
Appendix E

Development of Unit Area Load Export Coefficients

Memorandum

DATE: May 30, 2007
FROM: Hans Holmberg
PROJECT: CLFLWD
TO: John Erdmann, Ph.D., P.E.
CC: Penelope Moskus
SUBJECT: Summary of Recommended Unit Area Load Values

Introduction

The purpose of this memorandum is to summarize unit area loads (UALs) of total phosphorus for land use/land cover classifications for use in the watershed and water quality assessment of Comfort Lakes and Forest Lake. Site-specific UALs for the watershed were not readily available; therefore UALs were obtained from available, relevant literature. This memorandum summarizes the recommended values for the study area in the table below, as well as the range of literature values in the tables that follow for each land use. Note that the recommended values can serve as a starting point in the water quality assessment. Model calibration and further discussion of site-specific characteristics of the watershed may result in revisions to the recommended values below. The recommended values are largely based on the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (MPCA, 2004).

Land Use	Recommended TP UAL (kg/ha/yr)
Cropland	0.38
Forest	0.075
Grassland	0.169
Urban – High	1.5
Urban – Med	1.15
Urban – Low	0.91
Golf Course	0.91
Sand & Gravel Mining	0.0
Wetlands	0.0

Land Use: Cropland

Source	Description	TP (kg/ha/yr)
Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Appendix C. MPCA. 2004.	Dry Year Average Year Wet Year	0.18 – 0.22 0.38 – 0.39 0.69 – 0.70
Nonpoint Source - Stream Nutrient Level Relationships: A Nationwide Study. EPA-600/3-77-105. 1977.	> 90% agriculture	0.266
Nutrient Loading Estimates for Lakes. Rast. W. and Lee, G.F. Journal of Environmental Engineering. Vol. 109, No. 2. April 1983.	Rural/agriculture	0.3
Characteristics and comparative magnitude of non-point sources. Loehr, R.C. Journal of the Water Pollution Control Federation. Vol. 46, No. 8, August 1974.	Active cropland	0.06 – 2.9
Pollution from Land Runoff. Sonzogni, W.C., G. Chesters, D.R. Coote, D.N. Jeffs, J.C. Konrad, R.C. Ostry, J.B. Robinson. Environmental Science and Technology, Vol. 14, No. 2. 1980.	Cultivated fields - row crop (low animal density)	0.25 – 0.65
Pollution from Land Runoff. Sonzogni, W.C., G. Chesters, D.R. Coote, D.N. Jeffs, J.C. Konrad, R.C. Ostry, J.B. Robinson. Environmental Science and Technology, Vol. 14, No. 2. 1980.	Cultivated fields - mixed farming (medium animal density)	0.1 – 0.2
Estimating Nutrient Loadings of Lakes form Non-Point Sources. EPA-660/3-74/020. 1974.	Row crops	1.62
Sources and Transport of Phosphorus in Western Lake Michigan Drainages. Robertson, D.M. Fact Sheet 208-96. 1996.	Small watershed	3.13
Sources and Transport of Phosphorus in Western Lake Michigan Drainages. Robertson, D.M. Fact Sheet 208-96. 1996.	Large watershed	0.4

Land Use: Forest

Source	Description	TP (kg/ha/yr)
Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Appendix I. MPCA. 2004.	Deciduous	0.075
Nonpoint Source - Stream Nutrient Level Relationships: A Nationwide Study. EPA-600/3-77-105. 1977.	> 90% forest	0.091
Nutrient Loading Estimates for Lakes. Rast. W. and Lee, G.F. Journal of Environmental Engineering. Vol. 109, No. 2. April 1983.		0.05 – 0.1
Characteristics and comparative magnitude of non-point sources. Loehr, R.C. Journal of the Water Pollution Control Federation. Vol. 46, No. 8, August 1974.		0.03 – 0.09
Pollution from Land Runoff. Sonzogni, W.C., G. Chesters, D.R. Coote, D.N. Jeffs, J.C. Konrad, R.C. Ostry, J.B. Robinson. Environmental Science and Technology, Vol. 14, No. 2. 1980.		0.5
Estimating Nutrient Loadings of Lakes form Non-Point Sources. EPA-660/3-74/020. 1974.	Aspen & birch in northern Minnesota	0.08 – 0.18
Protocol for Developing Nutrient TMDLs. EPA 841-B-99-007. US EPA Office of Water. 1999.		0.11
Sources and Transport of Phosphorus in Western Lake Michigan Drainages. Robertson, D.M. Fact Sheet 208-96. 1996.		0.1
Loading rates of nutrients discharging from a golf course and a neighboring forested basin. Takao Kunimatsu, Miki Sudo and Takeshi Kawachi. Water Science and Technology Vol 39 No 12 pp 99–107. 1999.		0.133

Land Use: Grassland

Source	Description	TP (kg/ha/yr)
Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Appendix I. MPCA. 2004.		0.169
Protocol for Developing Nutrient TMDLs. EPA 841-B-99-007. US EPA Office of Water. 1999.		0.13

Land Use: Urban

Source	Description	TP (kg/ha/yr)
Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Appendix J. MPCA. 2004.	Low intensity High intensity Commercial /Industrial/ Transportation	0.88 - 0.94 1.11 – 1.19 1.45 – 1.55
Nonpoint Source - Stream Nutrient Level Relationships: A Nationwide Study. EPA-600/3-77-105. 1977.	> 40% urban	0.347
Nutrient Loading Estimates for Lakes. Rast. W. and Lee, G.F. Journal of Environmental Engineering. Vol. 109, No. 2. April 1983.		0.3
Characteristics and comparative magnitude of non-point sources. Loehr, R.C. Journal of the Water Pollution Control Federation. Vol. 46, No. 8, August 1974.		1.1 – 5.6
Fundamentals of Urban Runoff Management: Technical and Institutional Issues. Horner, R.R., J.J. Skupien, E. H. Livingston, and E. H. Shaver. Terrene Institute and U.S. EPA. 1994.	High Density Medium Density Low Density Commercial Industrial	1.12 0.56 0.04 1.68 1.46
Research on the Design Storm Concept. Marsalek, J. ASCE Urban Water Resources Research Program, TIM No. 33. September 1978.	Low – Medium High - commercial	1.6 3.4
Pollution from Land Runoff. Sonzogni, W.C., G. Chesters, D.R. Coote, D.N. Jeffs, J.C. Konrad, R.C. Ostry, J.B. Robinson. Environmental Science and Technology, Vol. 14, No. 2. 1980.	High – commercial Low – High res. High - industrial	0.1 – 0.2 0.4 – 1.3 0.9 - 14
Estimating Nutrient Loadings of Lakes form Non-Point Sources. EPA-660/3-74/020. 1974.	High – Madison, WI (residential High – Durham, NC (37% impermeable)	1.1 1.2
Protocol for Developing Nutrient TMDLs. EPA 841-B-99-007. US EPA Office of Water. 1999.	Low density High density	0.55 0.7

Land Use: Golf Course

Source	Description	TP (kg/ha/yr)
Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Appendix J. MPCA. 2004.	Urban recreational grasses	0.88 – 0.94
Preliminary Report on Storm Water Runoff from Effluent-Irrigated Golf Courses. Environmental Resource Management Division, Watershed Protection and Development Review Department, City of Austin, TX.		4.38 – 8.76
Loading rates of nutrients discharging from a golf course and a neighboring forested basin. Takao Kunimatsu, Miki Sudo and Takeshi Kawachi. Water Science and Technology Vol 39 No 12 pp 99–107. 1999.		3.04
Impact of a Turfgrass System on Nutrient Loadings to Surface Water. King, K., D. Harmel, H. Torbert, and J. Balogh. Journal of the American Water Resources Association. 2001. V. 37(3). P. 629-640. 2001.	Turfgrass	0.27 – 0.66

Land Use: Sand & Gravel Extraction

Source	Description	TP (kg/ha/yr)
Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Appendix I. MPCA. 2004.		0.0

Land Use: Wetlands

Source	Description	TP (kg/ha/yr)
Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Appendix I. MPCA. 2004.		0.0