Storm Water BMP Effectiveness Workgroup Report   **Date: 5/9/2005**

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Workgroup Tasks
The workgroup initially was tasked with the following:

- The "Analysis of Oregon Runoff Water Quality Monitoring Data Collected from 1990 – 1996" report (1997 ACWA Report) prepared by Woodward Clyde in 1997 did not include values for bacteria based on land use type. Evaluate data that was used for the ACWA Report and determine land use based concentrations for bacteria.
- Summarize data available in the ACWA Stormwater BMP Effectiveness Database
- Develop a reasonable range of median effluent concentrations for TMDL pollutants by BMP type
- Non-structural management practices: How can the land use concentrations be reduced to account for practices such as street sweeping, catch basin cleaning, public education, etc.?

As work progressed, concerns about the limitations of using median concentrations were raised the workgroup accomplished the following tasks:

- Calculated *median* and *mean* (using the maximum likelihood estimate (MLE) of log-normalized data) land use concentrations from the 1990-96 ACWA dataset for pollutants of concern in storm water runoff.
- Computed MLE mean effluent concentrations for the major BMP types and storm water pollutants.

Land-use-based Bacteria Data
Most of the bacteria data in the 1990-96 ACWA database was fecal coliform bacteria. This was because fecal coliform was the bacteria standard during most of the time period when the data was collected. In 1996, DEQ adopted an *E. coli* bacteria standard and municipalities are currently monitoring for this parameter. Since there was limited *E. coli* data, paired *E. coli* and fecal coliform data from Clean Water Services and the City of Portland were used to develop a regression equation. This regression equation was used to calculate E. coli bacteria values from the fecal coliform dataset. The resulting land use based *E.coli* bacteria values and the regression are presented in Tables 1 and 2.

Land-use-based Data for Storm Water Pollutants
Since the storm water data that was evaluated in the 1997 ACWA Report was log-normally distributed, the report used geometric means as an estimate of the median; it also presented "means", which are calculated using a maximum likelihood estimate (MLE) based on the log-normalized data. Since municipalities may use medians rather than geometric means or MLE means, land use based *medians* are presented in Table 1. Table 2 presents land use based MLE means; the MLE means are slightly different than those presented in the 1997 ACWA Report. This is because some sites that were included in the 1997 ACWA Report were excluded in this analysis and vice-versa.

If the purpose of the storm water analysis is to calculate a mean pollutant load, then the MLE mean, which provides a better estimate of the true mean than a median, should be used. It is appropriate to use the MLE mean to calculate the mean pollutant load as long as the data is log-normally distributed, the sample variance is small, and the number of samples is large (>30). If the number of samples is small, then the MLE mean would probably have a positive bias. If the sample size is small, or if the variance is large, or if the data isn't quite log-normally distributed, it is probably better to use medians to calculate pollutant loads. Medians are far more resistant to outliers but still characterize the central tendency of the data distribution; however, they do not account for the potentially significant pollutant load of these outliers. For log-normally distributed data, one can use the median because the median is independent of the data distribution.

Tables 1 and 2 present the land-use-based median and MLE mean land use data for pollutants of concern in storm water runoff.

Table 1: Median Land Use Data
(From ACWA Data 1990-96)

Land Use Categories	TSS (mg/L)	TP (mg/L)	Copper (dis/total) (µg/L)	Lead (dis/total) (µg/L)	Zinc (dis/total) (µg/L)	COD (mg/L)	BOD (mg/L)	E.coli Bacteria* (#/100 ml)
Commercial	55	0.23	4/12.5	2/17	50/90	46.5	6.7	1900
Industrial	91	0.550	7/31	2/30	220/282	81.0	24.0	800
Open Space	16	0.170	4/4	1.5/3	7.5/12	24.0	5.0	1100
Residential	38	0.200	5.5/10	3/9.5	50/80	32.4	5.0	1800
Transportation	120	0.310	6/26	1.2/40	56/185	47.0	10.0	1600

* E. coli bacteria values were calculated using the following relationship: E.coli = 0.81*fecal coliform. The resulting median value for each land use was then rounded to the nearest 100. This relationship was based on paired fecal coliform and E.coli data gathered by Clean Water Services and City of Portland

Table 2: Mean (using maximum likelihood estimate of log-normalized data) Land Use Data
(From ACWA Data 1990-96)

Land Use Categories	TSS (mg/L)	TP (mg/L)	Copper (dis/total) (μg/L)	Lead (dis/total) (μg/L)	Zinc (dis/total) (μg/L)	COD (mg/L)	BOD (mg/L)	E.coli Bacteria* (#/100 ml)
Commercial	83	0.368	8.6/16.9	3.9/32	95/143	63.0	9.5	2200
Industrial	147	0.637	8.7/45.7	3.3/50.7	420/536	105.7	42.6	700
Open Space	58	0.176	4/4.3	1.8/2.8	15.2/30	23.2	4.8	900
Residential	59	0.319	7.2/14.3	4.4/11.2	60/108	54.0	8.7	1700
Transportation	169	0.376	8.6/34.8	3.9/60.2	76/236	94.5	16.2	1400

* E. coli bacteria are presented as *geometric means*; these values were calculated using the following relationship: E.coli = 0.81*fecal coliform. The resulting value for each land use was then rounded to the nearest 100. This relationship was based on paired fecal coliform and E.coli data gathered by Clean Water Services and City of Portland

BMP Effluent Database

ACWA hired CH_2M Hill to develop a Microsoft ACCESS database that summarizes available storm water BMP effectiveness data. The database can be viewed by BMP type or by constituent. BMP types include five categories: Education, Erosion Prevention, Operation and Maintenance, Site Design/Building Codes, and Structural. A summary of the data that is available in the database is presented in Appendix A.

Removal Efficiencies for TMDL Pollutants by BMP Type

The workgroup developed a range of effluent concentrations for commonly used structural BMPs (dry ponds, wet ponds, wetlands, filters, swales, and centrifugal separators). Effluent concentrations were developed for the following parameters: total suspended solids, total phosphorus, bacteria, dissolved and total copper, dissolved and total lead, and dissolved and total zinc; for flow reduction percentages are provided.

The results of the workgroup's efforts are summarized in a series of spreadsheets (Appendix B); each spreadsheet specifies a pollutant, lists structural BMPs that were evaluated, and includes comments regarding the BMP and the data set. Best, medium and low performance is specified for each BMP category. Typically the 75th percentile removal efficiency (25th percentile effluent concentration) was specified as the "best" performance; the median removal efficiency or median effluent concentration was deemed to be representative of normal performance; and the 25th percentile removal efficiency (75th percentile effluent concentration) was specified as the "low" performance. It is anticipated that median performance level would be used in most cases. Higher or lower performance levels may be used in site-specific situations.

MLE mean effluent concentrations are also presented. These values should be used in conjunction with the MLE mean land use based data.

The following data was considered in developing the removal efficiencies or effluent concentrations presented in the spreadsheets in Appendix B:

- Memorandum by GeoSyntec Consultants with summary statistics from the International BMP (IBMP) database
- Memorandum titled, “Estimating BMP Performance for Gresham Water Quality Modeling” prepared by GeoSyntec Consultants, January 25, 2005
- City of Portland Data
- Clean Water Services Data
- BMP effectiveness database compiled by CH2M Hill for ACWA

The IBMP database was the most comprehensive of the data sources considered. The summary statistics prepared by GeoSyntec made this data source easy to use. This data source typically had a much larger number of samples than the other sources considered. For these reasons, effluent data from this source was used to define the concentration range for the effectiveness of a particular BMP in most cases.

However, there were circumstances where the workgroup believed that it was important to use local data (e.g. for phosphorus). In such cases, local data from City of Portland or Clean Water Service was used. City of Portland metals data was also used to define effectiveness for some BMPs. This was because the IBMP database did not include a full complement of dissolved and total metals data for some metals (i.e. number of dissolved metals samples were significantly less than the number of total metals). Since the City of Portland had a full complement of dissolved and total samples, their data was used. The workgroup used the BMP effectiveness database compiled by CH_2M Hill primarily for comparative purposes. A summary of the median and MLE mean effluent concentrations and flow reduction percentage for each BMP type are presented in the tables below:

Table 3: BMP Effectiveness Summary
(Median effluent concentrations)

BMP Type	**TSS** mg/L	**TP** mg/L	***E coli*** Count /100 ml	**Diss Copper** µg/L	**Total Copper** µg/L	**Diss. Lead** µg/L	**Total Lead** µg/L	**Diss Zinc** µg/L	**Total Zinc** µg/L	**Flow Reduction** %
Centrifugal Separator Hydrodynamic devices	57	0.13	--	6.9	12	1.1	5.7	25	70	0
Filters (Leaf/Sand/Other)	13	0.12	98	6.6	9.3	0.13	3	27	44	0
Ponds, Dry Vegetated Detention Pond	33	0.29	--	12	20	1.5	18	44	83	23
Ponds - Wet Retention Basin	16	0.14	--	2.9	7.1	0.1	1.88	17.6	31.7	5
Swales - Vegetated Filter Strips	23	0.24	--	5.1	11.9	0.42	7.43	19	47	29
Wetlands - Constructed Surface Flow	7	0.08	--	--	3	0.72	1	11	17	0
Sediment Manhole	50	--	--	--	--	--	--	--		--
Green Roofs (4" substrate)	--	--	--	--	--	--	--	--	--	60
Porous Pavement	--	--	--	--	--	--	--	--	--	77
Soakage Trenches	--	--	--	--	--	--	--	--	--	100

Table 4: BMP Effectiveness Summary
(MLE mean effluent concentrations)

BMP Type	**TSS** mg/L	**TP** mg/L	***E coli*** Count /100 mls	**Diss Copper** µg/L	**Total Copper** µg/L	**Diss. Lead** µg/L	**Total Lead** µg/L	**Diss Zinc** µg/L	**Total Zinc** µg/L	**Flow Reduction** %
Centrifugal Separator Hydrodynamic devices	151	0.22	--	14	15	2.1	14	35	103	0
Filters (Leaf/Sand/Other)	43	0.29	79	11	18	0.13	7.6	73	143	0
Ponds, Dry Vegetated Detention Pond	43	0.35	--	14	28	2.4	32	59	123	23
Ponds - Wet Retention Basin	29	0.16	--	3.2	7.7	0.1	2.5	30	74	5
Swales - Vegetated Filter Strips	32	0.42	--	5.9	12.5	0.50	7.8	20.6	55	29
Wetlands - Constructed Surface Flow	25	0.16	--	--	--	2.5	3.3	14	32	0
Sediment Manhole	67		--	--	--	--	--	--	--	--
Green Roofs (4" substrate)	--	--	--	--	--	--	--	--	--	60
Porous Pavement	--	--	--	--	--	--	--	--	--	77
Soakage Trenches	--	--	--	--	--	--	--	--	--	100

Non-Structural BMPs

Non-structural BMPs include street sweeping, catch basin cleaning, leaf pick up programs, public education activities, etc. It is difficult to quantify the effectiveness of such activities. Typically, the effectiveness of these activities will be evaluated as a percent reduction in the land use values. The percent reduction in the land use values is related to the frequency of the activity and the type of equipment used. The workgroup was not able to develop typical removal efficiencies associated with these activities. The workgroup suggests that municipalities refer to the Operations and Maintenance portion of the BMP effectiveness database to find the frequency of the activity and type of equipment that closely matches theirs.

Furthermore, it can be assumed that some of these BMPs (e.g. street sweeping) were going on when the ACWA land use data was collected. Unless the frequency and equipment changed substantially, these ACWA land use values may be appropriate and should not be altered.

Attachments

Appendix A: Summary of Data in the ACWA Stormwater BMP Effectiveness Database
Appendix B: Spreadsheets for TMDL Pollutants by BMP Type