

**Proposed Draft Total Maximum Daily Load for *E. coli*, pH,
Cadmium, Copper, Iron, Lead, Nickel and Zinc, 54 Pollutant-
Waterbody Combinations on 25 Stream Segments, Pond Creek,
Muhlenberg County, Kentucky**



Pond Creek Downstream, photo by KDOW

**Submitted to:
United States Environmental Protection Agency
Region IV
Atlanta Federal Building
61 Forsyth Street SW
Atlanta, GA 30303-1534**

**Prepared by:
Kentucky Department for Environmental Protection
Division of Water
300 Sower Blvd Frankfort, KY 40601**



Commonwealth of Kentucky
Matthew G. Bevin, Governor

Energy and Environment Cabinet
Charles G. Snavelly, Secretary

The Energy and Environment Cabinet (EEC) does not discriminate on the basis of race, color, national origin, sex, age, religion, or disability. The EEC will provide, on request, reasonable accommodations including auxiliary aids and services necessary to afford an individual with a disability an equal opportunity to participate in all services, programs and activities. To request materials in an alternative format, contact the Kentucky Division of Water, 300 Sower Blvd, Frankfort, KY 40601 or call (502) 564-3410. Hearing- and speech-impaired persons can contact the agency by using the Kentucky Relay Service, a toll-free telecommunications device for the deaf (TDD). For voice to TDD, call 800-648-6057. For TDD to voice, call 800-648-6056.

Printed on recycled/recyclable paper with state (or federal) funds.

**Proposed Draft Total Maximum Daily Load for *E. coli*, pH,
Cadmium, Copper, Iron, Lead, Nickel and Zinc, 54 Pollutant-
Waterbody Combinations on 25 Stream Segments, Pond Creek,
Muhlenberg County, Kentucky**

November 2016

**Kentucky Department for Environmental Protection
Division of Water**

This report is approved for release

**Peter Goodmann, Director
Division of Water**

Date

TABLE OF CONTENTS

1.0	Introduction.....	31
2.0	Problem Definition.....	32
2.1	303(D) LISTING HISTORY	32
2.2	TMDLS IN THE WATERSHED	32
3.0	Physical Setting	33
3.1	GEOLOGY.....	33
3.2	HYDROLOGY	40
3.3	LAND COVER DISTRIBUTION.....	41
3.4	MINING ACTIVITY.....	42
4.0	Monitoring.....	54
4.1	MONITORING HISTORY	54
4.2	KDOW TMDL MONITORING.....	55
5.0	Source Identification.....	59
5.1	KPDES-PERMITTED SOURCES.....	59
5.1.1	<i>E. coli</i>	64
5.1.2	<i>pH and Metals</i>	64
5.2	NON-KPDES-PERMITTED SOURCES	66
5.2.1	<i>E. coli</i>	66
5.2.2	<i>pH and Metals</i>	71
5.3	ILLEGAL SOURCES	72
6.0	Water Quality Criteria.....	73
6.1	WATER QUALITY CRITERIA	73
6.1.1	<i>E. coli</i>	73
6.1.2	<i>pH</i>	73
6.1.3	<i>Metals</i>	74
6.2	METALS HYDROLYSIS.....	76
7.0	Total Maximum Daily Load.....	79
7.1	TMDL EQUATION AND DEFINITIONS.....	79
7.2	TMDLS BY POLLUTANT	80
7.2.1	<i>E. coli</i>	80
7.2.2	<i>pH</i>	80
7.2.3	<i>Metals</i>	82
7.2.4	<i>Net Alkalinity</i>	84
7.3	MARGIN OF SAFETY	85
7.4	ALLOCATIONS.....	85
7.5	SEASONALITY	86
7.5.1	<i>E. coli</i>	86
7.5.2	<i>pH and Metals</i>	86
7.6	CRITICAL CONDITION	87
7.6.1	<i>E. coli</i>	87
7.6.2	<i>pH and Metals</i>	88
7.7	TMDL ALLOCATIONS.....	88
8.0	Individual Segments TMDL Calculations	96

8.1	BAT EAST CREEK 0.0 TO 3.4	98
8.2	BEECH CREEK 0.0 TO 3.9	105
8.3	BOGESS CREEK 0.0 TO 3.0	114
8.4	CANEY CREEK 0.0 TO 3.6.....	117
8.5	CANEY CREEK 3.6 TO 7.6.....	124
8.6	CARTERS CREEK 0.0 TO 3.1	132
8.7	OPOSSUM RUN 0.0 TO 1.6	135
8.8	PLUM CREEK 0.0 TO 1.65	138
8.9	PLUM CREEK 1.65 TO 3.9.....	143
8.10	POND CREEK 0.0 TO 5.0	148
8.11	POND CREEK 5.0 TO 7.5	151
8.12	POND CREEK 7.5 TO 11.7	160
8.13	POND CREEK 11.7 TO 14.4	170
8.14	POND CREEK 14.4 TO 18.1	178
8.15	POND CREEK 18.1 TO 18.7	184
8.16	SALTICK CREEK 0.0 TO 3.7	188
8.17	SANDLICK CREEK 0.0 TO 4.05.....	191
8.18	UT OF BAT EAST CREEK 0.0 TO 1.9	198
8.19	UT OF BAT EAST CREEK 0.0 TO 3.55	201
8.20	UT OF CANEY CREEK 0.0 TO 2.6.....	204
8.21	UT OF CANEY CREEK 0.0 TO 2.35.....	208
8.22	UT OF PLUM CREEK 0.0 TO 2.45	212
8.23	UT OF POND CREEK 0.0 TO 2.4	218
8.24	UT OF POND CREEK 2.4 TO 4.2	222
8.25	UT OF POND CREEK 0.0 TO 1.4	228
9.0	Implementation Options.....	233
9.1	WATERSHED PLAN.....	233
9.2	KENTUCKY WATERSHED MANAGEMENT FRAMEWORK	233
9.3	NON-GOVERNMENTAL ORGANIZATIONS	234
9.3.1	<i>Watershed Watch in Kentucky</i>	234
9.3.2	<i>Kentucky Waterways Alliance</i>	234
9.4	MINING RELATED IMPLEMENTATIONS	234
9.4.1	<i>Kentucky Division of Abandoned Mine Lands</i>	234
9.4.2	<i>Kentucky Division of Mine Permits</i>	237
9.4.3	<i>Kentucky Division of Mine Reclamation and Enforcement</i>	239
9.4.4	<i>Kentucky Division of Water</i>	244
10.0	Public Participation	249
11.0	References	250
Appendix A	Land Cover Definitions (NLCD2011)	254
Appendix B	Division of Mine Permits Numbering System	256

LIST OF FIGURES

Figure S.1 Location of the Pond Creek Watershed, TMDL Sampling Stations and Impaired Stream Segments	16
Figure 3.1 Generalized Geology within the Pond Creek Watershed	34
Figure 3.2 Mapped Coal Beds within the Pond Creek Watershed.....	34
Figure 3.3 Average Soil pH Value within the Pond Creek Watershed	36
Figure 3.4 Geologic Faults, Springs, and Karst within the Pond Creek Watershed	37
Figure 3.5 Groundwater Sensitivity Regions Map.....	38
Figure 3.6 Soil Hydrology Group in the Pond Creek Watershed.....	39
Figure 3.7 Soil Suitability for Septic Tanks in the Pond Creek Watershed	40
Figure 3.8 Stream Orders within the Pond Creek Watershed	41
Figure 3.9 Land Cover within the Pond Creek Watershed (NLCD 2011)	42
Figure 3.10 Mined Out Areas within the Pond Creek Watershed	43
Figure 3.11 Current Permits Issued by KDMP in the Pond Creek Watershed	52
Figure 4.1 Locations of Historical Sampling Sites within the Pond Creek Watershed	54
Figure 4.2 Locations of KDOW TMDL Sampling Sites within the Pond Creek Watershed.....	56
Figure 5.1 KPDES Permittees within the Pond Creek Watershed	60
Figure 5.2 Active KPDES-Permitted Mining in the Pond Creek Watershed	66
Figure 5.3 KNDOP Facility in the Pond Creek Watershed	67
Figure 5.4 2010 Census Blocks of Population of the Pond Creek Watershed	70
Figure 5.5 Existing and Proposed Sewer Lines in the Pond Creek Watershed	71
Figure 7.1 Ionic Strength vs. Activity Coefficient of H ⁺ Ions.....	82
Figure 8.1.1 TMDL Monitoring Location and the Drainage Area of Bat East Creek 0.0 to 3.4.....	98
Figure 8.1.2 Land Cover in the Bat East Creek 0.0 to 3.4 Subwatershed	99
Figure 8.1.3 KPDES Permittee in the Subwatershed	100
Figure 8.1.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	101
Figure 8.2.1 TMDL Monitoring Location and the Drainage Area of Beech Creek 0.0 to 3.9	105
Figure 8.2.2 Land Cover in the Beech Creek 0.0 to 3.9 Subwatershed.....	106
Figure 8.2.3 KPDES Permittees in the Subwatershed.....	107
Figure 8.2.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	108
Figure 8.3.1 TMDL Monitoring Location and the Drainage Area of Boggess Creek 0.0 to 3.0.....	114
Figure 8.3.2 Land Cover in the Boggess Creek 0.0 to 3.0 Subwatershed	115
Figure 8.4.1 TMDL Monitoring Locations and the Drainage Area of Caney Creek 0.0 to 3.6	117
Figure 8.4.2 Land Cover in the Caney Creek 0.0 to 3.6 Subwatershed	118
Figure 8.4.3 KPDES Permittees in the Caney Creek 0.0 to 3.6 Subwatershed	119
Figure 8.4.4 Active KPDES Mining Permittee in the Subwatershed	121
Figure 8.4.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	122

Figure 8.5.1 TMDL Monitoring Location and the Drainage Area of Caney Creek 3.6 to 7.6	124
Figure 8.5.2 Land Cover in the Caney Creek 3.6 to 7.6 Subwatershed	125
Figure 8.5.3 KPDES Permittees in the Caney Creek 3.6 to 7.6 Subwatershed	126
Figure 8.5.4 Active KPDES Mining Permittee in the Subwatershed	128
Figure 8.5.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	129
Figure 8.6.1 TMDL Monitoring Site and the Drainage Area of Carters Creek 0.0 to 3.1	132
Figure 8.6.2 Land Cover in the Carters Creek 0.0 to 3.1 Subwatershed	133
Figure 8.7.1 TMDL Monitoring Site and the Drainage Area of Opossum Run 0.0 to 1.6	135
Figure 8.7.2 Land Cover in the Opossum Run 0.0 to 1.6 Subwatershed	136
Figure 8.8.1 TMDL Monitoring Locations and the Drainage Area of Plum Creek 0.0 to 1.65	138
Figure 8.8.2 Land Cover in the Plum Creek 0.0 to 1.65 Subwatershed	139
Figure 8.8.3 KPDES Permittees in the Plum Creek 0.0 to 1.65 Subwatershed	140
Figure 8.8.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	141
Figure 8.9.1 TMDL Monitoring Locations and the Drainage Area of Plum Creek 1.65 to 3.9	143
Figure 8.9.2 Land Cover in the Plum Creek 1.65 to 3.9 Subwatershed	144
Figure 8.9.3 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	145
Figure 8.10.1 TMDL Monitoring Sites and the Drainage Area of Pond Creek Watershed	148
Figure 8.10.2 Land Cover in the Pond Creek Watershed	149
Figure 8.11.1 TMDL Monitoring Locations and the Drainage Area of Pond Creek 5.0 to 7.5	151
Figure 8.11.2 Land Cover in the Pond Creek 5.0 to 7.5 Subwatershed	152
Figure 8.11.3 KPDES Permittees in the Pond Creek 5.0 to 7.5 Subwatershed	153
Figure 8.11.4 Active KPDES-Permitted Mining in the Subwatershed	156
Figure 8.11.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	157
Figure 8.12.1 TMDL Monitoring Locations and the Drainage Area of Pond Creek 7.5 to 11.7	160
Figure 8.12.2 Land Cover in the Pond Creek 7.5 to 11.7 Subwatershed	161
Figure 8.12.3 KPDES Permittees in the Pond Creek 7.5 to 11.7 Subwatershed	162
Figure 8.12.4 Active KPDES-Permitted Mining in the Subwatershed	165
Figure 8.12.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	166
Figure 8.13.1 TMDL Monitoring Locations and the Drainage Area of Pond Creek 11.7 to 14.4	170
Figure 8.13.2 Land Cover in the Pond Creek 11.7 to 14.4 Subwatershed	171
Figure 8.13.3 KPDES Permittees in the Pond Creek 11.7 to 14.4 Subwatershed	172
Figure 8.13.4 Active KPDES-Permitted Mining in the Subwatershed	173
Figure 8.13.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed	174

Figure 8.14.1 TMDL Monitoring Locations and the Drainage Area of Pond Creek 14.4 to 18.1.....	178
Figure 8.14.2 Land Cover in the Pond Creek 14.4 to 18.1 Subwatershed	179
Figure 8.14.3 KPDES Permittees in the Subwatershed.....	180
Figure 8.14.4 Active KPDES-Permitted Mining in the Subwatershed	181
Figure 8.14.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed.....	182
Figure 8.15.1 TMDL Monitoring Sites and the Drainage Area of Pond Creek 18.1 to 18.7	184
Figure 8.15.2 Land Cover in the Pond Creek 18.1 to 18.7 Subwatershed	185
Figure 8.15.3 KPDES Permittees in the Subwatershed.....	186
Figure 8.16.1 TMDL Monitoring Locations and the Drainage Area of Saltlick Creek 0.0 to 3.7.....	188
Figure 8.16.2 Land Cover in the Saltlick Creek 0.0 to 3.7 Subwatershed	189
Figure 8.17.1 TMDL Monitoring Locations and the Drainage Area of Sandlick Creek 0.0 to 4.05.....	191
Figure 8.17.2 Land Cover in the Sandlick Creek 0.0 to 4.05 Subwatershed	192
Figure 8.17.3 KPDES Permittees in the Subwatershed.....	193
Figure 8.17.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed.....	194
Figure 8.18.1 TMDL Monitoring Sites and the Drainage Area of UT of Bat East Creek 0.0 to 1.9	198
Figure 8.18.2 Land Cover in the UT of Bat East Creek 0.0 to 1.9 Subwatershed.....	199
Figure 8.19.1 TMDL Monitoring Locations and the Drainage Area of UT of Bat East Creek 0.0 to 3.55	201
Figure 8.19.2 Land Cover in the UT of Bat East Creek 0.0 to 3.55 Subwatershed.....	202
Figure 8.20.1 TMDL Monitoring Locations and the Drainage Area of UT of Caney Creek 0.0 to 2.6	204
Figure 8.20.2 Land Cover in the UT of Caney Creek 0.0 to 2.6 Subwatershed	205
Figure 8.21.1 TMDL Monitoring Locations and the Drainage Area of UT of Caney Creek 0.0 to 2.35	208
Figure 8.21.2 Land Cover in the UT of Caney Creek 0.0 to 2.35 Subwatershed	209
Figure 8.22.1 TMDL Monitoring Location and Impaired Segment in the UT of Plum Creek 0.0 to 2.45 Subwatershed	212
Figure 8.22.2 Land Cover in the UT of Plum Creek 0.0 to 2.45 Subwatershed	213
Figure 8.22.3 KPDES Permittees in the Subwatershed.....	214
Figure 8.22.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed.....	215
Figure 8.23.1 TMDL Monitoring Location and Impaired Segment in the UT of Pond Creek 0.0 to 2.4 Subwatershed	218
Figure 8.23.2 Land Cover in the UT of Pond Creek 0.0 to 2.4 Subwatershed	219
Figure 8.23.3 KPDES Facilities in the Subwatershed.....	220
Figure 8.23.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed.....	221
Figure 8.24.1 TMDL Monitoring Location and Impaired Segment in the UT of Pond Creek 2.4 to 4.2 Subwatershed	222

Figure 8.24.2 Land Cover in the UT of Pond Creek 2.4 to 4.2 Subwatershed	223
Figure 8.24.3 KPDES Permittee in the Subwatershed	224
Figure 8.24.4 Data from the Department of Natural Resources on Licensed Mine Areas in the Subwatershed	225
Figure 8.25.1 TMDL Monitoring Location and Impaired Segment in the UT of Pond Creek 0.0 to 1.4 Subwatershed	228
Figure 8.25.2 Land Cover in the UT of Pond Creek 0.0 to 1.4 Subwatershed	229
Figure 8.25.3 KPDES Permittees in the Subwatershed.....	230
Figure 8.25.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed.....	231
Figure 9.1 AML Projects within the Pond Creek Watershed – Part1	236
Figure 9.2 AML Projects within the Pond Creek Watershed – Part II.....	236
Figure 9.3 AML Projects within the Pond Creek Watershed – Part III	237
Figure 9.4 Data from the Department of Natural Resources on Licensed Mine Areas in the Pond Creek Watershed.....	240

LIST OF TABLES

Table S.1 Impaired Waterbodies and Pollutants Addressed in this TMDL Document.....	13
Table S.2 <i>E. coli</i> WQC and TMDL Endpoint	16
Table S.3 pH WQC and TMDL Endpoint.....	16
Table S.4 Iron WQC and TMDL Endpoint	17
Table S.5 Cadmium, Copper, Lead, Nickel and Zinc WQCs and TMDL Endpoints	17
Table S.6 Net Alkalinity TMDL Endpoint	17
Table S.7 TMDLs and Allocations by Impaired Segments	19
Table S.8 KPDES Permittees within the Pond Creek Watershed.....	27
Table 3.1 Average Total Sulfur Percentages for Coal Beds in the TMDL Watershed	35
Table 3.2 Kentucky Statewide Summary Statistics for Ambient Soil Inorganic Chemicals	36
Table 3.3 Land Cover within the Pond Creek Watershed (NLCD 2011)	42
Table 3.4 Data from the Office of Mine Safety and Licensing on Mined Out Areas in the Pond Creek Watershed.....	43
Table 3.5 Current Permits Issued by KDMP in the Pond Creek Watershed	52
Table 4.1 Historical Monitoring Sites in the Pond Creek Watershed.....	54
Table 4.2 Sample Sites by KDOW TMDL in the Pond Creek Watershed	56
Table 4.3 KDOW TMDL Biological Sampling Events in the Pond Creek Watershed	58
Table 5.1 KPDES Permittees within the Pond Creek Watershed	60
Table 5.2 Active KPDES-Permitted Mining in the Pond Creek Watershed	65
Table 5.3 KNDOP Facility in the Pond Creek Watershed.....	67
Table 5.4 Agricultural Statistics from the 2012 USDA Agricultural Census.....	68
Table 5.5 Number of Deer in Muhlenberg County.....	69
Table 6.1 Iron WQCs.....	74
Table 6.2 Cadmium WQC.....	75
Table 6.3 Copper WQC.....	75
Table 6.4 Lead WQC	75
Table 6.5 Nickel WQC.....	75
Table 6.6 Zinc WQC.....	75
Table 7.1 <i>E. coli</i> WQCs and TMDL Load	80
Table 7.2 Range of Hydrogen Ion TMDL Loads Corresponding to a pH Range of 6.0 to 9.0	82
Table 7.3 Iron WQCs and TMDL Load	83
Table 7.4 Cadmium WQC and TMDL Load	83
Table 7.5 Copper WQC and TMDL Load	84
Table 7.6 Lead WQC and TMDL Load.....	84
Table 7.7 Nickel WQC and TMDL Load	84
Table 7.8 Zinc WQC and TMDL Load.....	84
Table 7.9 TMDLs and Allocations by Impaired Segments	89
Table 8.1.1 Bat East Creek 0.0 to 3.4 Segment/Upstream Catchment Information	98
Table 8.1.2 Land Cover in the Bat East Creek 0.0 to 3.4 Subwatershed	99
Table 8.1.3 KPDES Permittee in the Subwatershed	100
Table 8.1.4 <i>E. coli</i> and Flow Data Collected at DOW03011007.....	101
Table 8.1.5 Copper and Flow Data Collected at DOW03011007	102

Table 8.1.6 Lead and Flow Data Collected at DOW03011007.....	103
Table 8.2.1 Beech Creek 0.0 to 3.9 Segment/Subwatershed Information.....	105
Table 8.2.2 Land Cover within the Beech Creek 0.0 to 3.9 Subwatershed.....	106
Table 8.2.3 KPDES Permittees in the Subwatershed	107
Table 8.2.4 pH and Flow Data Collected at DOW03011015.....	108
Table 8.2.5 Iron and Flow Data Collected at DOW03011015.....	109
Table 8.2.6 Cadmium, Hardness and Flow Data Collected at DOW03011015.....	110
Table 8.2.7 Nickel, Hardness and Flow Data Collected at DOW03011015	111
Table 8.2.8 Zinc, Hardness and Flow Data Collected at DOW03011015	112
Table 8.3.1 Boggess Creek 0.0 to 3.0 Segment/Upstream Catchment Information	114
Table 8.3.2 Land Cover in the Boggess Creek 0.0 to 3.0 Subwatershed	115
Table 8.3.3 <i>E. coli</i> and Flow Data, DOW03011024.....	116
Table 8.4.1 Caney Creek 0.0 to 3.6 Segment/Upstream Catchment Information.....	117
Table 8.4.2 Land Cover in the Caney Creek 0.0 to 3.6 Subwatershed.....	118
Table 8.4.3 KPDES Permittees in the Caney Creek 0.0 to 3.6 Subwatershed.....	119
Table 8.4.4 Active KPDES Mining Permittee in the Subwatershed.....	121
Table 8.4.5 <i>E. coli</i> and Flow Data, DOW03011001	122
Table 8.4.6 Cadmium, Hardness and Flow Data Collected at DOW03011001	123
Table 8.5.1 Caney Creek 3.6 to 7.6 Segment/Upstream Catchment Information.....	124
Table 8.5.2 Land Cover in the Caney Creek 3.6 to 7.6 Subwatershed.....	125
Table 8.5.3 KPDES Permittees in the Caney Creek 3.6 to 7.6 Subwatershed.....	126
Table 8.5.4 Active KPDES Mining Permittee in the Subwatershed.....	128
Table 8.5.5 <i>E. coli</i> and Flow Data, DOW03011014.....	129
Table 8.5.6 Cadmium, Hardness and Flow Data Collected at DOW03011014.....	130
Table 8.5.7 Lead, Hardness and Flow Data Collected at DOW03011014	130
Table 8.6.1 Carters Creek 0.0 to 3.1 Segment/Upstream Catchment Information	132
Table 8.6.2 Land Cover in the Carters Creek 0.0 to 3.1 Subwatershed	133
Table 8.6.3 <i>E. coli</i> and Flow Data, DOW03011017	134
Table 8.7.1 Opossum Run 0.0 to 1.6 Segment/Upstream Catchment Information.....	135
Table 8.7.2 Land Cover in the Opossum Run 0.0 to 1.6 Subwatershed.....	136
Table 8.7.3 <i>E. coli</i> and Flow Data, DOW03011021	137
Table 8.8.1 Plum Creek 0.0 to 1.65 Segment/Upstream Catchment Information	138
Table 8.8.2 Land Cover in the Plum Creek 0.0 to 1.65 Subwatershed	139
Table 8.8.3 KPDES Permittees in the Plum Creek 0.0 to 1.65 Subwatershed	140
Table 8.8.4 <i>E. coli</i> and Flow Data, DOW03011030.....	141
Table 8.8.5 Cadmium, Hardness and Flow Data Collected at DOW03011030.....	142
Table 8.9.1 Plum Creek 1.65 to 3.9 Segment/Upstream Catchment Information	143
Table 8.9.2 Land Cover in the Plum Creek 1.65 to 3.9 Subwatershed	144
Table 8.9.3 <i>E. coli</i> and Flow Data, DOW03011029.....	145
Table 8.9.4 pH and Flow Data Collected at DOW03011029	146
Table 8.9.5 Cadmium, Hardness and Flow Data Collected at DOW03011029.....	146
Table 8.9.6 Nickel, Hardness and Flow Data Collected at DOW03011029	147
Table 8.9.7 Zinc, Hardness and Flow Data Collected at DOW03011029	147
Table 8.10.1 Pond Creek 0.0 to 5.0 Segment/Upstream Catchment Information.....	148
Table 8.10.2 Land Cover in the Pond Creek Watershed.....	149
Table 8.10.3 Iron and Flow Data Collected at DOW03011031.....	150

Table 8.11.1 Pond Creek 5.0 to 7.5 Segment/Upstream Catchment Information.....	151
Table 8.11.2 Land Cover in the Pond Creek 5.0 to 7.5 Subwatershed.....	152
Table 8.11.3 KPDES Permittees in the Pond Creek 5.0 to 7.5 Subwatershed.....	153
Table 8.11.4 Active KPDES-Permitted Mining in the Pond Creek Watershed	157
Table 8.11.5 <i>E. coli</i> and Flow Data, DOW03011009	157
Table 8.11.6 Cadmium, Hardness and Flow Data Collected at DOW03011009	158
Table 8.11.7 Iron and Flow Data Collected at DOW03011009.....	159
Table 8.12.1 Pond Creek 7.5 to 11.7 Segment/Upstream Catchment Information.....	161
Table 8.12.2 Land Cover in the Pond Creek 7.5 to 11.7 Subwatershed.....	161
Table 8.12.3 KPDES Permittees in the Pond Creek 7.5 to 11.7 Subwatershed.....	163
Table 8.12.4 Active KPDES-Permitted Mining in the Subwatershed.....	166
Table 8.12.5 <i>E. coli</i> and Flow Data, DOW03011026.....	166
Table 8.12.6 Cadmium, Hardness and Flow Data Collected at DOW03011026	167
Table 8.12.7 Iron and Flow Data Collected at DOW03011026.....	168
Table 8.13.1 Pond Creek 11.7 to 14.4 Segment/Upstream Catchment Information.....	171
Table 8.13.2 Land Cover in the Pond Creek 11.7 to 14.4 Subwatershed.....	171
Table 8.13.3 KPDES Permittees in the Pond Creek 11.7 to 14.4 Subwatershed.....	172
Table 8.13.4 Active KPDES-Permitted Mining in the Subwatershed.....	174
Table 8.13.5 pH and Flow Data Collected at DOW03011027	174
Table 8.13.6 Cadmium, Hardness and Flow Data Collected at DOW03011027	175
Table 8.13.7 Iron and Flow Data Collected at DOW03011027.....	177
Table 8.14.1 Pond Creek 14.4 to 18.1 Segment/Upstream Catchment Information.....	179
Table 8.14.2 Land Cover in the Pond Creek 14.4 to 18.1 Subwatershed.....	179
Table 8.14.3 KPDES Permittees in the Subwatershed	180
Table 8.14.4 Active KPDES-Permitted Mining in the Subwatershed.....	181
Table 8.14.5 <i>E. coli</i> and Flow Data, DOW03011006.....	182
Table 8.14.6 Lead, Hardness and Flow Data Collected at DOW03011006	183
Table 8.15.1 Pond Creek 18.1 to 18.7 Segment/Upstream Catchment Information.....	184
Table 8.15.2 Land Cover in the Pond Creek 18.1 to 18.7 Subwatershed.....	185
Table 8.15.3 KPDES Permittees in the Subwatershed	186
Table 8.15.4 <i>E. coli</i> and Flow Data, DOW03011020	187
Table 8.16.1 Saltlick Creek 0.0 to 3.7 Segment/Upstream Catchment Information.....	188
Table 8.16.2 Land Cover in the Saltlick Creek 0.0 to 3.7 Subwatershed.....	189
Table 8.16.3 <i>E. coli</i> and Flow Data, DOW03011023	190
Table 8.17.1 Sandlick Creek 0.0 to 4.05 Segment/Upstream Catchment Information.....	191
Table 8.17.2 Land Cover in the Sandlick Creek 0.0 to 4.05 Subwatershed.....	192
Table 8.17.3 KPDES Permittees in the Subwatershed	193
Table 8.17.4 <i>E. coli</i> and Flow Data, DOW03011004	194
Table 8.17.5 Iron and Flow Data Collected at DOW03011004.....	195
Table 8.17.6 Lead, Hardness and Flow Data Collected at DOW03011004	196
Table 8.18.1 UT of Bat East Creek 0.0 to 1.9 Segment/Upstream Catchment Information	198
Table 8.18.2 Land Cover in the UT of Bat East Creek 0.0 to 1.9 Subwatershed	199
Table 8.18.3 <i>E. coli</i> and Flow Data, DOW03011019	200
Table 8.19.1 UT of Bat East Creek 0.0 to 3.55 Segment/Upstream Catchment Information	201

Table 8.19.2 Land Cover in the UT of Bat East Creek 0.0 to 3.55 Subwatershed	202
Table 8.19.3 <i>E. coli</i> and Flow Data, DOW03011016	203
Table 8.20.1 UT of Caney Creek 0.0 to 2.6 Segment/Upstream Catchment Information..	204
Table 8.20.2 Land Cover in the UT of Caney Creek 0.0 to 2.6 Subwatershed.....	205
Table 8.20.3 <i>E. coli</i> and Flow Data, DOW03011013	206
Table 8.20.4 Lead, Hardness and Flow Data Collected at DOW03011013	206
Table 8.21.1 UT of Caney Creek 0.0 to 2.35 Segment/Upstream Catchment Information	208
Table 8.21.2 Land Cover in the UT of Caney Creek 0.0 to 2.35 Subwatershed.....	209
Table 8.21.3 <i>E. coli</i> and Flow Data, DOW03011012	210
Table 8.21.4 Lead, Hardness and Flow Data Collected at DOW03011012	210
Table 8.22.1 UT of Plum Creek 0.0 to 2.45 Segment/Subwatershed Information	212
Table 8.22.2 Land Cover within the UT of Plum Creek 0.0 to 2.45 Subwatershed	213
Table 8.22.3 KPDES Permittees in the Subwatershed	214
Table 8.22.4 pH and Flow Data Collected at DOW03011003	215
Table 8.22.5 Cadmium, Hardness and Flow Data Collected at DOW03011003	216
Table 8.22.6 Iron and Flow Data Collected at DOW03011003.....	216
Table 8.22.7 Nickel, Hardness and Flow Data Collected at DOW03011003	217
Table 8.22.8 Zinc, Hardness and Flow Data Collected at DOW03011003	217
Table 8.23.1 UT of Pond Creek 0.0 to 2.4 Segment/Subwatershed Information	218
Table 8.23.2 Land Cover within the UT of Pond Creek 0.0 to 2.4 Subwatershed	219
Table 8.23.3 KPDES Facilities in the Subwatershed	220
Table 8.23.4 Iron and Flow Data Collected at DOW03011028.....	221
Table 8.24.1 UT of Pond Creek 2.4 to 4.2 Segment/Subwatershed Information	222
Table 8.24.2 Land Cover within the UT of Pond Creek 2.4 to 4.2 Subwatershed	223
Table 8.24.3 KPDES Permittee in the Subwatershed	224
Table 8.24.4 <i>E. coli</i> and Flow Data, DOW03011002	225
Table 8.24.5 Cadmium, Hardness and Flow Data Collected at DOW03011002	226
Table 8.24.6 pH and Flow Data, DOW03011002	226
Table 8.25.1 UT of Pond Creek 0.0 to 1.4 Segment/Subwatershed Information	228
Table 8.25.2 Land Cover within the UT of Pond Creek 0.0 to 1.4 Subwatershed	229
Table 8.25.3 KPDES Permittees in the Subwatershed	230
Table 8.25.4 Cadmium, Hardness and Flow Data Collected at DOW03011011	232
Table 9.1 AML Projects within the Pond Creek Watershed	235
Table 9.2 Data from the Department of Natural Resources on Licensed Mine Areas in the Pond Creek Watershed.....	240
Table 9.3 Coal General Permit Limits and Reporting	244
Table 9.4 Quarterly Instream Monitoring Frequency and Limitations	246
Table 9.5 Annual Instream Monitoring Frequency and Limitations	246
Table 9.6 Effluent Limitations and Monitoring Requirements	247
Table 9.7 Effluent Limitations and Monitoring Requirements	248

GLOSSARY OF ACRONYMS

AFO	Animal Feeding Operations
AMD	Acid Mine Drainage
AML	Abandoned Mine Lands
APEL	Alternate Precipitation Effluent Limits
APHA	American Public Health Association
AWQA	Agricultural Water Quality Act
BMP	Best Management Practices
CAFOs	Concentrated Animal Feeding Operations
CAH	Cold Water Aquatic Habitat
CFR	Code of Federal Regulations
cfs	cubic feet per second
CPP	Continuing Planning Process
CWA	Clean Water Act
D.C.	District of Columbia
DMRE	Division of Mine Reclamation and Enforcement
DMR	Discharge Monitoring Report
ELG	Effluent Limit Guidelines
EPA	Environmental Protection Agency
ft ³ /s	cubic feet per second
GIS	Geographic Information System
GNIS	Geographic Names Information System
HUC	Hydrologic Unit Code
HSG	Hydrologic Soil Groups
ICIS	Integrated Compliance Information System
KAR	Kentucky Administrative Regulations
KDEP	Kentucky Department for Environmental Protection
KDMP	Kentucky Division of Mine Permits
KDMS	Kentucky Division of Mine Safety
KDNR	Kentucky Department for Natural Resources
KDOW	Kentucky Division of Water
KIBI	Kentucky Index of Biotic Integrity
KGS	Kentucky Geological Survey
KNDOP	Kentucky No Discharge Operating Permit
KRS	Kentucky Revised Statutes
KPDES	Kentucky Pollutant Discharge Elimination System
KWA	Kentucky Waterways Alliance
KPDES	Kentucky Pollutant Discharge Elimination System
L	liter

LA	Load Allocations
MBI	Macroinvertebrate Bioassessment Index
MGD	million gallons per day
ml	milliliter
mg/L	milligrams per liter
MOS	Margin of Safety
MS4	Municipal Separate Stormwater Sewer Systems
MSU	Murray State University
N/A	Not Applicable
NHD	National Hydrography Dataset
NLCD	National Landcover Database
NRCS	Natural Resources Conservation Service
NS	Non-Support
ONRW	Outstanding National Resource Water
OSRW	Outstanding State Resource Water
OSTDS	On-site Sewage Treatment Disposal System
PCR	Primary Contact Recreation
PS	Partial Support
RM	River Mile
SCR	Secondary Contact Recreation
SMCRA	Surface Mining Control and Reclamation Act
SMIS	Surface Mining Information System
STP	Sewage Treatment Plant
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
µg/L	micrograms per liter
µs/cm	microsiemens per centimeter
USGS	United States Geological Survey
USDA	United States Department of Agriculture
UT	Unnamed Tributary
WAH	Warm Water Aquatic Habitat
WBID	Waterbody Identification Number
WET	Whole Effluent Toxicity
WKY	Western Kentucky (Coal Bed Designation)
WKU	Western Kentucky University
WLA	Waste Load Allocation
WQC	Water Quality Criteria
WWTP	Wastewater Treatment Plant

Total Maximum Daily Load (TMDL) Synopsis

State: Kentucky

Major River Basin: Green

USGS HUC8 #: 05110003

County: Muhlenberg

Pollutant(s) of Concern: *E. coli*, pH, Cadmium, Copper, Iron, Lead, Nickel and Zinc

Table S.1 Impaired Waterbodies and Pollutants Addressed in this TMDL Document

Waterbody	GNIS Number⁽¹⁾	Pollutant	Suspected Sources	Impaired Use⁽²⁾ (Support Status)⁽³⁾
Bat East Creek 0.0 to 3.4	KY486462_01	<i>E. coli</i>	Source Unknown	PCR (NS)
		Copper	Legacy Coal Extraction	WAH (PS)
		Lead	Legacy Coal Extraction	WAH (PS)
Beech Creek 0.0 to 3.9	KY486697_01	Cadmium	Surface Mining	WAH (NS)
		Iron	Surface Mining	WAH (NS)
		Nickel	Surface Mining	WAH (NS)
		Zinc	Surface Mining	WAH (NS)
Boggess Creek 0.0 to 3.0	KY487614_01	<i>E. coli</i>	Loss of Riparian Habitat; Non-point Source	PCR (NS)
Caney Creek 0.0 to 3.6	KY488838_01	<i>E. coli</i>	Non-point Source; Urban Runoff/store Sewers	PCR (NS)
		Cadmium ⁽⁴⁾	Source Unknown	WAH (PS)
Caney Creek 3.6 to 7.6	KY488838_02	<i>E. coli</i>	Non-point Source	PCR (NS)
		Cadmium ⁽⁴⁾	Legacy Coal Extraction	WAH (NS)
		Lead ⁽⁴⁾	Legacy Coal Extraction	WAH (NS)
Carters Creek 0.0 to 3.1	KY489022_01	<i>E. coli</i> ⁽⁴⁾	Agriculture	PCR (PS)
Opossum Run 0.0 to 1.6	KY499964_01	<i>E. coli</i> ⁽⁴⁾	Non-point Source	PCR (NS)
Plum Creek 0.0 to 1.65	KY500964_01	<i>E. coli</i>	Upstream Source; Inappropriate Water Disposal	PCR (NS)
		Cadmium	Non-point Source; Legacy Coal Extraction	WAH (NS)
Plum Creek 1.65 to 3.9	KY500964_02	<i>E. coli</i>	Non-point Source; Upstream Source	PCR (NS)
		pH	Legacy Coal Extraction	PCR (NS), SCR (NS), WAH (NS)
		Cadmium	Non-point Source	WAH (NS)
		Nickel	Non-point Source	WAH (NS)
		Zinc	Non-point Source	WAH (NS)
Pond Creek 0.0 to 5.0	KY501042_01	Iron ⁽⁴⁾	Surface Mining; Legacy Coal Extraction	WAH (NS)

Total Maximum Daily Load (TMDL) Synopsis

Waterbody	GNIS Number⁽¹⁾	Pollutant	Suspected Sources	Impaired Use⁽²⁾ (Support Status)⁽³⁾
Pond Creek 5.0 to 7.5	KY501042_02	<i>E. coli</i>	Non-point Source; Upstream Source	PCR (PS)
		Cadmium	Legacy Coal Extraction	WAH (NS)
		Iron	Legacy Coal Extraction	WAH (NS)
Pond Creek 7.5 to 11.7	KY501042_03	<i>E. coli</i>	Non-point Source	PCR (PS)
		Cadmium	Petroleum /Natural Gas Production Activities; Non- point Source; Legacy Coal Extraction	WAH (NS)
		Iron	Petroleum /Natural Gas Production Activities; Non- point Source; Legacy Coal Extraction	WAH (NS)
Pond Creek 11.7 to 14.4	KY501042_04	Cadmium ⁽⁴⁾	Surface Mining; Legacy Coal Extraction; Petroleum /Natural Gas Production Activities	WAH (NS)
		Iron ⁽⁴⁾	Surface Mining; Legacy Coal Extraction; Petroleum /Natural Gas Production Activities	WAH (NS)
Pond Creek 14.4 to 18.1	KY501042_05	<i>E. coli</i>	Non-point Source	PCR (NS)
		Lead	Upstream Source	WAH (NS)
Pond Creek 18.1 to 18.7	KY501042_06	<i>E. coli</i>	Non-point Source	PCR (NS)
Saltlick Creek 0.0 to 3.7	KY502844_01	<i>E. coli</i>	Non-point Source	PCR (NS)
Sandlick Creek 0.0 to 4.05	KY502963_01	<i>E. coli</i>	Non-point Source	PCR (PS)
		Iron ⁽⁴⁾	Source Unknown	WAH (PS)
		Lead ⁽⁴⁾	Source Unknown	WAH (PS)
UT of Bat East Creek 0.0 to 1.9	KY486462-6.1_01	<i>E. coli</i>	Non-point Source	PCR (NS)
UT of Bat East Creek 0.0 to 3.55	KY486462-1.6_01	<i>E. coli</i>	Non-point Source	PCR (NS)
UT of Caney Creek 0.0 to 2.6	KY488838-2.3_01	<i>E. coli</i>	Municipal (Urbanized High Density Area); Urban Runoff / Store Water; Upstream Source	PCR (PS)
		Lead ⁽⁴⁾	Source Unknown	WAH (PS)
UT of Caney Creek 0.0 to 2.3	KY488838-1.8_01	<i>E. coli</i>	Loss of Riparian Habitat; Non-point Source	PCR (NS)
		Lead ⁽⁴⁾	Source Unknown	WAH (NS)

Total Maximum Daily Load (TMDL) Synopsis

Waterbody	GNIS Number⁽¹⁾	Pollutant	Suspected Sources	Impaired Use⁽²⁾ (Support Status)⁽³⁾
UT of Plum Creek 0.0 to 2.45	KY500964- 1.65_01	pH	Legacy Coal Extraction	PCR (NS), SCR (NS), WAH (NS)
		Cadmium	Legacy Coal Extraction	WAH (NS)
		Iron ⁽⁴⁾	Legacy Coal Extraction	WAH (NS)
		Nickel	Legacy Coal Extraction	WAH (NS)
		Zinc	Legacy Coal Extraction	WAH (NS)
UT of Pond Creek 0.0 to 2.4	KY501042-6.9_01	Iron	Surface Mining; Legacy Coal Extraction	WAH (NS)
UT of Pond Creek 2.4 to 4.2	KY501042-6.9_02	<i>E. coli</i>	Non-point Source; Rural Residential Areas	PCR (NS)
		pH	Surface Mining; Legacy Coal Extraction	PCR (NS), SCR (PS), WAH (NS)
		Cadmium ⁽⁴⁾	Surface Mining; Legacy Coal Extraction	WAH (NS)
UT of Pond Creek 0.0 to 1.4	KY501042- 11.1_01	Cadmium	Upstream Source; Legacy Coal Extraction	WAH (NS)
<p>⁽¹⁾ It is a combination of the Geographic Names Information System (GNIS) number and a 2-digit suffix denoting the segment. Any additional numbers following the GNIS number but before the segment number denote the river miles of unnamed tributaries.</p> <p>⁽²⁾ PCR: Primary Contact Recreation; SCR: Secondary Contact Recreation; WAH: Warm Water Aquatic Habitat</p> <p>⁽³⁾ NS: Non-Support; PS: Partial Support</p> <p>⁽⁴⁾ Included in 2016 303(d) List</p>				

Total Maximum Daily Load (TMDL) Synopsis

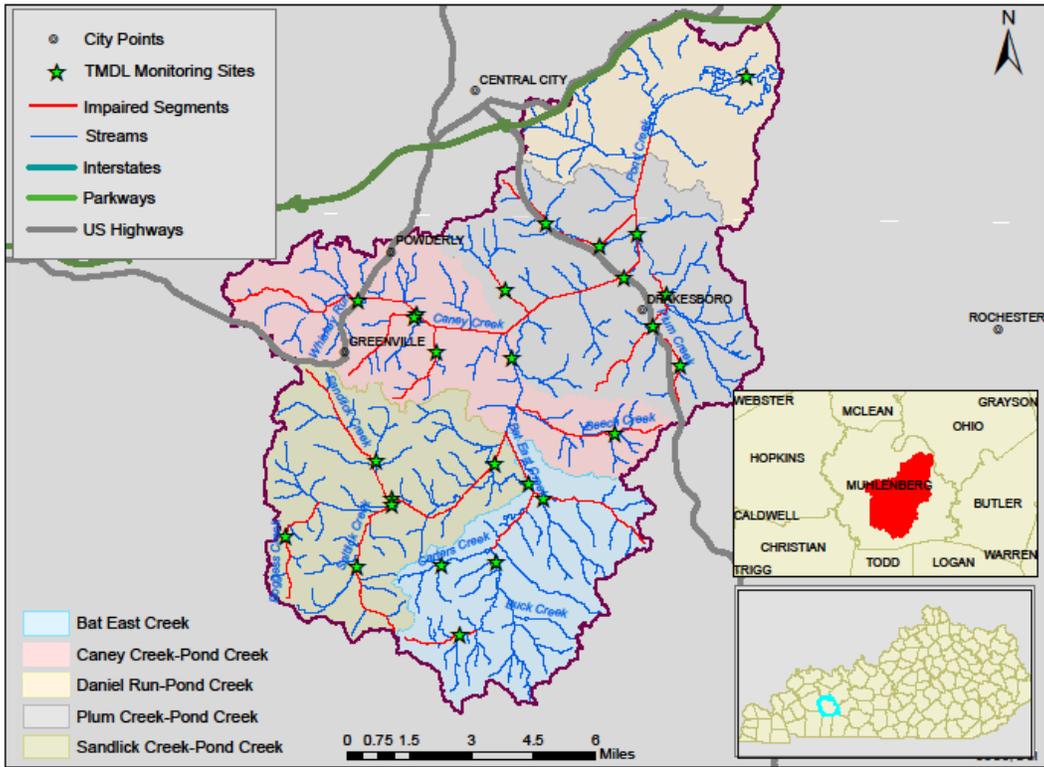


Figure S.1 Location of the Pond Creek Watershed, TMDL Sampling Stations and Impaired Stream Segments

Kentucky Water Quality Criteria (WQC) and the TMDL Endpoint (i.e. Water Quality Standard/ TMDL Target):

Table S.2 *E. coli* WQC and TMDL Endpoint

Condition	WQC, colonies/100ml ⁽¹⁾	TMDL Load, colonies/day ⁽²⁾
Instantaneous	240	$Q_s \times 240 \times 24,465,758.4$
Geomean	130	$Q_s \times 130 \times 24,465,758.4$

⁽¹⁾ ml: milliliter
⁽²⁾ Q_s is the flow in the stream in cubic feet per second (cfs or ft³/s).

Table S.3 pH WQC and TMDL Endpoint

Condition	WQC, pH standard units	TMDL Load, Hydrogen Ions, pounds/day ⁽¹⁾
All Conditions	6.0 (upper limit of hydrogen ion loading)	$Q_s \times 2.060$
All Conditions	9.0 (lower limit of hydrogen ion loading)	$Q_s \times 2.060E-3$

⁽¹⁾ Q_s is the flow in the stream in cfs.

Total Maximum Daily Load (TMDL) Synopsis

Table S.4 Iron WQC and TMDL Endpoint

Condition	WQC, mg/L ⁽¹⁾	TMDL Load, pounds/day ⁽²⁾
Chronic- aquatic life has not been shown to be adversely affected	3.5	$Q_S \times 18.8782$
Chronic-aquatic life is adversely affected	1.0	$Q_S \times 5.3938$
Acute	4.0	$Q_S \times 21.5751$
⁽¹⁾ mg/L: milligram per liter ⁽²⁾ Q_S is the flow in the stream in cfs.		

Table S.5 Cadmium, Copper, Lead, Nickel and Zinc WQCs and TMDL Endpoints

Condition	WQC ⁽¹⁾ , µg/L ⁽²⁾	TMDL Load, pounds/day ⁽³⁾
Cadmium		
Chronic	$e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Acute	$e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
Copper		
Chronic	$e^{(0.8545 * (\ln(\text{hardness})) - 1.702)}$	$Q_S \times 0.005394 \times e^{(0.8545 * (\ln(\text{hardness})) - 1.702)}$
Acute	$e^{(0.9422 * (\ln(\text{hardness})) - 1.700)}$	$Q_S \times 0.005394 \times e^{(0.9422 * (\ln(\text{hardness})) - 1.700)}$
Lead		
Chronic	$e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Acute	$e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$
Nickel		
Chronic	$e^{(0.846 * (\ln(\text{hardness})) + 0.0584)}$	$Q_S \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 0.0584)}$
Acute	$e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$	$Q_S \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$
Zinc		
Chronic	$e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$	$Q_S \times 0.005394 \times e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$
Acute	$e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$	$Q_S \times 0.005394 \times e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$
⁽¹⁾ Hardness is in units of mg/L as CaCO ₃ . ⁽²⁾ µg /L: microgram per liter ⁽³⁾ Q_S is the flow in the stream in cfs.		

Table S.6 Net Alkalinity TMDL Endpoint

Condition	Net Alkalinity ⁽¹⁾ , pounds/day
All Conditions	≥ 0
⁽¹⁾ Net alkalinity is defined as the alkalinity in mg/L as CaCO ₃ minus the calculated acidity; the calculated acidity is determined using the following equation: Calculated Acidity, mg/l as CaCO ₃ = $50 \times ((10^{(3-\text{pH})}) + (3 \times \text{Fe mg/L}/55.8) + (2 \times \text{Mn mg/L}/54.9) + (3 \times \text{Al mg/L}/27))$.	

TMDL Equation and Calculations:

A TMDL calculation is performed as follows:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

Equation S.1

Where:

TMDL: the WQC, expressed as a load.

MOS: the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the relationship between effluent limits and water quality. For this TMDL, the MOS is implicit.

WLA: the Wasteload Allocation, which is the allowable loading of pollutants into the stream from Kentucky Pollutant Discharge Elimination System (KPDES) permitted sources.

KPDES-WLA: the WLA for the existing KPDES-permitted facilities which have discharge limits for the pollutants of concern.

MS4-WLA: the WLA for KPDES-permitted municipal separate stormwater sewer systems (MS4) (including cities, counties, roads and right-of-ways owned by the Kentucky Transportation Cabinet, universities and military bases). There is no MS4 community within this watershed area.

LA: the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.

Seasonality: yearly factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.

Critical Condition: the time period when the pollutant conditions are expected to be at their worst.

Existing Conditions: the load that exists in the watershed at the time of TMDL development (i.e., sampling) and is causing the impairment.

Load: concentration * flow * conversion factor.

Concentration: colonies per 100 milliliter (*E. coli*), milligrams per liter (mg/L) (iron, alkalinity, acidity), micrograms per liter (µg/L) (cadmium, copper, lead, nickel, zinc) or standard units (pH).

Flow (i.e., stream discharge): cubic feet per second (cfs).

Total Maximum Daily Load (TMDL) Synopsis

Table S.7 TMDLs and Allocations by Impaired Segments

Pollutant	Units	TMDL⁽¹⁾	MOS⁽²⁾	KPDES-WLA⁽³⁾	LA⁽⁴⁾
Bat East Creek 0.0 to 3.4					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
Copper (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.8545 \times (\ln(\text{hardness})) - 1.702)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.8545 \times (\ln(\text{hardness})) - 1.702)}$	$Q_{LA} \times 0.005394 \times e^{(0.8545 \times (\ln(\text{hardness})) - 1.702)}$
Copper (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(0.9422 \times (\ln(\text{hardness})) - 1.700)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.9422 \times (\ln(\text{hardness})) - 1.700)}$	$Q_{LA} \times 0.005394 \times e^{(0.9422 \times (\ln(\text{hardness})) - 1.700)}$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}$
Beech Creek 0.0 to 3.9					
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Nickel (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$
Nickel (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$
Zinc (Acute and Chronic) ⁽⁶⁾	pounds/day	$Q_S \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$	$Q_{LA} \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$
Bogges Creek 0.0 to 3.0					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
Caney Creek 0.0 to 3.6					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$

Total Maximum Daily Load (TMDL) Synopsis

Pollutant	Units	TMDL⁽¹⁾	MOS⁽²⁾	KPDES-WLA⁽³⁾	LA⁽⁴⁾
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
Caney Creek 3.6 to 7.6					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$
Carters Creek 0.0 to 3.1					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Opossum Run 0.0 to 1.6					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Plum Creek 0.0 to 1.65					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
Plum Creek 1.65 to 3.9					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
pH ⁽⁷⁾	standard units	6.0 ≤ pH ≤ 9.0	Implicit	6.0 ≤ pH ≤ 9.0	6.0 ≤ pH ≤ 9.0
Alkalinity, Acidity ⁽⁸⁾	mg/L as CaCO ₃	Net Alkalinity ≥ 0	Implicit	Net Alkalinity ≥ 0	Net Alkalinity ≥ 0
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$

Total Maximum Daily Load (TMDL) Synopsis

Pollutant	Units	TMDL⁽¹⁾	MOS⁽²⁾	KPDES-WLA⁽³⁾	LA⁽⁴⁾
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$
Nickel (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$
Nickel (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$
Zinc (Acute and Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$	$Q_{LA} \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$
Pond Creek 0.0 to 5.0					
Iron (Chronic) ⁽⁹⁾	pounds/day	$Q_S \times 18.878$	Implicit	$Q_{KPDES} \times 18.878$	$Q_{LA} \times 18.878$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Pond Creek 5.0 to 7.5					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Pond Creek 7.5 to 11.7					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$

Total Maximum Daily Load (TMDL) Synopsis

Pollutant	Units	TMDL⁽¹⁾	MOS⁽²⁾	KPDES-WLA⁽³⁾	LA⁽⁴⁾
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Pond Creek 11.7 to 14.4					
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Pond Creek 14.4 to 18.1					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$
Pond Creek 18.1 to 18.7					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Saltlick Creek 0.0 to 3.7					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Sandlick Creek 0.0 to 4.05					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$

Total Maximum Daily Load (TMDL) Synopsis

Pollutant	Units	TMDL⁽¹⁾	MOS⁽²⁾	KPDES-WLA⁽³⁾	LA⁽⁴⁾
UT of Bat East Creek 0.0 to 1.9					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
UT of Bat East Creek 0.0 to 3.55					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
UT of Caney Creek 0.0 to 2.6					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}{e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}{e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}{e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}{e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}$
UT of Caney Creek 0.0 to 2.35					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}{e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}{e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}{e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}{e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}$
UT of Plum Creek 0.0 to 2.45					
pH ⁽⁷⁾	standard units	$6.0 \leq \text{pH} \leq 9.0$	Implicit	$6.0 \leq \text{pH} \leq 9.0$	$6.0 \leq \text{pH} \leq 9.0$
Alkalinity, Acidity ⁽⁸⁾	mg/L as CaCO ₃	Net Alkalinity ≥ 0	Implicit	Net Alkalinity ≥ 0	Net Alkalinity ≥ 0
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Nickel (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}}{e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}}{e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}}$

Total Maximum Daily Load (TMDL) Synopsis

Pollutant	Units	TMDL⁽¹⁾	MOS⁽²⁾	KPDES-WLA⁽³⁾	LA⁽⁴⁾
Nickel (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$
Zinc (Acute and Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$	$Q_{LA} \times 0.005394 \times e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$
UT of Pond Creek 0.0 to 2.4					
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
UT of Pond Creek 2.4 to 4.2					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
pH ⁽⁷⁾	standard units	$6.0 \leq \text{pH} \leq 9.0$	Implicit	$6.0 \leq \text{pH} \leq 9.0$	$6.0 \leq \text{pH} \leq 9.0$
Alkalinity, Acidity ⁽⁸⁾	mg/L as CaCO ₃	Net Alkalinity ≥ 0	Implicit	Net Alkalinity ≥ 0	Net Alkalinity ≥ 0
UT of Pond Creek 0.0 to 1.4					
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$

⁽¹⁾ TMDLs for *E. coli* are expressed as the flow in the stream, Q_S in ft³/s, multiplied by the WQCs: i) 240 *E. coli* colonies/100 ml which must be met in at least 80% of all samples taken within a 30-day period during the Primary Contact Recreational season of May through October; ii) 130 *E. coli* colonies/100 ml as a geometric mean based on not less than 5 samples taken within a 30-day period during the Primary Contact Recreational season of May through October. Then the multiple of Q_S and WQC is converted into *E. coli* load (colonies/day) by multiplying the conversion factor of 24,465,758.4. TMDLs for metals are expressed as the flow in the stream, Q_S in ft³/s, multiplied by the WQC in mg/L or µg/L and the appropriate conversion factor to convert the multiple of flow and the WQC into to units of load (pounds/day). The conversion factors are: iron, chronic = 5.3938 (when the WQC of 1.0 mg/L is applied) or 18.8782 (when the WQC of 3.5 mg/L is applied); iron, acute = 21.575; cadmium, copper, lead, nickel and zinc, chronic and acute = 0.005394. Also, pH must remain between 6.0 and 9.0 standard units, inclusive.

⁽²⁾ The MOS is implicit, see Section 7.3.

⁽³⁾ The KPDES-WLA for *E. coli* is expressed as the flow in the stream due to KPDES-permitted sources with *E. coli* permit limits, Q_{KPDES} in ft³/s, multiplied by the WQCs and the conversion factor to convert the multiple of flow and the WQC into the unit of load (colonies/day). All KPDES-permitted dischargers must meet both

Total Maximum Daily Load (TMDL) Synopsis

instantaneous and geomean *E. coli* WQCs. The KPDES-WLA for metals is expressed as the flow in the stream due to KPDES-permitted sources with permit limits for the pollutants addressed by this TMDL, Q_{KPDES} , in ft^3/s , multiplied by the WQC and the appropriate conversion factor. All KPDES-permitted dischargers must meet both the chronic and acute criteria for pollutants addressed by this TMDL whose WQCs are expressed in both chronic and acute terms. New or expanded KPDES-permitted dischargers with reasonable potential will be allowed contingent upon them meeting WQCs of the pollutants addressed in this document.

- (4) The LA is expressed as the flow in the stream from natural background or due to legal but non-KPDES-permitted sources of the pollutants addressed by this TMDL, Q_{LA} , in ft^3/s , multiplied by the WQC and the appropriate conversion factor, see Section 5.2.
- (5) The chronic iron WQC is 1.0 mg/L since the aquatic life is adversely affected. The acute iron WQC is not dependent on impacts to aquatic life; it is 4.0 mg/L in all streams.
- (6) The chronic and acute WQCs for zinc are identical.
- (7) pH can be converted to a range of allowable loads of hydrogen ions in units of g/day (gram per day); a pH of 6.0 represents a maximum allowable load of hydrogen ions equal to $Q_S \times 2.906$ g/day, and a pH of 9.0 represents a minimum allowable load of $Q_S \times 2.906E-3$ g/day, where Q_S is the flow in the stream in ft^3/s . The TMDL can then be allocated to the KPDES-WLA and the LA based on the fraction of the streamflow each contributes.
- (8) Net alkalinity is defined as the alkalinity in mg/L as CaCO_3 minus the calculated acidity; the calculated acidity is determined using the following equation: Calculated Acidity, mg/L as $\text{CaCO}_3 = 50 \times ((10^{(3-\text{pH})}) + (3 \times \text{Fe mg/L}/55.8) + (2 \times \text{Mn mg/L}/54.9) + (3 \times \text{Al mg/L}/27))$. Monitoring and reporting of net alkalinity will be required both instream and at outfalls at the same frequency as iron and manganese are monitored and reported. Aluminum must be added to KPDES mining permits as report-only in order to determine the calculated acidity. Net alkalinity must be greater than or equal to zero (in both mg/L and pounds/day) in order to buffer metals hydrolysis which can lower pH below acceptable levels.
- (9) The chronic iron WQC is 3.5 mg/L since the aquatic life has not been shown to be adversely affected. The acute iron WQC is not dependent on impacts to aquatic life; it is 4.0 mg/L in all streams.

Translation of WLAs into Permit Limits

All KPDES- permitted facilities must meet permit limits based on the Water Quality Standards in 401 KAR 10:031. WLAs will be translated into KPDES permit limits as

1. an *E. coli* effluent gross limit of 130 colonies/100 ml as a monthly average and 240 colonies/100 ml as a maximum weekly average;
2. a pH effluent gross limit of between 6.0 and 9.0 standard units and shall not change more than 1.0 standard unit over a period of 24 hours;
3. a chronic iron (Fe) effluent gross limit of 1.0 mg/L if aquatic life is adversely affected and of 3.5 mg/L if aquatic life has not been shown to be adversely affected, and an acute iron effluent gross limit of 4.0 mg/L;
4. a chronic cadmium (Cd) effluent gross limit of $e^{(0.7409*(\ln(\text{hardness}))-4.719)}$ µg/L and $e^{(1.0166*(\ln(\text{hardness}))-3.924)}$ µg/L as an acute limit;
5. a chronic copper (Cu) effluent gross limit of $e^{(0.8545*(\ln(\text{hardness}))-1.702)}$ µg/L and $e^{(0.9422*(\ln(\text{hardness}))-1.700)}$ µg/L as an acute limit;
6. a chronic lead (Pb) effluent gross limit of $e^{(1.273*(\ln(\text{hardness}))-4.705)}$ µg/L and $e^{(1.273*(\ln(\text{hardness}))-1.460)}$ µg/L as an acute limit;
7. a chronic nickel (Ni) effluent gross limit of $e^{(0.846*(\ln(\text{hardness}))+0.0584)}$ µg/L and $e^{(0.846*(\ln(\text{hardness}))+2.255)}$ µg/L as an acute limit;
8. a chronic and acute zinc (Zn) effluent gross limits are identical as of $e^{(0.8473*(\ln(\text{hardness}))+0.884)}$ µg/L.

The WLA for the KPDES permittees which only contain requirements to develop a Stormwater Pollution Prevention Plan (SWPPP) will be addressed through possible revision and implementation of a SWPPP. The KYG050000 (Inactive Mine Lands General Permit) permittees are in compliance if they comply with the permit. KPDES mining permittees must meet the discharge limits set in their KPDES permits.

The following changes to KPDES mining permittees who discharge to a waterbody with a pH TMDL addressed by this document are required:

1. Permittees must report alkalinity in mg/L as CaCO₃ and aluminum in units of mg/L whenever and wherever iron and manganese are reported. However, for aluminum this is report-only, no discharge limit is established.
2. There must be sufficient net alkalinity present to buffer metals hydrolysis whenever and wherever iron and manganese are reported. Net alkalinity is defined as the alkalinity of the discharge water minus the calculated acidity; net alkalinity must be greater than or equal to zero. The calculated acidity will be determined using Equation S.2, from Hedin *et al.* (1991), which conservatively assumes iron is in the form of Fe³⁺:

$$\text{Calculated Acidity, mg/L as CaCO}_3 = 50 \times ((10^{(3-\text{pH})}) + (3 \times \text{Fe mg/L}/55.8) + (2 \times \text{Mn mg/L}/54.9) + (3 \times \text{Al mg/L}/27.0))$$

Equation S.2

If the net alkalinity is below zero, then a violation has occurred.

Total Maximum Daily Load (TMDL) Synopsis

These changes will be made to the existing mining permittees who discharge to a waterbody with a pH TMDL addressed by this document when their permits are renewed. These requirements apply to any new or expanded mining permits which discharge to a waterbody with a pH TMDL addressed by this document.

Table S.8 lists the KPDES permittees within the Pond Creek watershed, with the KPDES number, permittee name, permittee status (as of June 2016), permittee location and the pollutant (addressed in this TMDL only) limits in their permits or the requirements in the permits. The permittees, which are inactive, were active during the data collection period and contributed to the impairment; those permittees will not receive a WLA.

Table S.8 KPDES Permittees within the Pond Creek Watershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KY0020010	Greenville STP	Yes	1.31	37.219167	-87.169444	bacteria, pH, Cd, Cu, Pb, Zn
KY0066575	Drakesboro STP	Yes	0.165	37.217222	-87.040833	bacteria, pH, Cd, Cu, Pb, Zn
KY0108537	Shaunaco LLC (889-0145)	Yes	0	37.228611	-87.218889	pH, Cd, Cu, Fe, Pb, Ni, Zn
KY0109606	Greenville Bulk Plant	Yes	0	37.212500	-87.184700	pH
KY0111996	Oxford Mining Co Kentucky LLC (889-0153)	Yes	0	37.265000	-87.094056	pH, Fe
KYG045755	Oxford Mining Co Ky LLC (889-0156)	Yes	0	37.179722	-87.113889	pH, Fe
KYG046498	Oxford Mining Co Kentucky LLC (889-0153)	Yes	0	37.265000	-87.094056	pH, Fe
KYG640029	Central City Water & Sewer	Yes	0.0005	37.173800	-87.073000	pH, Fe
KYG640108	Greenville Utilities Commission	Yes	0.027	37.113900	-87.103200	pH, Fe
KYGW40011	Thoroughfare Mining LLC (889-5018)	Yes	0	37.294720	-87.053060	bacteria, pH, Fe
KYGW40062	Armstrong Coal Co Inc (Consolidated)	Yes	0	37.294990	-87.052770	pH, Fe
KYP000064	Powderly, City of	Yes	0	37.235833	-87.163889	discharge to Greenville WWTP
KYR003239	Central Pallet Mills	Yes	0	37.237167	-87.121083	pH and to develop a SWPPP
KYR004015	Carl Mitchell & Son Implement - Paradise Rd	Yes	0	37.238014	-87.120822	pH and to develop a SWPPP

Total Maximum Daily Load (TMDL) Synopsis

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYR004021	Harsco Minerals	Yes	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR10J469	Muhlenberg County Airport	Yes	0	37.222067	-87.164333	to develop a SWPPP
KYR10K083	Owensboro Health Greenville Clinic	Yes	0	37.196391	-87.187716	to develop a SWPPP
KYR10K315	Western Kentucky Lateral	Yes	0	37.209464	-87.209069	to develop a SWPPP
KYR10K433	Owensboro Health Muhlenberg Healthplex	Yes	0	37.238889	-87.150189	to develop a SWPPP
KY0023329	Bremen Consolidated School	No	0.008	37.214000	-87.132800	bacteria
KY0099538	Texas Gas Transmission LLC - West Greenville	No	0	37.211111	-87.206944	pH
KY0106046	C & R Coal Co Inc (889-0151)	No	0	37.208333	-87.090000	pH, Fe
KY0107701	Armstrong Coal Co Inc (889-5014)	No	0	37.298889	-87.059167	pH, Cd, Cu, Fe, Pb, Ni, Zn
KYG043169	Black Hills Coal Inc (889-7010)	No	0	37.211111	-87.228611	pH, Fe
KYG043563	Beech Creek Energy Inc (889-0062)	No	0	37.196944	-87.051389	pH, Fe
KYG043825	Muhlenberg Coals Inc (889-0066)	No	0	37.250278	-87.068889	pH, Fe
KYG044318	Armstrong Coal Co Inc (889-0138)	No	0	37.294167	-87.043333	pH, Fe
KYG044386	Beech Creek Energy Inc (889-0062)	No	0	37.196944	-87.051389	pH, Fe
KYG044486	G & G Energies Inc (889-0074)	No	0	37.170457	-87.194335	pH, Fe
KYG044573	Friendship Energy Inc (889-0079)	No	0	37.217528	-87.175069	pH, Fe
KYG044789	Beech Creek Energy Inc (889-0084)	No	0	37.170833	-87.056111	pH, Fe

Total Maximum Daily Load (TMDL) Synopsis

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG044998	Beech Creek Energy Inc (889-0093)	No	0	37.186944	-87.070556	pH, Fe
KYG045704	Schoate Mining Co LLC (889-0155)	No	0	37.245000	-87.108333	pH, Fe
KYG046025	C & R Coal Co Inc (889-0126)	No	0	37.178333	-87.092778	pH, Fe
KYG046026	C & R Coal Co Inc (889-0122)	No	0	37.175833	-87.086944	pH, Fe
KYG046617	Armstrong Coal Co Inc (889-9005)	No	0	37.290278	-87.060278	pH, Fe
KYG046775	Armstrong Coal Co Inc (889-5014)	No	0	37.295000	-87.053600	pH, Fe
KYR000524	Central Pallet Mill Inc	No	0	37.220000	-87.118333	pH and to develop a SWPPP
KYR000918	Harsco Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR001665	Carl Mitchell & Son Implement	No	0	37.239428	-87.121152	pH and to develop a SWPPP
KYR001693	Meuth Construction Supply	No	0	37.243362	-87.085699	pH and to develop a SWPPP
KYR00A008	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR00A009	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR10E810	Muhlenberg Co High School Phas 3	No	0	37.216500	-87.189224	to develop a SWPPP
KYR10E960	Muhlenberg County Emergency SE	No	0	37.235680	-87.151550	to develop a SWPPP
KYR10F821	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10G145	Greenville WWTP	No	0	37.220472	-87.169111	to develop a SWPPP
KYR10G154	Knight Construction & Excavating Inc	No	0	37.212776	-87.196388	to develop a SWPPP
KYR10G285	Pogue Chrysler	No	0	37.229353	-87.157828	to develop a SWPPP
KYR10G428	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G429	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP

Total Maximum Daily Load (TMDL) Synopsis

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYR10G456	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G458	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G631	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10G632	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10H138	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10H705	Muhlenberg County Park Phase I	No	0	37.226610	-87.187427	to develop a SWPPP
KYR10I149	Pogue Electric Service Inc.	No	0	37.224749	-87.172138	to develop a SWPPP
KYG044105	Cleaton Coal Co (889-5014)	No	0	37.298889	-87.059167	pH, Fe
KYG050000*	N/A	N/A	N/A	N/A	N/A	N/A
<p>* KYG050000 is the Inactive Mine Lands General Permit, see Section 1 of the KPDES Permit KYG050000 for more information regarding the permit coverage eligibility and exclusions. As long as the permittees make good faith effort to comply with the permit, they are considered to be compliant with the TMDL. N/A: Not Applicable</p>						

1.0 Introduction

Section 303(d) of the Clean Water Act (CWA) requires States to identify waterbodies within their boundaries that have been assessed and are not currently meeting their designated uses (401 KAR 10:026 and 10:031) and that require the development of Total Maximum Daily Loads (TMDLs). States must establish a priority ranking for such waters, taking into account their intended uses and the severity of pollutants. Section 303(d) also requires that States provide a list of this information called the 303(d) list. This list is submitted to the Environmental Protection Agency (EPA) during even-numbered years and each submittal replaces the previous list.

States are also required to develop TMDLs for pollutants that cause each waterbody to fail to meet its designated uses. The TMDL process establishes the allowable amounts (i.e. “load”) of pollutants the waterbody can naturally assimilate while continuing to meet the water quality criteria (WQC) for each designated use. A pollutant load must be established at a level necessary to implement the applicable WQC with seasonal variations and a Margin of Safety (MOS) that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. This load is then divided among different sources of the pollutant in a watershed. Information on TMDLs from EPA can be found at: <http://www.epa.gov/owow/tmdl>.

2.0 Problem Definition

Pond Creek watershed is located in the United States Geological Survey (USGS) 8-digit hydrologic unit code (HUC) 05110003 and is designated with a 10-digit HUC 0511000304. Pond Creek is approximately 22 miles long and drains an area of 127 square miles, flowing into the Green River near Rockport, Kentucky. Major tributaries in the Pond Creek watershed include Bat East Creek, Beech Creek, Caney Creek, Plum Creek, Saltlick Creek, and Sandlick Creek.

2.1 303(d) Listing History

Monitoring of Pond Creek and its tributaries was conducted at 14 locations by the KDOW, Murray State University (MSU) and Western Kentucky University (WKU) between 1997 and 2001 and in 2006, see Figure 4.1 and Table 4.1. The monitoring efforts determined that thirteen waterbodies within the Pond Creek watershed did not support their designated uses for warm water aquatic life and/or primary and secondary contact recreation. Those waterbodies were listed as impaired on the 2010 303(d) list (KDOW 2010).

Since November 2010, KDOW TMDL monitoring staff revisited the Pond Creek watershed at 26 sites on Pond Creek and its tributaries. The most recent monitoring results revealed additional impaired segments or additional pollutants for existing impaired segments. The new impairments were included in the 2014 303(d) List (KDOW 2014). Some segments listed in 2010 303(d) have different River Miles (RMs) on the 2014 303(d) list due to more accurate National Hydrology Data (NHD). However, the physical stream segments and GNIS numbers are the same.

The TMDL monitoring staff collected more data on 20 of 26 sites since the 2014 303(d) List, and the new impairments will be included in the 2016 303(d) List, see Table S.1.

2.2 TMDLs in the Watershed

The CWA requires states to develop TMDLs for pollutants that cause each waterbody to fail to meet its designated uses. Two pH TMDLs were developed for this watershed and approved by EPA:

1. The Beech Creek pH TMDL addressed one segment, Beech Creek 0.0 to 3.9, and was approved by EPA in 2006 (KDOW 2006).
2. The Pond Creek pH TMDL addressed four pH-impaired segments: Pond Creek 9.4-13.6, Pond Creek 13.6-16.3, Pond Creek 16.3-20.0 and Pond Creek 20.0-23.8. The document was approved by EPA in 2007 (KDOW 2007).

This document addresses bacteria, pH and metals (cadmium, copper, iron, lead, nickel and zinc) for 25 impaired waterbodies. Table S.1 shows the segments and pollutants addressed in this TMDL document. KDOW also developed a Health Report for Pond Creek watershed including information on these and other pollutants, which can be accessed at <http://water.ky.gov/waterquality/TMDL%20Health%20Reports/Pond%20Creek%20Watershed%20Health%20Report.pdf>

3.0 Physical Setting

The Pond Creek watershed is located in central Muhlenberg County, Kentucky (Figure S.1). Its catchment area is approximately 127 square miles. Pond Creek is approximately 22 miles long and flows into Green River near Rockport, Kentucky. Pond Creek is a 5th order stream with 257 miles of tributaries based on the 1:24,000-scale NHD.

3.1 Geology

Pond Creek watershed lies within the Western Coal Field ecoregion of the Interior River Valleys and Hills Level III ecoregion (Woods *et al.*, 2002). It is underlain primarily by the Carbondale Formation of Middle Pennsylvanian age, Quaternary Alluvium, the Tradewater Formation of Middle to Lower Pennsylvanian age, and the Shelburn Formation of Upper Pennsylvanian age (KGS, 2004), see Figure 3.1.

Coal beds in the watershed include the Baker (also known as the Western Kentucky (WKY) Coal Bed Number 13, or WKY#13), Bancroft, Coiltown (WKY#14), Davis (WKY#6), Springfield (WKY#9), DeKoven (WKY#7) Herrin (WKY#11), Paradise (WKY#12), and the Mannington, Mining City, and Lewisport (WKY#4), and an unnamed coal bed, see Figure 3.2.

The sulfur content of coal, mostly from pyrite, is responsible for the production of sulfuric acid once the spoils are exposed to water and oxygen. Sulfuric acid is the predominant acid type in Acid Mine Drainage (AMD) although not all coal mining produces AMD that affects streams, see Section 5.1.2.1. The sulfur content of coal usually varies spatially, but any coal with average sulfur content of greater than or equal to 2.5% is considered to be high in sulfur (Jacobsen, 1993). The sulfur contents of the coal seams mined within the TMDL watershed are shown in Table 3.1.

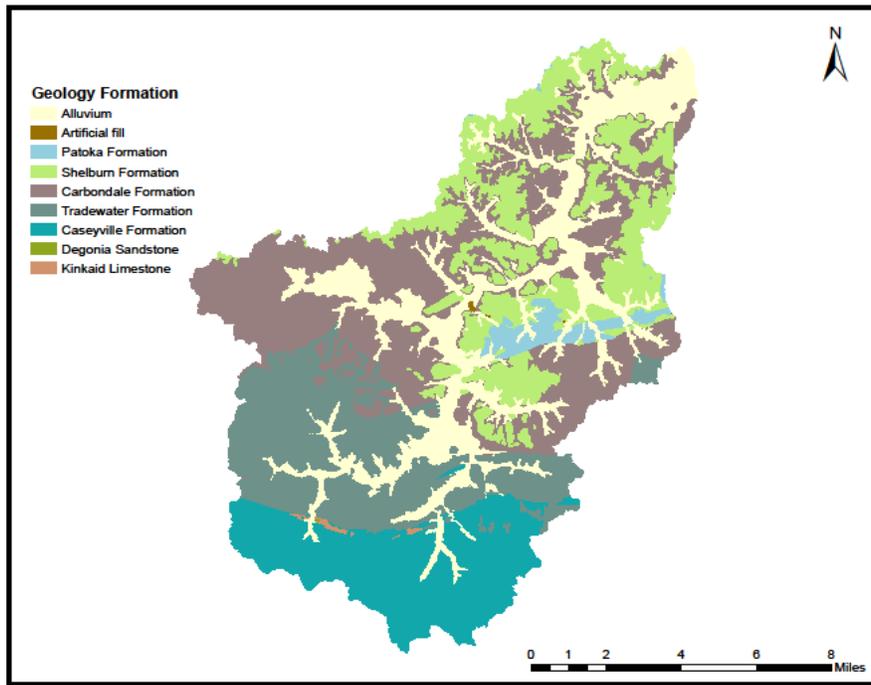


Figure 3.1 Generalized Geology within the Pond Creek Watershed

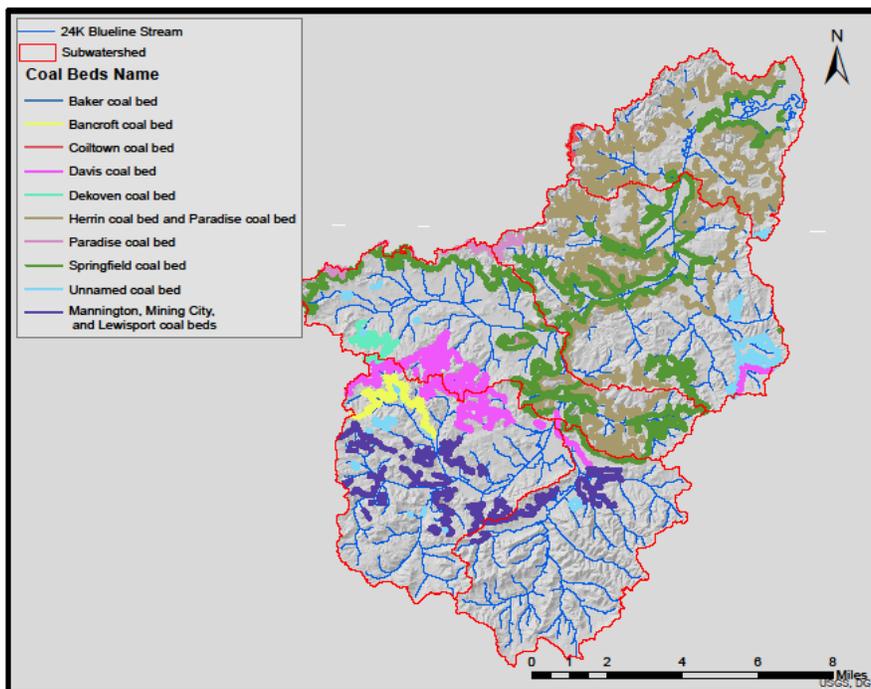


Figure 3.2 Mapped Coal Beds within the Pond Creek Watershed

Table 3.1 Average Total Sulfur Percentages for Coal Beds in the TMDL Watershed

Coal Bed	Average Total Sulfur, %	Source
Mannington, Mining City, and Lewisport (WKY#4)	3.01	Grebe, Williams, Williamson (1992)
Springfield (WKY#9)	3.3	Grebe, Williams, Williamson (1992)
Herrin (WKY#11)	3.98	Grebe, Williams, Williamson (1992)
Davis (WKY#6)	2.9	Grebe, Williams, Williamson (1992)
Coiltown (WKY#14)	3.2	Grebe, Williams, Williamson (1992)
DeKoven (WKY#7)	3.7	Jacobsen (1993)
Paradise (WKY#12)	3.3, 2.0	KGS (Proximate Analysis Downloaded 4/17/2014) Grebe, Williams, Williamson (1992)
Bancroft	NI ⁽¹⁾	
Baker (WKY#8b)	3.5	Grebe, Williams, Williamson (1992)
⁽¹⁾ No information.		

No information was found for the Bancroft coal bed, but Grebe *et al.* (1992) state “the coal of the Western Kentucky Coal Field is characterized as high-sulfur coal. Although coal with medium to even low sulfur contents occurs in the coal field, the majority of the coal produced is high in sulfur content. The average sulfur contents of the seven coal beds with the largest resources are all more than 3 percent.”

The range of soil pH value in the watershed is from 3.8 to 6.7, see Figure 3.3. The soil pH is lower in the upstream area with the values less than 5, while it’s around 6 in downstream area. Table 3.2 displays the statistical summary for ambient soil inorganic chemicals in Kentucky (KDEP, 2004).

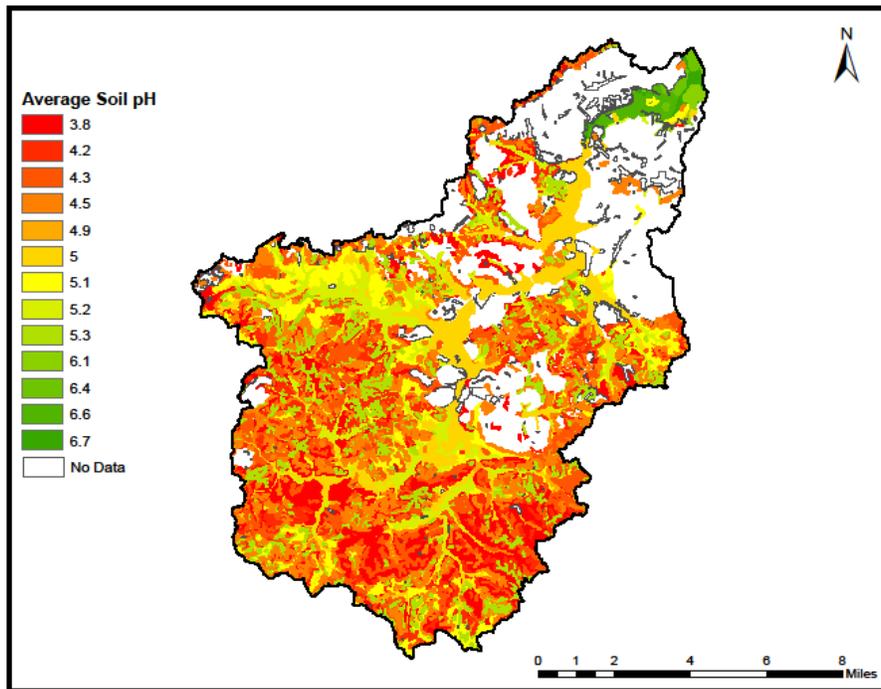


Figure 3.3 Average Soil pH Value within the Pond Creek Watershed

Table 3.2 Kentucky Statewide Summary Statistics for Ambient Soil Inorganic Chemicals

Element	Number of Samples	Range (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)
Cadmium	701	0.004 - 9.46	0.68	1.4
Copper	729	0.49 - 636	18.9	39.7
Iron	697	222 - 86,900	22456	13269.7
Lead	808	0.03 - 284	30	31.3
Nickel	716	0.39 - 83.7	20.9	13.1
Zinc	721	6 - 470	55	46.3

Geologic faults occur in the Pond Creek watershed. Springs are common in the watershed. Pond Creek is not prone to karst development throughout the majority of the watershed, although moderate potential for karst occurs near the headwaters, see Figure 3.4.

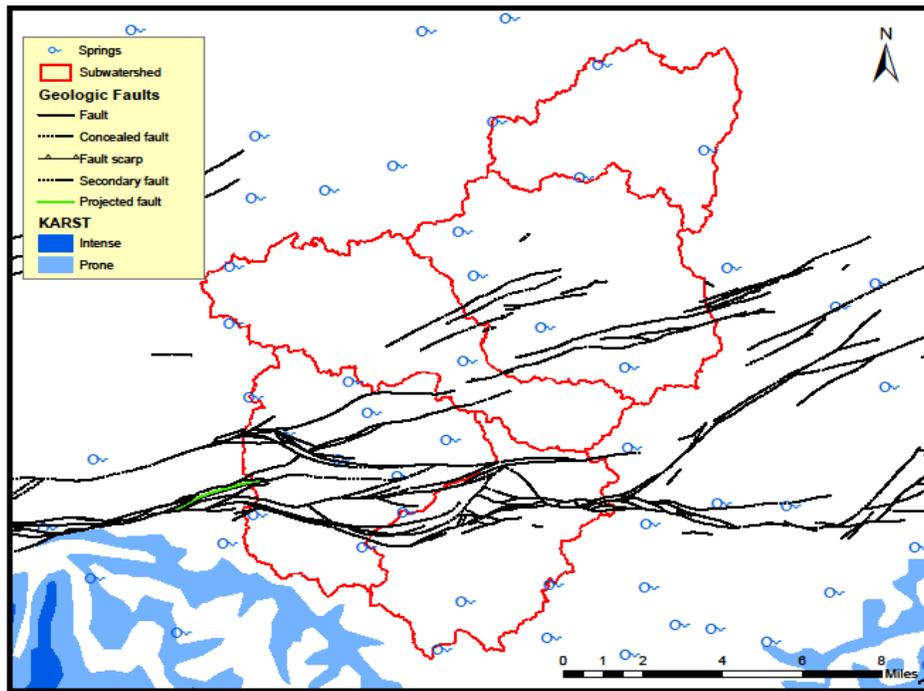


Figure 3.4 Geologic Faults, Springs, and Karst within the Pond Creek Watershed

The whole Pond Creek watershed is rated as 3 in groundwater sensitivity see Figure 3.5. Because much of the watershed is underlain by soluble carbonate rocks where dissolution fractures can develop, groundwater in the watershed is susceptible to contamination from surface activities. Dye traces have not been conducted in this watershed. Dye traces would provide data to understand connections between karst features and underground flow routes.

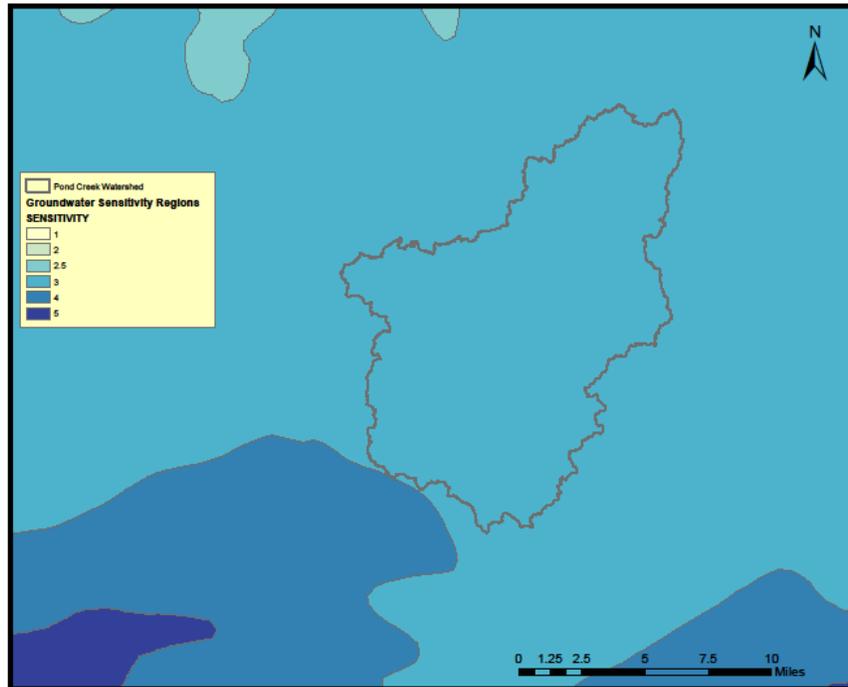


Figure 3.5 Groundwater Sensitivity Regions Map

Soil erosion and runoff due to precipitation can both move pollutants to a stream or to groundwater. Figure 3.6 shows the hydrologic soil groups (HSG) in the Pond Creek watershed. The HSG is used to relay information about the runoff potential of a soil when thoroughly wet. For runoff potential, ratings are low, moderately low, moderately high, and high for HSGs A, B, C and D, respectively (United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS), 2009). Dual HSGs (A/D, B/D, and C/D) are given for certain wet soils that could be adequately drained. The first letter applies to the drained and the second to the undrained condition. Soils are assigned to dual groups if the depth to a Permanent water table is the sole criteria for assigning a soil to hydrologic group D (USDA-NRCS, 2009). One third of the Pond Creek watershed, mostly in the downstream portion, is not rated in terms of hydrologic soil groupings. For the rated area, the dominant HSG is C, which indicates that this watershed has moderately high runoff potential.

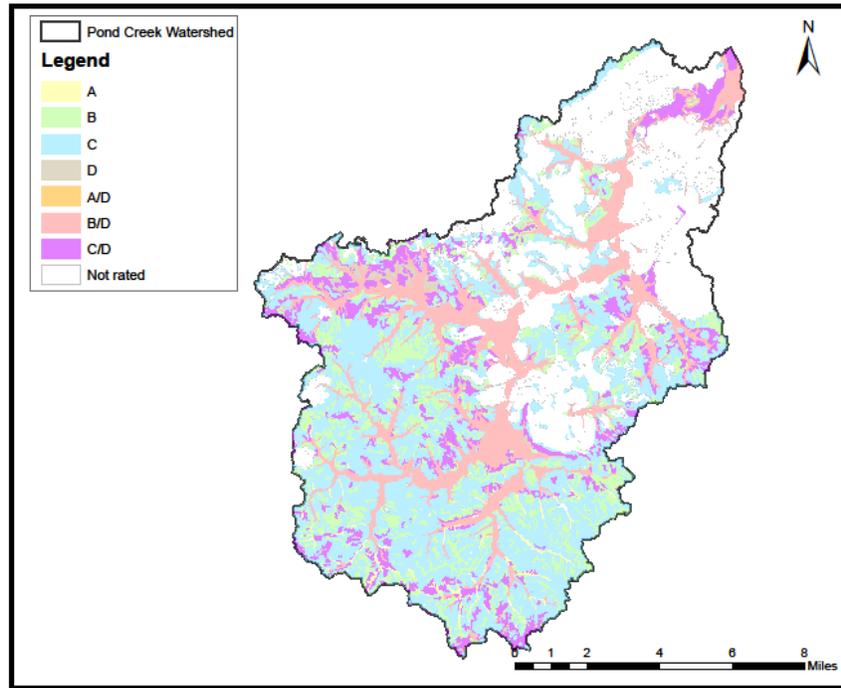


Figure 3.6 Soil Hydrology Group in the Pond Creek Watershed

The USDA-NRCS rates the performance of septic tank absorption fields, defined as the area in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Soil ratings are based on soil properties, site features, and the observed performance of the soils. Parameters such as permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of septic tank effluents. One third of the Pond Creek watershed, mostly in the downstream portion, is not rated. The majority of the rest of the watershed is rated as very limited in terms of septic tank absorption suitability, see Figure 3.7.

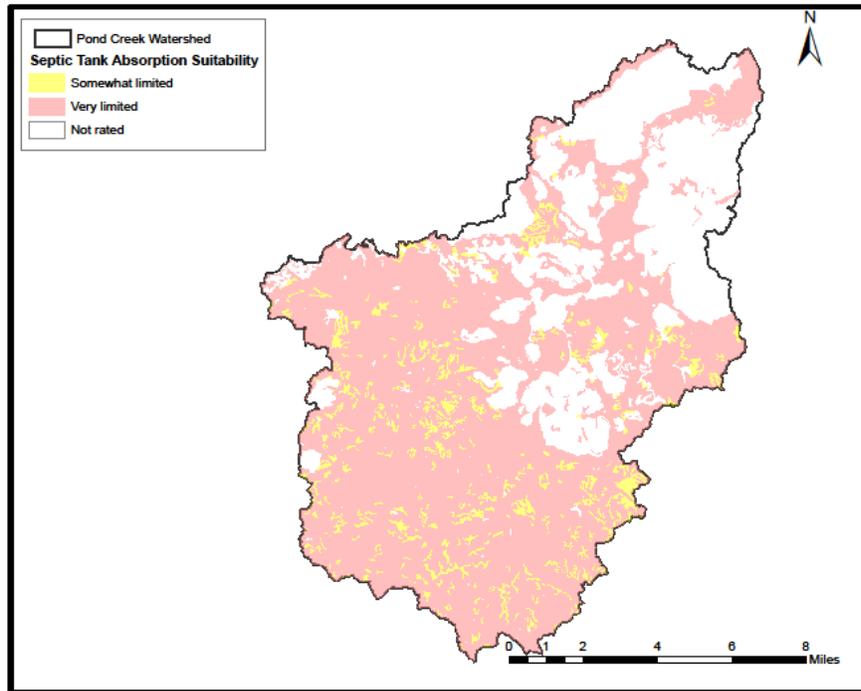


Figure 3.7 Soil Suitability for Septic Tanks in the Pond Creek Watershed

3.2 Hydrology

Stream orders were mapped using the 1:00,000-scale NHD, see Figure 3.8. Stream order was determined using the Strahler (1952) method. These streams are generally low-gradient with wetlands along portions of their lengths.

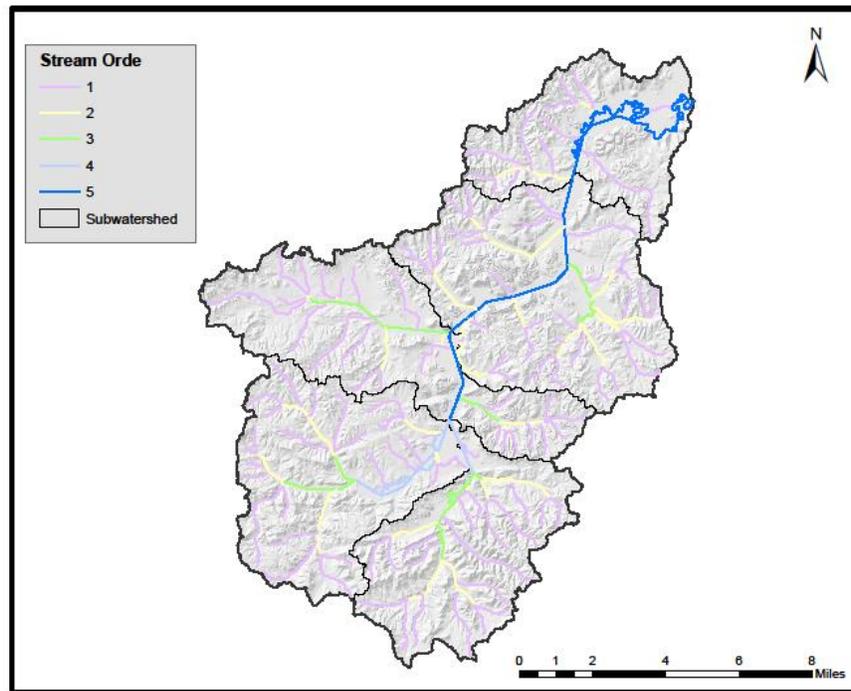


Figure 3.8 Stream Orders within the Pond Creek Watershed

Due to the lack of environmental controls during the period prior to the passage of the 1977 SMCRA (see Section 9.4.2), watershed areas must be considered approximate wherever coal operations exist from this era, as often large portions of watersheds had their drainage rerouted, and mapped boundaries may therefore be incorrect. Current mining permits require the return of the area mined to the Approximate Original Contour, reducing or eliminating the impact on watershed boundaries.

3.3 Land Cover Distribution

The 2011 National Land Cover Dataset (NLCD, 2011) was used to determine the land cover within the Pond Creek watershed. The NLCD Land Cover Class Definitions are in Appendix A. Table 3.3 lists the percent land cover by class within the watershed. To simplify the pollutant source analysis, some similar land cover categories were combined. All forested land (deciduous, evergreen and mixed) was aggregated and reported as one category - Forest; all residential land cover was aggregated and reported as one category - Developed; all wetland types were aggregated and reported as one category - Wetlands; and all agricultural land uses were aggregated into one category – Agriculture. Individual land covers are also presented in Figure 3.9.

The watershed land cover consists primarily of forest land (50.3%) and agriculture land (28.1%), see Table 3.3 and Figure 3.9.

Table 3.3 Land Cover within the Pond Creek Watershed (NLCD 2011)

Land Cover	% of Total Area	Square Miles
Developed	7.0	8.95
Water	2.1	2.61
Barren Land	0.6	0.72
Forest	50.3	64.00
Grassland	8.6	10.93
Agriculture	28.1	35.78
Pasture/Hay	18.5	23.54
Cultivated Crops	9.6	12.24
Wetland	3.0	3.88
Shrub/Scrub	0.2	0.31

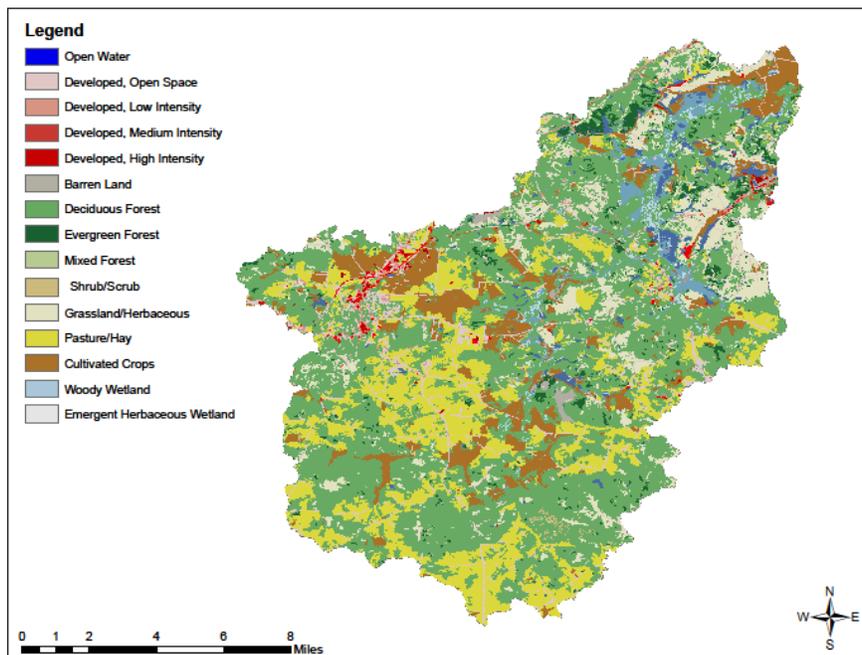


Figure 3.9 Land Cover within the Pond Creek Watershed (NLCD 2011)

3.4 Mining Activity

Mining is also a significant land use, with both active and inactive mines in the watershed. Coal, oil, and natural gas are among the natural resources of Muhlenberg County. Coal is the county’s important revenue-producing natural resource, and at one time Muhlenberg County was the largest coal-producing county in the United States. In 1973, this county produced over 19 million

tons of coal from strip mines and over 5 million tons from underground mines. The Pond Creek watershed contains three main land uses: resource extraction (mining and disturbed land area), forest, and agriculture.

The Kentucky Division of Mine Safety (KDMS, formerly the Office of Mine Safety and Licensing) licenses all mines, surface and underground, to operate from a safety as opposed to a revenue or environmental perspective. KDMS began scanning their available maps of mined out areas in 2004 and makes the map available as electronic files and as interactive maps in a GIS (Geographic Information System) framework on the Kentucky Mine Mapping Information System, <http://minemaps.ky.gov/MineSearch.aspx>. Figure 3.10 displays the mined out area maps in this watershed and Table 3.4 presents the data from KDMS. Of the Pond Creek watershed, 4.1% are surface mined out areas with the acreage of 3,362, 2.5% are underground mined out areas with the acreage of 2,029, and 41% are unknown mined out areas with 33,187 acres.

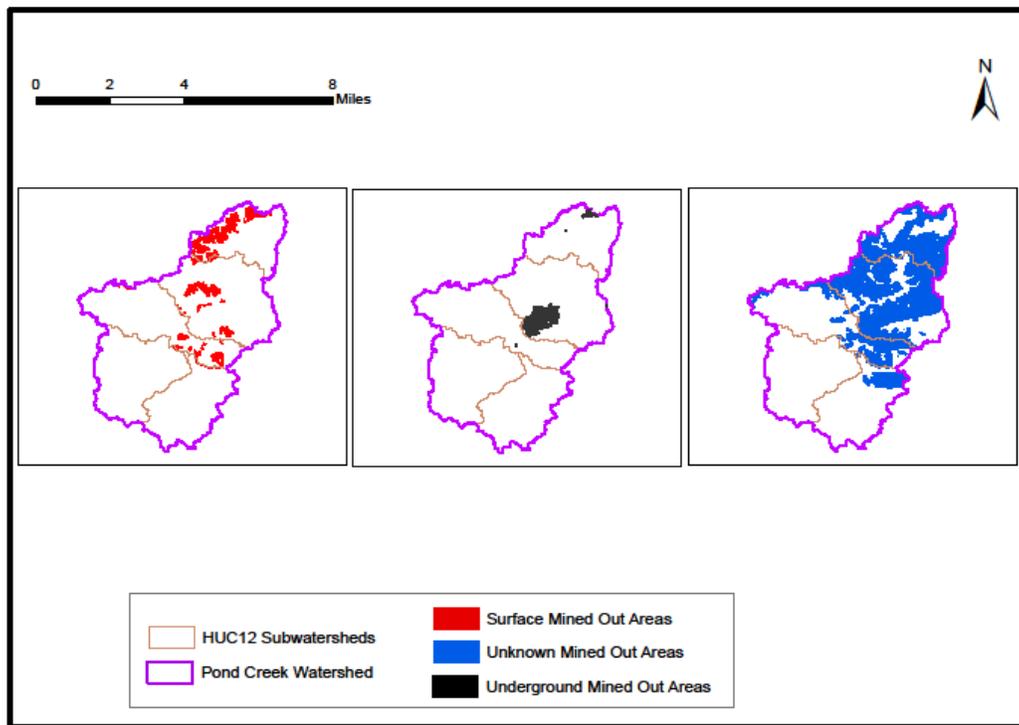


Figure 3.10 Mined Out Areas within the Pond Creek Watershed

Table 3.4 Data from the Office of Mine Safety and Licensing on Mined Out Areas in the Pond Creek Watershed

State File Number	SEAM	Mine Type	Surface/Subsurface	Status
04251	585	Auger-Strip Water Coal	Surface	Abandoned

State File Number	SEAM	Mine Type	Surface/Subsurface	Status
02106	585	Unknown	Unknown	Abandoned
04251	585	Auger-Strip Water Coal	Surface	Abandoned
04251	585	Auger-Strip Water Coal	Surface	Abandoned
02106	585	Unknown	Unknown	Abandoned
04251	585	Auger-Strip Water Coal	Surface	Abandoned
14136	585	Auger-Strip Truck Coal	Surface	Abandoned
04251	585	Auger-Strip Water Coal	Surface	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
09953	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
04251	585	Auger-Strip Water Coal	Surface	Abandoned
02106	580	Unknown	Unknown	Abandoned
-	580	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
00980	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
00723	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
02106	580	Unknown	Unknown	Abandoned

State File Number	SEAM	Mine Type	Surface/Subsurface	Status
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
04251	585	Auger-Strip Water Coal	Surface	Abandoned
06107	585	Auger-Strip Truck Coal	Surface	Abandoned
00825-2	585	Strip Truck Coal	Surface	Abandoned
-	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
10167	585	Unknown	Unknown	Abandoned
-	585	Unknown	Unknown	Abandoned
18152-2	600	Gob Strip Truck Coal	Surface	Active
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
09953	590	Unknown	Unknown	Abandoned
09953	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
04251	585	Auger-Strip Water Coal	Surface	Abandoned
18430-1	600	Strip Truck Coal	Surface	Active
00825-2	590	Strip Truck Coal	Surface	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
10167	590	Unknown	Unknown	Abandoned
06107	590	Auger-Strip Truck Coal	Surface	Abandoned
04444	590	Unknown	Unknown	Abandoned
09953	590	Unknown	Unknown	Abandoned
09953	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned

State File Number	SEAM	Mine Type	Surface/Subsurface	Status
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
00967	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
92789	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
90950	590	Unknown	Unknown	Abandoned
06107	590	Auger-Strip Truck Coal	Surface	Abandoned
90950	590	Unknown	Unknown	Abandoned
06107	590	Auger-Strip Truck Coal	Surface	Abandoned
-	590	Unknown	Unknown	Abandoned
-	590	Unknown	Unknown	Abandoned
06107	590	Auger-Strip Truck Coal	Surface	Abandoned
06107	590	Auger-Strip Truck Coal	Surface	Abandoned
01570	590	Unknown	Unknown	Abandoned
18152-2	590	Gob Strip Truck Coal	Surface	Active
18152-2	590	Gob Strip Truck Coal	Surface	Active
01570	590	Unknown	Unknown	Abandoned
18152-2	590	Gob Strip Truck Coal	Surface	Active
18152-2	590	Gob Strip Truck Coal	Surface	Active
18152-2	590	Gob Strip Truck Coal	Surface	Active
01570	590	Unknown	Unknown	Abandoned
01570	590	Unknown	Unknown	Abandoned
01570	590	Unknown	Unknown	Abandoned
01570	590	Unknown	Unknown	Abandoned
01570	590	Unknown	Unknown	Abandoned
01570	590	Unknown	Unknown	Abandoned
11949	590	Unknown	Unknown	Abandoned
-	595	Unknown	Unknown	Abandoned
-	595	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned

State File Number	SEAM	Mine Type	Surface/Subsurface	Status
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
02106	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
11324-3	600	Underground Truck Coal	Underground	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
06620-1	600	Unknown	Unknown	Abandoned
90540	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
00980	600	Unknown	Unknown	Abandoned
05032	600	Auger-Strip Truck Coal	Surface	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
05693	600	Unknown	Unknown	Abandoned
09509-3	600	Unknown	Unknown	Abandoned
92789	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
06107	600	Auger-Strip Truck Coal	Surface	Abandoned
05833	600	Unknown	Unknown	Abandoned
05833	600	Unknown	Unknown	Abandoned
01156	600	Underground Rail Coal	Underground	Abandoned
-	600	Unknown	Unknown	Abandoned
01156	600	Underground Rail Coal	Underground	Abandoned
06107	600	Auger-Strip Truck Coal	Surface	Abandoned
01156	600	Underground Rail Coal	Underground	Abandoned
06107	600	Auger-Strip Truck Coal	Surface	Abandoned
06107	600	Auger-Strip Truck Coal	Surface	Abandoned
06107	600	Auger-Strip Truck Coal	Surface	Abandoned
10888	600	Unknown	Unknown	Abandoned
17740-2	600	Auger-Strip Truck Coal	Surface	Abandoned
17740-2	600	Auger-Strip Truck Coal	Surface	Abandoned
09628-1	600	Unknown	Unknown	Abandoned
05520	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
11126	600	Unknown	Unknown	Abandoned

State File Number	SEAM	Mine Type	Surface/Subsurface	Status
09628-1	600	Unknown	Unknown	Abandoned
94478	600	Unknown	Unknown	Abandoned
00300	600	Unknown	Unknown	Abandoned
00157	600	Unknown	Unknown	Abandoned
09628-1	600	Unknown	Unknown	Abandoned
00757	600	Unknown	Unknown	Abandoned
91254	600	Unknown	Unknown	Abandoned
94478	600	Unknown	Unknown	Abandoned
01570	600	Unknown	Unknown	Abandoned
18430-1	600	Strip Truck Coal	Surface	Active
18430-1	600	Strip Truck Coal	Surface	Active
18430-1	600	Strip Truck Coal	Surface	Active
18430-1	600	Strip Truck Coal	Surface	Active
18430-1	600	Strip Truck Coal	Surface	Active
18430-1	600	Strip Truck Coal	Surface	Active
18152-2	600	Gob Strip Truck Coal	Surface	Active
01570	600	Unknown	Unknown	Abandoned
18152-2	600	Gob Strip Truck Coal	Surface	Active
01570	600	Unknown	Unknown	Abandoned
15577-3	600	Auger-Strip Truck Coal	Surface	Abandoned
01570	600	Unknown	Unknown	Abandoned
15577-3	600	Auger-Strip Truck Coal	Surface	Abandoned
18152-2	600	Gob Strip Truck Coal	Surface	Active
09628-1	600	Unknown	Unknown	Abandoned
01570	600	Unknown	Unknown	Abandoned
01570	600	Unknown	Unknown	Abandoned
00314	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
10888	600	Unknown	Unknown	Abandoned
10888	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
06620-2	600	Unknown	Unknown	Abandoned
90343	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned

State File Number	SEAM	Mine Type	Surface/Subsurface	Status
17949	600	Auger-Strip Truck Coal	Surface	Abandoned
09953	600	Unknown	Unknown	Abandoned
09509-1	600	Unknown	Unknown	Abandoned
09509-1	600	Unknown	Unknown	Abandoned
01570	600	Unknown	Unknown	Abandoned
09509-1	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
10640-1	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
09509-3	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
92789	600	Unknown	Unknown	Abandoned
06620-4	600	Unknown	Unknown	Abandoned
90344	600	Unknown	Unknown	Abandoned
00980	600	Unknown	Unknown	Abandoned
05877-15	600	Underground Truck Coal	Underground	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
-	600	Unknown	Unknown	Abandoned
01570	600	Unknown	Unknown	Abandoned

State File Number	SEAM	Mine Type	Surface/Subsurface	Status
18430-1	600	Strip Truck Coal	Surface	Active
18430-1	600	Strip Truck Coal	Surface	Active
18430-1	600	Strip Truck Coal	Surface	Active
18430-1	600	Strip Truck Coal	Surface	Active
03241	600	Underground Truck Coal	Underground	Abandoned
10182	620	Unknown	Unknown	Abandoned
18152-2	600	Gob Strip Truck Coal	Surface	Active
-	600	Unknown	Unknown	Abandoned
18152-2	600	Gob Strip Truck Coal	Surface	Active
06017	600	Unknown	Unknown	Abandoned
06107	600	Auger-Strip Truck Coal	Surface	Abandoned
01156	600	Underground Rail Coal	Underground	Abandoned
06017	600	Unknown	Unknown	Abandoned
18152-2	600	Gob Strip Truck Coal	Surface	Active
06017	600	Unknown	Unknown	Abandoned
00314	600	Unknown	Unknown	Abandoned
05877-25	600	Underground Truck Coal	Underground	Abandoned
-	655	Unknown	Unknown	Abandoned
17836	655	Auger-Strip Truck Coal	Surface	Abandoned
-	655	Unknown	Unknown	Abandoned
-: No Information				

The Pond Creek watershed is still actively being mined. Figure 3.11 and Table 3.5 displays the current permits issued by Kentucky Division of Mine Permits (KDMP) in this watershed (as of June 2016).

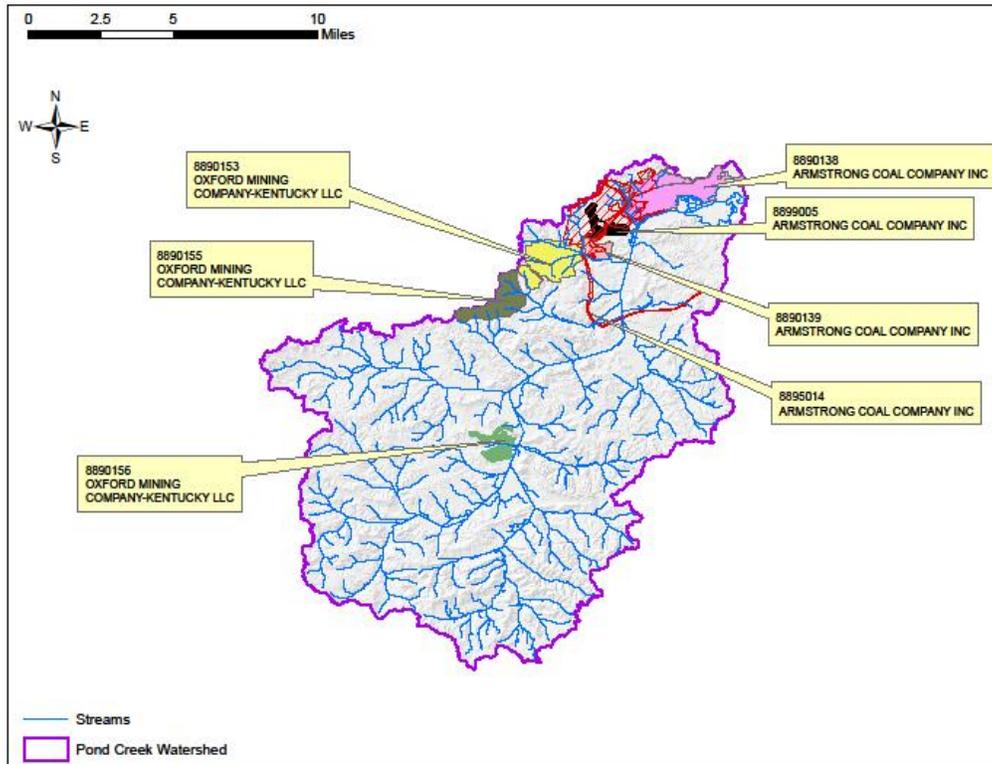


Figure 3.11 Current Permits Issued by KDMP in the Pond Creek Watershed

Table 3.5 Current Permits Issued by KDMP in the Pond Creek Watershed

Permit #	Mining Type	Mining Area in Acres	Permittee Name	Date Issued	Original Permit #
889-0138	Surface	1834.3	Armstrong Coal Company Inc	8/24/2007	8890032
889-0138	Underground	388.8	Armstrong Coal Company Inc	8/24/2007	8890032
889-0153	Surface	1207.2	Oxford Mining Company-Kentucky LLC	6/25/2010	8890153
889-0155	Underground	851.1	Oxford Mining Company-Kentucky LLC	1/27/2010	8890112
889-0156	Surface	420.4	Oxford Mining Company-Kentucky LLC	3/25/2010	8890114
889-9005	Surface	312.2	Armstrong Coal Company Inc	4/6/2011	8899005

Permit #	Mining Type	Mining Area in Acres	Permittee Name	Date Issued	Original Permit #
889-5014	Underground	1693.1	Armstrong Coal Company Inc	4/24/2007	895003
889-0139	Surface	260.6	Armstrong Coal Company Inc	7/30/2007	8890011
889-5014	Surface	731.5	Armstrong Coal Company Inc	4/24/2007	895003

4.0 Monitoring

4.1 Monitoring History

As stated in Section 2.1, monitoring of Pond Creek and its tributaries was conducted at 14 locations by the Kentucky Division of Water (KDOW), Murray State University, and Western Kentucky University between 1997 and 2001 and in 2006, see Figure 4.1 and Table 4.1.

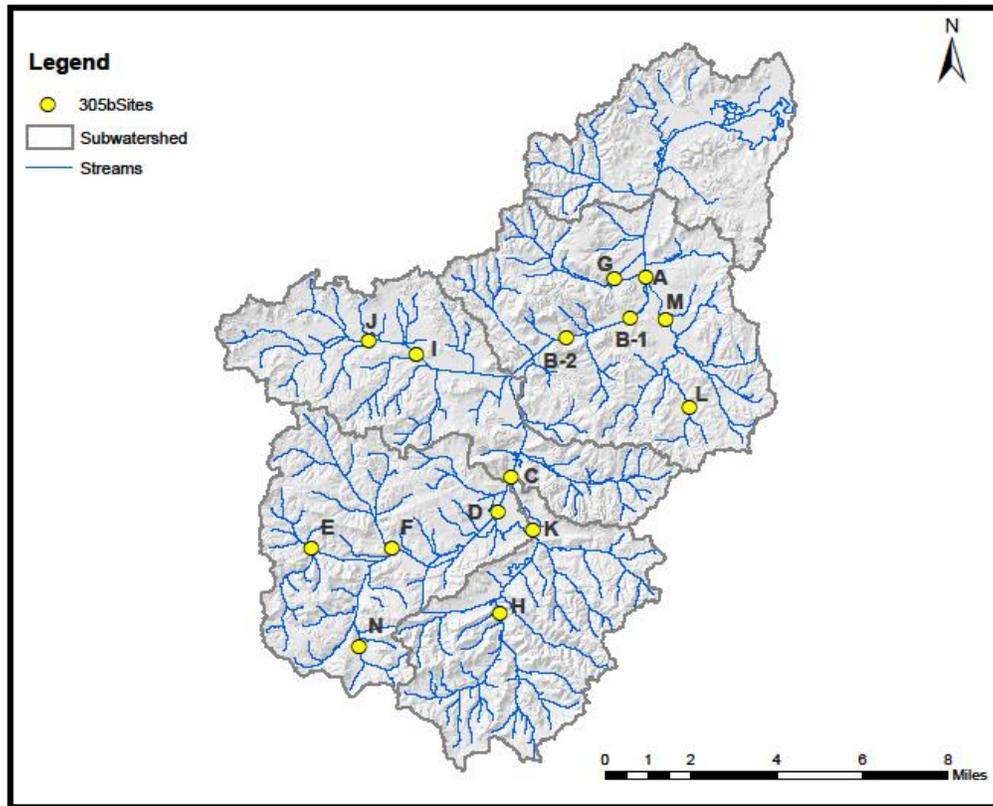


Figure 4.1 Locations of Historical Sampling Sites within the Pond Creek Watershed

Table 4.1 Historical Monitoring Sites in the Pond Creek Watershed

Site ID	Waterbody	Waterbody ID	Sample Mile Point	Collection Year	Collector
A	Pond Creek 4.8 to 7.6	KY501042_02	7.4	1997	KDOW
B-1	Pond Creek 7.6 to 11.7	KY501042_03	8.6	1997; 2000	MSU
B-2	Pond Creek 7.6 to 11.7	KY501042_03	10.2	1997; 2000	MSU

Site ID	Waterbody	Waterbody ID	Sample Mile Point	Collection Year	Collector
C	Pond Creek 11.7 to 14.4	KY501042_04	14.3	2000	MSU
D	Pond Creek 14.4 to 18.1	KY501042_05	15.2	2000; 2001	MSU
E	Pond Creek 18.1 to 22.1	KY501042_06	20.3	2000; 2001	KDOW
F	Sandlick Creek 0.0 to 4.0	KY502963_01	0.2	2001	KDOW
G	UT to Pond Creek 0.0 to 2.4	KY501042-6.9_01	1.0	2001	WKU
H	Bat East Creek 3.4 to 7.5	KY486462_02	3.9	2001	KDOW
I	Caney Creek 0.0 to 3.6	KY488838_01	3.6	2001	KDOW
J	Caney Creek 3.6 to 7.6	KY488838_02	3.6	1997	KDOW
K	Bat East Creek 0.0 to 3.3	KY486462_01	1.3	2001	WKU
L	Plum Creek 1.7 to 3.9	KY500964_02	2.9	2001	WKU
M	Plum Creek 0.0 to 1.7	KY500964_01	0.1	1997	KDOW
N	Salt lick Creek 0.0 to 3.7	KY502844_01	2.3	2002	KDOW

4.2 KDOW TMDL Monitoring

Since November 2010, KDOW TMDL monitoring staff revisited Pond Creek watershed at 26 sites on Pond Creek and its tributaries, see Figure 4.2 and Table 4.2. Those 26 sampling sites were selected by assessing the watershed’s accessibility, the location of exiting impaired segments, drainage areas, karst features, hydrologic changes, potential sources and land use. TMDL staff monitored flow, chloride, sedimentation/siltation, sulfate, total dissolved solids, nutrient/eutrophication biological indicators, specific conductance, *E. coli*, and metals. Table 4.3 shows the sampling sites where TMDL staff also collected biology data.

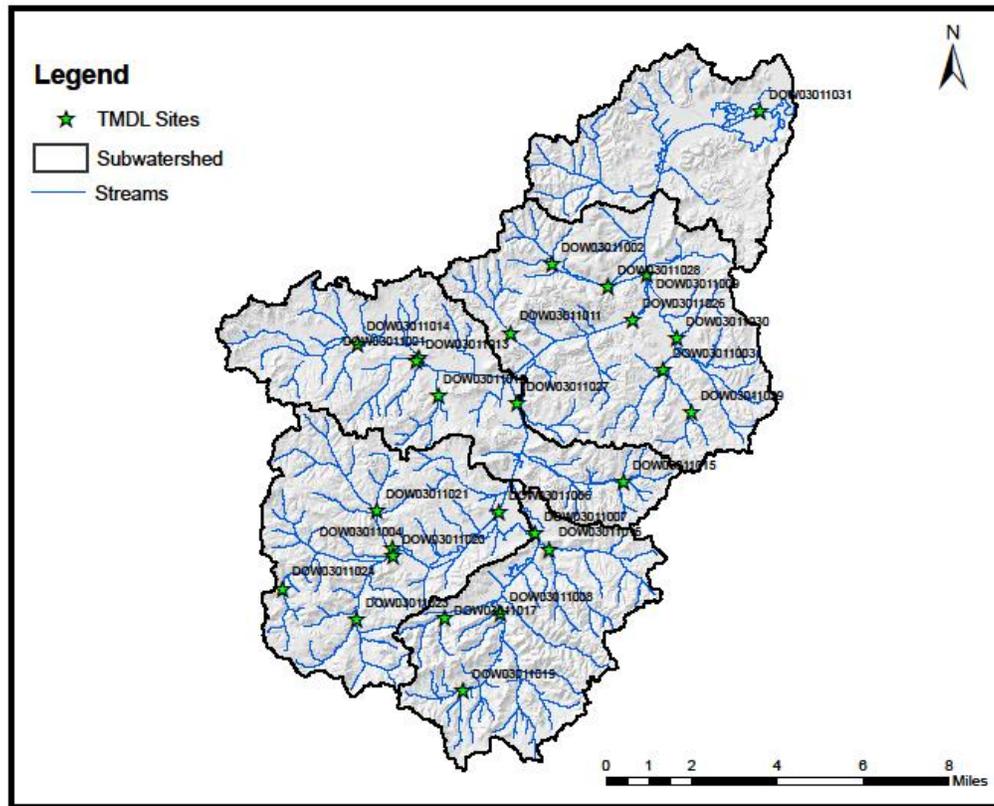


Figure 4.2 Locations of KDOW TMDL Sampling Sites within the Pond Creek Watershed

Table 4.2 Sample Sites by KDOW TMDL in the Pond Creek Watershed

Station ID	Stream	RM	UT* RM	Latitude	Longitude
DOW03011001	Caney Creek	2.35		37.21529	-87.14753
DOW03011002	UT to UT Pond Creek	7.4	0.2	37.24757	-87.09163
DOW03011003	UT to Plum Creek	1.65	0.1	37.2121	-87.04406
DOW03011004	Sandlick Creek	0.2		37.15018	-87.15736
DOW03011006	Pond Creek	15.2		37.163	-87.11255
DOW03011007	Bat East Creek	1.35		37.15612	-87.09737
DOW03011008	Bat East Creek	3.9		37.12857	-87.1113
DOW03011009	Pond Creek	7.4		37.24472	-87.05153

Station ID	Stream	RM	UT* RM	Latitude	Longitude
DOW03011011	UT to Pond Creek	11.1	0.85	37.22409	-87.10883
DOW03011012	UT to Caney Creek	1.8	0.64	37.20222	-87.13879
DOW03011013	UT to Caney Creek	2.3	0.12	37.21423	-87.14854
DOW03011014	Caney Creek	3.9		37.2198	-87.17342
DOW03011015	Beech Creek	2.7		37.17416	-87.0601
DOW03011016	UT to Bat East Creek	1.6	0.31	37.15078	-87.09112
DOW03011017	Carters Creek	1.55		37.12694	-87.13493
DOW03011019	UT to Bat East Creek	6.1	0.43	37.10246	-87.12669
DOW03011020	Pond Creek	18.35		37.14786	-87.1571
DOW03011021	Opossum Run	0.3		37.16317	-87.16434
DOW03011023	Saltlick Creek	1.55		37.12612	-87.17216
DOW03011024	Bogess Creek	1.4		37.13601	-87.20348
DOW03011026	Pond Creek	8.6		37.22927	-87.05717
DOW03011027	Pond Creek	12.45		37.20022	-87.10563
DOW03011028	UT to Pond Creek	7.35	0.97	37.24039	-87.06784
DOW03011029	Plum Creek	3		37.19817	-87.03188
DOW03011030	Plum Creek	0.65		37.22318	-87.03843
DOW03011031	Pond Creek	1.85		37.3006	-87.00456
*UT: unnamed tributary					

Table 4.3 KDOW TMDL Biological Sampling Events in the Pond Creek Watershed

Station ID	Stream	Sampling Date	MBI⁽¹⁾ Narrative Result
DOW03011001	Caney Creek	8/8/2013	Fair
DOW03011002	UT to UT Pond Creek	6/16/2011	Poor
DOW03011008	Bat East Creek	6/24/2014	Good
DOW03011012	Caney Creek UT	3/26/2014	Poor
DOW03011013	Caney Creek UT	4/1/2014	Fair
DOW03011015	Beech Creek	6/15/2011	Poor
DOW03011016	Bat East Creek UT	6/18/2014	Fair
DOW03011017	Carters Creek	5/10/2011	Poor
DOW03011019	Bat East Creek UT	4/1/2014	Fair
DOW03011021	Opossum Run	3/18/2014	Fair
DOW03011024	Bogges Creek	3/26/2014	Fair
DOW03011026	Pond Creek	6/25/2014	Fair
⁽¹⁾ MBI = Macroinvertebrate Bioassessment Index.			

5.0 Source Identification

For regulatory purposes, the pollutant sources in a watershed can be placed into two categories: KPDES-permitted and non-KPDES-permitted sources. A KPDES-permitted source requires a Kentucky Pollutant Discharge Elimination System discharge permit from the KDOW. KPDES discharge permits include wastewater treatment facilities that discharge directly to a stream, Municipal Separate Storm Sewer System, facilities discharging storm water, some agricultural operations and home units. KPDES discharge permits also include mining facilities which generally discharge to a stream from impoundments or ponds in response to precipitation events. KPDES is not the only permitting program that may affect water quality or quantity within a watershed; other permitting examples include water withdrawal permits, permits to build structures within a floodplain, permits to construct an on-site sewage treatment disposal system (OSTDS), and permits to land apply waste from sewage treatment plants. However, within the framework of the TMDL process, a KPDES-permitted source is defined as one regulated under the KPDES program. Non-KPDES-permitted sources include nonpoint sources of pollution. Nonpoint sources of pollution are often caused by runoff from precipitation over and/or through the ground and are correlated with land use.

5.1 KPDES-Permitted Sources

Permitted sources include all sources regulated by the KPDES permitting program. Figure 5.1 and Table 5.1 show all KPDES-permitted facilities within the Pond Creek watershed. In 401 KAR 10:001, KDOW adopted the definition of a point source per 33 U.S.C. 1362(14) as “any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, or concentrated animal feeding operation or vessel or other floating craft, from which pollutants are or may be discharged.” However, 401 KAR 10:001 exempts “agricultural storm water run-off or return flows from irrigated agriculture” from the definition of a point source. A WLA is assigned to a KPDES-permitted source.

Under the KPDES permit, most of the larger facilities are required to submit discharge monitoring report (DMR) data each month, while the smaller facilities are required to submit DMRs each quarter. DMR records for permitted entities are available upon request from the KDOW records custodian. Information on the Kentucky Open Records Act is available at <http://water.ky.gov>.

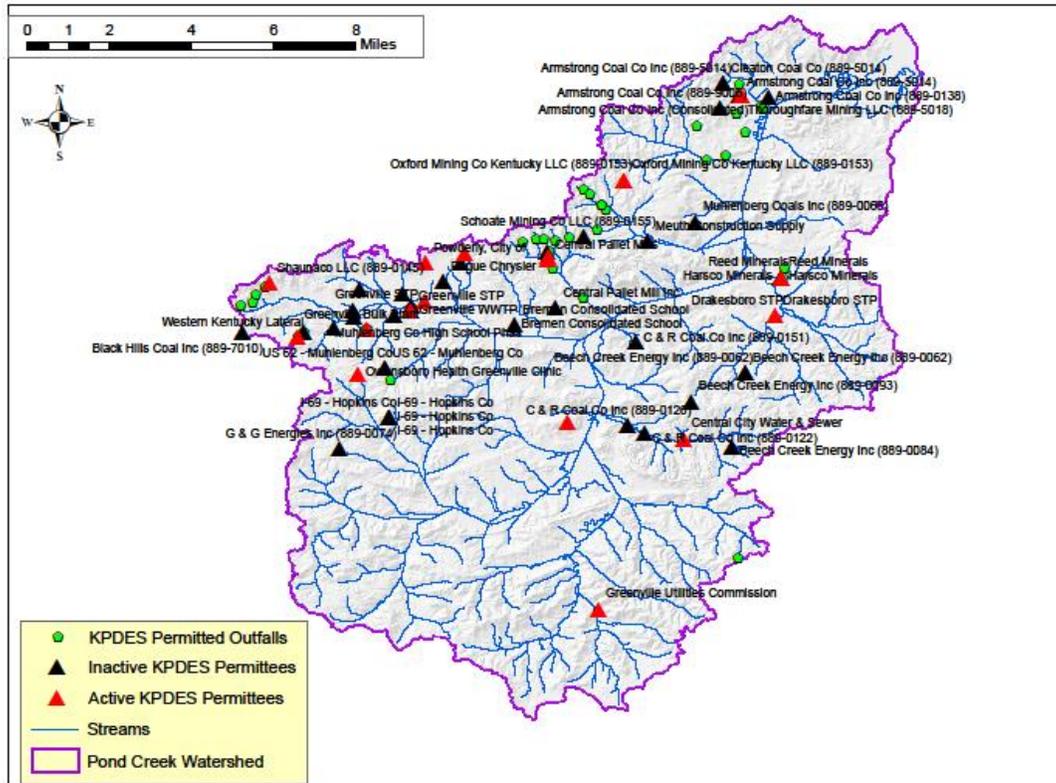


Figure 5.1 KPDES Permittes within the Pond Creek Watershed

Table 5.1 KPDES Permittes within the Pond Creek Watershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KY0020010	Greenville STP	Yes	1.31	37.219167	-87.169444	bacteria, pH, Cd, Cu, Pb, Zn
KY0066575	Drakesboro STP	Yes	0.165	37.217222	-87.040833	bacteria, pH, Cd, Cu, Pb, Zn
KY0108537	Shaunaco LLC (889-0145)	Yes	0	37.228611	-87.218889	pH, Cd, Cu, Fe, Pb, Ni, Zn
KY0109606	Greenville Bulk Plant	Yes	0	37.212500	-87.184700	pH
KY0111996	Oxford Mining Co Kentucky LLC (889-0153)	Yes	0	37.265000	-87.094056	pH, Fe
KYG045755	Oxford Mining Co Ky LLC (889-0156)	Yes	0	37.179722	-87.113889	pH, Fe
KYG046498	Oxford Mining Co Kentucky LLC (889-0153)	Yes	0	37.265000	-87.094056	pH, Fe

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG640029	Central City Water & Sewer	Yes	0.0005	37.173800	-87.073000	pH, Fe
KYG640108	Greenville Utilities Commission	Yes	0.027	37.113900	-87.103200	pH, Fe
KYGW40011	Thoroughfare Mining LLC (889-5018)	Yes	0	37.294720	-87.053060	bacteria, pH, Fe
KYGW40062	Armstrong Coal Co Inc (Consolidated)	Yes	0	37.294990	-87.052770	pH, Fe
KYP000064	Powderly, City of	Yes	0	37.235833	-87.163889	discharge to Greenville WWTP
KYR003239	Central Pallet Mills	Yes	0	37.237167	-87.121083	pH and to develop a SWPPP
KYR004015	Carl Mitchell & Son Implement - Paradise Rd	Yes	0	37.238014	-87.120822	pH and to develop a SWPPP
KYR004021	Harsco Minerals	Yes	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR10J469	Muhlenberg County Airport	Yes	0	37.222067	-87.164333	to develop a SWPPP
KYR10K083	Owensboro Health Greenville Clinic	Yes	0	37.196391	-87.187716	to develop a SWPPP
KYR10K315	Western Kentucky Lateral	Yes	0	37.209464	-87.209069	to develop a SWPPP
KYR10K433	Owensboro Health Muhlenberg Healthplex	Yes	0	37.238889	-87.150189	to develop a SWPPP
KY0023329	Bremen Consolidated School	No	0.008	37.214000	-87.132800	bacteria
KY0099538	Texas Gas Transmission LLC - West Greenville	No	0	37.211111	-87.206944	pH
KY0106046	C & R Coal Co Inc (889-0151)	No	0	37.208333	-87.090000	pH, Fe
KY0107701	Armstrong Coal Co Inc (889-5014)	No	0	37.298889	-87.059167	pH, Cd, Cu, Fe, Pb, Ni, Zn
KYG043169	Black Hills Coal Inc (889-7010)	No	0	37.211111	-87.228611	pH, Fe

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG043563	Beech Creek Energy Inc (889-0062)	No	0	37.196944	-87.051389	pH, Fe
KYG043825	Muhlenberg Coals Inc (889-0066)	No	0	37.250278	-87.068889	pH, Fe
KYG044318	Armstrong Coal Co Inc (889-0138)	No	0	37.294167	-87.043333	pH, Fe
KYG044386	Beech Creek Energy Inc (889-0062)	No	0	37.196944	-87.051389	pH, Fe
KYG044486	G & G Energies Inc (889-0074)	No	0	37.170457	-87.194335	pH, Fe
KYG044573	Friendship Energy Inc (889-0079)	No	0	37.217528	-87.175069	pH, Fe
KYG044789	Beech Creek Energy Inc (889-0084)	No	0	37.170833	-87.056111	pH, Fe
KYG044998	Beech Creek Energy Inc (889-0093)	No	0	37.186944	-87.070556	pH, Fe
KYG045704	Schoate Mining Co LLC (889-0155)	No	0	37.245000	-87.108333	pH, Fe
KYG046025	C & R Coal Co Inc (889-0126)	No	0	37.178333	-87.092778	pH, Fe
KYG046026	C & R Coal Co Inc (889-0122)	No	0	37.175833	-87.086944	pH, Fe
KYG046617	Armstrong Coal Co Inc (889-9005)	No	0	37.290278	-87.060278	pH, Fe
KYG046775	Armstrong Coal Co Inc (889-5014)	No	0	37.295000	-87.053600	pH, Fe
KYR000524	Central Pallet Mill Inc	No	0	37.220000	-87.118333	pH and to develop a SWPPP
KYR000918	Harsco Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR001665	Carl Mitchell & Son Implement	No	0	37.239428	-87.121152	pH and to develop a SWPPP
KYR001693	Meuth Construction Supply	No	0	37.243362	-87.085699	pH and to develop a SWPPP
KYR00A008	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR00A009	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYR10E810	Muhlenberg Co High School Phas 3	No	0	37.216500	-87.189224	to develop a SWPPP
KYR10E960	Muhlenberg County Emergency SE	No	0	37.235680	-87.151550	to develop a SWPPP
KYR10F821	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10G145	Greenville WWTP	No	0	37.220472	-87.169111	to develop a SWPPP
KYR10G154	Knight Construction & Excavating Inc	No	0	37.212776	-87.196388	to develop a SWPPP
KYR10G285	Pogue Chrysler	No	0	37.229353	-87.157828	to develop a SWPPP
KYR10G428	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G429	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G456	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G458	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G631	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10G632	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10H138	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10H705	Muhlenberg County Park Phase I	No	0	37.226610	-87.187427	to develop a SWPPP
KYR10I149	Pogue Electric Service Inc.	No	0	37.224749	-87.172138	to develop a SWPPP
KYG044105	Cleaton Coal Co (889-5014)	No	0	37.298889	-87.059167	pH, Fe
KYG050000*	N/A	N/A	N/A	N/A	N/A	N/A

* KYG050000 is the Inactive Mine Lands General Permit, see Section 1 of the KPDES Permit KYG050000 for more information regarding the permit coverage eligibility and exclusions. As long as the permittees make good faith effort to comply with the permit, they are considered to be compliant with the TMDL. KYG050000 is not listed in the Section 8 (Individual Segments TMDL Calculations).
N/A: Not Applicable

5.1.1 *E. coli*

5.1.1.1 *Sanitary Wastewater Systems*

Sanitary Wastewater System(s) include all facilities with a design flow which are permitted to discharge bacteria. This includes Wastewater Treatment Plants (WWTPs), Sewage Treatment Plants (STPs), package plants, and home units.

5.1.1.2 *Concentrated Animal Feeding Operations (CAFO)*

Operations that are defined as a CAFO pursuant to 401 KAR 5:002 are required to obtain a KPDES permit. Once defined as a CAFO, the operation can be permitted under a KPDES General Permit or a KPDES Individual Permit depending upon the nature of the operation. Conditions of both types of permits include no discharge to surface waters; however, holders of a KPDES Individual Permit may discharge to surface waters during a 25-year (24-hour) or greater storm event. There are no known regulated CAFOs in the Pond Creek watershed. However, there could be non-point source animal operations or small farm operations that do not require a KDOW permit.

5.1.2 pH and Metals

The KPDES-permitted facilities with pH/metal discharge limits within the Pond Creek watershed include WWTPs, industry facilities, stormwater, and coal mining. Urban stormwater runoff is a substantial source of pH and metals, such as building siding and roofs, automobile brakes, oil leakage and tires, as well as dry and wet atmospheric depositions.

There is an extensive amount of coal mining in the watershed, so the coal mining is discussed below in detail.

5.1.2.1 *Coal Mining Sources*

According to EPA (2014a), “coal mining employs basically the same traditional mining techniques used in hard rock mining - underground and surface ("strip") mining....[Strip mining] is analogous to the open pit mining techniques used in hard rock mining whereby the soil and rock above the coal seam are removed to expose the seam. The seam is then blasted and the coal is scooped up by huge front end loaders or electric shovels and transported to a coal processing plant. These coal preparation plants use a variety of physical (e.g., screening) and chemical (e.g., flotation using high gravity liquids) methods to separate the raw coal from all of the non-combustible waste rock and minerals (e.g., pyrite). The coarser waste rock is piled up adjacent to the mined out area and the finer coal tailings coming from the preparation plant are discharged as a thick slurry into a man-made impoundment. After coal mining operations have ceased, the mine is reclaimed by dumping the waste rock into the pit, re-grading the area to the approximate original contours of the land and then replanting the area using native grasses and trees.”

While not all mine runoff is acidic, coal mining can produce AMD as rainwater percolates through mine spoils and the porous strata of underground mines. EPA (2014b) characterizes

AMD as “...the formation and movement of highly acidic water rich in heavy metals. This acidic water forms through the chemical reaction of surface water (rainwater, snowmelt, pond water) and shallow subsurface water with rocks that contain sulfur-bearing minerals, resulting in sulfuric acid. Heavy metals can be leached from rocks that come in contact with the acid, a process that may be substantially enhanced by bacterial action. The resulting fluids may be highly toxic and, when mixed with groundwater, surface water and soil, may have harmful effects on humans, animals and plants.” AMD discharges were common to mining prior to the passage of SMCRA; see Section 9.4.2 for further discussion.

5.1.2.2 WLA Mining Sources

Prior to the beginning of operation, mining facilities must obtain a KPDES permit, either a Coal General or an Individual Permit. Facilities with a current KPDES permit are placed in the WLA. KPDES permits require monitoring of effluent quality and submittal of DMR data monthly or quarterly to Kentucky Department for Natural Resources (KDNR). Some basic facility data is available on EPA’s Integrated Compliance Information System (ICIS), which are available to the public at <http://www.epa.gov/enviro/facts/pcs-icis/search.html>, but currently DMR data must be requested through KDNR. In the future, DMR data will be available through ICIS, and DMRs will be submitted to KDOW instead of KDNR. Further information on KPDES permitting information can be found at <http://water.ky.gov/permitting/Pages/Mining.aspx>.

Mining facilities, unlike many industrial and wastewater facilities, do not have permitted design flows, and while they monitor flow, flow limits are not a condition of their permits. This is because mining sources generally discharge from impoundments or ponds in response to precipitation events, although the impoundments do have retention time requirements built in as necessary to treat the influent.

There are 5 active KPDES mining permittees within Pond Creek watershed (as of June 2016), see Table 5.2 and Figure 5.2. Those active facilities with a KPDES permit are placed in the WLA, while other sources are placed in the LA, see Sections 5.2.2.1 and 5.2.2.2, or are illegal, see Section 5.3.

Table 5.2 Active KPDES-Permitted Mining in the Pond Creek Watershed

KPDES Permit #	KDNR Permit #	Permittee Name	Date Issued
KY0108537	889-0145	Shaunaco LLC	12/1/2011
KYG046498	889-0153	Oxford Mining Co Kentucky LLC	8/4/2010
KYGW40011	889-5018	Thoroughfare Mining LLC	5/21/2015
KYG045755	889-0156	Oxford Mining Co Ky LLC	7/1/2009
KY0111996	889-0153	Oxford Mining Co Kentucky LLC	Pending

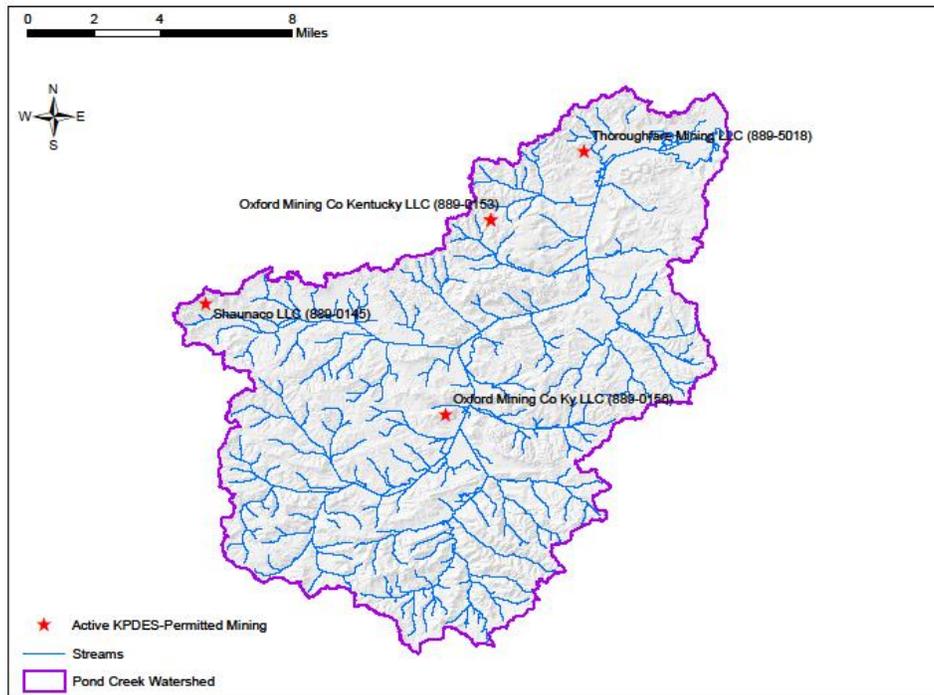


Figure 5.2 Active KPDES-Permitted Mining in the Pond Creek Watershed

5.2 Non-KPDES-Permitted Sources

Non-KPDES-permitted sources include all sources not permitted by the KPDES permitting program and are often associated with land use. The loads to surface water from non-KPDES-permitted sources are regulated by laws such as the Kentucky Agricultural Water Quality Act (AWQA, KRS 224.71-100 through 224.71-145, i.e., implementation of individual agriculture water quality plans and corrective measures), the federal CWA (i.e., the TMDL process) and 401 KAR 5:037 (Groundwater Protection Plans), among others. Unlike KPDES-permitted sources, non-KPDES-permitted sources typically discharge pollutants to surface water in response to rain events. A LA is assigned to non-KPDES-permitted sources.

5.2.1 *E. coli*

5.2.1.1 *Kentucky No Discharge Operating Permits*

As stated in 401 KAR 5:005, facilities with agricultural waste handling systems are required to obtain a Kentucky No Discharge Operating Permit (KNDOP) from the KDOW prior to construction and operation. Animal Feeding Operations (AFOs) receive KNDOP permits. These operations handle liquid waste in a storage component of the operation (e.g. lagoon, pit, or

tank) and may land apply the waste via spray irrigation or injection to cropped acreages. Land application of the waste that results in runoff to a stream is prohibited. Facilities that handle animal waste as a liquid are required to submit a Short Form B, construction plans, and a Comprehensive Nutrient Management Plan to the KDOW. Also included in KNDOP requirements are golf courses and some industrial operations with spray-irrigate.

There is one KNDOP agriculture facility with hog/pig farming in the Pond Creek watershed (Figure 5.3 and Table 5.3).

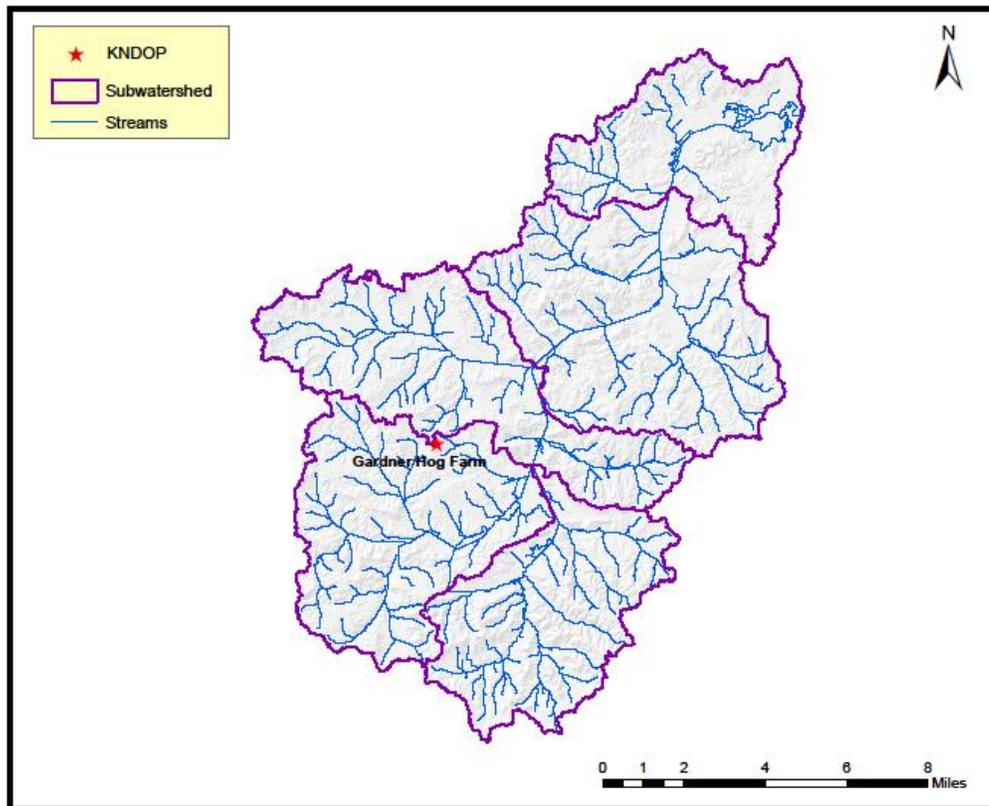


Figure 5.3 KNDOP Facility in the Pond Creek Watershed

Table 5.3 KNDOP Facility in the Pond Creek Watershed

KNDOP #	Facility Type	Latitude	Longitude
03004073	AGR-Hog & Pig Farming	37.180833	-87.150278

5.2.1.2 Agriculture

The Kentucky AWQA was passed by the 1994 General Assembly. The law focuses on the protection of surface water and groundwater resources from agricultural and silvicultural activities. The Act created the Kentucky AWQA, a 15-member peer group comprising farmers

and representatives from various agencies and organizations. The Act requires farms greater than 10 acres in size to adhere to the Best Management Practices (BMPs) specified in the Kentucky Agriculture Water Quality Plan. Specific BMPs have been designated for all operations.

The USDA National Agricultural Statistics Service compiles Census of Agriculture data by County for virtually every facet of U.S. agriculture (USDA, 2012). Selected agricultural data from the latest Census of Agriculture reports for Muhlenberg County are listed in Table 5.4. These data are based on County-wide data with no assumptions made on a watershed level. The percentage of agricultural types of land cover was calculated in Table 3.3 in Section 3.3.

Table 5.4 Agricultural Statistics from the 2012 USDA Agricultural Census

	Muhlenberg County
Farms (number/acres)	630/128,761
Total Cropland (acres)	67,127
Cattle and Calves Inventory (total number)	12,904
Beef Cows (total number)	(D)
Milk Cows (total number)	(D)
Horses and Ponies (total number)	-
Goats (total number)	-
Hogs and Pigs (total number)	(D)
Sheep and Lamb (total number)	222
Poultry Layers (total number)	(D)
Poultry Broilers (total number)	5,622,085
Corn for grain (acres)	15,481
Wheat for grain (acres)	2,537
Corn for Silage (acres)	173
Forage (acres)	-
(D) = data withheld to avoid disclosing data for individual farms - = No data	

5.2.1.3 *Wildlife*

Wildlife contributes bacteria to the Pond Creek watershed. Table 5.5 shows the estimates of deer density and population in Muhlenberg County, as provided by the Kentucky Department of Fish and Wildlife Resources (Kentucky Department of Fish and Wildlife Resources, 2012). Estimates

on numbers of other types of animals are not available. Although wildlife contributes bacteria to surface water, such contributions represent natural background conditions, and do not receive a reduction as part of the TMDL.

Table 5.5 Number of Deer in Muhlenberg County

County	Deer Per Square Mile	Number of Deer
Muhlenberg	23	10,562

5.2.1.4 Human Waste

Human waste disposal is of particular concern in rural areas. Areas not served by sewers either employ OSTDSs or do not treat their sewage. OSTDSs, including septic tank systems, are commonly used in areas where providing a centralized sewage collection and treatment system is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, septic systems are an effective means of disposing and treating domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, they can be a source of *E. coli* to both groundwater and surface water, see Section 5.3, Illegal Sources, for further discussion of failing OSTDSs. The soils information presented in Section 3.1 indicates that the soils in Pond Creek watershed are not ideal for installation of properly functioning septic systems.

Another type of non-KPDES-permitted source that may exist in the watershed is straight-pipes, which are discrete conveyances that discharge sewage, gray water (i.e., water from household sinks, laundry, etc.), and stormwater to the surface waters of the Commonwealth without treatment.

Figure 5.4 shows the 2010 census blocks of population data. The existing and proposed sewer lines in Pond Creek watershed are presented in Figure 5.5.

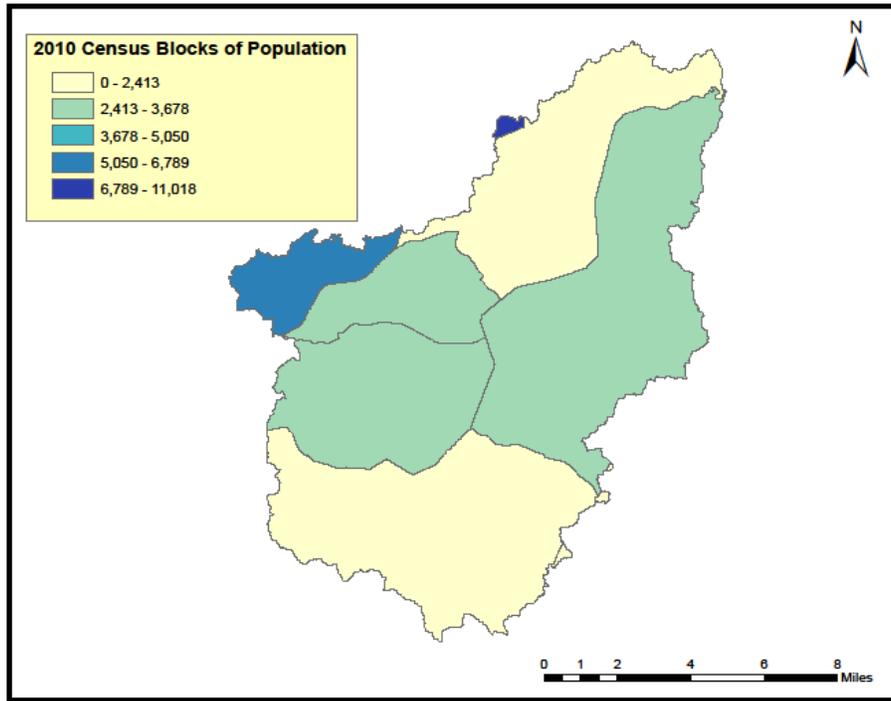


Figure 5.4 2010 Census Blocks of Population of the Pond Creek Watershed

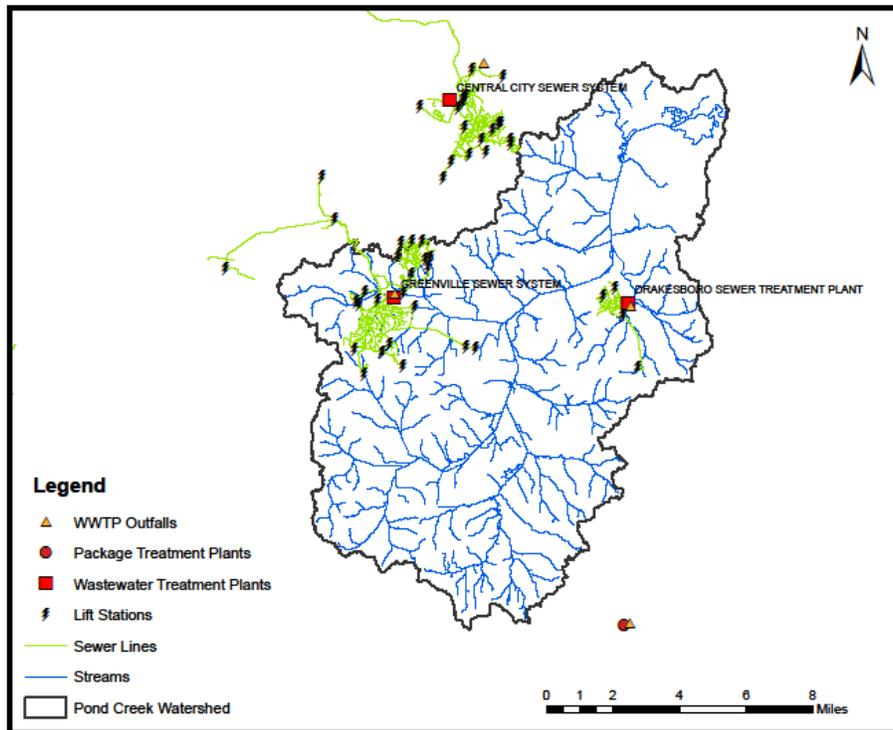


Figure 5.5 Existing and Proposed Sewer Lines in the Pond Creek Watershed

5.2.1.5 Household Pets

Although household pets undoubtedly exist in this watershed, their contribution to the LA is deemed to be minimal compared to other sources. Pet waste may, however, be a larger contributor to bacteria runoff in areas where there is a higher density of households and less-permeable surfaces.

5.2.2 pH and Metals

5.2.2.1 LA Mining Sources

The unregulated storm water runoff from the pre-SMCRA mine lands, which is not covered under KYG050000, is part of the LA. As stated, much of the mining in the watershed is pre-law, but inadequate recordkeeping means maps of pre-law mines are often unavailable.

5.2.2.2 LA Natural Background

Pollutants addressed in this document can all be present in surface water under natural background conditions. pH normally varies from a value of 7.0; iron may be present at higher

than trace amounts. Natural background levels for pH and metals were not established for this report. Any natural background is part of the LA.

5.3 Illegal Sources

Both KPDES-permitted and non-KPDES-permitted sources can discharge pollutants to surface water illegally. This includes sources that are illegal simply by their existence, such as straight-pipes and Sanitary System Overflows, which receive no allocation; or mining activities without an approved KPDES permit. There may also be legal sources that are operating illegally (e.g., outside of regulations, permit limits or conditions, etc.), such as a WWTP bypass or a failing OSTDS, which receive no allocation above that of a properly functioning system (see Section 7.0 for TMDL allocations).

Another potential illegal source is livestock on farms that have no BMPs (as required under the AWQA), as well as farms where BMPs are present but are insufficient or failing in a manner that causes or contributes to surface water impairment; such farms receive no allocation above that of a farm with properly installed and functioning BMPs. Also included are KNDOPs, AFOs and CAFOs not in compliance with the appropriate regulations that cause or contribute to surface water impairment.

KDOW expects implementation of these TMDLs to begin with the elimination of illegal sources. This is intended to prevent legally operating sources from having to effect reductions in order to accommodate the pollutant loading of illegal sources. Note, this section of the TMDL is not intended to summarize the universe of potential illegal sources that may discharge pollutants into surface waters, nor does it attempt to summarize the universe of legal sources that may be operating illegally. Instead, it gives examples of illegal sources known to be present or that could be present in the watersheds (e.g., straight-pipes).

6.0 Water Quality Criteria

6.1 Water Quality Criteria

The CWA requires states to designate uses for surface waters within their jurisdiction. The designated uses assigned to waterbodies in Kentucky can be found in 401 KAR 10:026. Designated uses impaired in the waterbodies addressed by this TMDL include Warm Water Aquatic Habitat, Primary Contact Recreation and Secondary Contact Recreation, whose definitions are found in 401 KAR 10:001:

1. WAH waters are those with surface water and associated substrate capable of supporting indigenous warm water aquatic life. WAH can be impaired by metals, pH and reduced alkalinity in addition to other pollutants. WAH criteria are in effect year-round.
2. PCR waters are those designated for full body contact recreation (e.g., swimming). PCR criteria are in effect during the recreation season of May 1 through October 31.
3. SCR waters are those designated for partial immersion (e.g., wading or boating). SCR criteria are in effect year-round.

The term *limit* is often used interchangeably with the terms *WQC* and *criterion*. WQCs are found in 401 KAR 10:031. Below are the WQCs for *E. coli*, metals, pH, alkalinity and limits on the relative concentration of alkalinity and acidity:

6.1.1 *E. coli*

The WQC in 401 KAR 10:031 (Kentucky's Surface Water Standards) for the PCR use are based on *E. coli* per 401 KAR 10:031:

"The following criteria shall apply to waters designated as primary contact recreation use during the primary contact recreation season of May 1 through October 31: Fecal coliform content or Escherichia coli content shall not exceed 200 colonies per 100 ml or 130 colonies per 100 ml respectively as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 400 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for fecal coliform or 240 colonies per 100 ml for Escherichia coli."

When there are insufficient *E. coli* measurements to calculate a 5-sample, 30-day geometric mean, the instantaneous criterion of 240 colonies/100 ml is applied to calculate allowable loadings to bring the watershed into compliance with the PCR designated use.

6.1.2 pH

The pH of water may result in impairment for WAH, PCR and SCR. The pH shall not be less than six and zero-tenths (6.0) nor more than nine and zero-tenths (9.0) standard units and shall not fluctuate more than one and zero-tenths (1.0) pH unit over a period of twenty-four (24) hours.

6.1.3 Metals

Metals impair for WAH. Metals WQCs are given in terms of chronic and acute limits. The chronic criterion is the highest instream concentration of a toxic substance or an effluent to which organisms are able to be exposed for ninety-six (96) hours without causing an unacceptable harmful effect. The acute criterion is the highest instream concentration of a toxic substance or an effluent to which an organism can be exposed for one (1) hour without causing an unacceptable harmful effect.

6.1.3.1 *Non-Hardness-Dependent Metals (Iron)*

The WQCs for iron are not hardness-dependent. Iron is the only metal whose chronic criterion varies depending on whether aquatic life has been adversely affected. The chronic iron limit is 3.5 mg/L where aquatic life has not been shown to be adversely affected and 1.0 mg/L where aquatic life has been adversely affected. The acute iron limit is 4.0 mg/L for all streams. Iron WQCs are shown in Table 6.1.

Table 6.1 Iron WQCs

Limit Type	Iron WQC, mg/L
Chronic—aquatic life is adversely affected	1.0
Chronic—aquatic life has not been shown to be adversely affected	3.5
Acute	4.0

6.1.3.2 *Hardness-Dependent Metals (Cadmium, Copper, Lead, Nickel, Zinc)*

It has been demonstrated that a number of elements that are metals, including cadmium, copper, lead, nickel and zinc, are less toxic to aquatic life as water hardness increases (EPA, 1986). Hardness refers to the dissolved mineral content of water. In residential plumbing, these minerals cause scale development. They also interfere with foam formation from soap—the soap forms a solid precipitate instead of a lather and it loses its surfactant property; this makes it ‘hard’ to clean clothing (Hach, 2014). When minerals constituting hardness dissolve in water they form a cation (with positive charge) and an anion (with negative charge). More specifically, hardness is the presence of divalent cations (i.e., those with a charge of 2+) (Lloyd and Heathcote, 1985). Mostly hardness comes from calcium and magnesium ions, but other metals can contribute, including barium, iron, manganese, strontium and zinc (WHO, 2003). The two most important anions associated with the cations that cause hardness are bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}), see alkalinity, below. These ions normally originate in limestone or dolomite rock made more acidic by the incorporation of atmospheric carbon dioxide into rainwater (EPA, 1986). Even though hardness indicates only the presence of cations, it is measured in mg/L of calcium carbonate (CaCO_3). However, this does not mean calcium is the only cation being measured; other cations contribute to hardness as described above: but for

measurement purposes, all contributors are reported as an equivalent molecular weight of CaCO₃.

Excess hardness may lower the toxicity of certain metals to aquatic organisms by combining with the metals to form less toxic compounds. Because of the variable toxicity of these metals, unlike most other WQCs the limits are not fixed, but vary as the hardness varies. Therefore the WQC equations employ the natural log of hardness, or ln(hardness), where hardness is in units of mg/L as CaCO₃, and *e*, which is an irrational number (i.e., it has an infinite number of digits to the right of the decimal point) referred to as Euler's number; *e* is approximately equal to 2.71828. Of the hardness-dependent metals included in this TMDL, zinc is the only metal with an identical chronic and acute criterion. Tables 6.2 through Table 6.5 show the WQCs for these metals.

Table 6.2 Cadmium WQC

Limit Type	Cadmium WQC, µg/L
Chronic	$e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Acute	$e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$

Table 6.3 Copper WQC

Limit Type	Copper WQC, µg/L
Chronic	$e^{(0.8545 * (\ln(\text{hardness})) - 1.702)}$
Acute	$e^{(0.9422 * (\ln(\text{hardness})) - 1.700)}$

Table 6.4 Lead WQC

Limit Type	Lead WQC, µg/L
Chronic	$e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Acute	$e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$

Table 6.5 Nickel WQC

Limit Type	Nickel WQC, µg/L
Chronic	$e^{(0.846 * (\ln(\text{hardness})) + 0.0584)}$
Acute	$e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$

Table 6.6 Zinc WQC

Limit Type	Zinc WQC, µg/L
Chronic	$e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$
Acute	$e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$

6.1.3.3 *Alkalinity*

Lowered alkalinity can impair for WAH. Alkalinity is the ability to neutralize an acid, and is quantified by titration; titration in this case is the iterative additions of an acid to the sample until a pH endpoint of 4.5 is reached (standard method 2320, APHA *et al.*, 2012). This is because below a pH of 4.5, carbonate alkalinity is neutralized: Carbonate alkalinity is the primary species present in natural systems, although other types, such as phosphorus or nitrogen species can also exist.

Alkalinity can also be thought of as a measurement of the buffering capacity of water, or its ability to resist change in pH. Unlike hardness, which is the presence of mineral cations, alkalinity is the presence of anions, mainly carbonate, bicarbonate and hydroxide but also potentially including borate, phosphate, silicate, nitrate, dissolved ammonia, sulfide, and the conjugate bases of organic acids, minus free hydrogen ions. Alkalinity in water is divided into two anion fractions based on the presence of the carbonate and bicarbonate anions; these fractions are known as carbonate and non-carbonate, although as stated the carbonate fraction contributes the majority of alkalinity, especially in limestone-dominated systems. These anions resist lowering pH by taking up free hydrogen ions (Stumm and Morgan, 1996). Alkalinity, like hardness, is measured as an equivalent molecular weight of CaCO₃. 401 KAR 10:031 states the instream alkalinity cannot be reduced by more than 25%, unless the natural alkalinity is 20 mg/L as CaCO₃ or less, in which case it shall not be reduced at all.

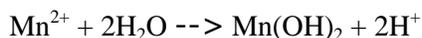
6.1.3.4 *Acidity*

Acidity does not have a specific limit set under 401 KAR 10:031. Acidity is the ability to neutralize a base and is quantified by titration, which in this case is the iterative additions of a base to the sample until a pH endpoint is reached; the endpoint may vary based on the constituents contributing to acidity, but is normally 3.7 to 8.3 (standard method 2310B, APHA *et al.*, 2012). Acidity is increased by the presence of dissolved carbon dioxide and carbonic acid (H₂CO₃), metals undergoing hydrolysis (see Section 6.2) and free hydrogen ions, among other constituents. Sulfide molecules such as pyrite in contact with air and water release hydrogen ions and increase acidity (Morel and Hering, 1993). Acidity, like alkalinity and hardness, is measured as an equivalent molecular weight of CaCO₃. Acidity can cause lowering of pH depending on other factors such as the presence of a buffer (i.e., alkalinity), but acidity and pH are not identical, see Section 6.2; this section also describes the specific application of standard method 2310B to AMD.

6.2 *Metals Hydrolysis*

Metallic cations in AMD, including zinc, copper, iron, aluminum and manganese, are precipitated during treatment. This process involves the free ionic (or dissolved) form of the metal binding to hydroxides (the OH⁻ molecule) provided by treating the runoff with a chemical alkaline addition or from hydrolysis if the pH in the receiving water is high enough. Hydrolysis means the breaking of chemical bonds by the addition of water; the water molecule itself may also have its molecular bonds broken during the process (Morel and Hering, 1993).

The metal hydroxides form insoluble compounds that then precipitate from the water. This process of precipitation is represented in the following equation using manganese, where the metal hydroxide (i.e., the manganese bound to OH through hydrolysis) forms the insoluble compound, manganese hydroxide, which then precipitates:



The hydrolysis reaction releases hydrogen ions, which can decrease pH (which is defined as the presence of hydrogen ions) if not enough excess hydroxide is present in the system to buffer the reaction. Other metals besides manganese undergo a similar reaction. This phenomenon makes it problematic to rely on pH as a sole indicator of the acidity of AMD, as treated mine effluent which meets the acceptable pH range of 6.0 to 9.0 standard units can be unstable (Kirby and Cravotta, 2005), and the final pH can fall below this range after discharge if not enough alkalinity is available in the water to buffer the total acidity.

This instability means special methods are needed to measure the acidity of AMD. To enhance metal precipitation in the laboratory, especially during titrations, heat and oxidation are used to speed up the reaction. More specifically, the addition of stronger bases like NaOH, and the use of heat and oxidation can improve the efficiency and speed of metal precipitation. For AMD, the determination of acidity by titration (2310B in Standard Methods, 2012) mandates that a hot peroxide treatment be employed (2310B.4a), called hot acidity or digested acidity.

In the environment, the primary metals of concern for AMD treatment are aluminum, iron and manganese. This is because other metals associated with AMD, including copper, nickel, and zinc normally drop out of solution in the process of properly treating AMD for iron and manganese. AMD generally has a low pH, and as the pH in the treatment pond is increased through addition of lime or limestone, the metals begin precipitating in the following order: ferric iron (i.e., Fe^{3+}) precipitates at a pH 3.0 to 3.5; aluminum precipitates at a pH of around 4.5, while copper and zinc precipitate at a pH of 7.0 to 8.0. Ferrous iron (i.e., Fe^{2+}) precipitates at around 8.0 to 8.5, but most treatment operations treat ferrous iron more quickly and economically by aerating the water to convert ferrous iron to ferric iron, and in this way a pH of only 3.0 to 4.0 is needed to precipitate the iron. Manganese precipitates at a much higher pH of 9.0 to 10.5, although the final numbers for these metals can vary based on field conditions and ionic composition. Because manganese precipitates last it is an indicator of the completeness of precipitation of other metals; this is the reason there is an effluent limit for manganese. However, aluminum can re-enter solution after initial precipitation at a pH of around 9.0 and thus can contribute hydrogen ions via hydrolysis even though it was initially removed earlier in the treatment process (Balintova and Petrilkova, 2011; Balintova *et al.*, 2012).

The potential drop in pH due to hydrolysis reactions with metals can be calculated using the following equations, which use the acute permitted discharge limits of iron and manganese, which are both 4.0 mg/L as stated in Table 6.2:

$$(\text{Iron, 4.0 mg/L}) \times (1/55.845 \text{ g/mol}) \times (1 \text{ g}/1000 \text{ mg}) = 7.1627\text{E-}5 \text{ mol/L}$$

Equation 6.1.

$$(\text{Manganese, 4.0 mg/L}) \times (1/54.938 \text{ g/mol}) \times (1 \text{ g}/1000 \text{ mg}) = 7.2809\text{E-}5 \text{ mol/L}$$

Equation 6.2.

As stated, any aluminum present contributes hydrogen ions as well. In the treatment pond system, iron is more often in the form Fe^{3+} unless conditions are anaerobic, and most AMD treatment ponds are designed as aerobic environments (Costello, 2003). Manganese is solely in the form Mn^{2+} . The amount of hydrogen ions generated during metal hydrolysis is therefore equal to the results of Equations 6.1 and 6.2 multiplied by the valence number of the metals, or 3 for iron and 2 for manganese, then summing these results. This figure is $3.60499\text{E-}4$ mol/L of H^+ . Since pH is defined specifically as the negative logarithm of the concentration of H^+ ions in solution in units of mol/L, the resultant pH from Equation 6.1 and 6.2 is equivalent of 3.44, which is far lower than the acceptable pH range of 6.0 to 9.0 standard units. If aluminum was also present, the potential pH drop would be even larger.

Metals hydrolysis can be countered by adding alkalinity to the solution. The amount of alkalinity necessary to neutralize the acidity generated by aluminum, iron and manganese at a specific pH can be calculated by the following equation, from Hedin, *et al.* (1991), which conservatively assumes all iron is in the form of Fe^{3+} :

$$\text{Calculated Acidity, mg/L as CaCO}_3 = 50 \times ((10^{(3-\text{pH})}) + (3 \times \text{Fe mg/L}/55.8) + (2 \times \text{Mn mg/L}/54.9) + (3 \times \text{Al mg/L}/27.0))$$

Equation 6.3.

Solving Equation 6.3 gives the net alkalinity which must be present in solution to buffer metals hydrolysis (i.e., net alkalinity is defined as the alkalinity present in solution minus the calculated acidity). Three of the variables, pH, iron and manganese, have effluent limits. Aluminum does not have an effluent limit, so it must be reported when the other constituents are reported: The calculated acidity will then be determined and compared to the alkalinity present in solution. The alkalinity must equal or exceed the calculated acidity, or in other words the net alkalinity must be greater than or equal to zero.

7.0 Total Maximum Daily Load

EPA defines a TMDL as “a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant’s sources. Water quality standards are set by States, Territories, and Tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation, and aquatic life support, and the scientific criteria to support that use. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality. The Clean Water Act, Section 303, establishes the water quality standards and TMDL programs (EPA, 2008).”

7.1 TMDL Equation and Definitions

A TMDL calculation is performed as follows:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

Equation 7.1

The WLA has those components:

$$\text{WLA} = \text{KPDES-WLA} + \text{MS4-WLA}$$

Equation 7.2

Where:

TMDL: the WQC, expressed as a load.

MOS: the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the relationship between effluent limits and water quality. For this TMDL, the MOS is implicit.

WLA: the Wasteload Allocation, which is the allowable loading of pollutants into the stream from Kentucky Pollutant Discharge Elimination System (KPDES) permitted sources.

KPDES-WLA: the WLA for the existing KPDES-permitted facilities which have discharge limits for the pollutants of concern.

MS4-WLA: the WLA for KPDES-permitted municipal separate stormwater sewer systems (MS4) (including cities, counties, roads and right-of-ways owned by the Kentucky Transportation Cabinet, universities and military bases). There is no MS4 community within this watershed area.

LA: the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.

Seasonality: yearly factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.

Critical Condition: the time period when the pollutant conditions are expected to be at their worst.

Existing Conditions: the load that exists in the watershed at the time of TMDL development (i.e., sampling) and is causing the impairment.

Load: concentration * flow * conversion factor.

Concentration: colonies per 100 milliliter (*E. coli*), milligrams per liter (mg/L) (iron, alkalinity, acidity), micrograms per liter (ug/L) (cadmium, copper, lead, nickel, zinc) or standard units (pH).

Flow (i.e., stream discharge): cubic feet per second (cfs).

7.2 TMDLs by Pollutant

The following sections set the loading associated with each pollutant addressed by this TMDL. The MOS, which is implicit, is discussed in Section 7.3. TMDLs are allocated to sources in Section 7.7.

However, despite the requirement that all pollutants be expressed as a load with a TMDL (D.C. Cir, 2006), KDOW and KDNR expect *E. coli*, metals and pH compliance to be evaluated in terms of concentration, not load.

7.2.1 *E. coli*

Table 7.1 *E. coli* WQCs and TMDL Load

Condition	WQC (Colonies/100ml)	TMDL Load ⁽¹⁾ (Colonies/day)
Instantaneous	240	$Q_s \times 240 \times 24,465,758.4$
Geomean	130	$Q_s \times 130 \times 24,465,758.4$
⁽¹⁾ Q_s is the flow in the stream in cfs.		

The number 24,465,758.4 is a conversion factor which changes the multiple of flow and the WQC into units of load in colonies/day.

7.2.2 pH

The acceptable range for pH is $6.0 \leq \text{pH} \leq 9.0$ standard units. In order to express this as a range of loads, pH can be converted to hydrogen ion concentration and then into load, where a pH of 6.0 equals a hydrogen ion concentration of $1.00\text{E-}6$ mol/L and a pH of 9.0 equals a hydrogen ion concentration of $1.00\text{E-}9$ mol/L (Milanco, 2014). Because the molecular weight of a hydrogen ion is 1.0 g/mol, the concentration of hydrogen ions in mol/L is the same as its concentration in g/L, or 1.0. Using the following equation, these hydrogen ion concentrations can be turned into load for any value of streamflow, Q_s :

$$(Q_s \text{ ft}^3/\text{s}) \times (1\text{E-}6 \text{ g/L}) \times (86,400 \text{ s/day}) \times (28.31685 \text{ L/ft}^3) = \text{pH TMDL Load (hydrogen ions g/day)}$$

Equation 7.3 (pH = 6.0)

$$(Q_S \text{ ft}^3/\text{s}) \times (1\text{E-}9 \text{ g/L}) \times (86,400 \text{ s/day}) \times (28.31685 \text{ L/ft}^3) = \text{pH TMDL Load (hydrogen ions g/day)}$$

Equation 7.4 (pH = 9.0)

Equation 7.3 simplifies to a TMDL Load for pH of $Q_S \times 2.44657 \text{ g/day}$ of hydrogen ions. Equation 7.4 simplifies to $Q_S \times 2.44657\text{E-}3 \text{ g/day}$ of hydrogen ions. However, KDOW regulates pH by the hydrogen ion activity as read by a pH meter. The actual hydrogen ion concentration is related to hydrogen ion activity through the following equation:

$$\{H^+\} = [H^+] \times \gamma$$

Equation 7.5

where $\{H^+\}$ is hydrogen ion activity, $[H^+]$ is the actual hydrogen ion concentration, and γ is the activity coefficient.

The activity coefficient of hydrogen ions in turn depends on ionic strength μ as shown in Figure 7.1 (Snoeyink and Jenkins, 1980). Figure 7.1 shows that the activity of hydrogen ions (γ) decreases with increasing ionic strength (μ) of the source water. This is because other ions limit the mobility of the hydrogen ions based on their charge and concentration. Ionic strength is a measure of total ion concentration and charge in a solution and is defined as:

$$\mu = 0.5 \times \sum m_i Z_i^2$$

Equation 7.6

where m_i is the molar concentration of each ion and Z_i is charge of each ion. Direct measurements of ionic strength require concentrations of each ion dissolved in water. Ionic strength can also be estimated indirectly. According to Snoeyink and Jenkins (1980), the ionic strength μ can be determined using the specific conductance (SC, also known as conductivity) of the source water in units of microSiemens per centimeter ($\mu\text{S/cm}$) with the following equation:

$$\mu = 1.6\text{E-}5 \times \text{SC}$$

Equation 7.7

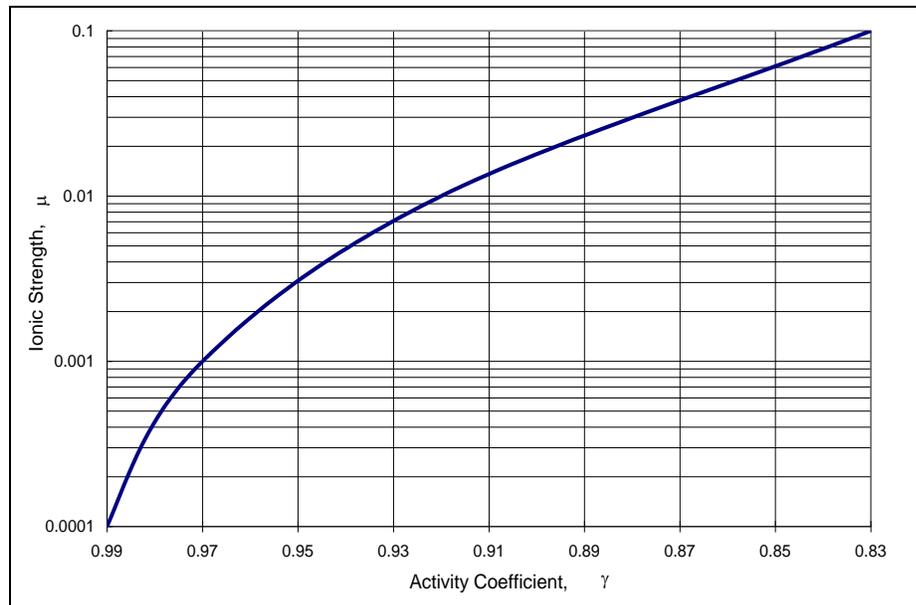


Figure 7.1 Ionic Strength vs. Activity Coefficient of H⁺ Ions

Using the maximum SC measured in the watershed, which is 4250 $\mu\text{S}/\text{cm}$ recorded on 10/20/2011 at DOW03011030 on Plum Creek, yields an ionic strength μ of approximately 0.068. Using Figure 7.1, the activity coefficient γ is approximately 0.842. Therefore the range of hydrogen ion loads between a pH of 6.0 and 9.0 is derived by dividing the result of Equations 7.3 and 7.4 by γ , or 0.842. This leaves the TMDL load range shown in Table 7.2:

Table 7.2 Range of Hydrogen Ion TMDL Loads Corresponding to a pH Range of 6.0 to 9.0

pH WQC, pH standard units	TMDL Load, Hydrogen Ions, g/day ⁽¹⁾
6.0 (upper limit of hydrogen ion loading)	$Q_S \times 2.906$
9.0 (lower limit of hydrogen ion loading)	$Q_S \times 2.906E-3$

⁽¹⁾ Q_S is the flow in the stream in cfs.

7.2.3 Metals

Since both the acute and chronic criteria must be met, TMDL loads for metals are set using both the chronic and acute WQCs. For metals with WQCs given in mg/L, the concentration is converted to load in pounds per day using the following equation:

$$(\text{WQC mg/L}) \times (Q_S \text{ ft}^3/\text{s}) \times (1 \text{ lb}/453,592.4 \text{ mg}) \times (86,400 \text{ s}/\text{day}) \times (28.31685 \text{ L}/\text{ft}^3) = \text{TMDL Load (pounds/day)}$$

Equation 7.8

The conversion factor for Equation 7.8 simplifies to 5.3938.

For metals with WQCs given in µg/L, the concentration is converted to load in pounds per day using the following equation:

$$(WQC \mu\text{g/L}) \times (1 \text{ mg}/1000\mu\text{g}) \times (Q_S \text{ ft}^3/\text{s}) \times (1 \text{ lb}/453,592.4 \text{ mg}) \times (86,400 \text{ s}/\text{day}) \times (28.31685 \text{ L}/\text{ft}^3) =$$

TMDL Load (pounds/day)
 Equation 7.9

The conversion factor for Equation 7.9 simplifies to 0.005394.

Metals are divided into two categories, those whose toxicity is not hardness-dependent, and those whose toxicity is hardness-dependent.

7.2.3.1 *Non-Hardness-Dependent Metals*

Since the WQCs for iron are given in concentrations of mg/L, the following loads were derived from Equation 7.8:

Table 7.3 Iron WQCs and TMDL Load

Limit Type	Iron WQC, mg/L	Iron TMDL Load, pounds/day ⁽¹⁾
Chronic–aquatic life is adversely affected	1.0	$Q_S \times 5.3938$
Chronic- aquatic life has not been shown to be adversely affected	3.5	$Q_S \times 18.8783$
Acute	4.0	$Q_S \times 21.5752$
⁽¹⁾ Q_S is the flow in the stream in cfs.		

7.2.3.2 *Hardness-Dependent Metals*

The WQCs for hardness-dependent metals are given in µg/L instead of mg/L, so the TMDL loads were derived using Equation 7.9. As stated, zinc is the only metal with identical chronic and acute criteria.

Table 7.4 Cadmium WQC and TMDL Load

Limit Type	Cadmium WQC, µg/L ⁽¹⁾	Cadmium TMDL Load, pounds/day ⁽²⁾
Chronic	$e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$
Acute	$e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$
⁽¹⁾ Hardness is in units of mg/L.		
⁽²⁾ Q_S is the flow in the stream in cfs.		

Table 7.5 Copper WQC and TMDL Load

Limit Type	Cadmium WQC, µg/L ⁽¹⁾	Copper TMDL Load, pounds/day ⁽²⁾
Chronic	$e^{(0.8545 \cdot (\ln(\text{hardness})) - 1.702)}$	$Q_S \times 0.005394 \times e^{(0.8545 \cdot (\ln(\text{hardness})) - 1.702)}$
Acute	$e^{(0.9422 \cdot (\ln(\text{hardness})) - 1.700)}$	$Q_S \times 0.005394 \times e^{(0.9422 \cdot (\ln(\text{hardness})) - 1.700)}$
⁽¹⁾ Hardness is in units of mg/L.		
⁽²⁾ Q_S is the flow in the stream in cfs.		

Table 7.6 Lead WQC and TMDL Load

Limit Type	Cadmium WQC, µg/L ⁽¹⁾	Lead TMDL Load, pounds/day ⁽²⁾
Chronic	$e^{(1.273 \cdot (\ln(\text{hardness})) - 4.705)}$	$Q_S \times 0.005394 \times e^{(1.273 \cdot (\ln(\text{hardness})) - 4.705)}$
Acute	$e^{(1.273 \cdot (\ln(\text{hardness})) - 1.460)}$	$Q_S \times 0.005394 \times e^{(1.273 \cdot (\ln(\text{hardness})) - 1.460)}$
⁽¹⁾ Hardness is in units of mg/L.		
⁽²⁾ Q_S is the flow in the stream in cfs.		

Table 7.7 Nickel WQC and TMDL Load

Limit Type	Nickel WQC, µg/L ⁽¹⁾	Nickel TMDL Load, pounds/day ⁽²⁾
Chronic	$e^{(0.846 \cdot (\ln(\text{hardness})) + 0.0584)}$	$Q_S \times 0.005394 \times e^{(0.846 \cdot (\ln(\text{hardness})) + 0.0584)}$
Acute	$e^{(0.846 \cdot (\ln(\text{hardness})) + 2.255)}$	$Q_S \times 0.005394 \times e^{(0.846 \cdot (\ln(\text{hardness})) + 2.255)}$
⁽¹⁾ Hardness is in units of mg/L.		
⁽²⁾ Q_S is the flow in the stream.		

Table 7.8 Zinc WQC and TMDL Load

Limit Type	Zinc WQC, µg/L ⁽¹⁾	Zinc TMDL Load, pounds/day ⁽²⁾
Chronic	$e^{(0.8473 \cdot (\ln(\text{hardness})) + 0.884)}$	$Q_S \times 0.005394 \times e^{(0.8473 \cdot (\ln(\text{hardness})) + 0.884)}$
Acute	$e^{(0.8473 \cdot (\ln(\text{hardness})) + 0.884)}$	$Q_S \times 0.005394 \times e^{(0.8473 \cdot (\ln(\text{hardness})) + 0.884)}$
⁽¹⁾ Hardness is in units of mg/L.		
⁽²⁾ Q_S is the flow in the stream in cfs.		

7.2.4 Net Alkalinity

As stated in Section 6.2, net alkalinity, or the alkalinity minus the calculated acidity, must be greater than or equal to zero to buffer metals hydrolysis. This concentration can be converted into a load as follows:

$$\begin{aligned}
 (\text{Net Alkalinity, mg/L as CaCO}_3) \times (Q_S \text{ ft}^3/\text{s}) \times (1 \text{ lb}/453,592.4 \text{ mg}) \times (86,400 \text{ s}/\text{day}) \times (28.31685 \text{ L}/\text{ft}^3) \\
 = \text{TMDL Load (pounds/day)} \\
 \text{Equation 7.10}
 \end{aligned}$$

This simplifies to a target load equal to or greater than zero pounds/day of net alkalinity as CaCO₃, which must be met at all times. Like metals and pH, KDOW expects compliance to be evaluated in terms of concentration, not load.

7.3 Margin of Safety

The MOS can be an implicit (using conservative assumptions) or explicit (a reserved portion) additional reduction applied to the WLA, LA or to both types of sources that accounts for uncertainties in the relationship between effluent limits and water quality. For this document, an implicit MOS has been incorporated by applying the following conservative assumptions:

1. All discharges are at the WQC at any given time; not all sources discharge at the WQC at the same time; some sources discharge below the WQC creating dilution water.
2. KPDES mining alkaline treatment pond systems normally over-treat the AMD before discharge, both in terms of precipitating metals by raising pH and leaving adequate alkalinity in the system as a buffer (EPA, 1982). Therefore, mine ponds discharge below their permitted effluent limits as a result of the need to retain adequate alkalinity. The WLAs for these sources were established at the water quality criteria, not below it.
3. Equation 6.3 for calculated acidity conservatively assumes that all iron is in the form of Fe³⁺ as opposed to Fe²⁺. Using Fe³⁺ yields a greater calculated acidity, which results in a higher measured alkalinity necessary to maintain a net alkalinity greater than or equal to zero.
4. Allowable hydrogen ion loads (Table 7.2) were calculated using the greatest specific conductance measured within the Pond Creek watershed. Higher specific conductance values result in lower allowable hydrogen ion loads, thus the allowable hydrogen ion load range was set at a minimum level for the Pond Creek watershed.
5. The WLA for *E. coli* from sanitary wastewater sources is set at the WQC. Due to the disinfection process, these sources frequently discharge below the allowable WQC.

7.4 Allocations

The TMDL load is divided up among the WLA (for current KPDES-permitted sources) and the LA (including natural background, non-KPDES-permitted sources and any mining source in operation prior to May 3, 1978). These sources receive allocations proportional to the flow each contributes to the surface water system at any given point. The instream flow can be divided among the various sources as follows:

$$Q_S = Q_{KPDES} + Q_{LA}$$

Equation 7.11

Where Q_S is the flow in the stream, Q_{KPDES} is the KPDES-related flow, and Q_{LA} is the flow from LA sources. The flow unit is cfs. Like the TMDL itself, allocations must be presented in terms of load. The TMDL was already expressed in terms of load in Tables 7.1 through 7.8 for *E. coli*, pH and metals, and in Section 7.2.4 for a net alkalinity. The flows for each source in Equation 7.11 were expressed in terms of allocated load by multiplying all the flows by the WQC for each pollutant (or target, in terms of net alkalinity) and by a conversion factor, i.e., using the same

procedure that generated the TMDL loads found in Tables 7.1 through 7.8 and Section 7.2.4. Table 7.9 shows the final allocations for all impaired segments in the TMDL watershed.

Expressing the TMDL allocations using variables for flow and hardness means that each source must achieve the WQCs for their portion of the instream flow at all times, under all flow conditions and all conditions of hardness. With all sources meeting their individual allocations, the TMDL will also be met at all times, under all flow conditions and all conditions of hardness, including the critical condition, see Sections 7.6 and 8.2.

7.5 Seasonality

Seasonality is defined as yearly factors such as temporal variations in source behavior and stream loading that can affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses. A TMDL calculation must take into account seasonality, including a description of the method chosen for including seasonal variations.

7.5.1 *E. coli*

KPDES-permitted sanitary wastewater facilities, like those that exist in the Pond Creek watershed, are required to disinfect the wastewater stream prior to discharge. The concentration of bacteria in the discharge is thus dependent upon the effectiveness of the disinfection process and is not expected to show any specific seasonal trend.

Bacteria deposited on land surfaces may die off or re-grow. A review of factors important in the survival of bacteria in soils showed, in general, longer bacteria survival time under moist, cool and low sunlight conditions (reviewed in Gerba *et al.*, 1975); thus, more bacteria may survive and be available for runoff from land surfaces during the late fall through early spring. Soil erosion and water runoff can both move bacteria to a stream or to groundwater. Precipitation averages for Central City, KY, which is located in Muhlenberg County just north of the Pond Creek watershed, indicate the highest average precipitation in the spring during the month of May (5 inches) and the lowest average precipitation in the fall during the month of October (2.9 inches) (<http://countrystudies.us/united-states/weather/kentucky/> accessed 4/13/2016).

The criteria for *E. coli* only apply during the PCR season May 1 through October 31. Seasonality is addressed in the bacteria TMDL calculations by requiring KPDES-permitted sanitary wastewater facilities to meet the WCQ for *E. coli* at the outlet of their discharge pipe at all times (a permit requirement). For storm water and nonpoint sources, seasonality is addressed by requiring the *E. coli* criteria to be met in-stream during the entire PCR season under all flow conditions.

7.5.2 pH and Metals

KPDES-permitted mining sources generally discharge in response to precipitation events, but treatment ponds are built to achieve a certain retention time. Ponds that are on a mine bench are usually designed to capture a 24-hour storm event with a 10-year recurrence interval, thus they should only discharge following large rainfall events (greater than 4 inches within 24-hours).

Ponds that are within the stream channel have a discharge that is more continuous and correlated with stream flow conditions. Acidic mine seeps discharge based upon groundwater flow, which is expected to be driven by groundwater recharge in response to rainfall events.

Precipitation over western Kentucky is acidic, with typical pH values in the 4s and 5s. Although rainfall pH in western Kentucky varies monthly, with higher pH values tending to occur in the spring/summer, there was enough yearly variability that no specific seasonal trend could be discerned (<http://nadp.sws.uiuc.edu/data/sites/list/?net=NTN> stations KY99 and KY10, accessed 5/17-18/2016). Additionally, even with this variability, the rainfall remained in the acidic range throughout various seasons.

If acidic precipitation falls on soils, it can be buffered to a more neutral pH by soil alkalinity. In the acidic state, it can leach metals from soil or exposed rock and carry it to a stream. Acidic rainfall that falls on metal-containing structures, including asphalt, buildings, roofs, fences, etc., can leach metals from these materials. Even neutral rainfall can move metals deposited on surfaces from atmospheric deposition, automobile brake dust or corrosion and other sources to streams.

Rainfall is greatest during the spring (see Section 7.5.1); therefore, the instances of low pH and metal loadings from rainfall related sources would be more frequent in the spring. However, more continuous discharges, such as may occur from an acid mine seep or an in-stream mine pond, may show no seasonal loading trend.

Seasonality is addressed in the pH TMDL calculations by requiring KPDES-permitted sources to discharge at a pH between 6.0 and 9.0, inclusive, and in metals calculations by requiring them to meet the applicable acute and chronic metals criteria at all times. For unregulated storm water and nonpoint sources, seasonality is addressed by requiring the pH and metals criteria to be met in-stream at all times during all types of precipitation and flow events.

7.6 Critical Condition

For TMDL purposes, the critical condition is defined as the period when the pollutant conditions or effects are expected to be at their worst. TMDLs are required to identify the critical conditions for both point and nonpoint source loadings and to protect designated uses during these conditions.

7.6.1 *E. coli*

As mentioned under the Seasonality Section, KPDES-permitted sanitary wastewater facilities are required to disinfect their discharge year-round. However, the relative contribution of fecal bacteria from sanitary wastewater dischargers versus other sources is expected to be greatest during dry periods when storm water sources are not contributing to the load and during periods of low stream flow when dilution is minimized. Therefore, the critical conditions for sanitary wastewater facilities are defined as dry events (i.e. during periods of no rainfall) and low stream flow conditions.

The critical condition for storm water and nonpoint source bacteria loadings is typically an extended dry period followed by a rainfall event that moves bacteria to a stream via soil erosion or storm water runoff. During the dry weather period, bacteria build up on the land surface and are washed off by subsequent rainfall. The critical condition for nonpoint and storm water source loading of bacteria is thus identified as rainfall-related events.

Once in a stream, fecal bacteria are known to sorb to soil particles and settle into the sediments of the stream bed. These soil-sorbed bacteria can become resuspended in the water column during turbulent water flow conditions. This resuspension of fecal bacteria along with rainfall-related source contributions frequently results in high fecal bacteria concentrations measured following rainfall events.

The TMDL calculations contained within this document protect the PCR use during the identified critical conditions by requiring in-stream concentrations of fecal bacteria to meet the WQC under all flow and precipitation conditions during the months of May through October.

7.6.2 pH and Metals

Acidic pH discharges can be buffered by alkalinity either on land or in a stream. Data from the Pond Creek watershed indicates that low pH (below 6.0) tends to occur in streams when in-stream alkalinity is non-detect.

It has been demonstrated that a number of metallic elements, including cadmium, nickel and zinc, are less toxic to aquatic life as water hardness increases (EPA, 1986). Excess hardness may lower the toxicity of certain metals to aquatic organisms by combining with the metals to form less toxic compounds. Also cations (likely calcium, perhaps others) may have an antagonistic effect on the metals in question by taking up binding sites on ion-regulating proteins, possibly in the organism's gills, which interferes with the uptake of metals. Several researchers suggest that both alkalinity and the associated cations synergistically contribute to the reduction in toxicity (Wurts and Perschbacher, 1994).

Although permitted mining sources generally discharge in response to precipitation events, this discharge may not immediately follow rainfall events as treatment ponds are built to achieve a certain retention time. Rainfall events may also cause surface runoff from the abandoned mine lands, which may exacerbate pH and metals in the stream. At low flow conditions, commonly occurring during the dry weather periods, the stream receives its base flow from groundwater, which may bring discharges from underground mining to the stream. The TMDLs within this document protect the human recreation activities and aquatic life habitats during the critical conditions by requiring KPDES-permitted sources to discharge at a pH between 6.0 and 9.0, inclusive, and to maintain a net alkalinity equal to or greater than 0.0 mg/L and in metals calculations by requiring them to meet the applicable acute and chronic metals criteria at all times. For unregulated storm water and nonpoint sources, critical conditions are addressed by requiring the pH and metals criteria to be met in-stream at all times under all rainfall conditions.

7.7 TMDL Allocations

Table 7.9 gives TMDL allocations for all pollutants for all impaired waterbodies addressed by this TMDL.

Table 7.9 TMDLs and Allocations by Impaired Segments

Pollutant	Units	TMDL ⁽¹⁾	MOS ⁽²⁾	KPDES-WLA ⁽³⁾	LA ⁽⁴⁾
Bat East Creek 0.0 to 3.4					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
Copper (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.8545 \times (\ln(\text{hardness})) - 1.702)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.8545 \times (\ln(\text{hardness})) - 1.702)}}{e^{(0.8545 \times (\ln(\text{hardness})) - 1.702)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.8545 \times (\ln(\text{hardness})) - 1.702)}}{e^{(0.8545 \times (\ln(\text{hardness})) - 1.702)}}$
Copper (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(0.9422 \times (\ln(\text{hardness})) - 1.700)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.9422 \times (\ln(\text{hardness})) - 1.700)}}{e^{(0.9422 \times (\ln(\text{hardness})) - 1.700)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.9422 \times (\ln(\text{hardness})) - 1.700)}}{e^{(0.9422 \times (\ln(\text{hardness})) - 1.700)}}$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}{e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}{e^{(1.273 \times (\ln(\text{hardness})) - 4.705)}}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}{e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}{e^{(1.273 \times (\ln(\text{hardness})) - 1.460)}}$
Beech Creek 0.0 to 3.9					
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Nickel (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}}{e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}}{e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}}$
Nickel (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}}{e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}}{e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}}$
Zinc (Acute and Chronic) ⁽⁶⁾	pounds/day	$Q_S \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}}{e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}}{e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}}$
Bogess Creek 0.0 to 3.0					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$	$\frac{Q_{LA} \times WQC \times 24,465,758.4}{WQC \times 24,465,758.4}$
Caney Creek 0.0 to 3.6					

Pollutant	Units	TMDL ⁽¹⁾	MOS ⁽²⁾	KPDES-WLA ⁽³⁾	LA ⁽⁴⁾
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES}}{WQC} \times 24,465,758.4$	$\frac{Q_{LA}}{WQC} \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}$
Caney Creek 3.6 to 7.6					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES}}{WQC} \times 24,465,758.4$	$\frac{Q_{LA}}{WQC} \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}}{e^{(1.273 * (\ln(\text{hardness})) - 4.705)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}}{e^{(1.273 * (\ln(\text{hardness})) - 4.705)}}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}}{e^{(1.273 * (\ln(\text{hardness})) - 1.460)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}}{e^{(1.273 * (\ln(\text{hardness})) - 1.460)}}$
Carters Creek 0.0 to 3.1					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES}}{WQC} \times 24,465,758.4$	$\frac{Q_{LA}}{WQC} \times 24,465,758.4$
Opossum Run 0.0 to 1.6					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES}}{WQC} \times 24,465,758.4$	$\frac{Q_{LA}}{WQC} \times 24,465,758.4$
Plum Creek 0.0 to 1.65					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES}}{WQC} \times 24,465,758.4$	$\frac{Q_{LA}}{WQC} \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}{e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$\frac{Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}$	$\frac{Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}{e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}}$
Plum Creek 1.65 to 3.9					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$\frac{Q_{KPDES}}{WQC} \times 24,465,758.4$	$\frac{Q_{LA}}{WQC} \times 24,465,758.4$

Pollutant	Units	TMDL ⁽¹⁾	MOS ⁽²⁾	KPDES-WLA ⁽³⁾	LA ⁽⁴⁾
pH ⁽⁷⁾	standard units	6.0 ≤ pH ≤ 9.0	Implicit	6.0 ≤ pH ≤ 9.0	6.0 ≤ pH ≤ 9.0
Alkalinity, Acidity ⁽⁸⁾	mg/L as CaCO ₃	Net Alkalinity ≥ 0	Implicit	Net Alkalinity ≥ 0	Net Alkalinity ≥ 0
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$
Nickel (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 0.0584)}$
Nickel (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 \times (\ln(\text{hardness})) + 2.255)}$
Zinc (Acute and Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$	$Q_{LA} \times 0.005394 \times e^{(0.8473 \times (\ln(\text{hardness})) + 0.884)}$
Pond Creek 0.0 to 5.0					
Iron (Chronic) ⁽⁹⁾	pounds/day	$Q_S \times 18.878$	Implicit	$Q_{KPDES} \times 18.878$	$Q_{LA} \times 18.878$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Pond Creek 5.0 to 7.5					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 \times (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Pond Creek 7.5 to 11.7					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$

Pollutant	Units	TMDL⁽¹⁾	MOS⁽²⁾	KPDES-WLA⁽³⁾	LA⁽⁴⁾
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Pond Creek 11.7 to 14.4					
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Pond Creek 14.4 to 18.1					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$
Pond Creek 18.1 to 18.7					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Saltlick Creek 0.0 to 3.7					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Sandlick Creek 0.0 to 4.05					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$

Pollutant	Units	TMDL ⁽¹⁾	MOS ⁽²⁾	KPDES-WLA ⁽³⁾	LA ⁽⁴⁾
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$
UT of Bat East Creek 0.0 to 1.9					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
UT of Bat East Creek 0.0 to 3.55					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
UT of Caney Creek 0.0 to 2.6					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$
UT of Caney Creek 0.0 to 2.35					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Lead (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 4.705)}$
Lead (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$	$Q_{LA} \times 0.005394 \times e^{(1.273 * (\ln(\text{hardness})) - 1.460)}$
UT of Plum Creek 0.0 to 2.45					
pH ⁽⁷⁾	standard units	$6.0 \leq \text{pH} \leq 9.0$	Implicit	$6.0 \leq \text{pH} \leq 9.0$	$6.0 \leq \text{pH} \leq 9.0$
Alkalinity, Acidity ⁽⁸⁾	mg/L as CaCO ₃	Net Alkalinity ≥ 0	Implicit	Net Alkalinity ≥ 0	Net Alkalinity ≥ 0

Pollutant	Units	TMDL⁽¹⁾	MOS⁽²⁾	KPDES-WLA⁽³⁾	LA⁽⁴⁾
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
Nickel (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 0.0584)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 0.0584)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 0.0584)}$
Nickel (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$	$Q_{LA} \times 0.005394 \times e^{(0.846 * (\ln(\text{hardness})) + 2.255)}$
Zinc (Acute and Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$	$Q_{LA} \times 0.005394 \times e^{(0.8473 * (\ln(\text{hardness})) + 0.884)}$
UT of Pond Creek 0.0 to 2.4					
Iron (Chronic) ⁽⁵⁾	pounds/day	$Q_S \times 5.3938$	Implicit	$Q_{KPDES} \times 5.3938$	$Q_{LA} \times 5.3938$
Iron (Acute)	pounds/day	$Q_S \times 21.575$	Implicit	$Q_{KPDES} \times 21.575$	$Q_{LA} \times 21.575$
UT of Pond Creek 2.4 to 4.2					
<i>E. coli</i>	colonies/day	$Q_S \times WQC \times 24,465,758.4$	Implicit	$Q_{KPDES} \times WQC \times 24,465,758.4$	$Q_{LA} \times WQC \times 24,465,758.4$
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 * (\ln(\text{hardness})) - 3.924)}$
pH ⁽⁷⁾	standard units	$6.0 \leq \text{pH} \leq 9.0$	Implicit	$6.0 \leq \text{pH} \leq 9.0$	$6.0 \leq \text{pH} \leq 9.0$
Alkalinity, Acidity ⁽⁸⁾	mg/L as CaCO ₃	Net Alkalinity ≥ 0	Implicit	Net Alkalinity ≥ 0	Net Alkalinity ≥ 0
UT of Pond Creek 0.0 to 1.4					
Cadmium (Chronic)	pounds/day	$Q_S \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$	$Q_{LA} \times 0.005394 \times e^{(0.7409 * (\ln(\text{hardness})) - 4.719)}$

Pollutant	Units	TMDL ⁽¹⁾	MOS ⁽²⁾	KPDES-WLA ⁽³⁾	LA ⁽⁴⁾
Cadmium (Acute)	pounds/day	$Q_S \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	Implicit	$Q_{KPDES} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$	$Q_{LA} \times 0.005394 \times e^{(1.0166 \times (\ln(\text{hardness})) - 3.924)}$

- 1) TMDLs for *E. coli* are expressed as the flow in the stream, Q_S in ft^3/s , multiplied by the WQCs: i) 240 *E. coli* colonies/100 ml which must be met in at least 80% of all samples taken within a 30-day period during the Primary Contact Recreational season of May through October; ii) 130 *E. coli* colonies/100 ml as a geometric mean based on not less than 5 samples taken within a 30-day period during the Primary Contact Recreational season of May through October. Then the multiple of Q_S and WQC is converted into *E. coli* load (colonies/day) by multiplying the conversion factor of 24,465,758.4. TMDLs for metals are expressed as the flow in the stream, Q_S in ft^3/s , multiplied by the WQC in mg/L or $\mu\text{g}/\text{L}$ and the appropriate conversion factor to convert the multiple of flow and the WQC into units of load (pounds/day). The conversion factors are: iron, chronic = 5.3938 (when the WQC of 1.0 mg/L is applied) or 18.8782 (when the WQC of 3.5 mg/L is applied); iron, acute = 21.575; cadmium, copper, lead, nickel and zinc, chronic and acute = 0.005394. Also, pH must remain between 6.0 and 9.0 standard units, inclusive.
- 2) The MOS is implicit, see Section 7.3.
- 3) The KPDES-WLA for *E. coli* is expressed as the flow in the stream due to KPDES-permitted sources with *E. coli* permit limits, Q_{KPDES} in ft^3/s , multiplied by the WQCs and the conversion factor to convert the multiple of flow and the WQC into the unit of load (colonies/day). All KPDES-permitted dischargers must meet both instantaneous and geomean *E. coli* WQCs. The KPDES-WLA for metals is expressed as the flow in the stream due to KPDES-permitted sources with permit limits for the pollutants addressed by this TMDL, Q_{KPDES} , in ft^3/s , multiplied by the WQC and the appropriate conversion factor. All KPDES-permitted dischargers must meet both the chronic and acute criteria for pollutants addressed by this TMDL whose WQCs are expressed in both chronic and acute terms. New or expanded KPDES-permitted dischargers with reasonable potential will be allowed contingent upon them meeting WQCs of the pollutants addressed in this document.
- 4) The LA is expressed as the flow in the stream from natural background or due to legal but non-KPDES-permitted sources of the pollutants addressed by this TMDL, Q_{LA} , in ft^3/s , multiplied by the WQC and the appropriate conversion factor, see Section 5.2.
- 5) The chronic iron WQC is 1.0 mg/L since the aquatic life is adversely affected. The acute iron WQC is not dependent on impacts to aquatic life; it is 4.0 mg/L in all streams.
- 6) The chronic and acute WQCs for zinc are identical.
- 7) pH can be converted to a range of allowable loads of hydrogen ions in units of g/day (gram per day); a pH of 6.0 represents a maximum allowable load of hydrogen ions equal to $Q_S \times 2.906$ g/day, and a pH of 9.0 represents a minimum allowable load of $Q_S \times 2.906E-3$ g/day, where Q_S is the flow in the stream in ft^3/s . The TMDL can then be allocated to the KPDES-WLA and the LA based on the fraction of the streamflow each contributes.
- 8) Net alkalinity is defined as the alkalinity in mg/L as CaCO_3 minus the calculated acidity; the calculated acidity is determined using the following equation: Calculated Acidity, mg/L as $\text{CaCO}_3 = 50 \times ((10^{(3-\text{pH})}) + (3 \times \text{Fe mg/L}/55.8) + (2 \times \text{Mn mg/L}/54.9) + (3 \times \text{Al mg/L}/27))$. Monitoring and reporting of net alkalinity will be required both instream and at outfalls at the same frequency as iron and manganese are monitored and reported. Aluminum must be added to KPDES mining permits as report-only in order to determine the calculated acidity. Net alkalinity must be greater than or equal to zero (in both mg/L and pounds/day) in order to buffer metals hydrolysis which can lower pH below acceptable levels.
- 9) The chronic iron WQC is 3.5 mg/L since the aquatic life has not been shown to be adversely affected. The acute iron WQC is not dependent on impacts to aquatic life; it is 4.0 mg/L in all streams.

8.0 Individual Segments TMDL Calculations

This section presents data collected by the TMDL Section and includes an individual analysis of each impaired stream segment. The maps in this document are developed by the KDOW TMDL Section and most of the spatial data can be accessed and downloaded from the KYGEONET (<http://kygeonet.ky.gov>).

Data Validation

1. Quality Analysis/Quality Control samples (e.g., duplicates) were not considered during TMDL analysis.
2. Only samples collected from a flowing stream were considered in analysis.
3. Some samples were reported using either the *less than* (denoted using the “<”) symbol or the *greater than* (denoted using the “>”) symbol, indicating the true concentration was unknown but was either below or above the reported value, respectively. For these samples, the reported value was used verbatim. For *greater than* values, the exact value of the exceedance is unknown and likely higher than the number reported, however the sample still provides insight into the status of the waterbody at the time the sample was taken.
4. J-flagged data, which are those results above the detection limit but below the limit of quantitation, were reported verbatim.

As stated in Sections 2.1 and 7.4, the data were used to assess the streams for the impairments but not used to set a unique TMDL for any segment. This is because the TMDL is constructed using variables for flow and hardness (for some metals); this means the TMDL is valid at all times, under all flow conditions and all conditions of hardness, including the critical condition for each segment.

General Information

Hydrology and monitoring results from 2010-2014 are discussed for each segment, which are presented alphabetically. Only data for the pollutants that impair a given segment are shown in this document.

Bacteria and flow data collected by TMDL staff are presented for each *E. coli* impaired segment. Metals, pH and flow data collected by TMDL staff are presented for the impaired segments. For pH and iron, the concentrations were presented without further analysis beyond flagging for exceedances of the WQCs (i.e., pH below 6.0 standard units, and iron above the chronic or acute criterion). However, for the hardness-dependent metals, further columns were added. These include the hardness, the WQC, which was calculated based on the hardness, and another column showing the amount by which the instream metal concentration exceeded the WQC. This last column was included because knowing the concentration of the metal by itself often gives little to no understanding of its toxicity at the time the sample was collected; on a day with low

hardness, a low concentration of the metal may pose more of a risk to aquatic life than a higher concentration of the metal on a day with significantly higher hardness. This is because hardness mitigates the toxicity of these metals, as described in Section 7.6.2. The amount by which the concentration of the hardness-dependent metal exceeded the WQC will be referred to as ‘the (cadmium/copper/lead/nickel/zinc) difference’ in places to avoid repetition. It is presented as a negative number when the concentration of the metal did not exceed the WQC.

8.1 Bat East Creek 0.0 to 3.4

The pollutants addressed in this document for Bat East Creek 0.0 to 3.4 are *E. coli*, copper and lead. Bat East Creek is a fourth order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 22.06 square miles. There is one TMDL monitoring site on the Bat East Creek 0.0 to 3.4 segment, DOW03011007, located at RM 1.35 with the drainage area of 21.44 square miles, see Figure 8.1.1 and Table 8.1.1. This subwatershed consists primarily of forest (59.6%) and agricultural land (31.8%), see Figure 8.1.2 and Table 8.1.2.

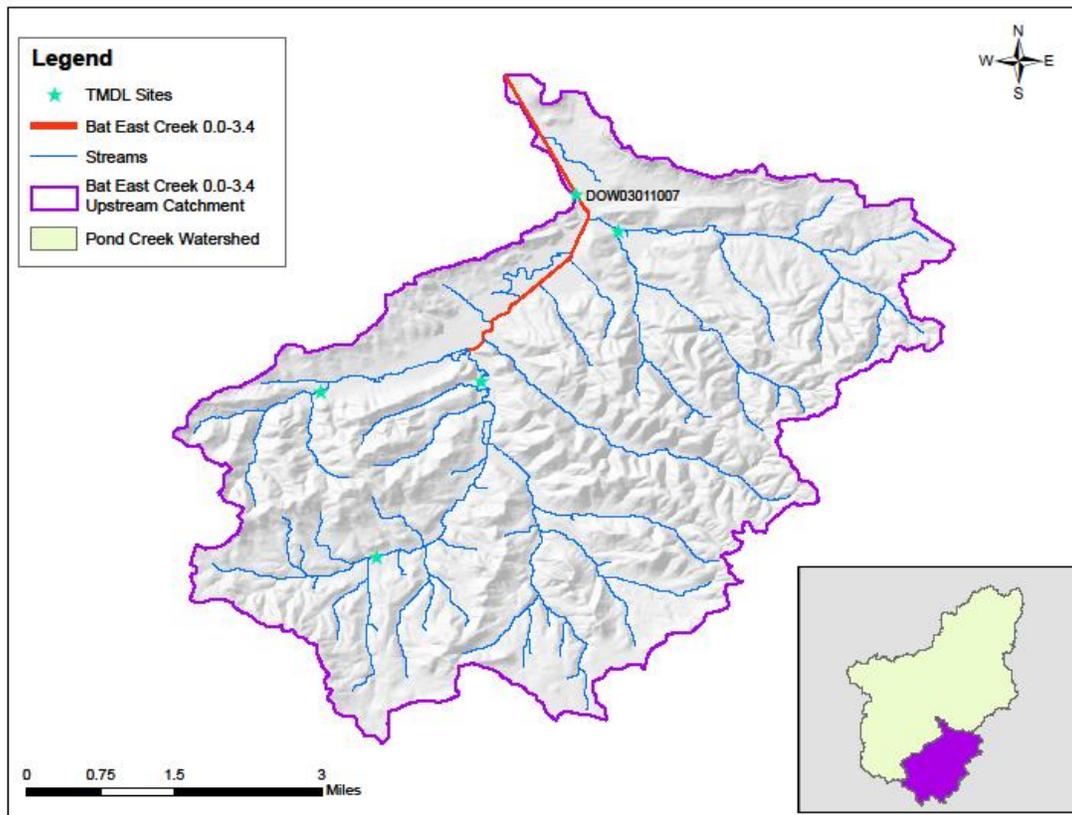


Figure 8.1.1 TMDL Monitoring Location and the Drainage Area of Bat East Creek 0.0 to 3.4

Table 8.1.1 Bat East Creek 0.0 to 3.4 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY486462_01	Bat East Creek 0.0 to 3.4	4	Muhlenberg	22.06	14120.4

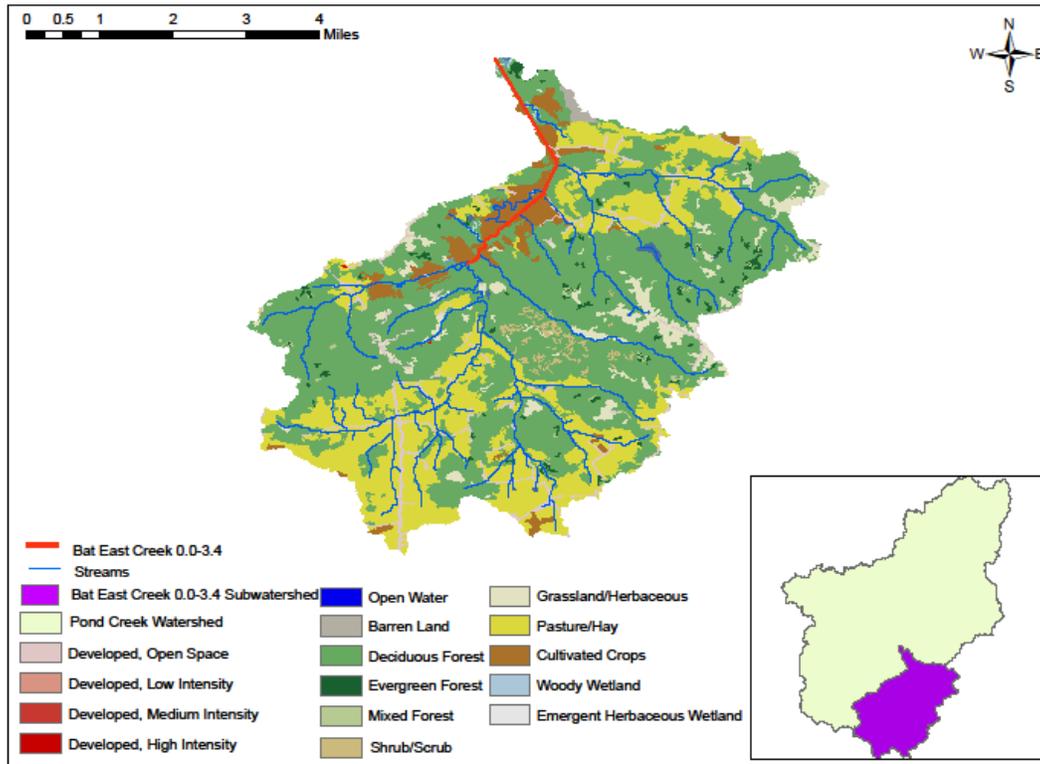


Figure 8.1.2 Land Cover in the Bat East Creek 0.0 to 3.4 Subwatershed

Table 8.1.2 Land Cover in the Bat East Creek 0.0 to 3.4 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.76	484.4	3.5
Agriculture	6.96	4452.5	31.8
Forest	13.05	8350.2	59.6
Barren Land	0.05	32.0	0.2
Grassland/Herbaceous	0.99	632.3	4.5
Wetlands	0.03	20.4	0.1
Water	0.06	36.3	0.3
Shrub/Scrub	0.18	112.7	0.8

There is one active KPDES- permitted facility in this subwatershed, see Figure 8.1.3 and Table 8.1.3. There are no active KPDES mining permits in this subwatershed, and a small portion of downstream watershed is licensed mining areas, see Figure 8.1.4 (see Section 9.4.3 for more

information). Tables 8.1.4 to 8.1.6 show *E. coli*, copper, lead and flow data collected by TMDL staff at DOW03011007.

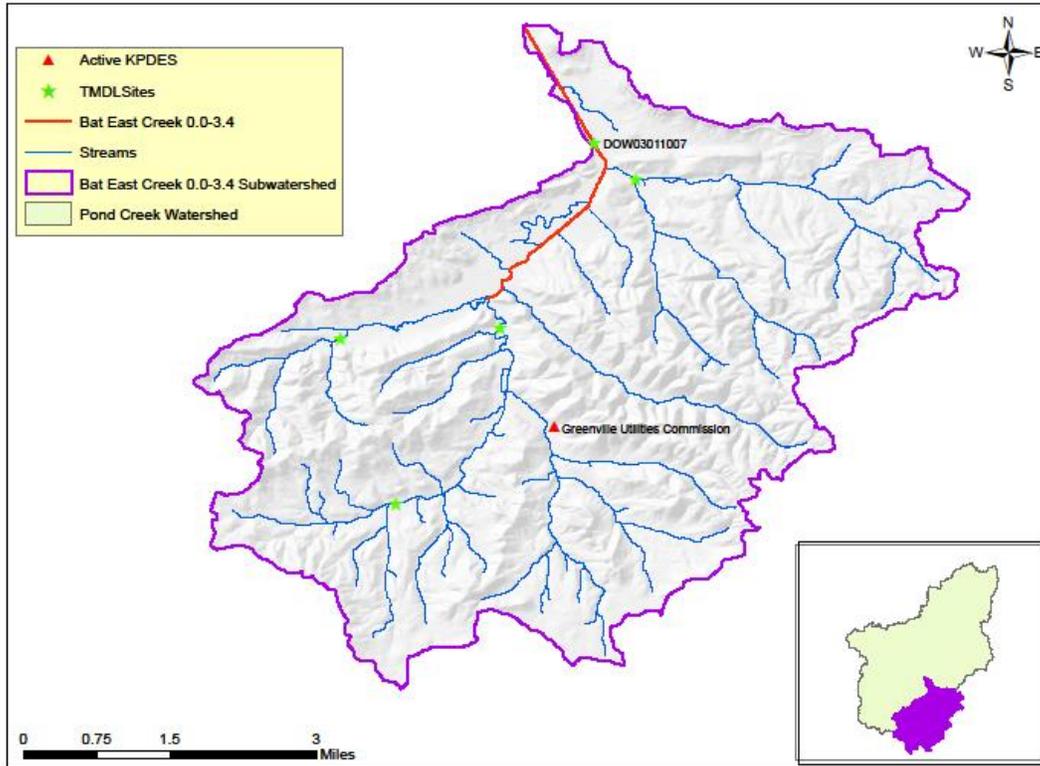


Figure 8.1.3 KPDES Permittee in the Subwatershed

Table 8.1.3 KPDES Permittee in the Subwatershed

KPDES	Status	Permit Name	Latitude	Longitude	Pollutants with Discharge Limit
KYG640108	Active	Greenville Utilities Commission	37.1139	-87.1032	pH, Iron

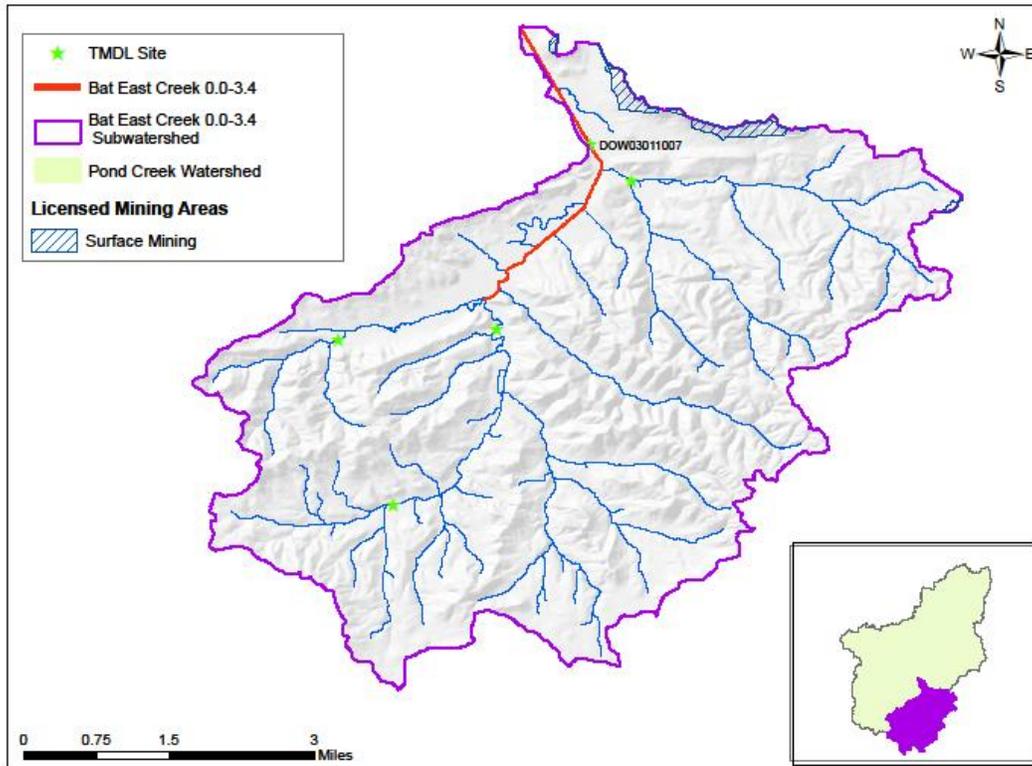


Figure 8.1.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.1.4 *E. coli* and Flow Data Collected at DOW03011007

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/11/2011	308	**
5/12/2011	292	**
5/24/2011	> 2420	**
5/25/2011	816	**
5/26/2011	> 2420	**
6/15/2011	111	**
6/16/2011	> 2420	**
6/21/2011	866	**
6/22/2011	1203	**
6/23/2011	> 2420	**
7/12/2011	14	**
7/13/2011	118	**

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
7/14/2011	> 2420	**
9/27/2011	> 2420	**
9/28/2011	1986	**
9/29/2011	235	**
Exceeds the instantaneous <i>E. coli</i> limit		

Table 8.1.5 Copper and Flow Data Collected at DOW03011007

Date	Copper (µg/L)	Hardness, Total (mg/L)	Copper Chronic Limit (µg/L)	Copper Acute Limit (µg/L)	Difference between the Copper Concentration and the Copper Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	2.86	951	63.93	116.88	-61.07	**
1/4/2011	0.507 (J)	64.2	6.39	9.22	N/A	**
1/5/2011	0.53 (J)	61.5	6.16	8.85	N/A	**
1/6/2011	< 1.0 (U)	62.9	6.28	9.04	N/A	**
2/15/2011	0.546 (J)	55.3	5.62	8.01	N/A	**
2/16/2011	0.536 (J)	57.7	5.83	8.34	N/A	**
2/17/2011	0.594 (J)	59.4	5.98	8.57	N/A	**
3/8/2011	0.936 (J)	43.9	4.62	6.45	N/A	**
3/9/2011	3.21	25.4	2.89	3.85	0.32	**
3/10/2011	0.895 (J)	35.9	3.89	5.33	N/A	**
4/26/2011	1.04 (J)	36	3.90	5.35	N/A	**
4/27/2011	5.24	23	2.66	3.51	2.58	**
4/28/2011	1.16 (J)	31.6	3.49	4.73	N/A	**
5/10/2011	0.669 (J)	46.2	4.82	6.76	N/A	**
5/11/2011	0.635 (J)	48.9	5.06	7.13	N/A	**
5/12/2011	0.948 (J)	279	22.42	36.81	N/A	**
6/15/2011	1.83	69.6	6.84	9.95	-5.01	**
6/16/2011	11.5	62.3	6.23	8.96	5.27	**
7/12/2011	1.24	131	11.75	18.05	-10.51	**
7/13/2011	1.71	73.2	7.15	10.43	-5.44	**
7/14/2011	3.86 (JD)	68.5	6.75	9.80	N/A	**

Date	Copper (µg/L)	Hardness, Total (mg/L)	Copper Chronic Limit (µg/L)	Copper Acute Limit (µg/L)	Difference between the Copper Concentration and the Copper Chronic Limit (µg/L)	Flow (cfs)
<p> Exceeds the acute limit</p> <p> Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

Table 8.1.6 Lead and Flow Data Collected at DOW03011007

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	0.791	951	55.96	1435.99	-55.17	**
1/4/2011	< 0.50 (U)	64.2	1.81	46.44	N/A	**
1/5/2011	< 0.50 (U)	61.5	1.71	43.97	N/A	**
1/6/2011	< 0.50 (U)	62.9	1.76	45.25	N/A	**
2/15/2011	< 0.50 (U)	55.3	1.50	38.41	N/A	**
2/16/2011	< 0.50 (U)	57.7	1.58	40.54	N/A	**
2/17/2011	0.528	59.4	1.64	42.07	-1.11	**
3/8/2011	0.371 (J)	43.9	1.12	28.63	N/A	**
3/9/2011	3.71	25.4	0.56	14.27	3.15	**
3/10/2011	0.728	35.9	0.86	22.16	-0.14	**
4/26/2011	0.651	36	0.87	22.24	-0.22	**
4/27/2011	7.29	23	0.49	12.57	6.80	**
4/28/2011	0.828	31.6	0.73	18.84	0.09	**
5/10/2011	0.395 (J)	46.2	1.19	30.55	N/A	**
5/11/2011	0.281 (J)	48.9	1.28	32.84	N/A	**
5/12/2011	0.405 (J)	279	11.75	301.43	N/A	**
6/15/2011	0.791	69.6	2.01	51.47	-1.21	**
6/16/2011	14.1	62.3	1.74	44.70	12.36	**
7/12/2011	0.734	131	4.49	115.14	-3.75	**
7/13/2011	1.24	73.2	2.14	54.88	-0.90	**

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
7/14/2011	3.45	68.5	1.97	50.44	1.48	**
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>J = Estimated Value</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

8.2 Beech Creek 0.0 to 3.9

The pollutants addressed in this document for Beech Creek 0.0 to 3.9 are cadmium, iron, nickel and zinc. A pH TMDL was developed for the segment of Beech Creek 0.0 to 3.4 and was approved by EPA in 2006. However, TMDL sampling data indicate that the stream was still impaired for pH at the time of data collection, see Table 8.2.5.

Beech Creek 0.0 to 3.9 is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 5.38 square miles. There is one TMDL monitoring site in the subwatershed, DOW03011015, located at RM 2.7 with the drainage area of 1.67 square miles, see Figure 8.2.1 and Table 8.2.1. This subwatershed consists primarily of forest (50.3%) and agricultural land (26.5%), see Figure 8.2.2 and Table 8.2.2.

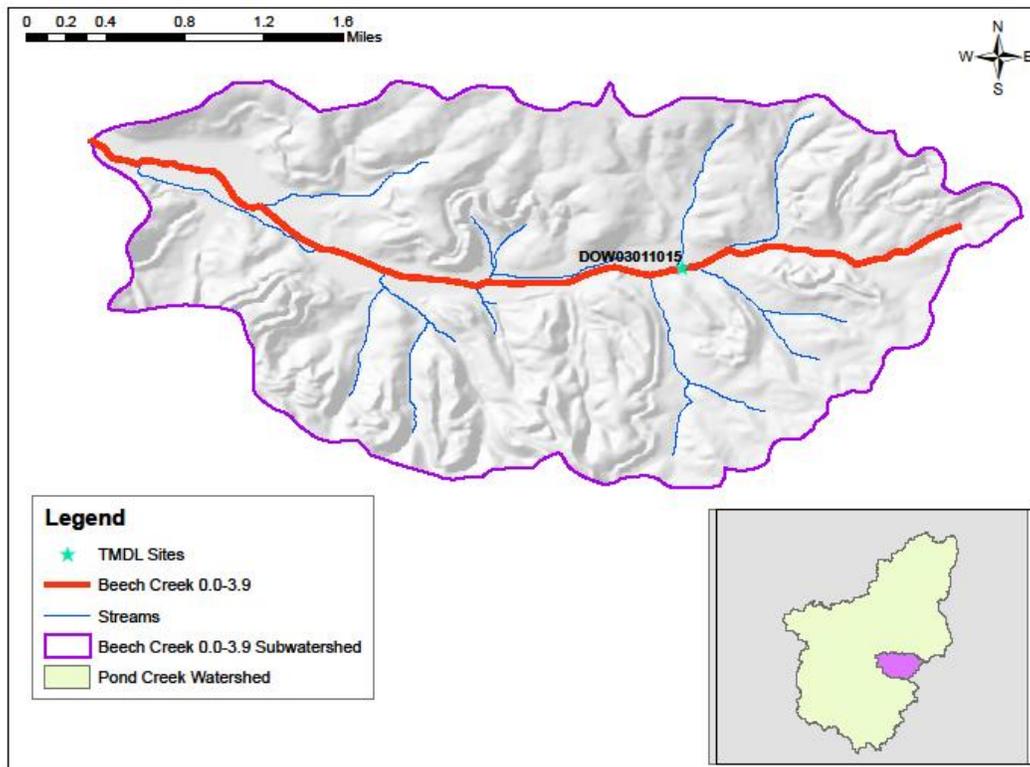


Figure 8.2.1 TMDL Monitoring Location and the Drainage Area of Beech Creek 0.0 to 3.9

Table 8.2.1 Beech Creek 0.0 to 3.9 Segment/Subwatershed Information

WBID	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY486697_01	Beech Creek 0.0 to 3.9	3	Muhlenberg	5.38	3443

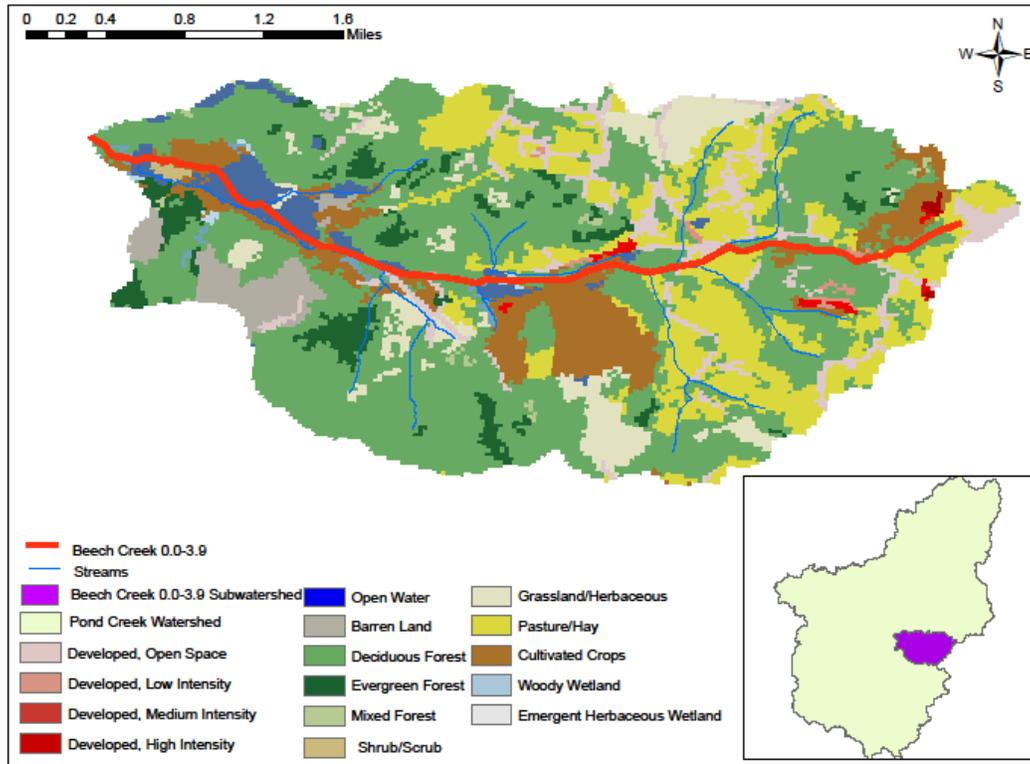


Figure 8.2.2 Land Cover in the Beech Creek 0.0 to 3.9 Subwatershed

Table 8.2.2 Land Cover within the Beech Creek 0.0 to 3.9 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.38	240.9	7.0
Agriculture	1.42	909.5	26.5
Forest	2.70	1727.5	50.3
Barren Land	0.30	191.0	5.6
Grassland/Herbaceous	0.38	243.6	7.1
Wetlands	0.01	6.8	0.2
Water	0.18	117.7	3.4
Shrub/Scrub	0.01	6.3	0.2

There are one active and three inactive KPDES-permitted facilities in this subwatershed, see Figure 8.2.3 and Table 8.2.3. Although those inactive KPDES facilities were active during the data collection period and may have contributed to the impairments of the Beech Creek 0.0 to 3.9, inactive KPDES permittee will not receive a WLA. There are no active KPDES mining

permits in this subwatershed, but the majority of the watershed is covered by licensed mining areas, see Figure 8.2.4 (see Section 9.4.3 for more information). Tables 8.2.4 through 8.2.8 show pH and metals data collected by TMDL staff at DOW03011015.

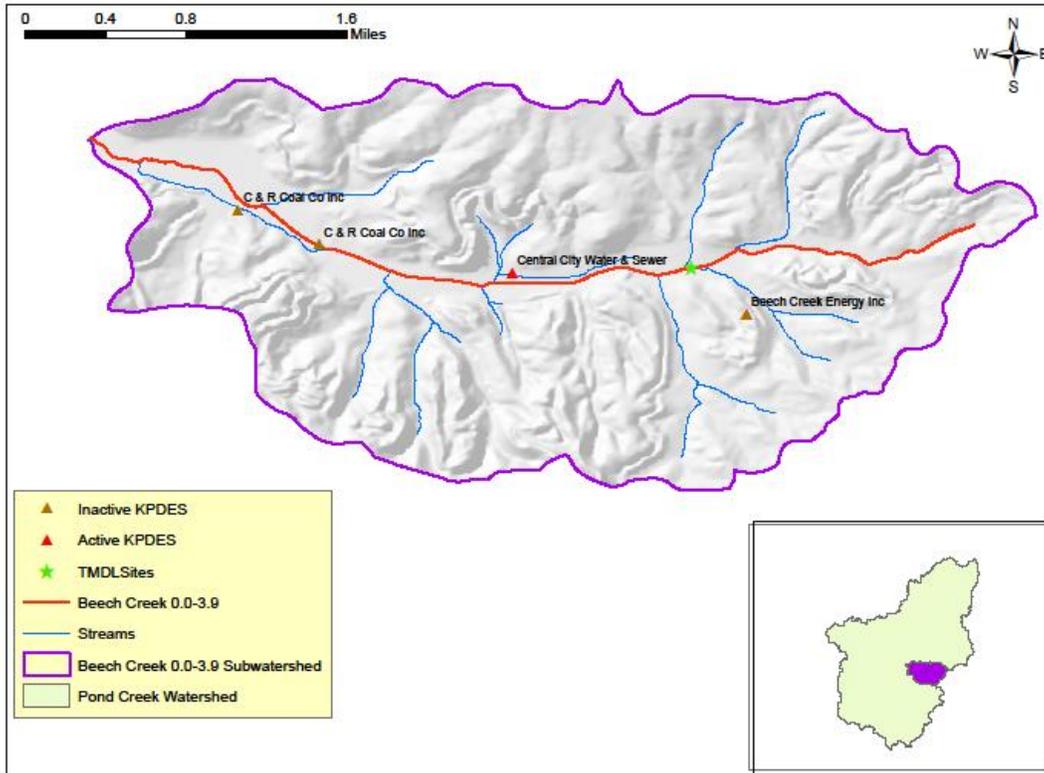


Figure 8.2.3 KPDES Permittees in the Subwatershed

Table 8.2.3 KPDES Permittees in the Subwatershed

KPDES	Status	Permit Name	Latitude	Longitude	Pollutants with Discharge Limit
KYG044789	Inactive	Beech Creek Energy Inc	37.170833	87.056111	pH, Iron
KYG640029	Active	Central City Water & Sewer	37.173800	87.073000	pH, Iron
KYG046025	Inactive	C & R Coal Co Inc	37.178333	87.092778	pH, Iron
KYG046026	Inactive	C & R Coal Co Inc	37.175833	87.086944	pH, Iron

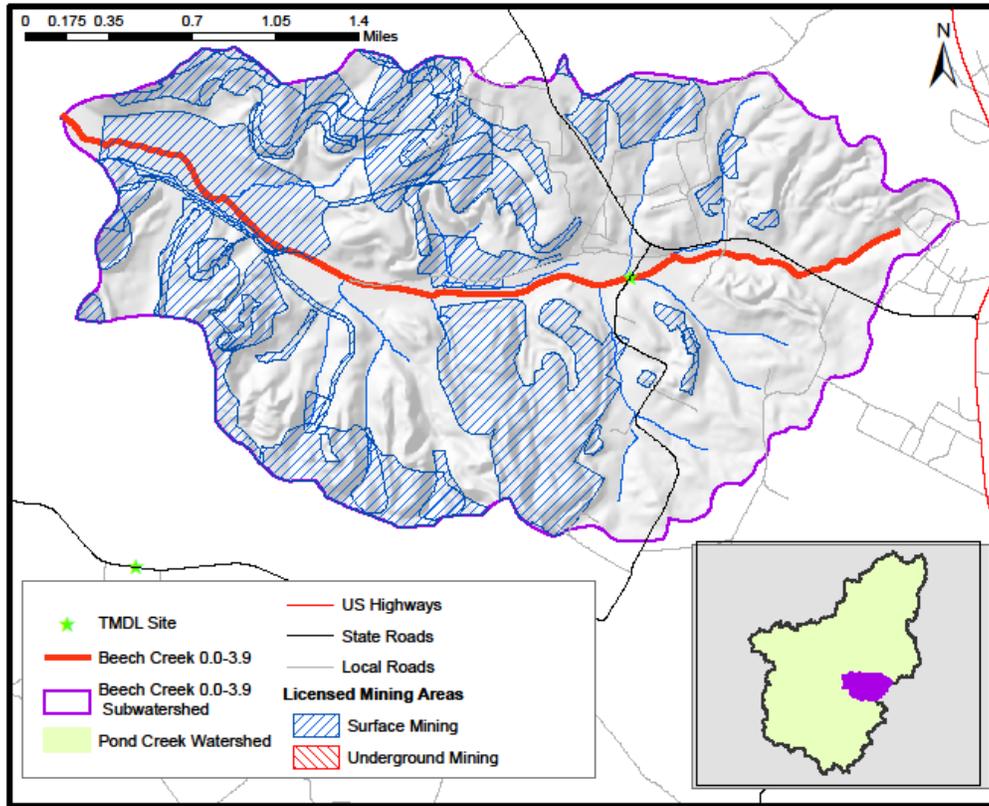


Figure 8.2.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.2.4 pH and Flow Data Collected at DOW03011015

Date	pH (standard units)	Flow (cfs)
11/17/2010	3.12	**
1/05/2011	5.04	0.676
5/11/2011	5.02	0.903
3/9/2011	5.57	**
4/27/2011	5.39	**
5/11/2011	3.03	1.934
5/25/2011	2.91	**
6/15/2011	2.68	0.167
6/22/2011	4.01	**
7/13/2011	2.77	0.135
7/27/2011	3.08	**
9/28/2011	5.08	0.087

Date	pH (standard units)	Flow (cfs)
10/19/2011	5.85	0.059
3/26/2013	5.03	2.560
4/24/2013	6.24	**
5/9/2013	3.33	**
6/27/2013	2.82	0.419
7/17/2013	2.93	0.209
8/6/2013	3.13	**
10/10/2013	3.86	0.293
11/13/2013	3.67	0.159
12/17/2013	5.29	0.843
3/18/2014	3.49	1.521
4/15/2014	5.12	3.973
5/21/2014	3.39	0.495
6/5/2014	4.76	0.902
10/29/2014	4.61	**
11/19/2014	4.63	**
12/23/2014	5.27	0.643
<p> Exceeds the pH limit ** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

Table 8.2.5 Iron and Flow Data Collected at DOW03011015

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
11/17/2010	4.2	**
1/5/2011	6.39	0.676
2/16/2011	5.25	0.903
3/9/2011	7.35	**
4/27/2011	5.77	**
5/11/2011	301 (D)	1.934
6/15/2011	110 (D)	0.167
7/13/2011	0.151 (B)	0.135
3/26/2013	0.0151	2.560
4/24/2013	3.62	**
5/9/2013	27	**
6/27/2013	56.4	0.419
7/17/2013	20.3	0.209
8/6/2013	6.69	**
10/10/2013	1.56	0.293

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
11/13/2013	1.73	0.159
12/17/2013	5.53	0.843
3/18/2014	27.4 (D)	1.521
4/15/2014	11.4 (D)	3.973
5/21/2014	14.3 (D)	0.495
6/5/2014	4.26	0.902
10/29/2014	1.37	**
11/19/2014	0.468	**
12/23/2014	2.83	0.643

⁽¹⁾Chronic limit is 1.0 mg/L since aquatic life is adversely affected
 Exceeds the acute limit
 Exceeds the chronic limit
** Unable to obtain flow because of water depth, swiftness, or lack of access
B = Analyte in Method Blank
D = Reanalyzed at a Higher Dilution

Table 8.2.6 Cadmium, Hardness and Flow Data Collected at DOW03011015

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	29 (DL)	779	1.24	17.19	27.76	**
1/5/2011	13.9 (DL)	386	0.74	8.42	13.16	0.676
2/16/2011	10.6 (DL)	330	0.66	7.18	9.94	0.903
3/9/2011	4.25 (DJ)	117	0.30	2.50	N/A	**
4/27/2011	4.23 (DJ)	97.9	0.27	2.09	N/A	**
5/11/2011	222 (L)	1400	1.91	31.20	220.09	1.934
6/15/2011	116 (DL)	1310	1.82	29.16	114.18	0.167
7/13/2011	68.2 (DL)	417	0.78	9.11	67.42	0.135
3/26/2013	6.38	169	0.40	3.64	5.98	2.560
4/24/2013	2.15	107	0.28	2.29	1.87	**
6/27/2013	29.4	923	1.40	20.43	28.00	0.419
7/17/2013	28.1	415	0.78	9.06	27.32	0.209
8/6/2013	20.1	803	1.27	17.73	18.83	**
10/10/2013	6.85	425	0.79	9.29	6.06	0.293

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/13/2013	10.6	625	1.05	13.74	9.55	0.159
12/17/2013	5	324	0.65	7.05	4.35	0.843
3/18/2014	13.3 (DL)	408	0.77	8.91	12.53	1.521
4/15/2014	4.52 (DJ)	262	0.55	5.68	3.97	3.973
5/21/2014	9.27 (DL)	531	0.93	11.65	8.34	0.495
6/5/2014	4.94 (D)	370	0.71	8.07	4.23	0.902
10/29/2014	7.52 (DL)	588	1.01	12.92	6.51	**
11/19/2014	5.93 (DL)	608	1.03	13.36	4.90	**
12/23/2014	4.9 (D)	435	0.80	9.51	4.10	0.643
<p>Exceeds the acute limit</p> <p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>L = Exceeds MCL or Action Limit</p> <p>N/A: Not Applicable</p>						

Table 8.2.7 Nickel, Hardness and Flow Data Collected at DOW03011015

Date	Nickel (µg/L)	Hardness, Total (mg/L)	Nickel Chronic Limit (µg/L)	Nickel Acute Limit (µg/L)	Difference between the Nickel Concentration and the Nickel Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	504 (D)	779	296.21	2664.23	207.79	**
1/5/2011	229	386	163.54	1470.91	65.46	0.676
2/16/2011	190	330	143.23	1288.23	46.77	0.903
3/9/2011	72	117	59.57	535.82	12.43	**
4/27/2011	66.5	97.9	51.23	460.82	15.27	**
5/11/2011	3380	1400	486.39	4374.78	2893.61	1.934
6/15/2011	2590	1310	459.80	4135.64	2130.20	0.167
7/13/2011	1640 (D)	417	174.58	1570.24	1465.42	0.135
3/26/2013	222	169	81.31	731.35	140.69	2.560
4/24/2013	62.1	107	55.24	496.81	6.86	**
6/27/2013	657	923	341.92	3075.33	315.08	0.419

Date	Nickel (µg/L)	Hardness, Total (mg/L)	Nickel Chronic Limit (µg/L)	Nickel Acute Limit (µg/L)	Difference between the Nickel Concentration and the Nickel Chronic Limit (µg/L)	Flow (cfs)
7/17/2013	891	415	173.87	1563.87	717.13	0.209
8/6/2013	815	803	303.91	2733.51	511.09	**
10/10/2013	272	425	177.41	1595.69	94.59	0.293
11/13/2013	360	625	245.85	2211.29	114.15	0.159
12/17/2013	181	324	141.02	1268.39	39.98	0.843
3/18/2014	333	408	171.39	1541.52	161.61	1.521
4/15/2014	148	262	117.83	1059.78	30.17	3.973
5/21/2014	406	531	214.19	1926.47	191.81	0.495
6/5/2014	184	370	157.78	1419.16	26.22	0.902
10/29/2014	232	588	233.48	2100.03	-1.48	**
11/19/2014	303	608	240.18	2160.30	62.82	**
12/23/2014	181	435	180.94	1627.40	0.06	0.643
<p> Exceeds the acute limit Exceeds the chronic limit ** Unable to obtain flow because of water depth, swiftness, or lack of access D = Reanalyzed at a Higher Dilution</p>						

Table 8.2.8 Zinc, Hardness and Flow Data Collected at DOW03011015

Date	Zinc (µg/L)	Hardness, Total (mg/L)	Zinc Chronic Limit (µg/L)	Zinc Acute Limit (µg/L)	Difference between the Zinc Concentration and the Zinc Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	1360 (D)	779	682.20	682.20	677.80	**
1/5/2011	782 (D)	386	376.30	376.30	405.70	0.676
2/16/2011	545 (D)	330	329.50	329.50	215.50	0.903
3/9/2011	209 (D, J)	117	136.86	136.86	N/A	**
4/27/2011	190 (D, J)	97.9	117.68	117.68	N/A	**
5/11/2011	7880	1400	1121.06	1121.06	6758.94	1.934
6/15/2011	5770 (D)	1310	1059.69	1059.69	4710.31	0.167
7/13/2011	3930 (D)	417	401.75	401.75	3528.25	0.135
3/26/2013	580	169	186.90	186.90	393.10	2.560
4/24/2013	135	107	126.89	126.89	8.11	**
6/27/2013	2150	923	787.64	787.64	1362.36	0.419

Date	Zinc (µg/L)	Hardness, Total (mg/L)	Zinc Chronic Limit (µg/L)	Zinc Acute Limit (µg/L)	Difference between the Zinc Concentration and the Zinc Chronic Limit (µg/L)	Flow (cfs)
7/17/2013	2540	415	400.12	400.12	2139.88	0.209
8/6/2013	1830	803	699.97	699.97	1130.03	**
10/10/2013	618	425	408.27	408.27	209.73	0.293
11/13/2013	1170	625	566.06	566.06	603.94	0.159
12/17/2013	395	324	324.41	324.41	70.59	0.843
3/18/2014	1090 (D)	408	394.39	394.39	695.61	1.521
4/15/2014	418 (D)	262	270.98	270.98	147.02	3.973
5/21/2014	1230 (D)	531	493.05	493.05	736.95	0.495
6/5/2014	467 (D)	370	363.04	363.04	103.96	0.902
10/29/2014	592 (D)	588	537.54	537.54	54.46	**
11/19/2014	668 (D)	608	552.99	552.99	115.01	**
12/23/2014	449 (D)	435	416.40	416.40	32.60	0.643
<p>Exceeds the acute limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>N/A: Not Applicable</p>						

8.3 Boggess Creek 0.0 to 3.0

The pollutant addressed in this document for Boggess Creek 0.0 to 3.0 is *E. coli*. Boggess Creek is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 2.37 square miles. There is one TMDL monitoring site on the Boggess Creek 0.0 to 3.0 segment, DOW03011024, located at RM 1.4 with the drainage area of 1.3 square miles, see Figure 8.3.1 and Table 8.3.1. This subwatershed consists primarily of forest (58.5%) and agricultural land (31.2%), see Figure 8.3.2 and Table 8.3.2.

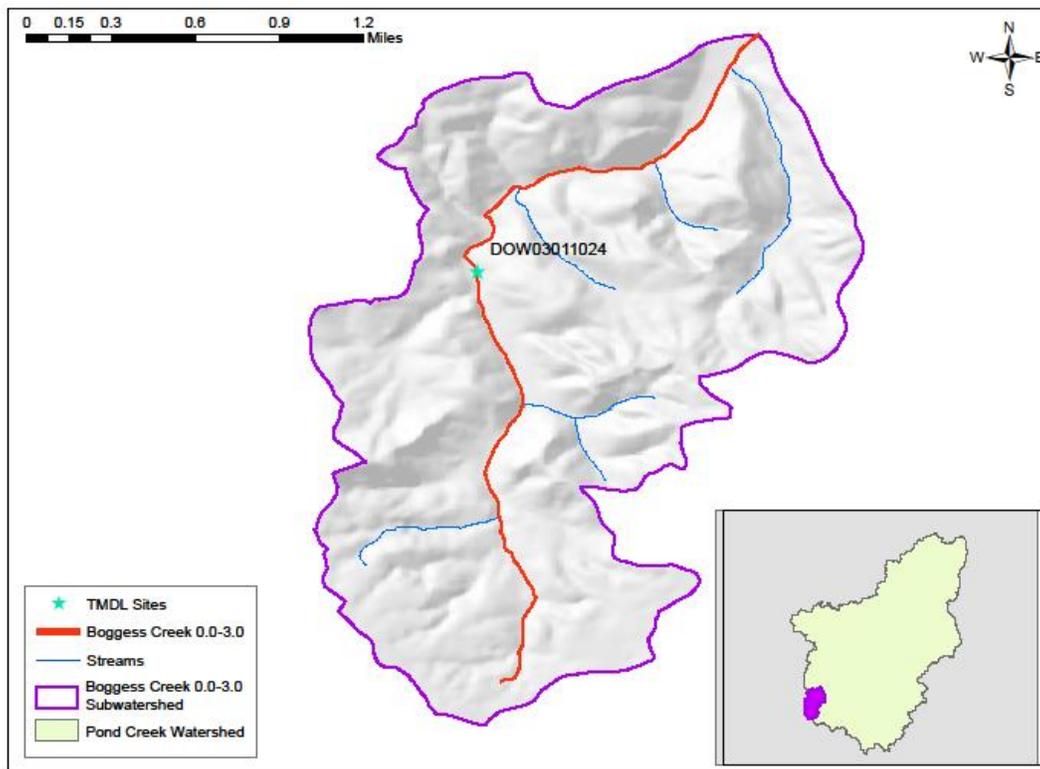


Figure 8.3.1 TMDL Monitoring Location and the Drainage Area of Boggess Creek 0.0 to 3.0

Table 8.3.1 Boggess Creek 0.0 to 3.0 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY487614_01	Boggess Creek 0.0 to 3.0	3	Muhlenberg	2.37	1517

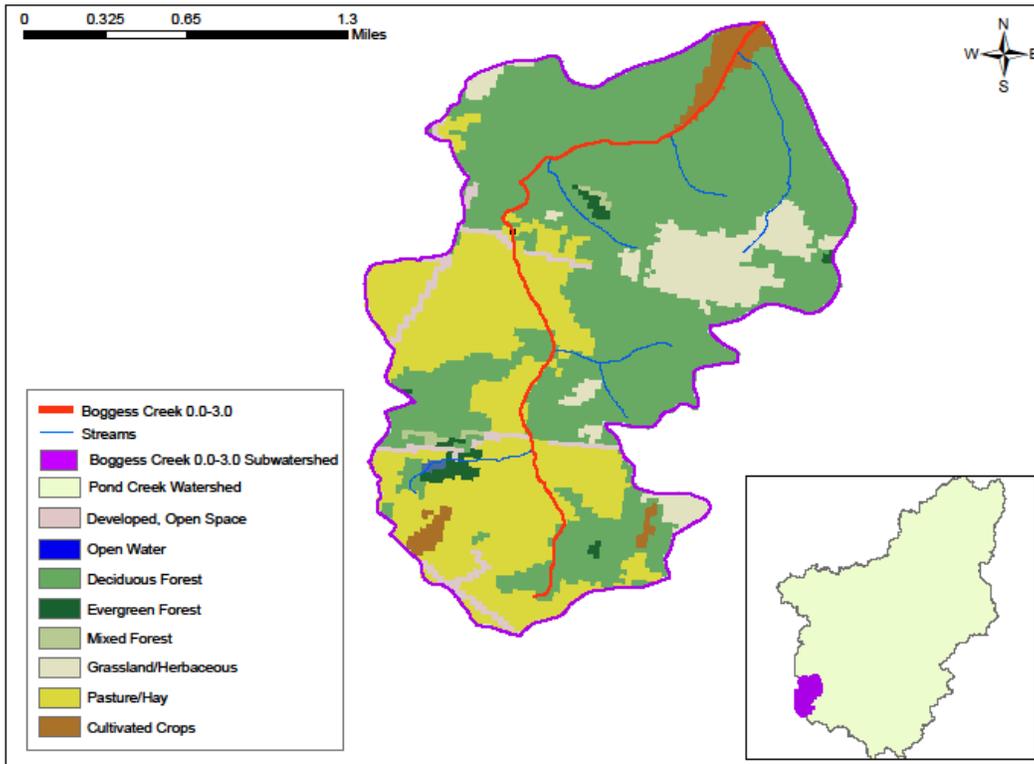


Figure 8.3.2 Land Cover in the Boggess Creek 0.0 to 3.0 Subwatershed

Table 8.3.2 Land Cover in the Boggess Creek 0.0 to 3.0 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.06	36.7	2.4
Agriculture	0.74	472.6	31.2
Forest	1.39	887.0	58.5
Barren Land	0	0	0
Grassland/Herbaceous	0.19	118.8	7.8
Wetlands	0	0	0
Water	0.003	1.8	0.1
Shrub/Scrub	0	0	0

There are no KPDES permittees in this subwatershed. *E. coli* and flow data monitored at DOW03011024 are shown in Table 8.3.3.

Table 8.3.3 *E. coli* and Flow Data, DOW03011024

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	461	0.892
6/21/2011	1553	**
5/8/2013	548	**
5/9/2013	613	**
5/23/2013	411	**
5/29/2013	687	**
6/6/2013	1733	**
6/27/2013	411	0.078
8/6/2013	62	0.031
8/15/2013	197	0.170
10/10/2013	285	0.139
<p> Exceeds the instantaneous <i>E. coli</i> limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

8.4 Caney Creek 0.0 to 3.6

The pollutants addressed in this document for Caney Creek 0.0 to 3.6 are *E. coli* and cadmium. Caney Creek is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 19.03 square miles. There is one TMDL monitoring site on the Caney Creek 0.0 to 3.6 segment, DOW03011001, located at RM 2.35 with the drainage area of 10.43 square miles, see Figure 8.4.1 and Table 8.4.1. This subwatershed consists primarily of forest (40.5%) and agricultural land (40.2%), see Figure 8.4.2 and Table 8.4.2.

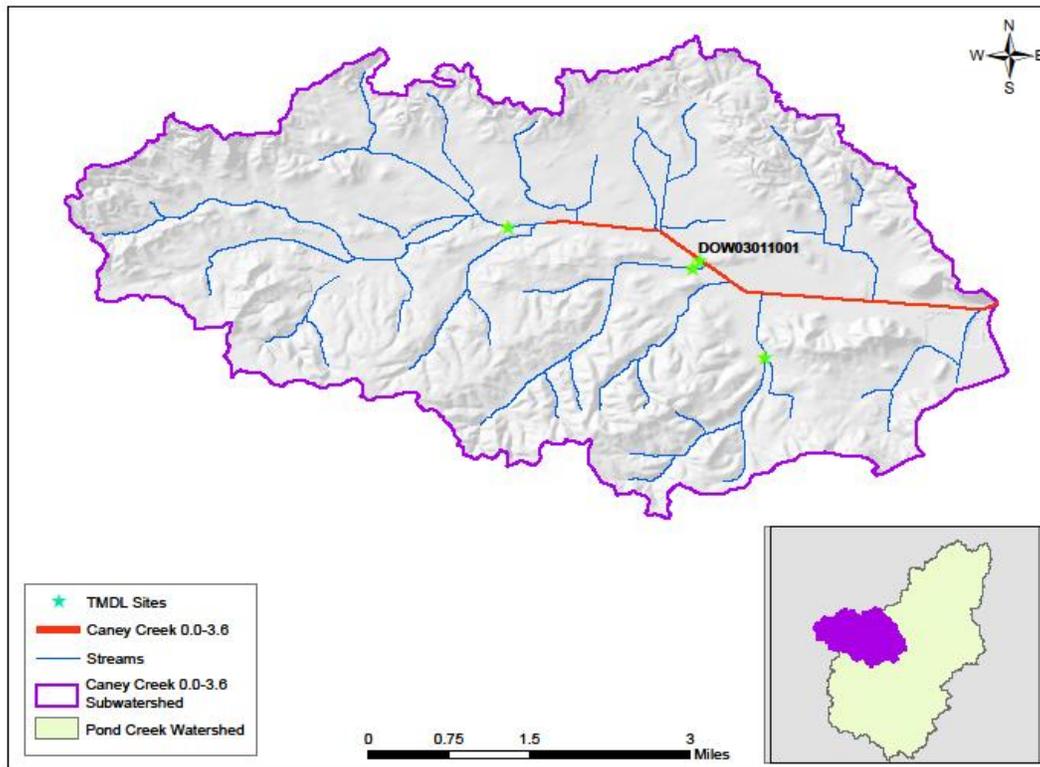


Figure 8.4.1 TMDL Monitoring Locations and the Drainage Area of Caney Creek 0.0 to 3.6

Table 8.4.1 Caney Creek 0.0 to 3.6 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY488838_01	Caney Creek 0.0 to 3.6	3	Muhlenberg	19.03	12179

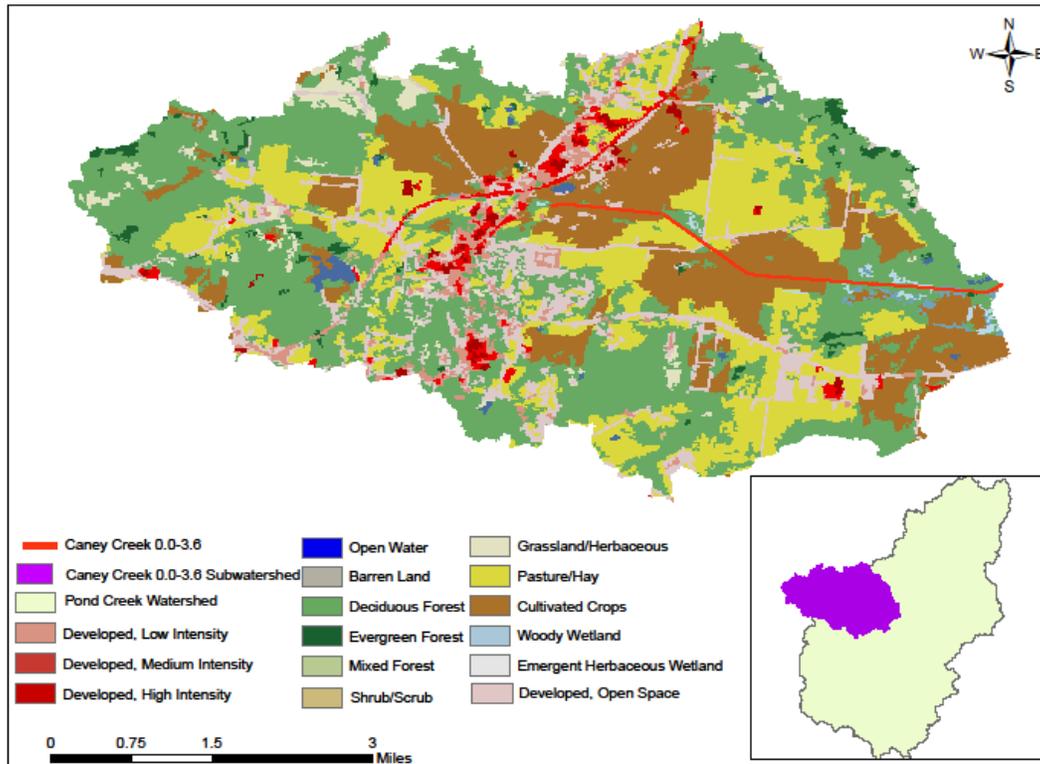


Figure 8.4.2 Land Cover in the Caney Creek 0.0 to 3.6 Subwatershed

Table 8.4.2 Land Cover in the Caney Creek 0.0 to 3.6 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	2.95	1887.4	15.5
Agriculture	7.65	4894.1	40.2
Forest	7.70	4926.8	40.5
Barren Land	0.02	12.1	0.1
Grassland/Herbaceous	0.48	309.3	2.5
Wetlands	0.11	68.5	0.6
Water	0.12	73.6	0.6
Shrub/Scrub	0.01	8.1	0.1

There are seven active and sixteen inactive KPDES permittees within the Caney Creek 0.0 to 3.6 subwatershed, see Figure 8.4.3 and Table 8.4.3. Although those inactive facilities were active during the data collection period and may have contributed to the impairments of this the Caney Creek 0.0 to 3.6, inactive KPDES permittee will not receive a WLA.

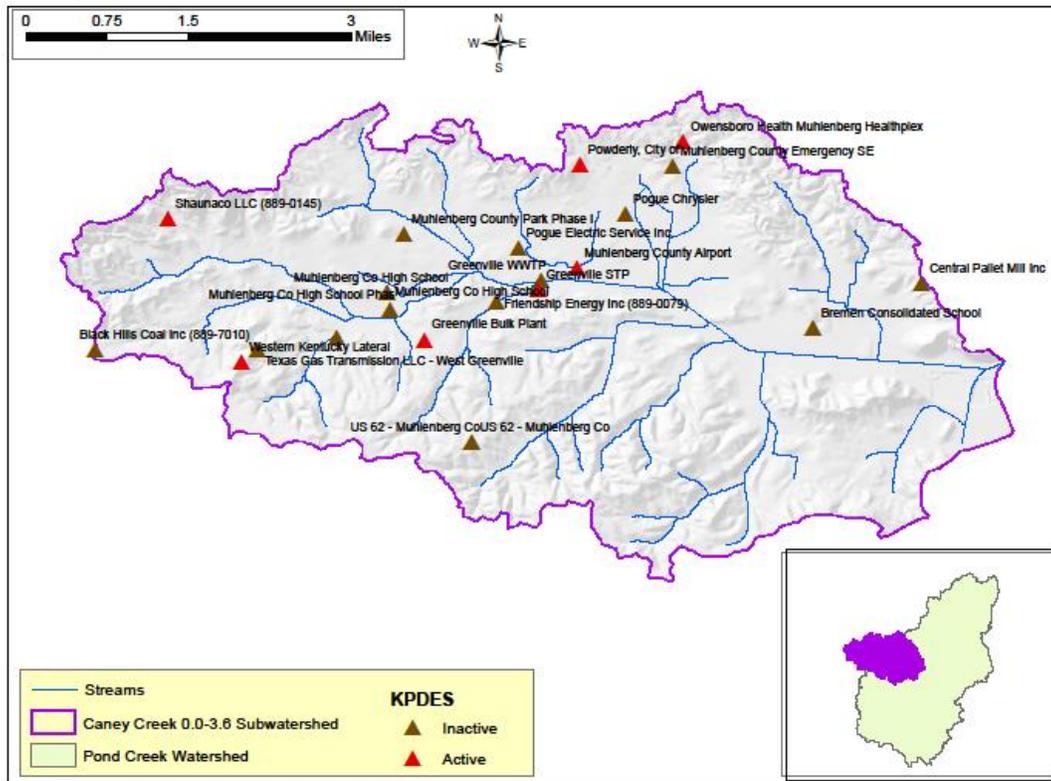


Figure 8.4.3 KPDES Permittees in the Caney Creek 0.0 to 3.6 Subwatershed

Table 8.4.3 KPDES Permittees in the Caney Creek 0.0 to 3.6 Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutants Limits /Requirements in Permit
KY0020010	Greenville STP	Yes	1.31	37.219167	-87.169444	bacteria, pH, Cd, Cu, Pb, Zn
KY0108537	Shaunaco LLC (889-0145)	Yes	0	37.228611	-87.218889	pH, Cd, Cu, Fe, Pb, Ni, Zn
KY0109606	Greenville Bulk Plant	Yes	0	37.212500	-87.184700	pH
KYP000064	Powderly, City of	Yes	0	37.235833	-87.163889	discharge to Greenville WWTP
KYR10J469	Muhlenberg County Airport	Yes	0	37.222067	-87.164333	to develop a SWPPP
KYR10K315	Western Kentucky Lateral	Yes	0	37.209464	-87.209069	to develop a SWPPP

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutants Limits /Requirements in Permit
KYR10K433	Owensboro Health Muhlenberg Healthplex	Yes	0	37.238889	-87.150189	to develop a SWPPP
KY0023329	Bremen Consolidated School	No	0.008	37.214000	-87.132800	bacteria
KY0099538	Texas Gas Transmission LLC - West Greenville	No	0	37.211111	-87.206944	pH
KYG043169	Black Hills Coal Inc (889-7010)	No	0	37.211111	-87.228611	pH, Fe
KYG044573	Friendship Energy Inc (889-0079)	No	0	37.217528	-87.175069	pH, Fe
KYR000524	Central Pallet Mill Inc	No	0	37.220000	-87.118333	pH and to develop a SWPPP
KYR10E810	Muhlenberg Co High School Phas 3	No	0	37.216500	-87.189224	to develop a SWPPP
KYR10E960	Muhlenberg County Emergency SE	No	0	37.235680	-87.151550	to develop a SWPPP
KYR10F821	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10G145	Greenville WWTP	No	0	37.220472	-87.169111	to develop a SWPPP
KYR10G154	Knight Construction & Excavating Inc	No	0	37.212776	-87.196388	to develop a SWPPP
KYR10G285	Pogue Chrysler	No	0	37.229353	-87.157828	to develop a SWPPP
KYR10G631	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10G632	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10H138	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10H705	Muhlenberg County Park Phase I	No	0	37.226610	-87.187427	to develop a SWPPP
KYR10I149	Pogue Electric Service Inc.	No	0	37.224749	-87.172138	to develop a SWPPP

There is one active KPDES mining permittee in this subwatershed, see Figure 8.4.4 and Table 8.4.4. A small portion of this subwatershed is covered by licensed mining areas, see Figure 8.4.5 (see Section 9.4.3 for more information). Tables 8.4.5 and 8.4.6 show *E. coli*, cadmium and flow data collected by TMDL staff at DOW03011001.

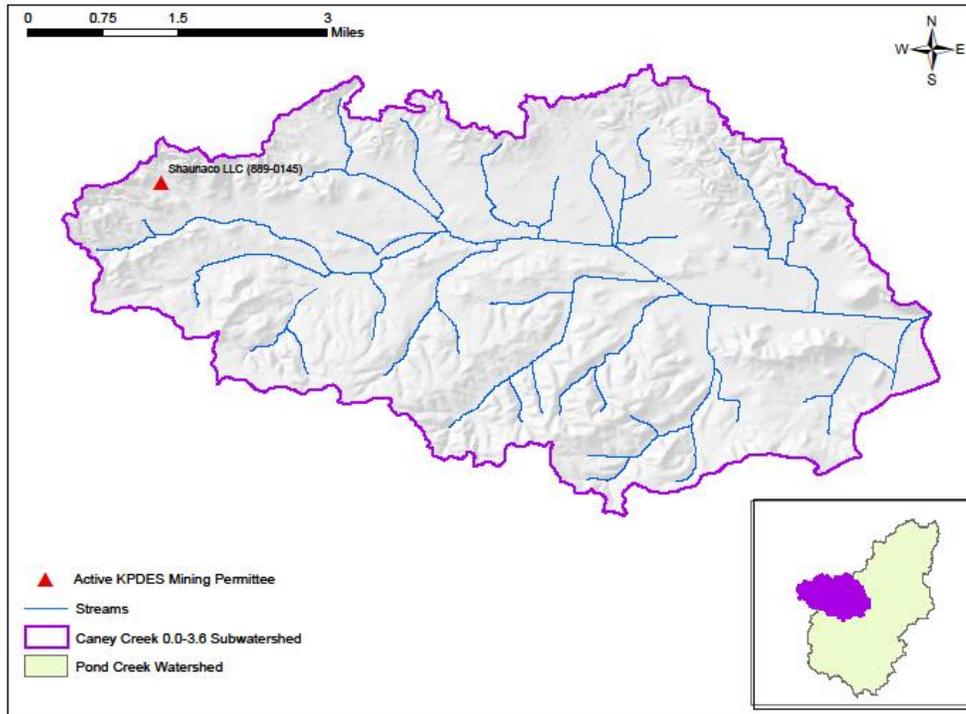


Figure 8.4.4 Active KPDES Mining Permittee in the Subwatershed

Table 8.4.4 Active KPDES Mining Permittee in the Subwatershed

KPDES Permit #	KDNR Permit #	Permittee Name	Date Issued
KY0108537	889-0145	Shaunaco LLC	12/1/2011

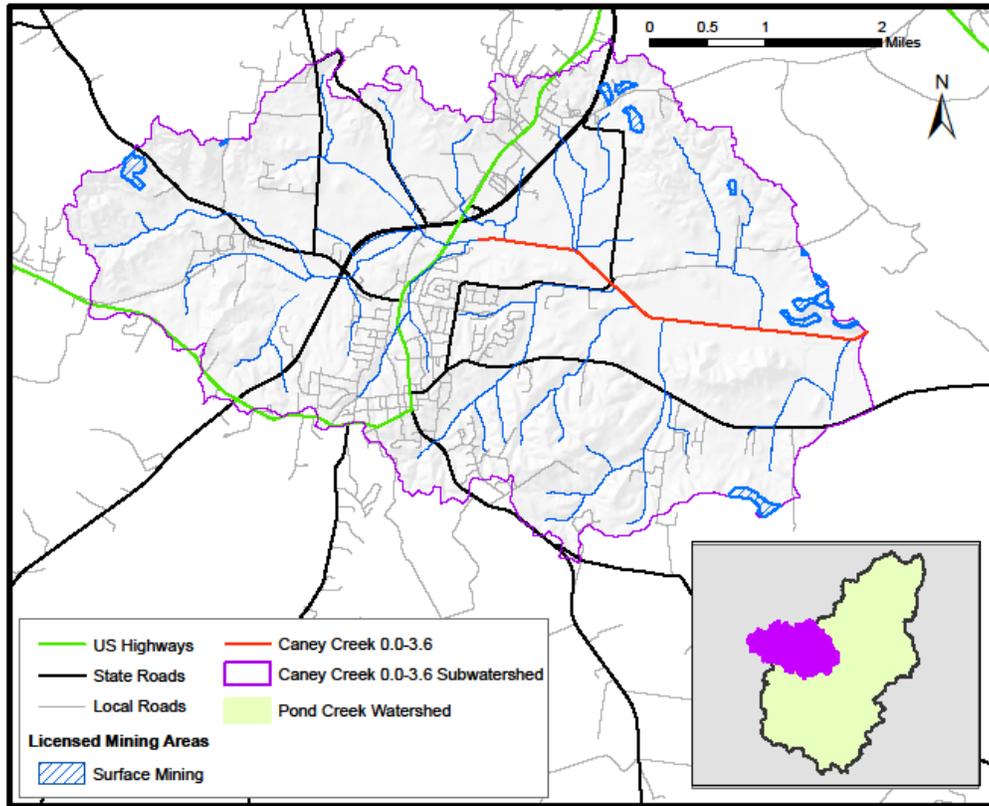


Figure 8.4.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.4.5 *E. coli* and Flow Data, DOW03011001

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
6/22/2011	> 2420	**
10/19/2011	1414	**
5/8/2013	120	**
5/9/2013	69	**
5/20/2013	91	**
5/23/2013	197	**
5/29/2013	128	**
6/6/2013	> 2420	**
6/26/2013	22	1.813
7/16/2013	54	1.578
7/30/2013	125	0.624
8/8/2013	727	0.433

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
8/15/2013	206	2.200
9/10/2013	218	0.626
9/24/2013	326	2.095
10/9/2013	285	2.181
10/14/2013	548	1.101
<p>Exceeds the instantaneous <i>E. coli</i> limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

Table 8.4.6 Cadmium, Hardness and Flow Data Collected at DOW03011001

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	< 0.80 (U)	205	0.46	4.43	N/A	**
1/5/2011	0.602 (J)	263	0.55	5.70	N/A	4.591
2/16/2011	0.567 (J)	248	0.53	5.37	N/A	6.929
3/21/2013	0.51	242	0.52	5.24	-0.01	10.939
4/18/2013	< 0.40 (U)	328	0.65	7.14	N/A	4.415
5/8/2013	0.38	225	0.49	4.86	-0.11	**
6/26/2013	0.28	337	0.67	7.34	-0.39	1.813
7/16/2013	< 0.50 (U)	259	0.55	5.61	N/A	1.578
8/8/2013	0.49	216	0.48	4.67	0.01	0.433
9/10/2013	< 0.50 (U)	203	0.46	4.38	N/A	0.626
10/9/2013	< 0.50 (U)	214	0.48	4.62	N/A	2.181
11/13/2013	0.27	234	0.51	5.06	-0.24	1.649
12/17/2013	0.35	254	0.54	5.50	-0.19	7.531
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>J = Estimated Value</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

8.5 Caney Creek 3.6 to 7.6

The pollutants addressed in this document for Caney Creek 3.6 to 7.6 are *E. coli*, cadmium and lead. Caney Creek 3.6 to 7.6 is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 7.14 square miles. There is one TMDL monitoring site on the Caney Creek 3.6 to 7.6 segment, DOW03011014, located at RM 3.9 with the drainage area of 6.28 square miles, see Figure 8.5.1 and Table 8.5.1. This subwatershed consists primarily of forest (49.0%), agricultural land (27.5%), and developed area (17.9%), see Figure 8.5.2 and Table 8.5.2.

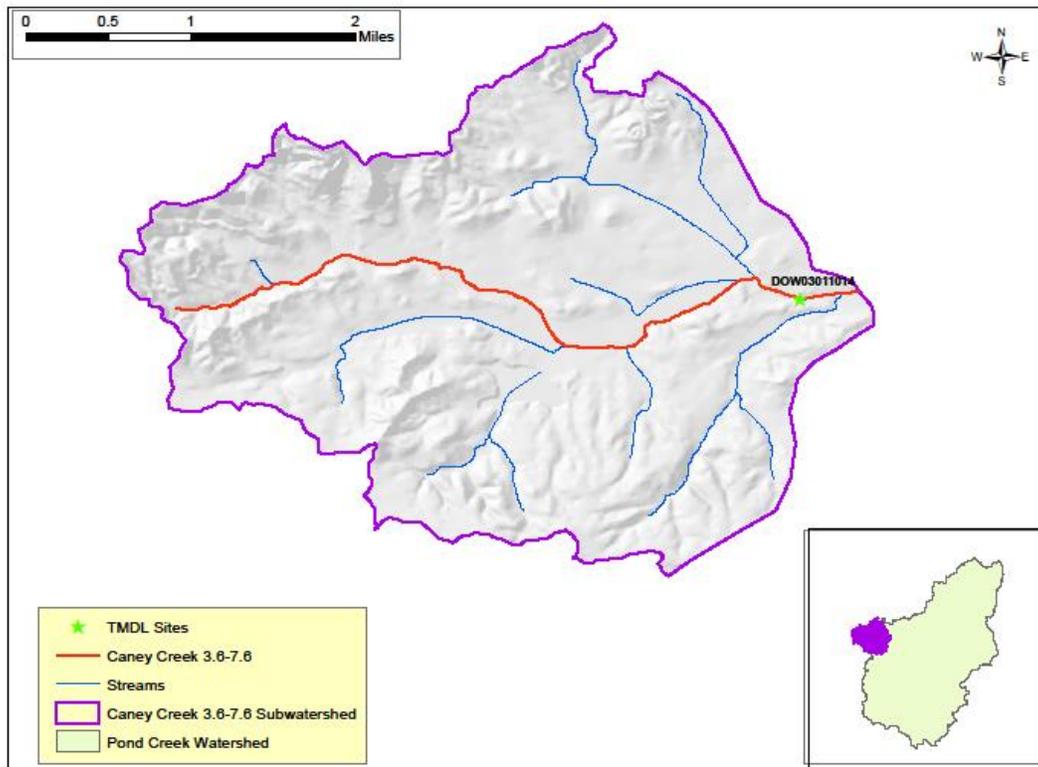


Figure 8.5.1 TMDL Monitoring Location and the Drainage Area of Caney Creek 3.6 to 7.6

Table 8.5.1 Caney Creek 3.6 to 7.6 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY488838_02	Caney Creek 3.6 to 7.6	3	Muhlenberg	7.14	4567

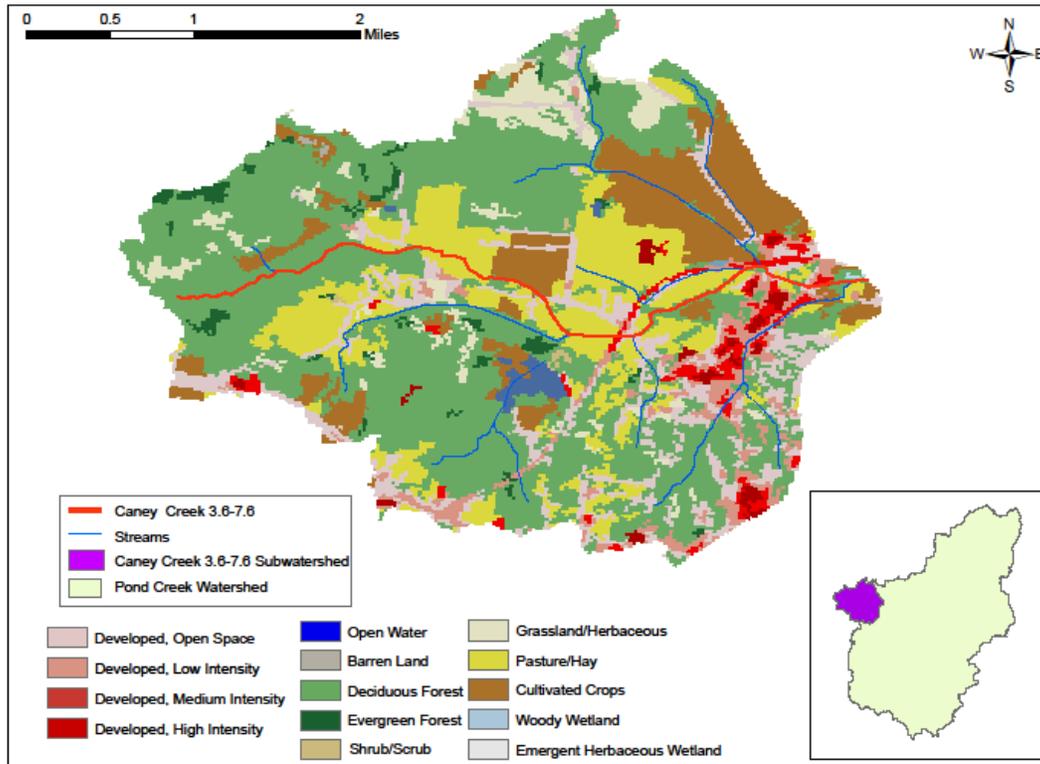


Figure 8.5.2 Land Cover in the Caney Creek 3.6 to 7.6 Subwatershed

Table 8.5.2 Land Cover in the Caney Creek 3.6 to 7.6 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	1.28	816.2	17.9
Agriculture	1.96	1257.0	27.5
Forest	3.51	2245.2	49.0
Barren Land	0.00	3.0	0.1
Grassland/Herbaceous	0.32	205.0	4.5
Wetlands	0.00	1.3	0.03
Water	0.06	39.3	0.9
Shrub/Scrub	0.01	6.4	0.1

There are four active and ten inactive KPDES-permitted facilities within the Caney Creek 3.6 to 7.6 subwatershed, see Figure 8.5.3 and Table 8.5.3. Although those inactive facilities were active

during the data collection period and may have contributed to the impairments of this waterbody, inactive KPDES permittee will not receive a WLA.

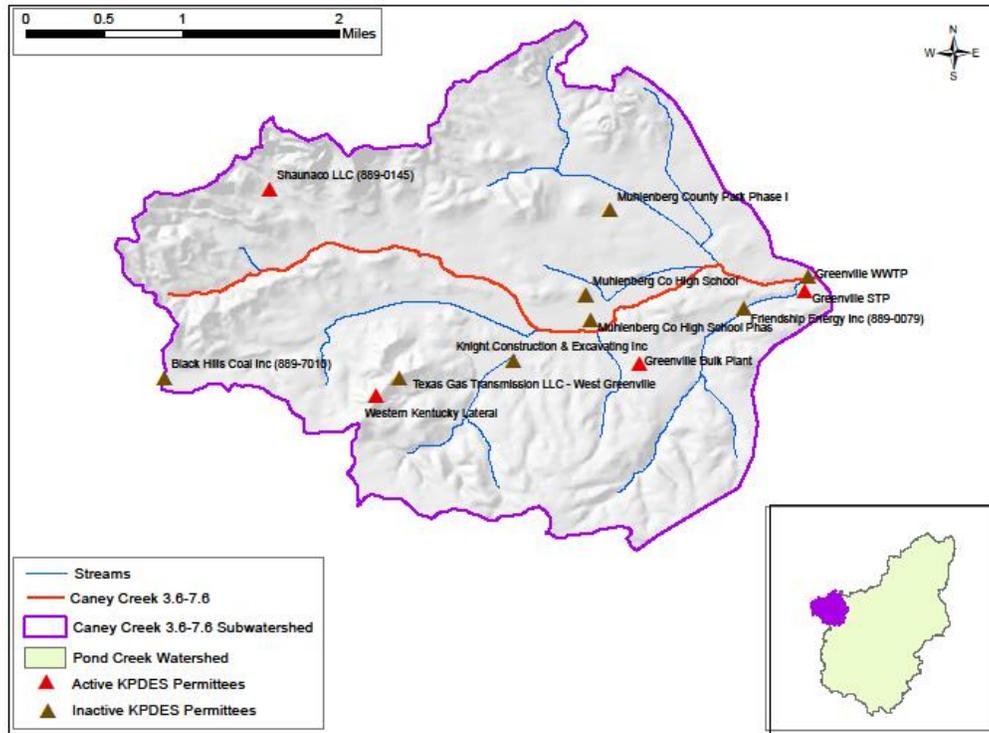


Figure 8.5.3 KPDES Permittees in the Caney Creek 3.6 to 7.6 Subwatershed

Table 8.5.3 KPDES Permittees in the Caney Creek 3.6 to 7.6 Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutants Limits /Requirements in Permit
KY0020010	Greenville STP	Yes	1.31	37.219167	-87.169444	bacteria, pH, Cd, Cu, Pb, Zn
KY0108537	Shaunaco LLC (889-0145)	Yes	0	37.228611	-87.218889	pH, Cd, Cu, Fe, Pb, Ni, Zn
KY0109606	Greenville Bulk Plant	Yes	0	37.212500	-87.184700	pH
KYR10K315	Western Kentucky Lateral	Yes	0	37.209464	-87.209069	to develop a SWPPP
KY0099538	Texas Gas Transmission LLC - West Greenville	No	0	37.211111	-87.206944	pH

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutants Limits /Requirements in Permit
KYG043169	Black Hills Coal Inc (889-7010)	No	0	37.211111	-87.228611	pH, Fe
KYG044573	Friendship Energy Inc (889-0079)	No	0	37.217528	-87.175069	pH, Fe
KYR10E810	Muhlenberg Co High School Phas 3	No	0	37.216500	-87.189224	to develop a SWPPP
KYR10F821	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10G145	Greenville WWTP	No	0	37.220472	-87.169111	to develop a SWPPP
KYR10G154	Knight Construction & Excavating Inc	No	0	37.212776	-87.196388	to develop a SWPPP
KYR10H138	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10H705	Muhlenberg County Park Phase I	No	0	37.226610	-87.187427	to develop a SWPPP

There is one active KPDES mining permittee in this subwatershed, see Figure 8.5.4 and Table 8.5.4. A small portion of upstream watershed is licensed mining areas, see Figure 8.5.5 (see Section 9.4.3 for more information). Tables 8.5.5 to 8.5.7 show *E. coli*, cadmium, lead and flow data collected by TMDL staff at DOW03011014.

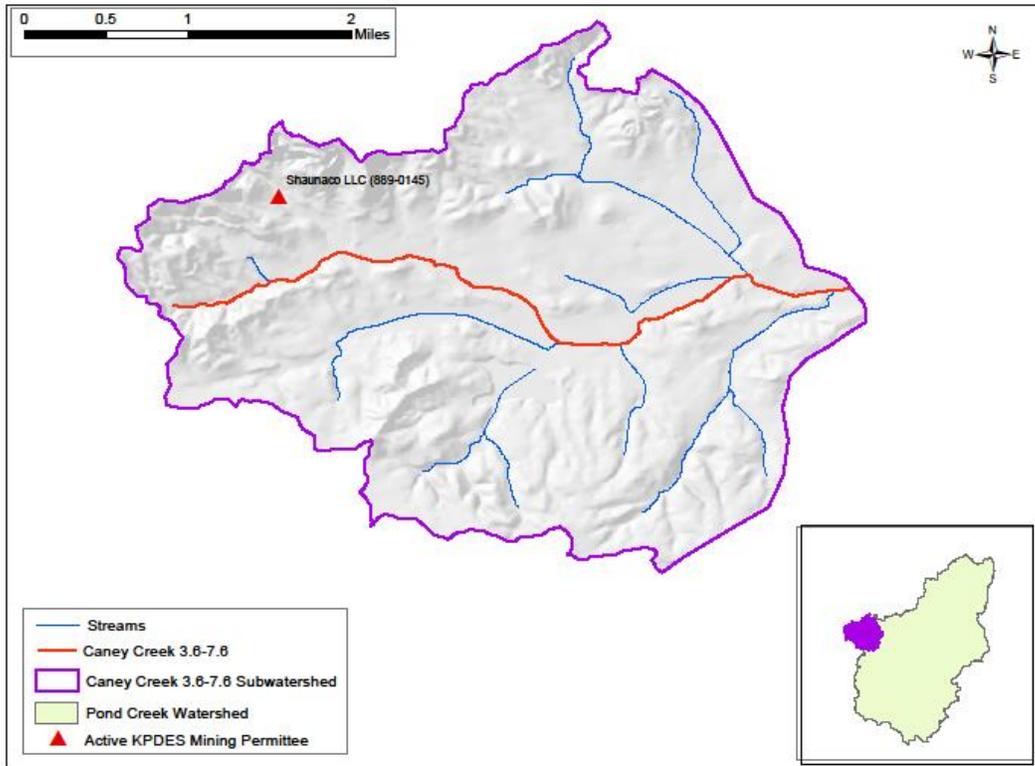


Figure 8.5.4 Active KPDES Mining Permittee in the Subwatershed

Table 8.5.4 Active KPDES Mining Permittee in the Subwatershed

KPDES Permit #	KDNR Permit #	Permittee Name	Date Issued
KY0108537	889-0145	Shaunaco LLC	12/1/2011

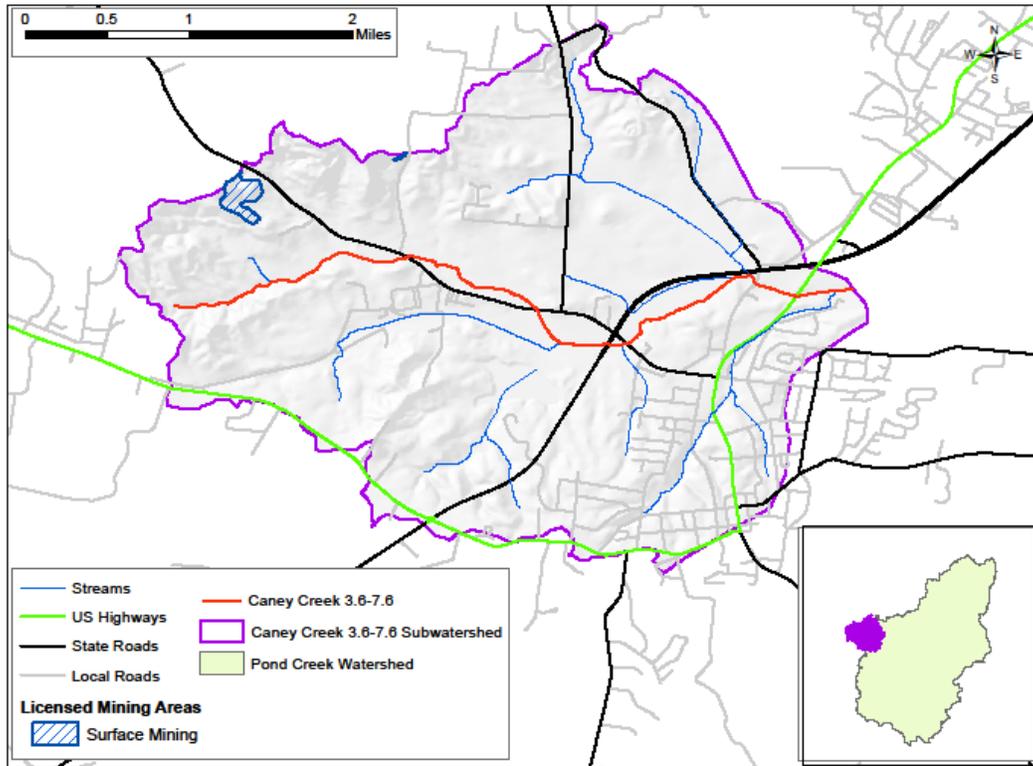


Figure 8.5.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.5.5 *E. coli* and Flow Data, DOW03011014

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/11/2011	39	**
5/25/2011	110	**
6/22/2011	1203	**
7/13/2011	461	**
9/28/2011	411	**
10/19/2011	> 2420	**
5/8/2013	317	**
5/9/2013	101	**
5/20/2013	73	**
5/23/2013	37	**
5/29/2013	272	**
6/6/2013	> 2420	**

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
6/26/2013	261	**
7/16/2013	178	**
8/15/2013	74	**
9/24/2013	> 2420	**
10/9/2013	411	**
10/14/2013	96	**

Exceeds the instantaneous *E. coli* limit
 ** Unable to obtain flow because of water depth, swiftness, or lack of access

Table 8.5.6 Cadmium, Hardness and Flow Data Collected at DOW03011014

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	< 0.80 (U)	112	0.29	2.39	N/A	**
1/5/2011	1.66	350	0.68	7.62	0.98	**
2/16/2011	1.16	274	0.57	5.94	0.59	**
3/9/2011	< 0.80 (U)	75.1	0.22	1.59	N/A	**
4/27/2011	< 0.80 (U)	56.6	0.18	1.20	N/A	**
5/11/2011	10.7 (L)	529	0.93	11.60	9.77	**
7/13/2011	0.898	343	0.67	7.47	0.22	**

Exceeds the chronic limit
 ** Unable to obtain flow because of water depth, swiftness, or lack of access
 L = Exceeds MCL or Action Limit
 U = Analyte Not Detected
 N/A: Not Applicable

Table 8.5.7 Lead, Hardness and Flow Data Collected at DOW03011014

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	0.926	112	3.68	94.32	-2.75	**
1/5/2011	0.245 (J)	350	15.68	402.28	N/A	**

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
2/16/2011	< 0.50 (U)	274	11.48	294.57	N/A	**
3/9/2011	2.74	75.1	2.21	56.70	0.53	**
4/27/2011	2.14	56.6	1.54	39.56	0.60	**
5/11/2011	0.537	529	26.52	680.59	-25.98	**
7/13/2011	< 0.50 (U)	343	15.28	392.06	N/A	**
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>J = Estimated Value</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

8.6 Carters Creek 0.0 to 3.1

The pollutant addressed in this document for Carters Creek 0.0 to 3.1 is *E. coli*. Carters Creek is a second order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 2.38 square miles. There is one TMDL monitoring site on the Carters Creek 0.0 to 3.1 segment, DOW03011017, located at RM 1.55 with the drainage area of 1.25 square miles, see Figure 8.6.1 and Table 8.6.1. This subwatershed consists primarily of forest (77.8%) and agricultural land (14.8%), see Figure 8.6.2 and Table 8.6.2.

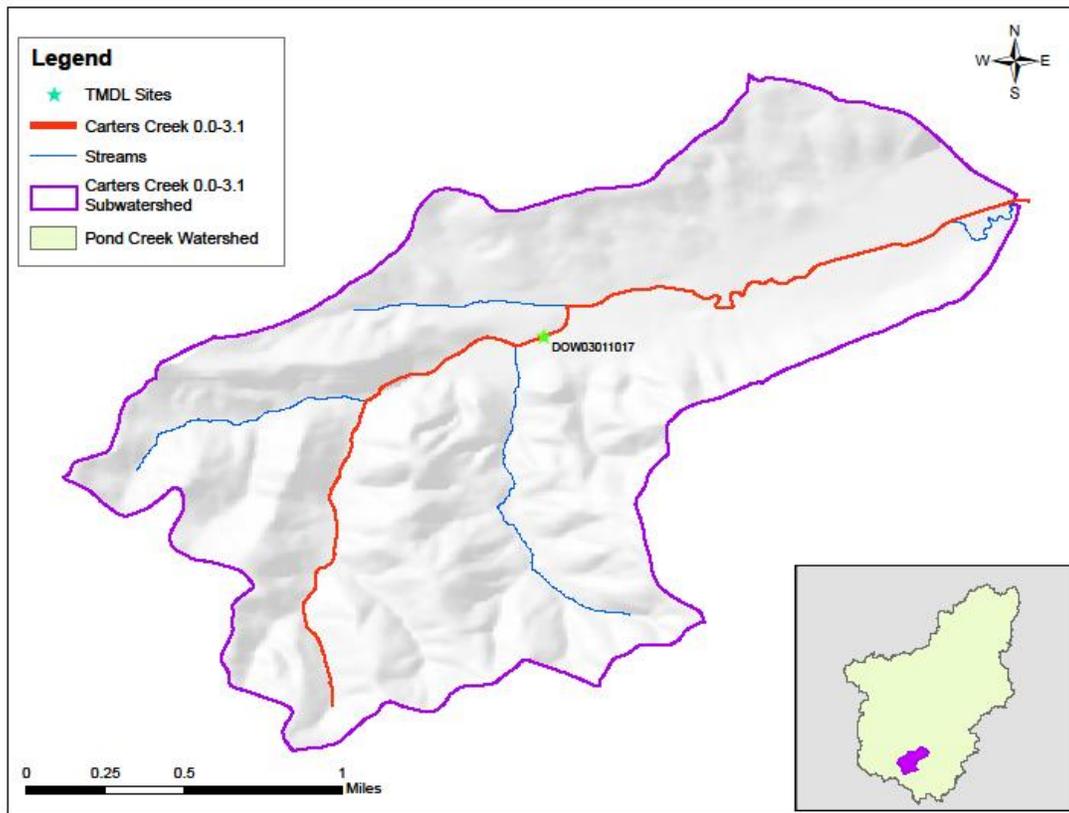


Figure 8.6.1 TMDL Monitoring Site and the Drainage Area of Carters Creek 0.0 to 3.1

Table 8.6.1 Carters Creek 0.0 to 3.1 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY489022_01	Carters Creek 0.0 to 3.1	2	Muhlenberg	2.38	1522

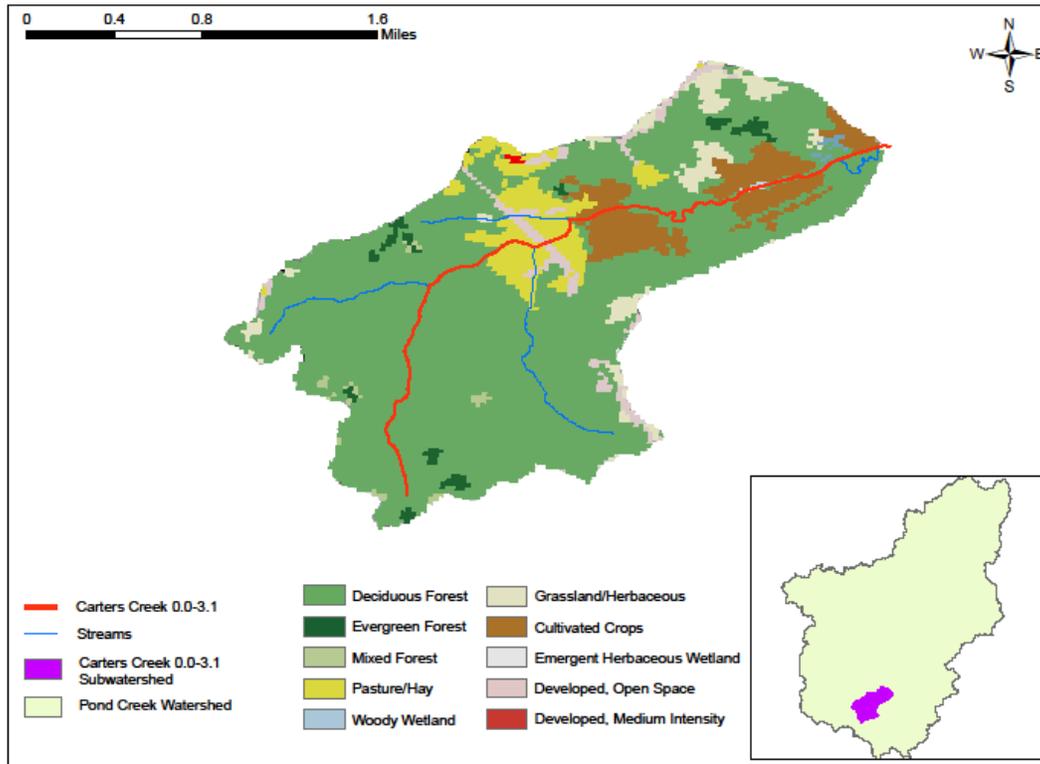


Figure 8.6.2 Land Cover in the Carters Creek 0.0 to 3.1 Subwatershed

Table 8.6.2 Land Cover in the Carters Creek 0.0 to 3.1 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.07	44.5	2.9
Agriculture	0.35	223.9	14.8
Forest	1.84	1180.6	77.8
Barren Land	0	0	0
Grassland/Herbaceous	0.10	66.5	4.4
Wetlands	0	1.5	0.1
Water	0	0	0
Shrub/Scrub	0	0	0

There are no KPDES permittees in this subwatershed. *E. coli* and flow data monitored at DOW03011017 are in Table 8.6.3.

Table 8.6.3 *E. coli* and Flow Data, DOW03011017

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	39	0.553
5/24/2011	78	**
6/21/2011	579	**
7/12/2011	866	0.114
5/8/2013	30	**
5/9/2013	165	**
5/20/2013	79	N/A
5/23/2013	99	**
5/29/2013	40	**
6/6/2013	435	**
6/27/2013	365	0.001
7/30/2013	140	**
8/15/2013	133	0.20
10/10/2013	65	**
<p>Exceeds the instantaneous <i>E. coli</i> limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

8.7 Opossum Run 0.0 to 1.6

The pollutant addressed in this document for Opossum Run 0.0 to 1.6 is *E. coli*. Opossum Run 0.0 to 1.6 is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 1.798 square miles. There is one TMDL monitoring site on the Opossum Run 0.0 to 1.6 segment, DOW03011021, located at RM 0.30 with the drainage area of 1.17 square miles, see Figure 8.7.1 and Table 8.7.1. This subwatershed consists primarily of agricultural land (60.8%) and forest (24.2%), see Figure 8.7.2 and Table 8.7.2.

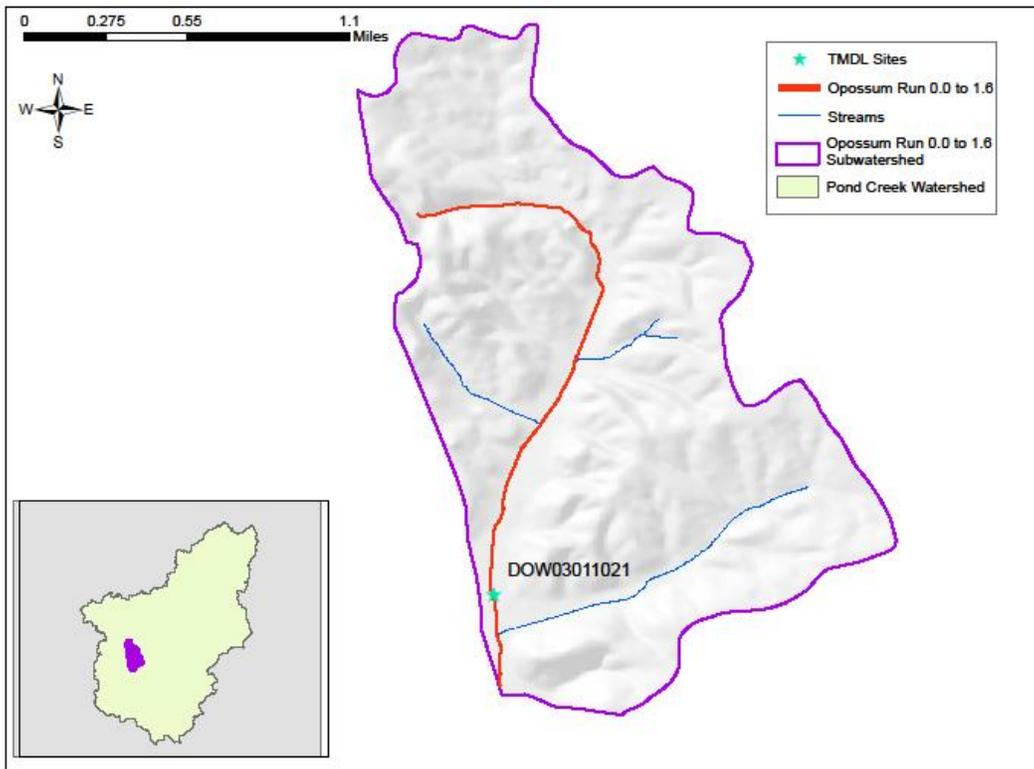


Figure 8.7.1 TMDL Monitoring Site and the Drainage Area of Opossum Run 0.0 to 1.6

Table 8.7.1 Opossum Run 0.0 to 1.6 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY499964_01	Opossum Run 0.0 to 1.6	3	Muhlenberg	1.798	1151

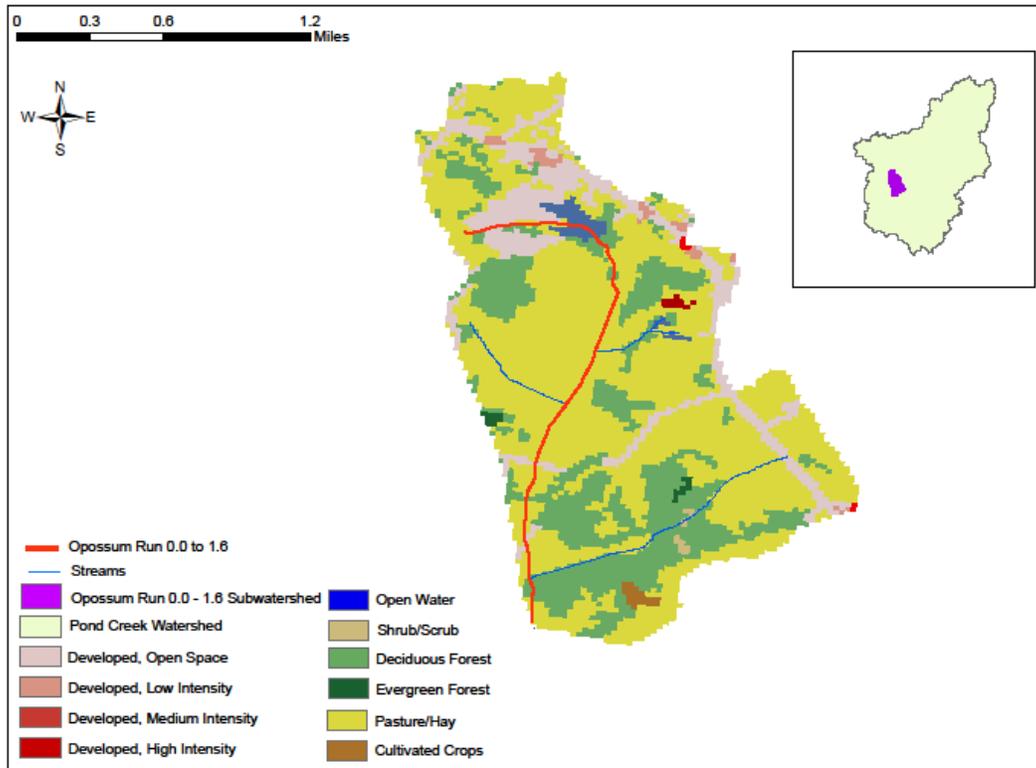


Figure 8.7.2 Land Cover in the Opossum Run 0.0 to 1.6 Subwatershed

Table 8.7.2 Land Cover in the Opossum Run 0.0 to 1.6 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.24	155.8	13.5
Agriculture	1.10	701.6	60.8
Forest	0.44	278.9	24.2
Barren Land	0	0	0
Grassland/Herbaceous	0	0	0
Wetlands	0	0	0
Water	0.02	14.6	1.3
Shrub/Scrub	0.003	2.1	0.2

There are no KPDES permittees within the Opossum Run 0.0 to 1.6 subwatershed. Table 8.7.3 shows *E. coli* and flow data collected by TMDL staff at DOW03011021.

Table 8.7.3 *E. coli* and Flow Data, DOW03011021

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	137	0.690
5/24/2011	488	**
5/8/2013	124	**
5/9/2013	118	**
5/20/2013	186	**
5/23/2013	179	**
5/29/2013	6	**
6/6/2013	> 2420	**
6/27/2013	387	0.127
7/30/2013	206	0.016
8/15/2013	167	0.18
9/24/2013	866	0.011
10/10/2013	548	0.181
<div style="display: flex; align-items: flex-start;"> <div style="width: 20px; height: 15px; background-color: yellow; margin-right: 5px;"></div> <div>Exceeds the instantaneous <i>E. coli</i> limit</div> </div> <div style="display: flex; align-items: flex-start; margin-top: 5px;"> <div style="width: 20px; height: 15px; background-color: white; border: 1px solid black; margin-right: 5px;"></div> <div>** Unable to obtain flow because of water depth, swiftness, or lack of access</div> </div>		

8.8 Plum Creek 0.0 to 1.65

The pollutants addressed in this document for Plum Creek 0.0 to 1.65 are *E. coli* and cadmium. Plum Creek 0.0 to 1.65 is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 12.24 square miles. There is one TMDL monitoring site on the Plum Creek 0.0 to 1.65 segment, DOW03011030, located at RM 0.65 with the drainage area of 10.40 square miles, see Figure 8.8.1 and Table 8.8.1. This subwatershed consists primarily of forest (49.5%), herbaceous land (22.1%), and agricultural land (16.5%), see Figure 8.8.2 and Table 8.8.2.

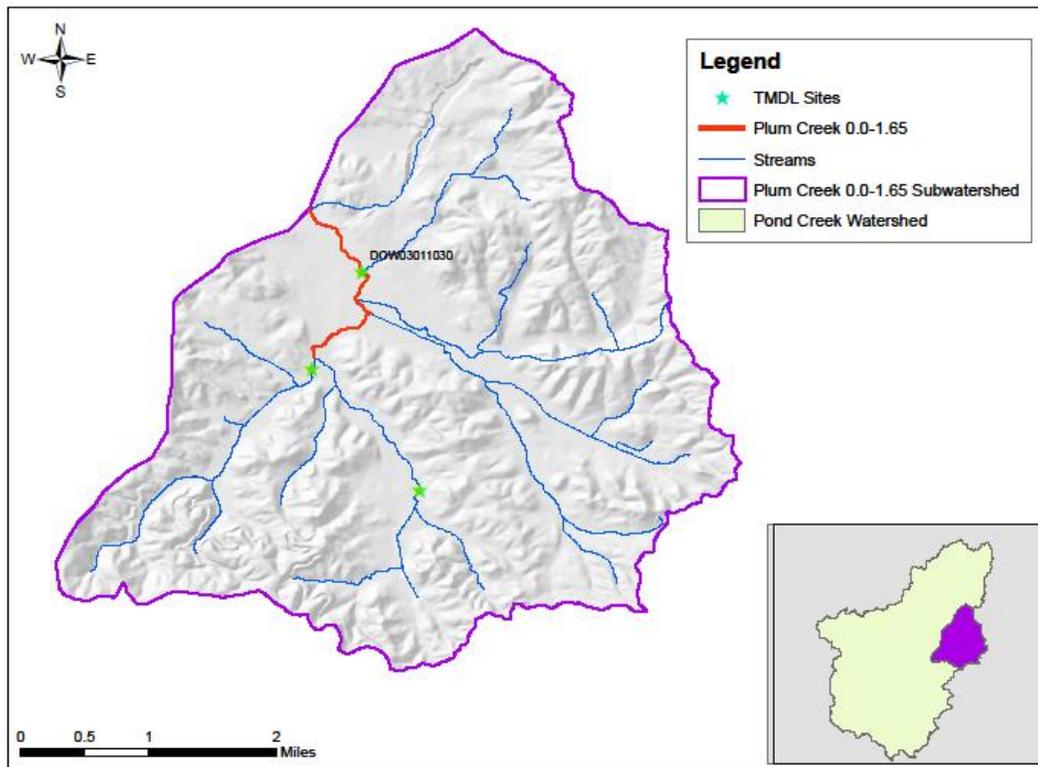


Figure 8.8.1 TMDL Monitoring Locations and the Drainage Area of Plum Creek 0.0 to 1.65

Table 8.8.1 Plum Creek 0.0 to 1.65 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY500964_01	Plum Creek 0.0 to 1.65	3	Muhlenberg	12.24	7835

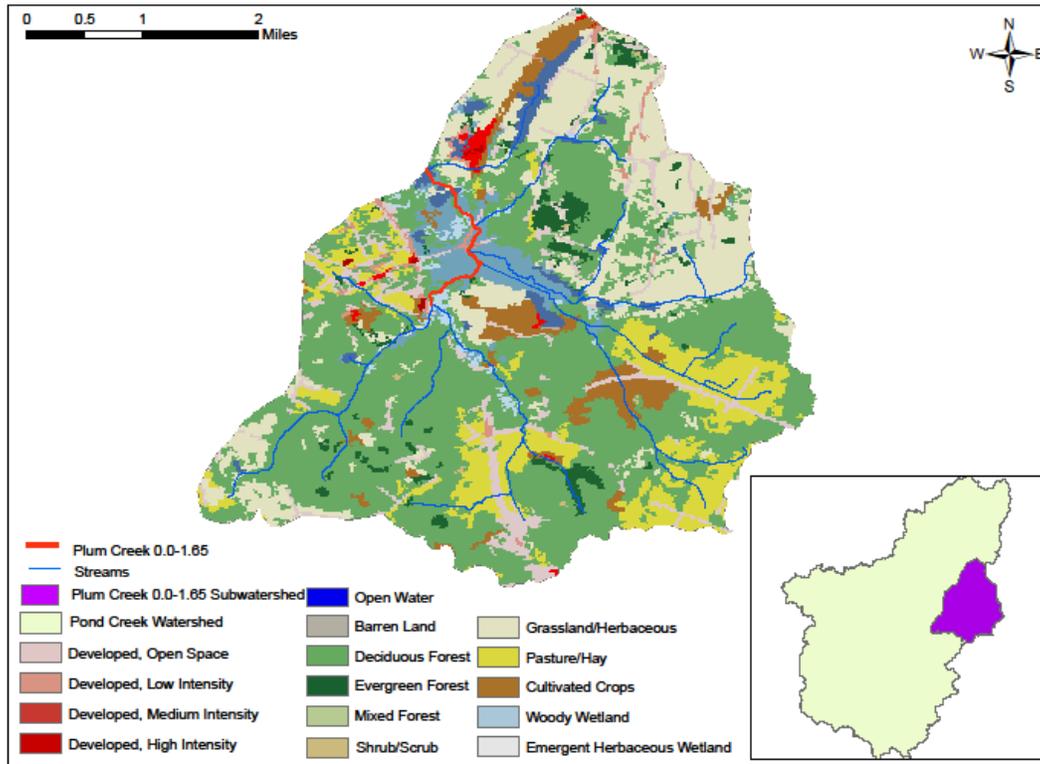


Figure 8.8.2 Land Cover in the Plum Creek 0.0 to 1.65 Subwatershed

Table 8.8.2 Land Cover in the Plum Creek 0.0 to 1.65 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	1.02	649.6	8.3
Agriculture	2.02	1294.4	16.5
Forest	6.08	3882.0	49.5
Barren Land	0.00	1.6	0.0
Grassland/Herbaceous	2.71	1734.5	22.1
Wetlands	0.13	85.6	1.1
Water	0.28	179.5	2.3
Shrub/Scrub	0.01	8.5	0.1

There are two active KPDES permittees and six inactive KPDES permittees within the Plum Creek 0.0 to 1.65 subwatershed, see Figure 8.8.3 and Table 8.8.3. Although those inactive

facilities were active during the data collection period and may have contributed to the impairments of this waterbody, inactive KPDES permittee will not receive a WLA.

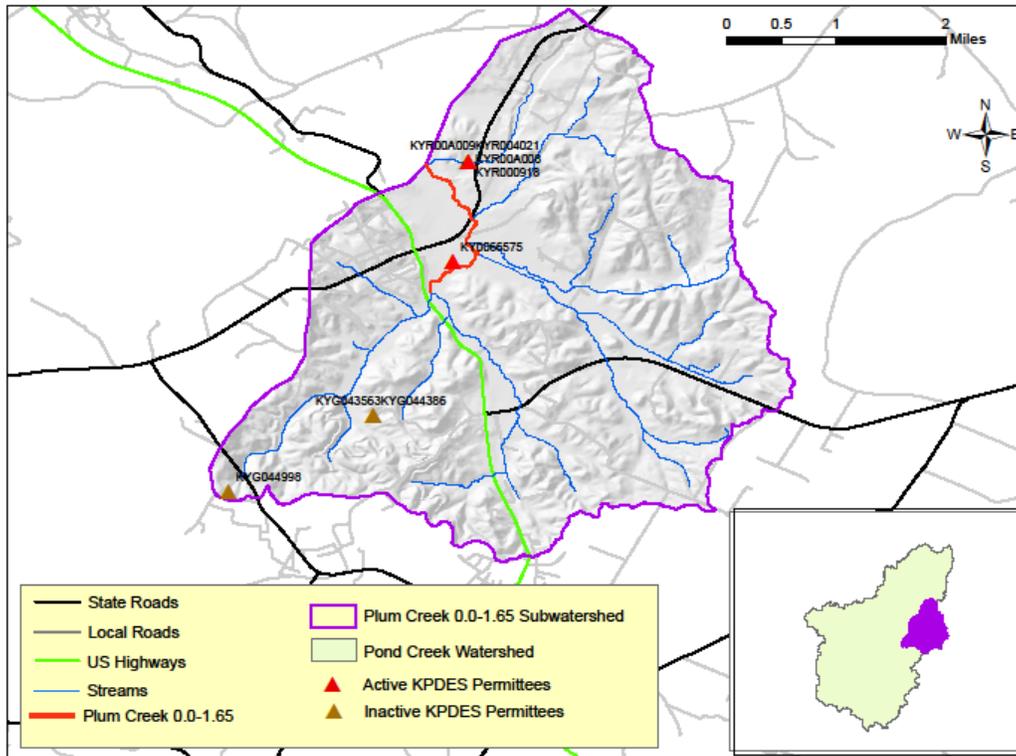


Figure 8.8.3 KPDES Permittees in the Plum Creek 0.0 to 1.65 Subwatershed

Table 8.8.3 KPDES Permittees in the Plum Creek 0.0 to 1.65 Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutants in Permit
KY0066575	Drakesboro STP	Yes	0.165	37.21722	-87.04083	bacteria, pH, Cd, Cu, Pb, Zn
KYR004021	Harsco Minerals	Yes	0	37.23067	-87.03886	pH and to develop a SWPPP
KYG043563	Beech Creek Energy Inc	No	0	37.19694	-87.05139	pH, Fe
KYG044386	Beech Creek Energy Inc	No	0	37.19694	-87.05139	pH, Fe
KYR000918	Harsco Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYG044998	Beech Creek Energy Inc	No	0	37.18694	-87.07056	pH, Fe
KYR00A008	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutants in Permit
KYR00A009	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP

There are no active KPDES mining permittees in this subwatershed, but the majority of downstream watershed is licensed mining areas, see Figure 8.8.4 (see Section 9.4.3 for more information). Tables 8.8.4 and 8.8.5 show *E. coli*, cadmium and flow data collected by TMDL staff at DOW03011030.

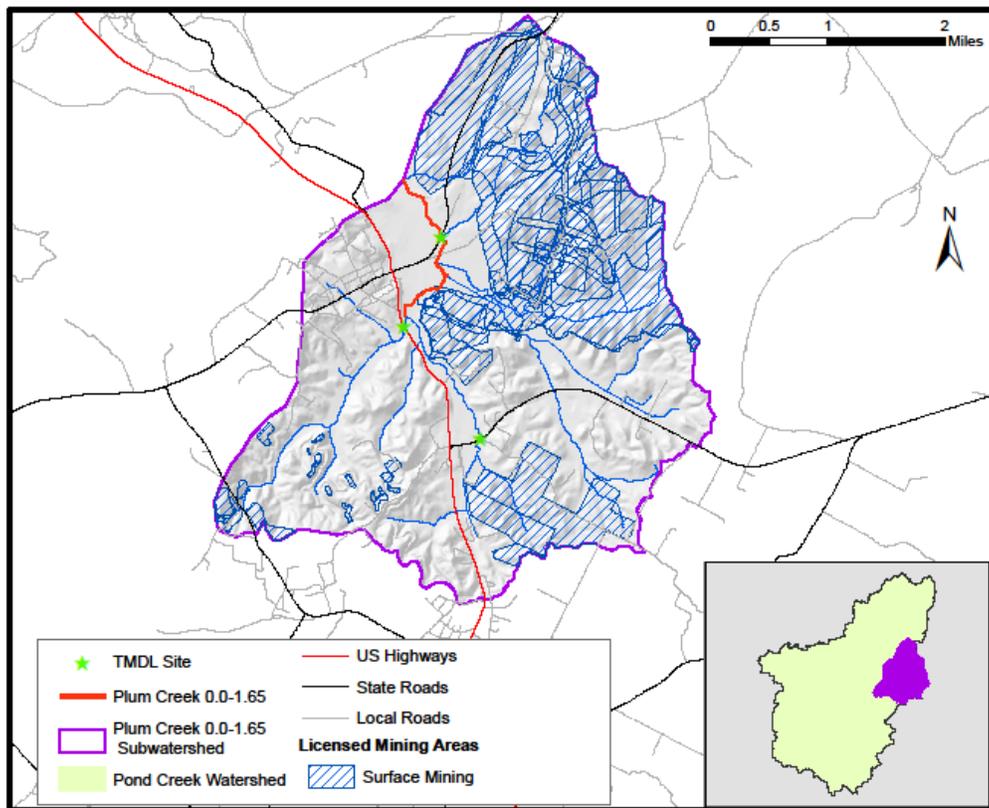


Figure 8.8.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.8.4 *E. coli* and Flow Data, DOW03011030

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/12/2011	40	**
5/26/2011	649	**
6/16/2011	32	**
6/23/2011	166	**

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
7/14/2011	16	**
7/28/2011	122	**
8/11/2011	1120	**
8/25/2011	548	**
9/15/2011	260	**
9/29/2011	122	**
10/13/2011	> 2420	**
10/20/2011	206	**

Exceeds the instantaneous *E. coli* limit
** Unable to obtain flow because of water depth, swiftness, or lack of access

Table 8.8.5 Cadmium, Hardness and Flow Data Collected at DOW03011030

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/18/2010	< 0.80 (U)	1140	1.64	25.32	N/A	**
1/6/2011	0.851 (J)	397	0.75	8.66	N/A	**
2/17/2011	1.34	406	0.76	8.86	0.58	**
3/10/2011	3.69	128	0.32	2.74	3.37	**
4/28/2011	2.67	93	0.26	1.98	2.41	**
5/12/2011	2.66	159	0.38	3.42	2.28	**
6/16/2011	< 0.80 (U)	928	1.41	20.54	N/A	**
7/14/2011	< 0.80 (U)	752	1.21	16.59	N/A	**
8/11/2011	< 0.80 (U)	1070	1.57	23.74	N/A	**
9/15/2011	< 0.80 (U)	1260	1.77	28.03	N/A	**
10/13/2011	< 0.80 (U)	1120	1.62	24.87	N/A	**

Exceeds the acute limit
 Exceeds the chronic limit
** Unable to obtain flow because of water depth, swiftness, or lack of access
U = Analyte Not Detected
J = Estimated Value
N/A: Not Applicable

8.9 Plum Creek 1.65 to 3.9

The pollutants addressed in this document for Plum Creek 1.65 to 3.9 are *E. coli*, pH, cadmium, nickel and zinc. Plum Creek 1.65 to 3.9 is a second order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 2.71 square miles. There is one TMDL monitoring site on the Plum Creek 1.65 to 3.9 segment, DOW03011029, located at RM 3.0 with the drainage area of 1.46 square miles, see Figure 8.9.1 and Table 8.9.1. This subwatershed consists primarily of forest (68.0%), and agricultural land (17.5%), see Figure 8.9.2 and Table 8.9.2.

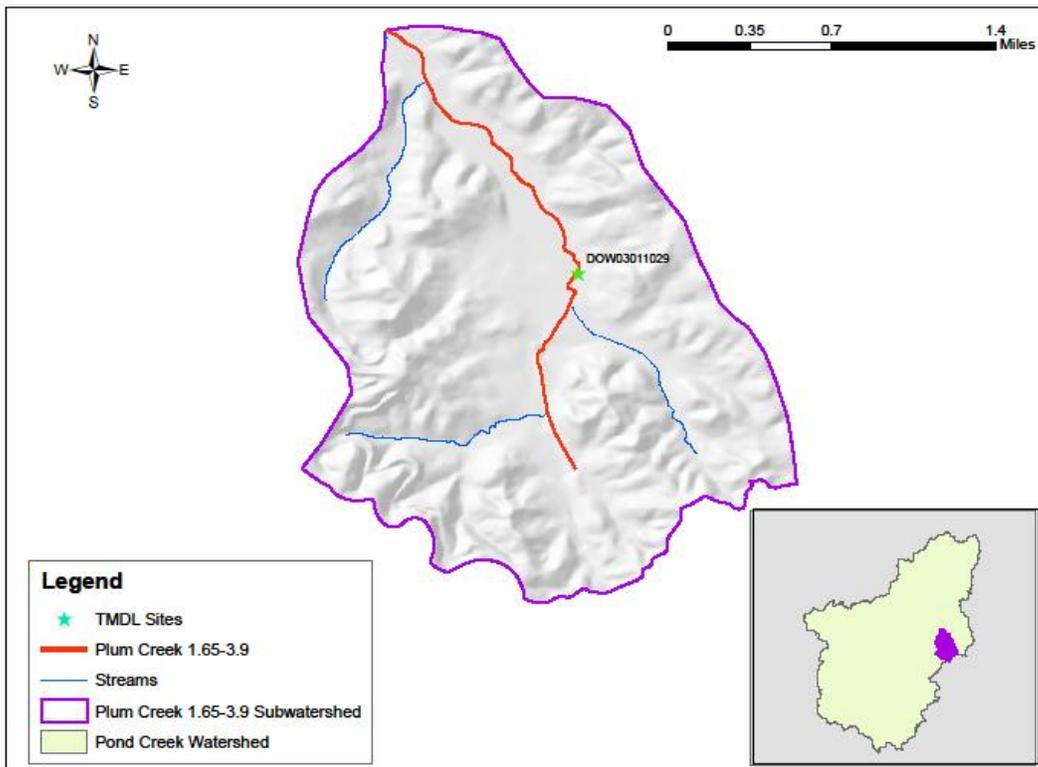


Figure 8.9.1 TMDL Monitoring Locations and the Drainage Area of Plum Creek 1.65 to 3.9

Table 8.9.1 Plum Creek 1.65 to 3.9 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY500964_02	Plum Creek 1.65 to 3.9	2	Muhlenberg	2.71	1735

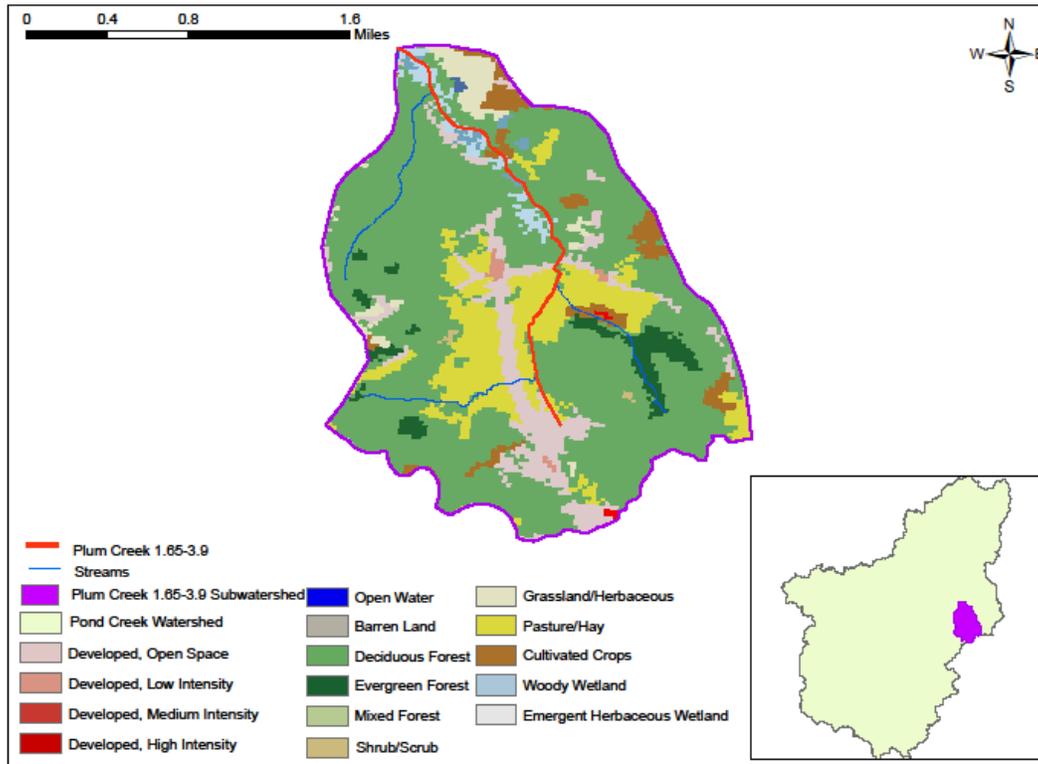


Figure 8.9.2 Land Cover in the Plum Creek 1.65 to 3.9 Subwatershed

Table 8.9.2 Land Cover in the Plum Creek 1.65 to 3.9 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.25	158.5	9.1
Agriculture	0.48	304.4	17.5
Forest	1.85	1180.3	68.0
Barren Land	0	0	0
Grassland/Herbaceous	0.09	56.0	3.2
Wetlands	0.05	31.4	1.8
Water	0.003	1.9	0.1
Shrub/Scrub	0.003	2.2	0.1

There are no KPDES permittees in this subwatershed. Some of the watershed is licensed mining areas, see Figure 8.9.3 (see Section 9.4.3 for more information). Table 8.9.3 to Table 8.9.7 show *E. coli*, pH, metals and flow data collected by TMDL staff at DOW03011029.

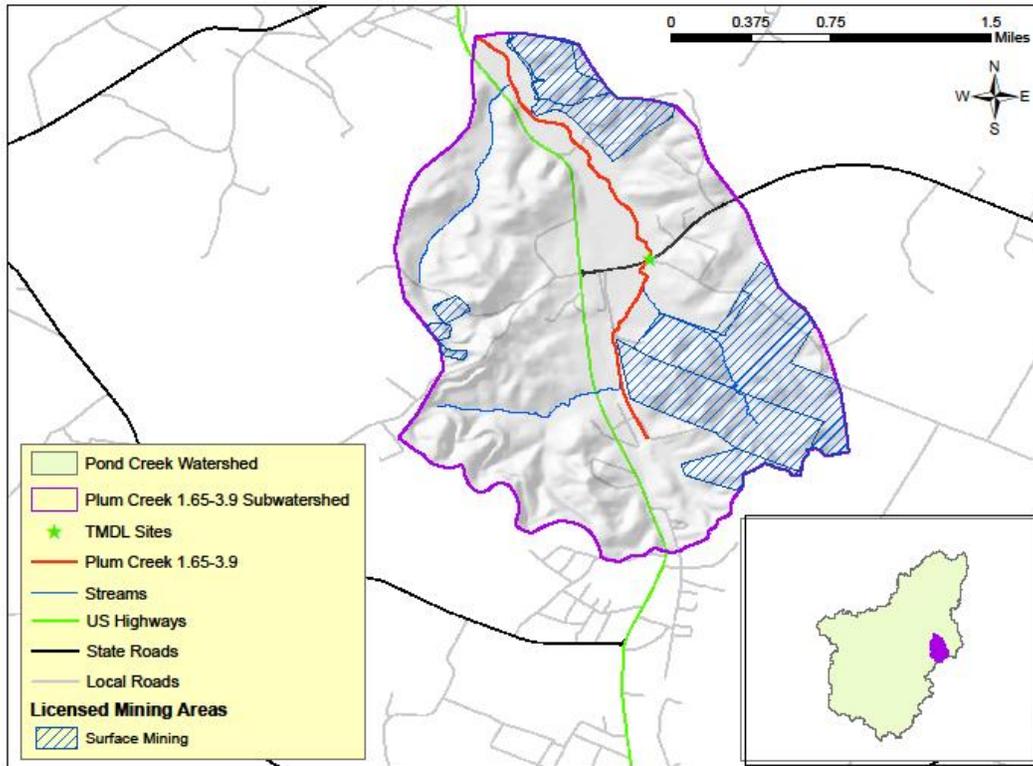


Figure 8.9.3 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.9.3 *E. coli* and Flow Data, DOW03011029

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/12/2011	6	**
5/26/2011	397	**
6/16/2011	> 2420	**
6/23/2011	185	**
7/14/2011	248	**
9/29/2011	261	**
10/13/2011	> 2420	**
Exceeds the instantaneous <i>E. coli</i> limit ** Unable to obtain flow because of water depth, swiftness, or lack of access		

Table 8.9.4 pH and Flow Data Collected at DOW03011029

Collection Date	pH (standard units)	Discharge (cfs)
11/18/2010	6.86	**
1/6/2011	6.64	**
2/17/2011	5.25	**
3/10/2011	5.65	**
4/28/2011	5.66	**
5/12/2011	5.86	**
5/26/2011	5.91	**
6/16/2011	7.25	**
6/23/2011	6.96	**
7/14/2011	5.80	**
9/29/2011	8.49	**
10/13/2011	8.86	**

Exceeds the pH limit
 ** Unable to obtain flow because of water depth, swiftness, or lack of access

Table 8.9.5 Cadmium, Hardness and Flow Data Collected at DOW03011029

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/18/2010	1.32	138	0.34	2.96	0.98	**
1/6/2011	41.6 (DL)	236	0.51	5.11	41.09	**
2/17/2011	28.8 (DL)	197	0.45	4.25	28.35	**
3/10/2011	17.9 (DL)	115	0.30	2.46	17.60	**
4/28/2011	12.2 (L)	96.7	0.26	2.06	11.94	**
5/12/2011	19.7 (DL)	149	0.36	3.20	19.34	**
6/16/2011	6.47 (L)	158	0.38	3.40	6.09	**
7/14/2011	1.8	218	0.48	4.71	1.32	**
10/13/2011	0.689 (J)	106	0.28	2.26	N/A	**

Exceeds the acute limit
 Exceeds the chronic limit
 ** Unable to obtain flow because of water depth, swiftness, or lack of access
 D = Reanalyzed at a Higher Dilution
 J = Estimated Value
 L = Exceeds MCL or Action Limit
 N/A: Not Applicable

Table 8.9.6 Nickel, Hardness and Flow Data Collected at DOW03011029

Date	Nickel (µg/L)	Hardness, Total (mg/L)	Nickel Chronic Limit (µg/L)	Nickel Acute Limit (µg/L)	Difference between the Nickel Concentration and the Nickel Chronic Limit (µg/L)	Flow (cfs)
11/18/2010	5.33	138	68.50	616.13	-63.17	**
1/6/2011	150	236	107.86	970.10	42.14	**
2/17/2011	127	197	92.57	832.63	34.43	**
3/10/2011	81.5	115	58.71	528.06	22.79	**
4/28/2011	73	96.7	50.70	456.04	22.30	**
5/12/2011	148	149	73.09	657.43	74.91	**
6/16/2011	54.1	158	76.81	690.87	-22.71	**
7/14/2011	20.4	218	100.85	907.12	-80.45	**
10/13/2011	6.89	106	54.80	492.88	-47.91	**
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>						

Table 8.9.7 Zinc, Hardness and Flow Data Collected at DOW03011029

Date	Zinc (µg/L)	Hardness, Total (mg/L)	Zinc Chronic Limit (µg/L)	Zinc Acute Limit (µg/L)	Difference between the Zinc Concentration and the Zinc Chronic Limit (µg/L)	Flow (cfs)
11/18/2010	16.3 (J)	138	157.41	157.41	N/A	**
1/6/2011	562 (D)	236	248.02	248.02	313.98	**
2/17/2011	408 (D)	197	212.82	212.82	195.18	**
3/10/2011	606 (D)	115	134.88	134.88	471.12	**
4/28/2011	190	96.7	116.46	116.46	73.54	**
5/12/2011	347 (D)	149	167.98	167.98	179.02	**
6/16/2011	127	158	176.54	176.54	-49.54	**
7/14/2011	26.1	218	231.89	231.89	-205.79	**
10/13/2011	18.9	106	125.88	125.88	-106.98	**
<p>Exceeds the limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>N/A: Not Applicable</p>						

8.10 Pond Creek 0.0 to 5.0

The pollutant addressed in this document for Pond Creek 0.0 to 5.0 is iron. Pond Creek 0.0 to 5.0 is a fifth order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 127.2 square miles, which covers the entire Pond Creek watershed. There is one TMDL monitoring site on the Pond Creek 0.0 to 5.0 segment, DOW03011031, located at RM 1.85 with the drainage area of 121.9 square miles, see Figure 8.10.1 and Table 8.10.1. This subwatershed consists primarily of forest (50.3%), and agricultural land (28.1%), see Figure 8.10.2 and Table 8.10.2.

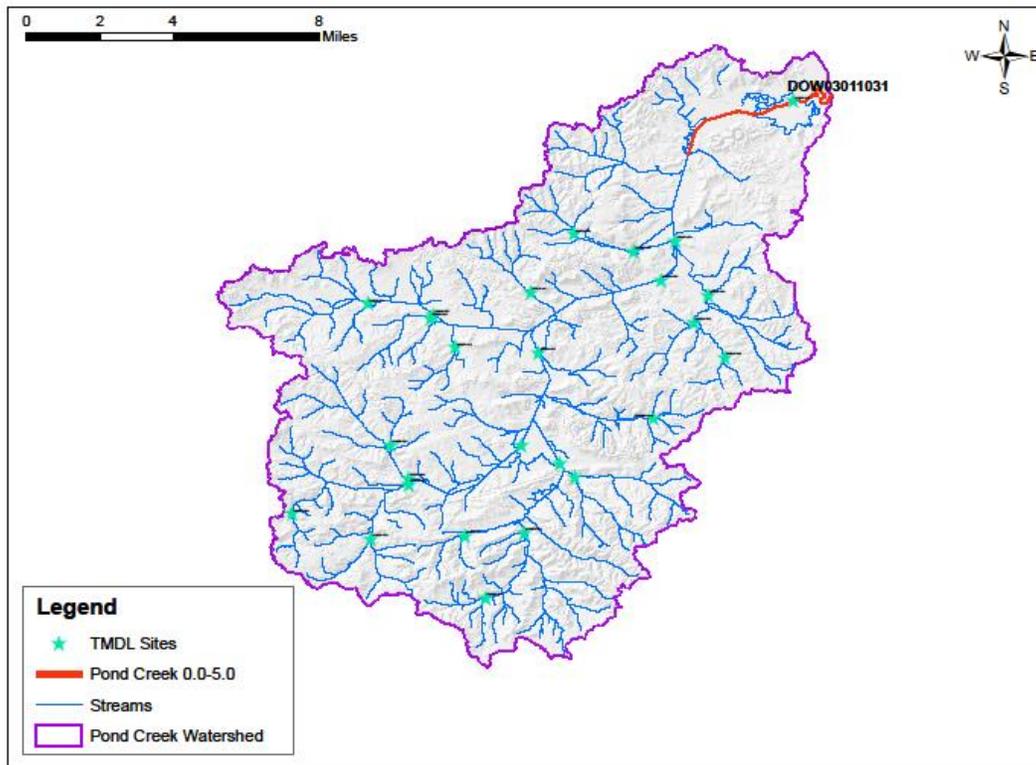


Figure 8.10.1 TMDL Monitoring Sites and the Drainage Area of Pond Creek Watershed

Table 8.10.1 Pond Creek 0.0 to 5.0 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042_01	Pond Creek 0.0 to 5.0	5	Muhlenberg	127.2	81395

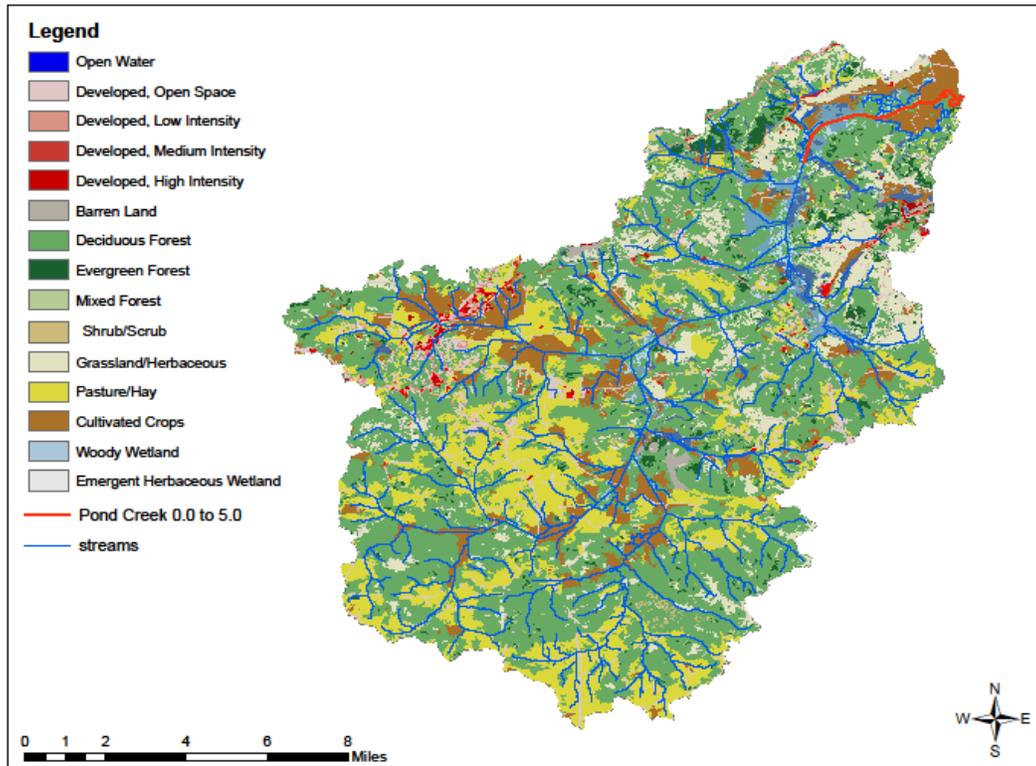


Figure 8.10.2 Land Cover in the Pond Creek Watershed

Table 8.10.2 Land Cover in the Pond Creek Watershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	8.95	5727.3	7.0
Water	2.61	1672.2	2.1
Barren Land	0.72	459.6	0.6
Forest	64.0	40960.9	50.3
Grassland	10.93	6995.2	8.6
Agriculture	35.78	22899.3	28.1
Wetland	3.88	2481.2	3.0
Shrub/Scrub	0.30	199.5	0.2

There are nineteen active and forty inactive KPDES permittees within the Pond Creek watershed, see Figure 5.1 and Table S.8. Although those inactive KPDES facilities were active during the

data collection period and may have contributed to the impairments of this waterbody, inactive KPDES permittee will not receive a WLA.

There are five active KPDES mining permittees in the Pond Creek watershed, see Figure 5.2 and Table 5.1. Some of the Pond Creek watershed is licensed mining areas, see Figure 9.2 and Table 9.2. Tables 8.10.3 show iron and flow data collected by TMDL staff at DOW03011031.

Table 8.10.3 Iron and Flow Data Collected at DOW03011031

Date	Iron(mg/L) ⁽¹⁾	Flow (cfs)
3/21/2013	0.877	**
4/18/2013	1.19	**
5/8/2013	1.32	**
6/26/2013	0.897	**
7/16/2013	0.604	**
8/6/2013	0.861	**
9/10/2013	0.722	**
10/9/2013	0.876	**
11/13/2013	1.15	**
12/17/2013	1.31	**
3/18/2014	1.61	**
4/15/2014	7.95	**
5/21/2014	0.766	**
6/5/2014	1.87	**
7/23/2014	0.577	**
8/13/2014	0.538	**
9/11/2014	0.915	**
10/29/2014	0.736	**
11/19/2014	6.82	**
12/23/2014	1.32	**
⁽¹⁾ Chronic limit is 3.5 mg/L since aquatic life has not been shown to be adversely affected  Exceeds the acute limit ** Unable to obtain flow because of water depth, swiftness, or lack of access		

8.11 Pond Creek 5.0 to 7.5

The pollutants addressed in this document for Pond Creek 5.0 to 7.5 are *E. coli*, cadmium, and iron. Pond Creek 5.0 to 7.5 is a fifth order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 113.60 square miles. There is one TMDL monitoring site on the Pond Creek 5.0 to 7.5 segment, DOW03011009, located at RM 7.4 with the drainage area of 99.68 square miles, see Figure 8.11.1 and Table 8.11.1. This subwatershed consists primarily of forest (50.8%), and agricultural land (29.4%), see Figure 8.11.2 and Table 8.11.2.

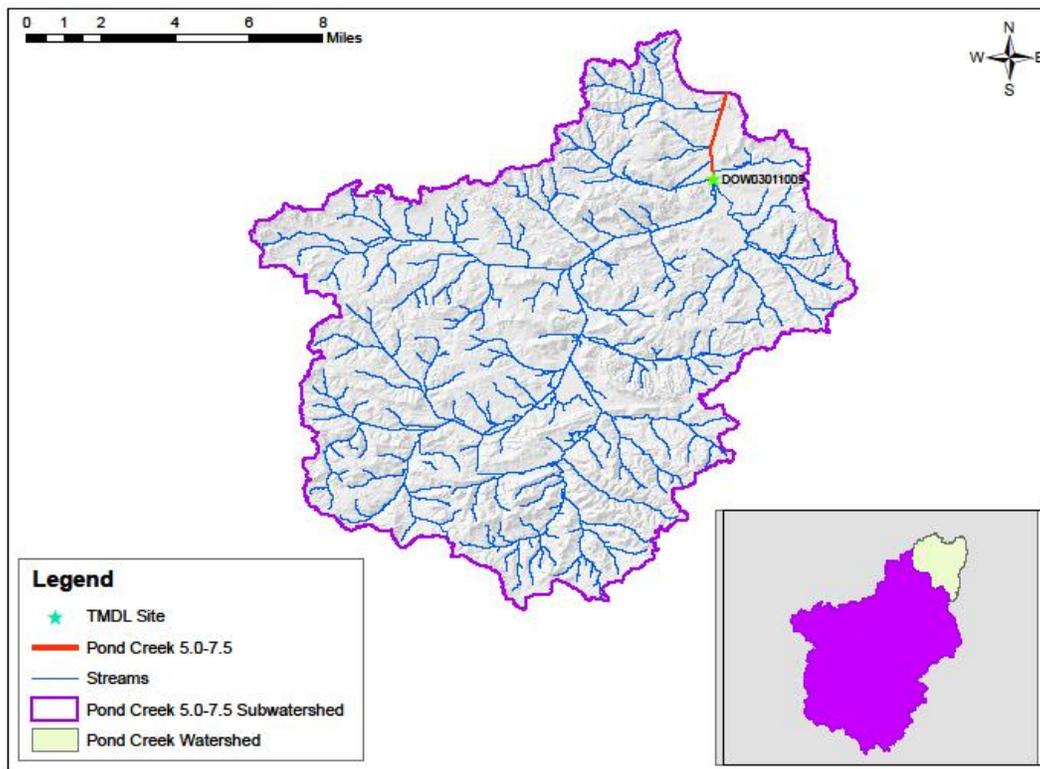


Figure 8.11.1 TMDL Monitoring Locations and the Drainage Area of Pond Creek 5.0 to 7.5

Table 8.11.1 Pond Creek 5.0 to 7.5 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042_02	Pond Creek 5.0 to 7.5	5	Muhlenberg	113.60	72701

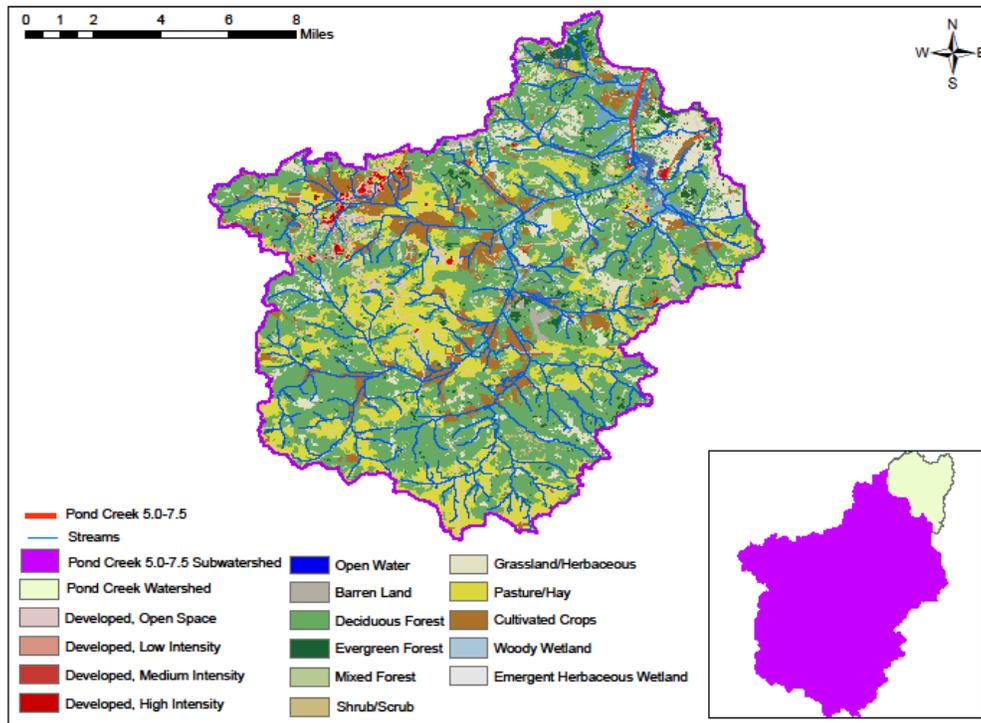


Figure 8.11.2 Land Cover in the Pond Creek 5.0 to 7.5 Subwatershed

Table 8.11.2 Land Cover in the Pond Creek 5.0 to 7.5 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	8.05	5153.7	7.1
Agriculture	33.35	21342.6	29.4
Forest	57.93	36910.7	50.8
Barren Land	1.04	663.8	0.9
Grassland/Herbaceous	10.57	6767.7	9.3
Wetlands	0.95	607.8	0.8
Water	1.71	1091.6	1.5
Shrub/Scrub	0.26	166.4	0.2

There are seventeen active and thirty-five inactive KPDES permittees within this subwatershed, see Figure 8.11.3 and Table 8.11.3. Although those inactive KPDES facilities were active during the data collection period and may have contributed to the impairments of this waterbody, inactive KPDES permittee will not receive a WLA.

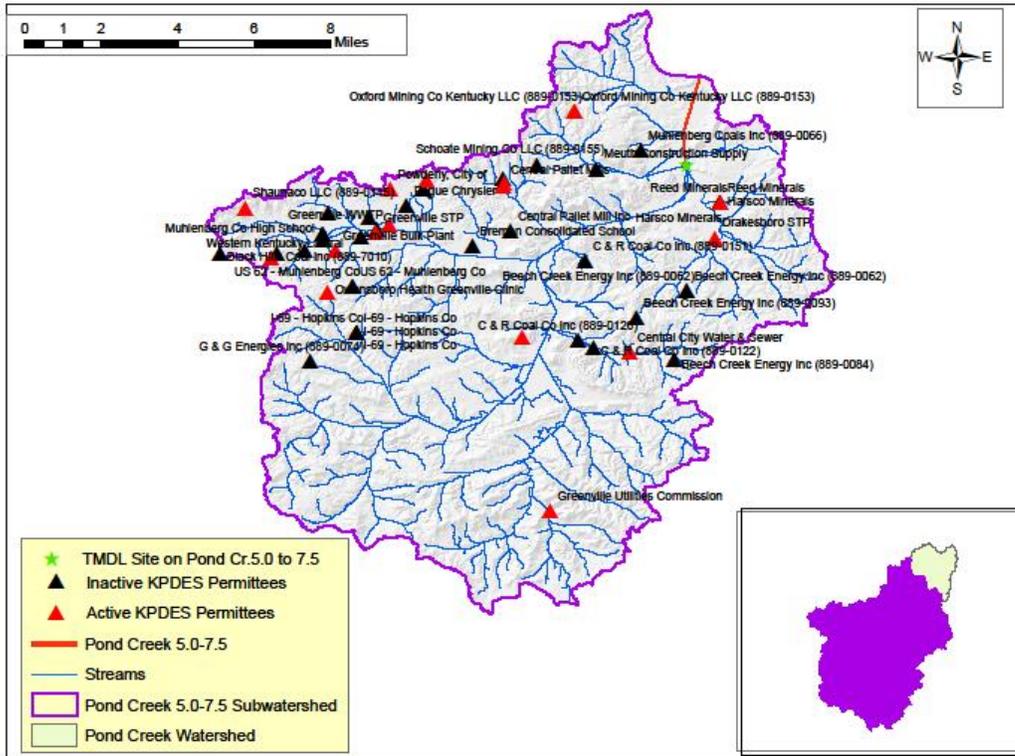


Figure 8.11.3 KPDES Permittees in the Pond Creek 5.0 to 7.5 Subwatershed

Table 8.11.3 KPDES Permittees in the Pond Creek 5.0 to 7.5 Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KY0020010	Greenville STP	Yes	1.31	37.219167	-87.169444	bacteria, pH, Cd, Cu, Pb, Zn
KY0066575	Drakesboro STP	Yes	0.165	37.217222	-87.040833	bacteria, pH, Cd, Cu, Pb, Zn
KY0108537	Shaunaco LLC (889-0145)	Yes	0	37.228611	-87.218889	pH, Cd, Cu, Fe, Pb, Ni, Zn
KY0109606	Greenville Bulk Plant	Yes	0	37.212500	-87.184700	pH
KY0111996	Oxford Mining Co Kentucky LLC (889-0153)	Yes	0	37.265000	-87.094056	pH, Fe
KYG045755	Oxford Mining Co Ky LLC (889-0156)	Yes	0	37.179722	-87.113889	pH, Fe
KYG046498	Oxford Mining Co Kentucky LLC (889-0153)	Yes	0	37.265000	-87.094056	pH, Fe

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG640029	Central City Water & Sewer	Yes	0.0005	37.173800	-87.073000	pH, Fe
KYG640108	Greenville Utilities Commission	Yes	0.027	37.113900	-87.103200	pH, Fe
KYP000064	Powderly, City of	Yes	0	37.235833	-87.163889	discharge to Greenville WWTP
KYR003239	Central Pallet Mills	Yes	0	37.237167	-87.121083	pH and to develop a SWPPP
KYR004015	Carl Mitchell & Son Implement - Paradise Rd	Yes	0	37.238014	-87.120822	pH and to develop a SWPPP
KYR004021	Harsco Minerals	Yes	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR10J469	Muhlenberg County Airport	Yes	0	37.222067	-87.164333	to develop a SWPPP
KYR10K083	Owensboro Health Greenville Clinic	Yes	0	37.196391	-87.187716	to develop a SWPPP
KYR10K315	Western Kentucky Lateral	Yes	0	37.209464	-87.209069	to develop a SWPPP
KYR10K433	Owensboro Health Muhlenberg Healthplex	Yes	0	37.238889	-87.150189	to develop a SWPPP
KY0023329	Bremen Consolidated School	No	0.008	37.214000	-87.132800	bacteria
KY0099538	Texas Gas Transmission LLC - West Greenville	No	0	37.211111	-87.206944	pH
KY0106046	C & R Coal Co Inc (889-0151)	No	0	37.208333	-87.090000	pH, Fe
KYG043169	Black Hills Coal Inc (889-7010)	No	0	37.211111	-87.228611	pH, Fe
KYG043563	Beech Creek Energy Inc (889-0062)	No	0	37.196944	-87.051389	pH, Fe
KYG043825	Muhlenberg Coals Inc (889-0066)	No	0	37.250278	-87.068889	pH, Fe
KYG044386	Beech Creek Energy Inc (889-0062)	No	0	37.196944	-87.051389	pH, Fe
KYG044486	G & G Energies Inc (889-0074)	No	0	37.170457	-87.194335	pH, Fe
KYG044573	Friendship Energy Inc (889-0079)	No	0	37.217528	-87.175069	pH, Fe
KYG044789	Beech Creek Energy Inc (889-0084)	No	0	37.170833	-87.056111	pH, Fe

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG044998	Beech Creek Energy Inc (889-0093)	No	0	37.186944	-87.070556	pH, Fe
KYG045704	Schoate Mining Co LLC (889-0155)	No	0	37.245000	-87.108333	pH, Fe
KYG046025	C & R Coal Co Inc (889-0126)	No	0	37.178333	-87.092778	pH, Fe
KYG046026	C & R Coal Co Inc (889-0122)	No	0	37.175833	-87.086944	pH, Fe
KYR000524	Central Pallet Mill Inc	No	0	37.220000	-87.118333	pH and to develop a SWPPP
KYR000918	Harsco Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR001665	Carl Mitchell & Son Implement	No	0	37.239428	-87.121152	pH and to develop a SWPPP
KYR001693	Meuth Construction Supply	No	0	37.243362	-87.085699	pH and to develop a SWPPP
KYR00A008	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR00A009	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR10E810	Muhlenberg Co High School Phas 3	No	0	37.216500	-87.189224	to develop a SWPPP
KYR10E960	Muhlenberg County Emergency SE	No	0	37.235680	-87.151550	to develop a SWPPP
KYR10F821	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10G145	Greenville WWTP	No	0	37.220472	-87.169111	to develop a SWPPP
KYR10G154	Knight Construction & Excavating Inc	No	0	37.212776	-87.196388	to develop a SWPPP
KYR10G285	Pogue Chrysler	No	0	37.229353	-87.157828	to develop a SWPPP
KYR10G428	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G429	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G456	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G458	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G631	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYR10G632	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10H138	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10H705	Muhlenberg County Park Phase I	No	0	37.226610	-87.187427	to develop a SWPPP
KYR10I149	Pogue Electric Service Inc.	No	0	37.224749	-87.172138	to develop a SWPPP

There are four active KPDES mining permits in this subwatershed, see Figure 8.11.4 and Table 8.11.4. Some of this subwatershed is licensed mining areas, see Figure 8.11.5 (see Section 9.4.3 for more information). Tables 8.11.5 to Table 8.11.7 show *E. coli*, cadmium, iron and flow data collected by TMDL staff at DOW03011009.

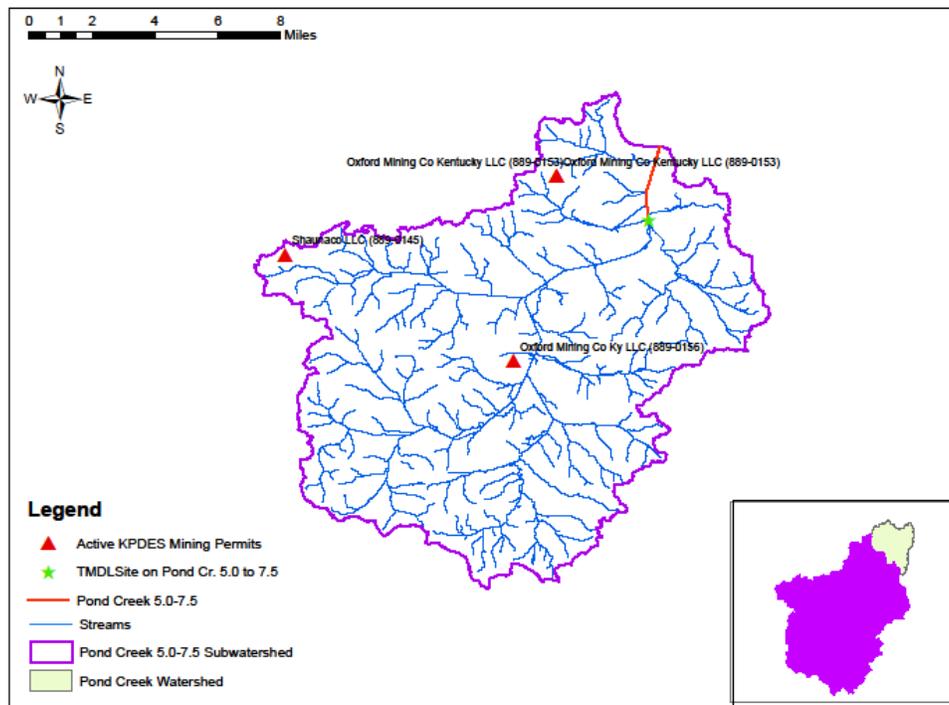


Figure 8.11.4 Active KPDES-Permitted Mining in the Subwatershed

Table 8.11.4 Active KPDES-Permitted Mining in the Pond Creek Watershed

KPDES Permit #	KDNR Permit #	Permittee Name	Date Issued
KY0108537	889-0145	Shaunaco LLC	12/1/2011
KYG046498	889-0153	Oxford Mining Co Kentucky LLC	8/4/2010
KYG045755	889-0156	Oxford Mining Co Ky LLC	7/1/2009
KY0111996	889-0153	Oxford Mining Co Kentucky LLC	Pending

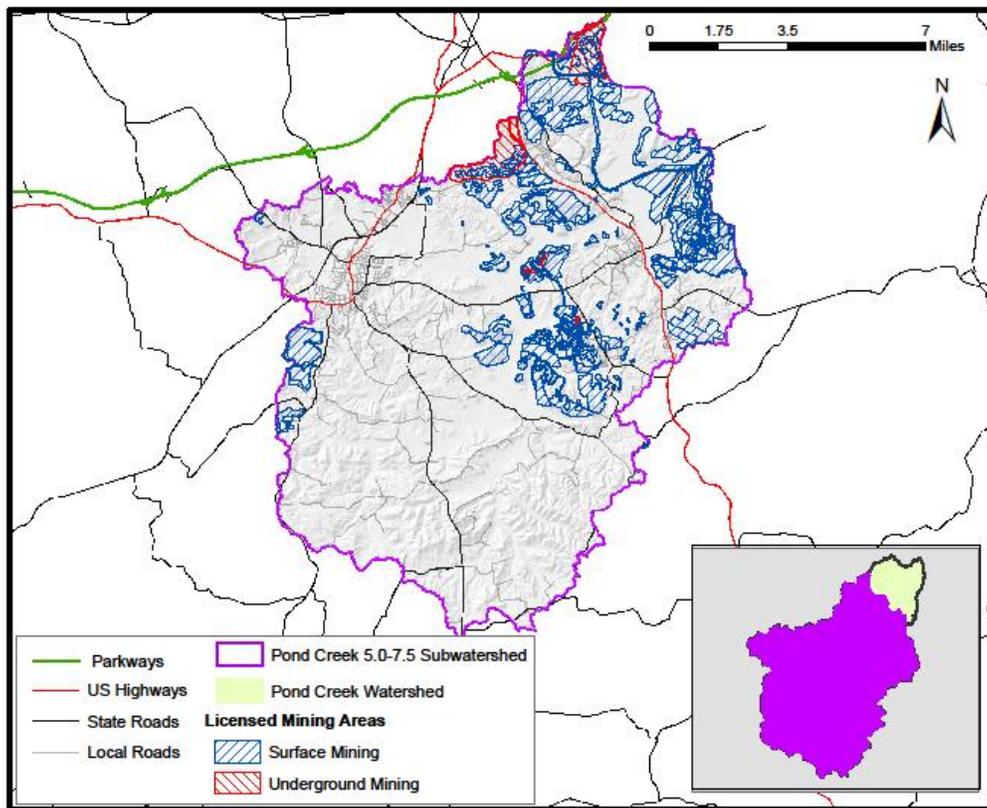


Figure 8.11.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.11.5 *E. coli* and Flow Data, DOW03011009

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/12/2011	58	**
5/26/2011	>2420	**

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
6/16/2011	16	**
6/23/2011	261	**
7/14/2011	1 (U)	**
7/28/2011	70	**
8/11/2011	18	**
8/25/2011	47	**
9/15/2011	166	**
9/29/2011	50	**
10/13/2011	1986	**
10/20/2011	1	**

Exceeds the instantaneous *E. coli* limit
** Unable to obtain flow because of water depth, swiftness, or lack of access
U = Analyte Not Detected

Table 8.11.6 Cadmium, Hardness and Flow Data Collected at DOW03011009

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/18/2010	2.32	1160	1.66	25.77	0.66	**
1/6/2011	1.68	503	0.90	11.02	0.78	**
2/17/2011	1.19	411	0.77	8.98	0.42	**
3/10/2011	0.59 (J)	115	0.30	2.46	N/A	**
4/28/2011	< 0.80 (U)	79.3	0.23	1.69	N/A	**
5/12/2011	3.05	183	0.42	3.94	2.63	**
6/16/2011	1.88	1640	2.15	36.65	-0.27	**
7/14/2011	< 16 (DU)	996	1.49	22.07	N/A	**
8/11/2011	2.49	1780	2.28	39.83	0.21	**
9/15/2011	< 0.80 (U)	1340	1.85	29.84	N/A	**
10/13/2011	0.418 (J)	1220	1.73	27.13	N/A	**

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

Table 8.11.7 Iron and Flow Data Collected at DOW03011009

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
11/18/2010	6.72	**
1/6/2011	2.68	**
2/17/2011	2.4	**
3/10/2011	1.14	**
4/28/2011	1.1	**
5/12/2011	2.28	**
6/16/2011	5.33	**
7/14/2011	18.5	**
8/11/2011	1.9	**
9/15/2011	0.342	**
10/13/2011	1.12	**
<p>⁽¹⁾ the chronic limit is 1.0 mg/L since aquatic life has been adversely affected</p> <p>Exceeds the acute limit</p> <p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

8.12 Pond Creek 7.5 to 11.7

The pollutants addressed in this document for Pond Creek 7.5 to 11.7 are *E. coli*, cadmium, and iron. A pH TMDL was developed for the Pond Creek segments and was approved by EPA in 2007. TMDL sampling data indicate that this segment had no impairment for pH during the data collection period; as a result, the pH will be delisted for Pond Creek 7.5 to 11.7 in 2016 303(d).

Pond Creek 7.5 to 11.7 is a fifth order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 99.62 square miles. There is one TMDL monitoring site on the Pond Creek 7.5 to 11.7 segment, DOW03011026, located at RM 8.6 with the drainage area of 86.43 square miles, see Figure 8.12.1 and Table 8.12.1. This subwatershed consists primarily of forest (50.3%) and agricultural land (32.2%), see Figure 8.12.2 and Table 8.12.2.

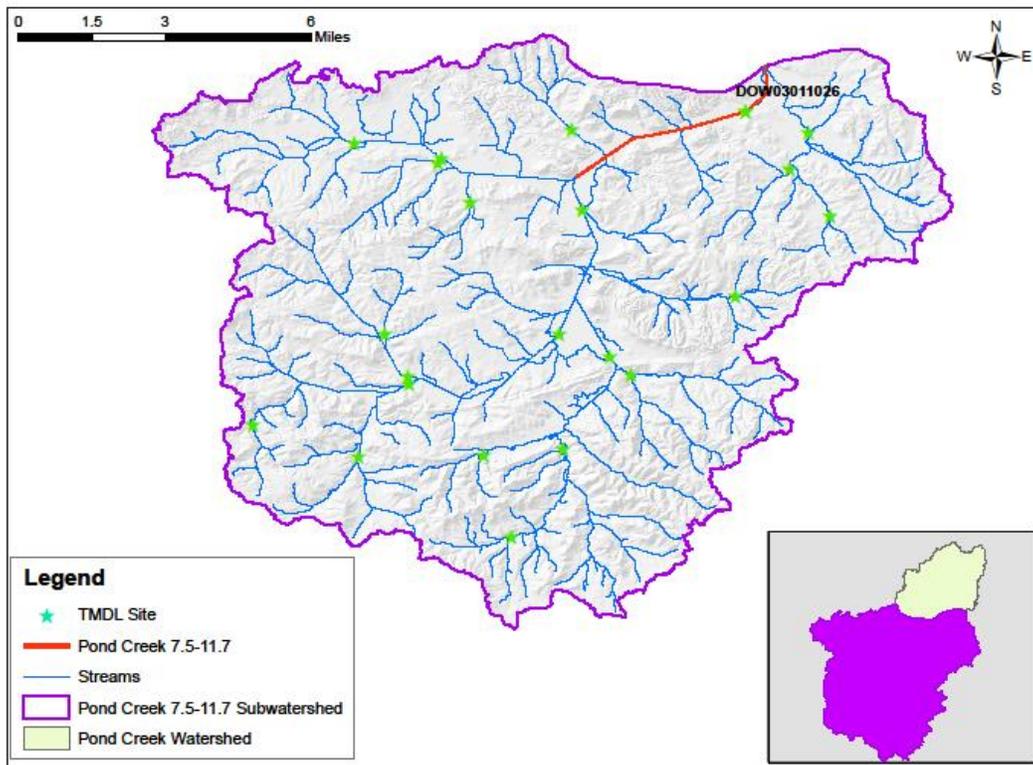


Figure 8.12.1 TMDL Monitoring Locations and the Drainage Area of Pond Creek 7.5 to 11.7

Table 8.12.1 Pond Creek 7.5 to 11.7 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042_03	Pond Creek 7.5 to 11.7	5	Muhlenberg	99.62	63757

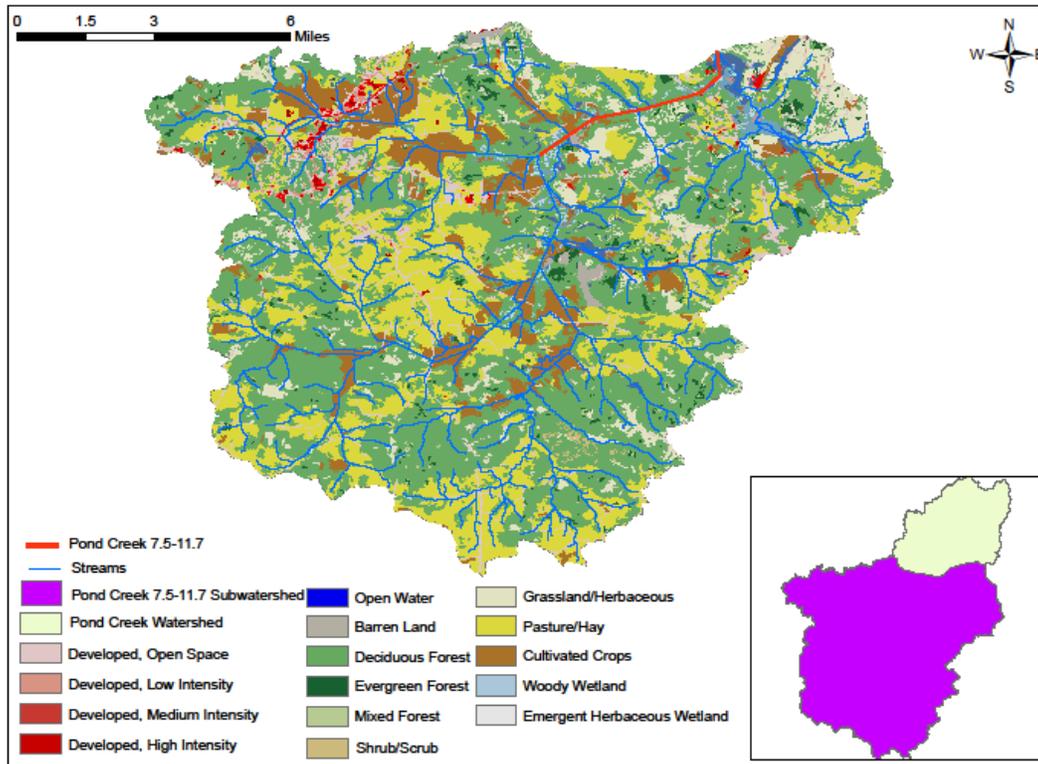


Figure 8.12.2 Land Cover in the Pond Creek 7.5 to 11.7 Subwatershed

Table 8.12.2 Land Cover in the Pond Creek 7.5 to 11.7 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	7.04	4502.5	7.1
Agriculture	32.05	20512.9	32.2
Forest	50.07	32041.9	50.3
Barren Land	0.76	483.3	0.8
Grassland/Herbaceous	7.65	4896.4	7.7
Wetlands	0.61	388.7	0.6

Land Cover	Square Miles	Acres	Percent (%)
Water	1.21	772.3	1.2
Shrub/Scrub	0.3	161.2	0.3

There are fifteen active and thirty-two inactive KPDES permittees within this subwatershed, see Figure 8.12.3 and Table 8.12.3. Although those inactive KPDES permittees were active during the data collection period and may have contributed to the impairments of the Pond Creek 7.5 to 11.7, inactive KPDES permittee will not receive a WLA.

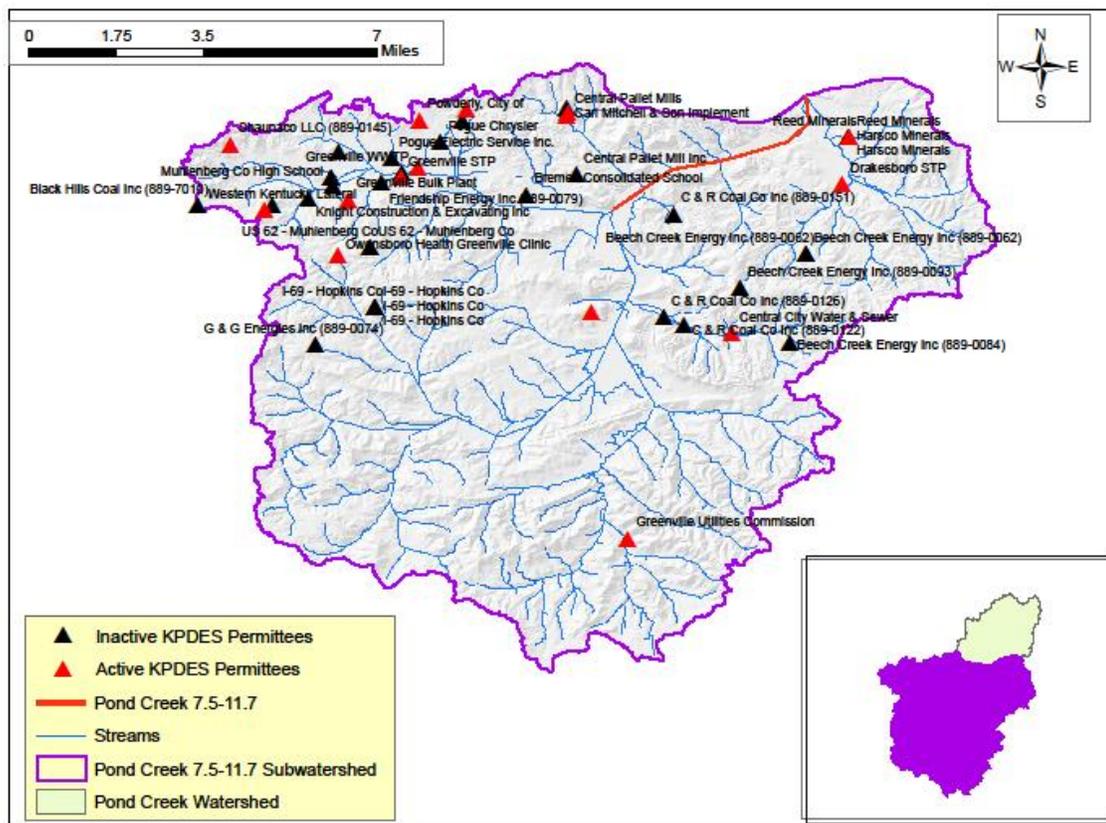


Figure 8.12.3 KPDES Permittees in the Pond Creek 7.5 to 11.7 Subwatershed

Table 8.12.3 KPDES Permittees in the Pond Creek 7.5 to 11.7 Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KY0020010	Greenville STP	Yes	1.31	37.219167	-87.169444	bacteria, pH, Cd, Cu, Pb, Zn
KY0066575	Drakesboro STP	Yes	0.165	37.217222	-87.040833	bacteria, pH, Cd, Cu, Pb, Zn
KY0108537	Shaunaco LLC (889-0145)	Yes	0	37.228611	-87.218889	pH, Cd, Cu, Fe, Pb, Ni, Zn
KY0109606	Greenville Bulk Plant	Yes	0	37.212500	-87.184700	pH
KYG045755	Oxford Mining Co Ky LLC (889-0156)	Yes	0	37.179722	-87.113889	pH, Fe
KYG640029	Central City Water & Sewer	Yes	0.0005	37.173800	-87.073000	pH, Fe
KYG640108	Greenville Utilities Commission	Yes	0.027	37.113900	-87.103200	pH, Fe
KYP000064	Powderly, City of	Yes	0	37.235833	-87.163889	discharge to Greenville WWTP
KYR003239	Central Pallet Mills	Yes	0	37.237167	-87.121083	pH and to develop a SWPPP
KYR004015	Carl Mitchell & Son Implement - Paradise Rd	Yes	0	37.238014	-87.120822	pH and to develop a SWPPP
KYR004021	Harsco Minerals	Yes	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR10J469	Muhlenberg County Airport	Yes	0	37.222067	-87.164333	to develop a SWPPP
KYR10K083	Owensboro Health Greenville Clinic	Yes	0	37.196391	-87.187716	to develop a SWPPP
KYR10K315	Western Kentucky Lateral	Yes	0	37.209464	-87.209069	to develop a SWPPP
KYR10K433	Owensboro Health Muhlenberg Healthplex	Yes	0	37.238889	-87.150189	to develop a SWPPP
KY0023329	Bremen Consolidated School	No	0.008	37.214000	-87.132800	bacteria
KY0099538	Texas Gas Transmission LLC - West Greenville	No	0	37.211111	-87.206944	pH
KY0106046	C & R Coal Co Inc (889-0151)	No	0	37.208333	-87.090000	pH, Fe
KYG043169	Black Hills Coal Inc (889-7010)	No	0	37.211111	-87.228611	pH, Fe
KYG043563	Beech Creek Energy Inc (889-0062)	No	0	37.196944	-87.051389	pH, Fe

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG044386	Beech Creek Energy Inc (889-0062)	No	0	37.196944	-87.051389	pH, Fe
KYG044486	G & G Energies Inc (889-0074)	No	0	37.170457	-87.194335	pH, Fe
KYG044573	Friendship Energy Inc (889-0079)	No	0	37.217528	-87.175069	pH, Fe
KYG044789	Beech Creek Energy Inc (889-0084)	No	0	37.170833	-87.056111	pH, Fe
KYG044998	Beech Creek Energy Inc (889-0093)	No	0	37.186944	-87.070556	pH, Fe
KYG046025	C & R Coal Co Inc (889-0126)	No	0	37.178333	-87.092778	pH, Fe
KYG046026	C & R Coal Co Inc (889-0122)	No	0	37.175833	-87.086944	pH, Fe
KYR000524	Central Pallet Mill Inc	No	0	37.220000	-87.118333	pH and to develop a SWPPP
KYR000918	Harsco Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR001665	Carl Mitchell & Son Implement	No	0	37.239428	-87.121152	pH and to develop a SWPPP
KYR00A008	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR00A009	Reed Minerals	No	0	37.230667	-87.038861	pH and to develop a SWPPP
KYR10E810	Muhlenberg Co High School Phas 3	No	0	37.216500	-87.189224	to develop a SWPPP
KYR10E960	Muhlenberg County Emergency SE	No	0	37.235680	-87.151550	to develop a SWPPP
KYR10F821	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10G145	Greenville WWTP	No	0	37.220472	-87.169111	to develop a SWPPP
KYR10G154	Knight Construction & Excavating Inc	No	0	37.212776	-87.196388	to develop a SWPPP
KYR10G285	Pogue Chrysler	No	0	37.229353	-87.157828	to develop a SWPPP
KYR10G428	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G429	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G456	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G458	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYR10G631	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10G632	US 62 - Muhlenberg Co	No	0	37.198889	-87.178333	to develop a SWPPP
KYR10H138	Muhlenberg Co High School	No	0	37.218839	-87.189686	to develop a SWPPP
KYR10H705	Muhlenberg County Park Phase I	No	0	37.226610	-87.187427	to develop a SWPPP
KYR10I149	Pogue Electric Service Inc.	No	0	37.224749	-87.172138	to develop a SWPPP

There are two active KPDES mining permittees in this subwatershed, see Figure 8.12.4 and Table 8.12.4. Some of this subwatershed is licensed mining areas, see Figure 8.12.5 (see Section 9.4.3 for more information). Tables 8.12.5 to 8.12.7 show *E. coli*, cadmium, iron and flow data collected by TMDL staff at DOW03011026.

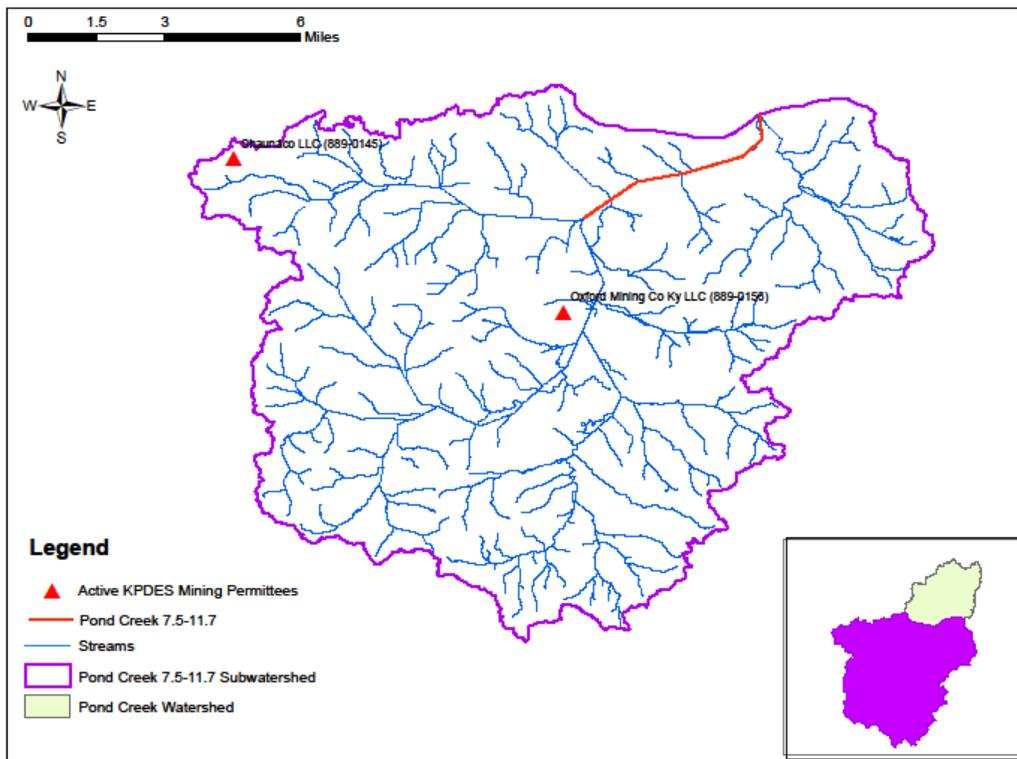


Figure 8.12.4 Active KPDES-Permitted Mining in the Subwatershed

Table 8.12.4 Active KPDES-Permitted Mining in the Subwatershed

KPDES Permit #	KDNR Permit #	Permittee Name	Date Issued
KY0108537	889-0145	Shaunaco LLC	12/1/2011
KYG045755	889-0156	Oxford Mining Co Ky LLC	7/1/2009

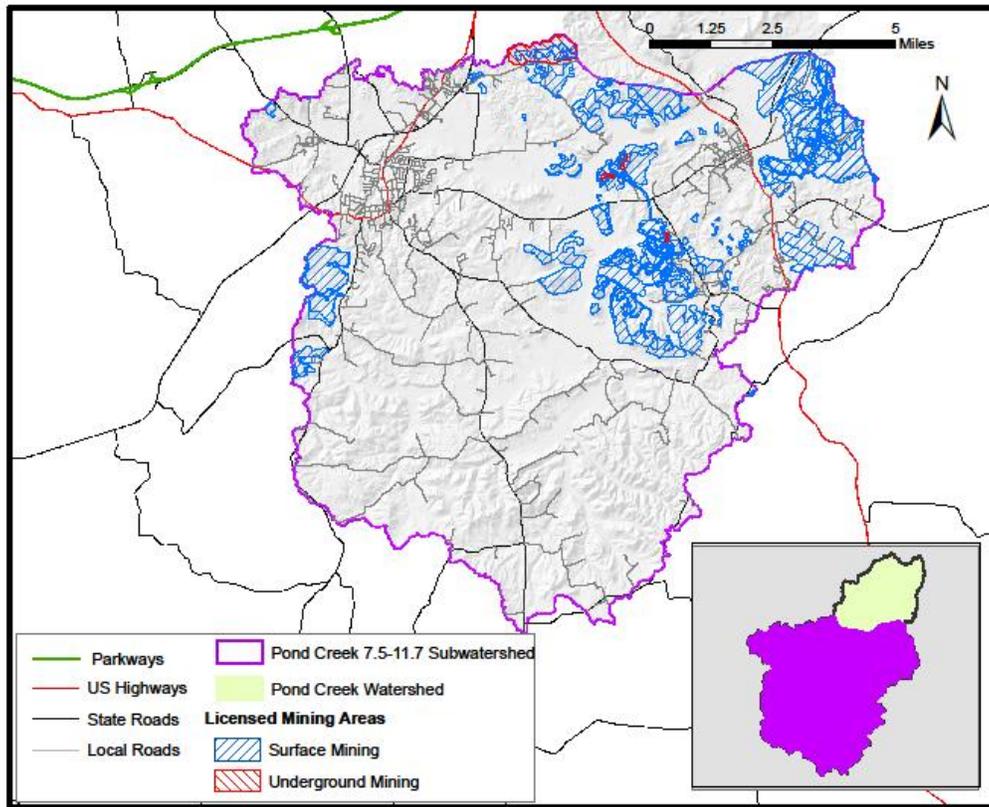


Figure 8.12.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.12.5 *E. coli* and Flow Data, DOW03011026

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/11/2011	30	**
5/12/2011	86	**
5/25/2011	63	**
5/26/2011	>2420	**
6/15/2011	727	**

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
6/16/2011	86	**
6/22/2011	1300	**
6/23/2011	517	**
7/13/2011	411	**
7/14/2011	4	**
7/27/2011	15	**
7/28/2011	17	**
8/10/2011	13	**
8/11/2011	28	**
8/24/2011	69	**
8/25/2011	115	**
9/14/2011	18	**
9/15/2011	125	**
9/28/2011	20	**
9/29/2011	62	**
10/12/2011	88	**
10/13/2011	727	**
10/20/2011	6	**

Exceeds the instantaneous *E. coli* limit
 ** Unable to obtain flow because of water depth, swiftness, or lack of access

Table 8.12.6 Cadmium, Hardness and Flow Data Collected at DOW03011026

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	< 8.0 (DU)	944	1.43	20.90	N/A	**
11/18/2010	< 0.80 (U)	1070	1.57	23.74	N/A	**
1/5/2011	2.08	381	0.73	8.31	1.35	**
1/6/2011	2.24	390	0.74	8.51	1.50	**
2/16/2011	1.41	268	0.56	5.81	0.85	**
2/17/2011	1.53	294	0.60	6.38	0.93	**
3/9/2011	0.402 (J)	80.4	0.23	1.71	N/A	**
3/10/2011	0.56 (J)	96.7	0.26	2.06	N/A	**
4/27/2011	< 0.80 (U)	106	0.28	2.26	N/A	**

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
4/28/2011	< 0.80 (U)	62.1	0.19	1.31	N/A	**
5/11/2011	8.23 (L)	595	1.01	13.07	7.22	**
5/12/2011	< 0.80 (U)	171	0.40	3.68	N/A	**
6/15/2011	1.31	1520	2.03	33.92	-0.72	**
6/16/2011	2.47	1610	2.12	35.97	0.35	**
7/13/2011	5.31 (J,D,L)	1070	1.57	23.74	N/A	**
7/14/2011	< 8.0 (DU)	1080	1.58	23.97	N/A	**
8/10/2011	2.98	1810	2.31	40.51	0.67	**
8/11/2011	2.27	1690	2.20	37.78	0.07	**
9/14/2011	1.21	1350	1.86	30.07	-0.65	**
9/15/2011	< 0.80 (U)	1250	1.76	27.81	N/A	**
10/12/2011	0.499 (J)	1360	1.87	30.30	N/A	**
10/13/2011	0.515 (J)	1280	1.79	28.49	N/A	**
6/25/2014	0.26 (J)	708	1.15	15.60	N/A	11.64

Exceeds the chronic limit
** Unable to obtain flow because of water depth, swiftness, or lack of access
D = Reanalyzed at a Higher Dilution
J = Estimated Value
U = Analyte Not Detected
L = Exceeds MCL or Action Limit
N/A: Not Applicable

Table 8.12.7 Iron and Flow Data Collected at DOW03011026

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
11/17/2010	7.67	**
11/18/2010	9.96	**
1/5/2011	3.44	**
1/6/2011	3.78	**
2/16/2011	2.87	**
2/17/2011	2.83	**
3/9/2011	1.99	**
3/10/2011	1.12	**
4/27/2011	1.07	**
4/28/2011	1.15	**
5/11/2011	7.12	**

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
5/12/2011	5.97	**
6/15/2011	6.13	**
6/16/2011	9.77	**
7/13/2011	12.5	**
7/14/2011	35.3 (D)	**
8/10/2011	3.6	**
8/11/2011	1.78	**
9/14/2011	2.7	**
9/15/2011	0.645	**
10/12/2011	0.775	**
10/13/2011	1.75	**
6/25/2014	3.57	11.64
⁽¹⁾ Chronic limit is 1.0 mg/L since aquatic life is adversely affected  Exceeds the acute limit  Exceeds the chronic limit ** Unable to obtain flow because of water depth, swiftness, or lack of access D = Reanalyzed at a Higher Dilution		

8.13 Pond Creek 11.7 to 14.4

The pollutants addressed in this document for Pond Creek 11.7 to 14.4 are cadmium and iron. A pH TMDL was developed for Pond Creek segments and was approved by EPA in 2007. However, TMDL sampling data indicate this segment was still impaired for pH during data collection period, see Table 8.13.5.

Pond Creek 11.7 to 14.4 is a fourth order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 56.2 square miles. There is one TMDL monitoring site on the Pond Creek 11.7 to 14.4 segment, DOW03011027, located at RM 12.45 with the drainage area of 56.0 square miles, see Figure 8.13.1 and Table 8.13.1. This subwatershed consists primarily of forest (53.2%) and agricultural land (35.8%), see Figure 8.13.2 and Table 8.13.2.

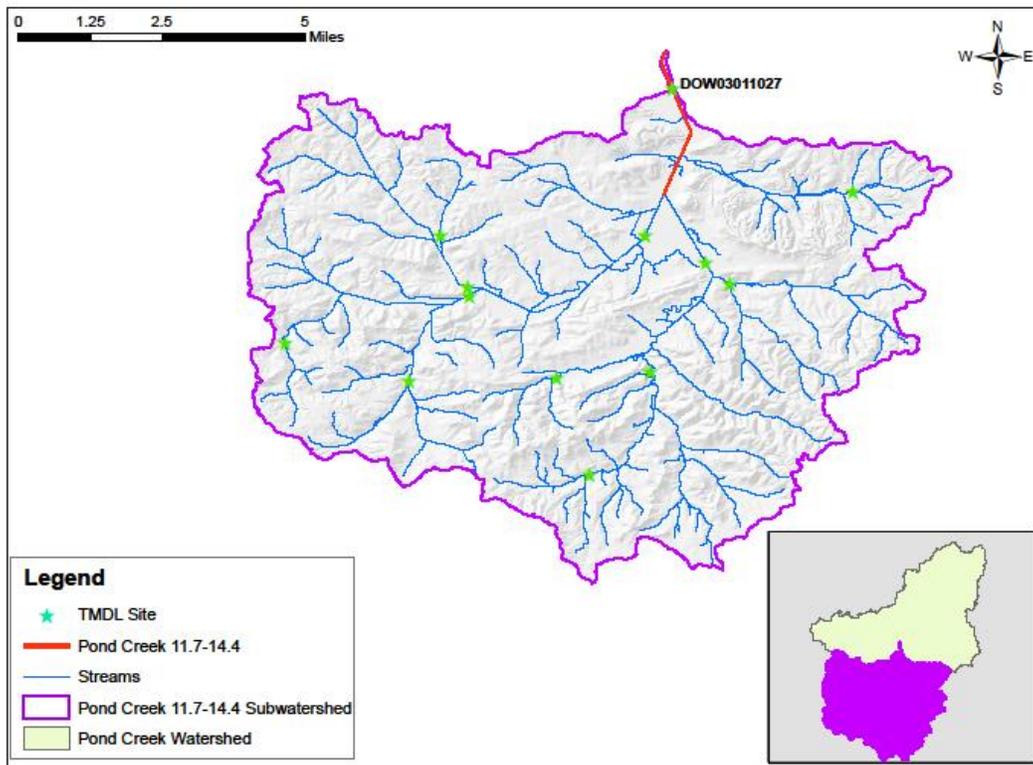


Figure 8.13.1 TMDL Monitoring Locations and the Drainage Area of Pond Creek 11.7 to 14.4

Table 8.13.1 Pond Creek 11.7 to 14.4 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042_04	Pond Creek 11.7 to 14.4	4	Muhlenberg	56.2	35978

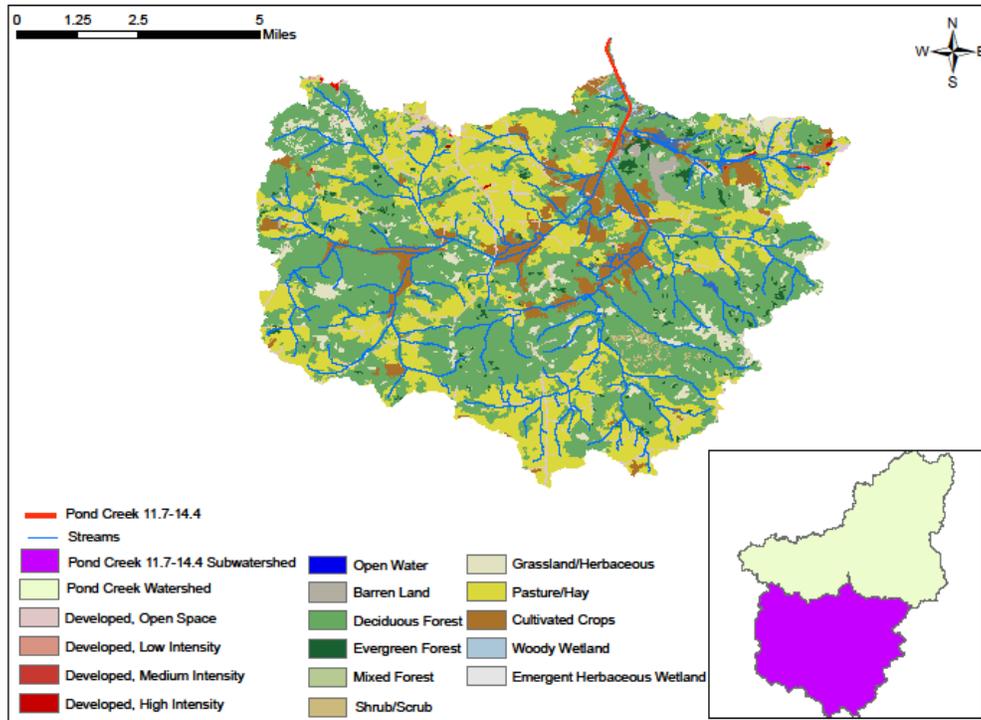


Figure 8.13.2 Land Cover in the Pond Creek 11.7 to 14.4 Subwatershed

Table 8.13.2 Land Cover in the Pond Creek 11.7 to 14.4 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	2.46	1576.5	4.4
Agriculture	20.12	12879.2	35.8
Forest	29.9	19134.7	53.2
Barren Land	0.50	317.2	0.9
Grassland/Herbaceous	2.54	1626.2	4.5
Wetlands	0.17	109.5	0.3
Water	0.31	201.2	0.6
Shrub/Scrub	0.2	134.6	0.4

There are four active and eight inactive KPDES-permitted facilities within this subwatershed, see Figure 8.13.3 and Table 8.13.3. Although those inactive KPDES facilities were active during the data collection period and may have contributed to the pollutants on the Pond Creek 11.7 to 14.4, inactive KPDES permittee will not receive a WLA.

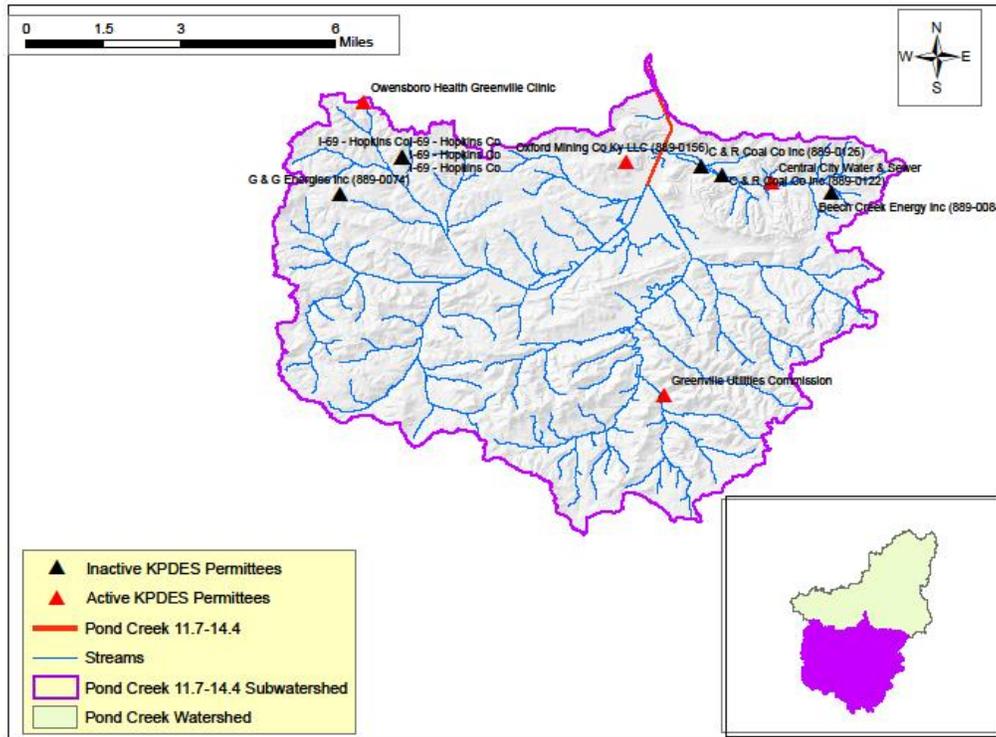


Figure 8.13.3 KPDES Permittees in the Pond Creek 11.7 to 14.4 Subwatershed

Table 8.13.3 KPDES Permittees in the Pond Creek 11.7 to 14.4 Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG045755	Oxford Mining Co Ky LLC (889-0156)	Yes	0	37.179722	-87.113889	pH, Fe
KYG640029	Central City Water & Sewer	Yes	0.0005	37.173800	-87.073000	pH, Fe
KYG640108	Greenville Utilities Commission	Yes	0.027	37.113900	-87.103200	pH, Fe
KYR10K083	Owensboro Health Greenville Clinic	Yes	0	37.196391	-87.187716	to develop a SWPPP
KYG044486	G & G Energies Inc (889-0074)	No	0	37.170457	-87.194335	pH, Fe

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG044789	Beech Creek Energy Inc (889-0084)	No	0	37.170833	-87.056111	pH, Fe
KYG046025	C & R Coal Co Inc (889-0126)	No	0	37.178333	-87.092778	pH, Fe
KYG046026	C & R Coal Co Inc (889-0122)	No	0	37.175833	-87.086944	pH, Fe
KYR10G428	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G429	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G456	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G458	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP

There is one active KPDES mining permittee in this subwatershed, see Figure 8.13.4 and Table 8.13.4. Some of the subwatershed is licensed mining areas, see Figure 8.13.5 (see Section 9.4.3 for more information). Tables 8.13.6 to 8.13.7 show cadmium, iron and flow data collected by TMDL staff at DOW03011027.

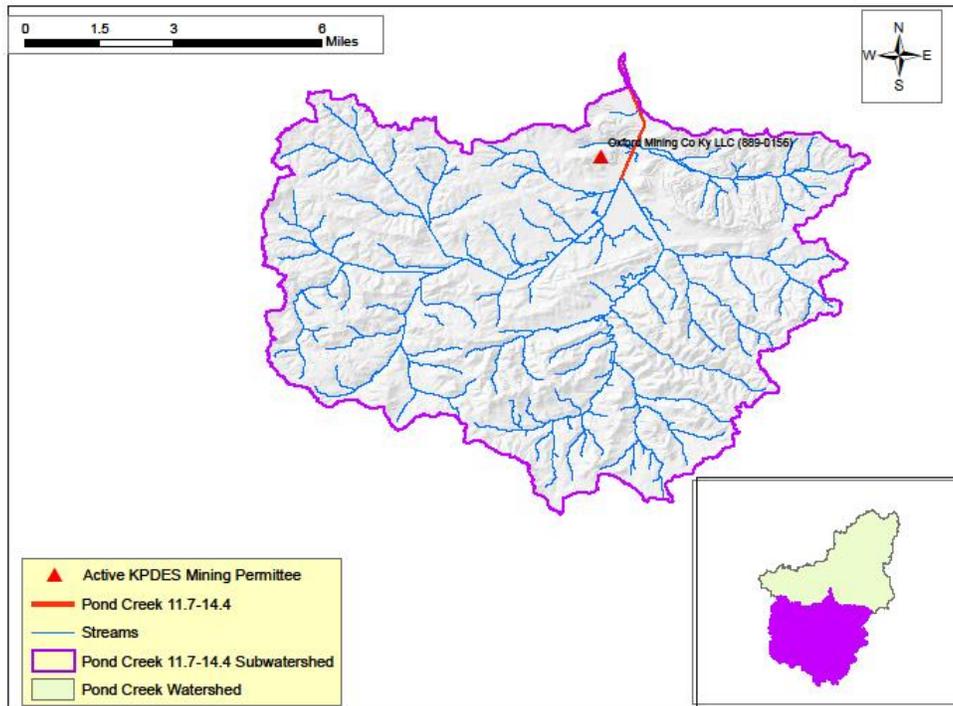


Figure 8.13.4 Active KPDES-Permitted Mining in the Subwatershed

Table 8.13.4 Active KPDES-Permitted Mining in the Subwatershed

KPDES Permit #	KDNR Permit #	Permittee Name	Date Issued
KYG045755	889-0156	Oxford Mining Co Ky LLC	7/1/2009

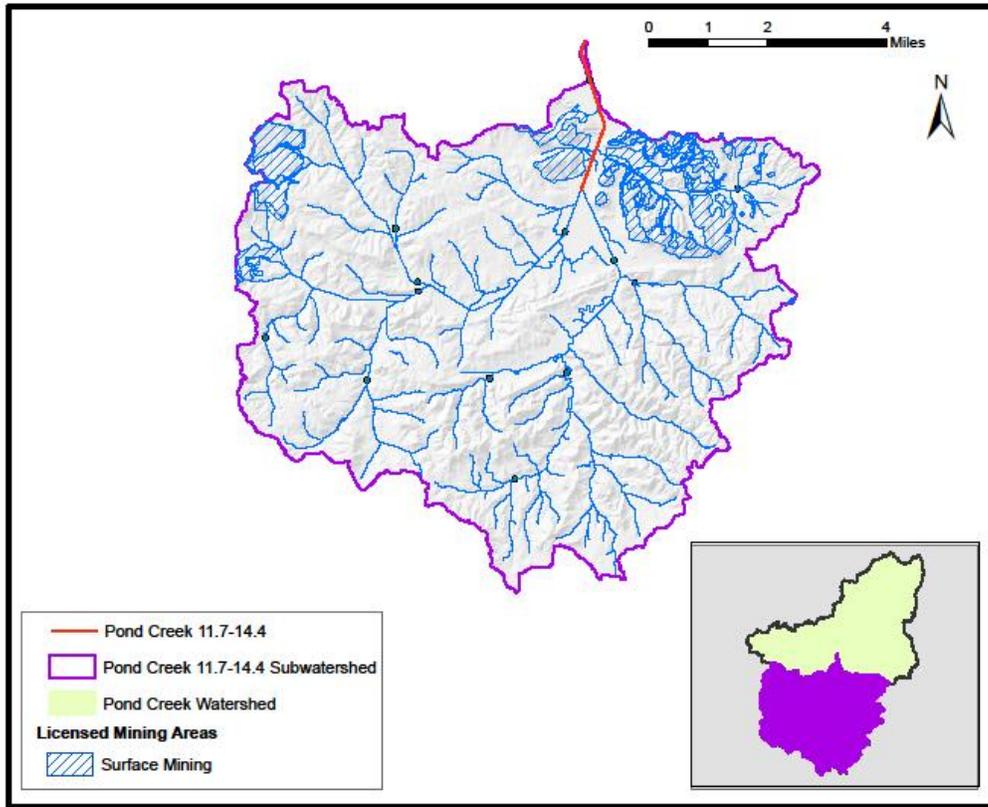


Figure 8.13.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.13.5 pH and Flow Data Collected at DOW03011027

Date	pH (standard units)	Flow (cfs)
11/17/10	5.46	**
1/5/11	6.61	**
2/16/11	6.38	**
5/11/11	4.93	**
6/22/11	6.01	**
7/13/11	5.69	**
7/27/11	5.89	**
8/10/11	8.64	**

Date	pH (standard units)	Flow (cfs)
8/24/11	9.41	**
9/14/11	9.91	**
9/28/11	5.69	**
10/12/11	9.78	**
10/19/11	6.49	**
3/21/13	7.34	**
4/24/13	6.47	**
5/8/13	6.94	**
6/26/13	6.80	**
7/16/13	6.21	**
8/6/13	6.68	**
9/10/13	6.76	**
10/9/13	6.66	**
11/13/13	7.42	**
12/17/13	7.09	**
3/18/14	6.01	**
4/15/14	7.05	**
5/21/14	6.01	**
6/5/14	6.37	**
7/23/14	7.73	**
8/13/14	7.61	**
9/11/14	8.29	**
10/29/14	6.45	**
11/19/14	6.47	**
12/23/14	6.45	**
<p>Exceeds the pH limit ** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

Table 8.13.6 Cadmium, Hardness and Flow Data Collected at DOW03011027

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	4.57 (JD)	1600	2.11	35.74	N/A	**
1/5/2011	2.25	365	0.71	7.96	1.54	**
2/16/2011	1.13	241	0.52	5.22	0.61	**

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
5/11/2011	21.3 (L)	832	1.30	18.38	20.00	**
7/13/2011	1.91	1460	1.97	32.56	-0.06	**
8/10/2011	3.2 (D)	1880	2.38	42.11	0.82	**
9/14/2011	< 8.0 (DU)	1500	2.01	33.47	N/A	**
10/12/2011	2.16	2010	2.50	45.07	-0.34	**
3/21/2013	1.2	190	0.44	4.10	0.76	**
4/24/2013	0.64	248	0.53	5.37	0.11	**
5/8/2013	0.57	218	0.48	4.71	0.09	**
6/26/2013	1.01	1050	1.55	23.29	-0.54	**
7/16/2013	0.62	1010	1.50	22.39	-0.88	**
8/6/2013	0.36	1460	1.97	32.56	-1.61	**
9/10/2013	0.24	909	1.39	20.11	-1.15	**
10/9/2013	0.96	591	1.01	12.98	-0.05	**
11/13/2013	< 0.50 (U)	597	1.02	13.12	N/A	**
12/17/2013	0.52	252	0.54	5.46	-0.02	**
3/18/2014	0.73	265	0.56	5.75	0.17	**
4/15/2014	< 0.50 (U)	118	0.31	2.52	N/A	**
5/21/2014	< 0.50 (U)	597	1.02	13.12	N/A	**
6/5/2014	0.23 (J)	493	0.88	10.80	N/A	**
7/23/2014	< 0.50 (U)	1580	2.09	35.28	N/A	**
8/13/2014	0.55	2120	2.60	47.58	-2.05	**
9/11/2014	0.31 (J)	1680	2.19	37.56	N/A	**
10/29/2014	0.76	1220	1.73	27.13	-0.97	**
11/19/2014	0.47 (J)	1060	1.56	23.52	N/A	**
12/23/2014	0.48 (J)	726	1.18	16.01	N/A	**
<p>Exceeds the acute limit</p> <p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>L = Exceeds MCL or Action Limit</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

Table 8.13.7 Iron and Flow Data Collected at DOW03011027

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
11/17/2010	3	**
1/5/2011	1.64	**
2/16/2011	1.28	**
5/11/2011	12.4	**
7/13/2011	1.82	**
8/10/2011	3.67	**
9/14/2011	0.694	**
10/12/2011	0.325	**
3/21/2013	1.07	**
4/24/2013	5.76	**
5/8/2013	1.42	**
6/26/2013	6.67	**
7/16/2013	10.4	**
8/6/2013	14.8	**
9/10/2013	4.47	**
10/9/2013	4.42	**
11/13/2013	4.62	**
12/17/2013	0.919	**
3/18/2014	1.53	**
4/15/2014	3.33	**
5/21/2014	1.72	**
6/5/2014	2.19	**
7/23/2014	1.29	**
8/13/2014	4.35	**
9/11/2014	0.513	**
10/29/2014	1.58	**
11/19/2014	5.73	**
12/23/2014	8.08	**
⁽¹⁾ Chronic limit is 1.0 mg/L since aquatic life is adversely affected Exceeds the acute limit Exceeds the chronic limit ** Unable to obtain flow because of water depth, swiftness, or lack of access		

8.14 Pond Creek 14.4 to 18.1

The pollutants addressed in this document for Pond Creek 14.4 to 18.1 are *E. coli* and lead. A pH TMDL was developed for the Pond Creek segments and was approved by EPA in 2007. TMDL sampling data indicate this segment had no impairment for pH during the data collection period; as a result, the pH for the Pond Creek 14.4 to 18.1 was delisted in 2014 303(d).

Pond Creek 14.4 to 18.1 is a fourth order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 26.95 square miles. There is one TMDL monitoring site on the Pond Creek 14.4 to 18.1 segment, located at RM 15.20 with the drainage area of 23.78 square miles, see Figure 8.14.1 and Table 8.14.1. This subwatershed consists primarily of forest (48.5%) and agricultural land (42.3%), see Figure 8.14.2 and Table 8.14.2.

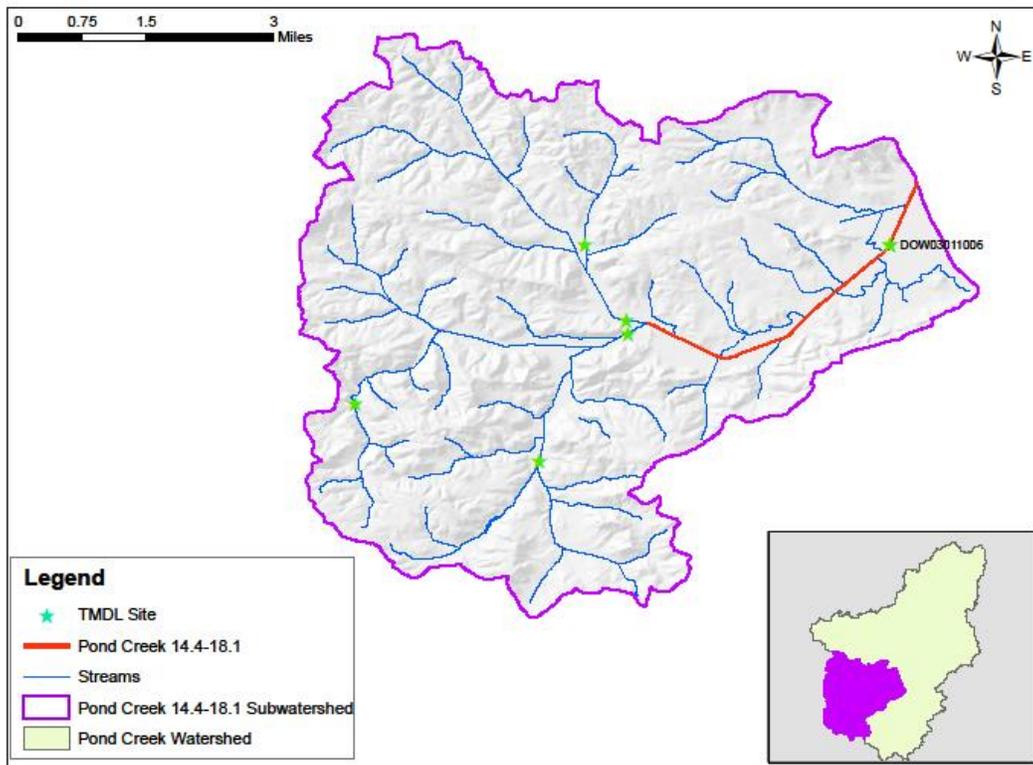


Figure 8.14.1 TMDL Monitoring Locations and the Drainage Area of Pond Creek 14.4 to 18.1

Table 8.14.1 Pond Creek 14.4 to 18.1 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042_05	Pond Creek 14.4 to 18.1	4	Muhlenberg	26.95	17246

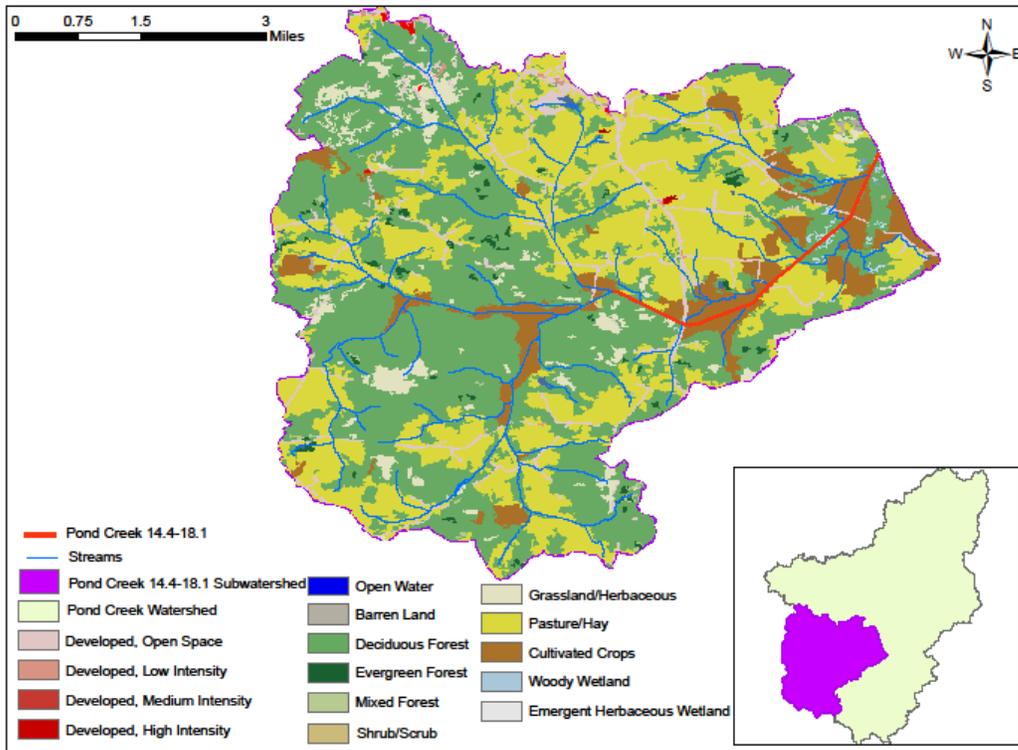


Figure 8.14.2 Land Cover in the Pond Creek 14.4 to 18.1 Subwatershed

Table 8.14.2 Land Cover in the Pond Creek 14.4 to 18.1 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	1.28	818.4	4.7
Agriculture	11.39	7288.0	42.3
Forest	13.08	8369.9	48.5
Barren Land	0.06	37.5	0.2
Grassland/Herbaceous	1.03	657.3	3.8
Wetlands	0.06	40.0	0.2
Water	0.05	30.9	0.2
Shrub/Scrub	0.01	4.5	0.03

There are two active and five inactive KPDES facilities within this subwatershed, see Figure 8.14.3 and Table 8.14.3. Although those inactive KPDES permittees were active during the data collection period and may have contributed to the impairment in the Pond Creek 14.4 to 18.1, inactive KPDES permittee will not receive a WLA.

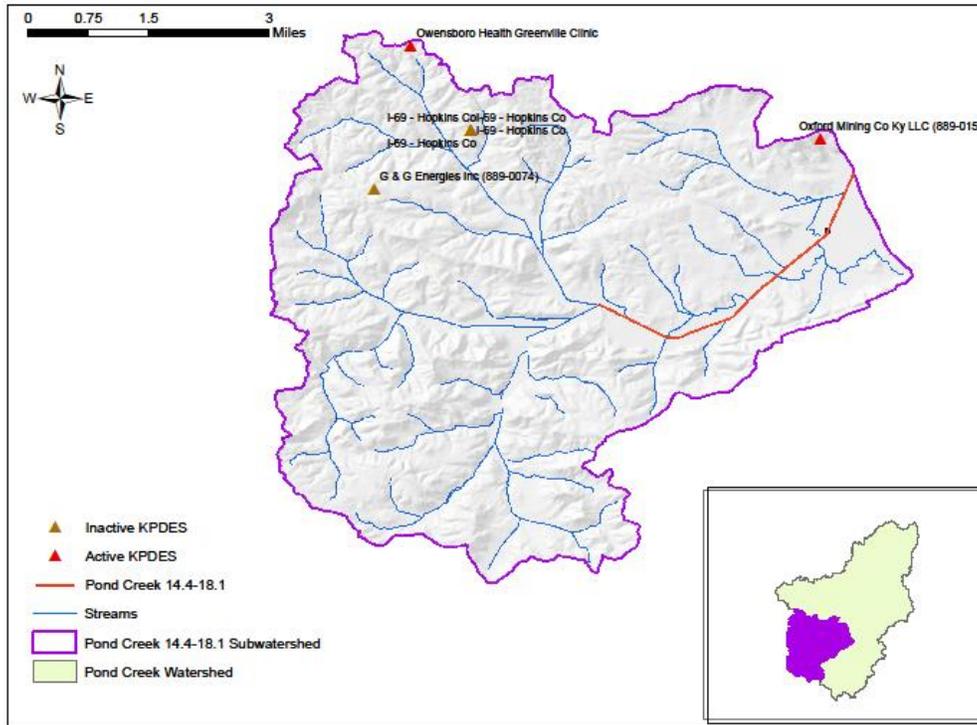


Figure 8.14.3 KPDES Permittees in the Subwatershed

Table 8.14.3 KPDES Permittees in the Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYG045755	Oxford Mining Co Ky LLC (889-0156)	Yes	0	37.179722	-87.113889	pH, Fe
KYR10K083	Owensboro Health Greenville Clinic	Yes	0	37.196391	-87.187716	to develop a SWPPP
KYG044486	G & G Energies Inc (889-0074)	No	0	37.170457	-87.194335	pH, Fe
KYR10G428	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G429	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G456	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G458	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP

There is one active KPDES-permitted mining in this subwatershed, see Figure 8.14.4 and Table 8.14.4. A small portion of watershed, mainly in upstream, is licensed mining areas, see Figure 8.14.5 (see Section 9.4.3 for more information). Table 8.14.5 and 8.14.6 shows *E. coli*, lead and flow data collected by TMDL staff at DOW03011006.

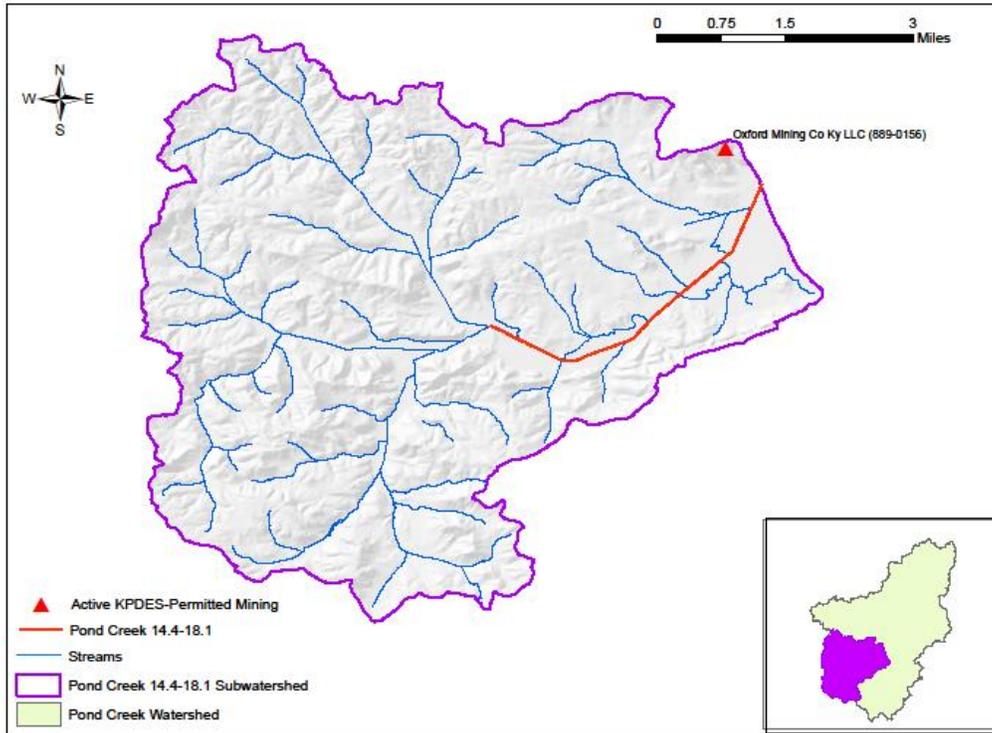


Figure 8.14.4 Active KPDES-Permitted Mining in the Subwatershed

Table 8.14.4 Active KPDES-Permitted Mining in the Subwatershed

KPDES Permit #	KDNR Permit #	Permittee Name	Date Issued
KYG045755	889-0156	Oxford Mining Co Ky LLC	7/1/2009

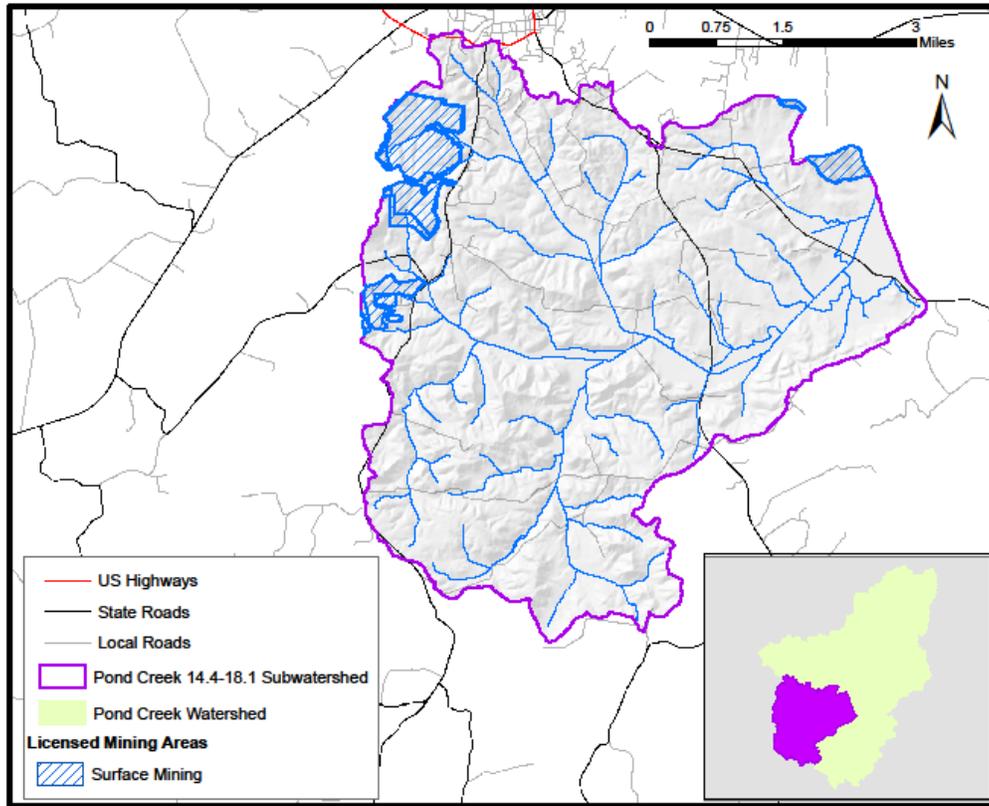


Figure 8.14.5 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.14.5 *E. coli* and Flow Data, DOW03011006

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	89	**
5/11/2011	81	**
5/12/2011	145	**
5/24/2011	201	**
5/25/2011	152	**
5/26/2011	>2420	**
6/21/2011	687	**
6/22/2011	1733	**
6/23/2011	> 2420	**
7/12/2011	131	**
7/13/2011	120	**
7/14/2011	131	**

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
9/27/2011	> 2420	**
9/28/2011	272	**
9/29/2011	155	**

Exceeds the instantaneous *E. coli* limit
** Unable to obtain flow because of water depth, swiftness, or lack of access

Table 8.14.6 Lead, Hardness and Flow Data Collected at DOW03011006

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
1/4/2011	0.44 (J)	92.2	2.87	73.63	N/A	**
1/5/2011	0.237 (J)	102	3.26	83.73	N/A	**
1/6/2011	0.324 (J)	105	3.39	86.88	N/A	**
2/15/2011	0.29 (J)	77.9	2.32	59.41	N/A	**
2/16/2011	< 0.50 (U)	78.8	2.35	60.28	N/A	**
2/17/2011	< 0.50 (U)	86.4	2.64	67.78	N/A	**
3/8/2011	0.489 (J)	70.4	2.04	52.23	N/A	**
3/9/2011	5.65	30.6	0.70	18.08	4.95	**
3/10/2011	1.54	42.6	1.07	27.55	0.47	**
4/26/2011	1.18	40.4	1.00	25.75	0.18	**
4/27/2011	5.77	24.1	0.52	13.34	5.25	**
4/28/2011	1.18	35.9	0.86	22.16	0.32	**
5/10/2011	0.414 (J)	90.1	2.79	71.50	N/A	**
5/11/2011	0.322 (J)	92.1	2.87	73.52	N/A	**
5/12/2011	0.251 (J)	133	4.57	117.38	N/A	**
7/12/2011	< 0.50 (U)	129	4.40	112.90	N/A	**
7/13/2011	< 0.50 (U)	136	4.71	120.76	N/A	**
7/14/2011	0.221 (J)	153	5.47	140.29	N/A	**

Exceeds the chronic limit
** Unable to obtain flow because of water depth, swiftness, or lack of access
D = Reanalyzed at a Higher Dilution
J = Estimated Value
U = Analyte Not Detected
N/A: Not Applicable

8.15 Pond Creek 18.1 to 18.7

The pollutant addressed in this document for Pond Creek 18.1 to 18.7 is *E. coli*. A pH TMDL was developed for the segment of Pond Creek 16.3 to 20.0 and was approved by EPA in 2007. Pond Creek 18.1 to 18.7 is a fourth order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 18.73 square miles. There is one TMDL monitoring site on the Pond Creek 18.1 to 18.7 segment, DOW03011020, located at RM 18.35 with the drainage area of 11.89 square miles, see Figure 8.15.1 and Table 8.15.1. This subwatershed consists primarily of forest (56.5%) and agricultural land (34.1%), see Figure 8.15.2 and Table 8.15.2.

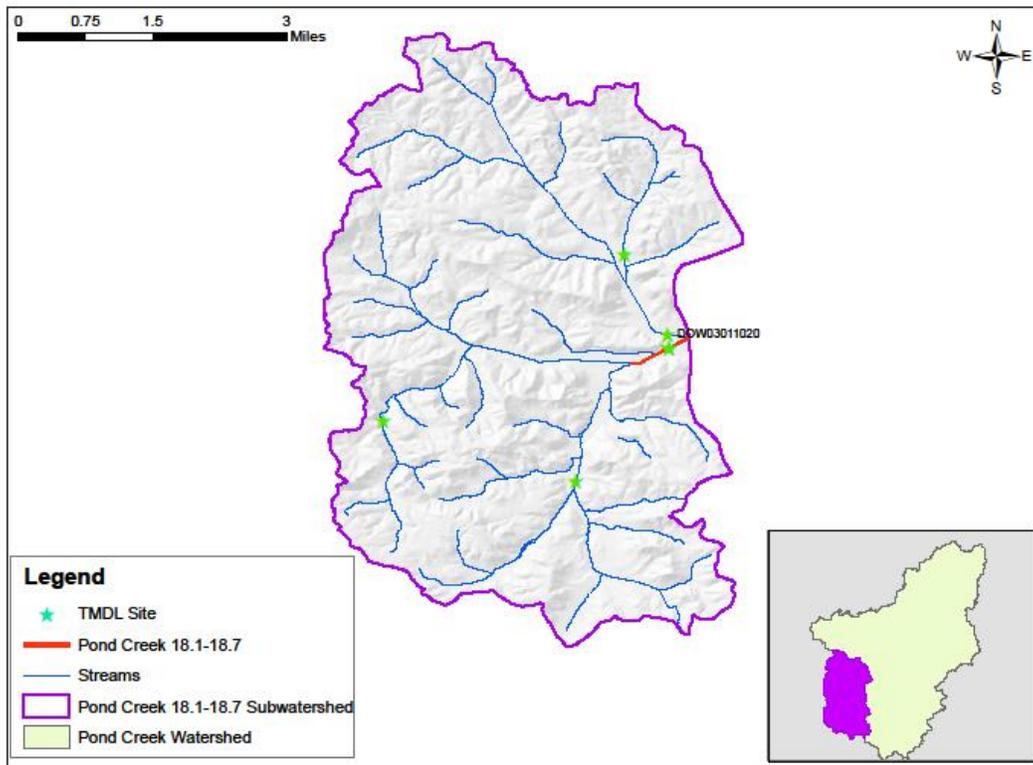


Figure 8.15.1 TMDL Monitoring Sites and the Drainage Area of Pond Creek 18.1 to 18.7

Table 8.15.1 Pond Creek 18.1 to 18.7 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042_06	Pond Creek 18.1-18.7	4	Muhlenberg	18.73	11990

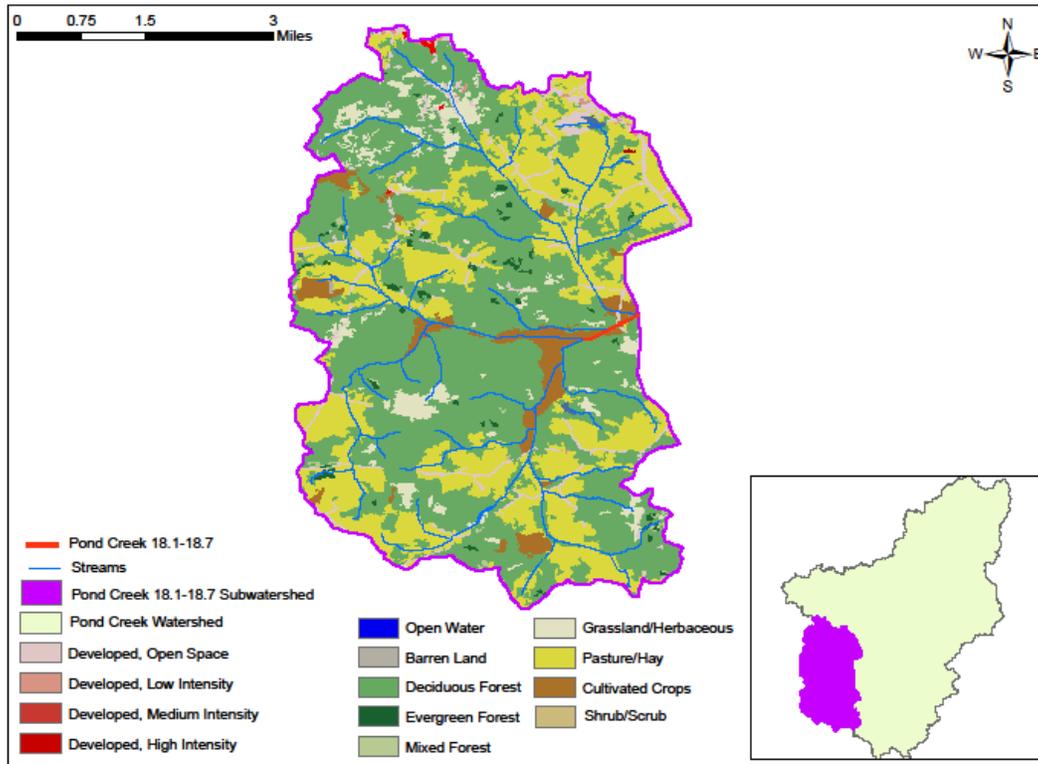


Figure 8.15.2 Land Cover in the Pond Creek 18.1 to 18.7 Subwatershed

Table 8.15.2 Land Cover in the Pond Creek 18.1 to 18.7 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.84	537.4	4.5
Agriculture	6.39	4092.2	34.1
Forest	10.59	6778.6	56.5
Barren Land	0.01	4.0	0.03
Grassland/Herbaceous	0.86	547.4	4.6
Wetland	0	0	0
Water	0.04	27.4	0.2
Shrub/Scrub	0.01	3.4	0.03

There are one active and five inactive KPDES facilities within this subwatershed, see Figure 8.15.3 and Table 8.15.3. Although those five inactive KPDES permittees were active during the data collection period and may have contributed to the impairments in the Pond Creek 18.1 to

18.8, inactive KPDES permittee will not receive a WLA. *E. coli* and flow data monitored at DOW03011020 are in Table 8.15.4.

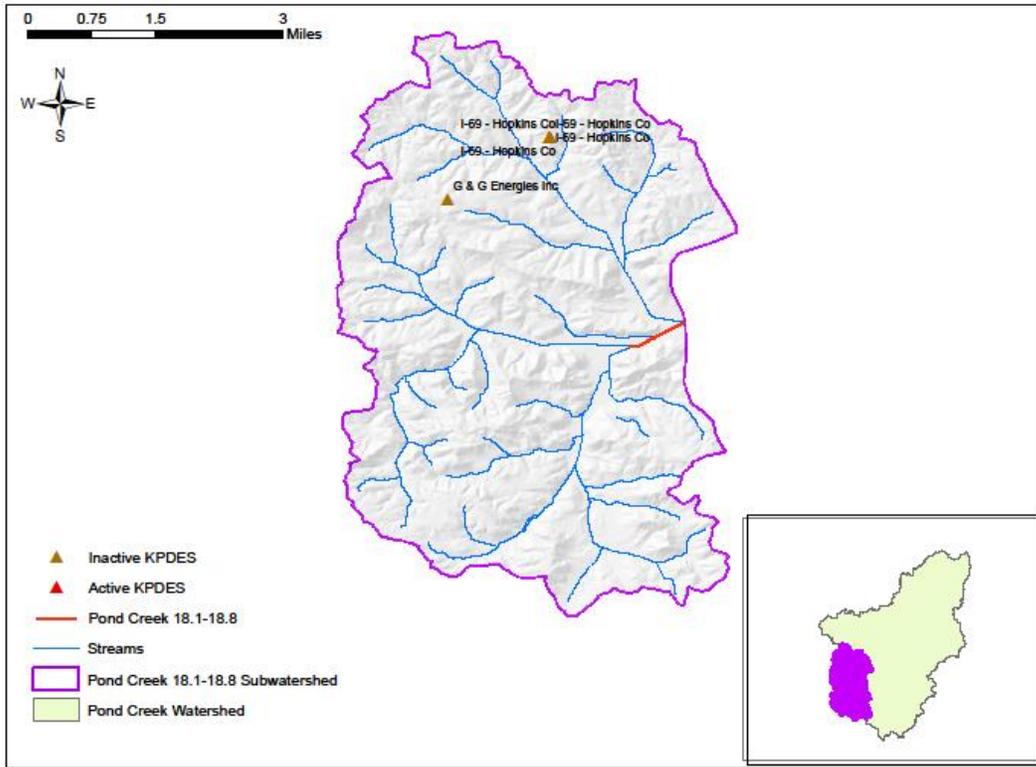


Figure 8.15.3 KPDES Permittees in the Subwatershed

Table 8.15.3 KPDES Permittees in the Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYR10K083	Owensboro Health Greenville Clinic	Yes	0	37.196391	-87.187716	to develop a SWPPP
KYG044486	G & G Energies Inc (889-0074)	No	0	37.170457	-87.194335	pH, Fe
KYR10G428	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G429	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G456	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G458	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP

Table 8.15.4 *E. coli* and Flow Data, DOW03011020

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	435	**
5/24/2011	135	**
6/14/2011	7	**
6/21/2011	299	**
7/12/2011	192	**
9/27/2011	> 2420	**
5/8/2013	193	**
5/9/2013	326	**
5/20/2013	206	**
5/23/2013	105	**
5/29/2013	101	**
6/6/2013	> 2420	**
6/27/2013	548	**
7/17/2013	113	**
7/30/2013	145	**
8/6/2013	461	**
8/15/2013	240	**
9/11/2013	48	**
9/24/2013	179	**
10/10/2013	816	**
10/14/2013	133	**
<p> Exceeds the instantaneous <i>E. coli</i> limit ** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

8.16 Saltlick Creek 0.0 to 3.7

The pollutant addressed in this document for Saltlick Creek 0.0 to 3.7 is *E. coli*. Saltlick Creek 0.0 to 3.7 is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 5.95 square miles. There is one TMDL monitoring site on the Saltlick Creek 0.0 to 3.7 segment, DOW03011023, located at RM 1.55 with the drainage area of 3.44 square miles, see Figure 8.16.1 and Table 8.16.1. This subwatershed consists primarily of forest (57.8%) and agricultural land (36.6%), see Figure 8.16.2 and Table 8.16.2.

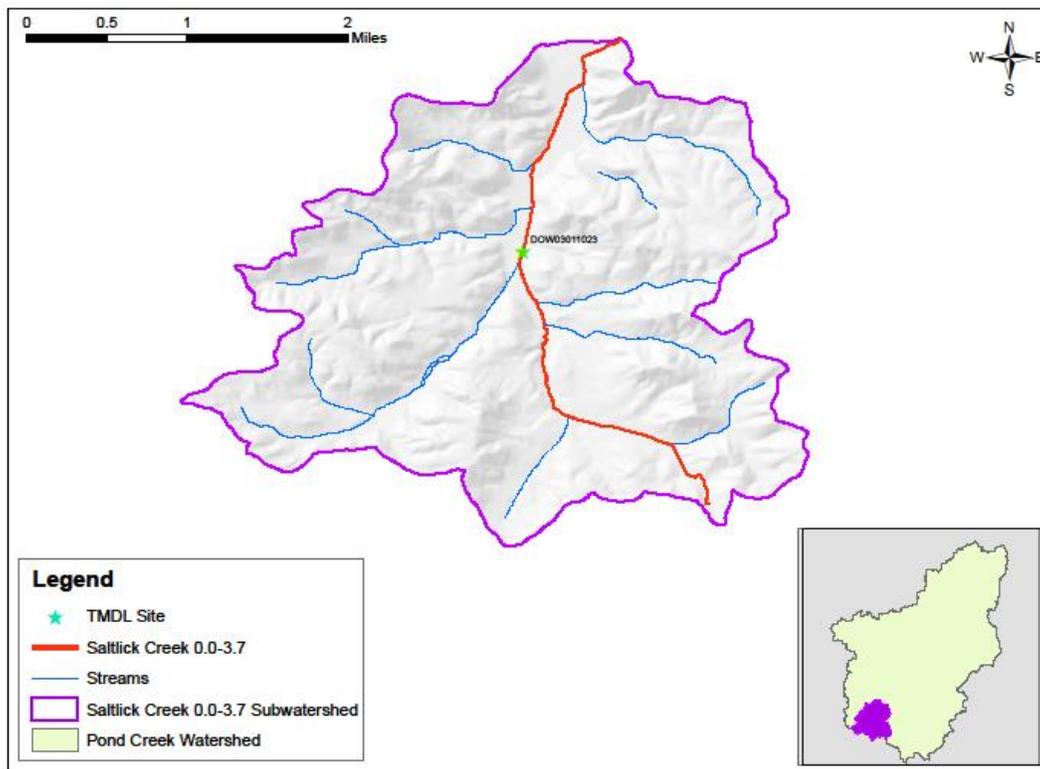


Figure 8.16.1 TMDL Monitoring Locations and the Drainage Area of Saltlick Creek 0.0 to 3.7

Table 8.16.1 Saltlick Creek 0.0 to 3.7 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY502844_01	Saltlick Creek 0.0 to 3.7	3	Muhlenberg	5.95	3807

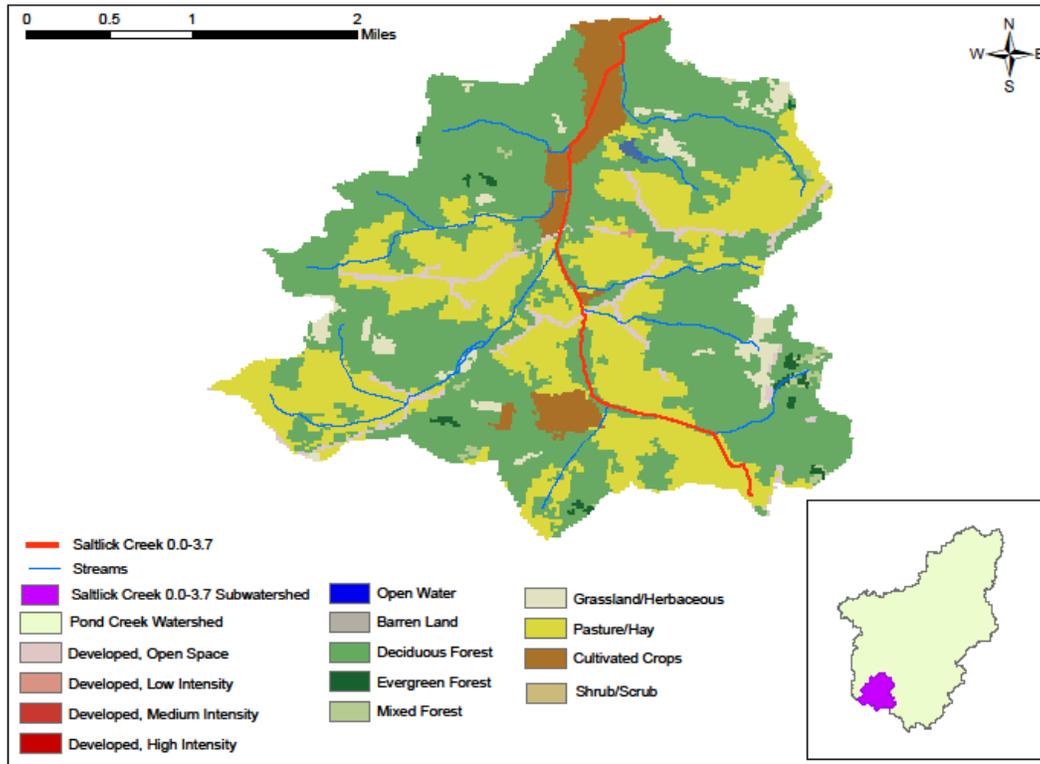


Figure 8.16.2 Land Cover in the Saltlick Creek 0.0 to 3.7 Subwatershed

Table 8.16.2 Land Cover in the Saltlick Creek 0.0 to 3.7 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.16	100.0	2.6
Agriculture	2.17	1391.9	36.6
Forest	3.44	2201.7	57.8
Barren Land	0	0	0
Grassland/Herbaceous	0.17	105.9	2.8
Water	0.01	6.3	0.2
Wetland	0	0	0
Shrub/Scrub	0.002	1.3	0.03

There are no KPDES permittees in this subwatershed. *E. coli* and flow data monitored at DOW03011023 are in Table 8.16.3.

Table 8.16.3 *E. coli* and Flow Data, DOW03011023

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	1414	0.988
5/24/2011	727	**
5/8/2013	326	**
5/9/2013	231	**
5/23/2013	172	**
6/6/2013	> 2420	**
6/27/2013	145	0.057
7/30/2013	153	0.042
8/6/2013	365	0.148
8/15/2013	411	**
10/10/2013	248	0.524
<p> Exceeds the instantaneous <i>E. coli</i> limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

8.17 Sandlick Creek 0.0 to 4.05

The pollutants addressed in this document for Sandlick Creek 0.0 to 4.05 are *E. coli*, iron and lead. Sandlick Creek 0.0 to 4.05 is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 6.68 square miles. There is one TMDL monitoring site on the Sandlick Creek 0.0 to 4.05 segment, DOW03011004, located at RM 0.20 with the drainage area of 6.64 square miles, see Figure 8.17.1 and Table 8.17.1. This subwatershed consists primarily of forest (51.3%) and agricultural land (34.5%), see Figure 8.17.2 and Table 8.17.2.

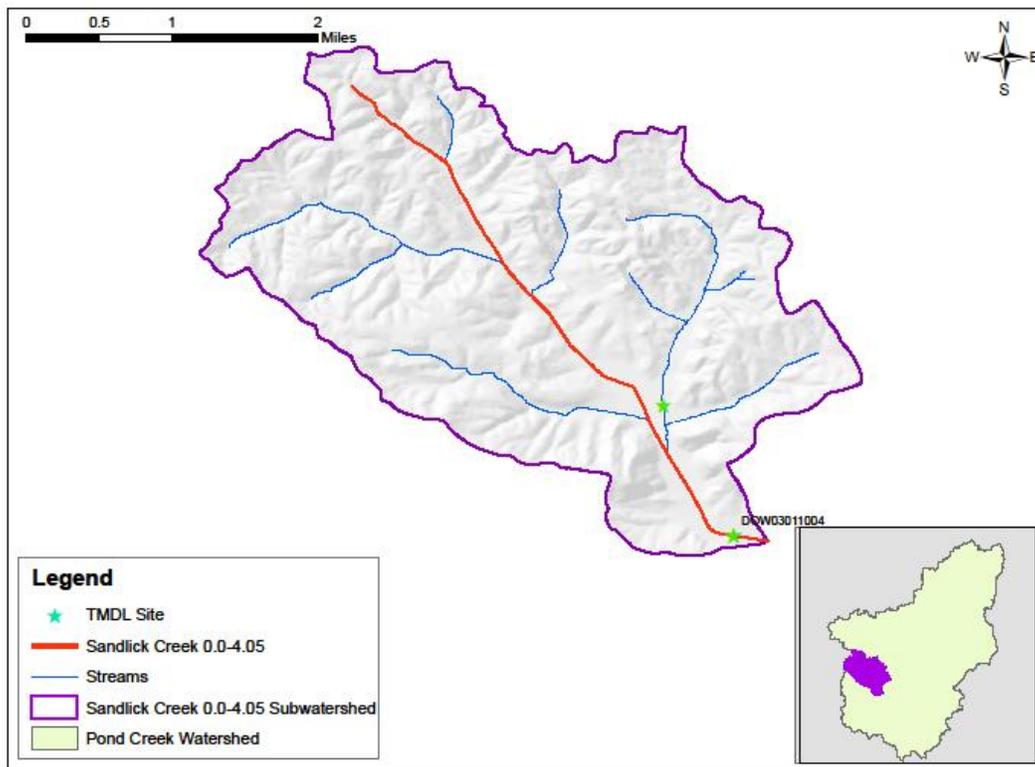


Figure 8.17.1 TMDL Monitoring Locations and the Drainage Area of Sandlick Creek 0.0 to 4.05

Table 8.17.1 Sandlick Creek 0.0 to 4.05 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY502963_01	Sandlick Creek 0.0 to 4.05	3	Muhlenberg	6.68	4270

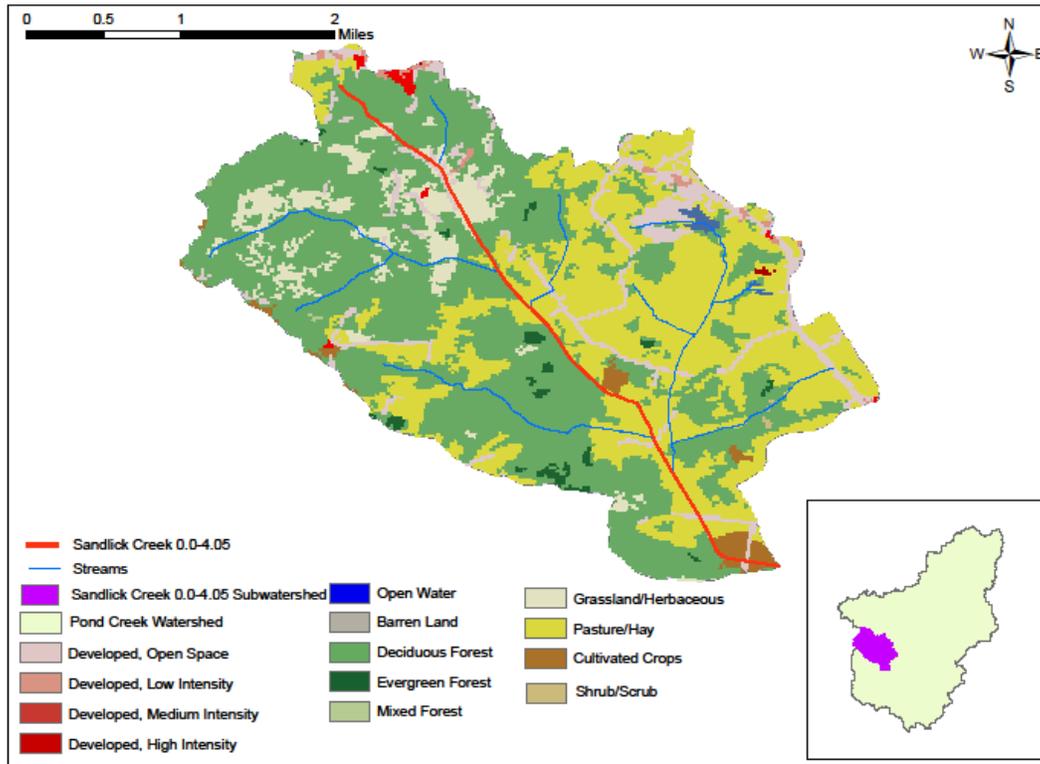


Figure 8.17.2 Land Cover in the Sandlick Creek 0.0 to 4.05 Subwatershed

Table 8.17.2 Land Cover in the Sandlick Creek 0.0 to 4.05 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.52	330.4	7.7
Agriculture	2.30	1471.9	34.5
Forest	3.42	2191.3	51.3
Barren Land	0	0	0
Grassland/Herbaceous	0.41	260.3	6.1
Water	0.02	14.6	0.3
Wetland	0	0	0
Shrub/Scrub	0.003	2.1	0.1

There are one active and five inactive KPDES facilities within this subwatershed, see Figure 8.17.3 and Table 8.17.3. Although those five inactive KPDES permittees were active during the

data collection period and may have contributed to the impairments in the Sandlick 0.0 to 4.05, inactive KPDES permittee will not receive a WLA.

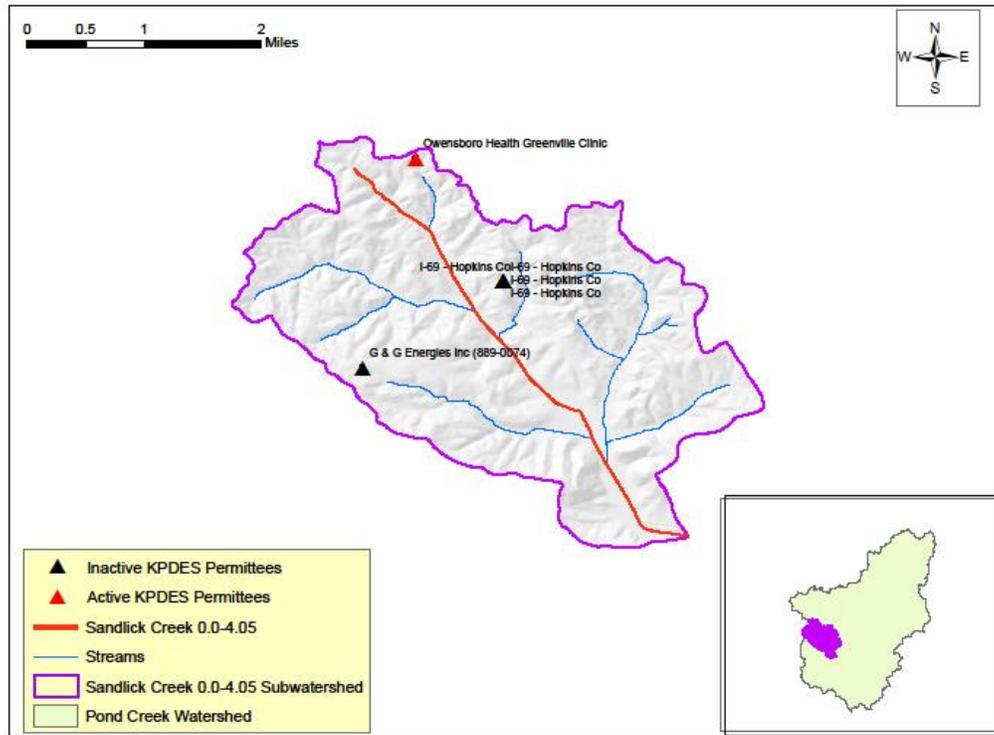


Figure 8.17.3 KPDES Permittees in the Subwatershed

Table 8.17.3 KPDES Permittees in the Subwatershed

KPDES#	Permit Name	Active	Design Flow	Latitude	Longitude	Pollutant Limits/Requirement in the Permit
KYR10K083	Owensboro Health Greenville Clinic	Yes	0	37.196391	-87.187716	to develop a SWPPP
KYG044486	G & G Energies Inc (889-0074)	No	0	37.170457	-87.194335	pH, Fe
KYR10G428	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G429	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G456	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP
KYR10G458	I-69 - Hopkins Co	No	0	37.181100	-87.176900	to develop a SWPPP

There are no active KPDES mining permits in this subwatershed. A small portion of the upstream watershed is licensed mining areas, see Figure 8.17.4 (see Section 9.4.3 for more information). Tables 8.17.4 to 8.17.6 show *E. coli*, iron, lead and flow data collected by TMDL staff at DOW03011004.

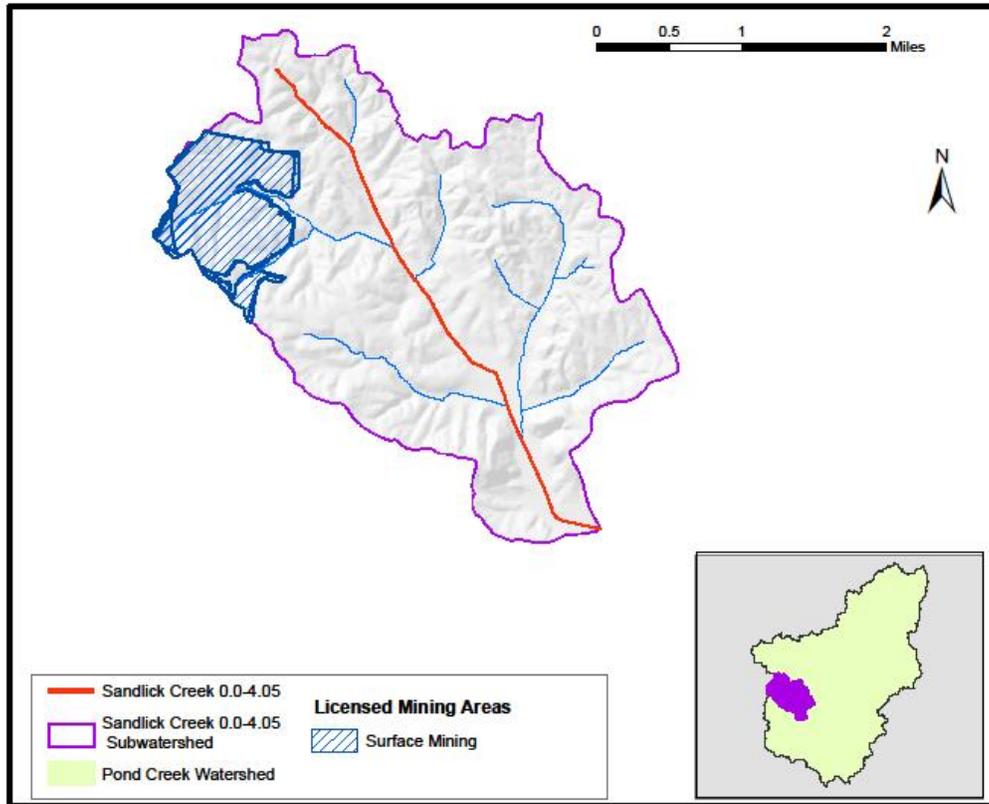


Figure 8.17.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.17.4 *E. coli* and Flow Data, DOW03011004

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	93	**
5/24/2011	291	**
6/14/2011	68	**
6/21/2011	225	**
7/12/2011	124	**
9/27/2011	1986	**
5/8/2013	236	**
5/9/2013	194	**

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/20/2013	194	**
5/23/2013	84	**
5/29/2013	78	**
6/6/2013	> 2420	**
6/27/2013	219	**
7/17/2013	113	**
7/30/2013	120	**
8/15/2013	488	**
8/20/2013	> 2420	**
9/11/2013	27	**
9/24/2013	387	**
10/10/2013	461	**
10/14/2013	411	**
<p>Exceeds the instantaneous <i>E. coli</i> limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

Table 8.17.5 Iron and Flow Data Collected at DOW03011004

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
1/4/2011	0.184	**
2/15/2011	0.135	7.196
3/8/2011	0.173	**
4/26/2011	0.673	**
5/10/2011	0.322	**
6/14/2011	0.192	**
7/12/2011	2.34	**
3/26/2013	0.317	**
4/24/2013	0.739	**
5/9/2013	0.305	**
6/27/2013	0.287	**
7/17/2013	0.174	**
8/20/2013	0.992	**
9/11/2013	0.216	**
10/10/2013	0.22	**
11/13/2013	0.121	**
12/17/2013	0.262	**
3/18/2014	0.297	7.174
4/15/2014	1.87	**

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
5/21/2014	0.162	1.693
6/5/2014	0.691	**
12/23/2014	0.226	**
⁽¹⁾ Chronic limit is 1.0 mg/L since aquatic life is adversely affected Exceeds the chronic limit ** Unable to obtain flow because of water depth, swiftness, or lack of access		

Table 8.17.6 Lead, Hardness and Flow Data Collected at DOW03011004

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
1/4/2011	0.201 (J)	59.9	1.66	42.52	N/A	**
2/15/2011	< 0.50 (U)	87.2	2.67	68.58	N/A	7.196
3/8/2011	0.292 (J)	80	2.39	61.46	N/A	**
4/26/2011	1.02	54	1.45	37.26	-0.43	**
5/10/2011	0.242 (J)	106	3.43	87.93	N/A	**
6/14/2011	< 0.50 (U)	241	9.75	250.17	N/A	**
7/12/2011	< 0.50 (U)	80.8	2.43	62.24	N/A	**
3/26/2013	0.23	71.9	2.09	53.65	-1.86	**
4/24/2013	2.54	49	1.28	32.93	1.26	**
5/9/2013	0.23	77.5	2.30	59.02	-2.07	**
6/27/2013	0.27	115	3.80	97.54	-3.53	**
7/17/2013	< 0.50 (U)	159	5.74	147.34	N/A	**
8/20/2013	4.08	106	3.43	87.93	0.65	**
9/11/2013	< 0.50 (U)	184	6.91	177.44	N/A	**
10/10/2013	< 0.50 (U)	113	3.72	95.39	N/A	**
11/13/2013	< 0.50 (U)	157	5.65	144.98	N/A	**
12/17/2013	0.22	102	3.26	83.73	-3.04	**
3/18/2014	0.22 (J)	78.5	2.34	59.99	N/A	7.174
4/15/2014	0.83	57	1.56	39.92	-0.73	**
5/21/2014	< 0.50 (U)	67.3	1.92	49.32	N/A	1.693
6/5/2014	2.09	117	3.89	99.71	-1.80	**
12/23/2014	< 0.50 (U)	172	6.35	162.84	N/A	**

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

8.18 UT of Bat East Creek 0.0 to 1.9

The pollutant addressed in this document for UT of Bat East Creek 0.0 to 1.9 is *E. coli*. This segment is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 2.35 square miles. There is one TMDL monitoring site on the UT of Bat East Creek 0.0 to 1.9 segment, DOW03011019, located at RM 0.43 with the drainage area of 2.11 square miles, see Figure 8.18.1 and Table 8.18.1. This subwatershed consists primarily of agricultural land (64.3%) and forest (29.5%), see Figure 8.18.2 and Table 8.18.2.

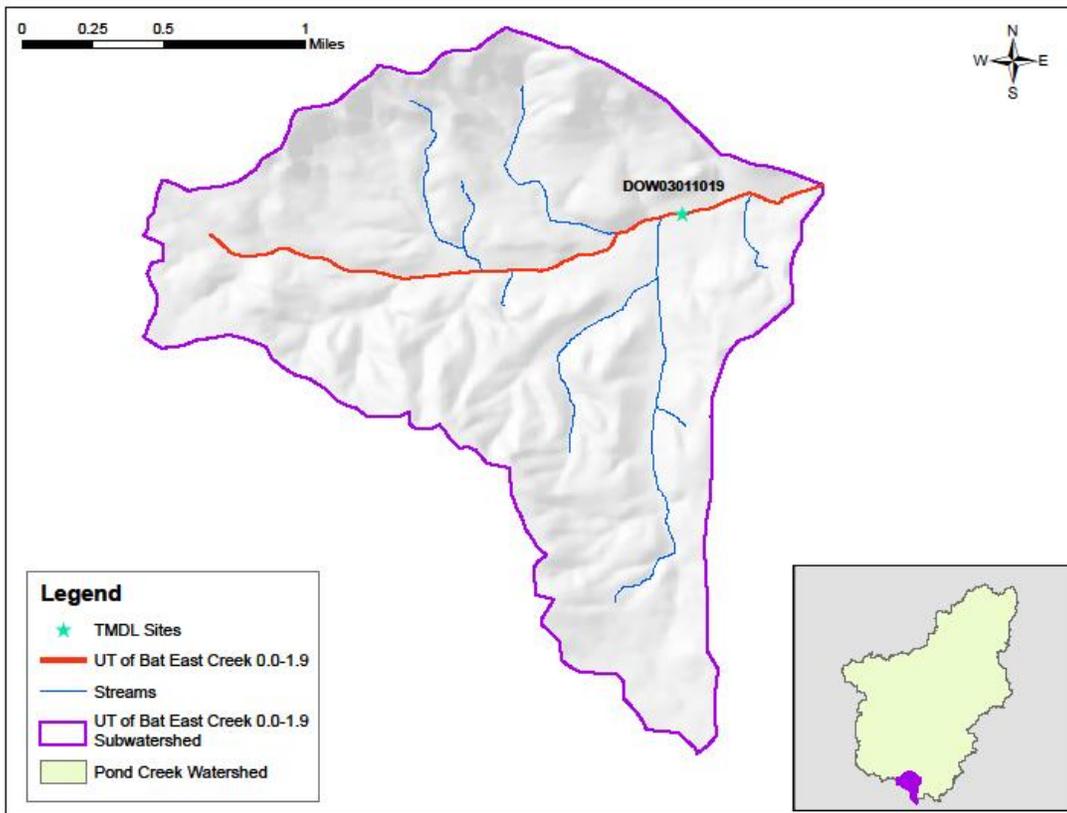


Figure 8.18.1 TMDL Monitoring Sites and the Drainage Area of UT of Bat East Creek 0.0 to 1.9

Table 8.18.1 UT of Bat East Creek 0.0 to 1.9 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY486462-6.1_01	UT of Bat East Creek 0.0 to 1.9	3	Muhlenberg	2.35	1504

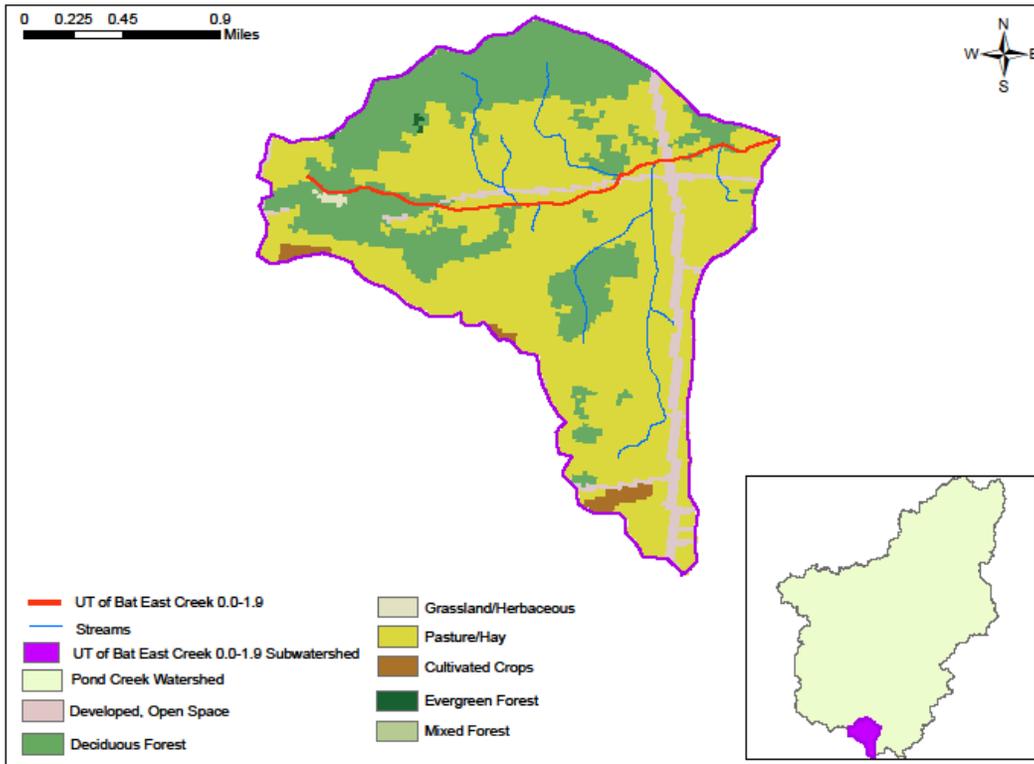


Figure 8.18.2 Land Cover in the UT of Bat East Creek 0.0 to 1.9 Subwatershed

Table 8.18.2 Land Cover in the UT of Bat East Creek 0.0 to 1.9 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.14	89.0	5.9
Agriculture	1.51	967.4	64.3
Forest	0.69	444.4	29.5
Grassland/Herbaceous	0.01	3.2	0.2
Wetland	0.01	3.2	0.2
Water	0	0	0
Shrub/Scrub	0	0	0
Barren Land	0	0	0

There are no KPDES permittees in this subwatershed. *E. coli* and flow data monitored at DOW03011019 are presented in Table 8.18.3.

Table 8.18.3 *E. coli* and Flow Data, DOW03011019

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	291	0.828
5/24/2011	1046	**
5/8/2013	548	**
5/9/2013	249	**
5/23/2013	78	**
6/6/2013	1553	**
8/15/2013	65	**
<p> Exceeds the instantaneous <i>E. coli</i> limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

8.19 UT of Bat East Creek 0.0 to 3.55

The pollutant addressed in this document for UT of Bat East Creek 0.0 to 3.55 is *E. coli*. This segment is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 5.52 square miles. There is one TMDL monitoring site on the UT of Bat East Creek 0.0 to 3.55 segment, DOW03011016, located at RM 0.31 with the drainage area of 5.47 square miles, see Figure 8.19.1 and Table 8.19.1. This subwatershed consists primarily of forest (68.6%) and agricultural land (21.1%), see Figure 8.19.2 and Table 8.19.2.

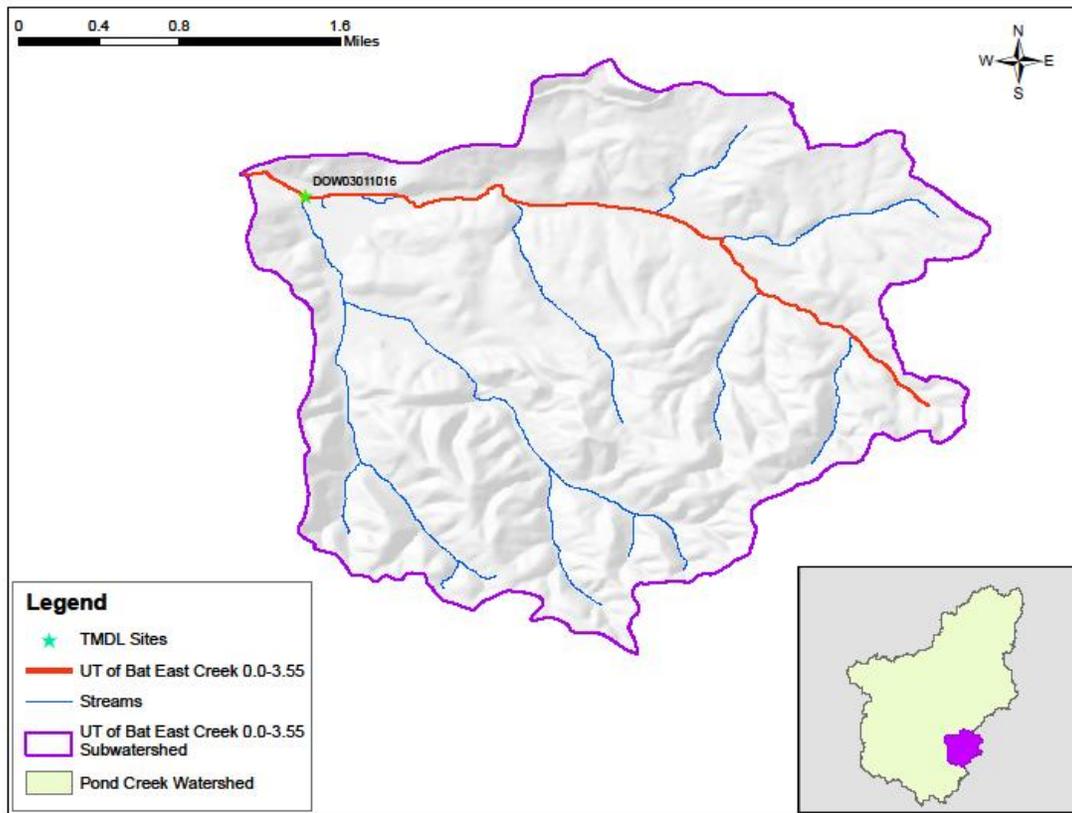


Figure 8.19.1 TMDL Monitoring Locations and the Drainage Area of UT of Bat East Creek 0.0 to 3.55

Table 8.19.1 UT of Bat East Creek 0.0 to 3.55 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY486462-1.6_01	UT of Bat East Creek 0.0 to 3.55	3	Muhlenberg	5.52	3533

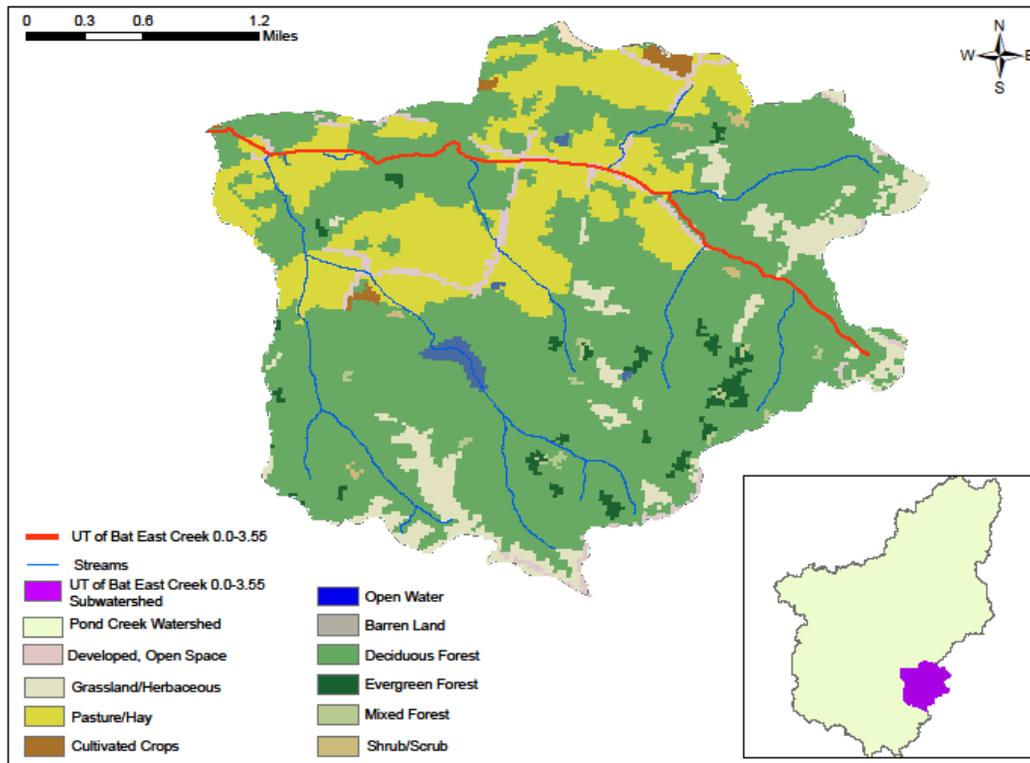


Figure 8.19.2 Land Cover in the UT of Bat East Creek 0.0 to 3.55 Subwatershed

Table 8.19.2 Land Cover in the UT of Bat East Creek 0.0 to 3.55 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.15	93.3	2.6
Agriculture	1.16	743.6	21.1
Forest	3.78	2419.7	68.6
Barren Land	0.01	6.1	0.2
Grassland/Herbaceous	0.36	231.7	6.6
Water	0.04	24.0	0.7
Wetland	0	0	0
Shrub/Scrub	0.01	7.2	0.2

There are no KPDES permittees in this subwatershed. *E. coli* and flow data monitored at DOW03011016 are in Table 8.19.3.

Table 8.19.3 *E. coli* and Flow Data, DOW03011016

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/10/2011	> 2420	**
5/24/2011	> 2420	**
6/21/2011	> 2420	**
5/8/2013	248	**
5/9/2013	365	**
5/20/2013	1986	**
5/23/2013	866	**
5/28/2013	>2420	**
6/27/2013	1733	**
7/17/2013	830	**
7/30/2013	687	**
8/6/2013	980	**
8/15/2013	272	**
9/24/2013	> 2420	**
10/10/2013	> 2420	**
10/14/2013	> 2420	**
<p> Exceeds the instantaneous <i>E. coli</i> limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

8.20 UT of Caney Creek 0.0 to 2.6

The pollutants addressed in this document for UT of Caney Creek 0.0 to 2.6 are *E. coli* and lead. This segment is a second order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 1.88 square miles. There is one TMDL monitoring site on the UT of Caney Creek 0.0 to 2.6 segment, DOW03011013, located at RM 0.12 with the drainage area of 1.82 square miles, see Figure 8.20.1 and Table 8.20.1. This subwatershed consists primarily of forest (35.6%) and agricultural land (41.8%), see Figure 8.20.2 and Table 8.20.2.

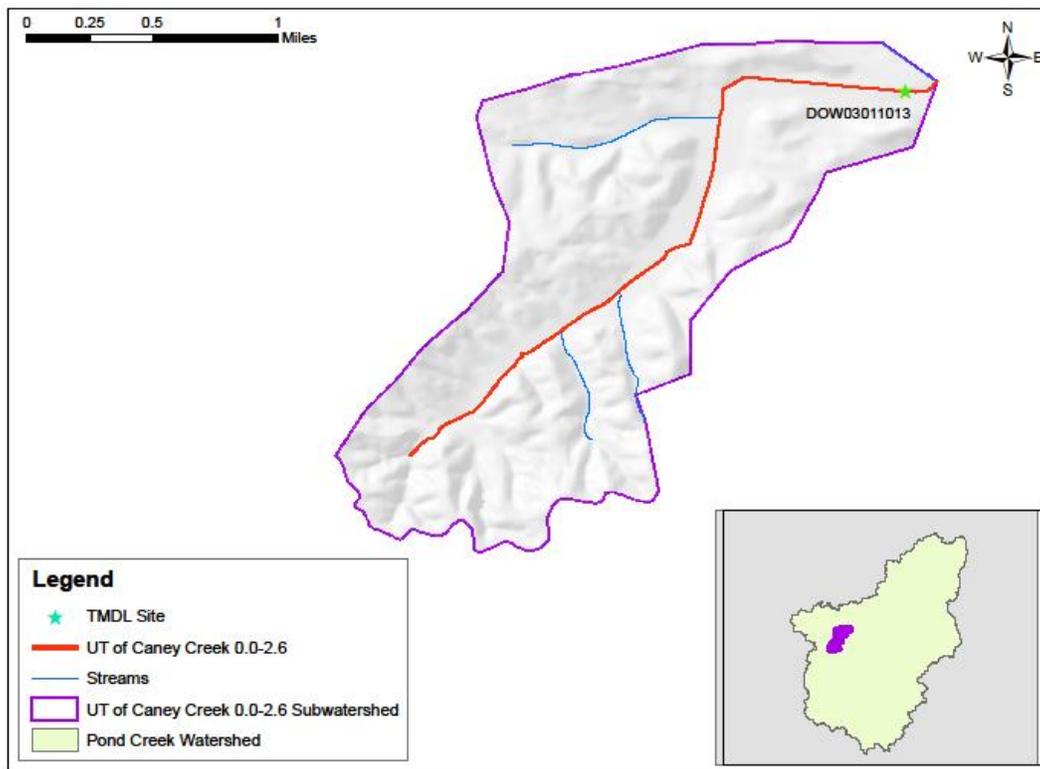


Figure 8.20.1 TMDL Monitoring Locations and the Drainage Area of UT of Caney Creek 0.0 to 2.6

Table 8.20.1 UT of Caney Creek 0.0 to 2.6 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY488838-2.3_01	UT of Caney Creek 0.0 to 2.6	2	Muhlenberg	1.88	1200

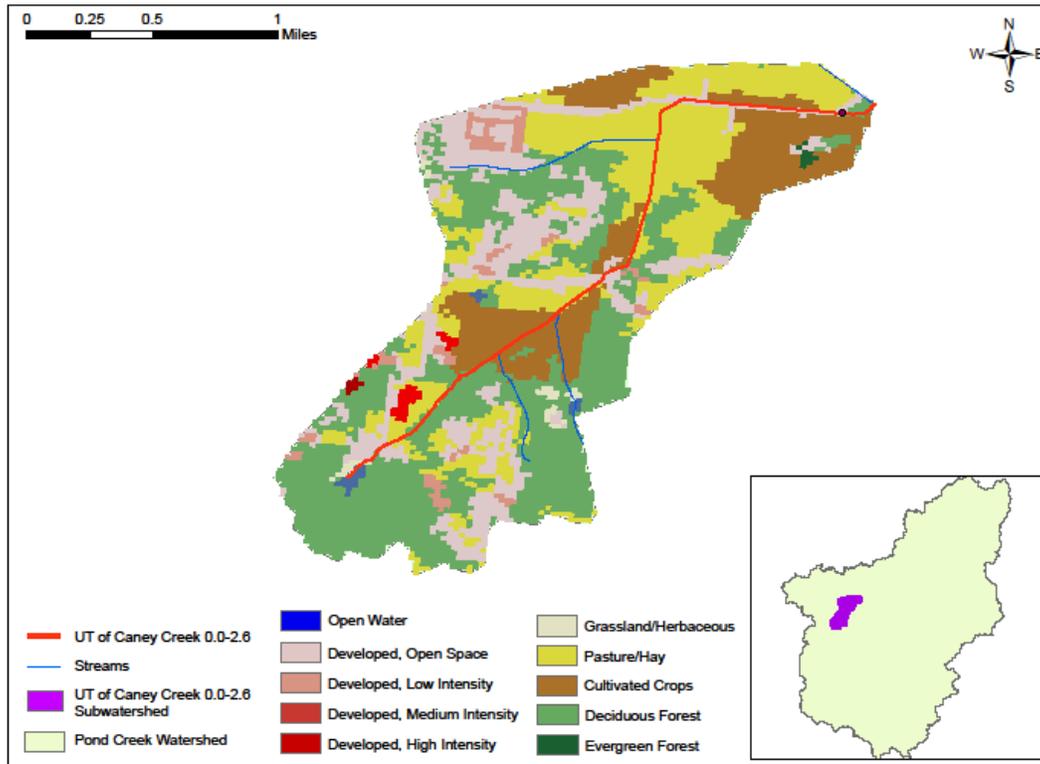


Figure 8.20.2 Land Cover in the UT of Caney Creek 0.0 to 2.6 Subwatershed

Table 8.20.2 Land Cover in the UT of Caney Creek 0.0 to 2.6 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.40	258.0	21.5
Agriculture	0.78	501.5	41.8
Forest	0.67	427.1	35.6
Grassland/Herbaceous	0.01	7.5	0.6
Water	0.01	5.5	0.5
Barren Land	0	0	0
Wetland	0	0	0
Shrub/Scrub	0	0	0

There are no KPDES permittees in this subwatershed. There are no licensed mining records from the Department of Natural Resources for this subwatershed. *E. coli*, lead and flow data monitored at DOW03011013 are in Table 8.20.3 and 8.20.4.

Table 8.20.3 *E. coli* and Flow Data, DOW03011013

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/11/2011	24	0.595
5/25/2011	517	**
6/22/2011	1733	**
5/8/2013	146	**
5/9/2013	58	**
5/23/2013	124	**
5/29/2013	15	**
6/6/2013	> 2420	**
6/26/2013	93	0.027
8/15/2013	44	0.209
9/10/2013	179	**
9/24/2013	> 2420	0.030
10/9/2013	173	**
10/14/2013	87	0.098

Exceeds the instantaneous *E. coli* limit
** Unable to obtain flow because of water depth, swiftness, or lack of access

Table 8.20.4 Lead, Hardness and Flow Data Collected at DOW03011013

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	0.354 (J)	103	3.30	84.78	N/A	**
1/5/2011	0.236 (J)	118	3.93	100.79	N/A	0.783
2/16/2011	0.625	123	4.14	106.26	-3.52	1.303
3/9/2011	2.1	45.4	1.16	29.88	0.94	**
4/27/2011	3.38	46.4	1.20	30.72	2.18	**
5/11/2011	0.394 (J)	103	3.30	84.78	N/A	0.595
3/21/2013	0.25	96.1	3.02	77.61	-2.77	**
4/18/2013	0.89	125	4.23	108.47	-3.34	0.869
5/8/2013	0.27	110	3.59	92.18	-3.32	**
6/26/2013	3.36	114	3.76	96.46	-0.40	0.027
9/10/2013	0.79	102	3.26	83.73	-2.47	**
10/9/2013	0.68	137	4.75	121.89	-4.07	**

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
11/13/2013	0.5	138	4.79	123.03	-4.29	**
12/17/2013	< 0.50 (U)	120	4.01	102.97	N/A	**
4/1/2014	0.41 (J)	116	3.84	98.62	N/A	1.853
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

8.21 UT of Caney Creek 0.0 to 2.35

The pollutants addressed in this document for UT of Caney Creek 0.0 to 2.35 are *E. coli* and lead. This segment is a second order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 2.01 square miles. There is one TMDL monitoring site on the UT of Caney Creek 0.0 to 2.35 segment, DOW03011012, located at RM 0.64 with the drainage area of 1.52 square miles, see Figure 8.21.1 and Table 8.21.1. This subwatershed consists primarily of agricultural land (52.5%), forest (32.2%) and developed urban area (14.7%), see Figure 8.21.2 and Table 8.21.2.

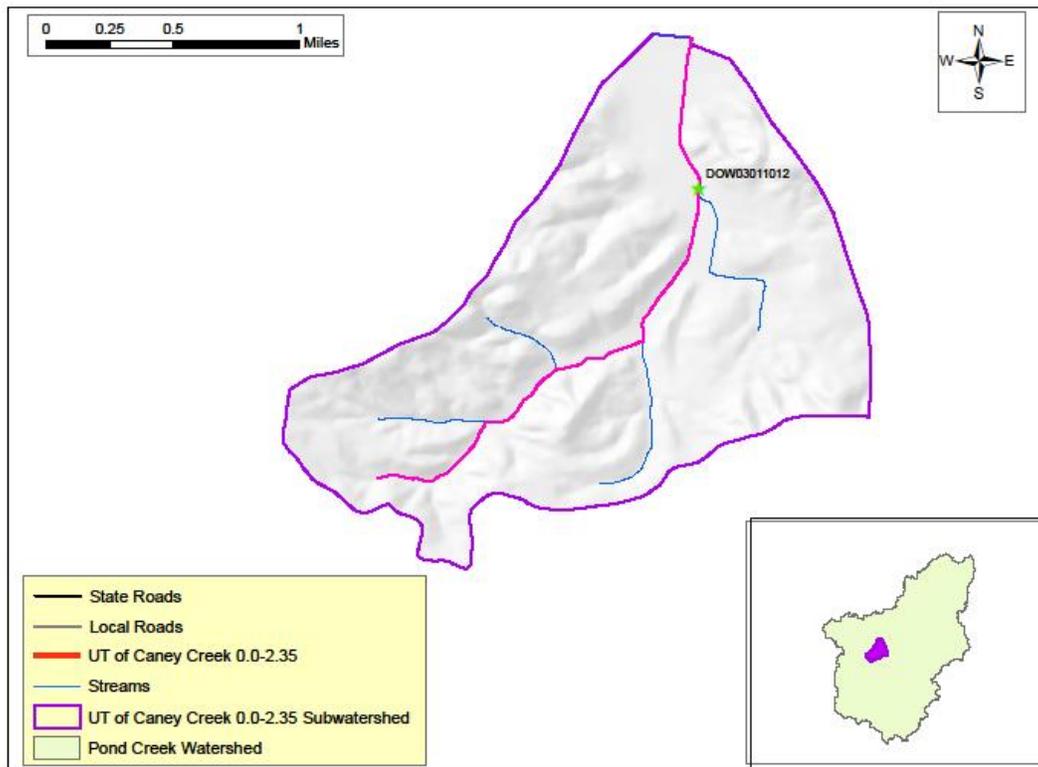


Figure 8.21.1 TMDL Monitoring Locations and the Drainage Area of UT of Caney Creek 0.0 to 2.35

Table 8.21.1 UT of Caney Creek 0.0 to 2.35 Segment/Upstream Catchment Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY488838-1.8_01	UT of Caney Creek 0.0 to 2.35	2	Muhlenberg	2.01	1286

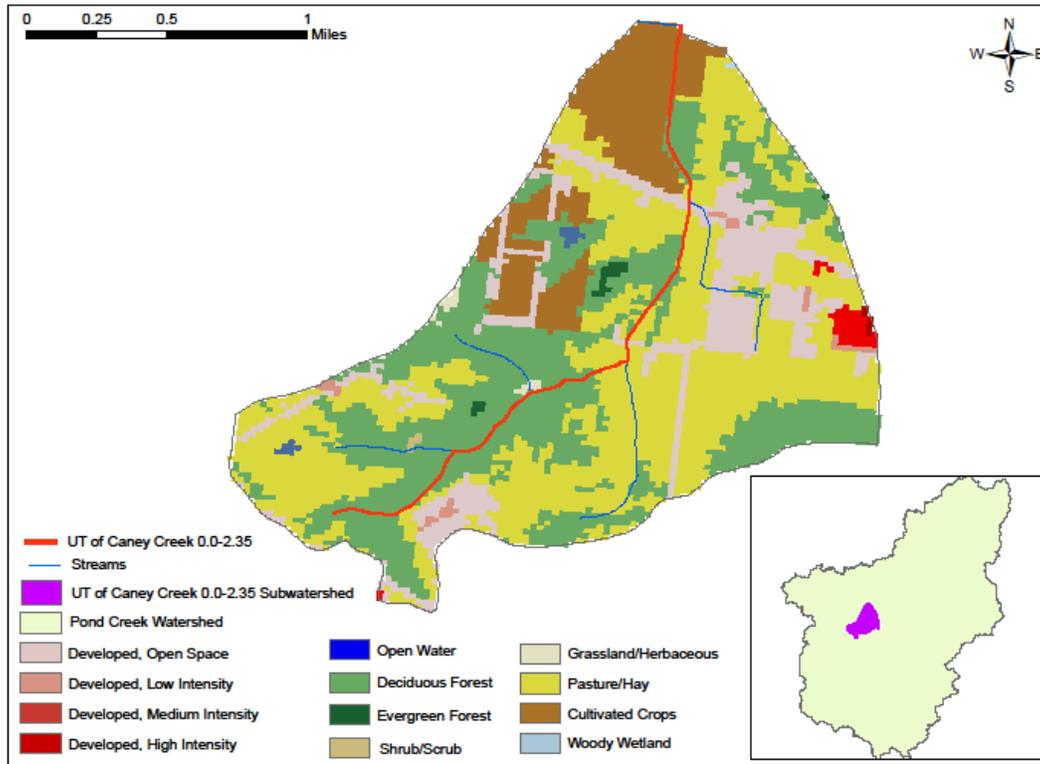


Figure 8.21.2 Land Cover in the UT of Caney Creek 0.0 to 2.35 Subwatershed

Table 8.21.2 Land Cover in the UT of Caney Creek 0.0 to 2.35 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.30	189.0	14.7
Agriculture	1.06	675.3	52.5
Forest	0.65	414.3	32.2
Grassland/Herbaceous	0.01	3.2	0.3
Wetlands	0.00	0.1	0.006
Water	0.01	3.5	0.3
Barren Land	0	0	0
Shrub/Scrub	0.001	0.9	0.1

There are no KPDES permittees in this subwatershed. There are no licensed mining records from the Department of Natural Resources for this subwatershed. Tables 8.21.3 and 8.21.4 show *E. coli*, lead and flow data collected by TMDL staff at DOW03011012.

Table 8.21.3 *E. coli* and Flow Data, DOW03011012

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/11/2011	275	0.580
5/25/2011	435	**
6/22/2011	1986	**
5/8/2013	199	**
5/9/2013	192	**
5/20/2013	649	**
5/23/2013	345	**
5/29/2013	102	**
6/6/2013	> 2420	**
6/26/2013	1553	0.202
8/15/2013	517	**
10/9/2013	1733	0.212
<p> Exceeds the instantaneous <i>E. coli</i> limit ** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

Table 8.21.4 Lead, Hardness and Flow Data Collected at DOW03011012

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
1/5/2011	< 0.50 (U)	110	3.59	92.18	N/A	0.721
2/16/2011	< 0.50 (U)	616	32.19	826.16	N/A	1.274
3/9/2011	1.11	33.3	0.78	20.14	0.33	**
4/27/2011	2.73	30.3	0.70	17.86	2.03	**
5/11/2011	2.08	79.4	2.37	60.87	-0.29	0.580
3/21/2013	< 0.50 (U)	66.9	1.91	48.94	N/A	2.011
4/18/2013	< 0.50 (U)	84.7	2.58	66.09	N/A	0.702
5/8/2013	0.38	59.6	1.65	42.25	-1.27	**
6/26/2013	0.31	92.5	2.88	73.93	-2.57	0.202
10/9/2013	0.25	98.9	3.14	80.50	-2.89	0.212
12/17/2013	< 0.50 (U)	112	3.68	94.32	N/A	1.131
3/26/2014	< 0.50 (U)	106	3.43	87.93	N/A	0.52

Date	Lead (µg/L)	Hardness, Total (mg/L)	Lead Chronic Limit (µg/L)	Lead Acute Limit (µg/L)	Difference between the Lead Concentration and the Lead Chronic Limit (µg/L)	Flow (cfs)
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

8.22 UT of Plum Creek 0.0 to 2.45

The pollutants addressed in this document for UT of Plum Creek 0.0 to 2.45 are pH, cadmium, iron, nickel and zinc. This segment is a third order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 4.99 square miles. There is one TMDL monitoring site in the subwatershed, DOW03011003, located at RM 0.10 with the drainage area of 2.18 square miles, see Figure 8.22.1 and Table 8.22.1. This subwatershed consists primarily of forest (67.1%) and agricultural land (14.3%), see Figure 8.22.2 and Table 8.22.2.

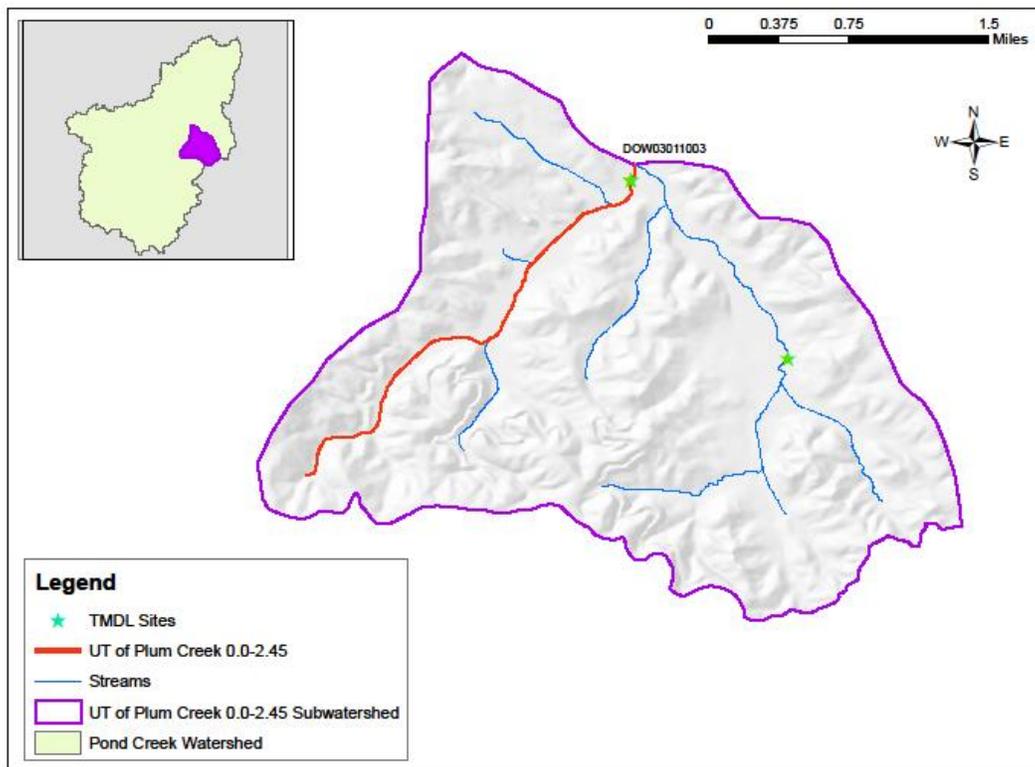


Figure 8.22.1 TMDL Monitoring Location and Impaired Segment in the UT of Plum Creek 0.0 to 2.45 Subwatershed

Table 8.22.1 UT of Plum Creek 0.0 to 2.45 Segment/Subwatershed Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY500964-1.65_01	UT of Plum Creek 0.0 to 2.45	3	Muhlenberg	4.99	3193

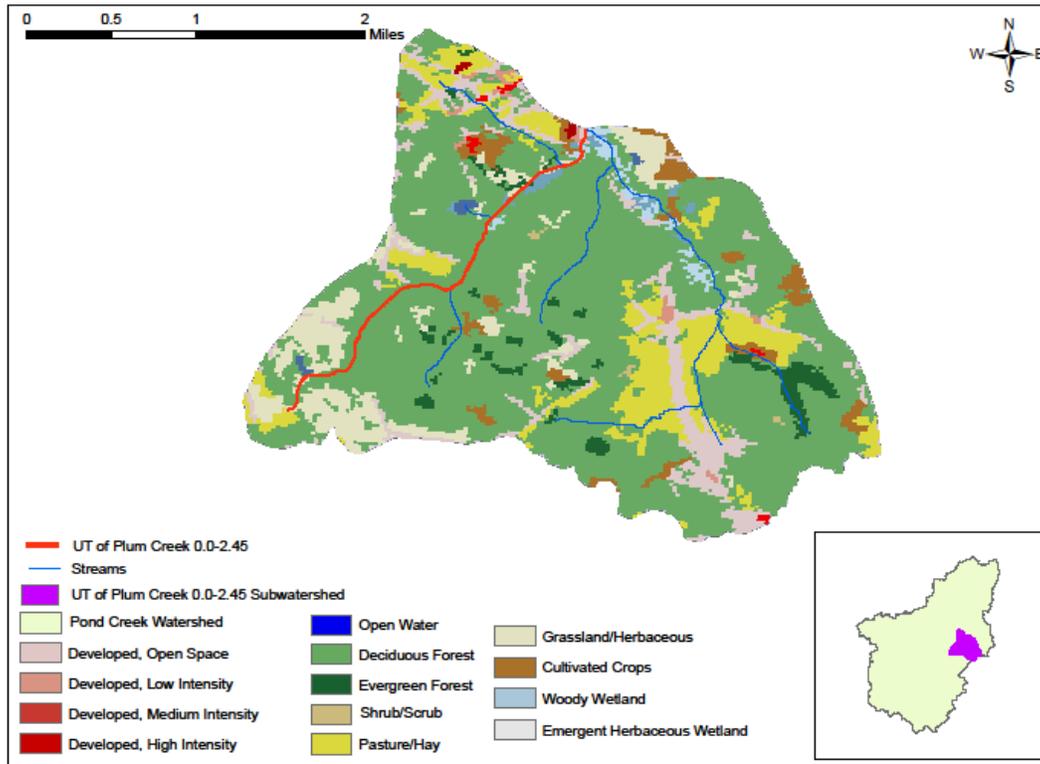


Figure 8.22.2 Land Cover in the UT of Plum Creek 0.0 to 2.45 Subwatershed

Table 8.22.2 Land Cover within the UT of Plum Creek 0.0 to 2.45 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.44	281.9	8.8
Agriculture	0.71	456.2	14.3
Forest	3.35	2141.7	67.1
Grassland/Herbaceous	0.41	263.8	8.3
Wetlands	0.06	35.8	1.1
Water	0.02	9.6	0.3
Barren Land	0	0	0
Shrub/Scrub	0.01	3.8	0.1

There are three inactive KPDES permittees in this subwatershed, see Figure 8.22.3 and Table 8.22.3. Although those three inactive KPDES facilities were active during the data collection

period and may have contributed to the impairments of this waterbody, inactive KPDES will not receive a WLA.

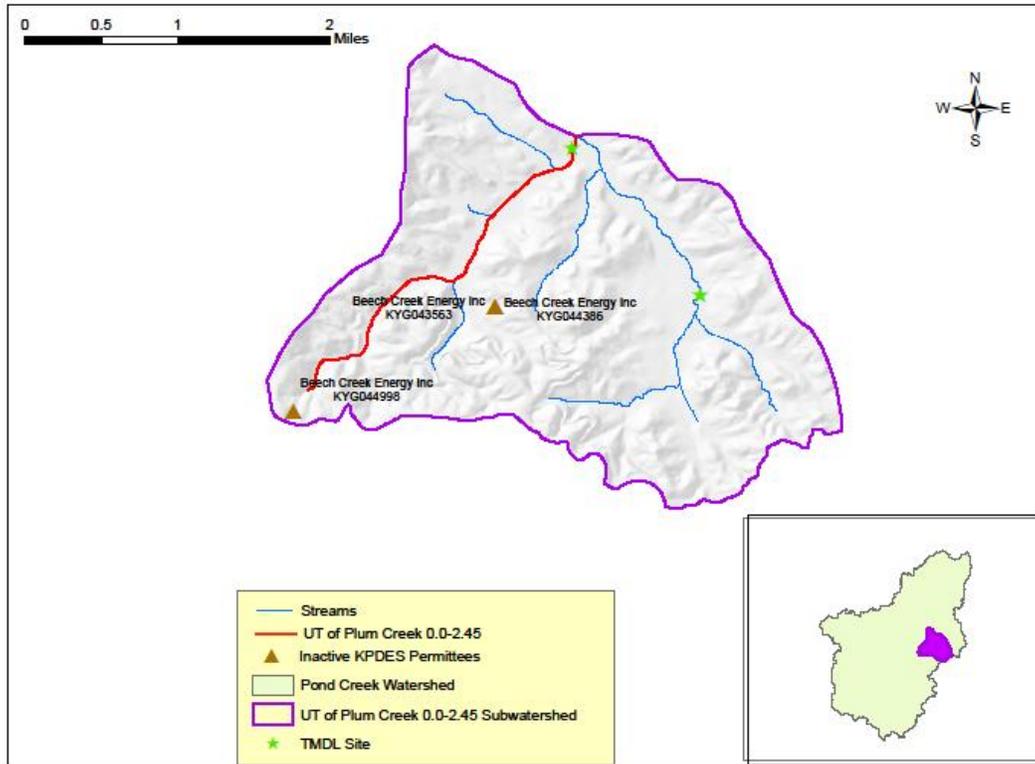


Figure 8.22.3 KPDES Permittees in the Subwatershed

Table 8.22.3 KPDES Permittees in the Subwatershed

KPDES	Status	Permit Name	Latitude	Longitude	Pollutants with Discharge Limit
KYG043563	Inactive	Beech Creek Energy Inc	37.196944	-87.051389	pH, Iron
KYG044386	Inactive	Beech Creek Energy Inc	37.196944	-87.051389	pH, Iron
KYG044998	Inactive	Beech Creek Energy Inc	37.186944	-87.070556	pH, Iron

There are no active KPDES mining permits in this subwatershed, but some of the watershed is licensed mining areas, see Figure 8.22.4 (see Section 9.4.3 for more information). Tables 8.22.4 through 8.22.8 show pH and metals data collected by TMDL staff at DOW03011003.

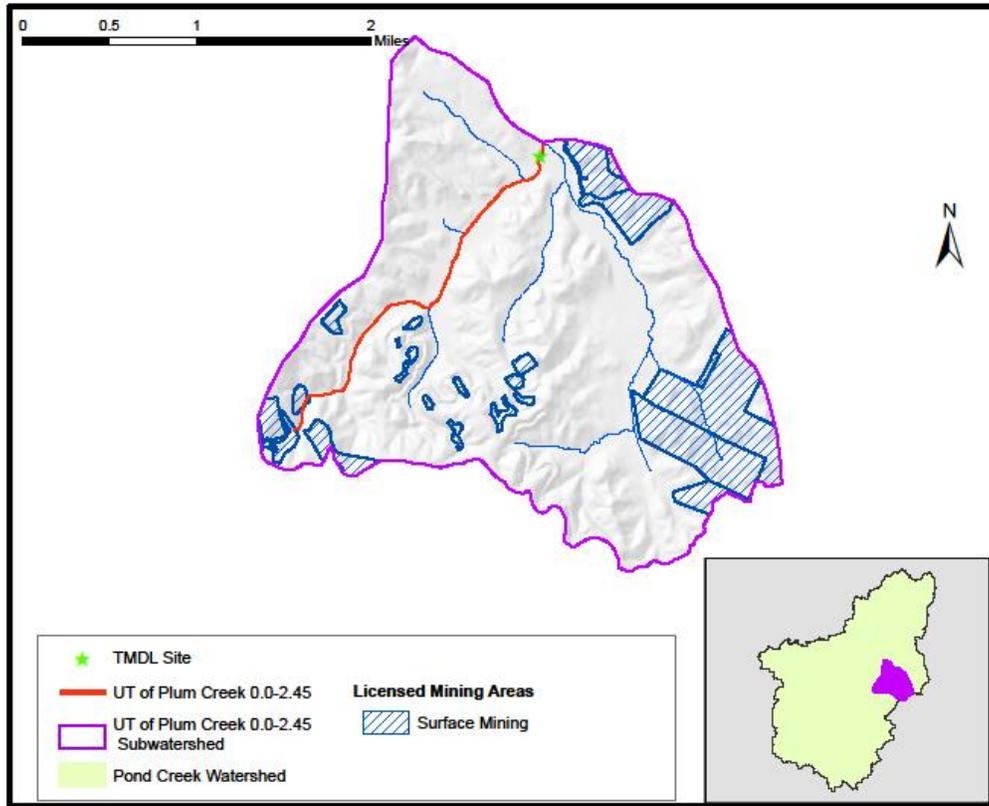


Figure 8.22.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.22.4 pH and Flow Data Collected at DOW03011003

Date	pH (standard units)	Flow (cfs)
1/6/2011	4.89	0.340
2/17/2011	4.92	**
3/10/2011	5.45	**
4/28/2011	5.15	**
5/12/2011	3.88	**
5/26/2011	4.19	**
6/23/2011	3.79	**
7/14/2011	3.60	**
7/28/2011	4.86	**
5/8/2013	4.85	**
5/9/2013	4.39	**
5/20/2013	4.01	**

Date	pH (standard units)	Flow (cfs)
5/23/2013	4.46	**
6/6/2013	5.88	**
6/26/2013	3.40	0.141
8/15/2013	3.40	**

Exceeds the pH limit
 ** Unable to obtain flow because of water depth, swiftness, or lack of access

Table 8.22.5 Cadmium, Hardness and Flow Data Collected at DOW03011003

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
1/6/2011	36.2 (DL)	315	0.63	6.85	35.57	0.340
2/17/2011	30.3 (DL)	323	0.65	7.03	29.65	**
3/10/2011	9.97 (DL)	165	0.39	3.55	9.58	**
4/28/2011	9.47 (L)	154	0.37	3.31	9.10	**
5/12/2011	17.5 (DL)	282	0.58	6.12	16.92	**
7/14/2011	< 16 (DU)	303	0.62	6.58	N/A	**

Exceeds the acute limit
 ** Unable to obtain flow because of water depth, swiftness, or lack of access
 D = Reanalyzed at a Higher Dilution
 L = Exceeds MCL or Action Limit
 U = Analyte Not Detected
 N/A: Not Applicable

Table 8.22.6 Iron and Flow Data Collected at DOW03011003

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
1/6/2011	0.16	0.340
2/17/2011	0.145	**
3/10/2011	0.164	**
4/28/2011	0.404	**
5/12/2011	3.72	**
7/14/2011	5.56	**

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
⁽¹⁾ Chronic limit is 3.5 mg/L since aquatic life has not been shown to be adversely affected  Exceeds the acute limit  Exceeds the chronic limit ** Unable to obtain flow because of water depth, swiftness, or lack of access		

Table 8.22.7 Nickel, Hardness and Flow Data Collected at DOW03011003

Date	Nickel (µg/L)	Hardness, Total (mg/L)	Nickel Chronic Limit (µg/L)	Nickel Acute Limit (µg/L)	Difference between the Nickel Concentration and the Nickel Chronic Limit (µg/L)	Flow (cfs)
1/6/2011	174	315	137.70	1238.52	36.30	0.340
2/17/2011	208	323	140.65	1265.08	67.35	**
3/10/2011	75.4	165	79.68	716.68	-4.28	**
4/28/2011	101	154	75.16	676.04	25.84	**
5/12/2011	421	282	125.39	1127.83	295.61	**
7/14/2011	222 (D)	303	133.25	1198.48	88.75	**
 Exceeds the chronic limit ** Unable to obtain flow because of water depth, swiftness, or lack of access D = Reanalyzed at a Higher Dilution						

Table 8.22.8 Zinc, Hardness and Flow Data Collected at DOW03011003

Date	Zinc (µg/L)	Hardness, Total (mg/L)	Zinc Chronic Limit (µg/L)	Zinc Acute Limit (µg/L)	Difference between the Zinc Concentration and the Zinc Chronic Limit (µg/L)	Flow (cfs)
1/6/2011	788 (D)	315	316.76	316.76	471.24	0.340
2/17/2011	767 (D)	323	323.57	323.57	443.43	**
3/10/2011	1210 (D)	165	183.14	183.14	1026.86	**
4/28/2011	291	154	172.74	172.74	118.26	**
5/12/2011	1240 (D)	282	288.41	288.41	951.59	**
7/14/2011	410 (D)	303	306.51	306.51	103.49	**
 Exceeds the acute limit ** Unable to obtain flow because of water depth, swiftness, or lack of access D = Reanalyzed at a Higher Dilution						

8.23 UT of Pond Creek 0.0 to 2.4

The pollutant addressed in this document for UT of Pond Creek 0.0 to 2.4 is iron. This segment is a second order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 4.21 square miles. There is one TMDL monitoring site in the subwatershed, DOW03011028, located at RM 1.15 with the drainage area of 3.62 square miles, see Figure 8.23.1 and Table 8.23.1. This subwatershed consists primarily of forest (57.2%) and grassland (16.4%), see Figure 8.23.2 and Table 8.23.2.

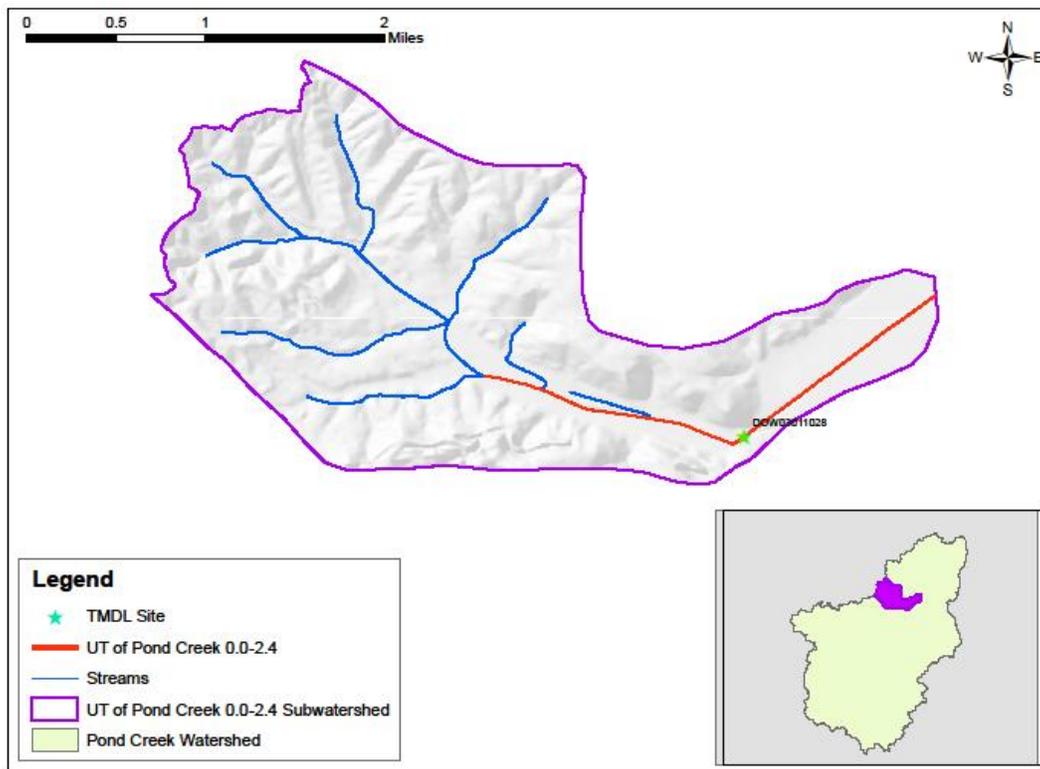


Figure 8.23.1 TMDL Monitoring Location and Impaired Segment in the UT of Pond Creek 0.0 to 2.4 Subwatershed

Table 8.23.1 UT of Pond Creek 0.0 to 2.4 Segment/Subwatershed Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042-6.9_01	UT of Pond Creek 0.0 to 2.4	2	Muhlenberg	4.21	2691

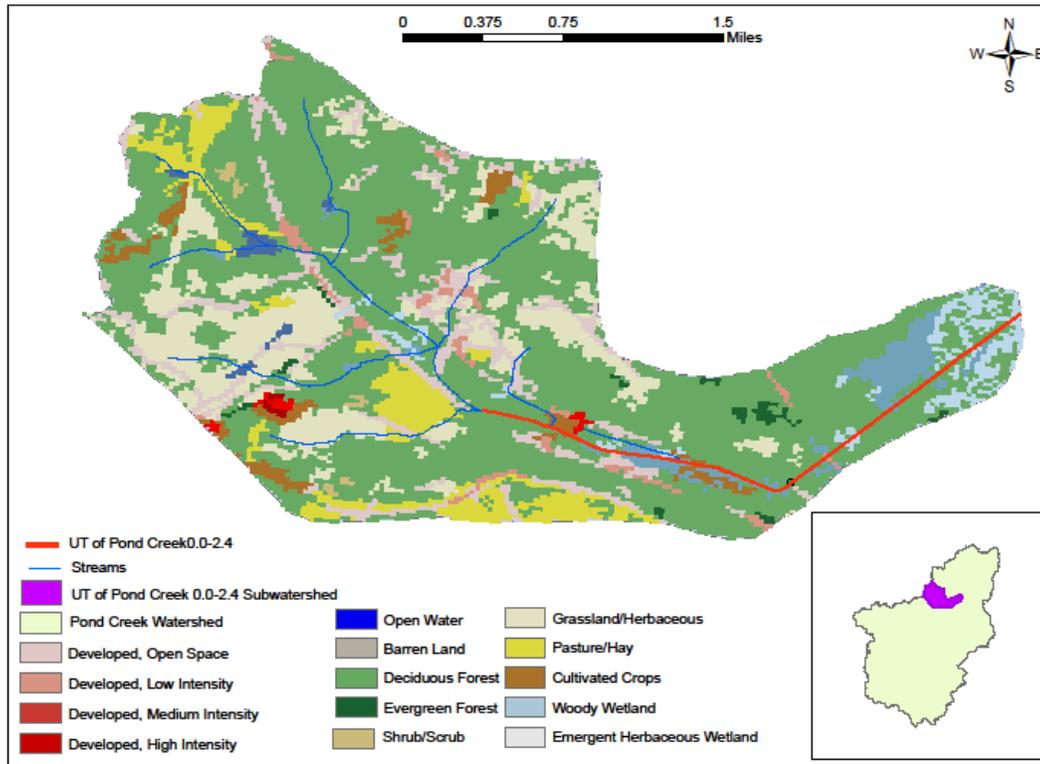


Figure 8.23.2 Land Cover in the UT of Pond Creek 0.0 to 2.4 Subwatershed

Table 8.23.2 Land Cover within the UT of Pond Creek 0.0 to 2.4 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.40	253.8	9.4
Agriculture	0.35	226.2	8.4
Forest	2.41	1539.6	57.2
Barren Land	0.22	139.7	5.2
Grassland/Herbaceous	0.69	441.5	16.4
Wetlands	0.11	70.8	2.6
Water	0.03	16.6	0.6
Shrub/Scrub	0.01	3.6	0.1

There are two inactive KPDES-permitted facilities in this subwatershed, see Figure 8.23.3 and Table 8.23.3. Although those two inactive KPDES facilities were active during the data

collection period and may have contributed to the pollutants in the UT of Pond Creek 0.0 to 2.4, inactive KPDES permittee will not receive a WLA.

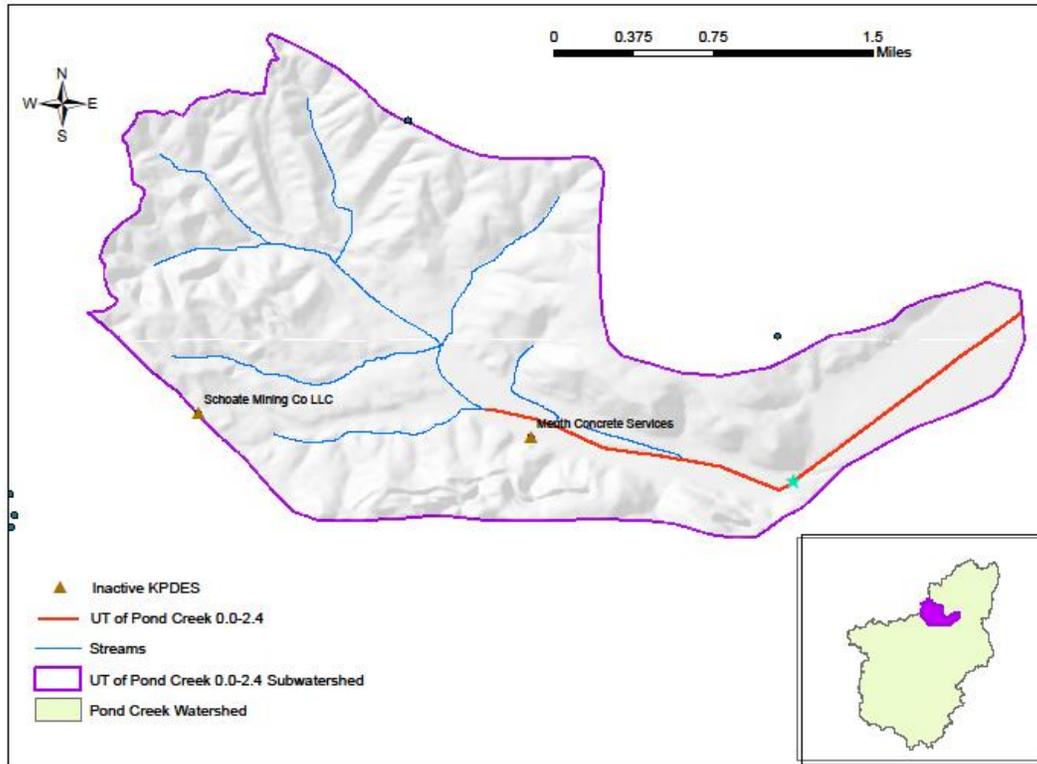


Figure 8.23.3 KPDES Facilities in the Subwatershed

Table 8.23.3 KPDES Facilities in the Subwatershed

KPDES	Status	Permit Name	Latitude	Longitude	Pollutants with Discharge Limit
KYG045704	Inactive	Schoate Mining Co LLC	37.245000	-87.108333	pH, Iron
KYR001693	Inactive	Meuth Concrete Services	37.243362	-87.085699	pH

There are no active KPDES mining permittees in this subwatershed, but the majority of the subwatershed is licensed mining areas, see Figure 8.23.4 (see Section 9.4.3 for more information). Table 8.23.4 displays iron and flow data collected by TMDL staff at DOW03011028.

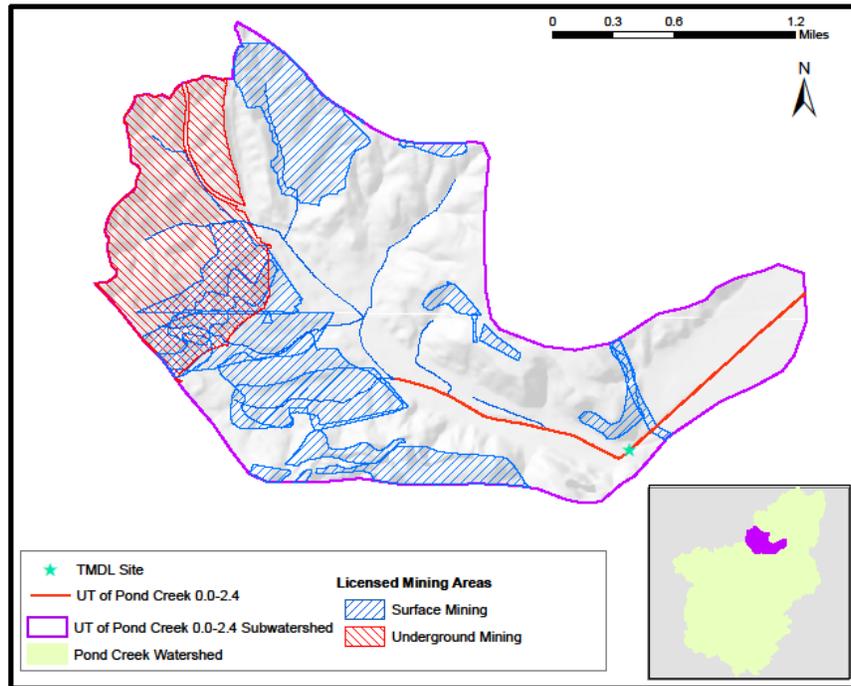


Figure 8.23.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.23.4 Iron and Flow Data Collected at DOW03011028

Date	Iron (mg/L) ⁽¹⁾	Flow (cfs)
11/18/2010	2.84	**
1/6/2011	1.08	**
2/17/2011	0.93	**
3/10/2011	0.884	**
4/28/2011	1.75	**
5/12/2011	6.19	**
6/16/2011	5.65	**
7/14/2011	10.5	**
9/15/2011	19.7	**
10/13/2011	30.7 (D)	**

⁽¹⁾Chronic limit is 1.0 mg/L since aquatic life is adversely affected

Exceeds the acute limit

Exceeds the chronic limit

** Unable to obtain flow because of water depth, swiftness, or lack of access

D = Reanalyzed at a Higher Dilution

8.24 UT of Pond Creek 2.4 to 4.2

The pollutants addressed in this document for UT of Pond Creek 2.4 to 4.2 are *E. coli*, pH and cadmium. This segment is a second order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 2.56 square miles. There is one TMDL monitoring site in the subwatershed, DOW03011002, located at RM 2.6 with the drainage area of 2.18 square miles, see Figure 8.24.1 and Table 8.24.1. This subwatershed consists primarily of forest (52.1%) and grassland (17.9%), see Figure 8.24.2 and Table 8.24.2.

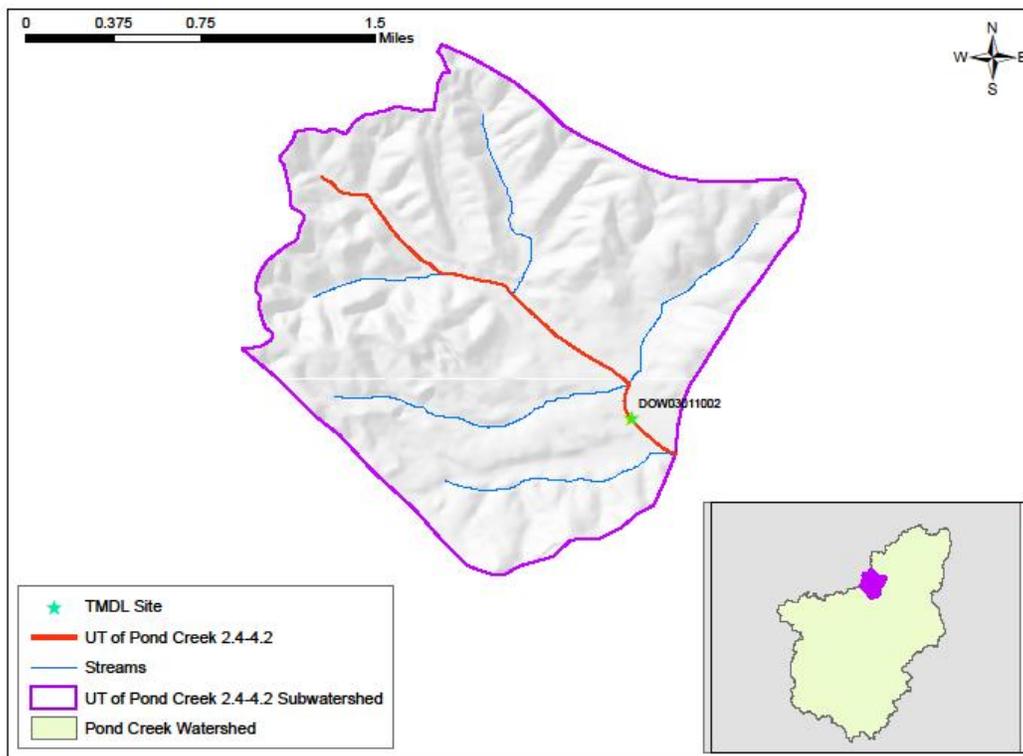


Figure 8.24.1 TMDL Monitoring Location and Impaired Segment in the UT of Pond Creek 2.4 to 4.2 Subwatershed

Table 8.24.1 UT of Pond Creek 2.4 to 4.2 Segment/Subwatershed Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042-6.9_02	UT of Pond Creek 2.4-4.2	2	Muhlenberg	2.56	1637

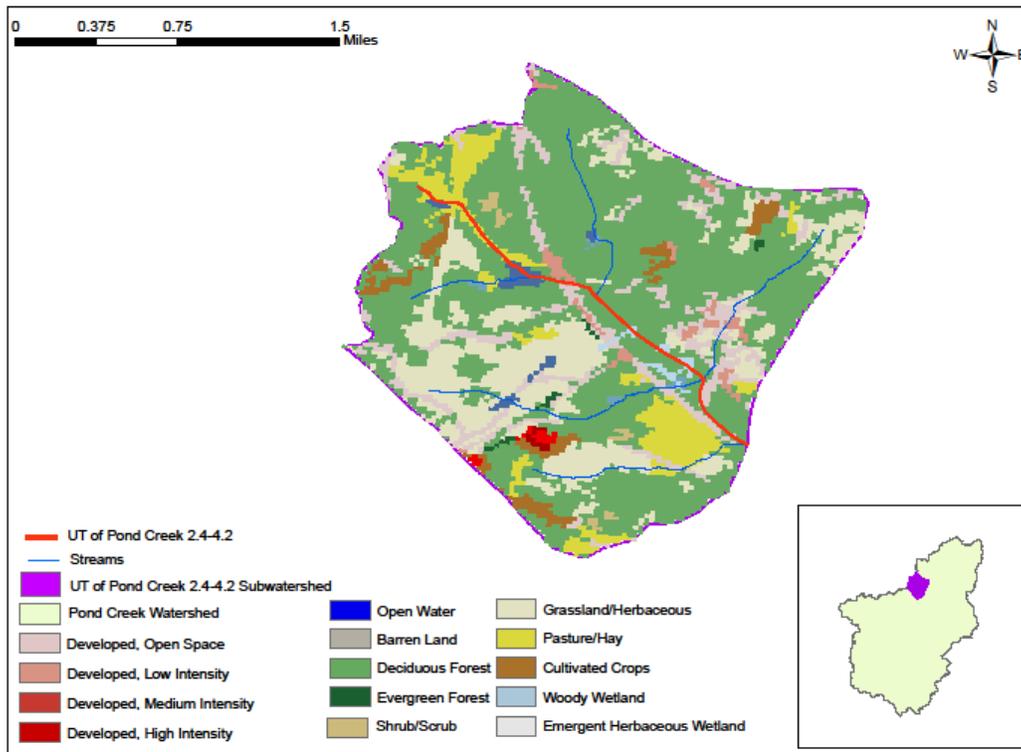


Figure 8.24.2 Land Cover in the UT of Pond Creek 2.4 to 4.2 Subwatershed

Table 8.24.2 Land Cover within the UT of Pond Creek 2.4 to 4.2 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.27	170.1	10.4
Agriculture	0.24	152.8	9.3
Forest	1.33	853.3	52.1
Barren Land	0.22	139.7	8.5
Grassland/Herbaceous	0.46	293.1	17.9
Wetlands	0.01	8.4	0.5
Water	0.03	16.6	1.0
Shrub/Scrub	0.01	3.6	0.2

There is one inactive KPDES permittee in this subwatershed, see Figure 8.24.3 and Table 8.24.3. Although this inactive KPDES facility was active during the data collection period and may have

contributed the impairments in the UT of Pond Creek 2.4 to 4.2, inactive KPDES will not receive a WLA.

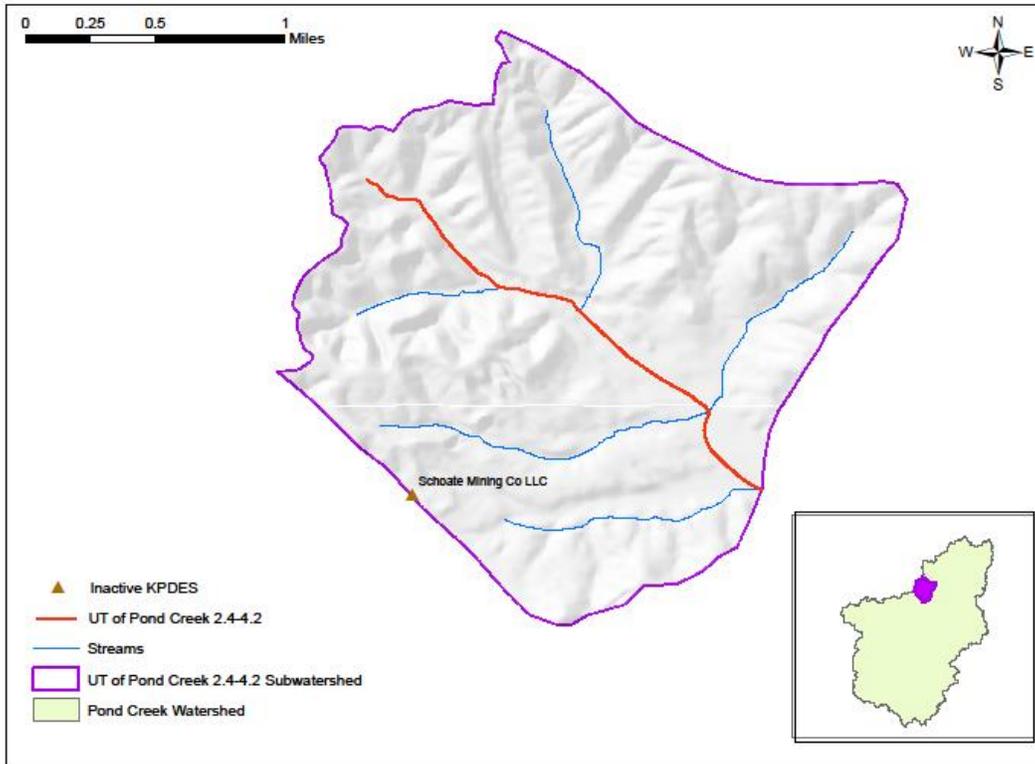


Figure 8.24.3 KPDES Permittee in the Subwatershed

Table 8.24.3 KPDES Permittee in the Subwatershed

KPDES	Status	Permit Name	Latitude	Longitude	Pollutants with Discharge Limit
KYG045704	Inactive	Schoate Mining Co LLC	37.245000	-87.108333	pH, Iron

There are no active KPDES mining permittees in this subwatershed, but the majority of this subwatershed is licensed mining areas, see Figure 8.24.4 (see Section 9.4.3 for more information). Table 8.24.4 to 8.24.6 display *E. coli*, pH, cadmium and flow data collected by TMDL staff at DOW03011002.

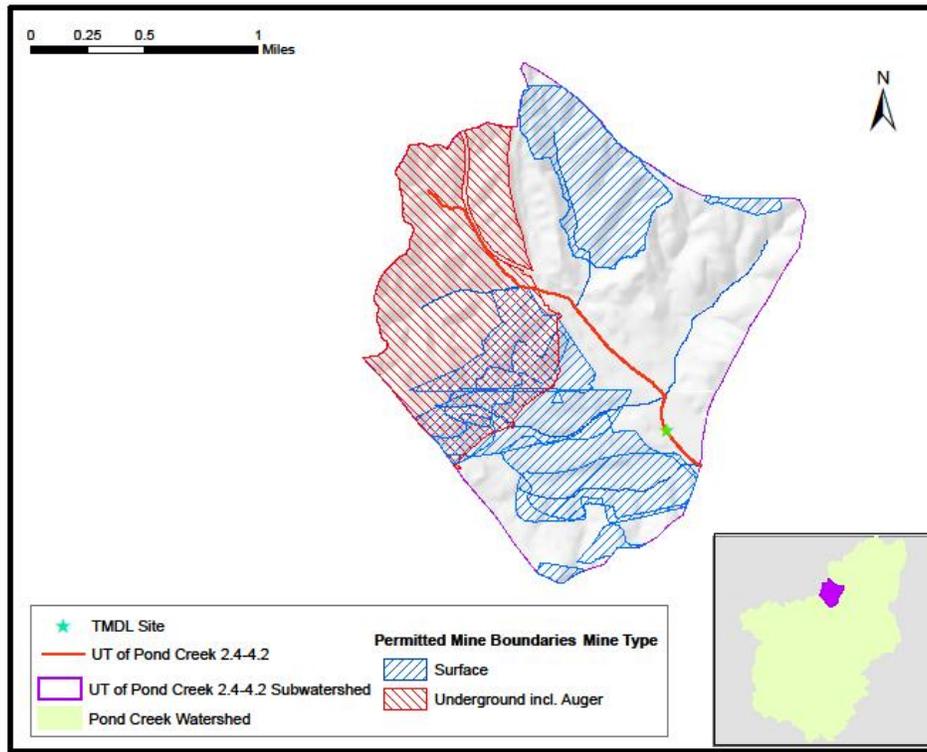


Figure 8.24.4 Data from the Department of Natural Resources on Licensed Mine Areas in the Subwatershed

Table 8.24.4 *E. coli* and Flow Data, DOW03011002

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
5/12/2011	365	**
5/26/2011	2420	**
6/16/2011	613	**
6/23/2011	866	**
7/14/2011	260	**
7/28/2011	980	**
8/11/2011	387	**
9/15/2011	122	**
9/29/2011	261	**
10/13/2011	1120	**
10/20/2011	101	**

Exceeds the *E. coli* limit
 ** Unable to obtain flow because of water depth, swiftness, or lack of access

Table 8.24.5 Cadmium, Hardness and Flow Data Collected at DOW03011002

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/18/2010	0.994 (J)	708	1.15	15.60	N/A	**
1/6/2011	1.06	478	0.86	10.46	0.20	1.788
2/17/2011	1.05	589	1.01	12.94	0.04	**
3/10/2011	0.618 (J)	300	0.61	6.52	N/A	**
4/28/2011	< 0.80 (U)	305	0.62	6.63	N/A	**
5/12/2011	< 0.80 (U)	652	1.09	14.35	N/A	**
6/16/2011	< 0.80 (U)	1240	1.75	27.58	N/A	**
7/14/2011	< 0.80 (U)	575	0.99	12.63	N/A	**
8/11/2011	< 0.80 (U)	1030	1.52	22.84	N/A	**
9/15/2011	< 0.80 (U)	992	1.48	21.98	N/A	**
10/13/2011	< 0.80 (U)	644	1.08	14.17	N/A	**
5/8/2013	0.4	424	0.79	9.26	-0.39	**
3/21/2013	0.72	252	0.54	5.46	0.18	**
4/18/2013	< 0.40 (U)	600	1.02	13.19	N/A	1.588
6/26/2013	< 0.50 (U)	485	0.87	10.62	N/A	1.441
7/16/2013	< 0.50 (U)	471	0.85	10.31	N/A	1.080
8/6/2013	< 0.50 (U)	814	1.28	17.98	N/A	0.311
9/10/2013	< 0.50 (U)	684	1.12	15.06	N/A	0.338
10/9/2013	< 0.50 (U)	373	0.72	8.13	N/A	1.268
11/13/2013	< 0.50 (U)	643	1.07	14.15	N/A	**
12/17/2013	0.25	518	0.92	11.36	-0.67	1.383

Exceeds the chronic limit
** Unable to obtain flow because of water depth, swiftness, or lack of access
D = Reanalyzed at a Higher Dilution
L = Exceeds MCL or Action Limit
U = Analyte Not Detected
N/A: Not Applicable

Table 8.24.6 pH and Flow Data, DOW03011002

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
11/18/2010	7.47	**
1/6/2011	7.99	1.788
2/17/2011	7.79	**

Collection Date	<i>E. coli</i> (colonies/100ml)	Discharge (cfs)
3/10/2011	7.81	**
4/28/2011	7.85	**
5/12/2011	7.95	**
5/26/2011	8.09	**
6/16/2011	8.30	**
6/23/2011	7.45	**
7/14/2011	7.88	**
7/28/2011	8.65	**
8/11/2011	8.56	**
9/15/2011	9.64	**
9/29/2011	8.86	**
10/13/2011	9.29	**
10/20/2011	8.86	**
5/8/2013	7.03	**
3/21/2013	7.80	**
4/18/2013	9.08	1.588
6/26/2013	7.64	1.441
7/16/2013	7.62	1.080
8/6/2013	8.07	0.311
9/10/2013	7.93	0.338
10/9/2013	7.64	1.268
11/13/2013	7.75	**
12/17/2013	7.62	1.383
<p> Exceeds the pH limit ** Unable to obtain flow because of water depth, swiftness, or lack of access</p>		

8.25 UT of Pond Creek 0.0 to 1.4

The pollutant addressed in this document for UT of Pond Creek 0.0 to 1.4 is cadmium. This segment is a second order stream based on the 1:24,000-scale NHD, with a total drainage area of approximately 3.08 square miles. There is one TMDL monitoring site in the subwatershed, DOW03011011, located at RM 0.85 with the drainage area of 2.59 square miles, see Figure 8.25.1 and Table 8.25.1. This subwatershed consists primarily of forest (51.4%), agricultural land (22.6%) and grassland (11.7%), see Figure 8.25.2 and Table 8.25.2.

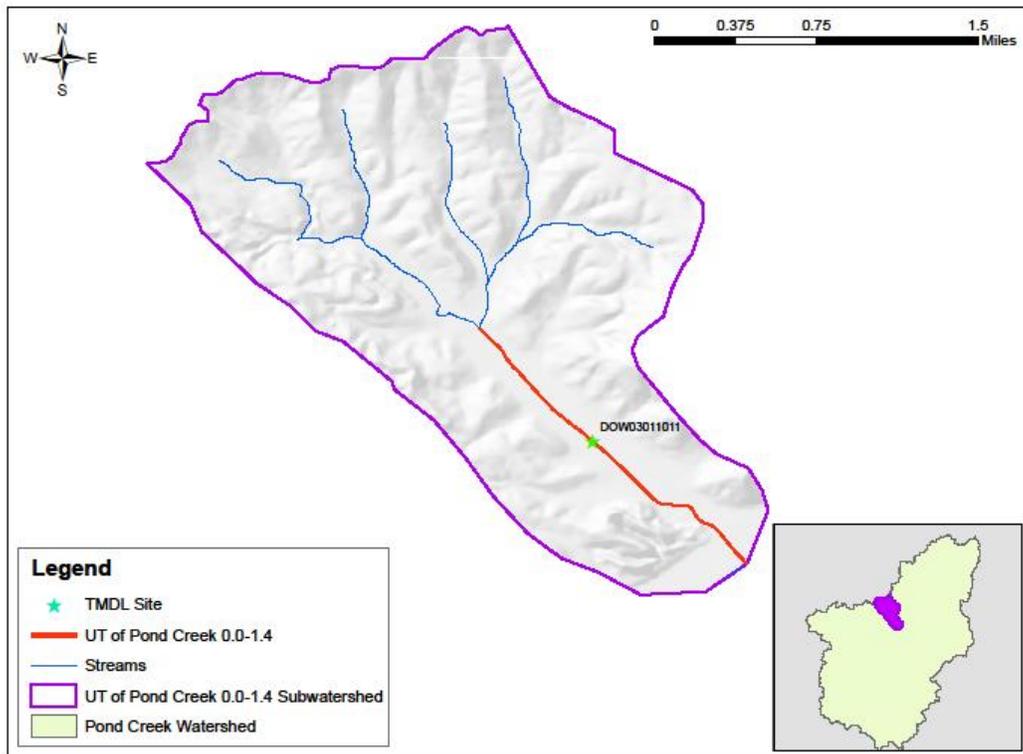


Figure 8.25.1 TMDL Monitoring Location and Impaired Segment in the UT of Pond Creek 0.0 to 1.4 Subwatershed

Table 8.25.1 UT of Pond Creek 0.0 to 1.4 Segment/Subwatershed Information

GNIS Number	Stream Segment	Stream Order	County	Watershed Area (square mile)	Watershed Area (acres)
KY501042-11.1_01	UT of Pond Creek 0.0 to 1.4	2	Muhlenberg	3.08	1974

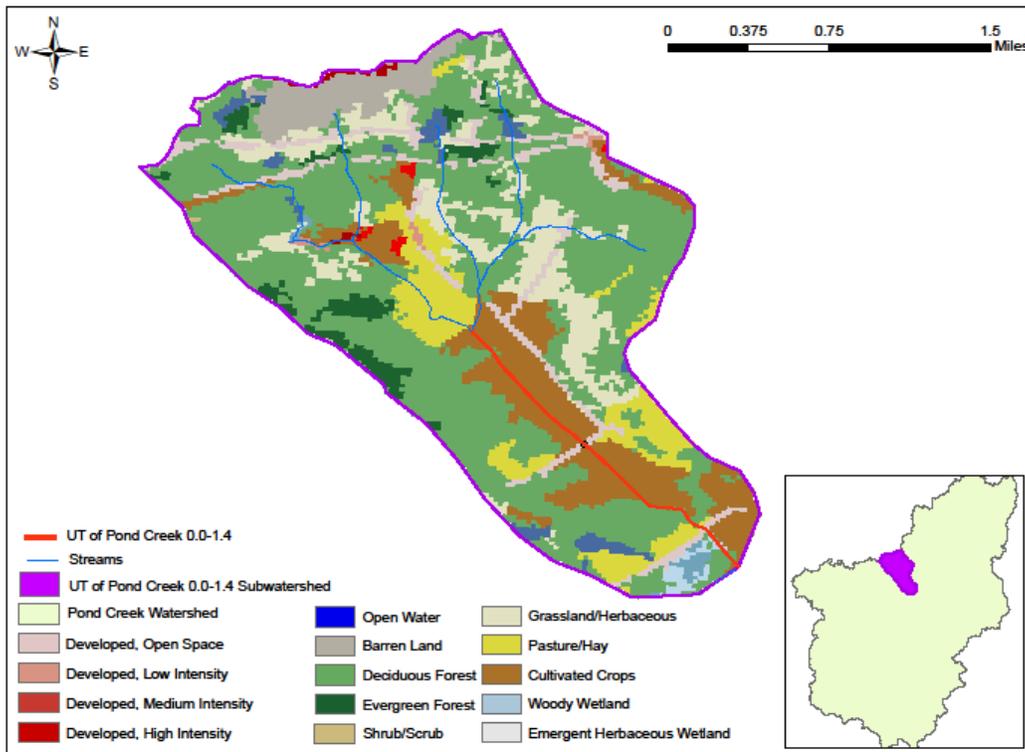


Figure 8.25.2 Land Cover in the UT of Pond Creek 0.0 to 1.4 Subwatershed

Table 8.25.2 Land Cover within the UT of Pond Creek 0.0 to 1.4 Subwatershed

Land Cover	Square Miles	Acres	Percent (%)
Developed	0.19	122.8	6.2
Agriculture	0.70	445.7	22.6
Forest	1.58	1013.8	51.4
Barren Land	0.17	107.7	5.5
Grassland/Herbaceous	0.36	231.8	11.7
Wetlands	0.02	11.6	0.6
Water	0.06	39.8	2.0
Shrub/Scrub	0.0005	0.3	0.02

There are two active and two inactive KPDES facilities with the pH and/or metals discharge limits, see Figure 8.25.3 and Table 8.25.3. Although those two inactive KPDES facilities were

active during the data collection period and may have contributed to the impairments on the UT of Pond Creek 0.0 to 1.4, inactive KPDES will not receive a WLA.

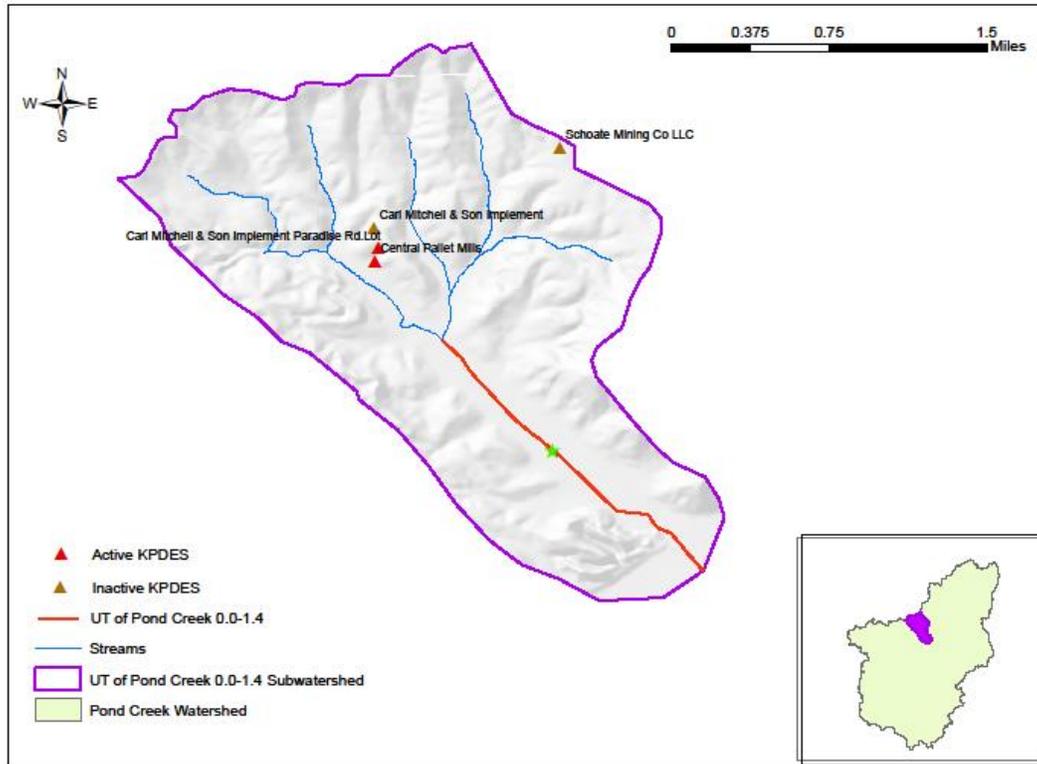


Figure 8.25.3 KPDES Permittees in the Subwatershed

Table 8.25.3 KPDES Permittees in the Subwatershed

KPDES	Status	Permit Name	Latitude	Longitude	Pollutants with Discharge Limit
KYR003239	Active	Central Pallet Mills	37.237167	-87.121083	pH
KYR004015	Active	Carl Mitchell & Son Implement Paradise Rd. Lot	37.238014	-87.120822	pH
KYG045704	Inactive	Schoate Mining Co	37.245000	-87.108333	pH, Iron
KYR001665	Inactive	Carl Mitchell & Son	37.239428	-87.121152	pH

There are no active KPDES mining permits in this subwatershed, but the majority of upstream subwatershed is licensed mining areas, see Figure 8.25.4 (see Section 9.4.3 for more information). Tables 8.25.4 displays cadmium and flow data collected by TMDL staff at DOW03011011.

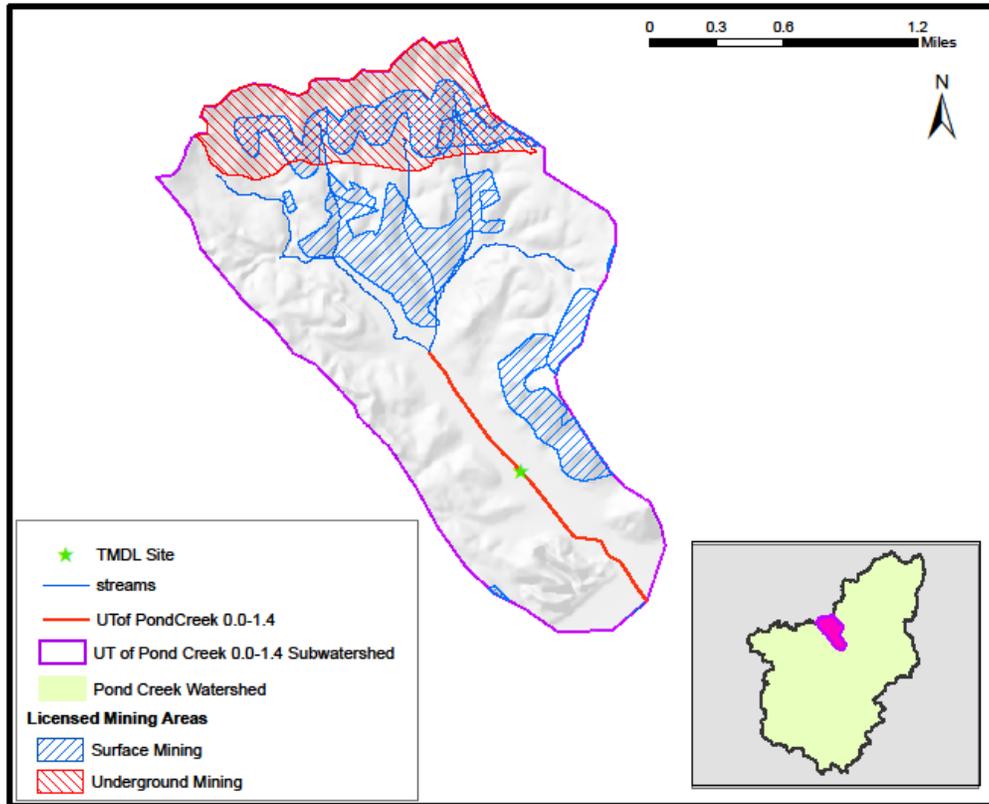


Figure 8.25.4 Data from the Department of Natural Resources on Licensed Mining Areas in the Subwatershed

Table 8.25.4 Cadmium, Hardness and Flow Data Collected at DOW03011011

Date	Cadmium (µg/L)	Hardness, Total (mg/L)	Cadmium Chronic Limit (µg/L)	Cadmium Acute Limit (µg/L)	Difference between the Cadmium Concentration and the Cadmium Chronic Limit (µg/L)	Flow (cfs)
11/17/2010	5.29 (J,D,L)	1550	2.06	34.60	N/A	**
1/5/2011	2.27	1080	1.58	23.97	0.69	1.835
2/16/2011	3.41	1080	1.58	23.97	1.83	1.794
3/9/2011	< 8.0 (DU)	326	0.65	7.09	N/A	**
4/27/2011	1.9	269	0.56	5.83	1.34	**
5/11/2011	2.22	1010	1.50	22.39	0.72	**
<p>Exceeds the chronic limit</p> <p>** Unable to obtain flow because of water depth, swiftness, or lack of access</p> <p>D = Reanalyzed at a Higher Dilution</p> <p>J = Estimated Value</p> <p>L = Exceeds MCL or Action Limit</p> <p>U = Analyte Not Detected</p> <p>N/A: Not Applicable</p>						

9.0 Implementation Options

9.1 Watershed Plan

Section 303(e) of the Clean Water Act and 40 CFR Part 130, Section 130.5, require states to have a continuing planning process (CPP) composed of several parts specified in the Act and the regulation. The CPP provides an outline of agency programs and the available authority to address water issues. Under the CPP umbrella, the Watershed Management Branch of KDOW will provide technical support and leadership with developing and implementing watershed plans to address water quality and quantity problems and threats. Developing watershed plans enables more effective targeting of limited restoration funds and resources, thus improving environmental benefit, protection and recovery.

Watershed plans provide an integrative approach for identifying and describing how, when, who and what actions should be taken in order to meet water quality standards. At this time, a comprehensive watershed restoration plan for the Pond Creek watershed has not been developed. This TMDL may assist with developing a detailed watershed plan to guide watershed restoration efforts.

A watershed plan for the Pond Creek watershed should address both point and nonpoint sources of pollution in the watershed and should build on existing efforts as well as evaluate new approaches. A watershed plan should incorporate all available restoration and protection mechanisms. A comprehensive watershed plan should consider both voluntary and regulatory approaches to meet water quality standards. When such a plan is developed, pollutant trading may be a viable management strategy to consider for meeting the TMDL load reduction goals.

9.2 Kentucky Watershed Management Framework

A watershed management framework approach to water quality management was adopted by the KDOW in 1998. The plan divides Kentucky's major drainage basins into five groups of basins which are cycled through a five year staggered process which involves monitoring, assessment, prioritization, plan development, and plan implementation. As part of the process, a basin coordinator is assigned to each river basin to work with the citizens of the basin to develop a local watershed management team associated with each priority watershed. For more information about the river basins see: <http://water.ky.gov/watershed/Pages/default.aspx>

9.3 Non-Governmental Organizations

There are several Non-Governmental Organizations that may be operating in the Pond Creek watershed that may help to implement the TMDL, particularly with regard to nonpoint source issues. These organizations include Watershed Watch groups in Kentucky and Kentucky Waterways Alliance.

9.3.1 Watershed Watch in Kentucky

Watershed Watch is a citizen's water monitoring effort that relies exclusively on volunteers to provide administration, training, and volunteer and equipment coordination. The volunteers measure basic parameters of stream health to determine whether streams meet important "uses" under the Clean Water Act including aquatic life, human recreation, and drinking water.

Several water quality measurements are taken annually by Watershed Watch groups. Volunteers collect physical measurements, such as temperature, pH, dissolved oxygen, and conductivity. Stream monitoring may also include macroinvertebrate and habitat assessments. Data from annual monitoring is routinely used to help identify problems in the watershed, and assist with prioritizing streams for restoration and protection activities.

For more information about Watershed Watch see: <http://water.ky.gov/wsw/Pages/default.aspx>.

9.3.2 Kentucky Waterways Alliance

The formation of Kentucky Waterways Alliance (KWA) was the result of a series of meetings sponsored by the Kentucky Environmental Quality Commission. The KWA has a mission to protect and restore Kentucky's waterways and their watersheds through alliances for watershed stewardship. This includes strengthening community and governmental stewardship for the restoration and preservation of Kentucky's water resources. The Alliance promotes networking, communication and mutual support among groups, government agencies, and businesses working on waterway issues.

For more information about KWA see: <http://www.kwalliance.org>.

9.4 Mining Related Implementations

9.4.1 Kentucky Division of Abandoned Mine Lands

The Kentucky Division of Abandoned Mine Lands (AML) within KDNR is charged with reclaiming land affected by mining before the passage of SMCRA. SMCRA Title IV authorized a reclamation fee which is charged on every ton of coal mined in the United States since 1977 and continuing through 2021. The money collected is kept in an account called the Abandoned Mine Reclamation Fund. SMCRA Title IV sets priorities for reclamation: Priority 1 and 2 are related to human health and safety. Priority 3 is AMD. The universe of AML projects also includes those post-SMCRA projects funded by forfeit bond money. AML projects can involve responding to emergencies such as threats to human health or imminent loss of property, often

from landslides or subsidences. However, AML funds are also spent on water line extensions to provide drinking water to communities whose groundwater supply has been impacted by mining. Other projects include closing mine openings, and all facets of work concerning AMD, which may include covering refuse (i.e., rejected coal), installing treatment ponds, eliminating rills and gullies, armoring channels, liming and re-vegetation. Pond Creek area has been funded for AML projects since early 1980s; Table 9.1 and Figures 9.1 to 9.3 present the AML projects dollars spends and their locations. Bond forfeiture sites are not shown.

Table 9.1 AML Projects within the Pond Creek Watershed

Project Name	Cost, Thousands	Awarded Year
Bilbro Slide	50	1983
Depoy	1647	1984
Pond Creek - Browder	450	1984
Pond Creek - Dboro 2	79	1986
Pond Creek - Dboro II	241	1985
Pond Creek - Dboro IMP	1937	1984
Pond Creek - Luzerne	615	1986
Pond Creek - Nonnell	435	1985
Pond Creek - Wilson Prop	35	1987
Pond Creek - Beech	608	1985
Pond Creek - Caney IMP	1363	1986
Pond Creek - Impoundments	2040	1985
Phoenix (4)	902	1987
Phoenix County Park	347	1989
Browder Trestle	4	*
Ebenezer AMD	2924	2012
Luzerne I AMD	678	2010
Luzerne II AMD	221	2010
Drakesboro Tipple	134	2003
Caney Creek Mine	85	2014
Bryan -Piper Highwalls	369	2008
HWY431 AMD	83	2011
*: No Information		

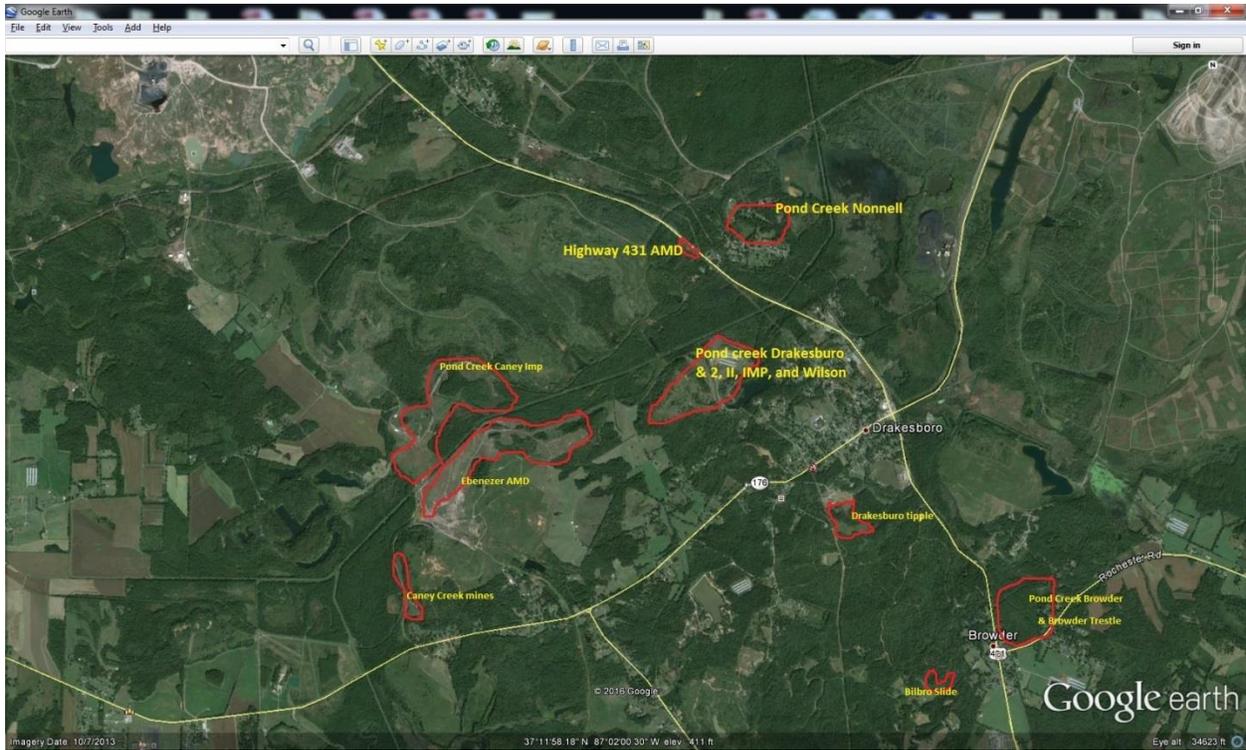


Figure 9.1 AML Projects within the Pond Creek Watershed – Part1

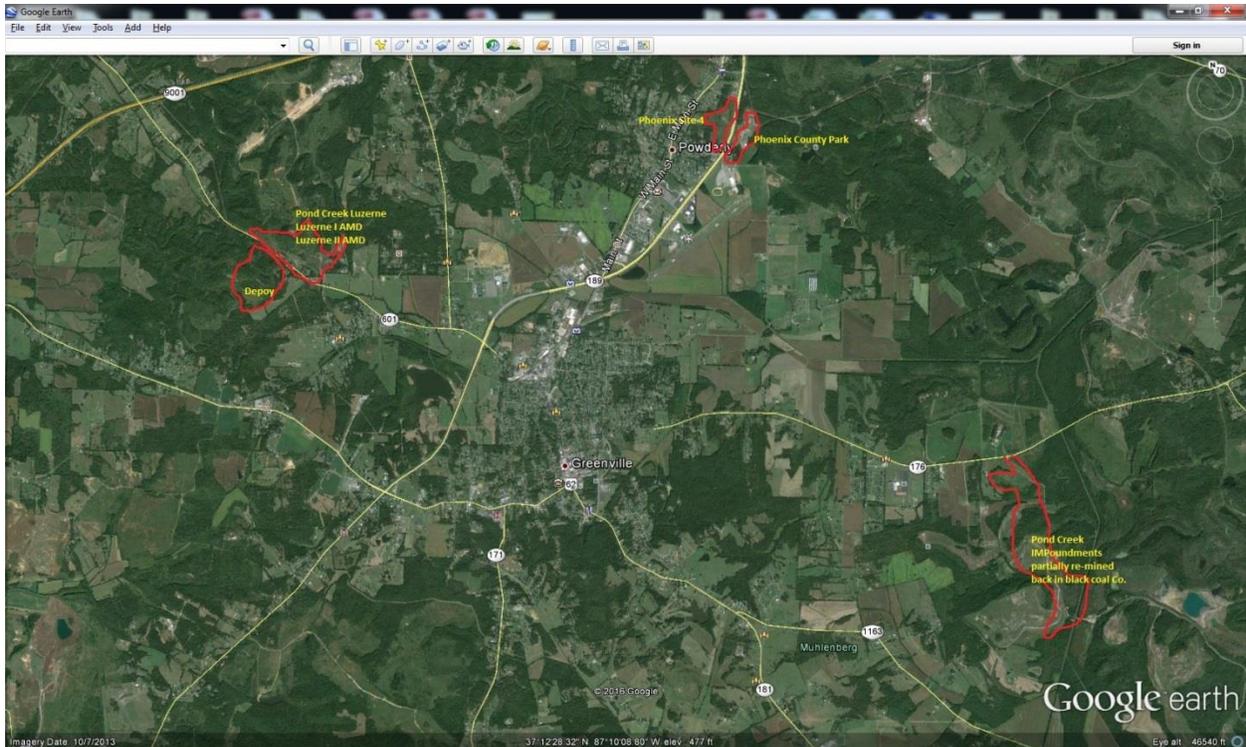


Figure 9.2 AML Projects within the Pond Creek Watershed – Part II

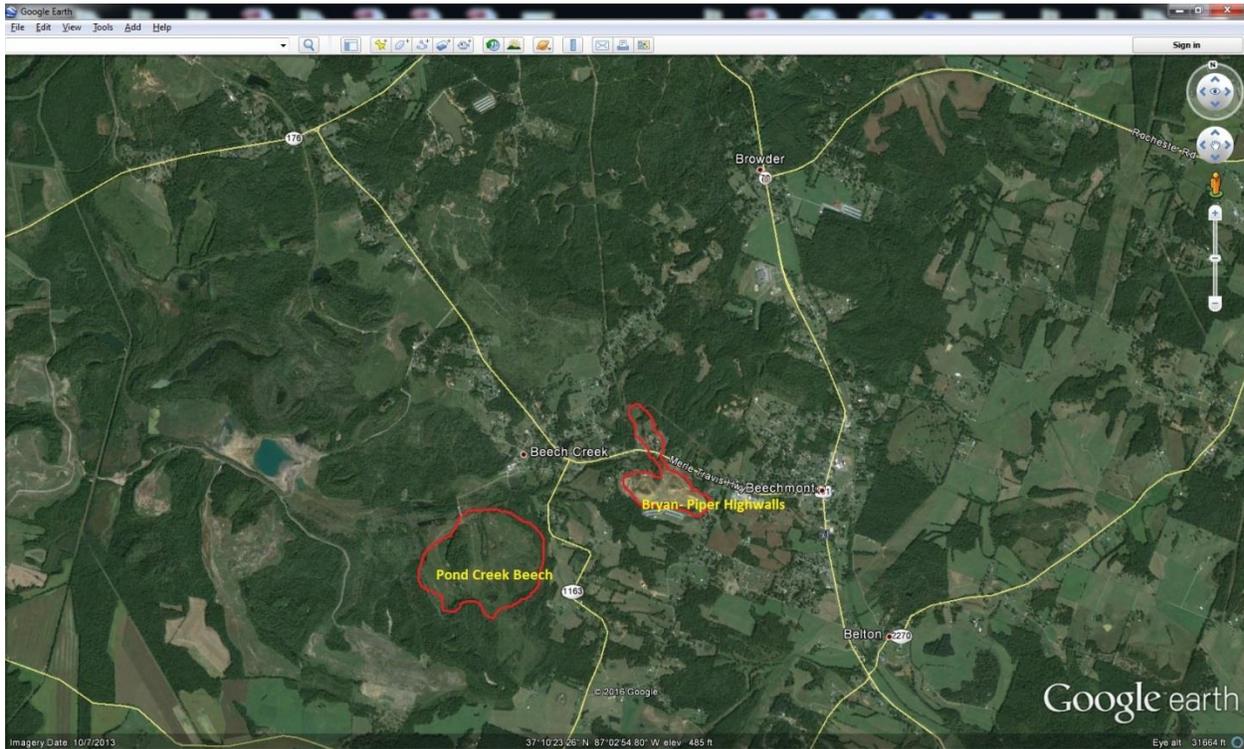


Figure 9.3 AML Projects within the Pond Creek Watershed – Part III

9.4.2 Kentucky Division of Mine Permits

Coal mining in Kentucky requires a permit from the KDMP within KDNR as mandated by Title V of the 1977 SMCRA, for which Kentucky has primacy, or primary responsibility for regulation of surface coal mining, the surface effects of underground mining, as well as mine reclamation. Prior to SMCRA, there were no environmental requirements for mines relative to earth disturbance. SMCRA requirements were phased in beginning in 1978: KDOW *et al.*, (2003) states “Mining permits [as opposed to KPDES permits] in Kentucky are classified on the basis of whether the original permit was issued prior to May 3, 1978 (pre-law permit), after January 18, 1983 (post-Kentucky primacy) or in-between these dates (interim period).” Under SMCRA the regulatory standards for issuance of a permit require that the operation be designed to prevent adverse changes in downstream water quantity or quality sufficient to cause material damage (401 KAR 8:10, Section 14, (3)). The permit review is designed to place burden on the applicant to either demonstrate that no potential source of degradation will be associated with operations or that operations have been designed to appropriately treat or remediate any adverse impact.

A SMCRA permit allows the earth disturbance associated with mining, requires measures to preclude offsite impacts during mining, and requires land reclamation at the conclusion of mining, but by itself does not allow the discharge of mine wastewater to waters of the

Commonwealth; this requires a separate KPDES permit, see Section 5.1.2.2. Although KDMP permits mines from an environmental perspective, the permit also requires safe mine operation.

Under SMCRA, KDMP cannot issue permits for mining operations that will knowingly create AMD. The primary goal is to identify and isolate potential acid-producing materials and target them for special handling to prevent acid production. Permit reviews conduct acid-base accounting of the levels of potential acidity and the neutralization potential of each stratum from submitted corehole data to prevent the production of AMD. All runoff from coal mining performed under SMCRA (excepting small areas qualifying for exemption or alternate controls) is captured in a pond where it is monitored. Where the monitoring reflects the presence of AMD despite these controls, the runoff is treated then discharged to surface water, see Section 5.1.2.2.

Environmental monitoring is also a requirement. SMCRA permit applicants must submit 6 water quality samples collected throughout a one-year period that capture both high and low flow events. SMCRA permittees must also collect quarterly water quality monitoring results (surface and ground water) beginning when mining commences through complete bond release. Depending on affected stream assessments, permittees may also be required to conduct benthic macroinvertebrate and/or fish surveys and calculate appropriate biological indices, such as the MBI and KIBI (Kentucky Index of Biotic Integrity) for fish. This sampling is independent of that required under the facility's KPDES permit.

Also, SMCRA permits regulate the production of coal to minimize environmental impacts following cessation of mining activities. Coal spoils or leavings that are expected to produce AMD when exposed to water and oxygen must be addressed by special handling plans: examples include burying spoils below the permanent water table, or encapsulating them within the mine backfill. For these reasons, KDOW believes most of the pollution in the watershed is due to mining operations that existed prior to the passage of SMCRA, or 'pre-law' mines.

As stated, KDMP issues permits related to earth disturbance and reclamation, and KDMP's permit numbers are 7-digit numbers in the format XXX-XXXX; these are commonly known as the KDNR permit number, see Appendix B for additional information. Each KDNR permit number is typically associated with one KPDES permit. KDMP maintains archived files by permit number; each file contains information relative to a single permit, including the application, final permit, reclamation plans, bond information, and associated data and maps. Any enforcement activity is also included. While the information in these files has historically been submitted and stored on paper, KDMP now requires new submissions to be made electronically. Information specific to KDMP permitting can be obtained from the Surface Mining Information System (SMIS), at <http://minepermits.ky.gov/Pages/SurfaceMiningInformationSystem.aspx>. Using the information in SMIS, KDMP publishes and maintains two types of GIS layer files of licensed coal mining areas available on the KyGeoportal (<http://kygisserver.ky.gov/geoportal/catalog/main/home.page>). One layer file shows all licensed mining areas, active and inactive, and Figure 9.2 shows this layer clipped with the Pond Creek watershed boundary. The other shows only the active mining permits (issued by KDMP), see Figure 3.11 which is clipped with the Pond Creek watershed boundary. While the KPDES permit numbers associated with the KDNR permit numbers are not included in the layers, within

KDOW the KPDES permit number is normally associated with the KDMP permit number within the TEMPO database.

9.4.3 Kentucky Division of Mine Reclamation and Enforcement

The Division of Mine Reclamation and Enforcement (DMRE) within KDNR is responsible for mine inspection, enforcement, and bond release/forfeiture. KDOW *et al.*, (2003) also state, “All permits are secured through reclamation bonds. A reclamation bond is a financial document submitted to the KDNR prior to mine permit issuance. A bond guarantees mining and reclamation operations will be conducted by mining companies according to regulations and the terms of the approved permit. If a coal company cannot comply with these conditions, the bond is “forfeited” (paid to the KDNR) for eventual use by the Division of Abandoned Mine Lands in reclaiming the mined area. Reclamation bonds may be submitted in the forms of cash, certificate of deposit, letter of credit or surety (insurance policy).

A reclamation bond may be returned to a coal company by either of two methods: administrative or phase (on-ground reclamation). Administrative releases occur when new bonds are substituted for the original bonds. Administrative releases are also given for areas of a mine site that are permitted but never disturbed by mining or for areas that are included under a second more recently issued permit.

Phase releases occur in three stages and according to specific reclamation criteria: Phase One – all mining is complete, and backfilling, grading and initial seeding of mined areas has occurred. Phase Two – a minimum of two years of growth on vegetated areas since initial seeding, the vegetation is of sufficient thickness to prevent erosion and pollution of areas outside the mine area with mine soils, and any Permanent water impoundments have met specifications for future maintenance by the landowner. Phase Three – a minimum of five years of vegetative growth since initial seeding and the successful completion of reclamation operations in order for the mined area to support the approved post-mining land use. Up to 60 percent of the original bond amount is released at phase one. An additional 25 percent is returned at phase two, with the remainder of the reclamation bond released at phase three. Once a permit is released and the reclamation bond returned, the state cannot require additional remediation action by the mining company unless it is determined that fraudulent documentation was submitted as part of the remediation process.” Bonds are not released if the water quality does not meet WQCs.

Figure 9.4 displays the licensed mining areas within the Pond Creek watershed from KDNR/KDMP, and Table 9.2 presents their status (as of June 2016).

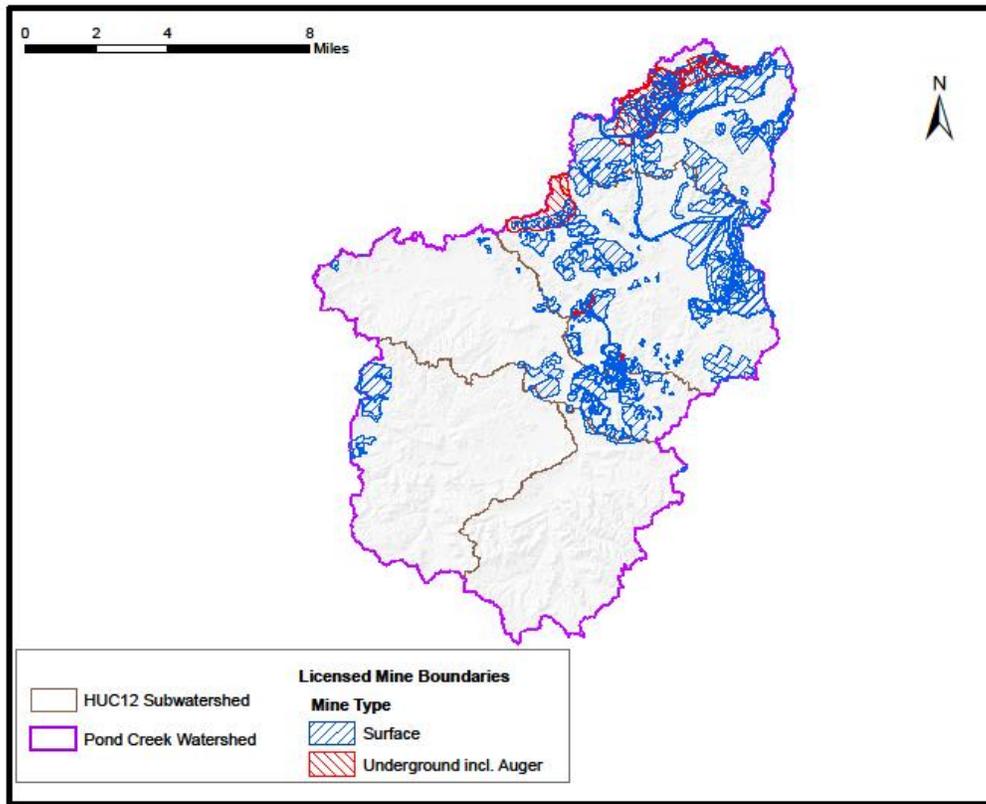


Figure 9.4 Data from the Department of Natural Resources on Licensed Mine Areas in the Pond Creek Watershed

Table 9.2 Data from the Department of Natural Resources on Licensed Mine Areas in the Pond Creek Watershed

KDNR Permit #	Mine Status ⁽¹⁾	Permit Name	Active/Inactive	Date Issued	Permit Type	Original Permit #
2890133	RC	West Ken Coal Corp	Released	12/9/1974	Interim	2890133
2890167	RC	Peabody Coal Company	Released	7/8/1976	Interim	2890167
2890352	RC	Peabody Coal Company	Released	6/22/1979	Interim	2890352
2890354	RC	Badgett Mine Stripping	Released	2/14/1978	Interim	2890354
0890021	RC	Peabody Coal Company	Released	12/1/1978	Interim	890021
0890025	RC	Peabody Coal Company	Released	4/20/1979	Interim	890025
0890026	RC	West Ken Coal Corp	Released	6/26/1979	Interim	890026
0890033	RC	West Ken Coal Corp	Released	2/28/1980	Interim	890033
0890034	RC	Arch On The Green Inc	Released	4/1/1980	Interim	890034
0890038	RC	Peabody Coal Company	Released	7/1/1980	Interim	890038
0890043	RC	Peabody Coal Company	Released	10/14/1980	Interim	890043
0890044	RC	West Ken Coal Corp	Released	12/11/1980	Interim	890044

KDNR Permit #	Mine Status⁽¹⁾	Permit Name	Active/Inactive	Date Issued	Permit Type	Original Permit #
0890045	RC	Arch On The Green Inc	Released	5/29/1981	Interim	890045
0890046	RC	Pond Creek Coal Co Inc	Released	12/11/1981	Interim	890046
0890048	RC	Gibraltar Coal Corp	Released	11/11/1981	Interim	890048
0897000	RC	Peabody Coal Company	Released	3/26/1979	Interim	897000
577876X	-	-	-	-	-	-
113476X	-	-	-	-	-	-
118367X	-	-	-	-	-	-
282572X	RC	Thornberry Const Co Inc	Released	3/5/1973	Pre Law	282572X
282574X	FF	Thornberry Const Co Inc	Released	1/14/1975	Pre Law	282574X
2897005	RC	Peabody Coal Company	Released	11/27/1979	Interim	2897005
8890107	RC	Andalex Resources Inc	Released	5/4/2000	Permanent	890026
530976X	RC	Amax Coal Co	Released	1/5/1977	Pre Law	530976X
561676X	FF	Thornberry Const Co Inc	Released	4/15/1977	Pre Law	561676X
16463	-	-	-	-	-	-
16464	-	-	-	-	-	-
16465	-	-	-	-	-	-
16469	-	-	-	-	-	-
1865	-	-	-	-	-	-
1866	-	-	-	-	-	-
1867	-	-	-	-	-	-
1868	-	-	-	-	-	-
1869	-	-	-	-	-	-
1870	-	-	-	-	-	-
1873	-	-	-	-	-	-
200968X	-	-	-	-	-	-
203369X	-	-	-	-	-	-
203473X	-	-	-	-	-	-
203474X	-	-	-	-	-	-
203475X	-	-	-	-	-	-
210171X	-	-	-	-	-	-
268771X	-	-	-	-	-	-
268774X	-	-	-	-	-	-
271171X	-	-	-	-	-	-
277372X	-	-	-	-	-	-
336274X	-	-	-	-	-	-
40763	-	-	-	-	-	-
40765	-	-	-	-	-	-
40766	-	-	-	-	-	-
40767	-	-	-	-	-	-

KDNR Permit #	Mine Status ⁽¹⁾	Permit Name	Active/Inactive	Date Issued	Permit Type	Original Permit #
40768	-	-	-	-	-	-
40769	-	-	-	-	-	-
40770	-	-	-	-	-	-
40771	-	-	-	-	-	-
40773	-	-	-	-	-	-
45367	-	-	-	-	-	-
597577X	FF	Thornberry Const Co Inc	Released	7/11/1977	Pre Law	597577X
637777X	RC	Amax Coal Co	Released	11/7/1977	Pre Law	637777X
642577X	RC	Amax Coal Co	Released	11/16/1977	Pre Law	642577X
8890162	RC	Armstrong Coal Company Inc	Active	6/18/2013	Permanent	8890007
710069X	-	-	-	-	-	-
74864X	-	-	-	-	-	-
74865	-	-	-	-	-	-
74866	-	-	-	-	-	-
74867	-	-	-	-	-	-
74868	-	-	-	-	-	-
74872	-	-	-	-	-	-
74873	-	-	-	-	-	-
74874	-	-	-	-	-	-
74875	-	-	-	-	-	-
87163	-	-	-	-	-	-
8890012	RC	Peabody Coal Company	Released	10/13/1983	Permanent	8890012
8890016	RC	West Ken Coal Corp	Released	1/30/1984	Permanent	8890016
8890032	RC	Peabody Coal Company, LLC	Released	8/30/1985	Permanent	8890032
8890035	RC	West Ken Coal Corp	Released	2/6/1986	Permanent	8890035
8890037	RC	Apogee Coal Company	Released	3/10/1986	Permanent	8890037
8890057	RC	Crown Energy Corp	Released	1/19/1990	Permanent	8890038
8890040	RC	West Ken Coal Corp	Released	7/17/1987	Permanent	8890040
8890041	RC	West Ken Coal Corp	Released	7/17/1987	Permanent	8890041
8890043	RC	West Ken Coal Corp	Released	7/15/1987	Permanent	8890043
8890045	RC	Taylor/Thomson-Joint Venture	Released	7/15/1988	Permanent	8890045
8890046	FF	Pond Creek Coal Co Inc	Released	1/11/1989	Permanent	8890046
8890049	RC	West Ken Coal Corp	Released	12/21/1988	Permanent	8890049
8890051	RC	Taylor/Thomson-Joint Venture	Released	8/25/1989	Permanent	8890051
8890053	RC	Crown Energy Corp	Released	12/8/1989	Permanent	8890052
8890061	RC	Canyon Coals Inc	Released	5/3/1990	Permanent	8890061
8890062	FF	Beech Creek Energy Inc	Released	4/4/1991	Permanent	8890062
8890066	RC	Muhlenberg Coals Inc	Released	1/30/1991	Permanent	8890066

KDNR Permit #	Mine Status⁽¹⁾	Permit Name	Active/Inactive	Date Issued	Permit Type	Original Permit #
8890067	RC	Black Magic Resources Inc	Released	1/30/1991	Permanent	8890067
8890069	FF	Pond Creek Coal Co Inc	Released	6/27/1991	Permanent	8890069
8890071	RC	Hawkins/Thomson Partnership	Released	9/24/1992	Permanent	8890071
8890076	RC	Canyon Coals Inc	Released	11/4/1993	Permanent	8890076
8890079	RC	Friendship Energy Inc	Released	11/18/1994	Permanent	8890076
8890084	FF	Beech Creek Energy Inc	Released	11/20/1995	Permanent	8890084
8890092	RC	Beech Creek Energy Inc	Released	12/3/1996	Permanent	8890092
8890101	RC	Marine Coal Sales Company	Released	12/22/1998	Permanent	8890101
8890138	P2	Armstrong Coal Company Inc	Released	8/24/2007	Permanent	8890032
8890138	P2	Armstrong Coal Company Inc	Released	8/24/2007	Permanent	8890032
8890142	RC	Cyprus Creek Land Company	Released	9/29/2008	Permanent	8890007
8890150	VF	C & R Coal Company Inc	Released	6/9/2009	Permanent	8890092
8890151	VF	C & R Coal Company Inc	Released	6/8/2009	Permanent	8890124
8890151	VF	C & R Coal Company Inc	Released	6/8/2009	Permanent	8890124
8890152	VF	C & R Coal Company Inc	Released	6/4/2009	Permanent	8890126
8890153	D6	Oxford Mining Company-Kentucky LLC	Active	6/25/2010	Permanent	8890153
8890155	D6	Oxford Mining Company-Kentucky LLC	Active	1/27/2010	Permanent	8890112
8890156	A2	Oxford Mining Company-Kentucky LLC	Released	3/25/2010	Permanent	8890114
8895008	RC	Peabody Coal Company	Released	3/8/1991	Permanent	895003
8898001	RC	West Ken Coal Corp	Released	8/24/1984	Permanent	8898001
8899001	RC	West Ken Coal Corp	Released	2/17/1984	Permanent	8899001
8899003	RC	Peabody Coal Company	Released	11/7/1989	Permanent	8899003
8899005	A1	Armstrong Coal Company Inc	Active	4/6/2011	Permanent	8899005
8890133	RC	Schoate Mining Co LLC	Released	9/27/2006	Permanent	8890101
8897006	RC	Friendship Energy Inc	Released	2/3/1995	Permanent	8897004
8895014	AP	Armstrong Coal Company Inc	Active	4/24/2007	Permanent	895003
8897011	A1	Armstrong Coal Company Inc	Active	7/23/2013	Permanent	8897011
8890139	P1	Armstrong Coal Company Inc	Active	7/30/2007	Permanent	8890011
8890060	FF	Pond Creek Coal Co Inc	Released	2/23/1990	Permanent	8890049
8890063	FF	Pond Creek Coal Co Inc	Released	2/4/1991	Permanent	8890040
Unknown	-	-	-	-	-	-
Unknown	-	-	-	-	-	-
Unknown	-	-	-	-	-	-
8890093	RC	Beech Creek Energy Inc	Released	3/4/1996	Permanent	8890093
8890093	RC	Beech Creek Energy Inc	Released	3/4/1996	Permanent	8890093
8895014	AP	Armstrong Coal Company Inc	Active	4/24/2007	Permanent	895003

⁽¹⁾ Mine Status Codes:

KDNR Permit #	Mine Status ⁽¹⁾	Permit Name	Active/Inactive	Date Issued	Permit Type	Original Permit #
A1 = Active, Currently Being Mined. A2 = Coal Removal Complete, Reclamation Action Only AP = Actively Producing Coal D6 = Six-month Reclamation Deferred FF = Final Forfeiture. O1 = Active Permits in Forfeiture P1 = Phase I Release P2 = Phase 2 Release RC = Permit Completely Released (Result of Transfer or Phase III Bond Release). VF = Voluntary Forfeiture -: No Information						

9.4.4 Kentucky Division of Water

9.4.4.1 Coal General Permits

KDOW has two general coal mining permits, KYGE40000 for mines in eastern Kentucky and KYGW40000 for mines in western Kentucky. Under these permits, permittees have limits for pH, total suspended solids, iron and manganese. They are also required to report flow, total sulfate and specific conductivity. Table 9.3 shows the effluent limits taken from the current KYGE40000 and KYGW40000 General Permits.

Table 9.3 Coal General Permit Limits and Reporting

Effluent Characteristics	Reported Discharge		Proposed Limits		Applicable Water Quality Criteria and/or Effluent Guidelines
	Monthly Average	Daily Maximum	Monthly Average	Daily Maximum	
Flow (MGD) ⁽¹⁾	Variable	Variable	Report	Report	401 KAR 5:065, Section 2(4)
Total Sulfate (as SO ₄) (mg/l)	Variable	Variable	Report	Report	401 KAR 5:065, Section 2(4)
Specific Conductivity (µS/cm) ⁽²⁾	Variable	Variable	Report	Report	401 KAR 5:070, Section 3
Total Recoverable Iron	Variable	Variable	3.0 mg/l	4.0 mg/l	401 KAR 10:031, Section 4, 401 KAR 5:065, Section 2(4), and 2(9)
Total Recoverable Manganese	Variable	Variable	2.0 mg/l	4.0 mg/l	401 KAR 5:065, Sections 2(4), and 2(9)
Total Suspended Solids	Variable	Variable	35mg/l	70mg/l	401 KAR 5:065, Sections 2(4) and 2(9)
pH ⁽³⁾ Standard Units	Variable	Variable	6.0 (min.)	9.0 (max.)	401 KAR 10:031, Section 4 401 KAR 5:065, Sections 2(4) and 2(9)

⁽¹⁾ MGD: million gallons per day
⁽²⁾ µS/cm: microsiemens per centimeter
⁽³⁾ These types of discharges shall not cause the pH of the receiving stream to fluctuate more that 1.0 standard unit over a period of 24 hours.

9.4.4.2 *Individual Permits*

Individual permits are those who are excluded from coverage under the general permit. The following are excluded from coverage under the general permit:

- 1) Coal mining and/or processing operations that directly discharge to or propose to directly discharge to a receiving water body that has been categorized as an “Impaired Water” for a pollutant or pollutants of concern that may be associated with such activities and for which an approved TMDL has been developed;
- 2) Coal mining and/or processing operations that directly discharge to or propose to directly discharge to a receiving water body that has been designated as Cold Water Aquatic Habitat (CAH) as listed in Table C of 401 KAR 10:026, Section 5;
- 3) Coal mining and/or processing operations that directly discharge to or propose to directly discharge to a receiving water body that has been designated as an Outstanding State Resource Water (OSRW) due its support of a federally listed Threatened or Endangered Species as listed in Table C of 401 KAR 10:026, Section 5;
- 4) Coal mining and/or processing operations that directly discharge to or propose to directly discharge to a receiving water body that has been categorized as an Outstanding National Resource Water (ONRW) as listed in 401 KAR 10:030, Section 1;
- 5) New or expanded coal mining and/or processing operations that propose to discharge within five (5) miles upstream of any existing domestic water supply intake listed in 401 KAR 10:026, Section 5(2)(b) Table B;
- 6) Coal mining and processing activities that KDOW has determined would be more appropriately addressed by an individual permit or an alternate general permit;
- 7) KYGW40000 adds the eligibility condition that they do not have a continuous discharge, which is defined as a discharge that occurs without interruption or has an average discharge duration of 96 hours or more.

9.4.4.3 *Monitoring*

General and Individual Permits require monthly monitoring for the effluent characteristics in Table 9.3. In-stream monitoring and trend sampling are required for new or expanded in-stream outfalls in eastern Kentucky, and for all outfalls in western Kentucky that discharge to a receiving stream that is impaired for Conductivity. Whole Effluent Toxicity (WET) testing is required for in-stream structures.

Whole Effluent Toxicity Testing. WET testing is performed by exposing live representative macroinvertebrates and/or fishes to effluent water in a laboratory setting to determine the toxic effects of the effluent on aquatic life, if any. WET testing is done quarterly. The Acute WET test requirements consist of two 48-hour static non-renewal toxicity tests (the same test water is used throughout) with water flea (*Ceriodaphnia dubia*, *Daphnia magna*, or *Daphnia pulex*) and two 48-hour static non-renewal toxicity tests with fathead minnow (*Pimephales promelas*) performed on discrete grab samples of 100% effluent, including maintaining control organisms which are not exposed to the effluent. Methods must comply with Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, EPA-821-R-02-012 (5th edition), the

most recently published edition of this publication, or another method approved in advance by KDOW.

Trend Sampling. After discharge commences, additional annual physiochemical and biological sampling is required to determine trends; this sampling continues to reclamation status. Trend sampling involves both quarterly and annual monitoring, see Tables 9.4 and 9.5.

Table 9.4 Quarterly Instream Monitoring Frequency and Limitations

Instream Characteristic	Units	Minimum	Monthly Average	Daily Maximum	Maximum	Frequency	Sample Type
Flow	MGD	N/A ⁽¹⁾	Report	Report	N/A	1/Quarter	Instantaneous
Total Suspended Solids	mg/l	N/A	Report	Report	N/A	1/Quarter	Grab
Specific Conductivity	µS/cm	N/A	Report	Report	N/A	1/Quarter	Grab
Total Sulfate (as SO ₄)	mg/l	N/A	Report	Report	N/A	1/Quarter	Grab

⁽¹⁾ N/A: Not Applicable

Table 9.5 Annual Instream Monitoring Frequency and Limitations

INSTREAM MONITORING REQUIREMENTS							MONITORING REQUIREMENTS	
Instream Characteristic	STORET Code	Units	Minimum	Monthly Average	Daily Maximum	Maximum	Frequency	Sample Type
Flow	00061	MGD	N/A	Report	Report	N/A	1/Year	Instantaneous
Total Suspended Solids	00530	mg/l	N/A	Report	Report	N/A	1/Year	Grab
Total Recoverable Iron	00980	mg/l	N/A	Report	Report	N/A	1/Year	Grab
pH	00400	SU	Report	N/A	N/A	Report	1/Year	Grab
Specific Conductivity	00095	µS/cm	N/A	Report	Report	N/A	1/Year	Grab
Total Sulfate (as SO ₄)	00945	mg/l	N/A	Report	Report	N/A	1/Year	Grab
Total Recoverable Selenium	00981	µg/l	N/A	Report	Report	N/A	1/Year	Grab
Turbidity	00070	NTU	N/A	Report	Report	N/A	1/Year	Grab
Alkalinity (as CaCO ₃)	00410	mg/l	N/A	Report	Report	N/A	1/Year	Grab
Dissolved Oxygen	00300	mg/l	Report	N/A	N/A	N/A	1/Year	Grab
Temperature	00011	°F	N/A	Report	Report	N/A	1/Year	Grab
Total Hardness (as CaCO ₃)	00900	mg/l	N/A	Report	Report	N/A	1/Year	Grab

INSTREAM MONITORING REQUIREMENTS							MONITORING REQUIREMENTS	
Instream Characteristic	STORET Code	Units	Minimum	Monthly Average	Daily Maximum	Maximum	Frequency	Sample Type
Biological Index Score ¹		None	XX ²	Report	Report	N/A	1/Year	Grab
¹ See Section 7.5 of the permit for more information regarding this stream characteristic and the sampling requirement.								
² Category minimum (See the Background Biological Conditions Table of the permit)								

Effluent Monitoring. Each discharge is subject to effluent monitoring. Effluent monitoring parameters are determined by the type of discharge; mine drainage (influent) to the treatment system (ponds) can be either acid or alkaline. 401 KAR 5:065, Section 2(9) and 40 CFR 434.11 define alkaline drainage as having pH ≥ 6.0 and total recoverable iron less than 10.0 mg/L. However, within the KPDES permitting program, the default assumption is that discharge consists of acid mine drainage, which has pH < 6.0 or total recoverable iron greater than 10.0 mg/L.

Table 9.6 shows the Effluent Limitations and Monitoring Requirements for instream or continuous flow sediment control structures in the eastern and western coal fields.

Table 9.6 Effluent Limitations and Monitoring Requirements

KPDES Outfalls								
EFFLUENT LIMITATIONS							MONITORING REQUIREMENTS	
Effluent Characteristic	STORET Code	Units	Minimum	Monthly Average	Daily Maximum	Maximum	Frequency	Sample Type
Flow	50050	MGD	N/A	Report	Report	N/A	2/Month	Instantaneous
Total Suspended Solids ¹	00530	mg/L	N/A	35	70	N/A	2/Month	Grab
Total Recoverable Iron	00980	mg/L	N/A	3.0	4.0	N/A	2/Month	Grab
Total Recoverable Manganese ¹	11123	mg/L	N/A	2.0	4.0	N/A	2/Month	Grab
pH	00400	SU	6.0	N/A	N/A	9.0	2/Month	Grab
Chronic WET ²	TT000	TU _C	N/A	N/A	N/A	1.00	1/Quarter	(²)
Specific Conductivity	00095	μS/cm	N/A	Report	Report	N/A	2/Month	Grab
Total Sulfate (as SO ₄)	00945	mg/L	N/A	Report	Report	N/A	2/Month	Grab
Total Recoverable Selenium	00981	μg/L	N/A	5.0 ³	20	N/A	2/Month	Grab
Total Recoverable Selenium (Fish Tissue)	01148	mg/Kg dry weight	N/A	N/A	N/A	8.6	(³)	(³)
Precipitation Volume	79777	Inches	N/A	N/A	N/A	Report	(⁴)	Grab

KPDES Outfalls								
EFFLUENT LIMITATIONS							MONITORING REQUIREMENTS	
Effluent Characteristic	STORET Code	Units	Minimum	Monthly Average	Daily Maximum	Maximum	Frequency	Sample Type
¹ See Section 4 of the permit for alternate monitoring and effluent limitations available for a qualifying precipitation event (for subsurface mines, this applies only to combined flows, which are those combining two or more types of drainage, i.e., groundwater discharge with surface water discharge). ² See Section 3 of the permit for additional requirements related to WET Testing including sampling requirements. ³ Should the monthly average concentration of total recoverable selenium exceed 5.0 µg/L; see Section 2.9 of the permit for additional requirements. ⁴ Precipitation volume required only when applying for APELs(Alternate Precipitation Effluent Limits), which are authorized by the coal ELGs (Effluent Limit Guidelines) and are alternate limits and monitoring requirements on manganese and total suspended solids effective during high precipitation events; APELs will be considered on a case-by-case basis for surface mines and underground mines with comingled discharge.								

Table 9.7 shows the Effluent Limitations and Monitoring Requirements reclamation areas in the eastern and western coal fields.

Table 9.7 Effluent Limitations and Monitoring Requirements

KPDES Outfalls								
EFFLUENT LIMITATIONS							MONITORING REQUIREMENTS	
Effluent Characteristic	STORET Code	Units	Minimum	Monthly Average	Daily Maximum	Maximum	Frequency	Sample Type
Flow	50050	MGD	N/A	Report	Report	N/A	2/Month	Instantaneous
Settleable Solids ¹	00530	mg/L	N/A	N/A	N/A	0.5	2/Month	Grab
pH	00400	SU	6.0	N/A	N/A	9.0	2/Month	Grab
Specific Conductivity	00095	µS/cm	N/A	Report	Report	N/A	2/Month	Grab
Total Sulfate (as SO ₄)	00945	mg/L	N/A	Report	Report	N/A	2/Month	Grab
Precipitation Volume	79777	Inches	N/A	N/A	N/A	Report	(²)	Grab
¹ See Section 4 of the permit for alternate monitoring and effluent limitations available for a qualifying precipitation event (for subsurface mines, this applies only to combined flows, which are those combining two or more types of drainage, i.e., groundwater discharge with surface water discharge). ² Precipitation volume required only when applying for APELs, which are authorized by the coal ELGs and are alternate limits and monitoring requirements on manganese and total suspended solids effective during high precipitation events; APELs will be considered on a case-by-case basis for surface mines and underground mines with comingled discharge.								

10.0 Public Participation

This TMDL will be published for a 30-day public comment beginning November 10, 2016 and ending December 10, 2016. A notification will be sent to all newspapers in the Commonwealth of Kentucky and an advertisement will be purchased in the local newspapers. Additionally, the public notice will be distributed electronically through the ‘Nonpoint Source Pollution Control’ mailing list (<http://water.ky.gov/nsp/Pages/MailingList.aspx>) of persons interested in water quality issues, and be emailed to the TMDL Listserv, which is a list of persons interested in TMDL-related issues.

Comments received during the public notice period will be incorporated into the administrative record for this TMDL. Revisions will be made to the final TMDL report.

11.0 References

- 33 U.S.C. § 1362, Clean Water Act, Definition. 1972.
- 40 CFR 434.11. General Definitions. 2013.
- 401 KAR 5:002. Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water. 2005.
- 401 KAR 5:005. Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water. 2005.
- 401 KAR 5:037. Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water. 2005.
- 401 KAR 5:065. Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water. 2005.
- 401 KAR 5:070. Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water. 2005.
- 401 KAR 10:001. Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water. 2005.
- 401 KAR 10:026. Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water. 2005.
- 401 KAR 10:031. Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water. 2005.
- American Public Health Association, American Waterworks Association, Water Environment Federation. 2012. Standard Methods for the Examination of Water and Wastewater, 22nd Edition, Laura Bridgewater, Editor. American Public Health Association. Washington, DC.
- Balintova, Magdalena, Aneta Petrilakova. 2011. Study of pH Influence on Selective Precipitation of Heavy Metals from Acid Mine Drainage (Unpublished). Technical University of Kosice, Kosice, Slovakia. Accessed at <http://www.nt.ntnu.no/users/skoge/prost/proceedings/pres2011-and-icheap10/PRES11/217Balintova.pdf>.
- Balintova, Magdalena, Aneta Petrilakova, Eva Singovszka. 2012. Study of Metals Distribution Between Water and Sediment in the Smolnik Creek (Slovakia) Contaminated by Acid Mine Drainage. Chemical Engineering Transactions, Vol. 28, 2012. The Italian Association of Chemical Engineering. Accessed at <http://www.aidic.it/cet/12/28/013.pdf>.

Costello, C., 2003, Acid Mine Drainage: Innovative Treatment Technologies, US EPA Office of Solid Waste and Emergency Response Technology Innovation Office, Washington, D.C. (2003) 52 pp.

Friends of the Earth, Inc., v. EPA, *et al.* No 05-5015 (D.C. Cir 2006). Decision on the Anacostia River TMDL.

Greb, Stephen F., Williams, David A., Williamson, Allen D. 1992. Geology and Stratigraphy of the Western Kentucky Coal Field. Bulletin 2, Series XI, Kentucky Geological Survey. ISSN 0075-559. University of Kentucky. Lexington, KY.

Hach. 2014. Application – Water Hardness Guide. Accessed 1/24/14 at <http://www.hach.com/hardnessguide>.

Hedin, R.S., D.H. Dvorak, S.L. Gustafson, D.M. Hyman, P.E. McIntire, R.W. Naim, R.C. Neupert, A.C. Woods, H.M. Edenborn. 1991. Final Report: Use of a Constructed Wetland for the Treatment of Acid Mine Drainage at the Friendship Hill National Historic Site, Fayette County, Pennsylvania. US. Bureau of Mines. Pittsburgh, Pennsylvania.

Jacobsen, Russell L. 1993. Coal Resources of the Dekoven and Davis Members (Carbondale Formation) in Gallatin and Saline Counties, Southeastern Illinois. Illinois State Geological Survey. Department of Energy and Natural Resources. Champaign, IL. Accessed at http://www.academia.edu/4965416/Coal_resources_of_the_Dekoven_and_Davis_Members_Carbondale_Formation_in_Gallatin_and_Saline_Counties_southeastern_Illinois.

Kentucky Department for Environmental Protection. 2004. Kentucky Guidance for Ambient Background Assessment. <http://waste.ky.gov/SFB/Documents/AmbientBackgroundAssessment.pdf>

Kentucky Division of Water. 2003. Total Maximum Daily Load pH (H⁺ Ion Mass), Craborchard Creek Watershed. TMDL Section, Frankfort, Kentucky. December, 2003.

Kentucky Division of Water. 2006. Final pH (H⁺ Ton Mass) Total Maximum Daily Load (TMDL) for Beech Creek Watershed. TMDL Section, Frankfort, Kentucky. December, 2006.

Kentucky Division of Water. 2007. Final pH (H⁺ Ton Mass) Total Maximum Daily Load (TMDL) for Pond Creek of Green River Watershed. TMDL Section, Frankfort, Kentucky. December, 2007.

Kentucky Division of Water. 2010. 2012 303(d) List of Impaired Waters; 2010 Integrated Reports to Congress on Water Quality in Kentucky. Water Quality Branch, Frankfort, Kentucky.

Kentucky Division of Water. 2014. 2012 303(d) List of Impaired Waters; 2014 Integrated Reports to Congress on Water Quality in Kentucky. Water Quality Branch, Frankfort, Kentucky.

Kentucky Geologic Survey. 2004. kyvector.SDE.KGS_GQ_FORMATIONS_24K shapefile. Kentucky Geological Survey, Geospatial Analysis Section, Digital Mapping Team. Sparks, Thomas N., Crawford, Matt M.

Kentucky Geological Survey. 2014. Coal Quality Database. Accessed 2/14/2014 at <http://kgs.uky.edu/kgsweb/DataSearching/coalsearch.asp>.

KRS 224.71-100 through 224.71-145. Kentucky Agriculture Water Quality Act. 1994.

Kirby, Carl S., Charles A. Cravotta III. 2005. Net Alkalinity and Net Acidity 2: Practical Considerations. Applied Geochemistry 20 (2005) 1941-1964. Elsevier Press, available at http://mine-drainage.usgs.gov/pubs/cravotta/ApGeoch_1941-1964.pdf.

Lloyd, J. W., Heathcote, J. A., 1985. Natural Inorganic Chemistry in Relation to Groundwater. Clarendon, Oxford, 296 pp.

Milanco Industrial Chemicals, Fundamentals of pH. 2014. Accessed 4/15/2014 at <http://www.milanco.com/training/fundamen.htm>.

Morel F, Hering J. 1993. Principles and Applications of Aquatic Chemistry. John Wiley, New York, NY, USA, 588pp.

NLCD 2011. National Land Cover Database 2011 Legend. Available at URL: http://www.mrlc.gov/nlcd11_leg.php

Snoeyink, V.L., D. Jenkins 1980. Water Chemistry. Wiley, Inc. New York.

[Strahler, A. N.](#) 1952. Hypsometric (Area-Altitude) Analysis of Erosional Topology. Geological Society of America Bulletin 63 (11): 1117–1142.

Stumm W, Morgan JJ. 1996, Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters, third edition, New York: Wiley Interscience, 1022 pp.

U.S. Department of Agriculture, 2007. National Agricultural Statistics Service. 2007 Census of Agriculture. Accessed April 16, 2014 at URL <http://www.nass.usda.gov/census/>.

United States Department of Agriculture, National Resource Conservation Service. 2009. Part 630 Hydrology in National Engineering Handbook. Chapter 7: Hydrologic Soil Groups. Available at URL <http://policy.nrcs.usda.gov/>.

United States Environmental Protection Agency (EPA). 1986. Quality Criteria for Water. Office of Water Regulations and Standards. Washington, DC.

United States Environmental Protection Agency. 1982. Development Document for Final Effluent Limitations Guidelines and Standards for the Coal Mining Point Source Category. Effluent Guidelines Division. Office of Water. EPA WH-552. Washington, DC.

United States Environmental Protection Agency. 2008. Introduction to Total Maximum Daily Loads. Accessed at <http://www.epa.gov/owow/tmdl/intro.html>.

U.S. Environmental Protection Agency (EPA). 2014a. NPDES Glossary. Accessed 1/30/2014 at <http://cfpub.epa.gov/npdes/glossary.cfm#M>.

U.S. Environmental Protection Agency (EPA). 2014b. Abandoned Mine Drainage. Accessed 1/30/2014 at http://water.epa.gov/polwaste/nps/acid_mine.cfm.

United States Geological Survey. Unpublished. Kentucky Stream Reach Drainage Polygons shapefile. USGS - Kentucky Water Science Center. Available at <ftp://ftp.kymartian.ky.gov/usgs/kyhydro polys.zip>.

West Virginia University. 2014. Overview of Acid Mine Drainage Treatment With Chemicals. Morgantown, West Virginia. Accessed at http://anr.ext.wvu.edu/land_reclamation/acid-mine-drainage/chemical_treatment.

World Health Organization. 2003. Hardness in Drinking Water. Available at http://www.who.int/water_sanitation_health/dwq/chemicals/en/hardness.pdf.

Woods, A. J., J. M. Omernik, W. H. Martin, G. J. Pond, W.M Andrews, S. M. Call, J.A Comstock, and D. D. Taylor. 2002. Ecoregions of Kentucky (2 sided color poster with map, descriptive text, summary tables, and photographs): Reston, VA, US Geological Survey (map scale 1:1,000,000).

Wurts, William A., and Peter W. Perschbacher. Effects of Bicarbonate Alkalinity and Calcium on the Acute Toxicity of Copper to Juvenile Channel Catfish. *Aquaculture* 125 (1994) 73-79. Elsevier Press, available at <http://www2.ca.uky.edu/wkrec/AlkalinityCopperToxicity.pdf>.

Appendix A Land Cover Definitions (NLCD2011)

11. **Open Water** - areas of open water, generally with less than 25% cover of vegetation or soil.
12. **Perennial Ice/Snow** - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
21. **Developed, Open Space** - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22. **Developed, Low Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23. **Developed, Medium Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24. **Developed, High Intensity** - highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
31. **Barren Land (Rock/Sand/Clay)** - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
41. **Deciduous Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
42. **Evergreen Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
43. **Mixed Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
51. **Dwarf Scrub** - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
52. **Shrub/Scrub** - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
71. **Grassland/Herbaceous** - areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
72. **Sedge/Herbaceous** - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
73. **Lichens** - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.

74. **Moss** - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.

81. **Pasture/Hay** - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.

82. **Cultivated Crops** - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

90. **Woody Wetlands** - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

95. **Emergent Herbaceous Wetlands** - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Appendix B Division of Mine Permits Numbering System

XXXX-XX Permit issued prior to May 3, 1978. Ex. 1357-76. The first four numbers represent the mine number. The last two numbers represent the year of issuance.

XXX-XXXX Permit issued after Ma/*0y 3, 1978. The first three numbers indicate the location of the mine by county and the timing of the original permit issuance.

If the first three numbers correspond to the county number, the permit was originally issued during the interim program.

If 200 has been added to the county number, the permit was originally issued prior to May 3, 1978, and carried through into the interim program.

If 400 has been added to the county number the permit was issued prior to the Permanent Program and was to remain active after January 18, 1983.

If 800 has been added to the county number: (1) the application is for a permit after January 18, 1983 or (2) two or more previously permitted areas have been combined into a single permit.

The last four numbers indicate the type of mining activity being permitted:

COAL

0000-4999	Surface Mining
5000-5999	Underground Mine
6000-6999	Crush/Load Facility
7000-7999	Haul Road Only
8000-8999	Preparation Plant
9000-9399	Refuse Disposal

NON COAL

9400-9499	Limestone
9500-9599	Clay
9600-9699	Sand/Gravel
9700-9799	Oil Shale
9800-9899	Fluorspar