9.0 POLLUTANT LOADINGS FOR MUNICIPAL STORM OUTFALLS AND REMOVAL BY ASSOCIATED BMPs

Annual stormwater loadings from municipal outfalls in Frederick County were calculated using the Simple Method (Schueler 1987) for each pollutant of interest. The Simple Method computes stormwater pollutant loading as a function of annual rainfall (P), percent imperviousness (I), area (A), pollutant concentration (C), and conversion factors. In addition, it employs a correction factor (P_j) to account for the fraction of storms that produce runoff. Values for the equation variables were taken from published literature and laboratory data. Analytical results from Part 2 outfall sampling, completed in 1999, were incorporated into the Simple Method formula to estimate pollutant loads for each of the identified municipal storm outfalls. Results of pollutant loading calculations for each outfall have been submitted on the accompanying CD. Calculation factors for outfall pollutant loading estimates and reductions by associated structural BMPs were derived in the following manner:

- The annual rainfall volume (P) for Frederick County was determined as the average of historic yearly rainfall data (1961-1990) taken from the NOAA annual summary for the Emmitsburg 2 SE site.

- The value for the correction factor, P_j, was taken from Schueler (1987). For all calculations, P_j was assumed to be 0.9.

Schueler (1987; Section 1.2.2) provides a range of values for percent imperviousness for each specific land use (Table 9.1). The median number from each range was calculated and used in the Simple Method calculation. For mixed land uses, the ranges for the individual land uses were combined, and the median value was used. ‘PARK’ was set to the same as ‘OTHER’.

BMP pollutant removal efficiency values were taken from Schueler (1987), Schueler (1997a), Schueler (1997b), Winer (2000), and Simpson and Weammert (2009) (Table 9-2). In cases of combined BMP use, the maximum removal efficiency was used except if one of the values was negative, then the values were added together. Note that in a few cases, removal efficiencies are negative values, indicating that these BMPs result in a release of some constituents. Winer (2000) explains that in the case of dissolved phosphorus, organic or sediment bound forms of the nutrient are transformed within certain structural BMPs and flushed out during subsequent storm events. Presumably similar processes occur for TSS, TP, and Cu within oil/grit separators as indicated in the table.

Concentration values are given as flow-weighted EMCs calculated from Part 2 stormwater sampling in Frederick County. Grab samples were collected from three storms at five different sites. From the flow values measured at each grab sample time, the total storm volume was calculated. A volume-weighted average was used to determine the mean concentration for each pollutant from all 15 storm events. The EMC of each pollutant for a particular storm (Table 9-3) was multiplied by the total volume of water for that storm to find the total mass of pollutant. The flow-weighted EMC for a given pollutant was determined to be the total mass of pollutant for the 15 storms, divided by total storm volume. See Table 9-2 for the concentrations used.

Table 9-1. Percent imperviousness for each specific land use (adapted from Schueler 1987)	
Land Use Category	**% Imperviousness**
Commercial (COM)	70
Residential (RES)	30
Institutional (INS)	50
Mixture (MIX)	70
Agricultural (AG)	0
Industrial (IND)	70
Other (OTH)	15
Park Lands (PARK)	15

Table 9-2. Percent removal of pollutants by stormwater management structure type (2010)

	TSS	**TP**	**TN**	**COD**	**BOD**	**Cd**	**Cu**	**Pb**	**Zn**	**TKN**	**TDS**	**Diss. Phos.**
Dry Pond (DP)	52	45	27	-1	-1	54	**10**	43	**5**	ND	ND	**0**
Dry Well (DW), Underground Structure (UGS), and Underground Device (UNG)	0	0	0	0	0	0	0	0	0	0	0	**0**
Extended Dry Detention Pond (EDSD) and Extended Detention Device (EDD)	60	20	20	25	25	54	**26**	43	**26**	ND	ND	**-11**
Extended Wet Detention Pond (EDSW)	60	45	20	27	27	24	**44**	73	**69**	ND	ND	**67**
Infiltration Basin (IB) [a]	95	85	80	80	80	75	75	75	75	ND	ND	ND
Infiltration Trench (IT) and Complete Exfiltration (ITCE)	95	85	80	66	66	ND	34	71	80	ND	ND	**100**
Oil/Grit Separator (OGS) [b]	**-8**	**-41**	15	ND	ND	ND	**-11**	10	**17**	21	ND	**40**
Sand Filter (SF) and Water Quality Exfiltration (ITWQE)	80	60	40	67	67	ND	**49**	ND	**88**	ND	ND	**3**
Shallow Marsh (SM)	60	45	20	21	21	69	**33**	63	**42**	ND	ND	**29**
Swale (SW), Bioretention (BIO), and Vegetative Filter (VEG)	80	75	70	67	67	42	**51**	67	**71**	ND	ND	**38**
Wet Pond (WP) and Retention (RTN)	60	45	20	45	45	24	**58**	73	**65**	ND	ND	**62**

Numbers in Red from:
Simpson, T. and S. Weammert. 2009. Developing Nitrogen, Phosphorus and Sediment Reduction Efficiencies for Tributary Strategy Practices. BMP Assessment: Final Report. University of Maryland/Mid-Atlantic Water Program. Available at: http://archive.chesapeakebay.net/pubs/bmp/BMP_ASSESSMENT_FINAL_REPORT.pdf

Numbers in Bold information from:
Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Prepared by Center for Watershed Protection for USEPA Office of Science and Technology.

Other (non-bold) information from:
Schueler, T. R. Technical Note 95. Comparative Pollutant Removal Capability of Urban BMPs: A Reanalysis. Watershed Protection Techniques. Vol. 2, No. 4. June 1997 except as noted below:

[a] (numbers not in red) Schueler, T. R. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Department of Environmental Programs Metropolitan Washington Council of Governments. July, 1987 Washington Metropolitan Water Resources Planning Board.

[b] Schueler, T.R. Technical Note 101. Performance of Oil-Grit Separators in Removing Pollutants at Small Sites. Watershed Protection Techniques. Vol. 2, No. 4 June 1997.

ND = No data available.

Table 9-3. Event mean concentrations (EMC) for each parameter used for estimating pollutant loads (Schueler 1987)

Parameter	Concentration (mg/L)
TSS	15.21
TP	0.13
TN	1.80
COD	13.65
BOD5	4.34
Cd	0.0004
Cu	0.0095
Pb	0.0046
Zn	0.0644
TKN	1.03
TDS	94.40
Diss. Phosphorus	0.09

Load=[(P)(P_j)(R_v)/12]*(C)(A)(2.72)
P=annual precipitation (inches)=43.8 C=concentration in mg/L
P_j=fraction of events that produce runoff=0.9
R_v=0.05+0.009(I) 2.72=conversion to pounds

Area values were supplied by the County's SWM facility database (current as of December 31, 2010), which provides both a total drainage area and a managed drainage area for each site. Between 2009 and 2010, total evaluated drainage area increased from 13,391 to 15,155 acres and total managed drainage area increased from 10,935 to 12,156 acres. In 2010, 80.2% of the total evaluated drainage area was managed and that value increased from 78.5% in 2009. To calculate annual loading in the absence of any BMPs, the total drainage area value was used; these are summarized by BMP type in Appendix D (Table D-1). The managed annual loading was found from the sum of the following two individual loading values. The first was calculated using the area managed by the BMPs, multiplied by the removal efficiency. The second loading value was calculated with an area equal to total area minus the managed area. These values were then summed to provide a loading estimate with the BMPs in place; a summary listing of these results is provided by BMP type in Appendix D (Table D-2). The difference between loadings with and without BMPs provides an estimate of pollutant removals by these BMPs (Appendix D, Table D-3); a percentage removal by BMP type, and pollutant, is presented in Appendix D (Table D-4) and Figure 9-1. Similar estimates can be made on a per-acre basis (Appendix D, Tables D-5 and D-6).

Extended Dry Detention Ponds, Infiltration Trenches, Extended Wet Detention Ponds, Bioretention Areas, and Dry Ponds make up 70% of the structural BMPs in Frederick County (29.7%, 13.0%, 9.6%, 9.1%, and 8.8%, respectively) (Figure 9-2). Results show that on a total removal basis Extended Wet and Dry Detention Ponds remove the most pollutants because of their dominance in total drainage area covered (44.8%; Figure 9-3). Extended Wet Detention Ponds are most efficient, removing an average 26.9% of all pollutants considered. Extended Wet Detention Ponds removed the most copper, lead, dissolved phosphorus, total phosphorus, and zinc (Figure 9-1, Appendix D-3). Extended Dry Detention Ponds were slight lower in overall removal rates, averaging 17.9% of all pollutants considered (Figure 9-3). Extended Dry

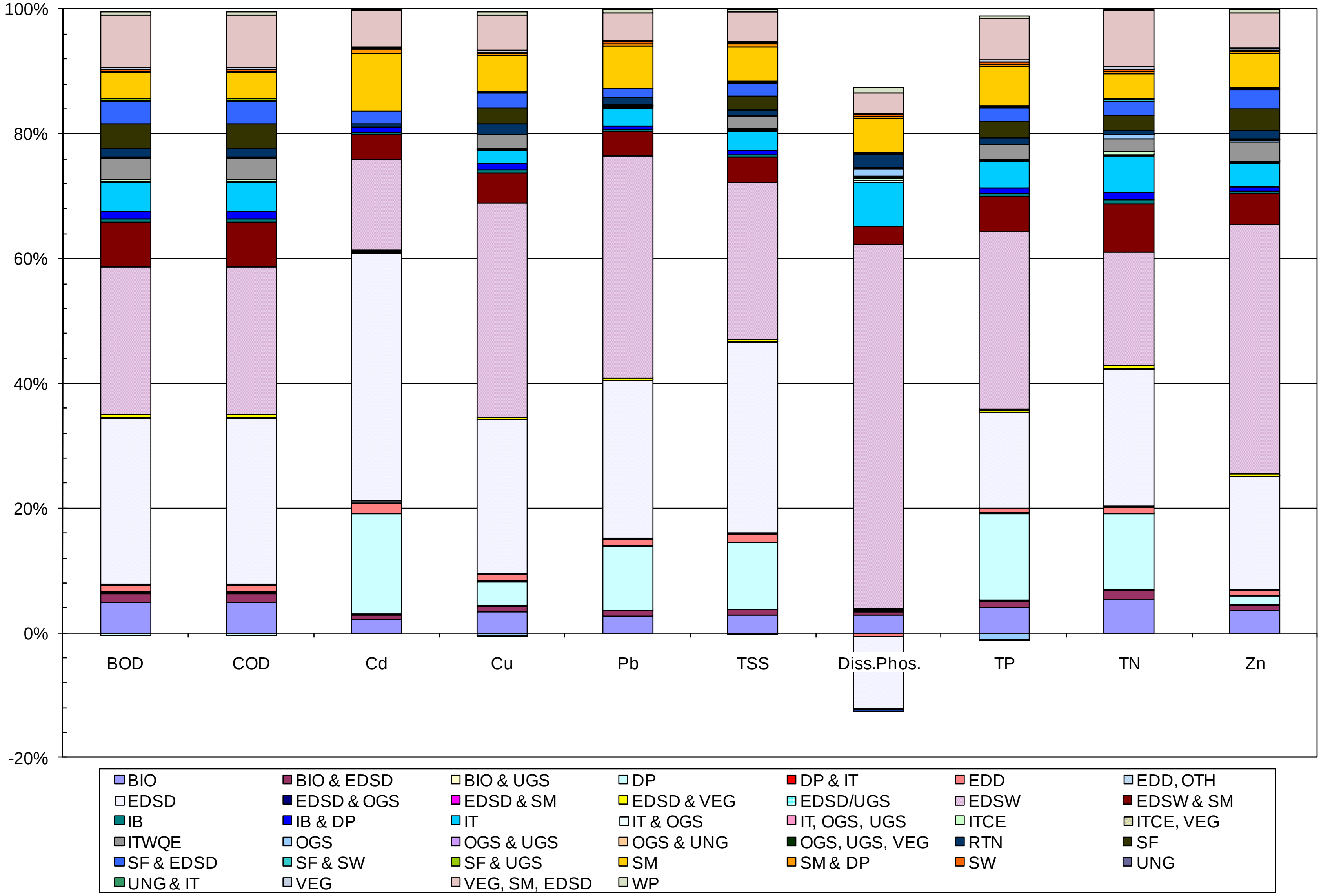

Figure 9-1. Percent pollutant removal by BMP type for Frederick County outfalls based on the Simple Method

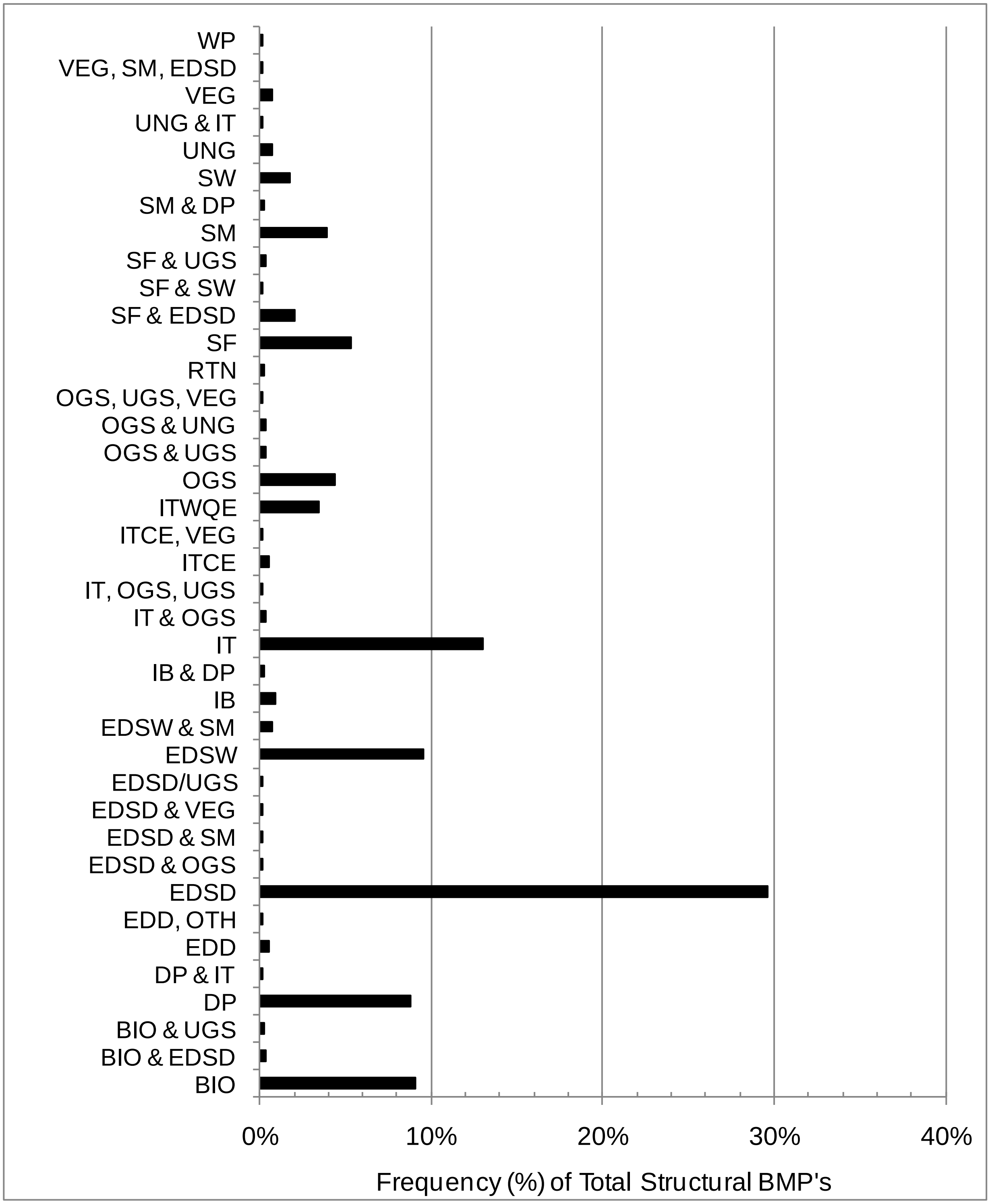

Figure 9-2. Frequency of total structural BMPs in Frederick County.

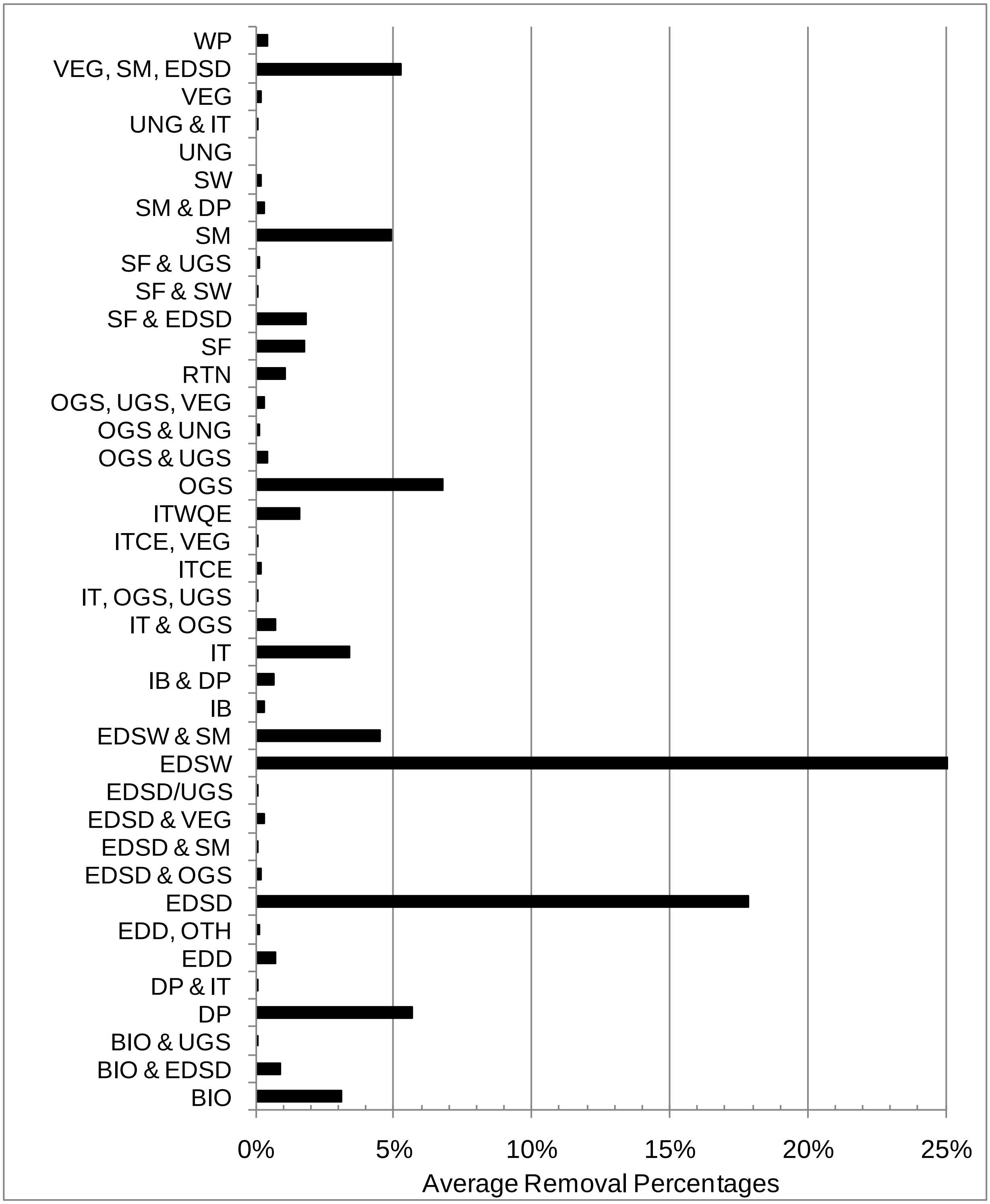

Figure 9-3. Average percent pollutant removals by BMP type for Frederick County outfalls based on the Simple Method.

Detention Ponds were most efficient at removing BOD, COD, cadmium, total suspended solids, and total nitrogen (Figure 9-1, Appendix D-3). Overall, these results are a function of area covered by BMP and their removal efficiencies.

On a per acre basis, removal percentages are much more uniform (Appendix D-6). Combined Infiltration Basins with Dry Ponds removed the greatest percentage of BOD, COD, cadmium, cooper, lead, and total phosphorus, while combined Infiltration Trenches and Dry Ponds removed the greatest percentage of dissolved phosphorus and total suspended solids. A combination of Infiltration Trench, Oil/Grit Separator, and Underground Device had the greatest removal percentage for TKN, total nitrogen, and zinc.

An overall summary of pollutant removals at outfalls in Frederick County, by associated management practices, is listed in Table 9-4. These results show that 49.7% of total suspended solids are removed by these facilities, with only 23% and 32.4% of total nitrogen and phosphorus being removed, respectively. These facilities also remove 17.9% of dissolved phosphorus and 23.7% of carbon (BOD and COD). Removal of metals ranged from 26.6% to 43.1%. One BMP structure in the database changed practice type category from Dry Pond in 2008 to Extended Wet Detention Pond in 2009. To make the results comparable across years, this BMP was reassigned in the 2008 database and recalculated.

Table 9-4. Summary of percent pollutant removal by stormwater BMPs

	2010 Total Loadings	**2010 Net Removal**	**2010 Percent Removal**	**2009 Percent Removal**	**2008 Percent Removal***
Total Evaluated Drainage Area, ac	15,155				
Managed Drainage Area, ac		12,156			
TSS (lbs.)	882,263	438,167	49.7%	48.1%	47.8%
Total Phos (lbs.)	7,541	2,445	32.4%	31.0%	30.6%
TN (lbs.)	104,410	24,064	23.0%	22.6%	22.2%
COD (lbs.)	791,775	187,577	23.7%	22.4%	21.9%
BOD (lbs.)	251,744	59,640	23.7%	22.4%	21.9%
Cadmium (lbs.)	23	8	34.5%	34.4%	34.4%
Copper (lbs.)	551	147	26.6%	25.1%	24.8%
Lead (lbs.)	267	115	43.1%	41.6%	41.6%
Zinc (lbs.)	3,736	1,353	36.2%	33.5%	32.9%
TKN (lbs)	59,746	127	0.21%	0.23%	0.26%
TDS	5,475,716	0	0%	0%	0%
Diss Phos (lbs.)	5,220	937	17.9%	16.1%	16.0%

* using 2009 removal efficiency values