FINAL REPORT

Roanoke Valley Regional Stormwater Management Plan

Water Quality Report

Prepared for

Fifth Planning District Commission
City of Roanoke
City of Salem
County of Roanoke
Town of Vinton

June 1997

CH2MHILL

625 Herndon Parkway
Herndon, VA 20170-5416

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TECHNICAL MEMORANDUM

Roanoke Valley Regional Stormwater Management Plan Water Quality Report

PREPARED FOR: Fifth Planning District Commission
City of Roanoke
City of Salem
County of Roanoke
Town of Vinton

PREPARED BY: Fernando Pasquel/CH2M HILL
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COPIES: Ed Beadenkopf/Dewberry & Davis

DATE: June 9, 1997

Contents

Attachments

1.0 Summary

This report summarizes the water quality analyses conducted on the Roanoke Valley Regional Stormwater Management Plan study area. This study area consists of 16 priority watersheds that are tributary to the Roanoke River and that drain a combined area of 247 square miles.

The primary components of this report include:

- This summary.
- Analysis and results of the pollutant loads assessment. The analysis is described and the values of each variable are included (i.e., event mean concentrations [EMCs], areas, runoff coefficients). Summaries of the results are provided.
- Recommendations for implementing regional best management practices (BMPs) (not specific to watersheds) and estimated phosphorus removal efficiencies of some BMPs.
- Summary of the currently anticipated requirements in the Phase II NPDES stormwater regulations that are expected in September 1997.
- List of references.

The 16 priority watersheds listed below and the pollutant loads assessment data for these watersheds are summarized in Table 1.

Back Creek
Barnhardt Creek
Butt Hollow Creek
Carvin Creek
Cole Hollow Branch
Dry Branch
Gish Branch
Glade Creek
Lick Run
Mason Creek
Mudlick Creek
Murray Run
Ore Branch
Peters Creek
Tinker Creek
Wolf Creek

2.0 Loads Assessment

The 16 priority watersheds are subdivided into 436 subwatersheds, and analyses were conducted at both the watershed and subwatershed levels. For each watershed and subwatershed, pollutant loading factors (pound/acre-year [lb/ac-yr]) and annual pollutant loads (pound/year [lb/yr]) were developed for the following pollutants:

- Total phosphorus (TP)
- Total nitrogen (TN)
- Total suspended solids (TSS)
- Lead (Pb)
- Zinc (Zn)

Annual runoff volumes also were estimated.

The approach used to estimate annual pollutant loads, pollutant loading factors, and annual runoff volumes for watersheds and subwatersheds located within the study area incorporated simplified, planning-level hydrologic techniques. In particular, the equation

Table 1
Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Wtd. CN[a]	Wtd. Rv	A (acres)	Runoff V (ac-ft/yr)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
					TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
Back Creek	68.7	0.13	37,588	14,600	18,221	161,521	2,532,375	925	1,545	0.5	4.3	67.4	0.025	0.041
Barnhardt Creek	74.3	0.2	2,659	1,601	1,169	10,686	251,473	89	209	0.4	4.0	94.6	0.033	0.079
Butt Hollow Creek	57.1	0.14	1,722	757	531	5,787	125,559	46	78	0.3	3.4	72.9	0.027	0.045
Carvin Creek	76.5	0.18	17,946	10,051	7,526	72,164	1,548,170	554	1,421	0.4	4.0	86.3	0.031	0.079
Cole Hollow Branch	68.9	0.2	3,757	2,278	1,942	17,548	365,310	138	427	0.5	4.7	97.2	0.037	0.114
Dry Branch	71.0	0.17	2,844	1,510	1,153	11,219	247,105	91	258	0.4	3.9	86.9	0.032	0.091
Gish Branch	75.7	0.3	1,285	1,170	1,008	8,174	173,482	74	418	0.8	6.4	135.0	0.058	0.325
Glade Creek	74.8	0.17	21,113	10,952	22,220	157,681	1,892,241	739	2,262	1.1	7.5	89.6	0.035	0.107
Lick Run	83.0	0.39	4,961	5,915	6,872	45,412	995,330	394	1,736	1.4	9.2	200.6	0.079	0.350
Mason Creek	74.1	0.15	17,662	8,271	6,560	65,693	1,404,834	496	1,173	0.4	3.7	79.5	0.028	0.066
Mudlick Creek	81.2	0.34	6,121	6,400	5,987	45,250	954,864	355	1,167	1.0	7.4	156.0	0.058	0.191
Murray Run	86.1	0.4	1,832	2,262	1,726	13,256	340,934	128	491	0.9	7.2	186.1	0.070	0.268
Ore Branch	79.0	0.39	2,603	3,129	2,577	20,304	473,098	190	894	1.0	7.8	181.7	0.073	0.344
Peters Creek	80.2	0.28	5,772	5,040	4,813	37,185	776,816	285	889	0.8	6.4	134.6	0.049	0.154
Tinker Creek	76.7	0.2	27,388	17,187	44,260	293,665	2,932,666	1,220	4,685	1.6	10.7	107.1	0.045	0.171
Wolf Creek	71.9	0.21	3,147	2,070	3,277	23,622	327,793	126	373	1.0	7.5	104.2	0.040	0.118
Totals	**N/A**	**N/A**	**158,399**	**93,194**	**129,843**	**989,167**	**15,342,051**	**5,850**	**18,026**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

(a) Runoff curve numbers (CN) were used in the hydrologic models. CNs are a measure of runoff potential of an area.

presented in the United States Environmental Protection Agency (EPA) *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Application for Discharges from Municipal Separate Storm Sewer Systems* (1992) was used to calculate annual pollutant loads for each land use and soil type in a watershed or subwatershed and summed over all land uses and soil types, as provided below.

$$L = [(P) \times (Pj) \times (Rv) / 12] \times (EMC) \times (A) \times (2.72)$$

where: L = Pollutant load (lb/yr)

and where: P = Annual average precipitation (inches/year [in/yr])

Pj = Rainfall correction factor

Rv = Runoff coefficient

EMC = Pollutant event mean concentration (milligrams per liter [mg/L])

A = Watershed area (acres)

and 12 and 2.72 are conversion factors where 12 inches = 1 foot and 2.72 lbs/yr = [(ft/yr)(mg/L)(acres)] x [(43,560 sf/acre)(lb/453,593 mg)(28.317 L/cf)]

Pollutant loading factors were computed as follows:

$$Lf = L/A$$

where: Lf = Pollutant loading factor (lb/ac-yr)

Annual runoff volumes were computed as follows:

$$Q = [(P \times Pj \times Rv_w)/12] \times A$$

= Annual runoff volume (ac-ft)

where: Rv_w = Weighted runoff coefficient for each area

2.1 Determination of Parameter Values

Determination of each parameter value in the above equations is described in this section.

Annual Average Precipitation (P)

The long-term average annual average precipitation recorded at the Roanoke Airport rain gauge is reported as 43 inches for 1948 through 1995.

Rainfall Correction Factor (Pj)

Multiplying the annual rainfall depth by Pj will reduce the annual runoff volume and accounts for that part of the annual rainfall that produces no runoff. As reported in the EPA Guidance Document, Pj typically is assigned a value of 0.9, which was used in this analysis.

Runoff Coefficients (Rv)

Runoff coefficients are based on the degree of watershed imperviousness, as follows:

$$Rv = 0.05 + 0.009\ (I)$$ (Metropolitan Washington Council of Governments [MWCOG], 1987)

where: I = the percent of site imperviousness

Site imperviousness is based on soil types and land use. Runoff coefficients and imperviousness values are shown in Table 2 for each land use and soil type.

Weighted Runoff Coefficients (Rv_w)

Weighted runoff coefficients were calculated for each watershed and are shown in Table 1.

Event Mean Concentrations (EMCs)

EMC values were developed for each combination of water-quality parameter and land-use category. Several sources of information were used to develop the EMCs. Table 3 summarizes the EMC data.

Watershed Areas (A)

Area values for the watersheds and subwatersheds were developed from the geographic information system (GIS) program. The 16 priority watersheds are divided into 35 tributary watersheds in the GIS. These tributary watersheds are divided further into 436 subwatersheds. The subwatersheds are identified by a three-letter code and a two-number code (e.g., BAC01). The letters identify the tributary watersheds and the numbers are assigned in order (i.e., 01, 02, 03, etc.). Table 4 shows the priority watershed areas and which tributary watersheds are included in each priority watershed. Table 5 shows the subwatershed areas.

2.2 Land Use

The data on land cover (land use) were obtained from Dewberry & Davis (D&D). Existing land use for the study area was developed using 1995 aerial photography, comprehensive plans, and other aerial photography and data. In this effort, D&D defined the following land cover categories:

- Open space (lawn, parks)
- Paved areas (parking lots, roads)
- Industrial districts
- Residential districts, 1/8 acre average lot size
- Residential districts, ½ acre average lot size
- Residential districts, 2 acres average lot size
- Pasture, grassland, or rangeland
- Woods and forest
- Open water (lakes, ponds)
- Commercial and business districts
- Railroad
- Residential districts, ¼ acre average lot size
- Residential districts, 1 acre average lot size
- Agricultural, cultivated land
- Brush, weed, and grass mix

TABLE 2
Runoff Coefficients and Imperviousness Values
Roanoke Valley Stormwater Management Plan

		Rv by Soil Type					Imperviousness by Soil Type				
Land Use (LU)	LU Code	A	B	C	D	W	A	B	C	D	W
Agriculture, cultivated land	AC	0.095	0.104	0.113	0.122	0.095	5	6	7	8	5
Pasture, grassland, or range land	AP	0.095	0.104	0.113	0.122	0.095	5	6	7	8	5
Brush, weed, and grass mix	BR	0.095	0.104	0.113	0.122	0.095	5	6	7	8	5
Commercial and business districts	CD	0.797	0.806	0.815	0.824	0.095	83	84	85	86	5
Industrial districts	ID	0.68	0.689	0.698	0.707	0.095	70	71	72	73	5
Noncontributing areas	NC	0.05	0.05	0.05	0.05	0.095	0	0	0	0	5
Open space	OS	0.095	0.104	0.113	0.122	0.095	5	6	7	8	5
Open water	OW	0.95	0.95	0.95	0.95	0.095	100	100	100	100	5
Paved parking lots, roofs, driveways, etc.	PP	0.86	0.86	0.86	0.86	0.095	90	90	90	90	5
Residential districts, 1 acre average lot size	R1	0.194	0.212	0.23	0.248	0.095	16	18	20	22	5
Residential districts, 1/2 acre average lot size	R12	0.239	0.257	0.275	0.293	0.095	21	23	25	27	5
Residential districts, 1/3 acre average lot size	R13	0.284	0.302	0.32	0.338	0.095	26	28	30	32	5
Residential districts, 1/4 acre average lot size	R14	0.356	0.374	0.392	0.41	0.095	34	36	38	40	5
Residential districts, 1/8 acre average lot size	R18	0.599	0.617	0.635	0.653	0.095	61	63	65	67	5
Residential districts, 2 acres average lot size	R2	0.122	0.14	0.158	0.176	0.095	8	10	12	14	5
Railroad	RR	0.104	0.122	0.14	0.158	0.095	6	8	10	12	5
Woods	WF	0.095	0.104	0.113	0.122	0.095	5	6	7	8	5

TABLE 3
Event Mean Concentrations (EMCs) and Loading Factors*
Roanoke Valley Regional Stormwater Management Plan

			Total Phosphorus		Total Nitrogen		Total Suspended Solids		Lead		Zinc	
EMCs (mg/L)												
Land Use	Land Use Code	Units	EMC	Reference	EMC	Reference	EMC	Reference	EMC	Reference	EMC	Reference
Agriculture, cultivated land	AC	mg/L	N/A	N/A	N/A	N/A	80		N/A	N/A	N/A	N/A
Pasture, grassland, or range land	AP	mg/L	N/A	N/A	N/A	N/A	75		N/A	N/A	N/A	N/A
Brush, weed, and grass mix	BR	mg/L	0.121	3	1.51	3	70	3	0.03	3	0.195	3
Commercial and business districts	CD	mg/L	0.38	2	2.77	2	56.5	2	0.027	2	0.198	2
Industrial districts	ID	mg/L	0.35	2	1.62	2	79.25	2	0.031	2	0.15	2
Noncontributing areas	NC	mg/L	0		0		0		0		0	
Open space	OS	mg/L	0.121	3	1.51	3	70	3	0.03	3	0.195	3
Open water	OW	mg/L	0		0		0		0		0	
Paved parking lots, roofs, driveways, etc.	PP	mg/L	0.26	1	2	1	52.6	2	0.018	1	0.037	1
Residential districts, 1 acre average lot size	R1	mg/L	0.26	1	2.0	1	52.6	2	0.018	1	0.037	1
Residential districts, 1/2 acre average lot size	R12	mg/L	0.26	1	2.0	1	52.6	2	0.018	1	0.037	1
Residential districts, 1/3 acre average lot size	R13	mg/L	0.26	1	2.0	1	52.6	2	0.018	1	0.037	1
Residential districts, 1/4 acre average lot size	R14	mg/L	0.26	1	2.0	1	52.6	2	0.018	1	0.037	1
Residential districts, 1/8 acre average lot size	R18	mg/L	0.26	1	2.0	1	52.6	2	0.018	1	0.037	1
Residential districts, 2 acres average lot size	R2	mg/L	0.26	1	2.0	1	52.6	2	0.018	1	0.037	1
Railroad	RR	mg/L	0.26	1	2.0	1	52.6	2	0.018	1	0.037	1
Woods	WF	mg/L	0.15	1	N/A	N/A	65		N/A	N/A	N/A	N/A

TABLE 3
Event Mean Concentrations (EMCs) and Loading Factors*
Roanoke Valley Regional Stormwater Management Plan

			Total Phosphorus		Total Nitrogen		Total Suspended Solids		Lead		Zinc	
LOADING RATE (lbs/ac-yr)												
Land Use	**Land Use Code**	**Units**	**Loading Rate**	**Reference**	**Loading Rate**	**Reference**	**Loading Rate**	**Reference**	**Loading Rate**	**Reference**	**Loading Rate**	**Reference**
Agriculture, cultivated land	AC	lbs/ac-yr	3.5	4	21.2	4	NA	NA	0.04	4	0.18	4
Pasture, grassland, or range land	AP	lbs/ac-yr	0.5	4	5.9	4	NA	NA	0.02	4	0.06	4
Woods	WF	lbs/ac-yr			2.4	4	NA	NA	0.02	4	0.01	4

* EMCs are shown for the land uses for which they were found. For the remainder of the land uses and constituents, loading rates were developed.
N/A Not Available

1. Metropolitan Washington Council of Governments, 1987.
2. CH2M HILL, 1993.
3. EPA, 1983.
4. Northern Virginia Planning District Commission, 1979.

TABLE 4
Watershed Basins and Areas
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Basin Names	Area (acres)	Area (square miles)
Back Creek	BAC, BCA, BCB, LBC, MAR	37,588	58.7
Barnhardt Creek	BAR	2,659	4.2
Butt Hollow Creek	BUT	1,722	2.7
Carvin Creek	CAR, DBR, WFC	17,946	28.0
Cole Hollow Branch	COL, PBB	3,757	5.9
Dry Branch	DRY	2,844	4.4
Gish Branch	GIS	1,285	2.0
Glade Creek	COK, GLA, GLB, GLD	21,113	33.0
Lick Run	LIC, TRT	4,961	7.8
Mason Creek	MAS, JUM	17,662	27.6
Mudlick Creek	MDC, MUD, MCT, WMC	6,121	9.6
Murray Run	MUR	1,832	2.9
Ore Branch	ORE, ORT	2,603	4.1
Peters Creek	PTA, PTB, PTC, PTR	5,772	9.0
Tinker Creek	TKR	27,388	42.8
Wolf Creek	WLF	3,147	4.9
Totals		**158,399**	**247**

TABLE 5
Estimated Subwatershed Areas
Roanoke Valley Regional Stormwater Management Plan

Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)
Back Creek		**Back Creek (cont)**		**Cole Hollow Creek (cont.)**		**Glade Creek (cont.)**		**Mason Creek (cont.)**		**Peters Creek (cont.)**	
BAC01	940.4	BCA05	436.3	COL12	33.2	GLD28	158.0	MAS28	513.0	PTR13	355.0
BAC02	254.1	BCB01	1530.8	COL13	77.0	GLD29	8.1	MAS29	201.7	PTR14	179.0
BAC03	1011.1	LBC01	761.5	COL14	40.5	GLD30	137.2	MAS30	173.8	PTR15	349.5
BAC04	418.5	LBC02	757.7	COL15	36.7	GLD31	8.0	MAS31	264.3	PTR16	261.4
BAC05	37.3	LBC03	256.1	COL16	218.7	GLD32	851.0	MAS32	159.1	PTR17	125.9
BAC06	106.0	LBC04	432.6	COL17	119.9	GLD33	265.5	MAS33	461.9	**Tinker Creek**	
BAC07	256.8	LBC05	319.4	PBB01	409.6	GLD34	308.6	MAS34	157.0	TKR01	1052.8
BAC08	394.8	MAR01	401.1	PBB02	148.4	GLD35	33.3	MAS35	696.8	TKR02	701.4
BAC09	131.1	MAR02	492.1	PBB03	149.2	GLD36	33.6	MAS36	303.5	TKR03	1156.2
BAC10	1161.3	MAR03	216.5	PBB04	17.9	GLD37	429.0	MAS37	190.1	TKR04	945.5
BAC11	46.1	**Barnhardt Creek**		PBB05	255.8	GLD38	149.4	MAS38	218.7	TKR05	133.6
BAC12	872.7	BAR01	114.2	**Dry Branch**		GLD39	238.5	MAS39	85.3	TKR06	2087.0
BAC13	28.1	BAR02	316.9	DRY01	933.2	GLD40	27.1	MAS40	168.9	TKR07	784.9
BAC14	932.0	BAR03	411.3	DRY02	185.1	GLD41	163.8	MAS41	312.0	TKR08	419.5
BAC15	13.0	BAR04	471.8	DRY03	198.3	GLD42	141.5	MAS42	107.6	TKR09	225.5
BAC16	670.0	BAR05	131.8	DRY04	30.4	GLD43	374.6	MAS43	400.2	TKR10	1197.4
BAC17	617.0	BAR06	34.4	DRY05	506.5	GLD44	341.0	MAS44	72.9	TKR11	957.8
BAC18	734.0	BAR07	309.7	DRY06	297.4	GLD45	264.9	MAS45	209.7	TKR12	1286.5
BAC19	164.7	BAR08	75.0	DRY07	157.6	GLD46	397.0	MAS46	325.6	TKR13	265.8
BAC20	475.7	BAR09	112.2	DRY08	41.9	GLD47	666.9	MAS47	210.8	TKR14	611.8
BAC21	150.5	BAR10	258.4	DRY09	87.8	GLD48	162.5	**Mudlick Creek**		TKR15	352.2
BAC22	52.4	BAR11	289.4	DRY10	223.5	**Lick Run**		MCT01	934.1	TKR16	48.8
BAC23	626.7	BAR12	46.6	DRY11	55.1	LIC01	220.6	MDC01	521.6	TKR17	5.4
BAC24	113.9	BAR13	87.4	DRY12	60.5	LIC02	443.2	MUD01	1039.8	TKR18	144.5
BAC25	538.4	**Butt Hollow**		DRY13	66.3	LIC03	372.5	MUD02	69.1	TKR19	757.1
BAC26	437.0	BUT01	564.1	**Gish Branch**		LIC04	518.8	MUD03	109.0	TKR20	1049.3
BAC27	201.6	BUT02	116.4	GIS01	266.7	LIC05	168.0	MUD04	320.5	TKR21	45.8
BAC28	360.8	BUT03	345.8	GIS02	181.8	LIC06	595.8	MUD05	28.9	TKR22	172.2
BAC29	203.9	BUT04	228.8	GIS03	71.2	LIC07	562.5	MUD06	165.5	TKR23	71.1
BAC30	370.2	BUT05	194.1	GIS04	12.6	LIC08	90.5	MUD07	63.4	TKR24	677.2
BAC31	293.4	BUT06	13.9	GIS05	53.7	LIC09	106.5	MUD08	219.7	TKR25	352.1
BAC32	744.5	BUT07	25.0	GIS06	12.9	LIC10	177.7	MUD09	507.4	TKR26	150.1
BAC33	670.6	BUT08	192.7	GIS07	33.3	LIC11	137.2	MUD10	562.2	TKR27	112.8
BAC34	666.3	BUT09	30.7	GIS08	89.8	LIC12	63.5	MUD11	34.6	TKR28	286.3
BAC35	577.1	BUT10	10.4	GIS09	46.7	TRT01	697.8	MUD12	238.5	TKR29	987.7
BAC36	1192.9	**Carvin Creek**		GIS10	113.2	TRT02	67.7	MUD13	545.3	TKR30	315.4
BAC37	876.7	CAR01	11199.9	GIS11	87.2	TRT03	43.2	MUD14	119.1	TKR31	251.0
BAC38	206.0	CAR02	613.6	GIS12	158.2	TRT04	689.0	WMC01	642.2	TKR32	56.5
BAC39	120.8	CAR03	794.2	GIS13	78.7	TRT05	6.5	MUR01	323.1	TKR33	514.7
BAC40	117.0	CAR04	152.1	GIS14	75.7	**Mason Creek**		MUR02	592.0	TKR34	486.3
BAC41	72.3	CAR05	145.4	GIS15	2.7	JUM01	495.0	MUR03	294.2	TKR35	495.3
BAC42	140.6	CAR06	181.0	**Glade Creek**		JUM02	427.8	MUR04	39.8	TKR36	362.7

TABLE 5
Estimated Subwatershed Areas
Roanoke Valley Regional Stormwater Management Plan

Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)	Subwatershed Name	Area (acres)
Back Creek		**Back Creek (cont)**		**Cole Hollow Creek (cont.)**		**Glade Creek (cont.)**		**Mason Creek (cont.)**		**Peters Creek (cont.)**	
BAC43	597.9	CAR07	243.3	COK01	602.3	JUM03	250.4	MUR05	236.8	TKR37	542.7
BAC44	39.7	CAR08	542.2	COK02	1306.1	JUM04	39.3	MUR06	346.4	TKR38	48.5
BAC45	915.4	CAR09	261.5	COK03	364.3	JUM05	135.3	**Ore Branch**		TKR39	1058.7
BAC46	196.5	DBR01	433.1	GLA01	813.1	JUM06	119.8	ORE01	311.9	TKR40	12.2
BAC47	872.2	DBR02	148.1	GLB01	695.7	JUM07	561.1	ORE02	72.8	TKR41	221.0
BAC48	689.5	DBR03	226.6	GLB02	340.6	JUM08	534.0	ORE03	778.5	TKR42	88.8
BAC49	839.4	DBR04	247.7	GLD01	333.2	MAS01	1807.4	ORE04	172.7	TKR43	327.1
BAC50	291.5	DBR05	46.4	GLD02	1667.7	MAS02	1311.4	ORT01	258.8	TKR44	78.5
BAC51	344.9	WFC01	752.8	GLD03	592.1	MAS03	531.2	ORT02	239.9	TKR45	520.8
BAC52	852.7	WFC02	232.3	GLD04	96.7	MAS04	198.9	ORT03	605.2	TKR46	208.5
BAC53	1126.5	WFC03	88.4	GLD05	30.5	MAS05	195.8	ORT04	163.3	TKR47	905.2
BAC54	571.5	WFC04	170.3	GLD06	485.8	MAS06	69.1	**Peters Creek**		TKR48	51.4
BAC55	176.6	WFC05	376.5	GLD07	635.9	MAS07	75.6	PTA01	424.7	TKR49	70.2
BAC56	114.0	WFC06	163.2	GLD08	479.8	MAS08	345.1	PTA02	214.4	TKR50	415.0
BAC57	96.4	WFC07	34.9	GLD09	1333.7	MAS09	275.8	PTB01	754.4	TKR51	138.8
BAC58	324.5	WFC08	213.3	GLD10	328.9	MAS10	182.2	PTB02	179.6	TKR52	2439.1
BAC59	119.1	WFC09	151.5	GLD11	299.7	MAS11	326.0	PTB03	176.5	TKR53	136.2
BAC60	96.4	WFC10	48.4	GLD12	468.3	MAS12	360.5	PTB04	197.7	TKR54	199.6
BAC61	448.6	WFC11	52.5	GLD13	1062.4	MAS13	608.8	PTC01	432.2	TKR55	246.5
BAC62	25.1	WFC12	351.5	GLD14	545.2	MAS14	750.5	PTC02	90.4	TKR56	159.2
BAC63	188.6	WFC13	75.0	GLD15	378.7	MAS15	186.4	PTC03	50.6	**Wolf Creek**	
BAC64	202.3	**Cole Hollow**		GLD16	176.1	MAS16	170.5	PTR01	150.4	WLF01	294.3
BAC65	683.8	COL01	469.1	GLD17	406.9	MAS17	44.4	PTR02	99.8	WLF02	146.5
BAC66	331.7	COL02	33.7	GLD18	79.1	MAS18	176.9	PTR03	166.8	WLF03	177.9
BAC67	31.5	COL03	294.6	GLD19	385.1	MAS19	22.6	PTR04	98.1	WLF04	31.5
BAC68	141.1	COL04	233.5	GLD20	26.4	MAS20	306.2	PTR05	3.7	WLF05	815.5
BAC69	158.4	COL05	72.2	GLD21	503.0	MAS21	212.1	PTR06	376.7	WLF06	404.1
BAC70	1155.5	COL06	386.3	GLD22	272.5	MAS22	88.3	PTR07	136.7	WLF07	16.0
BAC71	532.4	COL07	241.8	GLD23	259.1	MAS23	461.7	PTR08	298.3	WLF08	287.3
BCA01	857.9	COL08	177.8	GLD24	385.8	MAS24	174.7	PTR09	231.1	WLF09	233.9
BCA02	396.1	COL09	26.0	GLD25	500.4	MAS25	524.0	PTR10	53.7	WLF10	293.8
BCA03	517.7	COL10	160.6	GLD26	72.6	MAS26	140.0	PTR11	140.9	WLF11	358.0
BCA04	49.9	COL11	155.0	GLD27	25.5	MAS27	320.0	PTR12	224.5	WLF12	88.3

2.3 Analysis Results

Pollutant loading factors and average annual pollutant loads for the watersheds and subwatersheds are shown in Figures 1 through 20. The loading factors and pollutant loads by watershed were divided into ranges to show prioritization. The figures are organized as follows:

- **Pollutant Loading Factors by Watershed**

  Figure 1, Total Phosphorus; Figure 2, Total Nitrogen; Figure 3, Total Suspended Solids; Figure 4, Lead; and Figure 5, Zinc.

- **Average Annual Pollutant Loads by Watershed**

  Figure 6, Total Phosphorus; Figure 7, Total Nitrogen; Figure 8, Total Suspended Solids; Figure 9, Lead; and Figure 10, Zinc.

- **Pollutant Loading Factors by Subwatershed**

  Figure 11, Total Phosphorus; Figure 12, Total Nitrogen; Figure 13, Total Suspended Solids; Figure 14, Lead; and Figure 15, Zinc.

- **Average Annual Pollutant Loads by Subwatershed**

  Figure 16, Total Phosphorus; Figure 17, Total Nitrogen; Figure 18, Total Suspended Solids; Figure 19, Lead; and Figure 20, Zinc.

The results of the pollutant loads assessment analysis are in Figure 1–Pollutant Loading Factors by Watershed–Totals and provided in the following attachments:

- Attachment 1 includes estimated annual runoff volumes, average annual pollutant loads, and pollutant loading factors by watershed.

- Attachment 2 includes pollutant loading factors and annual pollutant loads for the 16 watersheds ranked by loading factors for total phosphorus, total nitrogen, total suspended solids, lead, and zinc.

- Attachment 3 includes pollutant loading factors and annual pollutant loads for the 436 subwatersheds.

3.0 Recommendations for BMP Implementation

There are two approaches to managing the quality of stormwater flows:

1. Provide numerous onsite stormwater management facilities, with water quality or best management practice (BMP) features, serving small drainage areas. These facilities typically are located within each development site, and their design does not take into consideration the hydrologic characteristics of the watershed in which they are located.

2. Provide regional stormwater management facilities serving at least 50 acres of drainage area. The location of these facilities will be based on models, such as the models

prepared for the Regional Stormwater Management Plan, and water quality analysis, such as the analysis presented in this technical memorandum.

To manage a watershed effectively, a combination of these two approaches is usually implemented.

3.1 Regional Facilities

The stormwater management facilities recommended in the Regional Stormwater Management Plan have as their main purpose the reduction of flooding problems in the Roanoke Valley. Converting these flood control facilities into BMP facilities is feasible and recommended during the final design of the facilities. The locations of proposed stormwater management projects are shown in Figure 21.

Adding water quality or BMP features to the regional facilities will reduce nutrients, metals, and sediment loads. In addition, properly designed facilities will significantly reduce the potential for streambank erosion and other impacts associated with future development.

The selection of appropriate BMP locations, or BMP targeting, will be facilitated with the use of the maps and tables presented in the previous section. Priority should be given to the watersheds and subwatersheds with the highest pollutant loads. In addition, erosion and sediment control practices should be enforced throughout the area, but priority for enforcement should be given to the watershed that produce the highest total suspended sediment loads.

3.2 Onsite Facilities

Onsite facilities should be constructed in areas not served by regional facilities. In future site development projects, the municipalities should consider the implementation of a runoff reduction hierarchy. The intent of this hierarchy would be to minimize runoff volumes and pollutant loads at the source and to mitigate uncontrollable runoff increases using accepted practices such as detention and retention. The following are some of the elements of the proposed runoff reduction hierarchy:

- Minimize impervious surfaces
- Attenuate flows in vegetated swales and depressional (bioretention) storage areas
- Infiltrate runoff onsite (if feasible, depending on soil characteristics)
- Detain/retain excess stormwater
- Construct storm sewers

The goal of this hierarchy is to reduce development costs and to maximize environmental protection.

3.3 Implementation

To manage the Roanoke Valley watersheds effectively, a combination of different controls and approaches (regional and onsite) can be used to fit different site constraints and to solve the erosion, flooding, stormwater, and habitat problems in each specific watershed. The design of the proposed controls should include careful consideration of the maintenance requirements to ensure long-term performance.

Traditionally, the control of stormwater has been based on managing the 2- and 10-year storms for solving quantity problems. In the 1980s, controlling the first half-inch of runoff

was the standard for solving water quality problems. Watershed managers have identified problems using these "standards" and are working on nontraditional approaches to meet the needs of the watersheds (Center for Watershed Protection, *Watershed Protection Techniques*, Vol. 1, No. 2, Summer 1994).

We recommend that the municipalities consider sizing water quality controls on the basis of a 1.25-inch rainfall event using a simple runoff coefficient. The resulting treatment volume will adequately control pollutants and will control velocities, thereby reducing erosion problems and providing opportunities for habitat enhancement. This type of "sizing rule" also can be used in designing retrofits for urban areas not currently served by BMPs and existing stormwater facilities. Stormwater retrofitting involves modifying or converting existing stormwater management facilities or conveyance facilities or constructing new facilities to remedy existing water quality and quantity-related problems.

The achievement of water quality and stream channel erosion protection, as well as stream restoration goals, depends on the timely and systematic implementation of effective, watershed-wide land use and stormwater management controls. Implementing regional and on-site BMPs, along with carefully selected retrofit sites, will improve water quality and stream habitat. Although the full restoration of moderately or severely degraded urban streams (to their predevelopment physical, chemical, and biological condition) is generally infeasible; significant improvements can be made if the appropriate tools and technologies are applied.

The following BMPs could be considered for new developments, in addition to traditional extended detention ponds and wet ponds:

- Off-line grass-swale and extended detention marshes
- Bioretention areas
- Constructed stormwater wetlands
- Culvert retrofits
- Stream restoration
- Sand filters
- Stormwater management ponds

Off-line grass-swale and extended detention marshes are constructed open-channel drainageways. They are used as an alternative to, or an enhancement of, conventional storm sewers. Swales vegetated with grass or other suitable vegetation are useful as both runoff conveyance facilities and as pollutant filtering and infiltration devices. Grass swales can be combined with shallow marshes and vegetated filter strips to convey sheet runoff from impervious surfaces to drainage pipes or other conveyance devices. A well-vegetated lawn can function as a filter strip. Filter strips are a recommended measure to "disconnect" impervious surfaces from storm sewers and channels.

The idea behind this nontraditional method is to use flow splitters to divert the small storms (less than a 2-year storm) from exiting drainage systems to a grass swale designed to slow down the water and planted with plant species that will increase pollutant removal. At the end of the grass swale, for example, an extended detention marsh retrofit can be constructed to further slow down the water, remove pollutants, and de-synchronize the peaks.

Bioretention areas. The bioretention areas are a combination of grasses, shrubs, and trees on top of a sand and topsoil mixture that either infiltrates or filters stormwater (depending on soil conditions and grades available) from parking lots, rooftops, or other impervious areas.

These areas combine physical, biological, and chemical processes to maximize pollutant removal. If enough of these areas are found in a watershed, the available storage can reduce the peaks and velocities in the affected stream reach. This is an experimental practice and no data are available on efficiency or long-term maintenance. However, demonstration projects in Maryland and Virginia are showing good results for the treatment of stormwater runoff. Bioretention facilities will require a different approach to site planning: (1) treat the stormwater as it moves through the subdivision, instead of piping the stormwater and constructing ponds in the low spots, and (2) look for multifunctional uses of all available green space.

Bioretention facilities are most effective if they receive runoff as close as possible to its source. A site designer needs to look for opportunities to incorporate bioretention facilities throughout the site, and minimize the use of inlets, pipes, and downstream controls. Prince George's County, Maryland, reports savings on drainage infrastructure costs of up to 50 percent in a development that incorporated bioretention facilities. Similar savings have been achieved in Prince William County, Virginia, in sections of developments with bioretention facilities.

Bioretention areas were used initially as off-line systems in urban and suburban areas. New configurations and designs include diverting the recommended treatment volume or the first flush from drainage pipes into a bioretention area, incorporating on-line bioretention concepts to swales and adding collector pipe systems in areas not conducive to exfiltration.

Constructed stormwater wetlands are shallow pools that create growing conditions suitable for marsh-plant growth. Stormwater wetlands are designed to maximize pollutant removal through wetland uptake, retention, and settling. Stormwater wetlands are constructed systems and typically are not located within delineated natural wetlands. In addition, stormwater wetlands differ from artificial wetlands created to comply with mitigation requirements in that they do not replicate all the ecological functions of natural wetlands.

Enhanced stormwater wetlands are designed for more effective pollutant removal and species diversity. They also include design elements such as a forebay, complex microtopography, and pondscaping with multiple species of wetland trees, shrubs, and plants.

Constructed wetlands are applicable to most sites, but require larger areas of land than other stormwater management facilities. However, properly designed stormwater wetlands can enhance the appearance of the site.

Culvert retrofits. Nontraditional retrofits create a small detention area upstream of existing culverts that can incorporate a micropool or a shallow marsh. All larger storms (larger than a 2-year storm) are safely passed through the culvert. The retrofitted culverts also will provide pollutant removal and stormwater storage for the small storms that cause erosion on the targeted stream channels.

Stream restoration. Once the regional facilities proposed in the stormwater plan are implemented to control the hydrologic regime, the targeted stream reaches can be restored using bioengineering techniques and natural stability concepts. These concepts are based on fluvial geomorphology studies developed in the 1950s and more recent practical applications developed by Dave Rosgen, a hydrologist formerly with the National Park Service. The stream restoration effort includes restoring the equilibrium channel geometry (recreating meanders and using the floodplain) to reduce streambank erosion, restoring the instream habitat structure, and augmenting the riparian cover.

Sand filters treat the first flush of runoff by diverting the flow into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes, and discharged into either a storm drain system or a stream or channel. **Enhanced sand filters** use layers of peat, limestone, or topsoil, and also may have a grass cover crop. The adsorptive media of enhanced sand filters is expected to improve removal rates.

Closed sand filters are BMPs that treat the first flush of runoff by diverting the flow into an underground vault. The runoff is strained through a bed of sand within the vault, collected in pipes at the bottom of the vault, and discharged into either a storm drain system or to a stream or channel. A variety of closed sand filter designs have been developed and implemented. The most extensive applications include:

- Stormwater sand filter basins in Austin, Texas
- Underground vault sand filters developed in the District of Columbia
- Delaware double-trench sand filters
- Modified District of Columbia and Delaware sand filters in Alexandria, Virginia

Stormwater management ponds. These types of facilities are constructed depressions with outflow capacities sufficiently restricted to store stormwater and gradually release it to the downstream drainage system. Stormwater management ponds are designed to control the *quantity* and the *quality* of runoff. These facilities reduce peak discharges, reduce downstream erosion problems, reduce pollutant loads, and help eliminate the environmental problems normally associated with development activities. Maximum discharge rates should be regulated to conform with the capacity of the downstream channel or drainage system.

Stormwater ponds can be divided into detention facilities (dry ponds) and retention facilities (wet ponds). *Dry ponds* rely primarily on settling to remove pollutants. However, additional removal can occur via biological uptake and transformation by aquatic organisms and wetland vegetation. Settling efficiency and, to some extent, biological uptake and transformation are dependent on the runoff detention time. Thus, pollutant removal efficiency primarily is dependent on detention time and the presence of appropriate wetland and aquatic vegetation. Pollutant removal efficiency can be increased by extending the detention time, and constructing forebays and micropools to treat runoff from small, more frequent, storms. In general, the site-specific conditions that potentially affect the design of dry ponds include land availability, site topography, environmental benefits, soil characteristics, and site size. Dry ponds may be used for a wide range of drainage areas. However, the upper range for contributing drainage area, without having to take base flow into consideration, is about 50 to 75 acres. Above this range, wet ponds are more applicable. Dry ponds are generally applicable in most new development situations or to retrofit existing development.

Wet ponds are an extremely effective BMP. If properly designed and maintained, wet ponds achieve higher pollutant removal rates than dry ponds. The degree of pollutant removal is a function of the size and design of the permanent pool and the characteristics of the runoff draining into the pond. Pollutant removal efficiencies can be increased by incorporating sediment forebays, biofilters, and aquatic benches in the design of the facility. The most important aspect in the design of a wet pond is the existence of an adequate base flow to ensure that the permanent pool can be maintained. Other factors to consider in the design of wet ponds include topography, soil characteristics, groundwater location and use, depth of bedrock, accessibility, and aesthetic and environmental concerns. Similar to dry ponds, wet

ponds generally are applicable in most new development situations where land and a reliable source of water are available.

Implementation of water quality requirements for stormwater management will require modifications to municipalities' ordinances and design manuals. The proposed model ordinance includes water quality requirements for consideration by the Technical Advisory Committee.

Estimated levels of pollutant removal efficiency and reliability for some of these BMPs are shown in Table 6.

4.0 Phase II NPDES Stormwater Permits

This section summarizes the currently anticipated requirements in the Phase II NPDES stormwater permit regulations that are expected in September 1997. The November 16, 1990, regulations that created the NPDES stormwater permit program applied only to urbanized areas with populations exceeding 100,000 that are served by a municipal separate storm sewer system (MS4), and to "stormwater discharges associated with industrial activity" in 11 categories of industrial activity. In the Clean Water Act revisions of 1987, Congress mandated that stormwater discharges that are potential sources of water quality problems and that were not covered in the November 1990 regulations will be addressed in Phase II regulations by October 1, 1992. That deadline was missed. The EPA is currently facing a court-ordered deadline of issuing regulations by September 1997.

TABLE 6
Pollutant Removal Efficiency and Reliability of BMPs
Roanoke Valley Regional Stormwater Management Plan

BMP Option	Phosphorus Removal Efficiency	Pollutant Removal Reliability
Wet Ponds	40 to 65%	Medium
Dry Ponds	30 to 50%	Medium
Constructed Wetlands	-120 to 97%[a]	Medium
Grass Swales	30%[b]	Medium
Modified Grass Swales/ Biofilters	30%[b]	Medium
Filter Strips	26 to 79%[c]	Low
Bioretention	18 to 74%[d]	Medium
Sand Filters (open)	40%, sand 70%, sand/peat[e]	Medium
Sand Filters (closed)	60%[f]	Medium

[a] Insufficient data are available. In this study, 22 sites were a sink for phosphorus and 6 sites were a source for phosphorus. The median removal efficiency was 46 percent (Shaver and Maxted, 1994).
[b] Predicted value for a well-designed and well-maintained grass swale (Schueler, 1992).
[c] Range of efficiencies reported in a study of agricultural areas was 26 percent to 79 percent. Use of this BMP in an urban setting is expected to provide efficiencies near the lower end of this range (Haan, Barfield, and Hayes, 1994).
[d] Prince George's County estimate (Prince George's County Government, 1993).
[e] City of Austin, 1988. Galli, 1990.
[f] City of Alexandria, Virginia, recognizes a 60 percent phosphorus removal rate based on Austin, Texas, and Alexandria monitoring of similar filters (Bell, 1996).

Roanoke Valley municipalities were not included in the 1990 regulations because the population of each municipality was not large enough. It is expected that the Roanoke Valley municipalities will need to comply with the Phase II regulations, because Phase II focuses on "urbanized areas" rather than municipal populations. The definition of an "urbanized area" as applied in these regulations is not clear currently.

In developing the Phase II permit program, the EPA has been working with an Urban Wet Weather Federal Advisory Committee (UWWFAC) Phase II Subcommittee. The following summary is based on information CH2M HILL has obtained through its participation in the UWWFAC as well from the Stormwater Permit Manual updates (Thompson Publishing Group). The UWWFAC stakeholder participation process has resulted in several changes in direction, so the information summarized below is likely to change again before the final regulations are issued.

The Phase II program includes requirements for stormwater discharges from:

- Industrial areas
- Construction sites
- Municipal separate storm sewer systems

The requirements associated with municipal separate storm sewer systems have the potential for the largest impact on Roanoke Valley municipalities. All three programs are described below.

4.1 Construction Permits

The threshold for coverage under construction general permits will be lowered from the current 5 acres of disturbed area to 1 acre. To avoid duplication, general permit programs would be coordinated with local and state erosion and sediment (E&S) control programs, such that if a construction facility is in compliance with the E&S programs, it would be considered to be covered and in compliance with the construction general permits.

4.2 Industrial Permits

Two additional categories of industrial facilities will be subject to requirements similar to those developed for the Phase I program, including preparation of stormwater pollution prevention plans. These include:

- Facilities engaged in heavy industrial vehicle maintenance (rehabilitation, repairs, painting, fueling and lubrication) or equipment cleaning operations related to construction equipment and municipal equipment yards
- Publicly owned bus maintenance facilities that engage in vehicle maintenance

Service stations will not be covered as a category under the Phase II rule, but would be considered on a case-by-case basis.

4.3 Municipal Stormwater Dischargers

Municipalities in urbanized areas as identified by the latest 10-year census would be required to obtain a Phase II permit. Municipalities that are not located in urbanized areas

may also be required to obtain Phase II permits if they meet certain criteria, such as high population density, high growth potential, or large amounts of rainfall.

To obtain a Phase II permit, municipalities would be required to develop local stormwater programs to address six stormwater minimum control measures:

- Public education and outreach
- Public involvement and participation
- Illicit discharge detection and elimination
- Construction site discharge control
- Post construction stormwater management
- Pollution prevention and good housekeeping in municipal operations

Specific requirements have not been established. EPA and authorized states, such as Virginia, would issue general permits that would provide details on the required program elements. EPA has indicated that the upcoming regulations will promote the use of BMPs rather than requiring numeric effluent limitations.

Municipalities will be required to submit a list of the BMPs to be implemented by the municipality and measurable goals for the six measures listed above. According to the draft regulations, the permitting authority, in this case the Virginia Department of Environmental Quality, may exempt an urbanized area for the NPDES requirements if:

- There is a comprehensive watershed plan or total maximum daily load (TMDL) evaluation and if relevant components of the plan are reflected in the NPDES permit

- The watershed plan or TMDL demonstrates that municipal discharges do not cause or have potential to cause water quality impact

- Any necessary nonpoint source controls identified in the watershed plan or TMDL are enforceable

Implementation of the Roanoke Valley Regional Stormwater Management Plan will facilitate compliance with the NPDES regulations, if Roanoke Valley municipalities are included in the Phase II implementation. In addition, much of the information needed to develop TMDLs has been developed through the preparation of the Roanoke Valley Regional Stormwater Management Plan.

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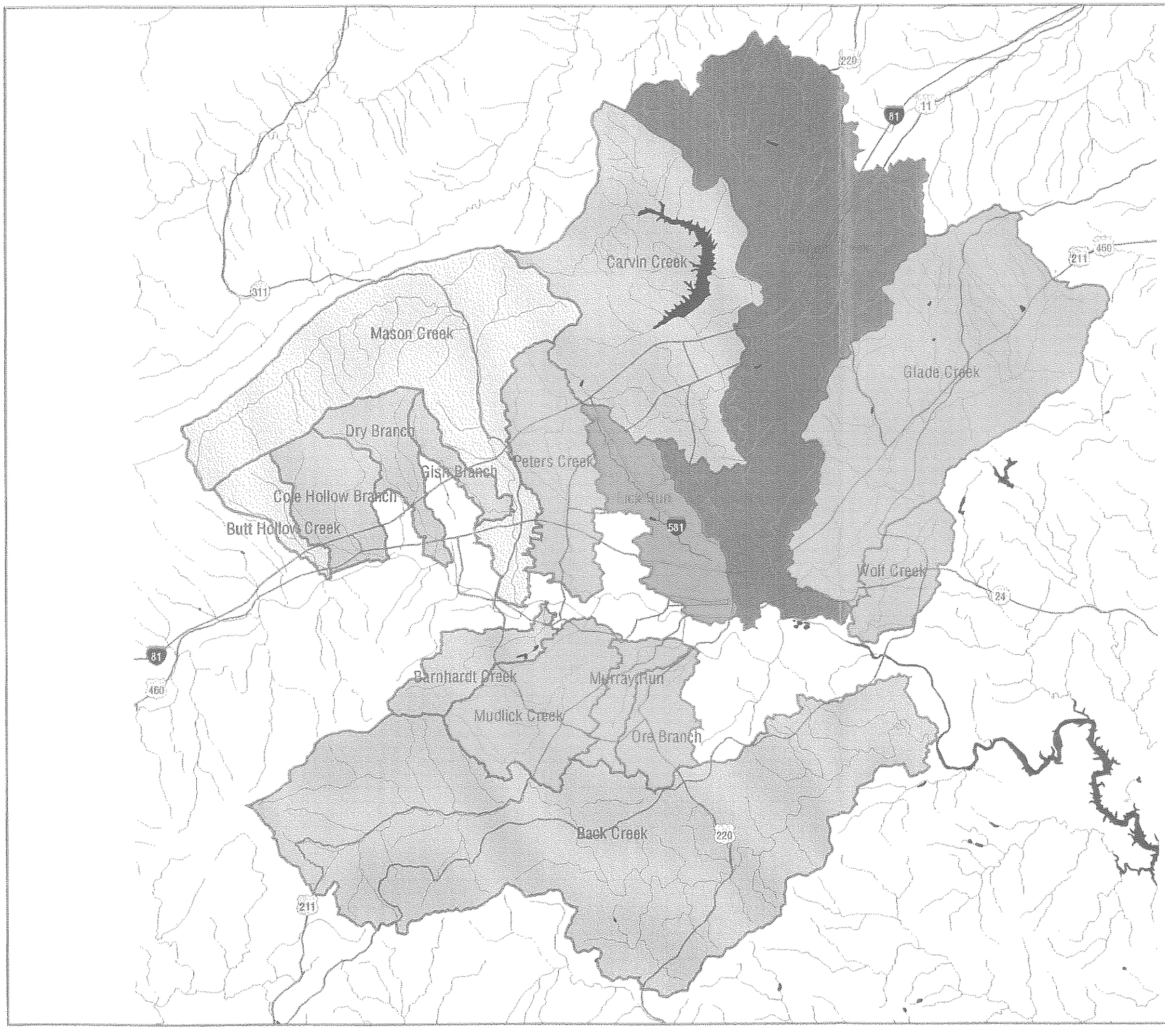
Figures 1 Through 21



ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 1

POLLUTANT LOADING FACTORS
BY WATERSHED

TOTAL PHOSPHORUS

CONCENTRATIONS in lbs/acre/year

- < 0.40
- 0.40 - 0.79
- 0.80 - 1.19
- 1.20 - 1.59
- >= 1.60

N

Scale 1:160000

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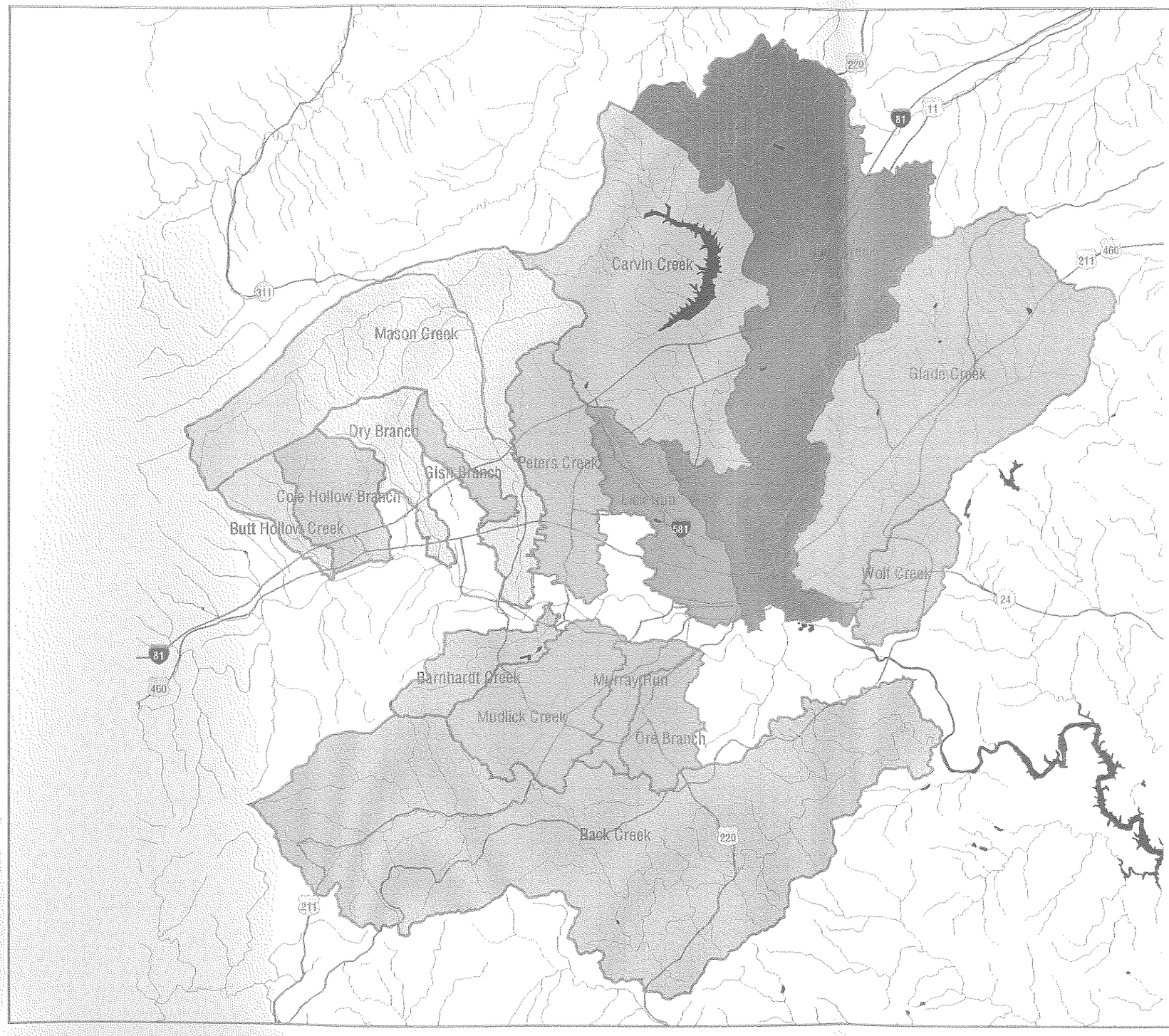


ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 2

POLLUTANT LOADING FACTORS
BY WATERSHED

TOTAL NITROGEN

CONCENTRATIONS in lbs/acre/year

- < 4
- 4 - 6
- 6 - 8
- 8 - 10
- > = 10

N

Scale 1:160000

KILOMETERS
0 1 2 3 4
MILES
0 .5 1 1.5 2

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

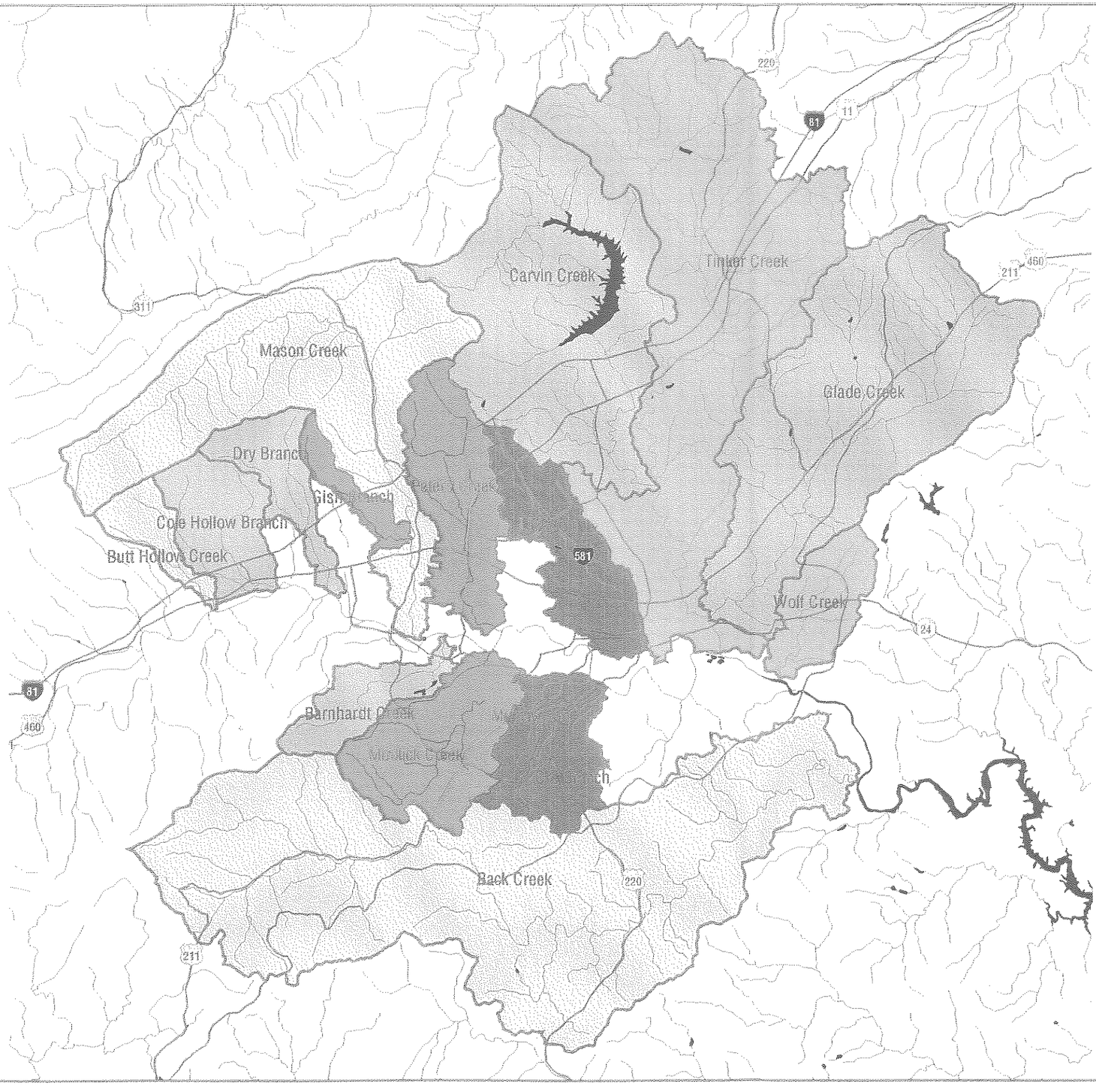
FIGURE 3

POLLUTANT LOADING FACTORS
BY WATERSHED

TOTAL SUSPENDED SOLIDS

CONCENTRATIONS in lbs/acre/year

- < 80
- 80 - 100
- 100 - 120
- 120 - 160
- > = 160



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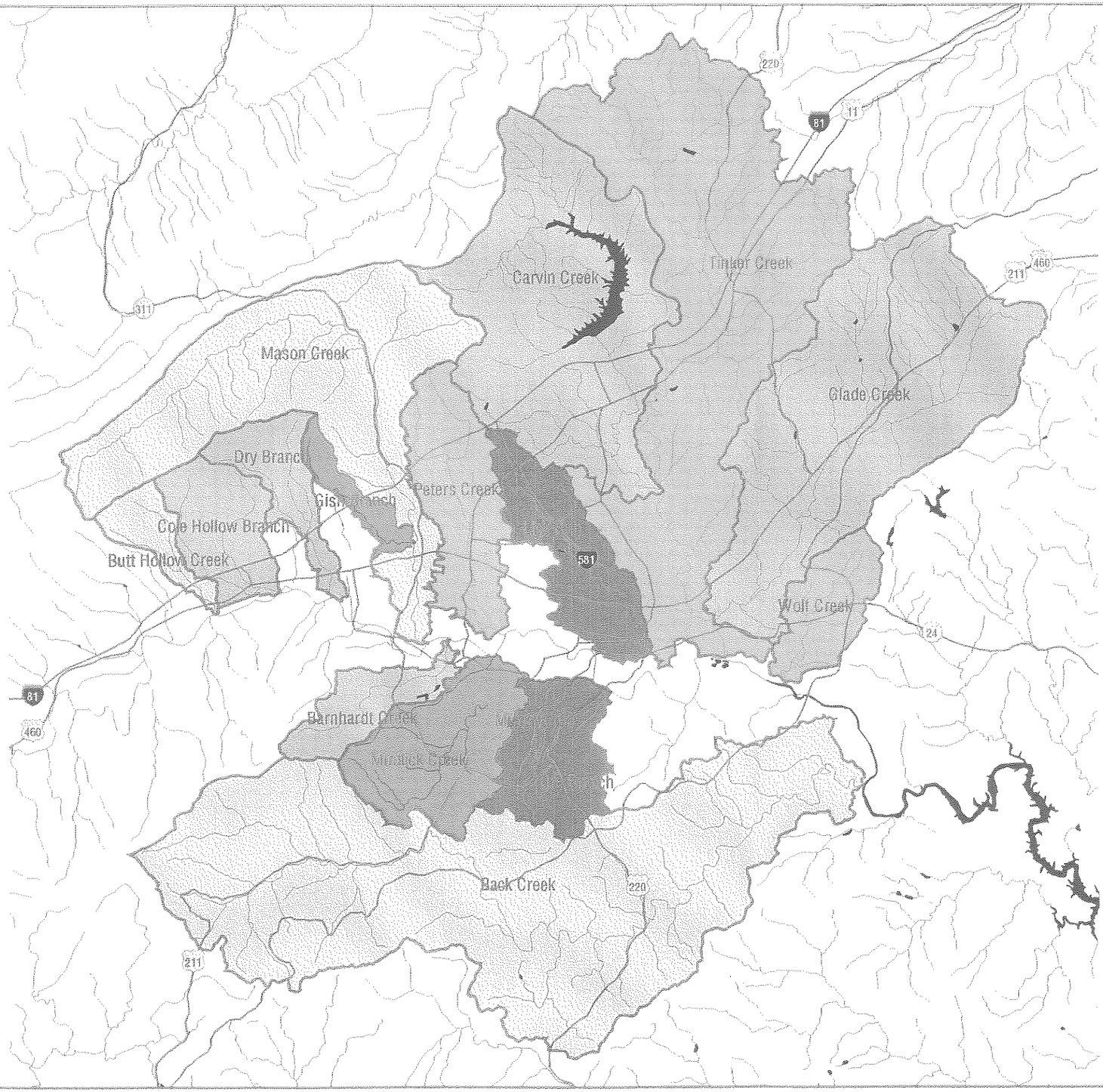


ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 4

POLLUTANT LOADING FACTORS
BY WATERSHED

LEAD

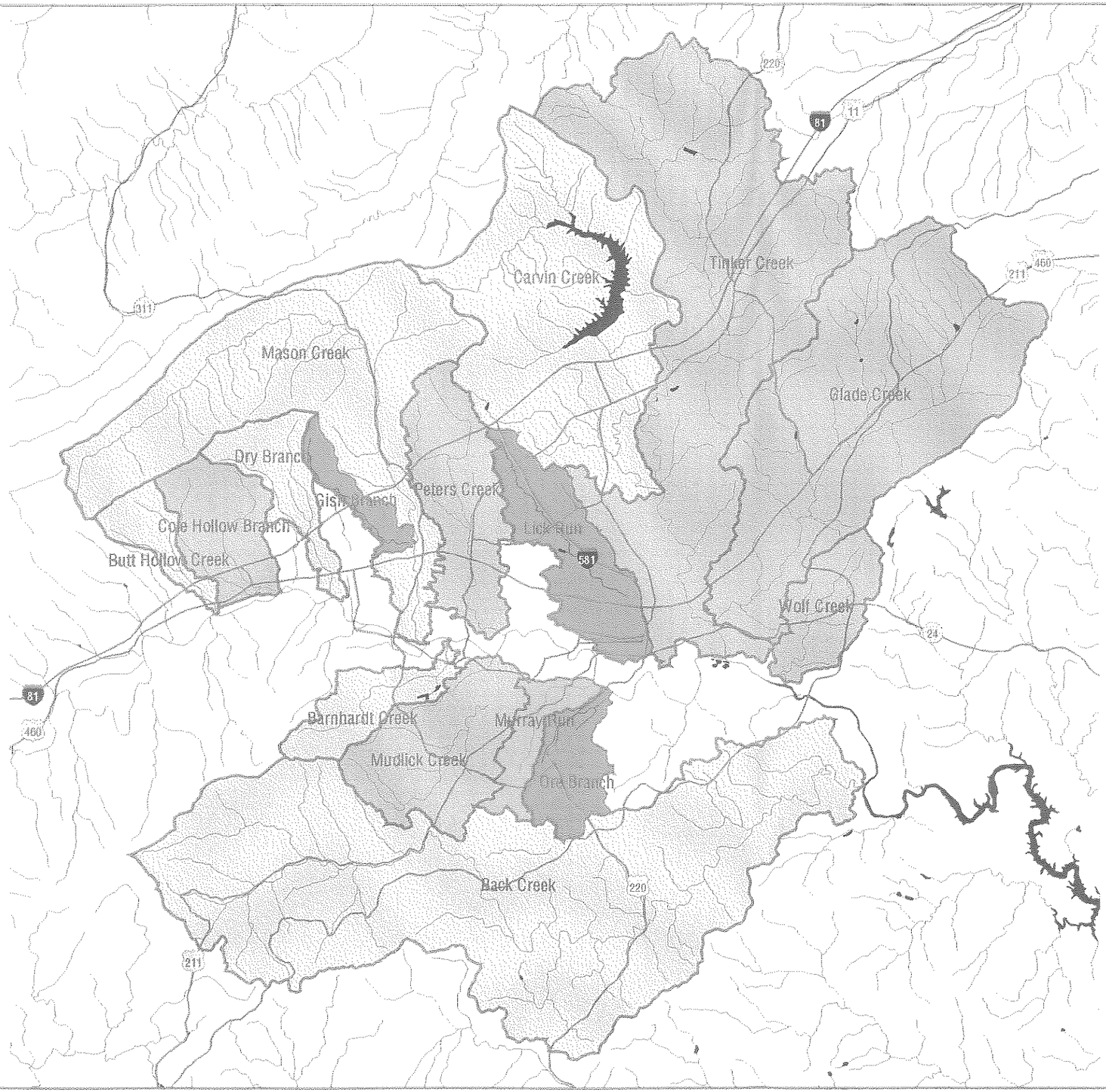
CONCENTRATIONS in lbs/acre/year

- < 0.030
- 0.030 - 0.039
- 0.040 - 0.049
- 0.050 - 0.059
- > = 0.060

N

Scale 1:160000

CH2MHILL



ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 5

POLLUTANT LOADING FACTORS
BY WATERSHED

ZINC

CONCENTRATIONS in lbs/acre/year

- < 0.10
- 0.10 - 0.19
- 0.20 - 0.29
- > = 0.30

N

Scale 1:160000

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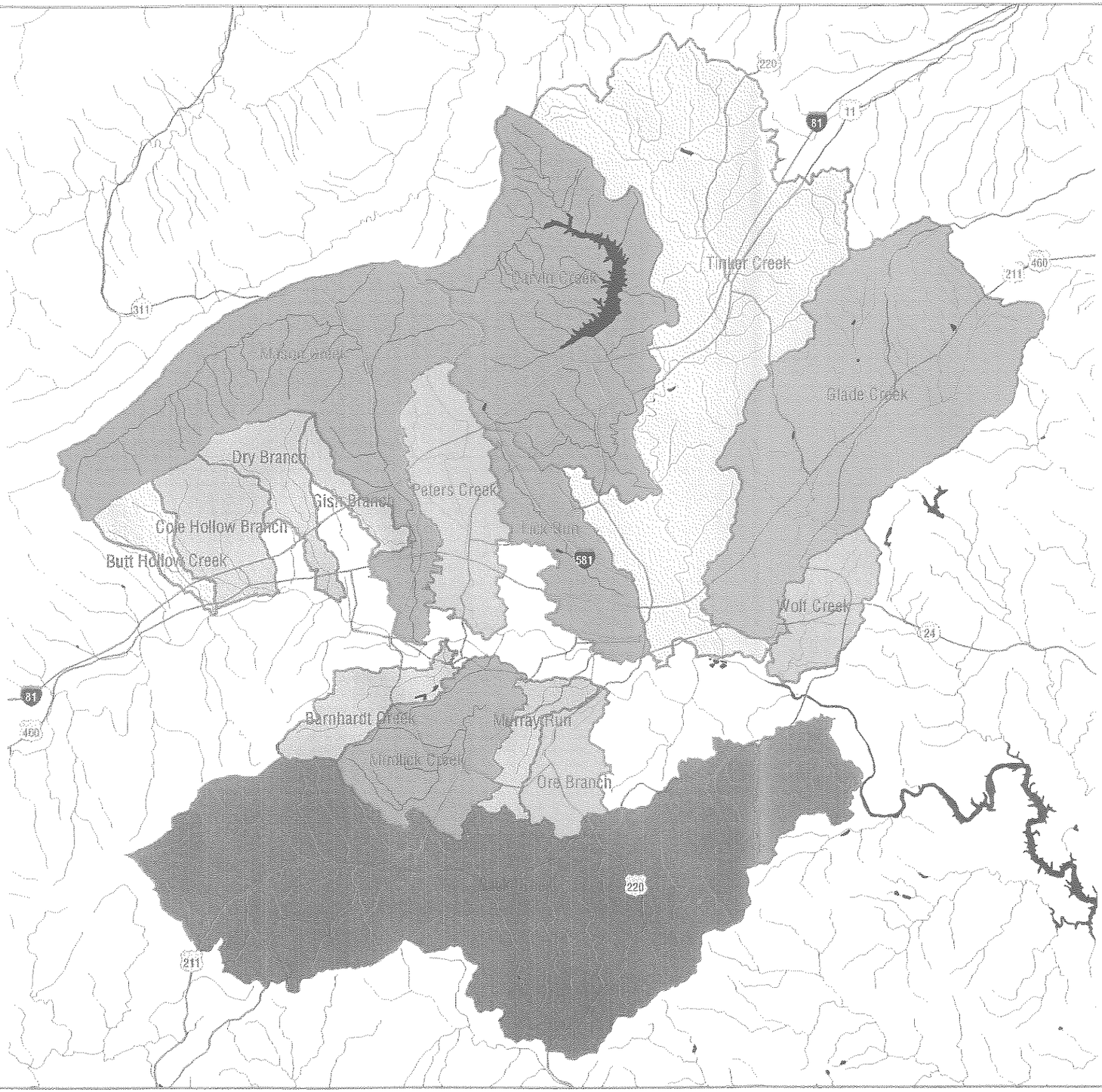


ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 6

AVERAGE ANNUAL POLLUTANT LOADS
BY WATERSHED

TOTAL PHOSPHORUS

LOADS in lbs/year

- < 1000
- 1000 - 2000
- 2000 - 5000
- 5000 - 10000
- 10000 - 20000
- 20000 - 25000
- > = 25000

N

Scale 1:160000

KILOMETERS
0 1 2 3 4
MILES
0 .5 1 2

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 7

AVERAGE ANNUAL POLLUTANT LOADS
BY WATERSHED

TOTAL NITROGEN

LOADS in lbs/year

- < 10000
- 10000 - 20000
- 20000 - 50000
- 50000 - 100000
- 100000 - 200000
- > = 200000

Scale 1:360000

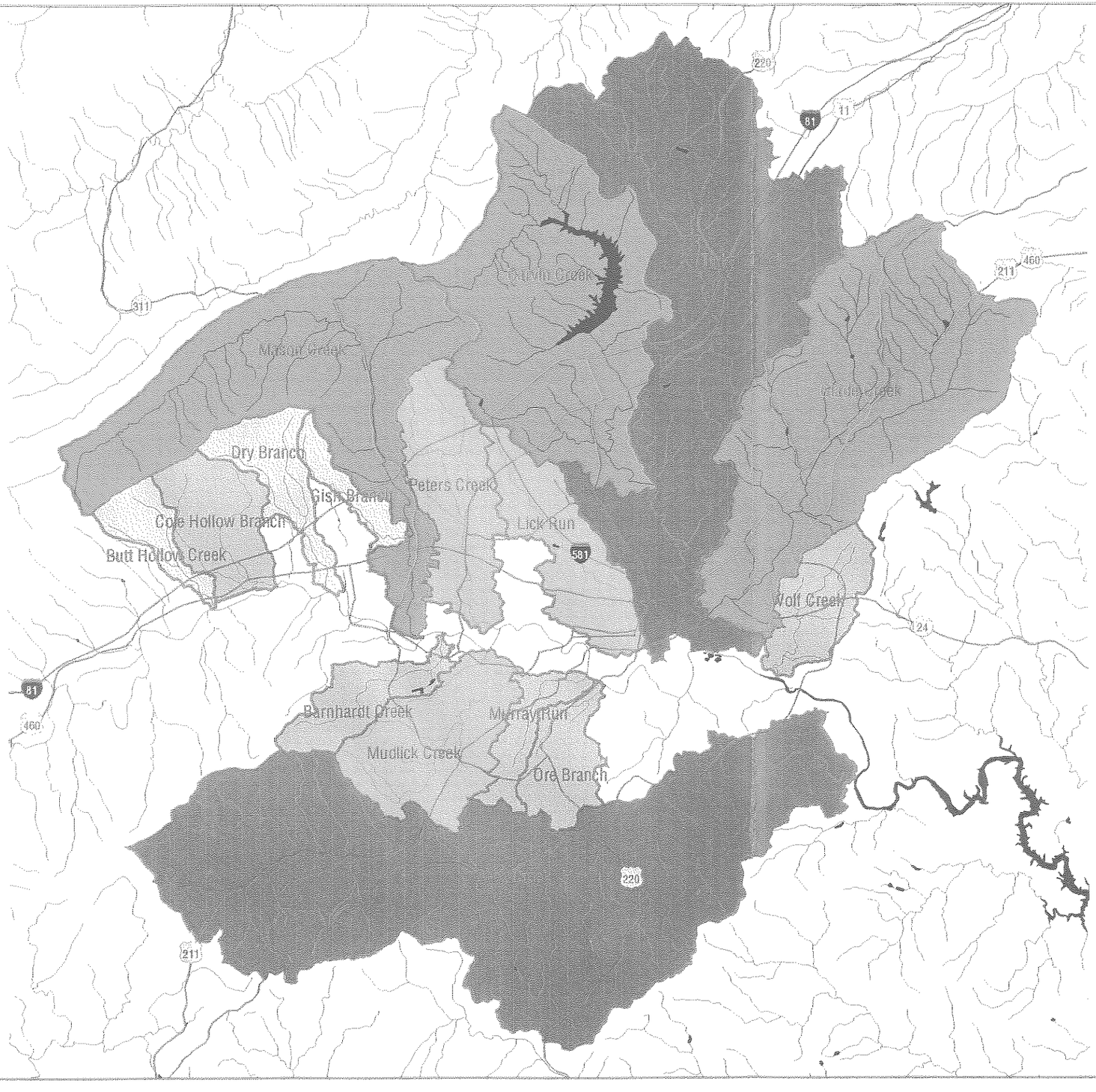
CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 8

AVERAGE ANNUAL POLLUTANT LOADS
BY WATERSHED

TOTAL SUSPENDED SOLIDS



LOADS in lbs/year

- < 250000
- 250000 - 500000
- 500000 - 1000000
- 1000000 - 2000000
- >= 2000000

N

Scale 1:160000

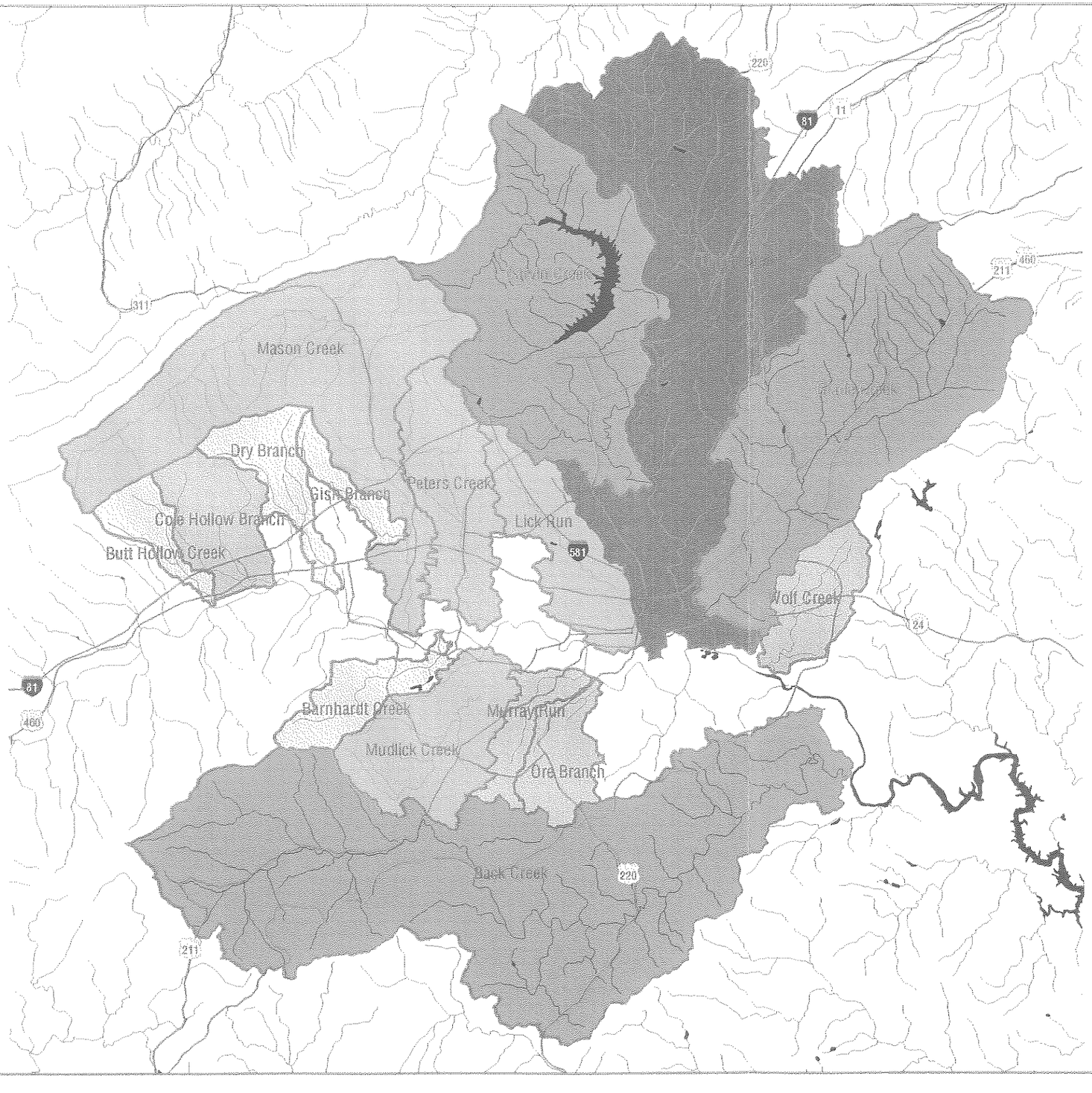
CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 9

AVERAGE ANNUAL POLLUTANT LOADS
BY WATERSHED

LEAD



LOADS in lbs/year

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000
- > = 1000

N

Scale 1:160000

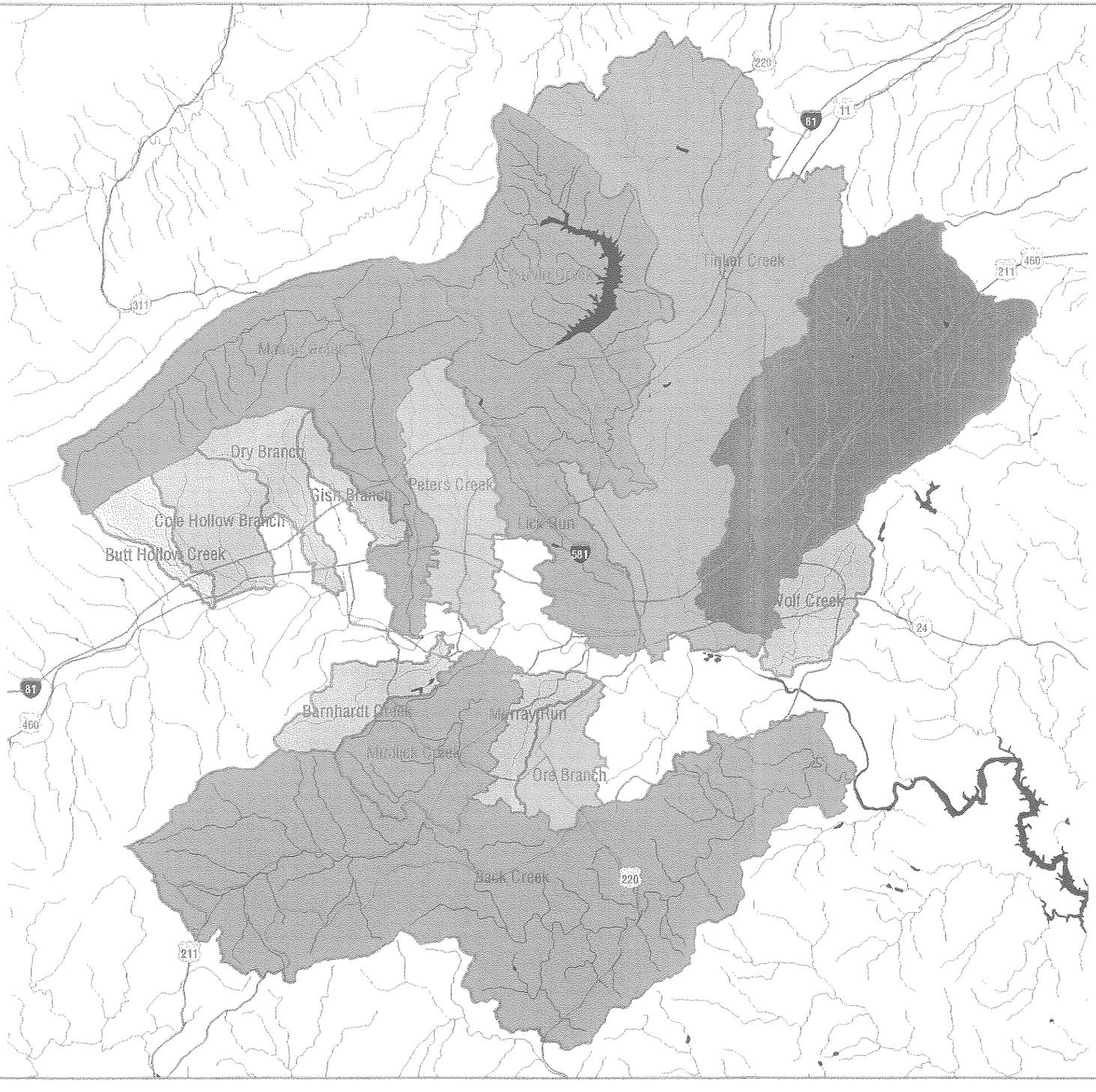
CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 10

AVERAGE ANNUAL POLLUTANT LOADS
BY WATERSHED

ZINC



LOADS in lbs/year

- < 200
- 200 - 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- > = 3000

N

Scale 1:160000

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 11

POLLUTANT LOADING FACTORS
BY SUBWATERSHED

TOTAL PHOSPHORUS

CONCENTRATIONS in lbs/acre/year

- < 0.40
- 0.40 - 0.79
- 0.80 - 1.19
- 1.20 - 1.59
- 1.60 - 1.99
- > = 2.00

N

Scale 1:160000

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

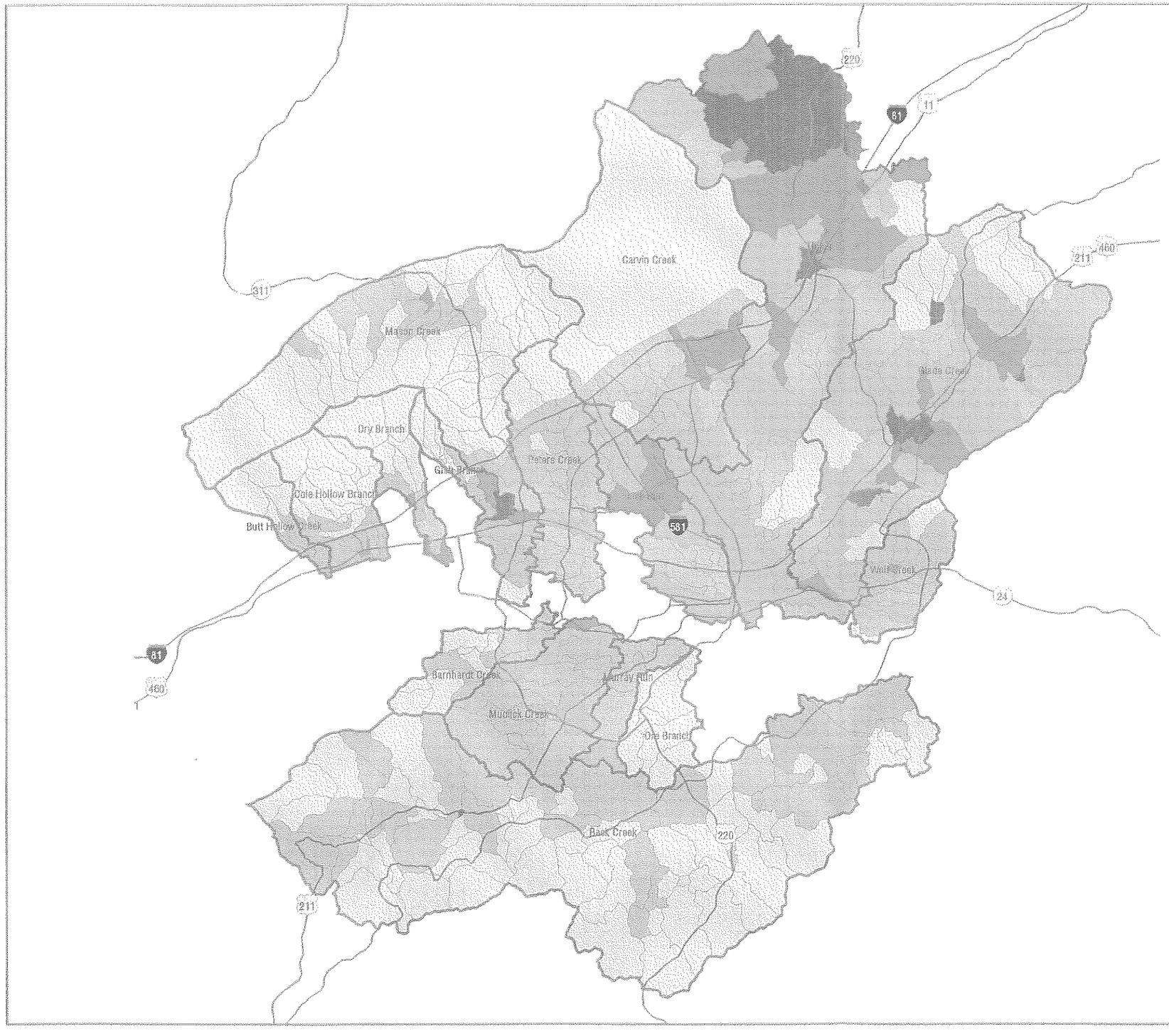
FIGURE 12

POLLUTANT LOADING FACTORS
BY SUBWATERSHED

TOTAL NITROGEN

CONCENTRATIONS in lbs/acre/year

- < 4
- 4 - 8
- 8 - 12
- 12 - 16
- > = 16



N

Scale 1:160000

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 13

POLLUTANT LOADING FACTORS
BY SUBWATERSHED

TOTAL SUSPENDED SOLIDS

CONCENTRATIONS in lbs/acre/year

- < 50
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 300
- > = 300

N

Scale 1:160000

KILOMETERS

MILES

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 14

POLLUTANT LOADING FACTORS
BY SUBWATERSHED

LEAD

CONCENTRATIONS in lbs/acre/year

- < 0.025
- 0.025 - 0.049
- 0.050 - 0.099
- 0.100 - 0.149
- > = 0.150

N

Scale 1:160000

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 15

POLLUTANT LOADING FACTORS
BY SUBWATERSHED

ZINC

CONCENTRATIONS in lbs/acre/year

- < 0.025
- 0.025 - 0.049
- 0.050 - 0.099
- 0.100 - 0.149
- 0.150 - 0.249
- > = 0.250

N

Scale 1:160000

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 16

AVERAGE ANNUAL POLLUTANT LOADS
BY SUBWATERSHED

TOTAL PHOSPHORUS

LOADS in lbs/year

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- > = 3000

N

Scale 1:160000

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 17

AVERAGE ANNUAL POLLUTANT LOADS
BY SUBWATERSHED

TOTAL NITROGEN

LOADS in lbs/year

- < 500
- 500 - 1000
- 1000 - 2000
- 2000 - 5000
- 5000 - 10000
- 10000 - 20000
- > = 20000

N

Scale 1:160000

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 18

AVERAGE ANNUAL POLLUTANT LOADS
BY SUBWATERSHED

TOTAL SUSPENDED SOLIDS

LOADS in lbs/year

- < 5000
- 5000 - 10000
- 10000 - 20000
- 20000 - 50000
- 50000 - 100000
- 100000 - 250000
- > = 250000

N

Scale 1:160000

METERS 0 1 2 3 4
MILES 0 1 2

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 19

AVERAGE ANNUAL POLLUTANT LOADS
BY SUBWATERSHED

LEAD

LOADS in lbs/year

- < 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- > = 100

N

Scale 1:160000

KILOMETERS 0 1 2 3 4

MILES 0 .5 1 2

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 20

AVERAGE ANNUAL POLLUTANT LOADS
BY SUBWATERSHED

ZINC

LOADS in lbs/year

- < 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 500
- >= 500

N

Scale 1:160000

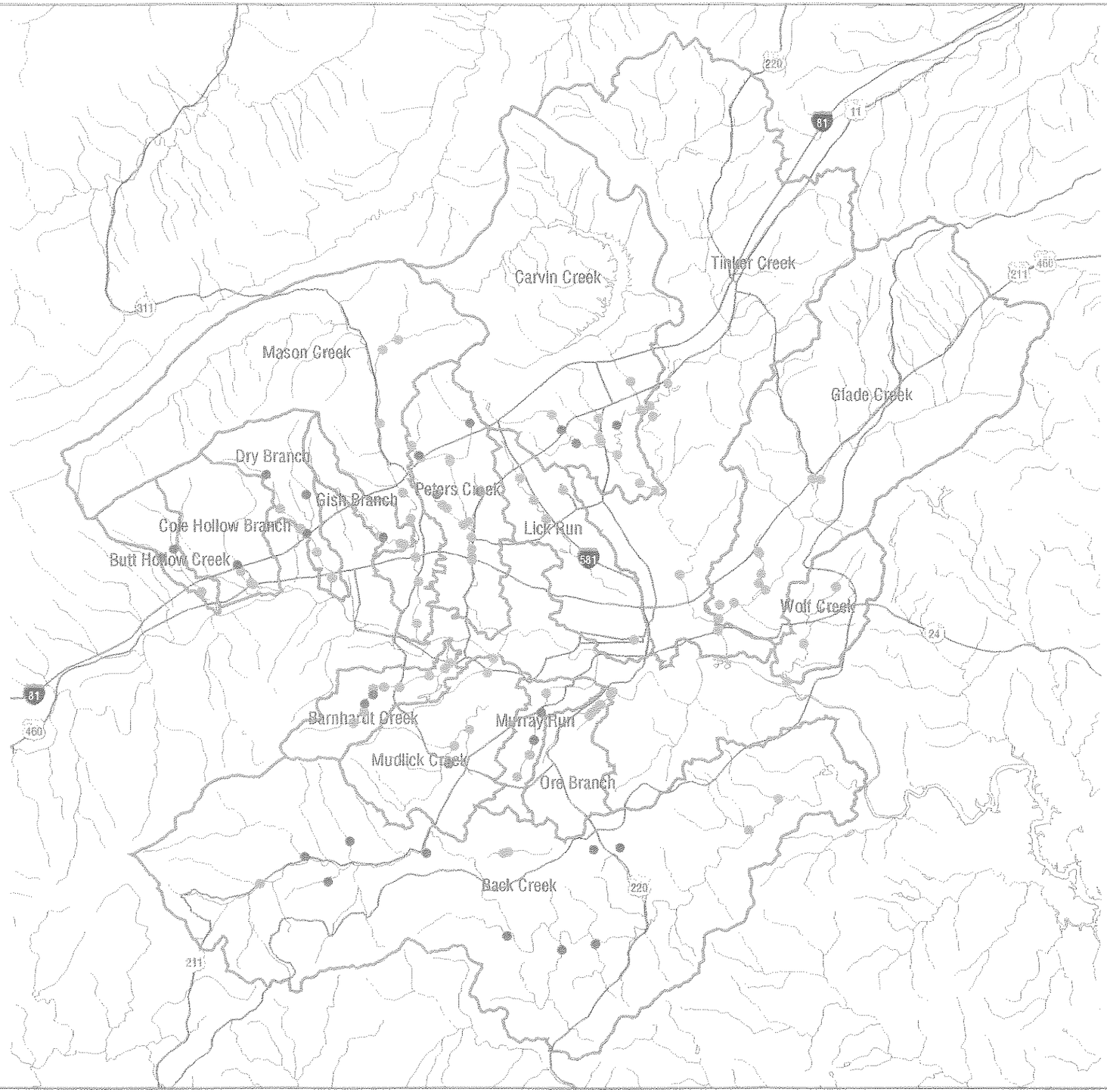
KILOMETERS 0 1 2 3 4
MILES 0 .5 1 2

CH2MHILL

ROANOKE VALLEY REGIONAL
STORMWATER MANAGEMENT PLAN

FIGURE 21

WATERSHEDS AND LOCATIONS
OF STORMWATER MANAGEMENT PROJECTS



- Regional Stormwater Management Ponds
- Other Stormwater Management Projects

N

Scale 1:160000

KILOMETERS 0 1 2 3 4
MILES 0 .5 1 2

CH2MHILL

Attachment 1

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors (by Watershed)

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Wtd. CN	Wtd. Rv	A (acres)	Runoff V (ac-ft/yr)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
					TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
Back Creek	68.7	0.13	37,588	14,600	18,221	161,521	2,532,375	925	1,545	0.5	4.3	67.4	0.025	0.041
Barnhardt Creek	74.3	0.2	2,659	1,601	1,169	10,686	251,473	89	209	0.4	4.0	94.6	0.033	0.079
Butt Hollow Creek	57.1	0.14	1,722	757	531	5,787	125,559	46	78	0.3	3.4	72.9	0.027	0.045
Carvin Creek	76.5	0.18	17,946	10,051	7,526	72,164	1,548,170	554	1,421	0.4	4.0	86.3	0.031	0.079
Cole Hollow Branch	68.9	0.2	3,757	2,278	1,942	17,548	365,310	138	427	0.5	4.7	97.2	0.037	0.114
Dry Branch	71.0	0.17	2,844	1,510	1,153	11,219	247,105	91	258	0.4	3.9	86.9	0.032	0.091
Gish Branch	75.7	0.3	1,285	1,170	1,008	8,174	173,482	74	418	0.8	6.4	135.0	0.058	0.325
Glade Creek	74.8	0.17	21,113	10,952	22,220	157,681	1,892,241	739	2,262	1.1	7.5	89.6	0.035	0.107
Lick Run	83.0	0.39	4,961	5,915	6,872	45,412	995,330	394	1,736	1.4	9.2	200.6	0.079	0.350
Mason Creek	74.1	0.15	17,662	8,271	6,560	65,693	1,404,834	496	1,173	0.4	3.7	79.5	0.028	0.066
Mudlick Creek	81.2	0.34	6,121	6,400	5,987	45,250	954,864	355	1,167	1.0	7.4	156.0	0.058	0.191
Murray Run	86.1	0.4	1,832	2,262	1,726	13,256	340,934	128	491	0.9	7.2	186.1	0.070	0.268
Ore Branch	79.0	0.39	2,603	3,129	2,577	20,304	473,098	190	894	1.0	7.8	181.7	0.073	0.344
Peters Creek	80.2	0.28	5,772	5,040	4,813	37,185	776,816	285	889	0.8	6.4	134.6	0.049	0.154
Tinker Creek	76.7	0.2	27,388	17,187	44,260	293,665	2,932,666	1,220	4,685	1.6	10.7	107.1	0.045	0.171
Wolf Creek	71.9	0.21	3,147	2,070	3,277	23,622	327,793	126	373	1.0	7.5	104.2	0.040	0.118
Totals	**N/A**	**N/A**	**158,399**	**93,194**	**129,843**	**989,167**	**15,342,051**	**5,850**	**18,026**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

WDCR1062/023.DOC

Attachment 2

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors (Ranked by Pollutant Loading Factor)

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Total Phosphorus (Ranked by Pollutant Loading Factor)
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Total Phosphorus Average Annual Pollutant Loading Factors (lb/ac-yr)	Total Phosphorus Average Annual Pollutant Loads (lb/yr)
Butt Hollow Creek	0.31	531
Mason Creek	0.37	6,560
Dry Branch	0.41	1,153
Carvin Creek	0.42	7,526
Barnhardt Creek	0.44	1,169
Back Creek	0.48	18,221
Cole Hollow Branch	0.52	1,942
Gish Branch	0.78	1,008
Peters Creek	0.83	4,813
Murray Run	0.94	1,726
Mudlick Creek	0.98	5,987
Ore Branch	0.99	2,577
Wolf Creek	1.04	3,277
Glade Creek	1.05	22,220
Lick Run	1.39	6,872
Tinker Creek	1.62	44,260
Totals	**N/A**	**129,843**

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Total Nitrogen (Ranked by Pollutant Loading Factor)
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Total Nitrogen Average Annual Pollutant Loading Factors (lb/ac-yr)	Total Nitrogen Average Annual Pollutant Loads (lb/yr)
Butt Hollow Creek	3.4	5,787
Mason Creek	3.7	65,693
Dry Branch	3.9	11,219
Barnhardt Creek	4.0	10,686
Carvin Creek	4.0	72,164
Back Creek	4.3	161,521
Cole Hollow Branch	4.7	17,548
Gish Branch	6.4	8,174
Peters Creek	6.4	37,185
Murray Run	7.2	13,256
Mudlick Creek	7.4	45,250
Glade Creek	7.5	157,681
Wolf Creek	7.5	23,622
Ore Branch	7.8	20,304
Lick Run	9.2	45,412
Tinker Creek	10.7	293,665
Totals	**N/A**	**989,167**

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Total Suspended Solids (Ranked by Pollutant Loading Factor)
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Total Suspended Solids Average Annual Pollutant Loading Factors (lb/ac-yr)	Total Suspended Solids Average Annual Pollutant Loads (lb/yr)
Back Creek	67.4	2,532,375
Butt Hollow Creek	72.9	125,559
Mason Creek	79.5	1,404,834
Carvin Creek	86.3	1,548,170
Dry Branch	86.9	247,105
Glade Creek	89.6	1,892,241
Barnhardt Creek	94.6	251,473
Cole Hollow Branch	97.2	365,310
Wolf Creek	104.2	327,793
Tinker Creek	107.1	2,932,666
Peters Creek	134.6	776,816
Gish Branch	135.0	173,482
Mudlick Creek	156.0	954,864
Ore Branch	181.7	473,098
Murray Run	186.1	340,934
Lick Run	200.6	995,330
Totals	**N/A**	**15,342,051**

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Lead (Ranked by Pollutant Loading Factor)
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Lead Average Annual Pollutant Loading Factors (lb/ac-yr)	Lead Average Annual Pollutant Loads (lb/yr)
Back Creek	0.025	925
Butt Hollow Creek	0.027	46
Mason Creek	0.028	496
Carvin Creek	0.031	554
Dry Branch	0.032	91
Barnhardt Creek	0.033	89
Glade Creek	0.035	739
Cole Hollow Branch	0.037	138
Wolf Creek	0.040	126
Tinker Creek	0.045	1,220
Peters Creek	0.049	285
Gish Branch	0.058	74
Mudlick Creek	0.058	355
Murray Run	0.070	128
Ore Branch	0.073	190
Lick Run	0.079	394
Totals	**N/A**	**5,850**

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Zinc (Ranked by Pollutant Loading Factor)
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Zinc Average Annual Pollutant Loading Factors (lb/ac-yr)	Zinc Average Annual Pollutant Loads (lb/year)
Back Creek	0.041	1,545
Butt Hollow Creek	0.045	78
Mason Creek	0.066	1,173
Barnhardt Creek	0.079	209
Carvin Creek	0.079	1,421
Dry Branch	0.091	258
Glade Creek	0.107	2,262
Cole Hollow Branch	0.114	427
Wolf Creek	0.118	373
Peters Creek	0.154	889
Tinker Creek	0.171	4,685
Mudlick Creek	0.191	1,167
Murray Run	0.268	491
Gish Branch	0.325	418
Ore Branch	0.344	894
Lick Run	0.350	1,736
Totals	**N/A**	**18,026**

Attachment 3

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors (by Subwatershed)

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Water-shed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
BAC	BAC01	940.4	432.5	4557.0	56,868	20.9	30.2	0.46	4.8	60.5	0.022	0.032
BAC	BAC02	254.1	287.0	2102.6	15,730	6.6	16.5	1.13	8.3	61.9	0.026	0.065
BAC	BAC03	1011.1	189.3	3444.6	59,884	20.4	15.0	0.19	3.4	59.2	0.020	0.015
BAC	BAC04	418.5	110.2	1470.7	24,981	8.7	8.8	0.26	3.5	59.7	0.021	0.021
BAC	BAC05	37.3	9.2	100.7	2,228	0.8	1.2	0.25	2.7	59.7	0.021	0.032
BAC	BAC06	106.0	51.6	467.6	9,193	3.2	6.4	0.49	4.4	86.7	0.030	0.060
BAC	BAC07	256.8	103.0	1157.3	15,410	5.6	6.5	0.40	4.5	60.0	0.022	0.025
BAC	BAC08	394.8	227.6	1980.1	29,977	11.1	22.7	0.58	5.0	75.9	0.028	0.057
BAC	BAC09	131.1	44.4	483.0	9,233	3.3	4.6	0.34	3.7	70.4	0.025	0.035
BAC	BAC10	1161.3	312.4	4384.0	70,837	24.3	31.1	0.27	3.8	61.0	0.021	0.027
BAC	BAC11	46.1	14.9	133.1	3,295	1.1	2.0	0.32	2.9	71.5	0.025	0.044
BAC	BAC12	872.7	987.5	7331.2	53,510	22.8	57.6	1.13	8.4	61.3	0.026	0.066
BAC	BAC13	28.1	23.5	185.1	1,732	0.7	1.4	0.83	6.6	61.6	0.025	0.050
BAC	BAC14	932.0	796.5	6279.1	58,175	23.2	55.2	0.85	6.7	62.4	0.025	0.059
BAC	BAC15	13.0	41.3	252.8	921	0.5	2.1	3.17	19.4	70.8	0.038	0.164
BAC	BAC16	670.0	101.2	2157.3	40,071	13.4	8.0	0.15	3.2	59.8	0.020	0.012
BAC	BAC17	617.0	132.6	2178.5	37,457	12.6	8.5	0.21	3.5	60.7	0.020	0.014
BAC	BAC18	734.0	304.8	3367.3	43,887	16.0	18.2	0.42	4.6	59.8	0.022	0.025
BAC	BAC19	164.7	33.3	562.9	9,524	3.4	2.5	0.20	3.4	57.8	0.021	0.015
BAC	BAC20	475.7	426.6	3333.6	31,612	12.5	27.0	0.90	7.0	66.5	0.026	0.057
BAC	BAC21	150.5	31.2	501.8	9,204	3.1	3.2	0.21	3.3	61.2	0.021	0.021
BAC	BAC22	52.4	10.3	171.3	3,319	1.2	1.1	0.20	3.3	63.4	0.022	0.021
BAC	BAC23	626.7	573.1	4308.0	45,607	17.8	45.0	0.91	6.9	72.8	0.028	0.072
BAC	BAC24	113.9	34.3	457.2	7,709	2.5	4.0	0.30	4.0	67.7	0.022	0.035
BAC	BAC25	538.4	199.8	2277.1	33,542	11.9	16.1	0.37	4.2	62.3	0.022	0.030
BAC	BAC26	437.0	224.4	2009.4	36,926	13.0	25.3	0.51	4.6	84.5	0.030	0.058
BAC	BAC27	201.6	75.2	762.7	18,983	6.8	18.6	0.37	3.8	94.2	0.034	0.092
BAC	BAC28	360.8	304.4	2478.4	24,513	9.6	20.1	0.84	6.9	67.9	0.027	0.056
BAC	BAC29	203.9	27.7	633.5	12,012	4.1	2.0	0.14	3.1	58.9	0.020	0.010
BAC	BAC30	370.2	48.1	1138.9	20,862	7.4	3.7	0.13	3.1	56.3	0.020	0.010
BAC	BAC31	293.4	55.0	964.2	20,029	7.1	9.3	0.19	3.3	68.3	0.024	0.032
BAC	BAC32	744.5	119.2	2327.9	46,294	15.4	10.2	0.16	3.1	62.2	0.021	0.014
BAC	BAC33	670.6	112.1	2157.3	40,203	13.7	8.7	0.17	3.2	59.9	0.020	0.013

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Water-shed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
BAC	BAC34	666.3	178.0	2527.6	40,877	14.2	13.0	0.27	3.8	61.4	0.021	0.020
BAC	BAC35	577.1	504.1	4078.1	34,631	14.1	27.5	0.87	7.1	60.0	0.024	0.048
BAC	BAC36	1192.9	210.8	3932.2	72,611	24.4	16.0	0.18	3.3	60.9	0.020	0.013
BAC	BAC37	876.7	155.3	2918.2	58,648	19.6	15.3	0.18	3.3	66.9	0.022	0.017
BAC	BAC38	206.0	123.5	1140.9	12,866	4.7	8.2	0.60	5.5	62.5	0.023	0.040
BAC	BAC39	120.8	48.4	541.6	7,496	2.7	3.1	0.40	4.5	62.1	0.022	0.026
BAC	BAC40	117.0	115.5	907.1	7,409	2.9	6.5	0.99	7.8	63.3	0.025	0.056
BAC	BAC41	72.3	89.3	652.2	4,425	1.9	4.8	1.24	9.0	61.2	0.027	0.066
BAC	BAC42	140.6	54.8	628.8	8,364	3.0	3.2	0.39	4.5	59.5	0.022	0.023
BAC	BAC43	597.9	96.2	1924.0	35,166	12.3	8.7	0.16	3.2	58.8	0.021	0.015
BAC	BAC44	39.7	5.7	124.2	2,410	0.8	0.4	0.14	3.1	60.7	0.020	0.011
BAC	BAC45	915.4	191.1	3121.5	59,159	19.7	18.7	0.21	3.4	64.6	0.022	0.020
BAC	BAC46	196.5	83.8	908.2	12,185	4.3	5.1	0.43	4.6	62.0	0.022	0.026
BAC	BAC47	872.2	325.1	3789.9	58,418	20.3	22.7	0.37	4.3	67.0	0.023	0.026
BAC	BAC48	689.5	288.2	3154.5	43,511	15.5	18.2	0.42	4.6	63.1	0.022	0.026
BAC	BAC49	839.4	220.7	3126.9	49,786	17.6	17.7	0.26	3.7	59.3	0.021	0.021
BAC	BAC50	291.5	111.9	1294.4	17,455	6.3	6.6	0.38	4.4	59.9	0.021	0.023
BAC	BAC51	344.9	99.5	1337.5	20,478	7.5	7.0	0.29	3.9	59.4	0.022	0.020
BAC	BAC52	852.7	242.7	3281.8	54,423	18.9	22.4	0.28	3.8	63.8	0.022	0.026
BAC	BAC53	1126.5	1046.5	8243.6	72,574	28.7	59.0	0.93	7.3	64.4	0.025	0.052
BAC	BAC54	571.5	263.2	2582.3	42,643	15.4	23.6	0.46	4.5	74.6	0.027	0.041
BAC	BAC55	176.6	175.1	1325.5	11,780	4.7	10.5	0.99	7.5	66.7	0.027	0.059
BAC	BAC56	114.0	46.9	459.9	10,938	3.8	6.3	0.41	4.0	95.9	0.033	0.055
BAC	BAC57	96.4	121.1	845.1	8,009	3.2	8.2	1.26	8.8	83.1	0.033	0.085
BAC	BAC58	324.5	453.1	3096.2	23,194	9.8	28.6	1.40	9.5	71.5	0.030	0.088
BAC	BAC59	119.1	36.1	463.5	7,225	2.5	3.0	0.30	3.9	60.6	0.021	0.025
BAC	BAC60	96.4	13.1	284.2	5,746	2.0	2.6	0.14	2.9	59.6	0.021	0.027
BAC	BAC61	448.6	637.4	4345.6	32,691	13.8	40.4	1.42	9.7	72.9	0.031	0.090
BAC	BAC62	25.1	36.0	253.1	1,583	0.7	1.9	1.43	10.1	63.1	0.028	0.076
BAC	BAC63	188.6	90.2	909.5	11,803	4.2	5.5	0.48	4.8	62.6	0.022	0.029
BAC	BAC64	202.3	89.4	939.1	13,234	4.7	6.0	0.44	4.6	65.4	0.023	0.030
BAC	BAC65	683.8	766.3	5509.2	50,542	21.6	84.8	1.12	8.1	73.9	0.032	0.124
BAC	BAC66	331.7	54.2	1045.7	20,584	6.8	5.6	0.16	3.2	62.1	0.021	0.017

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
BAC	BAC67	31.5	6.9	90.7	1,991	0.7	0.8	0.22	2.9	63.3	0.021	0.025
BAC	BAC68	141.1	28.3	430.4	9,093	3.1	3.3	0.20	3.1	64.5	0.022	0.023
BAC	BAC69	158.4	112.6	944.7	9,921	3.7	6.8	0.71	6.0	62.6	0.024	0.043
BAC	BAC70	1155.5	822.8	6795.6	68,950	26.7	51.5	0.71	5.9	59.7	0.023	0.045
BAC	BAC71	532.4	84.7	1691.5	32,256	10.8	7.1	0.16	3.2	60.6	0.020	0.013
BAC	BCA01	857.9	594.2	4928.3	58,384	22.7	51.6	0.69	5.7	68.1	0.027	0.060
BAC	BCA02	396.1	98.7	1339.3	20,598	7.5	6.9	0.25	3.4	52.0	0.019	0.017
BAC	BCA03	517.7	132.8	1825.4	39,367	13.4	16.0	0.26	3.5	76.0	0.026	0.031
BAC	BCA04	49.9	47.2	376.7	5,071	1.9	3.8	0.95	7.6	101.7	0.038	0.075
BAC	BCA05	436.3	69.6	1313.3	26,100	9.0	8.3	0.16	3.0	59.8	0.021	0.019
BAC	BCB01	1530.8	1121.9	9047.6	214,992	79.0	237.2	0.73	5.9	140.4	0.052	0.155
BAC	LBC01	761.5	287.1	3182.6	61,839	22.8	50.3	0.38	4.2	81.2	0.030	0.066
BAC	LBC02	757.7	226.6	2959.0	44,214	15.8	17.3	0.30	3.9	58.4	0.021	0.023
BAC	LBC03	256.1	205.2	1708.6	15,106	6.1	11.3	0.80	6.7	59.0	0.024	0.044
BAC	LBC04	432.6	309.3	2678.4	25,554	10.2	17.3	0.71	6.2	59.1	0.023	0.040
BAC	LBC05	319.4	63.7	1013.5	20,825	7.4	8.9	0.20	3.2	65.2	0.023	0.028
BAC	MAR01	401.1	107.8	1539.5	23,730	8.4	7.8	0.27	3.8	59.2	0.021	0.019
BAC	MAR02	492.1	340.3	2924.4	30,835	12.1	22.9	0.69	5.9	62.7	0.025	0.046
BAC	MAR03	216.5	143.9	1205.6	16,958	6.2	12.1	0.66	5.6	78.3	0.029	0.056
BAR	BAR01	114.2	20.5	380.4	7,126	2.3	1.4	0.18	3.3	62.4	0.020	0.012
BAR	BAR02	316.9	42.9	983.7	18,589	6.3	3.2	0.14	3.1	58.7	0.020	0.010
BAR	BAR03	411.3	122.3	1591.6	24,594	8.9	8.8	0.30	3.9	59.8	0.022	0.021
BAR	BAR04	471.8	258.9	2382.6	40,147	13.9	23.6	0.55	5.1	85.1	0.029	0.050
BAR	BAR05	131.8	54.3	579.3	13,321	4.4	7.5	0.41	4.4	101.1	0.033	0.057
BAR	BAR06	34.4	11.0	108.6	3,131	1.1	3.9	0.32	3.2	91.0	0.033	0.114
BAR	BAR07	309.7	96.6	1013.7	27,811	10.5	45.2	0.31	3.3	89.8	0.034	0.146
BAR	BAR08	75.0	35.7	309.4	8,244	2.9	7.0	0.48	4.1	110.0	0.038	0.094
BAR	BAR09	112.2	49.7	560.2	11,791	4.1	11.4	0.44	5.0	105.1	0.036	0.102
BAR	BAR10	258.4	183.2	1385.2	38,733	14.2	50.5	0.71	5.4	149.9	0.055	0.195
BAR	BAR11	289.4	198.0	1617.9	37,876	12.9	26.1	0.68	5.6	130.9	0.045	0.090
BAR	BAR12	46.6	25.5	201.3	5,245	1.8	3.6	0.55	4.3	112.5	0.038	0.077
BAR	BAR13	87.4	70.6	613.8	14,865	5.5	17.0	0.81	7.0	170.1	0.062	0.194
BUT	BUT01	564.1	72.6	1728.4	31,487	11.3	5.9	0.13	3.1	55.8	0.020	0.010

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Water-shed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
BUT	BUT02	116.4	23.8	357.2	7,345	2.6	2.9	0.20	3.1	63.1	0.022	0.025
BUT	BUT03	345.8	43.7	1057.2	18,934	6.9	3.5	0.13	3.1	54.7	0.020	0.010
BUT	BUT04	228.8	29.5	680.1	12,996	4.7	4.5	0.13	3.0	56.8	0.020	0.020
BUT	BUT05	194.1	107.4	981.3	12,534	4.7	7.7	0.55	5.1	64.6	0.024	0.039
BUT	BUT06	13.9	15.0	126.0	3,193	1.1	2.1	1.08	9.1	230.0	0.079	0.151
BUT	BUT07	25.0	19.9	152.7	4,016	1.4	2.8	0.79	6.1	160.4	0.055	0.113
BUT	BUT08	192.7	151.9	1159.7	23,416	8.4	20.3	0.79	6.0	121.5	0.044	0.106
BUT	BUT09	30.7	48.5	363.4	7,822	3.4	20.4	1.58	11.9	255.1	0.111	0.664
BUT	BUT10	10.4	18.3	103.4	3,816	1.6	8.2	1.76	9.9	366.6	0.149	0.791
CAR	CAR01	11199.9	1568.7	33444.3	649,854	210.5	110.6	0.14	3.0	58.0	0.019	0.010
CAR	CAR02	613.6	237.1	2797.0	43,517	14.6	26.8	0.39	4.6	70.9	0.024	0.044
CAR	CAR03	794.2	1455.8	9850.4	97,814	42.1	195.8	1.83	12.4	123.2	0.053	0.247
CAR	CAR04	152.1	264.6	1818.3	25,388	10.3	45.2	1.74	12.0	167.0	0.068	0.297
CAR	CAR05	145.4	113.3	892.2	22,154	7.6	15.5	0.78	6.1	152.4	0.052	0.106
CAR	CAR06	181.0	333.9	2423.7	49,274	21.8	134.9	1.84	13.4	272.2	0.120	0.745
CAR	CAR07	243.3	185.1	1517.0	37,607	13.3	33.7	0.76	6.2	154.6	0.055	0.138
CAR	CAR08	542.2	604.7	4782.5	105,293	43.5	222.8	1.12	8.8	194.2	0.080	0.411
CAR	CAR09	261.5	246.4	1924.3	46,894	17.6	63.8	0.94	7.4	179.3	0.067	0.244
CAR	DBR01	433.1	415.0	3086.4	61,825	22.0	53.2	0.96	7.1	142.7	0.051	0.123
CAR	DBR02	148.1	202.3	1456.1	28,225	11.6	57.7	1.37	9.8	190.6	0.078	0.390
CAR	DBR03	226.6	174.4	1447.4	30,721	10.9	26.0	0.77	6.4	135.6	0.048	0.115
CAR	DBR04	247.7	316.9	2464.1	54,732	22.4	117.7	1.28	9.9	221.0	0.090	0.475
CAR	DBR05	46.4	55.8	433.1	9,532	3.8	18.7	1.20	9.3	205.5	0.082	0.404
CAR	WFC01	752.8	114.1	2400.3	49,454	15.1	7.5	0.15	3.2	65.7	0.020	0.010
CAR	WFC02	232.3	95.1	1092.0	23,673	8.0	15.3	0.41	4.7	101.9	0.034	0.066
CAR	WFC03	88.4	88.5	663.2	6,953	2.7	7.8	1.00	7.5	78.7	0.030	0.088
CAR	WFC04	170.3	150.5	1099.9	21,803	8.2	27.7	0.88	6.5	128.0	0.048	0.163
CAR	WFC05	376.5	163.1	1650.8	34,202	11.8	23.2	0.43	4.4	90.8	0.031	0.062
CAR	WFC06	163.2	95.3	863.9	19,122	6.4	12.8	0.58	5.3	117.2	0.039	0.079
CAR	WFC07	34.9	28.0	234.0	5,728	2.0	4.9	0.80	6.7	164.2	0.057	0.142
CAR	WFC08	213.3	80.5	919.0	19,875	6.8	16.4	0.38	4.3	93.2	0.032	0.077
CAR	WFC09	151.5	125.3	1074.3	24,698	10.2	52.0	0.83	7.1	163.1	0.067	0.343
CAR	WFC10	48.4	60.6	467.7	10,651	4.3	21.7	1.25	9.7	220.0	0.090	0.448

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
CAR	WFC11	52.5	22.5	231.3	5,693	2.1	6.4	0.43	4.4	108.5	0.040	0.122
CAR	WFC12	351.5	247.3	2194.6	49,463	19.4	81.8	0.70	6.2	140.7	0.055	0.233
CAR	WFC13	75.0	80.6	657.2	14,024	5.3	21.5	1.08	8.8	187.0	0.071	0.286
COL	COL01	469.1	62.0	1439.6	26,954	9.4	5.6	0.13	3.1	57.5	0.020	0.012
COL	COL02	33.7	12.5	145.0	2,064	0.7	0.8	0.37	4.3	61.2	0.022	0.024
COL	COL03	294.6	62.3	1021.4	16,936	6.1	5.4	0.21	3.5	57.5	0.021	0.018
COL	COL04	233.5	94.9	1006.1	16,493	5.6	7.4	0.41	4.3	70.6	0.024	0.032
COL	COL05	72.2	16.5	237.2	5,079	1.7	1.8	0.23	3.3	70.3	0.023	0.025
COL	COL06	386.3	72.1	1262.6	24,013	8.1	7.6	0.19	3.3	62.2	0.021	0.020
COL	COL07	241.8	77.0	969.3	15,408	5.2	5.7	0.32	4.0	63.7	0.022	0.023
COL	COL08	177.8	45.8	650.0	11,809	3.9	3.4	0.26	3.7	66.4	0.022	0.019
COL	COL09	26.0	6.9	86.3	1,950	0.6	0.8	0.26	3.3	75.0	0.024	0.031
COL	COL10	160.6	152.3	1135.8	13,555	5.1	11.4	0.95	7.1	84.4	0.032	0.071
COL	COL11	155.0	63.8	700.0	12,427	4.2	6.0	0.41	4.5	80.2	0.027	0.039
COL	COL12	33.2	37.5	288.2	7,576	2.6	5.4	1.13	8.7	228.2	0.078	0.162
COL	COL13	77.0	87.7	659.9	15,761	6.1	26.5	1.14	8.6	204.6	0.080	0.344
COL	COL14	40.5	52.4	396.1	8,987	3.7	19.4	1.29	9.8	222.1	0.092	0.479
COL	COL15	36.7	69.5	524.9	11,104	5.0	32.2	1.89	14.3	302.5	0.136	0.877
COL	COL16	218.7	153.6	1370.7	30,762	11.9	46.5	0.70	6.3	140.7	0.055	0.213
COL	COL17	119.9	174.7	1324.9	29,015	12.7	77.1	1.46	11.1	242.1	0.106	0.643
COL	PBB01	409.6	54.1	1264.5	23,450	8.2	4.1	0.13	3.1	57.2	0.020	0.010
COL	PBB02	148.4	29.7	485.0	9,726	3.3	3.7	0.20	3.3	65.6	0.022	0.025
COL	PBB03	149.2	226.0	1532.5	15,676	6.2	16.5	1.51	10.3	105.1	0.041	0.111
COL	PBB04	17.9	21.7	161.5	3,782	1.3	2.8	1.21	9.0	210.8	0.073	0.155
COL	PBB05	255.8	368.8	2760.1	62,785	26.0	137.3	1.44	10.8	245.5	0.102	0.537
DRY	DRY01	933.2	128.0	2905.4	55,486	18.7	9.3	0.14	3.1	59.5	0.020	0.010
DRY	DRY02	185.1	48.7	669.8	12,406	4.2	4.7	0.26	3.6	67.0	0.023	0.026
DRY	DRY03	198.3	91.0	900.8	14,349	4.9	7.1	0.46	4.5	72.4	0.025	0.036
DRY	DRY04	30.4	58.7	383.0	2,727	1.1	3.6	1.93	12.6	89.7	0.038	0.117
DRY	DRY05	506.5	71.4	1582.0	30,993	10.2	5.6	0.14	3.1	61.2	0.020	0.011
DRY	DRY06	297.4	76.4	982.1	19,619	7.4	19.8	0.26	3.3	66.0	0.025	0.067
DRY	DRY07	157.6	31.0	470.1	11,051	3.8	8.1	0.20	3.0	70.1	0.024	0.051
DRY	DRY08	41.9	20.0	201.7	4,524	1.6	3.0	0.48	4.8	107.9	0.038	0.073

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
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Watershed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
DRY	DRY09	87.8	146.0	968.8	11,830	4.5	12.0	1.66	11.0	134.8	0.051	0.137
DRY	DRY10	223.5	170.3	1341.5	33,815	12.7	48.0	0.76	6.0	151.3	0.057	0.215
DRY	DRY11	55.1	88.5	658.0	14,813	6.3	35.0	1.61	11.9	268.6	0.114	0.635
DRY	DRY12	60.5	100.8	746.6	16,423	7.2	43.7	1.66	12.3	271.3	0.119	0.722
DRY	DRY13	66.3	122.2	910.3	19,069	8.7	57.7	1.84	13.7	287.5	0.131	0.870
GIS	GIS01	266.7	37.0	826.8	15,980	5.4	3.2	0.14	3.1	59.9	0.020	0.012
GIS	GIS02	181.8	33.4	599.2	12,075	4.1	3.9	0.18	3.3	66.4	0.023	0.021
GIS	GIS03	71.2	16.9	247.7	5,115	1.9	2.4	0.24	3.5	71.8	0.026	0.033
GIS	GIS04	12.6	4.8	53.9	1,230	0.4	0.6	0.38	4.3	97.8	0.033	0.049
GIS	GIS05	53.7	10.8	186.8	3,853	1.3	1.0	0.20	3.5	71.7	0.024	0.019
GIS	GIS06	12.9	9.4	89.8	2,176	0.7	1.3	0.73	6.9	168.1	0.057	0.097
GIS	GIS07	33.3	17.0	181.0	4,243	1.4	2.2	0.51	5.4	127.3	0.043	0.065
GIS	GIS08	89.8	42.9	410.7	9,998	3.4	5.7	0.48	4.6	111.3	0.037	0.063
GIS	GIS09	46.7	13.2	179.7	3,958	1.3	1.5	0.28	3.9	84.8	0.028	0.032
GIS	GIS10	113.2	107.9	920.5	19,415	8.2	46.7	0.95	8.1	171.6	0.073	0.412
GIS	GIS11	87.2	88.8	728.0	15,736	7.1	46.2	1.02	8.3	180.5	0.081	0.530
GIS	GIS12	158.2	264.2	1931.9	33,329	15.4	102.7	1.67	12.2	210.6	0.097	0.649
GIS	GIS13	78.7	187.4	1378.1	28,133	13.4	97.4	2.38	17.5	357.4	0.170	1.237
GIS	GIS14	75.7	194.5	1417.6	28,915	13.8	101.3	2.57	18.7	381.7	0.182	1.338
GIS	GIS15	2.7	6.9	50.6	1,033	0.5	3.6	2.55	18.6	379.6	0.181	1.330
GIS	COK01	602.3	483.5	3982.4	39,771	15.2	28.6	0.80	6.6	66.0	0.025	0.047
GIS	COK02	1306.1	1517.3	10942.3	112,659	45.0	140.3	1.16	8.4	86.3	0.034	0.107
GIS	COK03	364.3	252.3	2066.2	46,133	16.8	54.0	0.69	5.7	126.7	0.046	0.148
GLA	GLA01	813.1	1407.8	8656.5	155,997	60.3	235.6	1.73	10.6	191.9	0.074	0.290
GLA	GLB01	695.7	264.2	2829.8	55,121	19.0	38.7	0.38	4.1	79.2	0.027	0.056
GLA	GLB02	340.6	400.2	2864.2	34,165	12.6	30.7	1.18	8.4	100.3	0.037	0.090
GLA	GLD01	333.2	94.7	1205.3	26,225	9.0	11.4	0.28	3.6	78.7	0.027	0.034
GLA	GLD02	1667.7	1174.2	10248.7	108,808	39.2	65.0	0.70	6.1	65.2	0.024	0.039
GLA	GLD03	592.1	344.4	3258.4	37,593	13.4	19.1	0.58	5.5	63.5	0.023	0.032
GLA	GLD04	96.7	113.5	839.9	6,534	2.5	6.0	1.17	8.7	67.6	0.026	0.062
GLA	GLD05	30.5	106.7	646.4	2,262	1.2	5.5	3.50	21.2	74.2	0.040	0.180
GLA	GLD06	485.8	68.6	1522.7	29,740	9.7	4.9	0.14	3.1	61.2	0.020	0.010
GLA	GLD07	635.9	146.0	2147.7	44,942	15.4	16.3	0.23	3.4	70.7	0.024	0.026

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Water-shed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
GLA	GLD08	479.8	99.1	1587.8	32,271	11.2	10.6	0.21	3.3	67.3	0.023	0.022
GLA	GLD09	1333.7	916.8	7906.7	98,859	36.4	64.0	0.69	5.9	74.1	0.027	0.048
GLA	GLD10	328.9	632.0	4141.4	27,291	11.7	36.7	1.92	12.6	83.0	0.035	0.112
GLA	GLD11	299.7	341.7	2549.5	20,125	7.8	18.1	1.14	8.5	67.2	0.026	0.060
GLA	GLD12	468.3	930.4	6054.4	35,899	15.9	52.4	1.99	12.9	76.7	0.034	0.112
GLA	GLD13	1062.4	1299.7	9397.4	81,883	32.6	94.5	1.22	8.8	77.1	0.031	0.089
GLA	GLD14	545.2	1010.1	6730.1	37,175	16.5	52.8	1.85	12.3	68.2	0.030	0.097
GLA	GLD15	378.7	740.6	4875.5	26,329	11.7	38.8	1.96	12.9	69.5	0.031	0.103
GLA	GLD16	176.1	29.8	578.6	10,535	3.6	2.0	0.17	3.3	59.8	0.020	0.012
GLA	GLD17	406.9	89.6	1448.3	24,312	8.3	5.8	0.22	3.6	59.7	0.020	0.014
GLA	GLD18	79.1	210.6	1320.1	5,488	2.8	10.9	2.66	16.7	69.3	0.035	0.138
GLA	GLD19	385.1	132.1	1625.6	23,056	8.2	7.9	0.34	4.2	59.9	0.021	0.020
GLA	GLD20	26.4	76.1	472.1	1,769	1.0	3.9	2.88	17.9	67.0	0.036	0.149
GLA	GLD21	503.0	71.2	1574.5	30,216	10.1	5.3	0.14	3.1	60.1	0.020	0.010
GLA	GLD22	272.5	181.2	1504.4	20,963	7.6	14.8	0.67	5.5	76.9	0.028	0.054
GLA	GLD23	259.1	184.0	1528.3	25,551	8.8	20.1	0.71	5.9	98.6	0.034	0.078
GLA	GLD24	385.8	514.9	3400.5	35,113	13.9	41.4	1.33	8.8	91.0	0.036	0.107
GLA	GLD25	500.4	782.2	5429.0	45,018	19.2	68.8	1.56	10.8	90.0	0.038	0.137
GLA	GLD26	72.6	127.1	855.5	6,467	2.7	8.4	1.75	11.8	89.1	0.037	0.115
GLA	GLD27	25.5	31.1	233.2	2,470	0.9	2.1	1.22	9.1	96.9	0.037	0.083
GLA	GLD28	158.0	374.2	2362.9	10,861	5.3	21.3	2.37	15.0	68.7	0.034	0.135
GLA	GLD29	8.1	17.1	112.2	1,079	0.4	1.2	2.12	13.9	134.0	0.053	0.151
GLA	GLD30	137.2	365.4	2292.4	10,232	4.9	19.0	2.66	16.7	74.6	0.035	0.138
GLA	GLD31	8.0	13.1	89.7	1,378	0.5	1.2	1.65	11.3	173.2	0.063	0.154
GLA	GLD32	851.0	1049.8	7446.2	62,133	25.1	68.3	1.23	8.7	73.0	0.029	0.080
GLA	GLD33	265.5	697.9	4445.9	29,108	13.6	66.6	2.63	16.7	109.6	0.051	0.251
GLA	GLD34	308.6	655.3	4245.8	22,011	9.9	34.5	2.12	13.8	71.3	0.032	0.112
GLA	GLD35	33.3	64.3	414.3	3,837	1.5	4.6	1.93	12.4	115.3	0.046	0.137
GLA	GLD36	33.6	71.9	452.8	3,438	1.4	4.7	2.14	13.5	102.4	0.043	0.139
GLA	GLD37	429.0	766.9	5144.3	28,477	12.8	40.1	1.79	12.0	66.4	0.030	0.094
GLA	GLD38	149.4	304.6	1973.0	11,756	5.2	17.2	2.04	13.2	78.7	0.035	0.115
GLA	GLD39	238.5	234.6	1828.5	14,627	6.0	12.6	0.98	7.7	61.3	0.025	0.053
GLA	GLD40	27.1	32.0	236.4	1,716	0.7	1.7	1.18	8.7	63.3	0.026	0.063

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Watershed Name	Subwatershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
GLA	GLD41	163.8	440.2	2745.9	13,662	6.4	25.4	2.69	16.8	83.4	0.039	0.155
GLA	GLD42	141.5	209.3	1461.9	9,665	4.0	11.0	1.48	10.3	68.3	0.028	0.078
GLA	GLD43	374.6	259.4	2124.4	28,905	10.9	32.6	0.69	5.7	77.2	0.029	0.087
GLA	GLD44	341.0	109.8	1204.5	23,899	9.1	29.2	0.32	3.5	70.1	0.027	0.086
GLA	GLD45	264.9	155.9	1303.3	32,175	12.6	55.2	0.59	4.9	121.5	0.048	0.208
GLA	GLD46	397.0	533.6	4023.6	90,150	37.6	202.6	1.34	10.1	227.1	0.095	0.510
GLA	GLD47	666.9	782.9	5183.4	154,048	59.1	252.4	1.17	7.8	231.0	0.089	0.379
GLA	GLD48	162.5	308.2	2287.2	48,343	21.9	145.5	1.90	14.1	297.5	0.135	0.895
LIC	LIC01	220.6	325.5	2289.1	35,833	14.7	69.7	1.48	10.4	162.5	0.067	0.316
LIC	LIC02	443.2	370.0	2699.2	72,590	29.2	143.2	0.83	6.1	163.8	0.066	0.323
LIC	LIC03	372.5	682.1	4468.6	47,884	21.3	108.4	1.83	12.0	128.6	0.057	0.291
LIC	LIC04	518.8	1240.2	8281.4	107,695	44.7	194.8	2.39	16.0	207.6	0.086	0.376
LIC	LIC05	168.0	88.5	688.2	17,035	6.4	24.8	0.53	4.1	101.4	0.038	0.148
LIC	LIC06	595.8	1117.2	7828.3	127,040	53.9	279.2	1.88	13.1	213.2	0.090	0.469
LIC	LIC07	562.5	784.8	5318.3	87,145	32.8	100.7	1.40	9.5	154.9	0.058	0.179
LIC	LIC08	90.5	79.8	613.9	16,147	5.5	11.4	0.88	6.8	178.5	0.061	0.126
LIC	LIC09	106.5	78.0	627.3	16,816	5.8	13.8	0.73	5.9	157.9	0.055	0.130
LIC	LIC10	177.7	145.7	1178.5	32,481	11.4	30.8	0.82	6.6	182.7	0.064	0.173
LIC	LIC11	137.2	163.5	1014.7	35,982	13.8	60.9	1.19	7.4	262.2	0.101	0.444
LIC	LIC12	63.5	96.3	466.1	22,525	8.8	43.4	1.52	7.3	354.7	0.139	0.684
LIC	TRT01	697.8	412.3	3216.3	99,548	36.6	130.8	0.59	4.6	142.7	0.052	0.188
LIC	TRT02	67.7	110.9	526.3	25,285	9.9	47.6	1.64	7.8	373.3	0.146	0.703
LIC	TRT03	43.2	66.9	320.2	15,620	6.1	30.3	1.55	7.4	361.5	0.142	0.700
LIC	TRT04	689.0	1099.9	5950.0	233,718	92.0	444.0	1.60	8.6	339.2	0.133	0.644
LIC	TRT5	6.5	10.2	77.9	1,987	0.7	2.0	1.57	11.9	304.8	0.109	0.314
MAS	JUM01	495.0	75.7	1553.2	31,302	10.0	5.7	0.15	3.1	63.2	0.020	0.011
MAS	JUM02	427.8	76.6	1401.5	27,095	8.7	6.8	0.18	3.3	63.3	0.020	0.016
MAS	JUM03	250.4	45.6	858.7	16,386	5.0	3.7	0.18	3.4	65.4	0.020	0.015
MAS	JUM04	39.3	6.9	123.3	2,552	0.8	0.6	0.18	3.1	64.9	0.021	0.016
MAS	JUM05	135.3	20.5	431.4	8,897	2.7	1.4	0.15	3.2	65.8	0.020	0.010
MAS	JUM06	119.8	21.1	402.5	7,838	2.4	1.7	0.18	3.4	65.4	0.020	0.014
MAS	JUM07	561.1	104.9	1810.9	34,172	11.5	10.4	0.19	3.2	60.9	0.021	0.019
MAS	JUM08	534.0	101.8	1803.0	34,536	10.8	9.1	0.19	3.4	64.7	0.020	0.017

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Watershed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
MAS	MAS01	1807.4	254.9	5663.3	110,463	36.1	18.1	0.14	3.1	61.1	0.020	0.010
MAS	MAS02	1311.4	300.1	4714.0	83,054	26.9	20.0	0.23	3.6	63.3	0.021	0.015
MAS	MAS03	531.2	120.8	1910.3	34,566	10.9	7.4	0.23	3.6	65.1	0.020	0.014
MAS	MAS04	198.9	29.6	631.3	12,829	4.0	2.0	0.15	3.2	64.5	0.020	0.010
MAS	MAS05	195.8	102.8	1017.9	12,750	4.4	5.7	0.53	5.2	65.1	0.022	0.029
MAS	MAS06	69.1	10.5	220.2	4,530	1.4	0.7	0.15	3.2	65.5	0.020	0.010
MAS	MAS07	75.6	30.2	341.8	4,810	1.6	1.7	0.40	4.5	63.6	0.022	0.023
MAS	MAS08	345.1	51.5	1095.8	22,301	6.9	3.5	0.15	3.2	64.6	0.020	0.010
MAS	MAS09	275.8	60.1	963.4	18,081	5.9	4.4	0.22	3.5	65.6	0.021	0.016
MAS	MAS10	182.2	49.6	690.0	12,711	4.0	3.5	0.27	3.8	69.8	0.022	0.019
MAS	MAS11	326.0	232.1	2018.1	20,855	7.8	13.0	0.71	6.2	64.0	0.024	0.040
MAS	MAS12	360.5	56.2	1155.5	23,389	7.3	3.9	0.16	3.2	64.9	0.020	0.011
MAS	MAS13	608.8	383.7	3498.9	39,238	14.4	24.0	0.63	5.7	64.5	0.024	0.039
MAS	MAS14	750.5	133.7	2449.0	50,613	15.9	11.2	0.18	3.3	67.4	0.021	0.015
MAS	MAS15	186.4	95.1	927.1	12,891	4.5	6.5	0.51	5.0	69.2	0.024	0.035
MAS	MAS16	170.5	41.9	576.2	12,428	4.1	4.5	0.25	3.4	72.9	0.024	0.027
MAS	MAS17	44.4	110.0	693.0	3,272	1.6	5.9	2.48	15.6	73.7	0.035	0.132
MAS	MAS18	176.9	223.6	1575.5	13,340	5.2	13.4	1.26	8.9	75.4	0.029	0.076
MAS	MAS19	22.6	50.4	320.9	1,469	0.7	2.7	2.22	14.2	64.9	0.032	0.118
MAS	MAS20	306.2	118.3	1363.7	18,967	6.6	6.9	0.39	4.5	61.9	0.021	0.022
MAS	MAS21	212.1	101.4	1014.1	13,700	4.7	6.2	0.48	4.8	64.6	0.022	0.029
MAS	MAS22	88.3	157.2	1035.3	6,046	2.7	8.6	1.78	11.7	68.5	0.030	0.097
MAS	MAS23	461.7	58.0	1409.8	25,150	9.2	4.6	0.13	3.1	54.5	0.020	0.010
MAS	MAS24	174.7	35.3	584.3	10,563	3.6	3.7	0.20	3.3	60.4	0.021	0.021
MAS	MAS25	524.0	129.8	1941.9	33,651	10.8	7.9	0.25	3.7	64.2	0.021	0.015
MAS	MAS26	140.0	86.6	771.2	8,623	3.2	5.3	0.62	5.5	61.6	0.023	0.038
MAS	MAS27	320.0	216.5	1888.8	23,799	8.9	24.8	0.68	5.9	74.4	0.028	0.077
MAS	MAS28	513.0	88.9	1649.6	34,347	10.8	7.3	0.17	3.2	67.0	0.021	0.014
MAS	MAS29	201.7	60.0	683.3	15,725	5.3	7.4	0.30	3.4	78.0	0.026	0.037
MAS	MAS30	173.8	61.8	722.2	11,973	3.9	4.2	0.36	4.2	68.9	0.022	0.024
MAS	MAS31	264.3	68.7	994.1	17,305	5.5	4.2	0.26	3.8	65.5	0.021	0.016
MAS	MAS32	159.1	25.0	500.1	10,344	3.2	1.8	0.16	3.1	65.0	0.020	0.012
MAS	MAS33	461.9	71.6	1462.4	30,225	9.3	5.0	0.16	3.2	65.4	0.020	0.011

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Watershed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
MAS	MAS34	157.0	25.9	487.2	10,181	3.2	2.1	0.16	3.1	64.8	0.020	0.013
MAS	MAS35	696.8	102.5	2198.5	44,422	14.0	7.9	0.15	3.2	63.8	0.020	0.011
MAS	MAS36	303.5	139.5	1338.6	33,054	11.8	36.5	0.46	4.4	108.9	0.039	0.120
MAS	MAS37	190.1	35.3	617.6	12,823	4.2	3.6	0.19	3.2	67.5	0.022	0.019
MAS	MAS38	218.7	240.1	1741.3	40,168	15.5	63.4	1.10	8.0	183.7	0.071	0.290
MAS	MAS39	85.3	115.5	872.3	12,235	5.3	28.4	1.35	10.2	143.4	0.062	0.333
MAS	MAS40	168.9	200.4	1631.2	32,945	14.3	85.6	1.19	9.7	195.1	0.085	0.507
MAS	MAS41	312.0	290.8	2305.9	54,613	21.8	103.6	0.93	7.4	175.1	0.070	0.332
MAS	MAS42	107.6	187.4	1383.4	30,172	13.2	81.4	1.74	12.9	280.5	0.123	0.756
MAS	MAS43	400.2	459.0	3607.8	82,066	34.7	194.9	1.15	9.0	205.0	0.087	0.487
MAS	MAS44	72.9	39.7	384.7	9,519	3.2	7.0	0.55	5.3	130.6	0.044	0.096
MAS	MAS45	209.7	193.4	1513.9	36,781	15.9	95.7	0.92	7.2	175.4	0.076	0.456
MAS	MAS46	325.6	382.3	2944.9	67,227	27.3	136.7	1.17	9.0	206.5	0.084	0.420
MAS	MAS47	210.8	79.3	685.3	21,843	8.4	37.4	0.38	3.3	103.6	0.040	0.178
MUD	MCT01	934.1	893.2	6979.7	164,347	62.3	241.9	0.96	7.5	175.9	0.067	0.259
MUD	MDC01	521.6	753.3	5426.6	101,181	39.7	167.6	1.44	10.4	194.0	0.076	0.321
MUD	MUD01	1039.8	846.6	6742.8	74,095	28.1	64.2	0.81	6.5	71.3	0.027	0.062
MUD	MUD02	69.1	30.9	305.4	6,256	2.2	4.0	0.45	4.4	90.5	0.031	0.058
MUD	MUD03	109.0	154.2	1048.5	12,553	4.6	11.9	1.41	9.6	115.2	0.042	0.109
MUD	MUD04	320.5	254.5	2022.7	36,586	13.0	26.0	0.79	6.3	114.1	0.041	0.081
MUD	MUD05	28.9	15.7	143.4	3,613	1.2	2.3	0.54	5.0	124.8	0.042	0.081
MUD	MUD06	165.5	153.7	1199.0	31,174	10.9	27.3	0.93	7.2	188.4	0.066	0.165
MUD	MUD07	63.4	65.5	521.8	12,197	4.7	20.2	1.03	8.2	192.5	0.075	0.319
MUD	MUD08	219.7	211.1	1634.4	41,698	14.9	43.2	0.96	7.4	189.8	0.068	0.196
MUD	MUD09	507.4	632.4	4787.4	115,472	44.4	183.1	1.25	9.4	227.6	0.088	0.361
MUD	MUD10	562.2	601.3	4503.7	103,435	37.9	122.3	1.07	8.0	184.0	0.067	0.218
MUD	MUD11	34.6	30.7	236.3	6,214	2.1	4.4	0.89	6.8	179.8	0.062	0.126
MUD	MUD12	238.5	181.9	1478.8	38,245	13.0	25.7	0.76	6.2	160.4	0.054	0.108
MUD	MUD13	545.3	537.9	4070.3	96,340	34.4	96.1	0.99	7.5	176.7	0.063	0.176
MUD	MUD14	119.1	227.5	1594.2	26,146	11.2	61.1	1.91	13.4	219.4	0.094	0.513
MUD	WMC01	642.2	397.2	3468.3	85,311	29.9	65.9	0.62	5.4	132.8	0.047	0.103
MUR	MUR01	323.1	384.7	2782.8	75,141	29.2	128.8	1.19	8.6	232.6	0.090	0.399
MUR	MUR02	592.0	544.3	4311.7	108,075	40.0	141.6	0.92	7.3	182.6	0.068	0.239

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			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
MUR	MUR03	294.2	197.7	1624.2	42,830	15.8	56.2	0.67	5.5	145.6	0.054	0.191
MUR	MUR04	39.8	30.8	243.6	6,470	2.2	5.0	0.77	6.1	162.7	0.056	0.125
MUR	MUR05	236.8	217.5	1734.7	42,158	15.8	58.1	0.92	7.3	178.0	0.067	0.245
MUR	MUR06	346.4	351.4	2747.7	66,261	25.3	101.4	1.01	7.9	191.3	0.073	0.293
ORE	ORE01	311.9	263.5	353.9	8,024	3.4	18.2	0.84	1.1	25.7	0.011	0.058
ORE	ORE02	72.8	155.7	121.0	2,971	1.1	4.4	2.14	1.7	40.8	0.015	0.060
ORE	ORE03	778.5	926.0	539.3	12,027	5.0	26.9	1.19	0.7	15.4	0.006	0.035
ORE	ORE04	172.7	338.4	197.8	4,531	1.9	9.7	1.96	1.1	26.2	0.011	0.056
ORT	ORT01	258.8	120.1	171.4	4,221	1.6	5.6	0.46	0.7	16.3	0.006	0.022
ORT	ORT02	239.9	126.2	244.1	6,545	2.5	9.4	0.53	1.0	27.3	0.010	0.039
ORT	ORT03	605.2	381.7	475.6	10,881	4.4	20.6	0.63	0.8	18.0	0.007	0.034
ORT	ORT04	163.3	265.4	223.2	5,000	2.1	11.0	1.63	1.4	30.6	0.013	0.067
PTR	PTA01	424.7	66.9	1373.2	28,005	8.5	4.6	0.16	3.2	65.9	0.020	0.011
PTR	PTA02	214.4	290.7	2118.8	25,326	10.3	40.9	1.36	9.9	118.2	0.048	0.191
PTR	PTB01	754.4	113.7	2392.1	49,394	15.2	8.8	0.15	3.2	65.5	0.020	0.012
PTR	PTB02	179.6	179.7	1415.7	18,721	6.9	14.8	1.00	7.9	104.2	0.038	0.082
PTR	PTB03	176.5	283.1	1906.3	16,148	6.5	18.6	1.60	10.8	91.5	0.037	0.105
PTR	PTB04	197.7	180.7	1435.3	21,119	7.6	15.2	0.91	7.3	106.8	0.038	0.077
PTR	PTC01	432.2	579.0	3993.3	55,113	20.6	57.4	1.34	9.2	127.5	0.048	0.133
PTR	PTC02	90.4	61.2	492.2	13,066	4.5	10.4	0.68	5.4	144.5	0.050	0.115
PTR	PTC03	50.6	35.8	291.5	7,474	2.6	5.0	0.71	5.8	147.7	0.051	0.099
PTR	PTR01	150.4	106.2	877.1	22,756	7.8	16.2	0.71	5.8	151.3	0.052	0.108
PTR	PTR02	99.8	27.7	322.7	7,620	2.6	4.9	0.28	3.2	76.4	0.026	0.049
PTR	PTR03	166.8	157.8	1175.0	21,959	8.1	24.8	0.95	7.0	131.7	0.049	0.149
PTR	PTR04	98.1	81.0	619.9	15,769	5.6	15.8	0.83	6.3	160.8	0.057	0.161
PTR	PTR05	3.7	3.0	23.2	609	0.2	0.4	0.81	6.2	164.0	0.056	0.115
PTR	PTR06	376.7	432.1	3079.5	55,253	20.1	51.7	1.15	8.2	146.7	0.053	0.137
PTR	PTR07	136.7	161.0	1250.8	25,811	11.2	65.4	1.18	9.1	188.8	0.082	0.478
PTR	PTR08	298.3	274.3	2082.0	46,972	17.3	54.8	0.92	7.0	157.5	0.058	0.184
PTR	PTR09	231.1	210.0	1681.5	40,971	15.1	50.9	0.91	7.3	177.3	0.065	0.220
PTR	PTR10	53.7	82.7	616.0	14,058	5.8	30.6	1.54	11.5	261.7	0.108	0.570
PTR	PTR11	140.9	203.9	1537.9	35,309	14.5	75.4	1.45	10.9	250.6	0.103	0.535
PTR	PTR12	224.5	270.4	2066.5	49,568	19.4	86.6	1.20	9.2	220.8	0.087	0.386

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Watershed Name	Subwatershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
PTR	PTR13	355.0	280.2	2255.3	58,290	21.0	65.5	0.79	6.4	164.2	0.059	0.185
PTR	PTR14	179.0	138.8	1122.6	29,035	9.9	19.4	0.78	6.3	162.2	0.055	0.109
PTR	PTR15	349.5	225.3	1930.4	44,549	15.3	33.2	0.64	5.5	127.5	0.044	0.095
PTR	PTR16	261.4	240.2	1767.2	50,242	18.7	68.6	0.92	6.8	192.2	0.071	0.262
PTR	PTR17	125.9	127.9	1017.0	23,679	9.6	48.7	1.02	8.1	188.1	0.076	0.387
TKR	TKR01	1052.8	1681.9	11546.7	68,854	30.2	88.2	1.60	11.0	65.4	0.029	0.084
TKR	TKR02	701.4	569.2	4700.3	45,273	17.1	31.8	0.81	6.7	64.5	0.024	0.045
TKR	TKR03	1156.2	2672.0	17117.6	79,098	38.1	138.6	2.31	14.8	68.4	0.033	0.120
TKR	TKR04	945.5	2593.8	16196.7	65,635	33.6	134.1	2.74	17.1	69.4	0.036	0.142
TKR	TKR05	133.6	303.5	1949.5	8,917	4.4	15.8	2.27	14.6	66.7	0.033	0.118
TKR	TKR06	2087.0	6685.8	40954.5	157,721	81.7	347.7	3.20	19.6	75.6	0.039	0.167
TKR	TKR07	784.9	2338.8	14434.7	59,913	29.9	122.6	2.98	18.4	76.3	0.038	0.156
TKR	TKR08	419.5	1433.5	8706.6	30,778	16.6	73.8	3.42	20.8	73.4	0.040	0.176
TKR	TKR09	225.5	329.4	2247.7	16,201	6.8	19.2	1.46	10.0	71.8	0.030	0.085
TKR	TKR10	1197.4	2397.1	15590.0	90,244	40.3	135.0	2.00	13.0	75.4	0.034	0.113
TKR	TKR11	957.8	2182.9	13974.4	72,622	33.2	117.7	2.28	14.6	75.8	0.035	0.123
TKR	TKR12	1286.5	1459.0	10988.0	97,354	39.8	125.0	1.13	8.5	75.7	0.031	0.097
TKR	TKR13	265.8	676.7	4265.0	18,885	9.2	35.2	2.55	16.0	71.1	0.035	0.133
TKR	TKR14	611.8	205.8	2530.4	38,328	13.2	13.2	0.34	4.1	62.7	0.022	0.022
TKR	TKR15	352.2	421.9	3033.4	34,283	13.2	38.7	1.20	8.6	97.3	0.037	0.110
TKR	TKR16	48.8	128.2	794.0	4,662	2.1	7.6	2.63	16.3	95.5	0.043	0.155
TKR	TKR17	5.4	3.3	31.1	765	0.3	0.4	0.62	5.8	142.9	0.048	0.082
TKR	TKR18	144.5	124.9	1014.8	9,131	3.5	6.7	0.86	7.0	63.2	0.024	0.047
TKR	TKR19	757.1	1620.7	10603.0	78,226	32.5	106.6	2.14	14.0	103.3	0.043	0.141
TKR	TKR20	1049.3	2048.6	13485.0	82,855	38.0	147.0	1.95	12.9	79.0	0.036	0.140
TKR	TKR21	45.8	112.6	770.3	11,643	5.2	31.7	2.46	16.8	254.2	0.115	0.691
TKR	TKR22	172.2	423.6	2869.4	38,287	17.2	100.9	2.46	16.7	222.4	0.100	0.586
TKR	TKR23	71.1	25.0	335.5	5,046	1.6	2.8	0.35	4.7	70.9	0.022	0.040
TKR	TKR24	677.2	794.4	5357.6	110,396	43.3	193.4	1.17	7.9	163.0	0.064	0.286
TKR	TKR25	352.1	613.8	4013.0	25,887	11.7	42.1	1.74	11.4	73.5	0.033	0.120
TKR	TKR26	150.1	213.7	1440.3	18,867	7.4	25.2	1.42	9.6	125.7	0.049	0.168
TKR	TKR27	112.8	151.8	1028.5	16,783	6.3	19.4	1.35	9.1	148.8	0.056	0.172
TKR	TKR28	286.3	186.9	1685.1	17,966	6.6	10.3	0.65	5.9	62.7	0.023	0.036

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Water-shed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
TKR	TKR29	987.7	751.6	5961.2	66,403	25.2	51.0	0.76	6.0	67.2	0.026	0.052
TKR	TKR30	315.4	300.9	2175.2	32,364	12.0	30.7	0.95	6.9	102.6	0.038	0.097
TKR	TKR31	251.0	230.3	1740.5	32,000	11.7	34.3	0.92	6.9	127.5	0.046	0.137
TKR	TKR32	56.5	75.3	499.0	7,310	3.0	14.9	1.33	8.8	129.3	0.053	0.264
TKR	TKR33	514.7	456.2	3563.5	40,771	15.2	34.9	0.89	6.9	79.2	0.030	0.068
TKR	TKR34	486.3	1189.6	7449.9	63,730	27.8	118.2	2.45	15.3	131.0	0.057	0.243
TKR	TKR35	495.3	489.3	3832.5	75,659	29.3	120.2	0.99	7.7	152.8	0.059	0.243
TKR	TKR36	362.7	587.2	4167.8	49,551	21.6	112.5	1.62	11.5	136.6	0.059	0.310
TKR	TKR37	542.7	718.5	4997.6	67,743	26.7	91.3	1.32	9.2	124.8	0.049	0.168
TKR	TKR38	48.5	49.4	347.0	10,310	4.1	20.1	1.02	7.2	212.7	0.085	0.416
TKR	TKR39	1058.7	1252.4	9288.8	96,506	39.9	144.7	1.18	8.8	91.2	0.038	0.137
TKR	TKR40	12.2	7.9	67.8	1,631	0.6	1.6	0.65	5.6	133.8	0.048	0.133
TKR	TKR41	221.0	209.6	1441.3	43,807	15.6	46.0	0.95	6.5	198.2	0.071	0.208
TKR	TKR42	88.8	84.9	575.4	17,775	6.4	19.3	0.96	6.5	200.3	0.072	0.217
TKR	TKR43	327.1	219.0	1799.0	46,400	16.0	32.9	0.67	5.5	141.9	0.049	0.101
TKR	TKR44	78.5	67.4	509.4	12,301	4.3	9.1	0.86	6.5	156.8	0.054	0.116
TKR	TKR45	520.8	305.8	2693.5	51,477	18.4	41.5	0.59	5.2	98.8	0.035	0.080
TKR	TKR46	208.5	86.2	749.1	20,468	7.6	27.4	0.41	3.6	98.2	0.037	0.131
TKR	TKR47	905.2	352.6	2850.7	96,607	37.6	166.9	0.39	3.1	106.7	0.041	0.184
TKR	TKR48	51.4	18.0	199.5	4,938	1.7	4.0	0.35	3.9	96.0	0.034	0.077
TKR	TKR49	70.2	45.3	386.1	7,654	2.7	6.2	0.65	5.5	109.1	0.038	0.088
TKR	TKR50	415.0	415.2	2919.9	74,267	26.7	81.4	1.00	7.0	179.0	0.064	0.196
TKR	TKR51	138.8	202.5	1566.3	34,091	14.7	86.7	1.46	11.3	245.7	0.106	0.625
TKR	TKR52	2439.1	2964.5	22435.5	527,284	208.6	948.9	1.22	9.2	216.2	0.086	0.389
TKR	TKR53	136.2	144.8	1150.4	26,626	11.0	58.0	1.06	8.4	195.5	0.081	0.426
TKR	TKR54	199.6	251.9	1946.6	42,999	18.9	115.8	1.26	9.8	215.4	0.095	0.580
TKR	TKR55	246.5	235.9	1862.0	43,705	17.9	91.2	0.96	7.6	177.3	0.073	0.370
TKR	TKR56	159.2	149.2	991.5	33,667	12.4	44.6	0.94	6.2	211.4	0.078	0.280
WLF	WLF01	294.3	77.0	1050.0	22,173	7.7	9.1	0.26	3.6	75.3	0.026	0.031
WLF	WLF02	146.5	220.1	1504.8	12,913	5.3	15.0	1.50	10.3	88.1	0.036	0.102
WLF	WLF03	177.9	274.2	1878.4	13,108	5.7	16.0	1.54	10.6	73.7	0.032	0.090
WLF	WLF04	31.5	63.1	409.9	2,797	1.2	3.9	2.00	13.0	88.8	0.039	0.123
WLF	WLF05	815.5	817.5	6184.6	75,314	28.7	75.2	1.00	7.6	92.4	0.035	0.092

Estimated Average Annual Pollutant Loads and Pollutant Loading Factors
Roanoke Valley Regional Stormwater Management Plan

Water-shed Name	Sub-watershed Name	Area (acres)	Average Annual Pollutant Loads (lb/yr)					Average Annual Pollutant Loading Factors (lb/ac-yr)				
			TP	TN	TSS	Pb	Zn	TP	TN	TSS	Pb	Zn
WLF	WLF06	404.1	651.4	4354.3	39,994	17.1	66.4	1.61	10.8	99.0	0.042	0.164
WLF	WLF07	16.0	23.2	169.1	2,371	1.1	5.9	1.45	10.6	148.4	0.066	0.369
WLF	WLF08	287.3	218.5	1837.2	38,616	15.4	68.7	0.76	6.4	134.4	0.054	0.239
WLF	WLF09	233.9	145.3	1288.8	29,500	10.4	26.3	0.62	5.5	126.1	0.044	0.112
WLF	WLF10	293.8	382.0	2679.7	39,046	14.9	46.0	1.30	9.1	132.9	0.051	0.157
WLF	WLF11	358.0	367.6	2716.9	42,824	15.5	35.6	1.03	7.6	119.6	0.043	0.099
WLF	WLF12	88.3	36.8	390.3	9,138	3.1	4.7	0.42	4.4	103.5	0.035	0.054

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