

Appendix A : Updated Appendix J

Management Practice Efficiencies

For use in determining optimal management practices for implementation in urban and agricultural areas, the following reduction efficiencies were assumed. All values are load reductions unless otherwise stated.

URBAN MANAGEMENT PRACTICES

For use in determining optimal management practices for implementation in urban and agricultural areas, the following reduction efficiencies were assumed. All values are load reductions unless otherwise stated.

Definition of Acronyms:

Bacteria: *E. coli* or fecal bacteria

Cu: copper

Pb: lead

TP: total phosphorus

Zn: zinc

BOD: biological oxygen demand

Metals: heavy metals

TN: total nitrogen

TSS: total suspended solids

Table A1. Load reductions for Media Filters.

TSS	TN	TP	Metals	Bacteria	References	
89%	17%	59%	72-86%	65%	Glick et al., 1998	Calif Handbook
95%	- ²	41%	61-88%	-	Stewart 1992	
85%	-	4%	44-75%	-	Leif 1999	
85%	-	80%	65-90%	-	Pitt et al. 1997	
83%	-	-	9-100%	-	Pitt 1996	
98%	-	84%	83-89%	-	Greb et al. 1998	
70%	21%	33%	45%	76%(FC)	Galli, 1990	EPA Fact Sheet 1999
99%	38%	97%	94-99%	-	Hatt et al. 2008	StormWater BMPs FHWA
85%	35%	45%	-	-	NCDENR 2007	
82%	42%	49%	-	31%	N.P.R.D. 2007 ¹	
70-90%	30-50%	43-70%	-	-	Bell et al. 1995; Horner & Horner 1995; Young et al. 1996	
75-92%	27-71%	27-80%	-	-	City of Austin 1990; Welborn & Veenhuis 1987	
90-95%	55%	49%	48-90%	90%	Claytor & Schueler 1996; Stewart 1992; Stormwater Management 1994	
66-95%	44-47%	4-51%	34-88%	-	USEPA 2004	

¹ Reductions based on an average of multiple studies.

² No data.

Table A2. Load reductions for wetlands.

Volume	TSS	TN	TP	Bacteria	Metals	BOD	Reference		
10%	45%	27%*	28%	31% ²	- ⁵	28%	Newman & Clausen 1997		
-	83%	26%,	43%	76%** ²	36-85%	-	Winer 2000	EPA NPDES 2006	
-	69%	56%	39%	-	80-63%	-			
-	71%	19%	56%	-	0-57%	-			
-	83%	19%	64%	78% ²	21-83%	-			
-	-	37%	2%	-	-	-	Kovacic et al. 2000		
-	-	11%	17%	-	-	-	Raisin et al. 1997		
-	-	-	-	-	-	80%	Huddleston et al. 1999		
-	85%	85-90%	47% ⁴	-	84%(Fe)	-	Lake Tahoe	EPA National Management Measures 2005	
-	70%	-	-	-	-	-	Shop Creek		
-	94%	76%	90%	-	-	-	Lake Jackson		
-	55%	36%	43%	-	83%(Pb), 70%(Zn)	-	Orange County		
-	55-83%	36%	43%	-	55-83% (Pb, Zn)	-	Orlando		
-	50%	-	62%	-	-	-	Palm Beach		
-	71%	-	47%	-	-	-	Tampa		
-	86-90%	61-92%	65-78%	-	-	-	Des Plaines		
-	95-97%	-	82-91%	-	-	-	Long Lake		
-	95%	-	92%	-	-	-	St. Agatha		
-	96%	74%	78%	-	90%(Pb)	-	Spring Creek		
-	55%	24%	44%	76% ³	-	-	N.P.R.D. 2007***		
-	65%	20%	25%	-	35-65%		USEPA 1993		StormWater BMPs FHWA
				99% ¹			Stenstrom and Carlander		
				93% ²			de J. Quinonez-Diaz et al., Gerba et al., Khatiwada et al., Neralla et al., Rifai 2006		

* Total Kjeldahl-N reduction.

** Based on fewer than 5 data points.

*** Reductions based on an average of multiple studies.

¹ *E. coli*.² Fecal coliform.³ Indicator species not specified.⁴ Particulate phosphorus reduction only.⁵ No data.

Table A3. Load reductions for bioretention.

Volume	TSS	TP	TN	Cu	Pb	Zn	Oil & Grease	Bacteria	Reference
- ³	97%	35-65%	33-66%	36-93%	24-99%	31-99%	99%	70% ²	MD Envir. Service 2007
96.5%	60%	31% ¹	32%	54%	31%	77%	-	69%(FC) 71%(EC)	Hunt et al. 2008
-	-	-	40%	99%	81%	98%	-	-	Hunt et al. 2006
-	-	58-63%	47-88%	-	-	-	-	-	Passeport et al. 2009
-	-	65-87%	49%	43-97%	70-95%	64-95%	-	-	EPA BMP Menu
40%	-	35-50%	70-80%	-	-	-	-	97%(FC)*	Smith & Hunt
51%	-	16%	43%	-	-	-	-	-	Sharkey 2006
48%	-	-39%	38%	-	-	-	-	-	
-	-	65-87%	49%	43-97%	70-95%	64-95%	-	-	Davis et al. 1997 ; EPA NPDES 2005
-	29%	-11%	44%	68%	-	23%	-	-	N.P.R.D. 2007**
-	75%	50%	50%	75-80%	75-80%	75-80%	-	-	StormWater BMP FHWA; Prince George's County 1993
-	80%	65-87%	49%	-	-	-	-	-	USEPA 2004
								97%(EC) 44%(FC)	Peterson et al. 2011

* Values based on only 6 collected samples, not a statistically significant finding.

** Reductions based on an average of multiple studies.

¹ Negative value represents an increase in pollutant concentration.

² Indicator species not specified.

³ No data.

Table A4. Load reductions for infiltration trench/basin.

TSS	TN	TP	Metals	Bacteria	Reference	
50%	- ²	51%	52-93%	96%(FC)	Birch et al. 2005	
99%	60-70%	65-75%	95-99%	98% ¹	Schueler, 1987	Wisconsin Manual 2000
90%	60%	60%	90%	90% ¹	Schueler, 1992	EPA Fact Sheet
85%	-	85%	-	-	PA Stormwater Manual 2006	
75-99%	45-70%	50-75%	75-99%	75-98% ³	Young et al. 1996	StormWater BMPs FHWA
75%	55-60%	60-70%	85-90%	90% ¹	USEPA 2004	

¹ Indicator species not specified.² No data.**Table A5. Load reductions for dry ponds.**

TSS	TN	TP	Metals	Bacteria	Reference	
61%	31%	19%	26-54%	- ³	Schueler 1997	EPA BMP Menu
71%	-	-	26-55%	-	Stanley 1996	
47%	19%	21%	-	88% ²	N.P.R.D. 2007**	
61%	19%	31%	26-54%	-	USEPA 2004	
				90% ¹	BMP Database Project 3	

** Reductions based on an average of multiple studies.

¹ Fecal coliform.² Indicator species not specified.³ No data.**Table A6. Load reductions for wet ponds.**

TSS	TN	TP	Metals	Bacteria	Reference	
67%	31%	48%	24.73%	65% ¹	Schueler 1997	EPA BMP Menu
76%	31%	54%	- ²	68% ¹	N.P.R.D. 2007**	
68%	55%	32%	36-65%	-	USEPA 2004	
				47%(FC)	Rifai (2006),Gerba et al., Mallin	

** Reductions based on an average of multiple studies.

¹ Indicator species not specified.² No data.

Table A7. Load reductions for swales.

TSS	TN	TP	Cu	Pb	Zn	Bacteria	Reference	
60-85%	10-90%	15-90%	45-80%	- ⁴	68-88%	-	CRWA 2008	
81%	38% *	9%	51%	67%	71%	-	U.S. EPA Fact Sheet 1999	
--	51%, 41%	63%, 42%	70%, 49%	56%, 76%	93%, 77%	-	Yousef et al. 1987**	
30-90%	0-50%	20-85%	0-90%	0-90%	0-90%	-	City of Austin (1995) Claytor & Schueler (1996); Kahn et al. (1992); Yousef et al. (1985); Yu & Kaighn (1995); Yu et al. (1993 & 1994)	StormWater BMPs FHWA
-	-	-	-	-	-	-388 ²		

* Value reduction of nitrate only.

** Observations from two sites respectively.

² Fecal coliform.

³ MS Dept. of Marine Resources – <http://www.dmr.state.ms.us/CMP/Storm/APPENDIX-C/Dayton%20Biofilter%20Grass%20Swale.pdf>.

⁴ No data.

Table A8. Load reductions for street sweeping.

TSS	TP	TN	Metals	Bacteria	Reference	
55-93%	40-74%	42-77%	35-85%	- ¹	NVPDC 1992	StormWater BMPs FHWA

¹ No data.

Table A9. Load reductions for porous pavement.

Volume	TSS	TP	TN	Metals	Bacteria	Reference	
- ¹	82-95%	60-71%	80-85%	33-99%	-	MWCOG 1983 Hogland et al. 1987 Young et al. 1996	StormWater BMPs FHWA
-	82-95%	65%	80-85%	98-99%	-		
31-100%*	-	-	-	-	-	Smith et al. 2006	
66%**	-	-	-	-	-		
75%**	-	-	-	-	-		
81%**	-	-	-	-	-		
53%**	-	-	-	-	-		

* Represents the range of reduction for 4 types of porous pavement from 17 rainfall events.

** Represents an average reduction for one of the 4 types of porous pavement tested from 17 rainfall events.

¹ No data.

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Table A10. Load reductions for filter strips.

Sediment/Solids	N	P	Fecal Coliform*	Length of Strip		Reference
97.6%	95.3%	93.6%	- ¹	18.3m	Load(kg/ha)	Lim et al. 1998
91.9%	90.1%	83.8%	-	18.3m	Conc.(mg/L)	
77.3%	86.9%	92.6%	-	21m	Load(kg/ha)	Chaubey et al. 1994
92.1%	94.6%	96.9%	86.8%	21m	Conc.(mg/L)	
95%	80%	80%	-	9.1m	Load(kg/ha)	Dillaha et al. 1988
99%	-	-	74%	9m	Load(kg/ha)	Coyne et al. 1995
79%	84%	83%	69%		Conc.(cfu/mL)	Young et al. 1980
-	-	-	95%	1.37m	Conc.(cfu/mL)	Larsen et al. 1994
-	-	-	FC-54% EC-13%	-	-	Rifai (2006),Goel, et al.
-	-	-	FC-30-100% EC-58-99%	-	-	Peterson et al. 2011

* Concentration reductions are for fecal coliform unless otherwise labeled.

¹ No data.

Table A11. Load reductions for riparian herbaceous buffers.

Sediment/Solids	N	P	Fecal Coliform*	Width		Reference
79%	84%	83%	69%	27m		Young et al. 1980
84%	73%	79%	- ¹	9.1m		Lee et al. 1999
66%	0%	27%	-	4.6m		Magette et al. 1999
70%	50%	26%	-	4.3 & 5.3m		Parsons et al. 1991
99%	-	-	-	5-61m		Dosskey et al. 2002
67%	-	-	-	5-61m		Dosskey et al. 2002
59%	-	-	-	5-61m		Dosskey et al. 2002
41%	-	-	-	5-61m		Dosskey et al. 2002
			95%	1.37m		Larsen et al. 1994

* Concentration reductions in cfu/mL.

¹ No data.

Table A12. Load reductions for Field Borders.

Sediment/Solids	N	P			Reference
57%	55%	50%	Load(kg/ha)		Arabi 2005
45%	35%	30%	Load(kg/ha)		Arabi 2005
50%	45%	25%	Load(kg/ha)		Arabi et al. 2006
48%	45%	24%	Load(kg/ha)		Arabi et al. 2006
81%	32%	- ¹	Load(kg/ha)		Tate et al. 2000

¹ No data.

Table A13. Load reductions for grassed waterways.

Sediment/Solids	N	P	Fecal Coliform		Reference
97%	- ¹	-	-	Load(kg/ha)	Fiener & Auerswald 2003
77%	-	-	-	Load(kg/ha)	Fiener & Auerswald 2003
95%	-	-	-	Load(t/ha)	Chow et al. 1999
-	-	-	95%	Conc.(cfu/mL)	Larsen et al. 1994
-	-	-	16%	Conc.(cfu/mL)	Dickey and Vanderholm, 1981

¹ No data.

Table A14. Load reductions for riparian forest buffers.

Sediment/Solids	N	P		Reference
97.2%	93.9%	91.3%	Load(kg/ha)	Lee et al. 2003
76%	- ¹	-	Mass(g/event)	Schoonover et al. 2005
61.3%	-	-	Conc.(mg/L)	Schoonover et al. 2005
90%	-	-	Conc.(mg/L)	Peterjohn & Correll 1984
-	89%	80%	Load(kg/ha)	Peterjohn & Correll 1984

¹ No data.**Table A15. Load reductions for alternative watering facilities.**

Sediment/ Solids	N	P	Bacteria	Reduction in Time Spent in Stream	Reduction in Time Spent Near Stream	Reduction in Time Spent Drinking From Stream		Reference
96.2%	55.6%	97.5%	- ³	-	-	92%	Load (kg/ha) ¹	Sheffield et al. 1997
90%	54%	81%	FC-51%	-	-	92%	Conc. (mg/L) ²	Sheffield et al. 1997
-	-	-	-	85%	53%	73.5%	-	Clawson 1993
-	-	-	-	-	75%	-	-	Godwin & Miner et al. 1996
-	-	-	-	90%	-	-	-	Miner et al. 1992
77%*	-	-	EC-85% FC-51-94%	-	-	-	-	Peterson et al. 2011

* Estimated reduction in stream bank erosion.

¹ Load Reductions based on measurements taken only from the watershed outlet.² Concentration Reduction based on measurements averaged from all 5 sample sites in the studied watershed.³ No data.**Table A16. Load reductions for nutrient management.**

N*	NO ₃ -N**	P*	Management Practice	Reference
- ¹	47%	-	Variable Rate Application	Delgado & Bausch 2005
-	59%	-	Nitrification Inhibitor	Di & Cameron 2002
-	-	12-41%	Variable Rate Application	Wittry & Mallarino 2004

* Reductions in Nutrient Applied to crop and continuing to maintain yield.

** Reduction in Residual Soil NO₃-N and NO₃-N leaching potential.¹ No data.**Table A17. Load reductions for conservation cover.**

Sediment/Solids	N	P	Bacteria	Reference
71%	-	-	-	USEPA 2009 STEPL BMP Efficiency Rates
90%	-	-	-	Grace 2000
99%	-	-	-	Robichaud et al. 2006
89%	-	-	-	Robichaud et al. 2006

¹ No data.

Table A18. Load reductions for prescribed grazing.

Consumption of Weed Species	Reduction of Weed Population	Reduction of Stem Density	Increase in Population of Preferred Veg.	Weed Species	Livestock Species	Reference
40-90%	-	-	-	Tall larkspur	Sheep	Ralphs et al. 1991
-	-	98%*	-	Leafy Spurge	Goats	Lym et al. 1997
-	93%	-	13%	Leafy Spurge	Sheep	Johnston & Peake 1960
-	90%	-	-	Barley	Sheep	Hartley et al. 1978
-	100%	-	-	Bull Thistle	Goats	Rolston et al. 1981
-	90%	-	-	Leafy Spurge	Sheep	Olson & Lacey 1994

* Reduction achieved in combination with herbicide application.

¹ No data.

Table A19. Load reductions for prescribed grazing.

Sediments / Solids	N	Bacteria	Runoff Volume*	Livestock Species	Reference
8%	34%	EC – 66-72% FC – 90-96%	¹ Mod. Grazed—29% ² Lightly Grazed—89%	Cattle	Peterson et al. 2011

* Reduction as compared to Heavily Grazed (1.35 AUM/acre).

¹ (2.42 AUM/acre).

² (3.25 AUM/acre).

Table A20. Load reductions for stream crossings.

Sediments / Solids	N	P	Bacteria*	References
18-25%	18-25%	18-25%	EC—46% FC—44%-52%	Peterson et al. 2011
³	35% ^{1*}	78% ^{2*}		

* Concentration Reductions.

¹ Nitrate Nitrogen.

² Particulate Phosphorus.

³ No data.

Table A21. Load reductions for alternative shade.

Sediments / Solids	N	Bacteria	Reference
¹	-	EC – 85%*	Peterson et al. 2011

* When combined with an off-stream water source.

¹ No data.

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