APPENDIX B

COMMENTS ON THE SIMPLE METHOD FOR DETERMINING WATERSHED LOADS

(MPCA, May 2004)

Comments on the Simple Method
For Determining Watershed Loads
May, 2004.

The Simple Method is a planning level tool that estimates urban runoff pollutant loads. It was developed by Thomas Schueler of the Metropolitan Washington Council of Governments in 1987 [Schueler, 1987]. The Method utilizes an equation which relates watershed pollutant load to rainfall depth, event mean runoff pollutant concentration, percent impervious cover, and area of a particular landuse. The Simple Method is being used by Minnesota Pollution Control Agency staff to estimate pollutant loads from municipal separate stormsewer systems located within urbanized areas. Given below are comments regarding the Simple Method and an inventory of data that could be used as input for the Simple Method.

Urban Data. The Simple Method is based on urban runoff monitoring data from four metropolitan Washington DC area sites and from of 40 monitoring sites in 16 Nationwide Urban Runoff Program locations across the United States. No attempt was made to extend the method to construction, industrial, rural development, or agricultural areas.

Dry and Wet Weather Conditions. Methodology as presented does not discriminate loads under dry (baseflow) and wet weather conditions. Given the land use of the watershed and the water quality constituents under consideration, this may or may not be an important factor.

Storm Event Loads. The Simple Method estimates annual pollutant loads generated by storm event runoff. The method does not include pollutant loads generated by baseflow.

Peak Flow. Methodology does not estimate the runoff peak flow from a watershed. This variable is important for prediction of streambank erosion.

Drainage Area. Method is applicable to drainage areas of less than one square mile. "Scaling up" the method to watersheds larger than one square mile may produce uncertain results due to appreciable baseflow which is not incorporated in the Simple Method. No references were found on "scaling up" the method.

Receiving Water Modeling. An average annual load, as that produced by the Simple Method, does not incorporate the timing of the arrival of the pollutant load to the receiving water. This is of less importance for lakes with long detention times (years) as opposed to river reaches with short travel times (hours to days). The timing of a moderate size pollutant load may have significant impact upon a stream or river reach which is not revealed by the average annual load.

Correction Factor (P_j). This factor adjusts the amount of runoff determined by the runoff coefficient by removing those storm events which do not produce runoff. It was determined from runoff monitoring data obtained in the Washington DC area that 90% of the storm events produce runoff. Assuming that most of the monitoring was performed in urban land use, it appears that the results of this study are not transferable to non–urban areas. Since this factor is directly proportional to the watershed pollutant load, and pollutant loads from different types of landuses are to be directly compared, it is important to determine a realistic value for this factor.

Runoff Coefficient (R_v). The data used to develop the equation for the runoff coefficient was obtained from monitoring urban runoff at 48 Nationwide Urban Runoff Program (NURP) sites. The equation for this coefficient is not readily transferable to non–urban areas (agricultural, forest, grassland, etc.). This coefficient is dependent upon the percent imperviousness in the watershed. Knowledge of the percent imperviousness is necessary to determine the runoff coefficient.

Runoff Coefficients for pervious areas will vary based on the antecedent moisture condition and the soil type. The range of coefficients for various soil types with a given land cover is quite significant (see Table 1 from Barfield et al. [1987]). For example, woodland with a flat slope has a runoff coefficient of 0.10 for an open sandy loam and 0.40 for a tight clay soil. Since the equation for the Simple Method is linear, the resulting load difference between the two factors for a forest area is a factor of 4.

Urban areas - The use of average coefficients for various surface types, which are assumed not to vary through the duration of the storm, is common. The range of coefficients, classified with respect to the general character of the tributary reported in use is:

Description of area	Runoff coefficients
Business:	
Downtown areas	0.70 to 0.95
Neighborhood areas	0.50 to 0.70
Residential:	
Single-family areas	0.30 to 0.50
Multi-units, detached	0.40 to 0.60
Multi-units, attached	0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment dwelling areas	0.50 to 0.70
Industrial:	
Light areas	0.50 to 0.80
Heavy areas	0.60 to 0.90
Parks, cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad yard areas	0.20 to 0.35
Unimproved areas	0.10 to 0.30

It is often undesirable to develop a composite runoff coefficient based on the percentage of different types of surface in the drainage area. This procedure is often applied to typical "sample" blocks as a guide to selection of reasonable values of the coefficient for an entire area. Coefficients with respect to surface type currently in use are:

Character or surface	Runoff coefficients
Streets:	
Asphaltic and concrete	0.70 to 0.95
Brick	0.70 to 0.85
Roofs	0.75 to 0.95
Lawns; sandy soil:	
Flat, 2%	0.05 to 0.10
Average, 2% to 7%	0.10 to 0.15
Steep, 7%	0.15 to 0.20
Lawns; heavy soil:	
Flat, 2%	0.13 to 0.17
Average, 2% to 7%	0.18 to 0.22
Steep, 7%	0.25 to 0.35

The coefficients in these two tabulations are applicable for storms of 5-year to 10-year frequencies. Less frequent higher intensity storms will require the use of higher coefficients because infiltration and other losses have a proportionally smaller effect on runoff. The coefficients are based upon the assumption that the design storm does not occur when the ground surface is frozen.

Rural Areas	Soil Texture		
Topography & Vegetation	Open Sandy Loam	Clay & Silt Loam	Tight Clay
Woodland			
Flat 0-5% slope	0.10	0.30	0.40
Rolling 5-10% slope	0.25	0.35	0.50
Hilly 10-30% slope	0.30	0.50	0.60
Pasture			
Flat	0.10	0.30	0.40
Rolling	0.16	0.36	0.55
Hilly	0.22	0.42	0.60
Cultivated			
Flat	0.30	0.50	0.60
Rolling	0.40	0.60	0.70
Hilly	0.52	0.72	0.82

Table 1. Rational Method Runoff Coefficients [Barfield et al., 1987]

Suspended Sediment Concentrations. Analysis of the NURP nutrient monitoring showed no significant difference in average nutrient pollutant concentrations between sites and no consistent correlation between pollutant concentrations and storm volume or intensity. Therefore, a single value can be used for the runoff nutrient concentration for an urban area. Suspended sediment monitoring results do not illustrate these statistical properties. Individual monitoring site means and variances were significantly different from each other. Because of the high degree of storm event and site variability, a single value cannot be used for suspended sediment concentration. However. suspended sediment concentration is generally related to watershed size. As watershed size increases, susceptibility to channel erosion increases due to the increase in length of the stream channel network. This relationship has a wide range of variability, and has limited capability as a predictive tool.

Figure 1 [Schueler, 1987] reflects the variability in suspended sediment event mean concentrations. This table and graph can be utilized to produce an event mean suspended sediment concentration given a watershed channel network condition and watershed size.

The concentrations presented in Figure 1 do not include the presence of construction sites in the watershed. Yorke and Herb [1976] [as given in Schueler, 1987] estimate that construction site runoff has a suspended sediment concentration of approximately 10,000 mg/l.

Table A.4 Watershed Channel Network Conditions

	LOW EMC	MODERATE EMC	HIGH EMC
Stability condition of channel	Vegetated swales or storm sewers	Intermediate	Open channel, cut banks alternating w/channel sandbars, fallen trees
Channel sediment storage	Small deposits in storm drains, stabilized land use	"	Large silt or clay deposits evidence of recent or ongoing construction. Water becomes murky after disturbing bottom
Stream velocity	Low slope, low imperviousness	"	High slope, high imperviousness

Figure A.1: Storm Sediment EMC's As a Function of Watershed Size

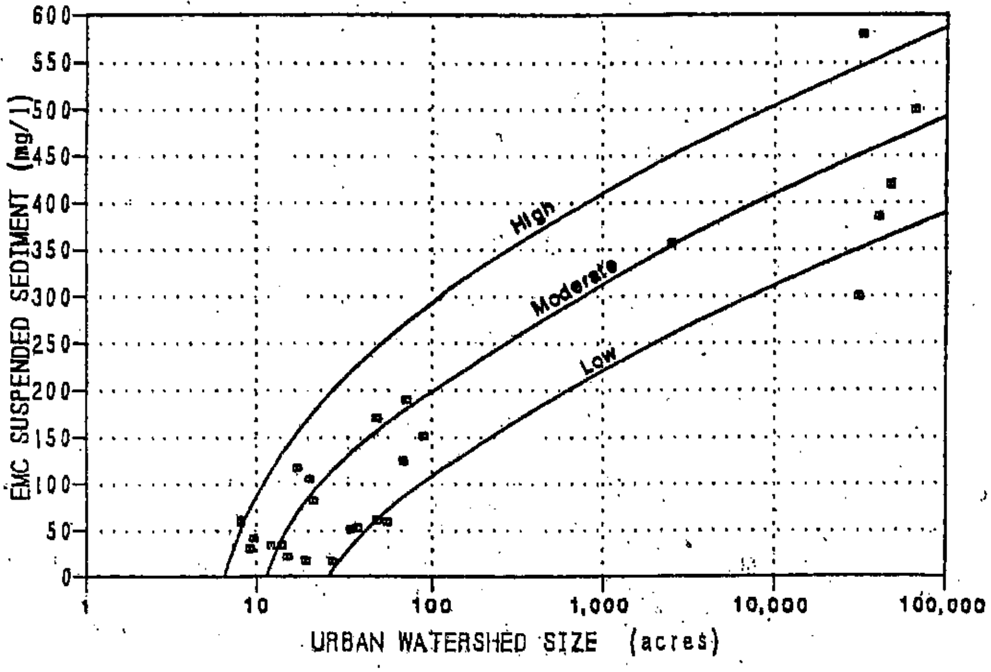


Figure 1. Urban Runoff Suspended Sediment Concentration [Schueler, 1987]

Percent Impervious. The runoff coefficient – the backbone of the Simple Method – is based on the percent imperviousness in the watershed. The US Environmental Protection Agency contracted with the Center for Watershed Protection (CWP) to develop estimates for impervious cover for various land uses. The CWP developed a methodology for estimating impervious cover, and produced impervious cover estimates for various land uses in the Chesapeake Bay Region [Center for Watershed Protection, 2000], which are presented in Table 2. For a Wake County, North Carolina study, impervious cover estimates were compiled from local estimates of impervious cover in North Carolina [CH2MHill, 2002]. These estimates are presented in Table 3.

Land Use Category	Sample Number (N)	Mean Impervious Cover (SE)
Agriculture	8	1.9 ± 0.3
Open Urban Land	11	8.6 ± 1.64
2 Acre Lot Residential	12	10.6 ± 0.65
1 Acre Lot Residential	23	14.3 ±0.53
½ Acre Lot Residential	20	21.2 ± 0.78
¼ Acre Lot Residential	23	27.8 ± 0.60
⅛ Acre Lot Residential	10	32.6 ± 1.6
Townhome Residential	20	40.9 ± 1.39
Multifamily Residential	18	44.4 ± 2.0
Institutional	30	34.4±3.45
Light Industrial	20	53.4 ± 2.8
Commercial	23	72.2 ± 2.0

Table 2. Impervious Cover Estimates for the Chesapeake Bay Region [Center for Watershed Protection, 2000].

Percent Imperviousness by Land Use Classification

Land Use Description	Percent Imperviousness
Agriculture – Cultivated	1
Agriculture - Non Cultivated	1
Wetland	2
Herbaceous Upland	3
Forest	3
Low Density Residential	6
Sewered Low Density Residential	12
Barren Land	20
Medium Density Residential	21
Sewered Medium Density Residential	21
High Density Residential [1]	44
Multi-Family Residential[1]	44
Institutional	62
Commercial and Services	82
Industrial	87
Transportation	87
Water	90

Sources:

CH2MHILL, 2000. Urban Stormwater Pollutant Assessment Report prepared for the North Carolina Department of Environmental and Natural Resources, Division of Water Quality (DWQ.)

1 Center for Watershed Protection, 2000. Derivations of Impervious Cover for Suburban Land Uses in the Chesapeake Bay Watershed.

Table 3. Percent Impervious by Land Use Classification [CH2MHill, 2002]

Agricultural and Forest Runoff Concentrations.

A majority of the literature reports agricultural runoff nutrient and suspended sediment concentrations in the form of unit area loads, as opposed to concentrations. This is indeed the case with one of the most widely cited references for watershed runoff quality, which was completed for the U.S. Environmental Protection Agency in 1980 by Kenneth Reckhow and Jonathan Simpson [US EPA, 1980]. However, some of the monitoring studies cited in this report included the average yearly runoff from the monitored watershed as well as the average yearly unit area nitrogen and phosphorus load. Therefore, it is possible to calculate an average runoff nutrient concentration by dividing the nutrient load by the watershed runoff, with the caveat that average values are being used. A more accurate method to calculate runoff concentrations is to use the runoff which corresponds to the unit area load for a given year. The amount of error introduced by utilizing average values is unknown. Not all of the nutrient load research presented in US EPA [1980] was converted to concentrations. Research performed in the midwest United States and south–central Canada was targeted, unless sufficient data from these locations was not available for a given landuse.

Forest. Table 4 contains phosphorus and nitrogen runoff concentrations for forested watersheds. These values were calculated from average unit area loading values and average runoff volumes given in the U.S. EPA report "Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients." The range of nitrogen and phosphorus concentrations for forested watersheds has a relatively narrow range as compared to nutrient concentrations in agricultural field runoff which are presented in Tables 5–7 that follow. However, nitrogen concentrations still varied by a factor of 2.5, and phosphorus concentrations varied by an order of magnitude. Note the monitoring completed at the Marcell Experimental Forest in Minnesota by Sandy Verry and others.

Land Use	Location	Runoff (cm/yr)	Total N Export (kg/ha/yr)	Total P Export (kg/ha/yr)	Total N Concentration (mg/l)	Total P Concentration (mg/l)	Reference
75-10 yr old jack pine and black spruce, with birch and trembling aspen	Rawson Lake, Ontario	26.55	6.26	0.309	2.358	0.116	Schindler et al., 1976
Climax hardwoods maple, beech, red oak, with yellow birch and hemlock	Clear Lake Watershed, Haliburton County, Ontario	68.00		0.09		0.013	Schindler and Nighswander, 1970
Mixed deciduous forest	Lake Minnetonka Watershed, Minnesota	84.30		0.09		0.011	Singer and Rust, 1975
70% aspen 30% black spruce and alder	Marcell Experimental Forest, Minnesota	17.70	2.26	0.157	1.277	0.089	Verry, 1979
70% aspen 30% black spruce and alder	Marcell Experimental Forest, Minnesota	19.20	2.37	0.179	1.234	0.093	Verry, 1979
Aspen - birch forest	Marcell Experimental Forest, Minnesota	15.56	2.46	0.28	1.581	0.180	Timmons, et. Al., 1977
Maple, birch and beech	Hubbard Brook Experimental Forest, New Hampshire	83.30	4.01	0.019	0.481	0.002	Likens et al., 1977
Deciduous hardwood and pine	Coshocton, Ohio	32.00	2.82	0.035	0.881	0.011	Taylor, et al., 1971

Table 4. Nutrient Runoff Concentrations from Forested Watersheds [EPA, 1980].

Row Crops. Table 5 presents agricultural row crop runoff nitrogen and phosphorus concentrations that were calculated from average unit area loads and average watershed runoff volumes presented in US EPA [1980]. Variance in average concentrations were significant, with nitrogen values varying by a factor of 40 and phosphorus concentrations varying by a factor of 24. It is important to keep in mind that this is a variance of averages – each average has another associated variance. The variance in tillage, crop residue, and nutrient management has a significant effect upon field runoff nutrient concentrations. In addition, these results did not include monitoring of subsurface drainage. Elevated nutrient concentrations in subsurface agricultural tile lines can have a pronounced effect upon receiving water quality. Note the research completed by Dr. Robert Young and others at the USDA Agricultural Research Laboratory in Morris, Minnesota in the 1970's. Runoff nutrient concentrations calculated from the Minnesota research are higher than other research presented in the table.

Land Use	Fertilizer Application (kg/ha/yr)			Location	Runoff (cm/yr)	Total N Export (kg/ha/yr)	Total P Export (kg/ha/yr)	Total N Concentration (mg/l)	Total P Concentration (mg/l)	Reference
	N	P	K							
Corn	0	0	0	Lancaster, Wisconsin	10.7	3.96	1.22	3.701	1.140	Minshall et al., 1970
Corn, fresh manure applied in winter	109	39	99	Lancaster, Wisconsin	12.26	7.97	2.00	6.501	1.631	Minshall et al., 1970
Corn, fermented manure applied in spring	102	44	85	Lancaster, Wisconsin	11.51	3.38	0.75	2.937	0.652	Minshall et al., 1970
Corn; liquid manure applied in spring	78	33	114	Lancaster, Wisconsin	12.45	2.88	0.95	2.313	0.763	Minshall et al., 1970
Corn	0	0	0	Wisconsin	11.52	4.33	1.30	3.759	1.128	Hensler et al., 1970
Corn; fresh manure applied in winter	108	39	99	Wisconsin	9.32	15.25	3.40	16.363	3.648	Hensler et al., 1970
Corn; fermented manure applied in spring	108	39	99	Wisconsin	8.81	4.22	0.81	4.790	0.919	Hensler et al., 1970
Corn; liquid manure applied in spring	108	39	99	Wisconsin	9.45	3.88	0.94	4.106	0.995	Hensler et al., 1970
Corn	112	29	0	Morris, Minnesota	8.6	79.6	18.60	92.558	21.628	Young and Holt, 1977
Corn	29	81	0	Morris, Minnesota	10.00	44.2	14.00	44.200	14.000	Young and Holt, 1977
Corn; surface spread manure	268	124	0	Morris, Minnesota	3.80	27.9	8.60	73.421	22.632	Young and Holt, 1977
Corn; plowdown manure	268	124	0	Morris, Minnesota	4.00	33.00	9.80	82.500	24.500	Young and Holt, 1977
Corn	56	29	0	Morris, Minnesota	4.57	14.24	3.14	31.160	6.871	Burwell et al., 1975
Corn	112	29	0	Morris, Minnesota	8.03	23.63	5.55	29.427	6.912	Burwell et al., 1975
Corn; contour planting	448	64	0	Treynor, Iowa	5.47	8.69	0.59	15.887	1.079	Alberts et al., 1978
Corn; contour planting	168	39	0	Treynor, Iowa	3.86	5.36	0.35	13.886	0.907	Alberts et al., 1978
Corn; contour planting	280	64	0	Treynor, Iowa	1.75	2.10	0.26	12.000	1.486	Alberts et al., 1978

Table 5 Runoff Nutrient Concentrations for Row Crops [US EPA, 1980].

Nonrow Crops. Table 6 presents agricultural nonrow crop runoff nitrogen and phosphorus concentrations that were calculated from average unit area loads and average watershed runoff volumes presented in US EPA [1980]. Nitrogen concentrations varied by a factor of 3, which is a relatively low variance compared to row crops. Phosphorus concentrations varied by a factor of 18. Note the phosphorus monitoring done on oats and hay fields in Morris, Minnesota by Burwell. The same caveat regarding nutrients present in subsurface tile lines applies to nonrow crops as well. Nonrow crops tend to be subject to less intensive agricultural management practices than row crops, hence the tighter range in nutrient concentrations.

Land Use	Fertilizer Application (kg/ha/yr)			Location	Runoff (cm/yr)	Total N Export (kg/ha/yr)	Total P Export (kg/ha/yr)	Total N Concentration (mg/l)	Total P Concentration (mg/l)	Reference
	N	P	K							
Alfalfa	0	0	0	Madison, Wisconsin	14.20	6.28	0.76	4.423	0.535	Converse et al., 1976
Alfalfa; fall applied manure	121	24	100	Madison, Wisconsin	7.80	6.63	1.24	8.500	1.590	Converse et al., 1976
Alfalfa; winter applied manure	121	24	100	Madison, Wisconsin	10.30	7.82	0.64	7.592	0.621	Converse et al., 1976
Alfalfa; spring applied manure	121	24	100	Madison, Wisconsin	10.10	6.43	1.81	6.366	1.792	Converse et al., 1976
Alfalfa and Bromegrass				Eastern South Dakota	2.69	0.97	0.10	3.606	0.372	Harms et al., 1974
Spring wheat and summer stubble	0	0	0	Swift Current, Saskatchewan	35.00		0.35		0.100	Nicholaichuk and Read, 1978
Spring wheat and summer fallow	0	0	0	Swift Current, Saskatchewan	58.50		1.35		0.231	Nicholaichuk and Read, 1978
Spring wheat and fall fertilized summer fallow	50	54		Swift Current, Saskatchewan	28.00		2.90		1.036	Nicholaichuk and Read, 1978
Oats	18	30		Morris, Minnesota	6.89	4.22	0.65	6.125	0.943	Burwell et al., 1975
Hay	0	0	0	Morris, Minnesota	14.20	4.09	0.64	2.880	0.451	Burwell et al., 1975

Table 6. Runoff Nutrient Concentrations for Non–Row Crops [US EPA, 1980].

Pastures. Table 7 presents pasture runoff nitrogen and phosphorus concentrations that were calculated from average unit area loads and average watershed runoff volumes presented in US EPA [1980]. There is significant variance present in average nitrogen concentrations, which vary by a factor of 72. Animal density, land slope, land cover, and pasture management all are important factors which contribute to this variance. Phosphorus concentrations had a much tighter range – they varied by a factor of 2.5. No monitoring results were presented in US EPA [1980] for Minnesota.

Land Use	Fertilizer Application (kg/ha/yr)			Location	Runoff (cm/yr)	Total N Export (kg/ha/yr)	Total P Export (kg/ha/yr)	Total N Concentration (mg/l)	Total P Concentration (mg/l)	Reference
	N	P	K							
Pasture				Eastern South Dakota	4.44	1.52	0.25	3.423	0.563	Harms et al., 1974
Winter grazed and summer rotational, orchardgrass and bluegrass cover	56	0	0	Coshocton, Ohio	12.94	30.85	3.60	23.841	2.782	Chichester et al., 1979
Summer grazed	56	0	0	Coshocton, Ohio	2.92	21.85	0.85	74.829	2.911	Chichester et al., 1979
Rotational grazing	168	39		Treynor, Iowa	3.86	2.32	0.25	6.010	0.650	Schuman et al., 1973
Continuous grazing, little bluestem cover, active gullies	0	0	0	Chickasha, Oklahoma	15.10	6.13	1.46	4.060	0.967	Menzel et al., 1978
Rotational grazing little bluestem cover; good cover	0	0	0	Chickasha, Oklahoma	5.95	1.48	0.25	2.487	0.420	Menzel et al., 1978
Continuous grazing, little bluestem cover	83	72	0	Chickasha, Oklahoma	14.70	9.20	4.90	6.259	3.333	Olness et al., 1980
Rotational grazing little bluestem cover	87	76	0	Chickasha, Oklahoma	4.30	4.72	3.09	10.977	7.186	Olness et al., 1980
Continuous grazing, little bluestem cover, active gullies	0	0	0	Chickasha, Oklahoma	10.20	5.19	0.76	5.088	0.745	Olness et al., 1980
Rotational grazing little bluestem cover	0	0	0	Chickasha, Oklahoma	4.30	1.73	0.20	4.023	0.465	Olness et al., 1980

Table 7. Runoff Nutrient Concentrations for Pastured Watersheds [US EPA, 1980].

Suspended Solids. US EPA [1980] only presents agricultural runoff loads for nutrients. The report does not present suspended solids loads. Gaynor and Findlay [1995] monitored runoff from corn plots in southwestern Ontario under three different tillage operations: conventional moldboard plow, ridge till, and no–till. Runoff average suspended sediment concentrations are presented in Table 8. While concentrations vary significantly between 1988–1989 and 1990, the reduction in runoff average suspended sediment concentration is consistent between conventional, ridge and no–till management. Soil type is an additional variable which affects the presence of suspended sediment in runoff. This study was performed on plots with a clay–loam soil. Other soil types will produce different results.

Year	Tillage	Runoff Average Suspended Sediment Concentration (mg/l)
1988	Conventional	910
1988	Ridge	460
1988	Zero	270
1989	Conventional	850
1989	Ridge	650
1989	Zero	400
1990	Conventional	290
1990	Ridge	220
1990	Zero	170

Table 8. Corn Field Runoff Suspended Sediment Concentrations [Gaynor and Findlay, 1995].

Compilation of Runoff Pollutant Concentrations.

Several watershed studies have been performed where the Simple Method has been applied. Some of these studies used runoff pollutant concentrations presented by Schueler in the documentation for the Simple Method [Schueler, 1987] (see Table 9), others have used the default values presented in the US EPA watershed model PLOAD [US EPA, 2001] (see Table 10), while others have obtained local and regional runoff data [CH2MHill, 2002] (see Table 11).

Agricultural Runoff Suspended Sediment. As illustrated in Table 9, the documentation for the Simple Method does not provide runoff pollutant concentrations for agricultural landuses. The default value for PLOAD is 132 mg/l for cropland, pasture, and other agricultural land (see Table 10). Runoff of cultivated agricultural land and non–cultivated agricultural land were assumed to have total suspended solids concentrations of 1200 mg/l and 688 mg/l, respectively, in the Wake County, North Carolina study (see Table 11). Corn field runoff suspended sediment concentrations ranged from 170 mg/l for no–till to 910 mg/l for conventional moldboard plow tillage in the Gaynor and Findlay study. It is difficult to assign a single suspended sediment value to tilled cropland due to the wide range of tillage, soil types, slopes, cover crops, and residue.

Agricultural Runoff Total Phosphorus. From Table 10, the default total phosphorus value from PLOAD for cropland, pasture, and other agricultural land is 1 mg/l. Table 11 shows that the Wake County, North Carolina study assumed a value of 4 mg/l for cultivated agricultural land, and 0.5 mg/l for non–cultivated agricultural land. Young and Holt reported average total phosphorus values as high as 25 mg/l for runoff from corn fields near Morris, Minnesota (see Table 5). Runoff average total phosphorus from pastures were shown to range from 0.5 to 7.1 mg/l (see Table 7). A portion of the total phosphorus measured in the runoff is dissolved in the water column, while the remaining phosphorus is adsorbed to sediment. Therefore, the comments regarding the variance in suspended sediment concentrations given above apply to sediment adsorbed phosphorus as well. Additional variance is due to varying levels of application of commercial fertilizer and manure.

Agricultural Runoff Total Nitrogen. As shown in Table 10, the default nitrogen runoff concentration values used by PLOAD are in the form of nitrate + nitrite (NO_X), total Kjeldahl nitrogen, and ammonia. Total nitrogen in runoff is the sum of the total Kjeldahl nitrogen and NO_X. Therefore, the default total nitrogen value from PLOAD for cropland, pasture, and other agricultural land is 1.71 mg/l. Table 11 shows that the Wake County, North Carolina study assumed a value of 24.5 mg/l for cultivated agricultural land, and 7.9 mg/l for non–cultivated agricultural land. Young and Holt reported average total phosphorus values as high as 93 mg/l for runoff from corn fields near Morris, Minnesota (see Table 5). The average total nitrogen concentration of runoff from pastured watersheds was found to be as high as 74 mg/l. A portion of the total nitrogen measured in the runoff is dissolved in the water column in the forms of organic nitrogen, ammonia, ammonium, nitrite, and nitrate – depending upon the level of oxidation and the pH. The ammonium ion will adsorb to sediment. Therefore, the comments regarding the variance in suspended sediment concentrations given above apply to sediment adsorbed nitrogen as well. Additional variance in the dissolved forms of nitrogen present in the runoff is due to varying levels of application of commercial fertilizer and manure.

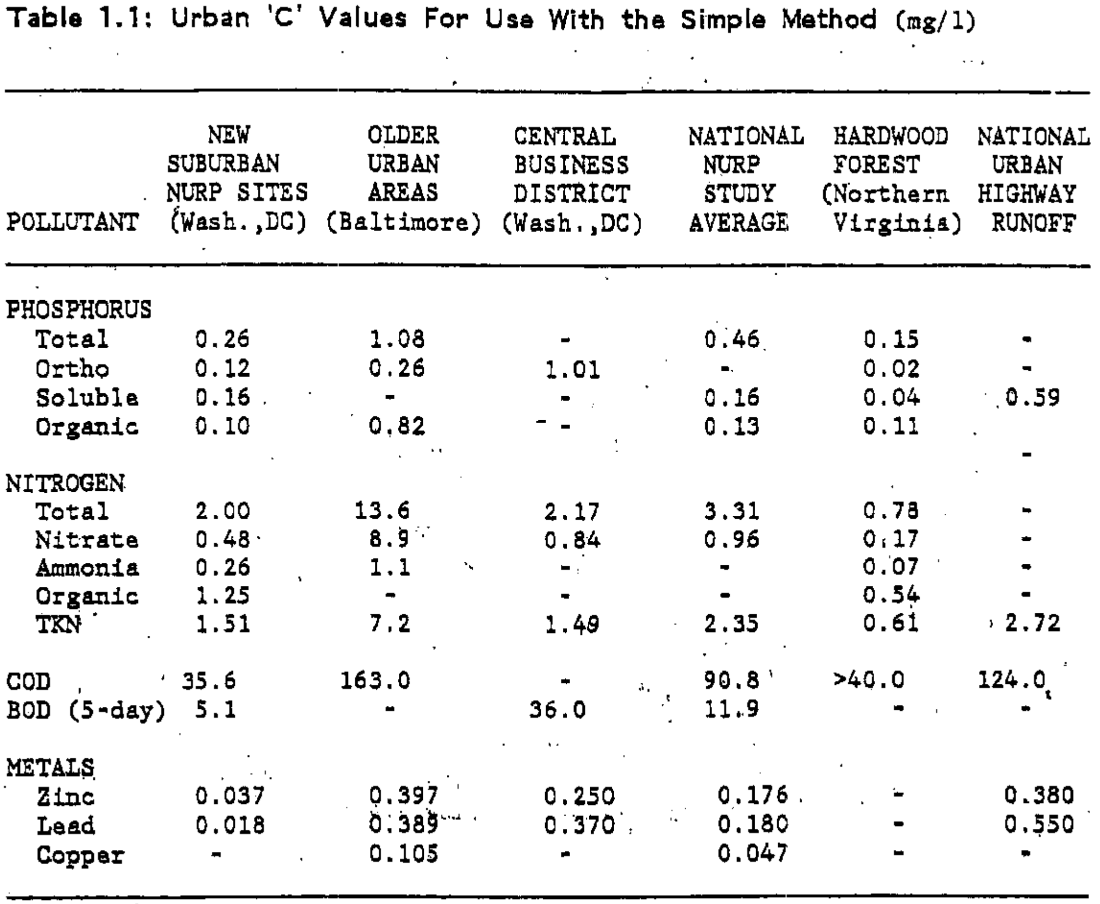
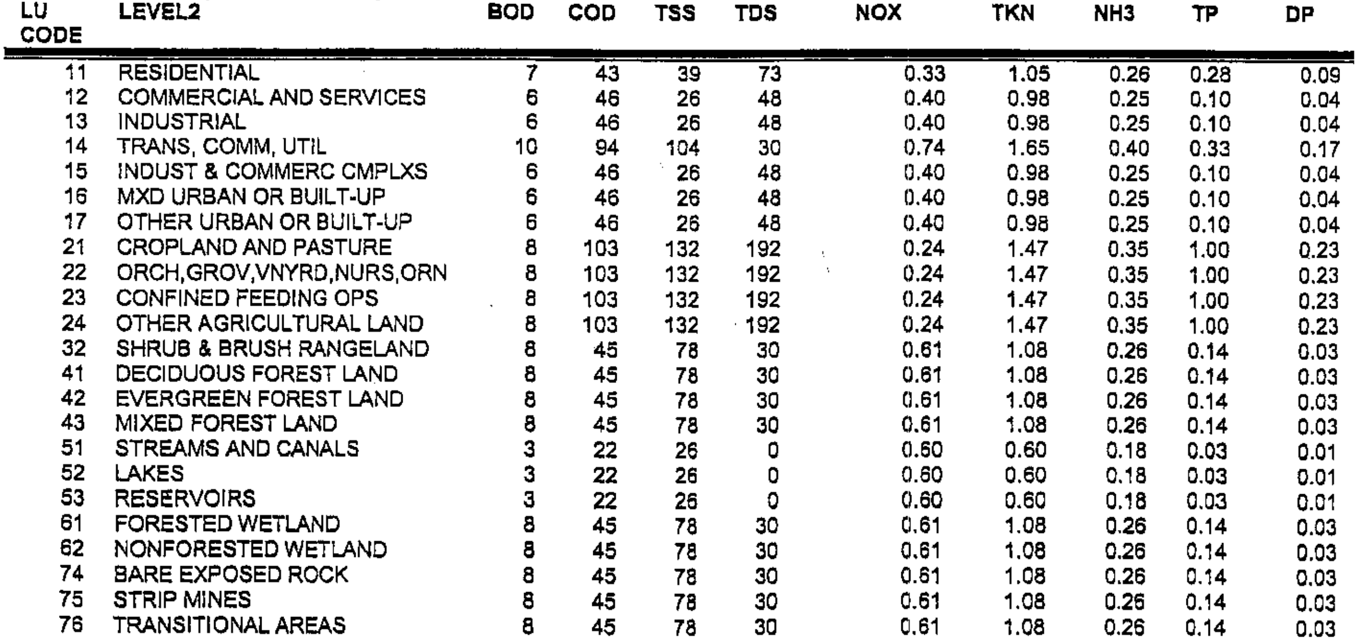


Table 1.1: Urban 'C' Values For Use With the Simple Method (mg/l)

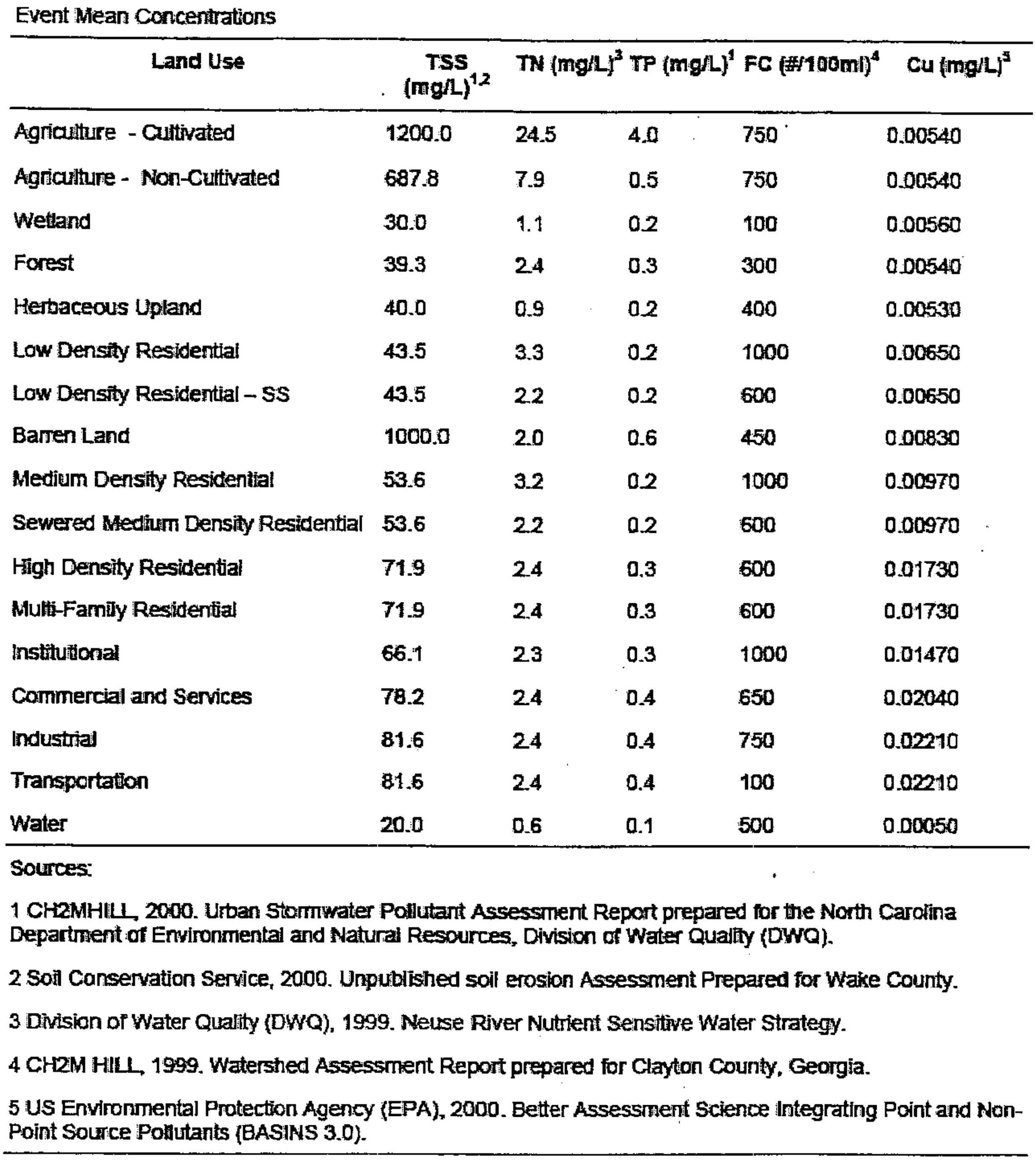
POLLUTANT	NEW SUBURBAN NURP SITES (Wash.,DC)	OLDER URBAN AREAS (Baltimore)	CENTRAL BUSINESS DISTRICT (Wash.,DC)	NATIONAL NURP STUDY AVERAGE	HARDWOOD FOREST (Northern Virginia)	NATIONAL URBAN HIGHWAY RUNOFF
PHOSPHORUS						
Total	0.26	1.08	-	0.46	0.15	-
Ortho	0.12	0.26	1.01	-	0.02	-
Soluble	0.16	-	-	0.16	0.04	0.59
Organic	0.10	0.82	- -	0.13	0.11	-
NITROGEN						
Total	2.00	13.6	2.17	3.31	0.78	-
Nitrate	0.48	8.9	0.84	0.96	0.17	-
Ammonia	0.26	1.1	-	-	0.07	-
Organic	1.25	-	-	-	0.54	-
TKN	1.51	7.2	1.49	2.35	0.61	2.72
COD	35.6	163.0	-	90.8	>40.0	124.0
BOD (5-day)	5.1	-	36.0	11.9	-	-
METALS						
Zinc	0.037	0.397	0.250	0.176	-	0.380
Lead	0.018	0.389	0.370	0.180	-	0.550
Copper	-	0.105	-	0.047	-	-

Table 9. Average Urban Runoff Pollutant Concentration Values for Use With the Simple Method [Schueler, 1987].



LU CODE	LEVEL2	BOD	COD	TSS	TDS	NOX	TKN	NH3	TP	DP
11	RESIDENTIAL	7	43	39	73	0.33	1.05	0.26	0.28	0.09
12	COMMERCIAL AND SERVICES	6	46	26	48	0.40	0.98	0.25	0.10	0.04
13	INDUSTRIAL	6	46	26	48	0.40	0.98	0.25	0.10	0.04
14	TRANS, COMM, UTIL	10	94	104	30	0.74	1.65	0.40	0.33	0.17
15	INDUST & COMMERC CMPLXS	6	46	26	48	0.40	0.98	0.25	0.10	0.04
16	MXD URBAN OR BUILT-UP	6	46	26	48	0.40	0.98	0.25	0.10	0.04
17	OTHER URBAN OR BUILT-UP	6	46	26	48	0.40	0.98	0.25	0.10	0.04
21	CROPLAND AND PASTURE	8	103	132	192	0.24	1.47	0.35	1.00	0.23
22	ORCH,GROV,VNYRD,NURS,ORN	8	103	132	192	0.24	1.47	0.35	1.00	0.23
23	CONFINED FEEDING OPS	8	103	132	192	0.24	1.47	0.35	1.00	0.23
24	OTHER AGRICULTURAL LAND	8	103	132	192	0.24	1.47	0.35	1.00	0.23
32	SHRUB & BRUSH RANGELAND	8	45	78	30	0.61	1.08	0.26	0.14	0.03
41	DECIDUOUS FOREST LAND	8	45	78	30	0.61	1.08	0.26	0.14	0.03
42	EVERGREEN FOREST LAND	8	45	78	30	0.61	1.08	0.26	0.14	0.03
43	MIXED FOREST LAND	8	45	78	30	0.61	1.08	0.26	0.14	0.03
51	STREAMS AND CANALS	3	22	26	0	0.60	0.60	0.18	0.03	0.01
52	LAKES	3	22	26	0	0.60	0.60	0.18	0.03	0.01
53	RESERVOIRS	3	22	26	0	0.60	0.60	0.18	0.03	0.01
61	FORESTED WETLAND	8	45	78	30	0.61	1.08	0.26	0.14	0.03
62	NONFORESTED WETLAND	8	45	78	30	0.61	1.08	0.26	0.14	0.03
74	BARE EXPOSED ROCK	8	45	78	30	0.61	1.08	0.26	0.14	0.03
75	STRIP MINES	8	45	78	30	0.61	1.08	0.26	0.14	0.03
76	TRANSITIONAL AREAS	8	45	78	30	0.61	1.08	0.26	0.14	0.03

Table 10. PLOAD Runoff Event Mean Concentrations [US EPA, 2001].



Event Mean Concentrations

Land Use	TSS (mg/L)[1,2]	TN (mg/L)[3]	TP (mg/L)[1]	FC (#/100ml)[4]	Cu (mg/L)[5]
Agriculture - Cultivated	1200.0	24.5	4.0	750	0.00540
Agriculture - Non-Cultivated	687.8	7.9	0.5	750	0.00540
Wetland	30.0	1.1	0.2	100	0.00560
Forest	39.3	2.4	0.3	300	0.00540
Herbaceous Upland	40.0	0.9	0.2	400	0.00530
Low Density Residential	43.5	3.3	0.2	1000	0.00650
Low Density Residential – SS	43.5	2.2	0.2	600	0.00650
Barren Land	1000.0	2.0	0.6	450	0.00830
Medium Density Residential	53.6	3.2	0.2	1000	0.00970
Sewered Medium Density Residential	53.6	2.2	0.2	600	0.00970
High Density Residential	71.9	2.4	0.3	600	0.01730
Multi-Family Residential	71.9	2.4	0.3	600	0.01730
Institutional	66.1	2.3	0.3	1000	0.01470
Commercial and Services	78.2	2.4	0.4	650	0.02040
Industrial	81.6	2.4	0.4	750	0.02210
Transportation	81.6	2.4	0.4	100	0.02210
Water	20.0	0.6	0.1	500	0.00050

Sources:

1 CH2MHILL, 2000. Urban Stormwater Pollutant Assessment Report prepared for the North Carolina Department of Environmental and Natural Resources, Division of Water Quality (DWQ).

2 Soil Conservation Service, 2000. Unpublished soil erosion Assessment Prepared for Wake County.

3 Division of Water Quality (DWQ), 1999. Neuse River Nutrient Sensitive Water Strategy.

4 CH2M HILL, 1999. Watershed Assessment Report prepared for Clayton County, Georgia.

5 US Environmental Protection Agency (EPA), 2000. Better Assessment Science Integrating Point and Non-Point Source Pollutants (BASINS 3.0).

Table 11. Runoff Event Mean Pollutant Concentrations used in Wake County, North Carolina Study [CH2MHill, 2002].

Limitations

Runoff Concentrations. In the case of the nondegradation analysis, the Simple Method is being used to make a relative comparison of pollutant loads from municipalities during three different time periods. Therefore, the values used for the variables in the Simple Method will determine the relative difference in pollutant load. The three variables in the Simple Method analysis are land area, percent imperviousness, and the mean concentration of the pollutant. These three variables solely determine the relative change in pollutant load. Land area values obtained from geographical information systems can be assumed to be fairly accurate. Readily obtainable values for imperviousness are less accurate. Values for runoff concentration, especially suspended sediment, have a high degree of variability. This variability for urban watersheds can be reduced with knowledge of the watershed channel network (see Figure 1). Such variability for agricultural watersheds can only be reduced with a more detailed model which incorporates, at a minimum, land slope and soil type, and preferably tillage and residue.

Agricultural Drainage. Agricultural areas commonly have intensive subsurface drainage networks which can transport significant nutrient loads that can have a marked impact upon receiving water quality. The Simple Method as being used in the nondegradation analysis does not incorporate these loadings.

Best Management Practice Effectiveness. In order to evaluate best management practice effectiveness and the pollutant load reduction to the receiving water, the available locations in the watershed of structural BMPs and buffers must be known. If this is not the case, any desired pollutant reduction can be achieved with unlimited application of BMPs. Indeed, PLOAD requires as input the location and area served by each BMP.

PLOAD

The U.S. Environmental Protection Agency developed the software "Better Assessment Science Integrating Point and Nonpoint Sources" (BASINS) to assist States in developing Total Maximum Daily Loads for listed waters exceeding water quality standards. A recently–added component of BASINS is a simple watershed loading tool, PLOAD. PLOAD is based upon the Simple Method loading prediction tool, but also estimates watershed loads with the export coefficient method, which utilizes unit–area loading factors for various landuses. BASINS, and consequently, PLOAD, utilize the ESRI ArcView geographical information system software. Watershed boundaries are entered into PLOAD as a GIS coverage. Site specific runoff concentrations and imperviousness can be entered via Excel lookup tables. The locations of BMPs and the area serviced by each BMP are entered as a GIS coverage. The assumed pollutant removal efficiency for each BMP is entered via an Excel lookup table. Point sources of pollutants can also be entered into PLOAD. Locations of the point sources are entered as a GIS coverage, and the associated loads for each point source are entered as an Excel lookup table.

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United States Environmental Protection Agency. *Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients."* EPA 440/5–80–011 Office of Water Regulations and Standards, Washington, DC, 1980.

United States Environmental Protection Agency. *PLOAD Version 3.0. An ArcView GIS Tool to Calculate Nonpoint sources of Pollution in Watershed and Stormwater Projects. User's Manual.* January, 2001.

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