Pennsylvania Stormwater Best Management Practices Manual

Appendix A – Water Quality

Pollutant Event Mean Concentrations by Land Cover & BMP Pollutant Removal Efficiencies

363-0300-002 / December 30, 2006

Pollutant Event Mean Concentrations by Land Cover

TABLE A-1. EVENT MEAN CONCENTRATIONS (EMCs) FOR TOTAL SUSPENDED SOLIDS

	LAND COVER CLASSIFICATION	TSS EMC *(mg/l)*	SOURCES	COMMENTS
Pervious Surfaces	Forest	39	B, G, M	---
	Meadow	47	B, N	---
	Fertilized Planting Area	55	Q, R	R: "Residential" area had considerable mulched areas
	Native Planting Area	55	Q, R	R: "Residential" area had considerable mulched areas
	Lawn, Low-Input	180	C, O, Q, R	Median of four values
	Lawn, High-Input	180	C, O, Q, R	Median of four values
	Golf Course Fairway/Green	305	M, R	Average of two values
	Grassed Athletic Field	200	M, N	Average of two values
Impervious Surfaces	Rooftop	21	Q, S, V	Average of Residential, Commercial, and Industrial Roofs
	High Traffic Street / Highway	261	E, F, H, P, Q	Median of five values
	Medium Traffic Street	113	A, B, H, I, J, P, Q	Median of seven values
	Low Traffic / Residential Street	86	E, P, Q	Average of three values
	Res. Driveway, Play Courts, etc.	60	M	"Urban Recreation"
	High Traffic Parking Lot	120	J, N, Q	Median of three values
	Low Traffic Parking Lot	58	I, M, N, Q	Median of 4 values w/ "comm.", "indust.", "parking" & "comm/res."

TABLE A-2. EVENT MEAN CONCENTRATIONS (EMCs) FOR TOTAL PHOSPHORUS

	LAND COVER CLASSIFICATION	TP EMC *(mg/l)*	SOURCES	COMMENTS
Pervious Surfaces	Forest	0.15	B, I, J, M, R, X	---
	Meadow	0.19	F, W	Value from F, W reported no soluble phosphorus from meadow
	Fertilized Planting Area	1.34	F	Study indicated highly maintained landscapes in "High Density Resid."
	Native Planting Area	0.40	F, W	W had no soluble P from mulch, assumed equivalent to low-input lawn
	Lawn, Low-Input	0.40	F	Value for "Low Density Residential"
	Lawn, High-Input	2.22	K, L, S, V	Median of four values
	Golf Course Fairway/Green	1.07	R	---
	Grassed Athletic Field	1.07	R	No data found, assumed eqivalent to golf course
Impervious Surfaces	Rooftop	0.13	L, S, V	Median of three values
	High Traffic Street / Highway	0.40	L, P, S	Median of 3 values including "Arterial St." and "Urban St."
	Medium Traffic Street	0.33	I, L, M, X	Median of 4 values including "Transportation"
	Low Traffic / Residential Street	0.36	L, P, S, V	Median of 4 values including "Feeder St." and "Rural Rd."
	Res. Driveway, Play Courts, etc.	0.46	L, M, S, V	Median of 4 values including "Urban Recreation"
	High Traffic Parking Lot	0.39	S	---
	Low Traffic Parking Lot	0.15	N, S, V	Median of three values

TABLE A-3. EVENT MEAN CONCENTRATIONS (EMCs) FOR NITRATE

	LAND COVER CLASSIFICATION	Nitrate-Nitrite EMC *(mg/l as N)*	SOURCES	COMMENTS
Pervious Surfaces	Forest	0.17	J	---
	Meadow	0.3	B	EMC for TN adjusted
	Fertilized Planting Area	0.73	F, R	Studies indicated mulched areas & highly maintained landscapes
	Native Planting Area	0.33	T	Assumed equivalent to turfgrass w/o chemical treatment
	Lawn, Low-Input	0.44	T, U, W	Based on studies of lawn runoff and leachate
	Lawn, High-Input	1.46	C, T, U	Median of 3 studies in T and NURP data in C - consistent with U
	Golf Course Fairway/Green	1.84	M, R, U	Average of 3 values including one study of leachate
	Grassed Athletic Field	1.01	M	---
Impervious Surfaces	Rooftop	0.32	L, U	---
	High Traffic Street / Highway	0.83	D, F, I, L, P	Median of five values
	Medium Traffic Street	0.58	D, I, L, P	Median of four values
	Low Traffic / Residential Street	0.47	V	EMC for TN adjusted
	Res. Driveway, Play Courts, etc.	0.47	V	Assumed equivalent to residential street
	High Traffic Parking Lot	0.60	F	Value reported for "Retail"
	Low Traffic Parking Lot	0.39	C, F, L	Median of 3 values after EMC for TN adjusted

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REFERENCES FOR TABLES A-1, A-2, AND A-3

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BMP Pollutant Removal Efficiencies- Percent Efficiency

Table A-4. Summary of pollutant removal efficiencies of stormwater BMPs.

COMPREHENSIVE BMP LIST				
		Pollutant Removal Efficiency %		
		TSS	TP	NO3
Non-Structural BMP				
5.4.1	Protect Sensitive / Special Value Features	SC	SC	SC
5.4.2	Protect / Conserve / Enhance Riparian Areas	SC	SC	SC
5.4.3	Protect / Utilize Natural Flow Pathways in Overall Stormwater Planning and Design	30	20	0
5.5.1	Cluster Uses at Each Site; Build on the Smallest Area Possible	SC	SC	SC
5.5.2	Concentrate Uses Areawide through Smart Growth Practices	SC	SC	SC
5.6.1	Minimize Total Disturbed Area - Grading	40	0	0
5.6.2	Minimize Soil Compaction in Disturbed Areas	30	0	0
5.6.3	Re-vegetate and Re-forest Disturbed Areas using Native Species	85	85	50
5.7.1	Reduce Street Imperviousness	SC	SC	SC
5.7.2	Reduce Parking ImperviousnesS	SC	SC	SC
5.8.1	Rooftop Disconnection	30	0	0
5.8.2	Disconnection from Storm Sewers	30	0	0
5.9.1	Streetsweeping	85	85	50
Structural BMP				
6.4.1	Porous Pavement with Infiltration Bed	85	85	30
6.4.2	Infiltration Basin	85	85	30
6.4.3	Subsurface Infiltration Bed	85	85	30
6.4.4	Infiltration Trench	85	85	30
6.4.5	Rain Garden / Bioretention	85	85	30
6.4.6	Dry Well / Seepage Pit	85	85	30
6.4.7	Constructed Filter	85	85	30
6.4.8	Vegetated Swale	50	50	20
6.4.9	Vegetated Filter Strip	30	20	10
6.4.10	Infiltration Berm and Retentive Grading	60	50	40
6.5.1	Vegetated Roof	85	85	30
6.5.2	Rooftop Runoff - Capture and Reuse	100	100	100
6.6.1	Constructed Wetland	85	85	30
6.6.2	Wet Pond / Retention Basin	70	60	30
6.6.3	Dry Extended Detention Basin	60	40	20
6.6.4	Water Quality Filter	60	50	20
6.7.1	Riparian Buffer Restoration	65	50	50
6.7.2	Landscape Restoration	85	85	50
6.7.3	Soils Amendment and Restoration	85	85	50

SC, Self Crediting: The BMP reduces the pollutant load, thus is self-crediting. BMPs with this designation are labeled as " Preventive" in Section 5.

** All values shown represent professional interpretation, based upon best available data as provided in Appendix A.**

5.9.1 STREETSWEEPING

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Biweekly Sweeping	40-60					20-40	Kurahashi & Associates, Inc. 1997. Port of Seattle - Stormwater Treatment BMP Evaluation. Prepared for the Port of Seattle, Pier 66. Prepared by Kurahashi & Associates, in association with AGI Technologies.	Federal Highway Administration (FHWA). “Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring – Monitoring Case Study-Streetsweeping BMP Evaluation, Port of Seattle, Washington.” U.S. Department of Transportation.	Land Use = cargo container yards
Weekly Sweeping	45-65					30-55	Kurahashi & Associates, Inc. 1997. Port of Seattle - Stormwater Treatment BMP Evaluation. Prepared for the Port of Seattle, Pier 66. Prepared by Kurahashi & Associates, in association with AGI Technologies.	Federal Highway Administration (FHWA). “Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring – Monitoring Case Study-Streetsweeping BMP Evaluation, Port of Seattle, Washington.” U.S. Department of Transportation.	Land Use = cargo container yards
Twice Weekly Sweeping	45-70					35-60	Kurahashi & Associates, Inc. 1997. Port of Seattle - Stormwater Treatment BMP Evaluation. Prepared for the Port of Seattle, Pier 66. Prepared by Kurahashi & Associates, in association with AGI Technologies.	Federal Highway Administration (FHWA). “Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring – Monitoring Case Study-Streetsweeping BMP Evaluation, Port of Seattle, Washington.” U.S. Department of Transportation.	Land Use = cargo container yards
Vacuum-assisted sweeper efficiency	42	77				74	NVPDC. 1992. Northern Virginia BMP Handbook: A Guide to Planning and Designing Best Management Practices in Northern Virginia. Prepared by Northern Virginia Planning District Commission (NVPDC) and Engineers and Surveyors Institute.	Federal Highway Administration (FHWA). “Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Fact Sheet - Street Sweepers.” U.S. Department of Transportation.	
Mechanical Sweeper	55	42				40	NVPDC. 1992. Northern Virginia BMP Handbook: A Guide to Planning and Designing Best Management Practices in Northern Virginia. Prepared by Northern Virginia Planning District Commission (NVPDC) and Engineers and Surveyors Institute.	Federal Highway Administration (FHWA). “Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Fact Sheet - Street Sweepers.” U.S. Department of Transportation.	
RANGE	**40 - 70**	**42 - 77**				**20 - 74**			

6.4.1 POROUS PAVEMENT

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Porous Pavement	80	80					Johnston Smith Consulting Limited. *Sustainable Urban Drainage Systems - SUDS.*		
Porous Pavement	95	88					Metropolitan Washington Council of Governments (MWCOG). 1983. Urban Runoff in the Washington Metropolitan Area: Final Report, Urban Runoff Project, EPA Nationwide Urban Runoff Program. Metropolitan Washington Council of Governments, Washington, DC.		
Porous Pavement	82	80				65	Schueler, T.R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments. Department of Environmental Programs.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 13; STP Size = 0.553acres; Percent efficiency calculated using mass efficiency method.
Porous Pavement	95	85				65	Schueler, T.R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments. Department of Environmental Programs.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Percent efficiency calculated using mass efficiency method.
Porous Pavement	97					94	St. John, M. 1997. Effect of Road Shoulder Treatments on Highway Runoff Quality and Quantity. University of Washington.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Asphalt void volume 22%"; # of storms = 9
Porous Pavement	95	82					Stormwater Manager's Resource Center (SMRC). *Stormwater Management Fact Sheet: Porous Pavement.*		
Porous Pavement	65-100	65-100				30-65	USEPA. 1999. Preliminary Data Summary of Urban Stormwater BMPs.		
RANGE	**65-100**	**65-100**				**30 - 94**			

6.4.2 INFILTRATION BASIN

	Pollutant Removal % Efficiency								
Type	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Infiltration Basin	95	65					Cahill Assoc. Technical BMP Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed. Nov 2002.		
Infiltration Basin	75	45 - 55				50 - 55	Schueler, T. 1987. Controlling urban runoff – a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington, DC.	FHWA, 1999. *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring* . Federal Highway Administration, U.S. Department of Transportation.	Capture of 12.7 mm (0.5 in) of runoff (first flush)
Infiltration Basin	99	60 - 70				65 - 75	Schueler, T. 1987. Controlling urban runoff – a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington, DC.	FHWA, 1999. *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring* . Federal Highway Administration, U.S. Department of Transportation.	Capture of 25.4 mm (1 in) of runoff
Infiltration Basin	90	55 - 60				60 - 70	Schueler, T. 1987. Controlling urban runoff – a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington, DC.	FHWA, 1999. *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring* . Federal Highway Administration, U.S. Department of Transportation.	Capture of 50.8 mm (2 in) of runoff
Infiltration Basin	50-80	50-80				50-80	USEPA. Preliminary Data Summary of Urban Storm Water Best Management Practices. Aug 1999.		
RANGE	**50 - 99**	**45 - 80**				**50 - 80**			

6.4.3 SUBSURFACE INFILTRATION BED

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Subsurface Infiltration Bed	90	60	27				Cahill Assoc. Technical BMP Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed. Nov 2002.		
Subsurface Infiltration Bed	95	51				70	Chester County Conservation District. *Chester County Stormwater BMP Tour Guide: Infiltration Beds*. 2002.		
RANGE	**90 - 95**	**51 - 60**	**27**			**70**			

6.4.4 INFILTRATION TRENCH

	Pollutant Removal % Efficiency								
Type	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Infiltration Trench		3.4	100		-12.3	4.5	Kuo, C.Y., G. D. Boardman and K.T. Laptos. 1990. Phosphorous and Nitrogen Removal Efficiencies of Infiltration Trenches. Dept. of Civil Engineering. VA Polytechnic Institute and State University. Prepared for: No. VA Planning District Commission, Occoquan Technical Advisory Committee and VA State Water Control Board.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"49.5 hours detention time", soil type = loam; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Infiltration Trench		42.3	-100		100	100	Kuo, C.Y., G. D. Boardman and K.T. Laptos. 1990. Phosphorous and Nitrogen Removal Efficiencies of Infiltration Trenches. Dept. of Civil Engineering. VA Polytechnic Institute and State University. Prepared for: No. VA Planning District Commission, Occoquan Technical Advisory Committee and VA State Water Control Board.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"47.75 hours detention time", soil type = sandy loam; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Infiltration Trench		50.5	82		70.1	100	Kuo, C.Y., G. D. Boardman and K.T. Laptos. 1990. Phosphorous and Nitrogen Removal Efficiencies of Infiltration Trenches. Dept. of Civil Engineering. VA Polytechnic Institute and State University. Prepared for: No. VA Planning District Commission, Occoquan Technical Advisory Committee and VA State Water Control Board.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"51.5 hours detention time", soil type = sandy; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Infiltration Trench	50-80	50-80				15-45	USEPA. *Preliminary Data Summary of Urban Storm Water Best Management Practices* . Aug 1999.		
Infiltration Trench	90	60					Schueler, T.R., 1992. A Current Assessment of Urban Best Management Practices. Metropolitan Washington Council of Governments.	United States Environmental Protection Agency (USEPA). *Storm Water Technology Fact Sheet: Infiltration Trench* (EPA 832-F-99-019). 1999.	
WQ Trench	75	45 - 55				50 - 55	Schueler, T. 1987. Controlling urban runoff – a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington, DC.	FHWA, 1999. *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring* . Federal Highway Administration, U.S. Department of Transportation.	Capture of 12.7 mm (0.5 in) of runoff (first flush)
WQ Trench	90	55 - 60				55 - 60	Schueler, T. 1987. Controlling urban runoff – a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington, DC.	FHWA, 1999. *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring* . Federal Highway Administration, U.S. Department of Transportation.	Capture of 50.8 mm (2 in) of runoff
RANGE	**50 - 90**	**3.4 - 80**	**(-100) - 100**		**(-12.3) - 100**	**4.5 - 100**			

6.4.5 RAIN GARDEN / BIORETENTION

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Rain Garden	53	49	16				Cahill Assoc. Technical BMP Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed. Nov 2002.		
Rain Garden	87						Davis, A.P. "Bioretention – Studies Completed by the University of Maryland" http://www.ence.umd.edu/~apdavis/Biodata.htm. Updated: August 27, 2002.	Low Impact Development Center. "Watershed Benefits of Bioretention Techniques". http://www.lid-stormwater.net/bioretention/bio_benefits.htm. Accessed: December 13, 2002.	
Rain Garden		57					Davis, A.P., M. Shokouhian, H. Sharma, and C. Minami. 2001. Laboratory Study of Biological Retention for Urban Stormwater Management. Water Environment Research. 73(1): 5-14.	Tetra Tech, Inc., 2003. Mecklenburg County Site Evaluation Tool Model Documentation.	
Rain Garden	91		-16			63	Hsieh, C. and A.P. Davis. Multiple-event Study of Bioretention for Treatment of Urban Storm Water Runoff. 2003. Percent efficiency calculated using mass efficiency method.		
Rain Garden	90						United States Environmental Protection Agency (USEPA). *Storm Water Technology Fact Sheet: Bioretention* (EPA 832-F-99-012). 1999.		
RANGE	**53 - 91**	**49 - 57**	**(-16) - 16**			**63**			

6.4.6 DRY WEL SEEPAGE PIT

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Dry Well	50-80	50-80				15-45	USEPA. Preliminary Data Summary of Urban Storm Water Best Management Practices. Aug 1999.		
RANGE	**50 - 80**	**50 - 80**				**15 - 45**			

6.4.7 CONSTRUCTED FILTER

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Filtering Practice	48					-78.5	Leif, W. 1999. Compost Stormwater Filter Evaluation. Snohomish County Public County Works. Everett, WA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 8; Drainage area = 0.69acres; "Filter is 12" deep"; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Organic Filter	98			32		88	Corsi, S. and S. Greb. 1997. Demonstration project of Wisconsin Department of Natural Resources, United States Geological Survey and the City of Milwaukee. Personal communication with R. Pitt. 1997. In: Multi-Chamber Treatment Train Developed for Stormwater Hot Spots. Watershed Protection Techniques. Center for Watershed Protection. February 1997.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = City Maintenance yard (pavement); %Impervious Cover = 100%; "treatment provided for the first 1/2in of runoff. (80% of the annual water load)"; # of storms = 5; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Organic Filter	88				61	47	Lower Colorado River Authority. 1997. Innovative NPS Pollution Control Program for Lake Travis in Central Texas. LCRA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Large parking lot, % Impervious Cover = 82%; "Peat/sand filter media wit surface ED. Retrofit Site. Steep Slopes. Retention Capacity 1420ft3"; # of storms = 21; Percent efficiency calculated using event mean concentration (EMC) efficiency method
Organic Filter	90				68	73	Lower Colorado River Authority. 1997. Innovative NPS Pollution Control Program for Lake Travis in Central Texas. LCRA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Large parking lot, % Impervious Cover = 82%; "Peat/sand filter media wit surface ED. Retrofit Site. Steep Slopes. Retention Capacity 1420ft3"; # of storms = 21; Percent efficiency calculated using mass efficiency method
Organic Filter	83		14			80	Pitt, R. 1996. The Control of Toxicants at Critical Source Areas. The Univerisity of Alabama at Birmingham. In: Multi-Chamber Treatment Train Developed for Stormwater Hot Spots. Watershed Protection Techniques. Center for Watershed Protection. February 1997. 2(3): 445-449	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Parking Lot, vehicle service area; Treatment provided for 0.25-0.8in of rain; # of storms = 14; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Organic Filter	85					80	Pitt, R. 1997. Multi-Chamber Treatment Train Developed for Stormwater Hot Spots. Watershed Protection Techniques. Center for Watershed Protection. February 1997. 2(3): 445-449	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Commercial Parking Lot; # of storms = 7; Drainage area = 2.5 acres; Percent efficiency calculated using event mean concentration (EMC) efficiency method
Organic Filter	95		-34			41	Stewart, W. 1992. Compost Stormwater Treatment System. W&H Pacific Consultants. Draft Report. Portland, OR.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = 95%Residential, rest roadway; # of storms = 7, Drainage area = 73.9; "Compost media filter"; Percent efficiency calculated using event mean concentration (EMC) efficiency method
Organic Media Filters	92		-145		57	49	Stormwater Management. 1994. Three Year Performance Summary of Stormwater Pollutant and Treatment – 185th Avenue, Hillsboro, Oregon. Technical Memorandum. Stormwater Management. Portland, Oregon.	US Department of Transportation, Federal Highway Administration. "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Fact Sheet - Organic Media Filters."	"3-year results for CSF® Type I system"
Other Media Filters	65-100	15-45				<30	USEPA. Preliminary Data Summary of Urban Storm Water Best Management Practices. Aug 1999.		

6.4.7 CONSTRUCTED FILTER (cont.)

	Pollutant Removal % Efficiency								
Type	**TSS**	**TN**	**NO_3**	**NO_x**	**TKN**	**TP**	**Primary Source**	**Secondary Source**	**Comments**
Packed Bed Filter	81	63	75				Egan, T., S. Burroughs and T. Attaway. 1995. Packed Bed Filter. Pp. 264-274 in Proceedings Fourth Biennial Stormwater Research Conference. October 19-20. Clearwater, FL. SW Florida Water Management District.	Center for Watershed Protection. *Design of Stormwater Filtering Systems*. Dec 1996. (pg 4-8)	Percent efficiency calculated using mass efficiency method.
Sand Filter	98		64		65	66	Barrett, M., M. Keblin, J. Malina, R. Charbeneau. 1998. Evaluation of the Performance of Permanent Runoff Controls: Summary and Conclusions. Center for Transportation Research. Texas Department of Transportation. University of Texas, Austin, TX	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = 67% Highway/33%Commercial; Drainage area = 82.95acres; # of storms = 10; Treament Vol = first 0.5in of runoff; Percent efficiency calculated using mass efficiency method.
Sand Filter	79	47	-53.3		70.6	65.5	Bell, W., L. Stokes, L.J. Gavan and T.N. Nguyen. 1995. Assessment of the Pollutant Removal Efficiences of Delaware Sand Filter BMPs. Final Report. Department of Transportation and Environmental Services. Alexandria, VA	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Parking Lot; STP Size = 477.6ft3; Drainage area = 0.7acres; # of storms = 20; "Perimeter sand filter"; Percent efficiency calculated using mass efficiency method.
Sand Filter	86	31	-5		48	19	City of Austin, TX. 1990. Removal Efficiences of Stormwater Control Structures. Final Report. Environmental Resource Management Division.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Multi-family housing; Impervious Cover = 50%; # of storms = 18; Drainage area = 3.1acres; Treatment Vol = 0.5in; "Surface sand filter"; Percent efficiency calculated using mass efficiency method.
Sand Filter	87	32	-79		62	61	City of Austin, TX. 1990. Removal Efficiences of Stormwater Control Structures. Final Report. Environmental Resource Management Division.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Road; Impervious Cover = 81%; # of storms = 16; Drainage area = 9.5acres; "Surface sand filter"; Percent efficiency calculated using mass efficiency method.
Sand Filter	75	44	-13		64	59	City of Austin, TX. 1990. Removal Efficiences of Stormwater Control Structures. Final Report. Environmental Resource Management Division.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Mall 86%; Commercial Cover = 86%; # of storms = 18; Drainage area = 79acres; Treatment Vol = 0.5in; STP Size = 3.5acre/ft; "Surface sand filter"; Percent efficiency calculated using mass efficiency method.
Sand Filter	92	71	23		90	80	City of Austin, TX. 1990. Removal Efficiences of Stormwater Control Structures. Final Report. Environmental Resource Management Division.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 68%; # of storms = 17; Drainage area = 50acres; "Surface sand filter"; Percent efficiency calculated using mass efficiency method.
Sand Filters	70	21					United States Environmental Protection Agency (USEPA). *Storm Water Technology Fact Sheet: Sand Filters* (EPA 832-F-99-007) 1999		
Sand Filter	78	27	-100		57	27	Welborn, C. and J. Veenhuis. 1987. Effects of Runoff Controls on the Quantity and Quality of Urban Runoff in Two Locations in Austin, TX. USGS Water Resources Investigations Report. 87-4004	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Commercial; Drainage area = 80acres; # of storms = 22; "Surface sand filter"; Percent efficiency calculated using mass efficiency method.
Surface Sand Filters	50-80	<30				50-80	USEPA. Preliminary Data Summary of Urban Storm Water Best Management Practices. Aug 1999.		
RANGE	**48 - 100**	**21 - 71**	**(-145) - 75**	**32**	**48 - 90**	**(-78.5) - 88**			

6.4.8 VEGETATED SWALE

	Pollutant Removal % Efficiency								
Type	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
100 Foot Swale	60						Delaware DNREC and Brandywine Conservancy. *Conservation Design for Stormwater Management* . Sep. 1997.		
200 Foot Swale	83						Delaware DNREC and Brandywine Conservancy. *Conservation Design for Stormwater Management* . Sep. 1997.		
Drainage Channel	65		11				Dorman, M.E., J. Hartigan, R.F. Steg and T. Quasebarth. 1989. Retention, Detention and Overland Flow for Pollutant Removal from Highway Stormwater Runoff. Vol. 1. Research Report. Federal Highway Administration. FHWA/RD 89/202.		
Drainage Channel	33						Oakland H. An evaluation of Stormwater Pollutant Removal Through Grassed Swale Treatment. Proceedings of the International Symposium of Urban Hydrology, Hydraulics and Sediment Control. 1983.		
Drainage Channel	31	37					Occoquan Watershed Monitoring Labortory (OWML). Final Report. Washington Area NURP Report. VPISU. Metropolitan Washington Council of Governments. Manassas, VA. 1983.		
Drainage Channel		13	11				Yoursef, Y. et al. Best Management Practices – Removal of Highwy Contaminants by Roadside Swales. Final Report. Univerisity of Central Florida. Florida Department of Transportation. Orlando, FL. 1985.		
Dry Swale	87	84	80			83	Harper, H. 1988. Effects of Stormwater Management Systems on Groundwater Quality. Final Report. Environmental Research and Design, Inc. Prepared for Florida Department of Environmental Regulation.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Interstate highway; 70% Impervious; # of storms = 16; "Infiltration Rate = 13.4in/hour. Time of Concentration = 45min" Drainage area = 0.83acres; Percent efficiency calculated using mass efficiency method.
Dry Swale	99	99	99			99	Kercher, W.C., J.C. Landon and R. Massarelli. 1983. Grassy Swales Prove Cost-Effective for Water Pollution Control. Public Works. Vol. 16: 53-55.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Residential; Soil Type = Sandy; # of storms = 13; drainage area = 14 acres; slope = 2%; Percent efficiency calculated using mass efficiency method.
Grass Channel	60			-25		45	Seattle Metro and Washington Department of Ecology. 1992. Biofiltration Swale Performance: Recommendations and Design Considerations. Publication No. 657. Water Pollution Control Department, Seattle Washington.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Major roadway; residences, parks; impervious Cover = 47%; "grass channel design. 10 minute residence time for design storm; Drainage area = 15.5acres; slope = 4%; "Length 200ft. 5ft wide"; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Grass Channel	67.8			31.4		4.5	Goldberg. 1993. Dayton Avenue Swale Biofiltration Study. Seattle Engineering Department. Seattle, WA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	%Impervious Cover = 20; "600ft long grass channel"; # of storms = 8; Drainage area = 90acres; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Grass Channel	83			-25		29	Seattle Metro and Washington Department of Ecology. 1992. Biofiltration Swale Performance: Recommendations and Design Considerations. Publication No. 657. Water Pollution Control Department, Seattle Washington.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Major roadway; residences, parks; impervious Cover = 47%; "grass channel design. 10 minute residence time for design storm; Drainage area = 15.5acres; slope = 4%; "Length 200ft. 5ft wide"; Percent efficiency calculated using event mean concentration (EMC) efficiency method.

6.4.8 VEGETATED SWALE (cont.)

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Grassed Swales	30-65	15-45				15-45	USEPA. 1999. Preliminary Data Summary of Urban Stormwater BMPs.		
Swales		24	-21				Yousef, Y.A., M.P. Wanielista, H.H. Harper, D.B. Pearce, and R.D. Tolbert. 1985. Best Management Practices Removal of Highway Contaminants by Roadside Swales. Final Report. Florida Department of Transportation, Tallahassee.		
Swales		27	-2				Yousef, Y.A., M.P. Wanielista, H.H. Harper, D.B. Pearce, and R.D. Tolbert. 1985. Best Management Practices Removal of Highway Contaminants by Roadside Swales. Final Report. Florida Department of Transportation, Tallahassee.		
Swales		39	48				Yousef, Y.A., M.P. Wanielista, H.H. Harper, D.B. Pearce, and R.D. Tolbert. 1985. Best Management Practices Removal of Highway Contaminants by Roadside Swales. Final Report. Florida Department of Transportation, Tallahassee.		
Swales		61	57				Yousef, Y.A., M.P. Wanielista, H.H. Harper, D.B. Pearce, and R.D. Tolbert. 1985. Best Management Practices Removal of Highway Contaminants by Roadside Swales. Final Report. Florida Department of Transportation, Tallahassee.		
Swales		73	67				Yousef, Y.A., M.P. Wanielista, H.H. Harper, D.B. Pearce, and R.D. Tolbert. 1985. Best Management Practices Removal of Highway Contaminants by Roadside Swales. Final Report. Florida Department of Transportation, Tallahassee.		
Swales		100	100				Yousef, Y.A., M.P. Wanielista, H.H. Harper, D.B. Pearce, and R.D. Tolbert. 1985. Best Management Practices Removal of Highway Contaminants by Roadside Swales. Final Report. Florida Department of Transportation, Tallahassee.		
Vegetated Filter Strip	87		50			44	Barrett, M.E. et al. Evaluation of the Performance of Permanent Runoff controls: Summary and Conclusions. Center for Research in Water Resources, University of Texas at Austin. Austin, TX: Nov. 1997.		Site 1; Treatment Length = 7.5 to 8.8m; slope = .73%; vegetation = buffalo grass; higher traffic than site 2; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Vegetated Filter Strip	85		23			34	Barrett, M.E. et al. Evaluation of the Performance of Permanent Runoff controls: Summary and Conclusions. Center for Research in Water Resources, University of Texas at Austin. Austin, TX: Nov. 1997.		Site 2; Treatment Length = 7.8 to 8.1m; slope = 1.7%; vegetation = mixed; lower traffic than site 1; Percent efficiency calculated using event mean concentration (EMC) efficiency method.

6.4.8 VEGETATED SWALE (cont.)

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Vegetated Swales	81		38				United States Environmental Protection Agency (USEPA). *Storm Water Technology Fact Sheet: Vegetated Swales* (EPA 832-F-99-006). 1999		
Wet Swale	81	40	52			17	Harper, H. 1988. Effects of Stormwater Management Systems on Groundwater Quality. Final Report. Environmental Research and Design, Inc. Prepared for Florida Department of Environmental Regulation.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Length= 210ft; Land Use = Interstate highway (100% Impervious); Treatment Vol= 2year critical velocity, 10 year capacity; Soil Type = saturated sandy; # of storms = 11; drainage area = 1.17 acres; slope = 1.8%; Percent efficiency calculated using mass efficiency method
WQ Swale	98		45		48	18	Dorman, M.E., J. Hartigan, R.F. Steg and T. Quasebarth. 1989. Retention, Detention and Overland Flow for Pollutant Removal from Highway Stormwater Runoff. Vol. 1. Research Report. Federal Highway Administration. FHWA/RD 89/202	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = highway, Impervious cover = 63%, soil type = sandy; length 185'; Age of facility = 5years
WQ Swale	80						Wang, T., D. Spyridakis, B. Mar and R. Horner. 1981. Transport, deposition, and control of heavy metals in highway runoff. FHWA-WA-RD-39-10. Dept. of Civil Engineering. University of Washington. Seattle, WA	Center for Watershed Protection. *Design of Stormwater Filtering Systems*. Dec 1996. (pg 4-19)	
RANGE	**30 - 99**	**13 - 100**	**(-21) - 100**	**(-25) - 31.4**	**48**	**4.5 - 99**			

6.4.9 VEGETATE FILTER STRIP

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
15 Foot Grass Filter Strip	70						Klapproth, J.C. and J.E. Johnson. *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*. Virgina Tech. Oct 2000.		
30 Foot Grass Filter Strip	84						Klapproth, J.C. and J.E. Johnson. *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*. Virgina Tech. Oct 2000.		
75 Foot Filter Strip	54		-27				Center for Watershed Protection. *Design of Stormwater Filtering Systems*. Dec 1996. (pg 4-26)		
150 Foot Filter Strip	84		20				Center for Watershed Protection. *Design of Stormwater Filtering Systems*. Dec 1996. (pg 4-26)		
Grass/Grass-Forest Filter Strip	60-90						Klapproth, J.C. and J.E. Johnson. *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*. Virgina Tech. Oct 2000.		
Vegetated Filter Strip	70	30	0				Center for Watershed Protection. *Design of Stormwater Filtering Systems*. Dec 1996. (pg 4-33)		
Vegetated Filter Strip	75	45	22				Cahill Assoc. Technical BMP Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed. Nov 2002		
RANGE	**54 - 90**	**30 - 45**	**(-27) - 22**						

6.6.1 CONSTRUCTED WETLAND

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Constructed Wetlands	50-80	<30				15-45	USEPA. 1999. Preliminary Data Summary of Urban Stormwater BMPs.		
Extended Detention Wetland	24			35		16	Athanas C. and C. Stevenson. 1986. Nutrient Removal from Stormwater Runoff by a Vegetated Collection Pond - The Mays Chapel Wetland Basin Project. Prepared for the City of Baltimore, Department of Public Works, Bureau of Water and Wastewater, Water Quality Management Office.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Treatment volume = 0.1in/acre; Drainage area = 97acres
Extended Detention Wetland	76				25	54	Barten, J.M. 1983. Treatment of Stormwater Runoff Using Aquatic Plants. The Use of Wetlands for Controlling Stormwater Pollution. Strecker, E.W. J.M. Kersnar and E.E. Dris coll (Eds.). Woodward-Clyde Consultants. Portland, Oregon. Prepared for the USEPA, Region V, Water Division, Watershed Management Unit. EPA/600 February	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Treatment volume = 0.15in/acre; Drainage area = 1070acres
Extended Detention Wetland	62		23		40	24	Oberts, G.L., P.J. Wotzka and J.A. Hartsoe. 1989. The water Quality Performance of Select Urban Runoff Treatment Systems. Prepared for the Legislative Commision on Minnesota Resources. Metropolitan Council. St. Paul, MN. Publication No. 590-89-062a	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 10; Treatment volume = 0.1in/acre; Drainage area = 413acres
Extended Detention Wetland	62	-2.1	1.2		15	8.3	Occoquan Watershed Monitoring Laboratory and George Mason Univeristy. 1990. Final Report: The Evaluation of a Created Wetland as an Urban Best Management Practice. Prepared for the Northern Virginia Soil and Water Conservation District.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; # of storms = 23; Treatment volume = 0.1in/acre; Drainage area = 40acres; "Data collected from Large storms >0.1watershed inch. Large storms overwhelm capacity of wetlands to remove nutrients."
Extended Detention Wetland	93	76	68		81	76	Occoquan Watershed Monitoring Laboratory and George Mason Univeristy. 1990. Final Report: The Evaluation of a Created Wetland as an Urban Best Management Practice. Prepared for the Northern Virginia Soil and Water Conservation District.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; # of storms = 23; Treatment volume = 0.1in/acre; Drainage area = 40acres; "Data collected from Small storms <0.1watershed inch."; Percent efficiency calculated using mass efficiency method.
Shallow Marsh	65	22.8	54.9	54.5		39.1	Athanas, C. and C. Stevenson. 1991. The Use of Artificial Wetlands in Treating Stormwater Runoff. Prepared for the Maryland Sediment and Stormwater Administration. Maryland Department of the Environment.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = High School roof, parking lot, athletic; Surface area of wetland = 0.6acres; Treatment volume = 0.5in/acre; Drainage area = 16acres; Percent efficiency calculated using mass efficiency method.
Shallow Marsh	37.5	13	25.5		11.5	47.5	Blackburn, R., P.L. Pimentel and G.E. French. 1986. Treament of Stormwater Runoff Using Aquatic Plants. The Use of Wetlands for Controlling Stormwater Pollution. Strecker, E.W. J.M. Kersnar and E.E. Dris coll (Eds.). Woodward-Clyde Consultants. Portland, Oregon. Prepared for the USEPA, Region V, Water Division, Watershed Management	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = Golf Course; Size of Wetland = 296acres; # of storms = 72; Treatment volume = 1in; Drainage area = 2340acres; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Shallow Marsh	86	46		94	34	70	Carr, D. and B. Rushton. 1995. Integrating a Herbaceous Wetland into Stormwater Management. Stormwater Research Program. Southwest Florida Water Management District. Brooksville	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 81; Drainage area = 15.3; STP size = 3acres; Percent efficiency calculated using mass efficiency method.

6.6.1 CONSTRUCTED WETLAND (cont.)

	Pollutant Removal % Efficiency								
Type	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Shallow Marsh	82.9	-1.6	80.2			7	Harper, H.H., M.P. Wanielista, B.M. Fries and D.M. Baker. 1986. The Use of Wetlands for Controlling Stormwater Pollution. Strecker, E.W. J.M. Kersnar and E.E. Dris coll (Eds.). Woodward-Clyde Consultants. Portland, Oregon. Prepared for the USEPA, Region V, Water Division, Watershed Management Unit. EPA/600 February 1992	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Runoff enters through a small shallow canal. This is a NATURAL WETLAND." Land Use = Large Residential Community; Treatment Volume = 1.08in/acre; Drainage area = 55.4acres; STP size = 2.47acres; Percent efficiency calculated using mass efficiency method.
Shallow Marsh	85.5		67			75	Hey, D.L., A.L. Kenimer and K.R. Barrett. 1994. Water Quality Improvement by Four Experimental Wetlands Ecological Engineering Vol. 3: 381-397.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Wetland 4. Land Use = 80%Agriculture, 20%Urban; "5 - 8.6 acre wetland. Max depth 5ft. Subject to low flow conditions (2.8-6.3 in/week)" Drainage area = 128000acres; Percent efficiency calculated using mass efficiency method
Shallow Marsh	87		82.5			77.5	Hey, D.L., A.L. Kenimer and K.R. Barrett. 1994. Water Quality Improvement by Four Experimental Wetlands Ecological Engineering Vol. 3: 381-397.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Wetland 1. Land Use = 80%Agriculture, 20%Urban; "5 - 8.6 acre wetland. Max depth 5ft. Subject to high flow conditions (13.4 - 38.2 in/week)" Drainage area = 128000acres; Percent efficiency calculated using mass efficiency method
Shallow Marsh	95.5		86			87	Hey, D.L., A.L. Kenimer and K.R. Barrett. 1994. Water Quality Improvement by Four Experimental Wetlands Ecological Engineering Vol. 3: 381-397.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Wetland 2. Land Use = 80%Agriculture, 20%Urban; "5 - 8.6 acre wetland. Max depth 5ft. Subject to high flow conditions (13.4 - 38.2 in/week)" Drainage area = 128000acres; Percent efficiency calculated using mass efficiency method
Shallow Marsh	99.5		99			99.5	Hey, D.L., A.L. Kenimer and K.R. Barrett. 1994. Water Quality Improvement by Four Experimental Wetlands Ecological Engineering Vol. 3: 381-397.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Wetland 3. Land Use = 80%Agriculture, 20%Urban; "5 - 8.6 acre wetland. Max depth 5ft. Subject to low flow conditions (2.8-6.3 in/week)" Drainage area = 128000acres; Percent efficiency calculated using mass efficiency method
Shallow Marsh	94					78	Hickok, E.A., M.C. Hannaman and N.C. Wenck. 1977. Urban Runoff Treatment Methods. Volume 1: Non-structural Wetland Treatment. The Use of Wetlands for Controlling Stormwater Pollution. Strecker, E.W. J.M. Kersnar and E.E. Dris coll (Eds.). Woodward-Clyde Consultants. Portland, Oregon. Prepared for the USEPA, Region V, Water Division, Watershed Management	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = 47%Residential. "This is a NATURAL WETLAND." STP size = 7.6acres. Treatment volume = 1.25 in/acre; Drainage area = 73.2acres;
Shallow Marsh	20			67		33	Koon, J. 1995. Evaluation of Water Quality Ponds and Swales in the Issaquah/East Lake Sammamish Basins. King County Surface Water Management and Washington Department of Ecology. Seattle, WA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Two cell wetland; first cell 2ft deep pool with emergent wetlands; second cell is free." # of storms = 5; Design Basis = 2 & 25 year quantity control only; Drainage area = 7.7acres; Percent efficiency calculated using event mean concentration (EMC) efficiency method
Shallow Marsh		54	78				Phipps, R.G. and W.G. Crumpton. 1994. Factors Affecting Nitrogen Loss in Experimental Wetlands With Different Hydrologic Loads. Ecological Engineering. December 1994. Vol. 3(4): 399-408	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"High Hydraulic Loading." Average Detention Time = 12days; Land Use = 80%Ag; STP size = 5.9acres, avg 24in deep; Drainage area = 128000acres; Percent efficiency calculated using mass efficiency method
Shallow Marsh		59	84				Phipps, R.G. and W.G. Crumpton. 1994. Factors Affecting Nitrogen Loss in Experimental Wetlands With Different Hydrologic Loads. Ecological Engineering. December 1994. Vol. 3(4): 399-408	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"High Hydraulic Loading." Average Detention Time = 13days; Land Use = 80%Ag; STP size = 4.7acres, avg 28in deep; Drainage area = 128000acres; Percent efficiency calculated using mass efficiency method

6.6.1 CONSTRUCTED WETLAND (cont.)

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Shallow Marsh		75	95				Phipps, R.G. and W.G. Crumpton. 1994. Factors Affecting Nitrogen Loss in Experimental Wetlands With Different Hydrologic Loads. Ecological Engineering. December 1994. Vol. 3(4): 399-408	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Low Hydraulic Loading." Average Detention Time = 95days; Land Use = 80%Ag; STP size = 5.9acres, avg 28in deep; Drainage area = 128000acres; Percent efficiency calculated using mass efficiency method
Stormwater Wetland	67	28					Center for Watershed Protection, 1997. National Pollutant Removal Performance Database for Stormwater Best Management Practices. Prepared for the Chesapeake Research Consortium.	United States Environmental Protection Agency (USEPA). *Storm Water Technology Fact Sheet: Storm Water Wetlands* (EPA 832-F-99-025) 1999.	
Stormwater Wetland	56		20			-2	Reinelt et al., 1990. In:The Use of Wetlands for Controlling Stormwater Pollution. Strecker, E.W. J.M. Kersnar and E.E. Dris coll (Eds.). Woodward-Clyde Consultants. Portland, Oregon. Prepared for the USEPA, Region V, Water Division, Watershed Management Unit. EPA/600 February 1992	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 13; Treatment Volume = 0.03in/acre; Drainage Area = 214.8acres; "Channelization reduced effectiveness."
Stormwater Wetland	14		4			-2	Reinelt et al., 1992. In:The Use of Wetlands for Controlling Stormwater Pollution. Strecker, E.W. J.M. Kersnar and E.E. Dris coll (Eds.). Woodward-Clyde Consultants. Portland, Oregon. Prepared for the USEPA, Region V, Water Division, Watershed Management Unit. EPA/600 February 1992	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 13; Treatment Volume = 0.01in/acre; Drainage Area = 461.7acres; "Channelization reduced effectiveness."
Stormwater Wetland	57			67		57	Rushton, B. and C. Dye. 1993. An In-Depth Analysis of a Wet Detention Stormwater System. Southwest Florida Water Management District. Brooksville, FL.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 25; Drainage Area = 6acres; Surface Area = 0.32acres, Max Depth = 18ft; Runoff conveyed by 200ft drainage channel; BMP apprx. 3-5 years old.; Percent efficiency calculated using event mean concentration (EMC) efficiency method
Stormwater Wetland	-1.32					14.86	Yu, S; G. Fitch, and T. Earles. 1998. Constructed Wetlands for Stormwater Management. Virginia Transportation Research Council. Charlottesville, VA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = parking lot and highway; # of storms = 5; STP size = 0.7acres; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Stormwater Wetland	30.1					27.46	Yu, S; G. Fitch, and T. Earles. 1998. Constructed Wetlands for Stormwater Management. Virginia Transportation Research Council. Charlottesville, VA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = parking lot and highway; # of storms = 5; STP size = 0.7acres; Percent efficiency calculated using mass efficiency method.
Stormwater Wetland	52.02					68.09	Yu, S; G. Fitch, and T. Earles. 1998. Constructed Wetlands for Stormwater Management. Virginia Transportation Research Council. Charlottesville, VA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Highway; # of storms = 13; STP size = 5acres; Percent efficiency calculated using mass efficiency method.
Stormwater Wetland	56.96					68.61	Yu, S; G. Fitch, and T. Earles. 1998. Constructed Wetlands for Stormwater Management. Virginia Transportation Research Council. Charlottesville, VA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Highway; # of storms = 13; STP size = 5acres; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
RANGE	**(-1.32) - 99.5**	**(-2.1) - 76**	**1.2 - 99**	**35 - 94**	**11.5 - 81**	**(-2) - 95.5**			

6.6.2 WET POND / RETENTION BASIN

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Retention Basin	50-80	30-65				30-65	USEPA. 1999. Preliminary Data Summary of Urban Stormwater BMPs.		
Wet Extended Detention Pond	60.4	16	18.2			46.2	Borden, R.C., J.L. Dorn, J.B. Stillman and S.K. Liehr. 1996. Draft Report. Evaluation of Ponds and Wetlands For Protection of Public Water Supplies. Water Resources Research Institute of the Univeristy of North Carolina. Department of Civil Engineering. North Carolina State University. Raleigh, NC.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Dairy Farms, woodland; Impervious Cover = 16%; Percent efficiency calculated using mass efficiency method.
Wet Extended Detention Pond	54	39	45		26	46	City of Austin, TX. 1991. Design Guidelines for Water Quality Control Basins. Public Works Department. Austin, TX.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious cover = 39%
Wet Extended Detention Pond	87			24	59	79	Fellows, D., W. Liang, S. Ristic, and M. Thompson. 1999. Performance Assessment of MTOs Rouge River, Highway 40, Stormwater Management Pond. SWAMP. Ontario Ministry of Environment and Energy.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Mostly residential; Impervious Cover = 34%; Percent efficiency calculated using mass efficiency method.
Wet Extended Detention Pond	83	55		85	52	52	Lower Colorado River Authority. 1997. Innovative NPS Pollution Control Program for Lake Travis in Central Texas. LCRA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = parking lot/commercial
Wet Extended Detention Pond	98	54				79	Ontario Ministry of the Environment. 1991. Stormwater Quality Best Management Practices. Marshall Macklin Monaghan Limited. Toronto, Ontario.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	
Wet Extended Detention Pond	61			63		56	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995. Houston, TX.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%
Wet Extended Detention Pond	67			61		57	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995. Houston, TX.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; Residence time = 5 days
Wet Extended Detention Pond	69	28		67	25	75	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995. Houston, TX.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; Residence time = 5 days
Wet Extended Detention Pond	71			64		62	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995. Houston, TX.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%
Wet Extended Detention Pond	94			88		90	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995. Houston, TX.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; Land Use = rooftops, parking lots, vehicle storage; Residence Time = 14days

6.6.2 WET POND / RETENTION BASIN (cont.)

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Wet Extended Detention Pond	95			88		89	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995. Houston, TX.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; Land Use = rooftops, parking lots, vehicle storage; Residence Time = 14days
Wet Extended Detention Pond	76		75		65	70	Yu, S.L. and D.E. Benelmouffok. 1998. Field Testing of Selected Urban BMPs in Critical Water Issues and Computer Applications. In Proceedings of the 15th Annual Water Resources Conference. American Society of Civil Engineers, New York, NY.	Federal Highway Administration (FHWA). "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Fact Sheet -Detention Ponds." U.S. Department of Transportation.	
Wet Pond	46		36		14	37	City of Austin. 1990. Removal Efficiencies of Stormwater Control Structures. Environmental Resources Management Division, Environmental and Conservation Services Department, City of Austin. Austin, TX.	Federal Highway Administration (FHWA). "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Fact Sheet -Detention Ponds." U.S. Department of Transportation.	
Wet Pond	94		64		44	81	City of Austin. 1995 (Draft). Characterization of Stormwater Pollution for Austin, Texas Area. Environmental Resources Management Division, Environmental and Conservation Services Department, City of Austin, Austin, TX.	Federal Highway Administration (FHWA). "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Fact Sheet -Detention Ponds." U.S. Department of Transportation.	
Wet Pond	68	12		93	-31	55	Cullum, M. 1984. Volume II Evaluation of the Water Management System at a Single Family Residential Site: Water Quality Analysis for Selected Storm Events at Timbercreek Subdivision in Boca Raton, FL. South Florida Water Management District.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = single family residential; Soil type = group A; Treatment Vol = 3.11in/acre; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Wet Pond	54			97	68	69	Dorman, M.E., J. Hartigan, R.F. Steg, and T. Quasebarth. 1989. Retention, Detention and Overland Flow for Pollutant Removal from Highway Stormwater Runoff. Vol. 1. Research Report. Federal Highway Administration. FHWA/RD 89/202.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	
Wet Pond	65			61	23	25	Dorman, M.E., J. Hartigan, R.F. Steg, and T. Quasebarth. 1989. Retention, Detention and Overland Flow for Pollutant Removal from Highway Stormwater Runoff. Vol. 1. Research Report. Federal Highway Administration. FHWA/RD 89/202.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Highway; Percent efficiency calculated using mass efficiency method.
Wet Pond	32	6	-1		7	12	Driscoll, E.D. 1983. Performance of Detention Basins for Control of Urban Runoff Quality. Presented at the 1983 International Symposium on Urban Hydrology, Hydraulics and Sedimentation Control. University of Kentucky. Lexington, KY.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	
Wet Pond	32		7		14	18	Driscoll, E.D. 1983. Performance of Detention Basins for Control of Urban Runoff Quality. Presented at the 1983 International Symposium on Urban Hydrology, Hydraulics and Sedimentation Control. University of Kentucky. Lexington, KY.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	

6.6.2 WET POND / RET NTION BASIN (cont.)

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Wet Pond	60					45	Driscoll, E.D. 1983. Performance of Detention Basins for Control of Urban Runoff Quality. Presented at the 1983 International Symposium on Urban Hydrology, Hydraulics and Sedimentation Control. University of Kentucky. Lexington, KY.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	
Wet Pond	81	37			27	54	Driscoll, E.D. 1983. Performance of Detention Basins for Control of Urban Runoff Quality. Presented at the 1983 International Symposium on Urban Hydrology, Hydraulics and Sedimentation Control. University of Kentucky. Lexington, KY.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	
Wet Pond	84					34	Driscoll, E.D. 1983. Performance of Detention Basins for Control of Urban Runoff Quality. Presented at the 1983 International Symposium on Urban Hydrology, Hydraulics and Sedimentation Control. University of Kentucky. Lexington, KY.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	
Wet Pond	91	62	66		60	79	Driscoll, E.D. 1983. Performance of Detention Basins for Control of Urban Runoff Quality. Presented at the 1983 International Symposium on Urban Hydrology, Hydraulics and Sedimentation Control. University of Kentucky. Lexington, KY.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	
Wet Pond	54	16		24		30	Gain, S.W. The effects of Flow-Path Modifications on Urban Water-Quality Constitiuent Retention in Urban Stormwater Detention Pond and Wetland System, Orlando, Florida. Florida Departemtn of Transportation, Orlando, FL. 1996.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Pond was modified to increse detention time and was previously studied by Martin and Smoot (1988)." Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Wet Pond	85		92		26	54	Harper, H.H., and J.L. Herr. 1993. Treatment Efficiencies of Detention with Filtration Systems. Environmental Research and Design, Inc. Orlando, FL.	Claytor, Richard, and T. Schueler, 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Silver Spring, MD.	
Wet Pond	7			23		40	Kantrowitz, I. And W. Woodham. 1995. Efficiency of a Stormwater Detention Pond in Reducing Loads of Chemical and Physical Constituents in Urban Streamflow, Pinellas County, Florida. U.S. Geological Survey. Water Resources Investigations Report: 94-4217. Tallahassee, FL.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Very large online wet pond with detention" Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Wet Pond	45			36		45	Kantrowitz, I. And W. Woodham. 1995. Efficiency of a Stormwater Detention Pond in Reducing Loads of Chemical and Physical Constituents in Urban Streamflow, Pinellas County, Florida. U.S. Geological Survey. Water Resources Investigations Report: 94-4217. Tallahassee, FL.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Very large online wet pond with detention"
Wet Pond	80			62	0	80	Liang, W. 1996. Performance Assessment of an Off-Line Stormwater Management Pond. Ontario Ministry of Environment and Energy.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Residential; Impervious Cover = 55%; Residential cover = 100%; Soil Type = clay till and clay loam

6.6.2 WET POND / RETENTION BASIN (cont.)

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Wet Pond	85						NC DENR, 1999. North Carolina Stormwater Best Management Practices Manual. Division of Water Quality.		
Wet Pond	85	30	24		31	48	Oberts, G.L., P.J. Wotzka and J.A. Hartsoe. 1989. The Water Quality Performance of Select Urban Runoff Treatment Systems. Prepared for the Legislative Commission on Minnesota Resources. Metropolitan Council. St. Paul, MN. Publication No. 590-89-062a	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Age of Facility = 4years; Percent efficiency calculated using mass efficiency method.
Wet Pond	90	41	10		50	61	Oberts, G.L., P.J. Wotzka and J.A. Hartsoe. 1989. The Water Quality Performance of Select Urban Runoff Treatment Systems. Prepared for the Legislative Commission on Minnesota Resources. Metropolitan Council. St. Paul, MN. Publication No. 590-89-062a	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Age of Facility = 6years
Wet Pond	-33.3	32				39	Occoquan Watershed Monitoring Laboratory. 1983. Final Report: Metropolitan Washington Urban Runoff Project. Prepared for the Metropolitan Washington Council of Governments. Manassas, VA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Medium density residential; Impervious cover = 25%
Wet Pond	85	34				86	Occoquan Watershed Monitoring Laboratory. 1983. Final Report: Metropolitan Washington Urban Runoff Project. Prepared for the Metropolitan Washington Council of Governments. Manassas, VA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Agriculture
Wet Pond	80-90						United States Environmental Protection Agency (USEPA). *Storm Water Technology Fact Sheet: Wet Detention Ponds* (EPA 832-F-99-048). 1999.		
Wet Pond	62				21	36	Wu, J. 1989. Evaluation of Detention Basin Performance in the Piedmont region of North Carolina. North Carolina Water Resources Research Institute. Report No. 89-248. Raleigh, NC.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = multi-unit housing, woodland; Impervious cover = 38%; Soil type = clay; Surface area = 3.3 acres, Mean pond depth = 3.8'; Volume=12.3acre feet; "No geese present." Percent efficiency calculated using mass
Wet Pond	93				32	45	Wu, J. 1989. Evaluation of Detention Basin Performance in the Piedmont region of North Carolina. North Carolina Water Resources Research Institute. Report No. 89-248. Raleigh, NC.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = mixed residential; Impervious cover = 46%; Residential = 100%; Pond = 4.9 acres; Mean pond depth = 8'; Volume = 38.8 acre feet; "Geese population present increase N and P values." Percent efficiency calculated using mass efficiency method
RANGE	**(-33.3) - 98**	**6 - 65**	**(-1) - 92**	**23 - 97**	**(-31) - 68**	**12 - 90**			

6.6.3 DRY EXTENDED DETENTION BASIN

	Pollutant Removal % Efficiency								
Type	**TSS**	**TN**	**NO_3**	**NO_x**	**TKN**	**TP**	**Primary Source**	**Secondary Source**	**Comments**
Dry Detention Basins	30-65	15-45				15-45	USEPA. 1999. Preliminary Data Summary of Urban Stormwater BMPs.		
Dry Detention Pond	96		64		44	81	Yu, S.L., M. Barnes, R.J. Kaighn, and S.L. Laio. 1994. Field Test of Stormwater Best Management Practices in Watershed Wastewater Treatment. In Proceedings of the 1994 National Conference on Environmental Engineering. American Society of Civil	Federal Highway Administration (FHWA). "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Fact Sheet -Detention Ponds." U.S. Department of Transportation.	"Removal efficiencies based on mass loading."
Dry Extended Detention Pond	87		-10			26	Baltimore Department of Public Works. 1989. Detention Basin Retrofit Project and Monitoring Study Results. Water Quality Management Office. Baltimore, MD	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 9; Treatment Vol = 0.50in/acre; drainage area = 16.8acres
Dry Extended Detention Pond	89		-3		26	51	Barrett, M.E. et al., 1997. *Evaluation of the Performance of Permanent Runoff Controls: Summary and Conclusions, CRWR Online Report 97-3*. Center for Research in Water Resources, Bureau of Engineering Research, The University of Texas at Austin, TX.		Land Use = Highway; Percent efficiency calculated using mass efficiency method.
Dry Extended Detention Pond	30	35	52			18	City of Austin, TX. 1991. Design Guidelines for Water Qualit Control Basins. Public Works Department. Austin, TX.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 17; Treatment Vol = 0.50in/acre; drainage area= 28 acres
Dry Extended Detention Pond	47					21	Miller, T. 1987. Appraisal of Storm-Water Quality Near Salem, Oregon. US Geological Survey. Water Resources Report 87-4064.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious = 53%; Residential = 39%; Commercial = 38%; Industrial = 1%; # of storms = 11; soil = HSG-C; Drainage area = 512acres
Dry Extended Detention Pond	51.5	42.5				48	Occoquan Watershed Monitoring Laboratory. 1987. Final Report: London Commons Extended Detention Facility. Urban BMP Research and Demonstration Project. Virginia Tech University. Manassas, VA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 27; Treatment Vol = 0.22in/acre; detention provided up to 20hours; drainage area = 11.4 acres
Dry Extended Detention Pond	70	24			30	13	Schueler, T.R. and M. Helfrich. 1988. Design of Extended Detention Wet Pond Systems. In: Design of Urban Runoff Quality Controls. L.L. Roesner, B. Urbonas and M.B. Sonnen (Eds.). American Society of Civil Engineers. New York, NY.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 25; Treatment Vol = 0.30in/acre; drainage area = 34acres
Dry Extended Detention Pond	71	26	-2			14	Stanley, D. 1994. An Evaluation of the Pollutant Removal of a Demonstration Urban Stormwater Detention Pond. Albermarle-Pamlico Estuary Study. APES Report 94-07.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 31%; Land Use = Residential/Commerical; # of storms = 8; Treatment Vol = 72hours detention for the first 0.5in; drainage area = 200acres; Percent efficiency calculated using mass efficiency method.
RANGE	**30 - 96**	**15 - 45**	**(-10) - 64**		**26 - 44**	**13 - 81**			

6.6.4 WATER QUALITY FILTER

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Catch Basins	60 - 97						Aronson, G. et al. Evaluation of Catch Basin Performance for Urban Stormwater Pollution Control. EPA-600/2-83-043	Stormwater Manager's Resource Center (SMRC). *Pollution Prevention Fact Sheet: Catch Basins.*	Only very small storms used
Catch Basins	10 - 25					5 - 10	Pitt, R. and G. Shawley.1982. *A Demonstration of Non-Point Pollution Management on Castro Valley Creek*, Alameda County Flood Control District (Hayward, California) and U.S. EPA, Washington, DC	Stormwater Manager's Resource Center (SMRC). *Pollution Prevention Fact Sheet: Catch Basins.*	
Catch Basins	32						Pitt, R. et al. 1997. Guidance Manual for Integrated Wet Weather Flow Collection and Treamtne Systems for Newly Urbanized Areas. US EPA. Office of Research and Development. Cincinnati, OH	Stormwater Manager's Resource Center (SMRC). *Pollution Prevention Fact Sheet: Catch Basins.*	
RANGE	**10 - 97**					**5 - 10**			

6.7.1 RIPARIAN BU ER RESTORATION

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
25' buffer	57	27				34	Desbonnet, A., P, Pogue, V. Lee, and N. Wolff. 1994. Vegetated Buffers in the Coastal Zone: An Annotated Review and Bibliography. Coastal Resources Center, University of RI	Schueler, T. 1995. Site Planning for Urban Stream Protection. The Center for Watershed Protection.	
50' buffer	62	31				38	Desbonnet, A., P, Pogue, V. Lee, and N. Wolff. 1994. Vegetated Buffers in the Coastal Zone: An Annotated Review and Bibliography. Coastal Resources Center, University of RI	Schueler, T. 1995. Site Planning for Urban Stream Protection. The Center for Watershed Protection.	
75' buffer	65	33				41	Desbonnet, A., P, Pogue, V. Lee, and N. Wolff. 1994. Vegetated Buffers in the Coastal Zone: An Annotated Review and Bibliography. Coastal Resources Center, University of RI	Schueler, T. 1995. Site Planning for Urban Stream Protection. The Center for Watershed Protection.	
100' buffer	67	34				43	Desbonnet, A., P, Pogue, V. Lee, and N. Wolff. 1994. Vegetated Buffers in the Coastal Zone: An Annotated Review and Bibliography. Coastal Resources Center, University of RI	Schueler, T. 1995. Site Planning for Urban Stream Protection. The Center for Watershed Protection.	
200' buffer	72	38				47	Desbonnet, A., P, Pogue, V. Lee, and N. Wolff. 1994. Vegetated Buffers in the Coastal Zone: An Annotated Review and Bibliography. Coastal Resources Center, University of RI	Schueler, T. 1995. Site Planning for Urban Stream Protection. The Center for Watershed Protection.	
Deciduous Forest Buffers		68					Lowrance, R., R. Todd, J. Fail, Jr., O. Hendrickson, Jr., R. Leonard, and L. Asmussen. 1984b. Riparian forests as nutrient filters in agricultural watersheds. Bioscience 34:374-377	Klapproth, J.C. and J.E. Johnson. *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*. Virgina Tech. Oct 2000.	
Hardwood Riparian Area	84-90						Cooper, J.R., J.W. Gilliam, R.B. Daniels, and W.P. Robarge. 1987. Riparian areas as filters for agricultural sediment. Soil Science Society of America Journal 51:416-420	Klapproth, J.C. and J.E. Johnson. *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*. Virgina Tech. Oct 2000.	
Riparian Buffer			95				Jordan, T.E., D.L. Correll, and D.E. Weller. 1993. Nutrient interception by a riparian forest receiving inputs from adjacent croplands. Journal of Environmental Quality 22:467-473	Klapproth, J.C. and J.E. Johnson. *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*. Virgina Tech. Oct 2000.	

6.7.1 RIPARIAN BUFFER RESTORATION (con't.)

Type	Pollutant Removal % Efficiency								
	TSS	TN	NO_3	NO_x	TKN	TP	Primary Source	Secondary Source	Comments
Riparian Buffer		89					Peterjohn, W.T. and D.L. Correll. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. Ecology 65:1466-1475.	Klapproth, J.C. and J.E. Johnson. *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*. Virgina Tech. Oct 2000.	
Riparian Buffer			48				Snyder, N.J., S. Mostaghimi, D.F. Berry, R.B. Reneau, E.P. Smith. 1995. Evaluation of a riparian wetland as a naturally occurring decontamination zone. Pages 259-262. In: Clean Water, Clean Environment - 21st Century. Volume III: Practices, Systems, and Adoption. Proceedings of a conference March 5-8, 1995 Kansas City, Mo. American Society of Agricultural	Klapproth, J.C. and J.E. Johnson. *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*. Virgina Tech. Oct 2000.	
Switchgrass Buffer (7.1m)	95	80	62			78	Lee, K.H., T.M. Isenhart, and R.C. Schultz. "Sediment and nutrient removal in an established multi-species riparian buffer," Journal of Water Conservation, Vol. 58, No. 1	SWCS, 2003. Soil and Water Conservation Society.	
Switchgrass/ Woody Buffer (16.3m)	97	94	85			91	Lee, K.H., T.M. Isenhart, and R.C. Schultz. "Sediment and nutrient removal in an established multi-species riparian buffer," Journal of Water Conservation, Vol. 58, No. 1	SWCS, 2003. Soil and Water Conservation Society.	
RANGE	**57 - 97**	**27 - 94**	**48 - 95**			**34 - 91**			

BMP Pollutant Removal Efficiencies- Inflow vs. Outflow Pollutant concentrations

6.4.4 INFILTRATION TRENCH

****UNITS ARE IN MG/L UNLESS OTHERWISE NOTED****

Type	TSS		TN		NO_3		NO_x		TKN		TP				
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Primary Source	Secondary Source	Comments
Infiltration Trench			6.59	3.8	0.95	3.8					0.24	0	Kuo, C.Y., G. D. Boardman and K.T. Laptos. 1990. Phosphorous and Nitrogen Removal Efficiencies of Infiltration Trenches. Dept. of Civil Engineering. VA Polytechnic Institute and State University. Prepared for: No. VA Planning District Commission, Occoquan Technical Advisory Committee and VA State	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"47.75 hours detention time", soil type = sandy loam
Infiltration Trench			5.38	5.2	0.75	0					0.66	0.63	Kuo, C.Y., G. D. Boardman and K.T. Laptos. 1990. Phosphorous and Nitrogen Removal Efficiencies of Infiltration Trenches. Dept. of Civil Engineering. VA Polytechnic Institute and State University. Prepared for: No. VA Planning District Commission, Occoquan Technical Advisory Committee and VA State	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"49.5 hours detention time", soil type = loam
Infiltration Trench			2.04	1.01	0.5	0.09					0.2	0	Kuo, C.Y., G. D. Boardman and K.T. Laptos. 1990. Phosphorous and Nitrogen Removal Efficiencies of Infiltration Trenches. Dept. of Civil Engineering. VA Polytechnic Institute and State University. Prepared for: No. VA Planning District Commission, Occoquan Technical Advisory Committee and VA State	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"51.5 hours detention time", soil type = sandy

6.4.5 RAIN GARDEN

****UNITS ARE IN MG/L UNLESS OTHERWISE NOTED****

Type	TSS		TN		NO_3		NO_x		TKN		TP				
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Primary Source	Secondary Source	Comments
Rain Garden	87.4g	7.6g			1.60g	1.85g					1.62g	0.60g	Hsieh, C. and A.P. Davis. Multiple-event Study of Bioretention for Treatment of Urban Storm Water Runoff. 2003. Percent efficiency calculated using mass efficiency method		

6.4.7 CONSTRUCTED FILTER

****UNITS ARE IN MG/L UNLESS OTHERWISE NOTED****

Type	TSS		TN		NO_3		NO_x		TKN		TP				
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Primary Source	Secondary Source	Comments
Organic Filter	35.5	16											Leif, W. 1999. Compost Stormwater Filter Evaluation. Snohomish County Public County Works. Everett, WA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 8; Drainage area = 0.69acres; "Filter is 12" deep";
Organic Filter	49	6	1.76	0.858			0.481	0.552					Lower Colorado River Authority. 1997. Innovative NPS Pollution Control Program for Lake Travis in Central Texas. LCRA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Large parking lot; % Impervious Cover = 82%; "Peat/sand filter media wit surface ED. Retrofit Site. Steep Slopes. Retention Capacity 1420ft3"; # of storms = 21
Organic Filter	39.95	4.47					0.3	0.4					Stewart, W. 1992. Compost Stormwater Treatment System. W&H Pacific Consultants. Draft Report. Portland, OR.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = 95%Residential, rest roadway; # of storms = 7, Drainage area = 73.9; "Compost media filter"
Sand Filter	204	3.5	2.83	1.065			1.24	0.474					Barrett, M.; M. Keblin; J. Malina; R. Charbeneau. 1998. Evaluation of the Performance of Permanent Runoff Controls: Summary and Conclusions. Center for Transportation Research. Texas Department of Transportation. University of	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = 67% Highway/33%Commercial; Drainage area = 82.95acres; # of storms = 10; Treament Vol = first 0.5in of runoff
Sand Filter	76.2	16.84	7.93	3.8			1.27	1.99					Bell, W.; L. Stokes; L.J. Gavan and T.N. Nguyen. 1995. Assessment of the Pollutant Removal Efficiences of Delaware Sand Filter BMPs. Final Report. Department of Transportation and Environmental Services. Alexandria, VA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Parking Lot; STP Size = 477.6ft3; Drainage area = 0.7acres; # of storms = 20; "Perimeter sand filter"

6.4.8 VEGETATED SWALE

****UNITS ARE IN MG/L UNLESS OTHERWISE NOTED****

Type	TSS		TN		NO_3		NO_x		TKN		TP				
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Primary Source	Secondary Source	Comments
Dry Swale	50	4					0.549	0.347	0.83	0.74	0.218	0.304	Dorman, M.E., J. Hartigan, R.F. Steg and T. Quasebarth. 1989. Retention, Detention and Overland Flow for Pollutant Removal from Highway Stormwater Runoff. Vol. 1. Research Report. Federal Highway Administration.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = highway, Impervious cover = 63%, soil type = sandy; length 185'; Age of facility = 5years
Grass Channel	47	15.13					1.24	0.85			0.228	0.22	Goldberg. 1993. Dayton Avenue Swale Biofiltration Study. Seattle Engineering Department. Seattle, WA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	%Impervious Cover = 20; "600ft long grass channel"; # of storms = 8; Drainage area = 90acres
Grass Channel	94.67	14					0.35	0.77			0.2	0.14	Seattle Metro and Washington Department of Ecology. 1992. Biofiltration Swale Performance: Recommendations and Design Considerations. Publication No. 657. Water Pollution Control Department, Seattle	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Major roadway, residences, parks; impervious Cover = 47%; "grass channel design. 10 minute residence time for design storm; Drainage area = 15.5acres; slope = 4%; "Length 200ft. 5ft wide" Soil Type = glacial till
Grass Channel	128	30					0.26	0.31			0.1	0.06	Seattle Metro and Washington Department of Ecology. 1992. Biofiltration Swale Performance: Recommendations and Design Considerations. Publication No. 657. Water Pollution Control Department, Seattle	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Major roadway, residences, parks; impervious Cover = 47%; "grass channel design. 10 minute residence time for design storm; Drainage area = 15.5acres; slope = 4%; "Length 100ft. 5ft wide" Soil Type = glacial till
Vegetated Swale	157	21			0.91	0.46			2.17	1.46	0.55	0.31	Barrett, M.E. et al. Evaluation of the Performance of Permanent Runoff controls: Summary and Conclusions. Center for Research in Water Resources, University of Texas at Austin. Austin, TX: Nov. 1997		Site 1; Treatment Length = 7.5 to 8.8m; slope = .73%; vegetation = buffalo grass; higher traffic than site 2; Percent efficiency calculated using event mean concentration (EMC) efficiency method.
Vegetated Swale	190	29			1.27	0.97			2.61	1.45	0.24	0.16	Barrett, M.E. et al. Evaluation of the Performance of Permanent Runoff controls: Summary and Conclusions. Center for Research in Water Resources, University of Texas at Austin. Austin, TX: Nov. 1997		Site 2; Treatment Length = 7.8 to 8.1m; slope = 1.7%; vegetation = mixed; lower traffic than site 1; Percent efficiency calculated using event mean concentration (EMC) efficiency method.

6.4.9 VEGETATED FILTER STRIP

****UNITS ARE IN MG/L UNLESS OTHERWISE NOTED****

Type	TSS		TN		NO_3		NO_x		TKN		TP				
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Primary Source	Secondary Source	Comments
Vegetated Filter Strip	157	21			0.91	0.46							Barrett, M.E. et al. Evaluation of the Performance of Permanent Runoff controls: Summary and Conclusions. Center for Research in Water Resources, University of Texas at Austin. Austin, TX: Nov. 1997.	Site 1; Treatment Length = 7.5 to 8.8m; slope = .73%; vegetation = buffalo grass; higher traffic than site 2; Percent efficiency calculated using event mean concentration (EMC) efficiency method.	
Vegetated Filter Strip	190	29			1.27	0.97							Barrett, M.E. et al. Evaluation of the Performance of Permanent Runoff controls: Summary and Conclusions. Center for Research in Water Resources, University of Texas at Austin. Austin, TX: Nov. 1997.	Site 2; Treatment Length = 7.8 to 8.1m; slope = 1.7%; vegetation = mixed; lower traffic than site 1; Percent efficiency calculated using event mean concentration (EMC) efficiency method.	

6.6.1 CONSTRUCTED WETLAND

****UNITS ARE MG/L UNLESS OTHERWISE NOTED****

Type	TSS		TN		NO_3		NO_x		TKN		TP				
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Primary Source	Secondary Source	Comments
Shallow Marsh	11.85 ppm	7.85 ppm	1.14 ppm	0.99 ppm			0.2 ppm	0.15 ppm			0.085ppm	0.045ppm	Blackburn, R., P.L. Pimentel and G.E. French. 1986. Treament of Stormwater Runoff Using Aquatic Plants. The Use of Wetlands for Controlling Stormwater Pollution. Strecker, E.W. J.M. Kersnar and E.E. Dris coll (Eds.). Woodward-Clyde Consultants. Portland, Oregon. Prepared for the USEPA, Region V, Water Division, Watershed Management Unit. EPA/600	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = Golf Course; Size of Wetland = 296acres; # of storms = 72; Treatment volume = 1in; Drainage area = 2340acres
Shallow Marsh	7.55	1.801	0.756	1.206			0.085	0.016			0.98	0.04	Carr, D. and B. Rushton. 1995. Integrating a Herbaceous Wetland into Stormwater Management. Stormwater Research Program. Southwest Florida Water Management District. Brooksville, FL	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	# of storms = 81; Drainage area = 15.3; STP size = 3acres
Shallow Marsh	14	12									0.097	0.071	Koon, J. 1995. Evaluation of Water Quality Ponds and Swales in the Issaquah/East Lake Sammamish Basins. King County Surface Water Management and Washington Department of Ecology. Seattle, WA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	"Two cell wetland; first cell 2ft deep pool with emergent wetlands; second cell is free." # of storms = 5; Design Basis = 2 & 25 year quantity control only; Drainage area = 7.7acres; "Inflow and Outflow values are presented as mean concentrations."

6.6.2 WET POND / RETENTION BASIN

****UNITS ARE MG/L UNLESS OTHERWISE NOTED****

Type	TSS		TN		NO_3		NO_x		TKN		TP				
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Primary Source	Secondary Source	Comments
Wet Extended Detention Pond	177	39	3.352	1.459							0.761	0.214	Borden, R.C., J.L. Dorn, J.B. Stillman and S.K. Liehr. 1996. Draft Report. Evaluation of Ponds and Wetlands For Protection of Public Water Supplies. Water Resources Research Institute of the Univeristy of North Carolina. Department of Civil Engineering. North Carolina State University.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Dairy Farms, woodland; Impervious Cover = 16
Wet Extended Detention Pond	71	12	1.713	0.769			0.416	0.062			0.232	0.112	Lower Colorado River Authority. 1997. Innovative NPS Pollution Control Program for Lake Travis in Central Texas. LCRA.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = parking lot/commercial
Wet Extended Detention Pond	45	14	1.27	0.91			0.096	0.032			0.651	0.164	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; Residence time = 5 days
Wet Extended Detention Pond	28	11	1.35	1.16			0.24	0.09			0.4	0.176	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; Residence Time = 2 days
Wet Extended Detention Pond	131	7	1.61	0.722			0.396	0.062			0.497	0.053	Rushton, B., C. Miller and H. Hull. 1995. The Effect of Residence Time on the Efficiency of a Wet Detention Stormwater Treatment Pond. Presented at the 31st Annual Conference and Symposium in Urban Areas. November 10-12, 1995.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Impervious Cover = 30%; Land Use = rooftops, parking lots, vehicle storage; Residence Time = 14days
Wet Pond	20.6	6.5	0.93	0.65			0.18	0.02			0.136	0.035	Cullum, M. 1984. Volume II Evaluation of the Water Management System at a Single Family Residential Site: Water Quality Analysis for Selected Storm Events at Timbercreek Subdivision in Boca Raton, FL. South Florida Water Management	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = single family residential; Soil type = group A; Treatment Vol = 3.11in/acre

6.6.2 WET POND / RETENTION BASIN (cont.)

****UNITS ARE MG/L UNLESS OTHERWISE NOTED****

Type	TSS		TN		NO_3		NO_x		TKN		TP				
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Primary Source	Secondary Source	Comments
Wet Pond	7	15							1.2	1.27	0.272	0.155	Dorman, M.E., J. Hartigan, R.F. Steg, and T. Quasebarth. 1989. Retention, Detention and Overland Flow for Pollutant Removal from Highway Stormwater Runoff. Vol. 1. Research Report. Federal Highway Administration.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Highway
Wet Pond	52	23	2.62	1.92			0.729	0.224	1.89	1.7	0.3	0.4	Dorman, M.E., J. Hartigan, R.F. Steg, and T. Quasebarth. 1989. Retention, Detention and Overland Flow for Pollutant Removal from Highway Stormwater Runoff. Vol. 1. Research Report. Federal Highway Administration.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land Use = Highway
Wet Pond	45	19	1.64	1.39					0.31	0.31	0.17	0.12	Gain, S.W. The effects of Flow-Path Modifications on Urban Water-Quality Constitiuent Retention in Urban Stormwater Detention Pond and Wetland System, Orlando, Florida. Florida Departemtn of Transportation, Orlando, FL.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Inflow and Outflow are reported as a mean concentration. "Pond was modified to increse detention time and was previously studied by Martin and Smoot (1988)." Percent efficiency calculated using event mean concentration (EMC)
Wet Pond									0.79	0.63	0.12	0.08	Wu, J. 1989. Evaluation of Detention Basin Performance in the Piedmont region of North Carolina. North Carolina Water Resources Research Institute. Report No. 89-248. Raleigh, NC.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = multi-unit housing, woodland; Impervious cover = 38%; Soil type = clay; Surface area = 3.3 acres, Mean pond depth = 3.8'; Volume=12.3acre feet; "No geese present." Percent efficiency calculated using
Wet Pond									0.86	0.59	0.14	0.08	Wu, J. 1989. Evaluation of Detention Basin Performance in the Piedmont region of North Carolina. North Carolina Water Resources Research Institute. Report No. 89-248. Raleigh, NC.	Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.	Land use = mixed residential; Impervious cover = 46%; Residential = 100%; Pond = 4.9 acres; Mean pond depth = 8'; Volume = 38.8 acre feet; "Geese population present increase N and P values." Percent efficiency calculated using mass efficiency method