutant load model results.
FIGURE 5
Total Phosphorus in Stormwater during Dry Season (May–October)

The Middle Tualatin phosphorus load in the TMDL does not reflect changes that were made to the phosphorus concentrations for the tributaries. Phosphorus concentrations for most tributaries were changed from 0.09 mg/L in the draft TMDL to 0.12–0.14 mg/L in the final TMDL. However, the mass load for phosphorus in the final TMDL (234.9 lb/TMDL season) was not adjusted to reflect the increased phosphorus concentrations assigned to the tributaries. The TMDL load for the Middle Tualatin presented in Figure 5 has been adjusted to reflect the higher tributary concentrations (339 lb/TMDL season).

For phosphorus, the pollutant load in the Rock Creek sub-watershed after implementation of all BMPs is below the TMDL load. In the other sub-watersheds, the pollutant loads are above the TMDL loads. While the TMDL assigns pollutant loads (WLAs) on a sub-watershed basis, the location of the primary effect of the phosphorus loading is on the lower portion of the Tualatin River. This is consistent with the TMDL - section 4.4.9.2 of the Tualatin Sub-basin TMDL states the following:

_The loading capacities – and therefore the allocations – contained in this portion of the TMDL were developed to address water quality issues specific to the lower mainstem Tualatin River. As such, the aggregate loading from all sources to the lower mainstem is the critical factor. Therefore, the allocations given to each DMA in Table 49 may be met by addressing the aggregate of the 5th-field subbasin loadings for the DMA._
Thus, the aggregate phosphorus loading to the lower Tualatin River was evaluated. The aggregate phosphorus loading predicted by PLOAD ranges from 2700 to 8200 lbs/TMDL season with a median of 5523 lbs/TMDL season; whereas, the aggregate TMDL load is 5,199 lb/TMDL season.

Tualatin River data show that the median TMDL phosphorus concentrations are being met in the lower Tualatin River; 2000-2007 data from two locations in the lower Tualatin River along with the TMDL concentrations at those locations are presented in Figure 6.

![Summer Median Total Phosphorus Concentrations in the Tualatin River](image)

**FIGURE 6**
Summer Median Total Phosphorus Concentrations in the Tualatin River

**PLOAD Model Runs: Settleable Volatile Solids**

The 2001 Tualatin TMDL established percent reduction allocations for settleable volatile solids (SVS) related to reducing sediment oxygen demand (SOD). This was done to improve DO concentrations, particularly in some of the tributaries streams. These reductions were expressed in terms of SVS because it was assumed that settling organic matter is the primary contributor of SOD. However, there are no established SVS procedures, and hence no SVS data. Therefore, TSS was used as an available surrogate parameter as allowed by the 2001 TMDL. TSS data are available for EMCs and BMPs.

The same hydrologic and seasonal conditions that were used for TP were also used for TSS. This is because the TMDL determined that the critical season for DO effects is also the summer and early fall, and set the TMDL period to be May through October.
The resulting TSS loads for each sub-watershed (except for the Upper Tualatin) are presented in Figure 7. Using the City of Portland’s statistical analysis of land use based concentration data, an upper and lower confidence interval has been included in the TSS load predictions (represented by the “whiskers” on the bar chart). For TSS, a confidence interval of ±50% was used for the pollutant load predictions. The results represent the District’s best estimate of the general range of variability with regards to the TSS pollutant load model results.

As noted in Table 2, structural BMP influent data support the use of a 40 percent reduction in TSS from land-use-based EMC levels. The Tualatin TMDL requires a 20 percent to 30 percent reduction in TSS levels in each sub-watershed except the Lower Tualatin, which requires a 50 percent reduction. Thus, the required TSS reductions are being met in all the sub-watersheds except the Lower Tualatin.

**Annual Stormwater Pollutant Load Estimates**

The original Part 2 application included pollutant load estimates for biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids, nitrate, total kjeldahl nitrogen (TKN), total phosphorus, ortho-phosphate, cadmium, copper, lead and zinc. This section updates the pollutant load calculations in the original Part 2 application.
The original pollutant load calculations were conducted in 1994 and were based on District stormwater sample data and supplemented by the National Urban Runoff Program (NURP) data. The updated annual pollutant load estimates were developed on a TMDL sub-basin level and were based on the following assumptions:

- **Permit Area:** The annual pollutant load estimates are based on the permit area at the time of permit renewal (i.e., 2008).

- **Land Use Data:** The annual pollutant load estimates are based on zoned land uses at the time of permit renewal. Note that this is different than the land use file used for modeling the TMDL pollutants; the TMDL pollutant land use files represent current conditions and include a “vacant” layer which is overlaid onto the zoned land uses.

- **Stormwater Data:** The geometric mean concentrations from the ACWA land use study were used to estimate the annual pollutant loads and are presented in Table 4.

- **Load Reduction from BMPs:** Non-structural and structural BMPs effectiveness information was used in estimating the annual pollutant loads. Non-structural BMP effectiveness was based on the approach noted in Section 5.3.1.1. Structural BMP effectiveness was mostly based on work done by the ACWA Rangers and supplemented by information in the ACWA BMP database. The flow reduction percentages used in the TMDL calculations (Table 3) were based on expected reductions during the TMDL season (May-October). Year-around flow reduction percentages were not available. Therefore, the annual pollutant load estimates did not include a flow reduction component for structural BMPs.

The PLOAD model was used to conduct the annual pollutant load estimates. The following inputs were used to run the PLOAD model and to calculate annual pollutants loads:

- **GIS files:**
  - Zoned land use: GIS land use file obtained from Metro
  - Structural BMPs –GIS point file with location, type and acreage associated with each structural BMP

- **Lookup Tables:**
  - Impervious Area (use of effective impervious area as discussed earlier in this section)
  - Land use based EMCs (ACWA geometric mean concentrations for pollutants of concern (Table 4)
  - Non-structural BMP effluent concentration (25% removal efficiency was used for most pollutants except TSS (40%) and TDS (0%).
  - Structural BMP effluent concentrations based on work done by the ACWA Rangers and supplemented by information in the ACWA BMP database (Table 5).
The results of the calculations are presented in Table 6. It should be noted that the annual pollutant load estimates presented in Table 6 do not include the same assumptions as those made in the original Part 2 application and therefore, are not comparable with those in the original application.
### TABLE 4
Land-Use-Based EMCs
*From ACWA Data: 1990–1996*

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>BOD</th>
<th>COD</th>
<th>TSS</th>
<th>TDS</th>
<th>NO3</th>
<th>TKN</th>
<th>TP</th>
<th>Ortho-P</th>
<th>Cadmium</th>
<th>Copper</th>
<th>Lead</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>5.8</td>
<td>33.4</td>
<td>43.2</td>
<td>45</td>
<td>0.37</td>
<td>0.84</td>
<td>0.21</td>
<td>0.05</td>
<td>0.0003</td>
<td>0.01</td>
<td>0.01</td>
<td>0.069</td>
</tr>
<tr>
<td>Multi-family</td>
<td>5.8</td>
<td>33.4</td>
<td>43.2</td>
<td>45</td>
<td>0.37</td>
<td>0.84</td>
<td>0.21</td>
<td>0.05</td>
<td>0.0003</td>
<td>0.01</td>
<td>0.01</td>
<td>0.069</td>
</tr>
<tr>
<td>Commercial</td>
<td>7.4</td>
<td>47.2</td>
<td>55.6</td>
<td>69</td>
<td>0.36</td>
<td>1.00</td>
<td>0.25</td>
<td>0.05</td>
<td>0.0005</td>
<td>0.022</td>
<td>0.026</td>
<td>0.115</td>
</tr>
<tr>
<td>Industrial</td>
<td>18</td>
<td>81</td>
<td>93.2</td>
<td>77</td>
<td>0.30</td>
<td>1.53</td>
<td>0.55</td>
<td>0.05</td>
<td>0.00078</td>
<td>0.032</td>
<td>0.021</td>
<td>0.251</td>
</tr>
<tr>
<td>Multi-use</td>
<td>6.6</td>
<td>40.3</td>
<td>49.4</td>
<td>57</td>
<td>0.37</td>
<td>0.92</td>
<td>0.23</td>
<td>0.05</td>
<td>0.0004</td>
<td>0.016</td>
<td>0.018</td>
<td>0.092</td>
</tr>
<tr>
<td>Public Open Space</td>
<td>3.7</td>
<td>19</td>
<td>24.7</td>
<td>106</td>
<td>1.60</td>
<td>0.69</td>
<td>0.17</td>
<td>0.09</td>
<td>0.00017</td>
<td>0.004</td>
<td>0.002</td>
<td>0.012</td>
</tr>
<tr>
<td>Vacant</td>
<td>3.7</td>
<td>19</td>
<td>24.7</td>
<td>106</td>
<td>1.60</td>
<td>0.69</td>
<td>0.17</td>
<td>0.09</td>
<td>0.00017</td>
<td>0.004</td>
<td>0.002</td>
<td>0.012</td>
</tr>
<tr>
<td>Rural</td>
<td>3.7</td>
<td>19</td>
<td>24.7</td>
<td>106</td>
<td>1.60</td>
<td>0.69</td>
<td>0.17</td>
<td>0.09</td>
<td>0.00017</td>
<td>0.004</td>
<td>0.002</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Note that the values presented herein are the geometric concentrations from the ACWA land use study.

TDS, NO3 for POS/VAC/RUR land use categories and ortho-P calcs by CWS; not enough data to calc EMC values for ortho-P for all land uses.

Cadmium calculations based on using entire land use based data set (not site based geometric means) and assuming one-half detection limit for NDs.

Multi-use assumed to equal average of residential and commercial land uses.

Vacant and rural assumed equal to open space.
### TABLE 5

<table>
<thead>
<tr>
<th>Description</th>
<th>BOD</th>
<th>TSS</th>
<th>NO2+NO3</th>
<th>TKN</th>
<th>TP</th>
<th>Ortho-P</th>
<th>Copper</th>
<th>Lead</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jurisdictional Wetland</td>
<td>6</td>
<td>25</td>
<td>0.19</td>
<td>1.1</td>
<td>0.16</td>
<td>0.04</td>
<td>0.003</td>
<td>0.001</td>
<td>0.017</td>
</tr>
<tr>
<td>Constructed Wetland</td>
<td>6</td>
<td>25</td>
<td>0.19</td>
<td>1.1</td>
<td>0.16</td>
<td>0.04</td>
<td>0.003</td>
<td>0.001</td>
<td>0.017</td>
</tr>
<tr>
<td>Wetpond</td>
<td>6</td>
<td>29</td>
<td>0.1</td>
<td>0.95</td>
<td>0.16</td>
<td>0.035</td>
<td>0.007</td>
<td>0.0018</td>
<td>0.032</td>
</tr>
<tr>
<td>Extended Dry Pond</td>
<td>12</td>
<td>43</td>
<td>0.22</td>
<td>1.6</td>
<td>0.35</td>
<td>0.065</td>
<td>0.02</td>
<td>0.018</td>
<td>0.083</td>
</tr>
<tr>
<td>Compost Filter Facility</td>
<td>2.5</td>
<td>43</td>
<td>0.25</td>
<td>1.5</td>
<td>0.29</td>
<td>0.036</td>
<td>0.009</td>
<td>0.003</td>
<td>0.044</td>
</tr>
<tr>
<td>Swale</td>
<td>3</td>
<td>32</td>
<td>0.28</td>
<td>1.5</td>
<td>0.42</td>
<td>0.05</td>
<td>0.012</td>
<td>0.0074</td>
<td>0.047</td>
</tr>
<tr>
<td>Retention Basin</td>
<td>6</td>
<td>29</td>
<td>0.1</td>
<td>0.95</td>
<td>0.16</td>
<td>0.035</td>
<td>0.007</td>
<td>0.0018</td>
<td>0.032</td>
</tr>
</tbody>
</table>

Notes: No removal assumed for COD, TDS and cadmium
TABLE 6
Annual Pollutant Load Estimates with and without BMPs

<table>
<thead>
<tr>
<th>Sub-watershed</th>
<th>Area (acres)</th>
<th>BOD</th>
<th>COD</th>
<th>TSS</th>
<th>TDS</th>
<th>Total Phosphorus</th>
<th>Ortho-phosphate</th>
<th>Nitrate</th>
<th>Total Kjeldahl Nitrogen</th>
<th>Cadmium</th>
<th>Copper</th>
<th>Lead</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gales</td>
<td>640</td>
<td>7,500</td>
<td>33,000</td>
<td>37,400</td>
<td>101,000</td>
<td>260</td>
<td>70</td>
<td>820</td>
<td>1,080</td>
<td>0.3</td>
<td>12</td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td>Dairy</td>
<td>6,500</td>
<td>112,000</td>
<td>613,000</td>
<td>601,000</td>
<td>1,055,000</td>
<td>4,200</td>
<td>720</td>
<td>5,300</td>
<td>15,500</td>
<td>6</td>
<td>220</td>
<td>190</td>
<td>1,400</td>
</tr>
<tr>
<td>Middle</td>
<td>8,050</td>
<td>108,000</td>
<td>545,000</td>
<td>578,000</td>
<td>1,313,000</td>
<td>4,200</td>
<td>930</td>
<td>8,900</td>
<td>16,300</td>
<td>5</td>
<td>200</td>
<td>175</td>
<td>1,180</td>
</tr>
<tr>
<td>Rock</td>
<td>33,600</td>
<td>463,000</td>
<td>2,491,000</td>
<td>2,656,000</td>
<td>5,453,000</td>
<td>19,200</td>
<td>4,000</td>
<td>32,100</td>
<td>80,000</td>
<td>23</td>
<td>890</td>
<td>800</td>
<td>5,000</td>
</tr>
<tr>
<td>Lower</td>
<td>23,800</td>
<td>328,000</td>
<td>1,793,000</td>
<td>1,798,000</td>
<td>3,778,000</td>
<td>11,800</td>
<td>2,600</td>
<td>24,000</td>
<td>44,900</td>
<td>17</td>
<td>620</td>
<td>570</td>
<td>3,960</td>
</tr>
<tr>
<td>Cumulative with all BMPs</td>
<td>72,590</td>
<td>1,018,500</td>
<td>5,475,000</td>
<td>5,670,400</td>
<td>11,700,000</td>
<td>39,660</td>
<td>8,320</td>
<td>71,120</td>
<td>157,780</td>
<td>51</td>
<td>1,942</td>
<td>1,745</td>
<td>11,610</td>
</tr>
<tr>
<td>Cumulative with no BMPs</td>
<td>72,590</td>
<td>1,308,100</td>
<td>7,290,800</td>
<td>9,079,000</td>
<td>11,700,000</td>
<td>46,200</td>
<td>10,800</td>
<td>103,700</td>
<td>175,400</td>
<td>68</td>
<td>2,400</td>
<td>2,500</td>
<td>16,200</td>
</tr>
</tbody>
</table>
Attachment

Effective Impervious Area Documentation