Total Maximum Daily Load (TMDL) Development

- pH (H^+ Ion Mass) -

For

Pleasant Run Watershed

(Hopkins County, Kentucky)

Kentucky Department for Environmental Protection

Division of Water

Frankfort, Kentucky

December 2003

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This report has been approved for release:

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Jeffrey W. Pratt, Director

Division of Water

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Date

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List of Contributors

Dr. Lindell Ormsbee
Emily Zechman

Department of Civil Engineering
University of Kentucky, Lexington, Kentucky 40506-0281

Table of Contents

List of Figures and Tables

Figures **Page**

Tables **Page**

Pleasant Run, Kentucky

TMDL Fact Sheet

Project Name: Pleasant Run

Location: Hopkins County, Kentucky

Scope/Size: Pleasant Run, watershed 8054.5 acres (12.59 mi^2)
The listed segment is from river mile 0.0 to 7.9.

Land Type: Forest, agricultural, barren/spoil

Type of Activity: Acid Mine Drainage (AMD) caused by Strip/Abandoned Mines

Pollutant(s): **H^+ Ion mass,** Sulfuric Acid

TMDL Issues: Non-point sources

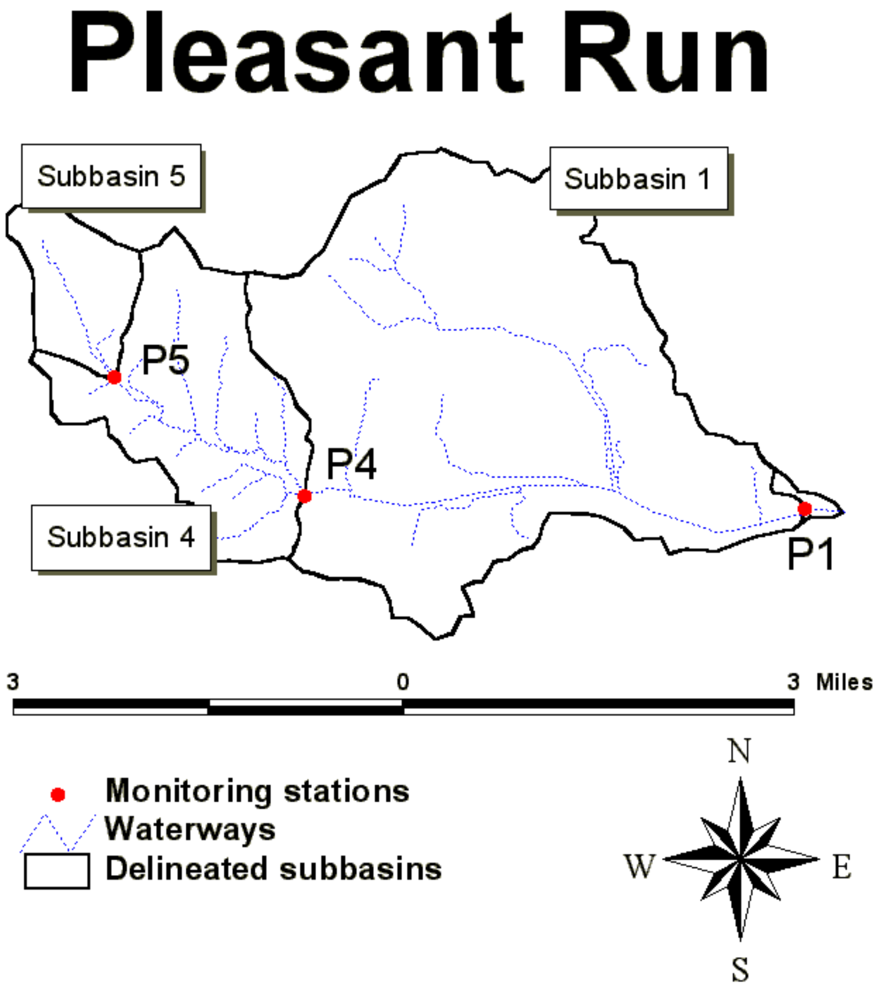
Water Quality Standard/Target: pH shall not be less than six (6.0) or more than nine (9.0) and shall not fluctuate more than one and zero-tenths (1.0) pH unit over a 24-hour period. This standard is found within regulation 401 KAR 5:031.

Data Sources: KPDES Permit Historical Sampling Data, Murray State University Sampling Data

Control Measures: Kentucky non-point source TMDL implementation plan, Kentucky Watershed Framework

Summary: Pleasant Run was determined as not supporting the designated uses of primary and secondary contact recreation (swimming and wading), and warm water aquatic habitat (aquatic life). Therefore, the creek was placed on the 1996 and subsequent 303(d) lists for Total Maximum Daily Load (TMDL) development. The creek segment is characterized by a depressed pH, the result of acid mine drainage from strip and abandoned mining sites. The period of lowest pH is at low-flow conditions; however, the period of greatest hydrogen ion load has been determined at a critical flow condition for selected subbasins of Pleasant Run. For pH violations on such streams, the Kentucky DOW has determined that maximum

daily mean flow having a 3-year exceedance frequency be used for setting the appropriate TMDL and associated loading reduction. However, for this TMDL the critical flow was defined from the observed data. This flow will be used for this TMDL.



TMDL Development: Total maximum daily loads in grams H^+ ions per day were computed based on the allowable minimum pH value (6.0) for creeks and streams with recreation and aquatic life designated uses. The TMDL was calculated for grams of ions (subsequently converted to pounds per day) because the units for pH do not allow for the computation of a quantitatively useful load or reduction amount.

Total TMDL for Pleasant Run = 0.207 lbs H+ Ions/day				
	Critical Incremental Flow Rate (cfs)	Incremental TMDL for a pH of 6.0 (lbs/day)	Predicted Maximum Incremental Load (lbs/day)	Incremental Reduction Needed (lbs/day)
Subbasin 1	29.30	0.178	39.69	39.52
Subbasin 4	3.40	0.020	64.76	64.74
Subbasin 5	1.30	0.008	24.76	24.75
Total	34.00	0.207	129.22	129.01

Permitting in the Pleasant Run Watershed: All of the streams in the watershed are considered to be impaired for low pH based on the available data.

New and Reissued Permits: New permits (except for new remining permits) and reissued permits for discharges to streams in the Pleasant Run Watershed could be allowed anywhere in the watershed, contingent upon the end-of-pipe pH being permitted at a range of 7.0 to 9.0 standard units. Water quality standards state that for meeting the designated uses of aquatic life and swimming, the pH value should not be less than 6.0, nor greater than 9.0. This range of 6.0 to 9.0 for pH is generally the value assigned for end-of-pipe effluent limits. However, because a stream impairment exists (low pH), new discharges can not cause or contribute to an existing impairment. A pH of 7.0 represents a neutral state between an acidic and a non-acidic condition. As such, a discharge having a pH of 7.0 to 9.0 standard units will not cause or contribute to the existing impairment. The discharge will not cause an impairment because the effluent discharge has a pH greater than 6.0 standard units. The discharge will not contribute to the existing impairment because a pH of 7.0 represents a neutral condition with respect to acidity and effectively represents a background condition. The hydrogen ion load associated with a pH of 7.0 is insignificant (effectively zero) and therefore does not represent a contribution to the existing impairment. As such, new permits and reissued permits specifying an effluent limit pH of 7.0 to 9.0 would not be assigned a hydrogen ion load as part of a Waste Load Allocation.

There is only one active Kentucky Pollutant Discharge Elimination System (KPDES) permit in the Pleasant Run Watershed. The permit (KY0067121) is issued to Charolais Corporation. Mining has not been initiated under this permit. The KPDES permit includes an outfall that will receive flow from a disturbed area of 5 acres. The discharge from the permitted outfall will enter an unnamed tributary to Pleasant Run that drains to the site at P4. Because mining has not been initiated, there is currently not a discharge from the outfall that is defined in the permit. The KPDES permit will expire on May 31, 2005. At the time of reissuance of the KPDES permit, any discharge points draining to streams in the Pleasant Run Watershed would need to meet the criteria for new and reissued permits as described previously (an end-of-pipe pH of 7.0 to 9.0).

Remining Permits: New remining permits may be approved on a case-by-case basis where streams are impaired because of low pH from abandoned mines. Permit approval is contingent on reclamation of the site after remining activities are completed. During remining, existing conditions of the water coming from the site must be maintained or improved. Reclamation of the site is the ultimate goal, but water quality standards (pH of 6.0 to 9.0 standard units) may not necessarily be met in the interim if the Commonwealth issues a variance to the discharger as defined by 401 Kentucky Administrative Regulation (KAR) 5:029. In instances where the Commonwealth issues a variance for a remining activity consistent with this regulation, hydrogen ion loads from this remining activity are allowed to exceed the waste load allocation. The variance allows an exception to the applicable water quality standard as well as the TMDL. Remining therefore constitutes a means whereby a previously disturbed and unreclaimed area can be reclaimed. The authority for remining is defined in Section 301(p) of the Federal Clean Water Act; Chapter 33, Section 1331(p) of the U.S. Code – Annotated (the Rahall Amendment to the Federal Clean Water Act); and the Kentucky Administrative Regulations (401 KAR 5:029 and 5:040). The eventual reclamation of the remining site should result in a reduction of the overall ion load (specifically the nonpoint source load) of the subbasin where the remining was done. The reclamation should therefore result in an improved stream condition (increased pH) because a previously disturbed unreclaimed area will be reclaimed. Follow-up, in-stream monitoring would need to be done at the subbasin outfall to determine the effect of reclamation activities (following remining) on the overall ion load coming from the subbasin. This constitutes a phased TMDL, where a remedial measure (reclamation at the end of remining) would then need to be followed by in-stream monitoring to see how well the remedial measure did in improving the low pH condition for that subbasin. There are currently no active remining permits in the Pleasant Run watershed.

Distribution of Load: Because there were no point source discharges during the study period (and at this time there are still no point source discharges, but one has been permitted), the existing Hydrogen Ion load for the watershed was defined entirely as a load allocation and that is what is reflected in the TMDL table. Because new permits (pH 7.0 to 9.0) would not cause or contribute to the existing impairment and remining permits would be exempt from the TMDL requirements, no load has been provided for the waste load allocation category. Therefore, the table below allocates all of the load to the load allocation category. New and reissued permits having a minimum pH effluent limit of 7.0, and new remining permits with modified effluent limits for pH essentially represent no net change in conditions in the subwatershed with respect to pH.

Waste Load and Load Allocation for Each Subbasin in the Pleasant Run Watershed

	Critical Flow Rate (cfs)	TMDL for pH = 6.0 (lbs/day)	Waste Load Allocation (lbs/day)	Load Allocation (lbs/day)
Subbasin 1	29.30	0.178	0.000	0.178
Subbasin 4	3.40	0.020	0.000	0.020
Subbasin 5	1.30	0.008	0.000	0.008

Implementation/ Remediation Strategy: Remediation of pH-impaired streams as a result of current mining operations is the responsibility of the mine operator. The Kentucky Division of Field Services of the Kentucky Department of Surface Mining Reclamation and Enforcement (DSMRE) is responsible for enforcing the Surface Mining Control and Reclamation Act of 1977 (SMCRA). No governmental entity bears the responsibility to remediate pH-impaired streams as a result of pre-law mining operations or mining operations associated with forfeited reclamation bonds. The Kentucky Division of Abandoned Mine Lands (KDAML) is charged with performing reclamation to address the impacts from pre-law mine sites in accordance with priorities established in SMCRA. SMCRA sets environmental problems as third in priority in the list of AML problem types. Just recently, 319 funding (specifically Clean Water Action Plan funds) has been awarded to the KDAML, which is part of the DSMRE. This grant is the Homestead Refuse Reclamation Project and includes reclamation of most of the area above site P5 that lies to the west of Pleasant Run (the western slope). The project also includes reclamation in the eastern portion of the adjacent watershed to the west of Pleasant Run, which is the Fox Run watershed. Therefore, the project area includes the eastern slope of the upper Fox Creek watershed, the western slope of the Pleasant Run watershed upstream from site P5, and the ridgeline between the two watersheds. The project involves a 92-acre area. The total cost of the reclamation project is $1.26 Million, of which 60% is federal funds and 40% is supplied by the KDAML. The project includes grade work of coal refuse fills to eliminate gullies and redirect drainage. The area will then be capped with an agricultural limestone barrier and 2 feet of top soil and will then be revegetated. This approach is very similar to what was done in the Brier Creek watershed described below. Also, three other AML projects have been performed in the Pleasant Run drainage area: Pleasant Run, Pleasant Run II and Pleasant Run - Area 5. The projects were conducted in 1986 - 1987 at a combined cost of approximately $2.6 million and resulted in the reclamation of 274 acres. The work involved covering coal refuse, grading strip mine spoil, eliminating impoundments, and establishing a vegetated cover for the project areas.

Reclamation activities are also underway at other locations within the state where water quality is affected by acid mine drainage (AMD). The success of the reclamation activities in these watersheds was to be evaluated before developing remediation strategies for other watersheds affected by AMD. The KDAML developed a reclamation project in response to documented sedimentation and flooding problems in the nearby Brier Creek Watershed. The project included reclamation of approximately 120 acres of barren or poorly vegetated areas affected by past strip mining. The project also entailed six acres of channel restoration to minimize sedimentation caused by erosion. The restoration of streams included construction of ditches and PVC coated gabion baskets utilized as velocity reducers and energy dissipaters; bale silt checks and silt trap dugouts were also utilized for sediment control. The reclamation project consisted of 67 acres of gradework to remove erosion gullies, redistribute sediment deposits, and prepare a surface to receive a soil cover. The area under consideration received a two foot soil cover layer, taken from 20 acres of watershed area designated for borrow. Gradework areas were treated with an application of agricultural limestone to neutralize acidic conditions and all areas were revegetated using a combination of seedbed preparation, agricultural limestone, fertilizer, seed, mulch, and crimping. The agricultural limestone provided a variety of particle sizes so that it dissolved at different rates and mobilized under a range of flow conditions. The strategy employed at Brier Creek is similar in some respects to a project that is currently underway on Rock Creek and a tributary, White Oak Creek in McCreary County, Kentucky. This 12-acre project is also funded as a Clean Water Action Plan. It involves the removal of coal refuse from the banks of Rock Creek, the establishment of a vegetative cover on other refuse areas in the watershed, and the application of limestone sand at selected locations to neutralize the effects of AMD.

The total cost for the Brier Creek project was $913,000.00 (i.e. $7600/acre) while the total cost of the Rock Creek project is estimated to be approximately $650,000 (i.e. $54,200/acre). For 2000, the total federal KDAML budget allocation was approximately $17 million. However the bulk of these funds were used to support priority 1 (extreme danger of adverse effects to public health, safety, welfare, and property) and priority 2 (adverse effects to public health, safety, and welfare) projects. Based on the cost of current remediation efforts, it would appear that a significant increase in federal funding to AML projects, particularly priority 3 projects, would be required in order for the AML program to play a significant part in meeting the TMDL implementation requirement associated with pH impaired streams in the state of Kentucky.

Introduction

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for their water bodies that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions. This method exists so that states can establish water-quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991a). This report provides the TMDL for Pleasant Run.

Location

The Pleasant Run watershed is entirely contained within Hopkins County, in southwestern Kentucky (Figure 1). Hopkins County is bounded on the northeast by the Green River, on the east by the Pond River, and on the west by the Tradewater River.

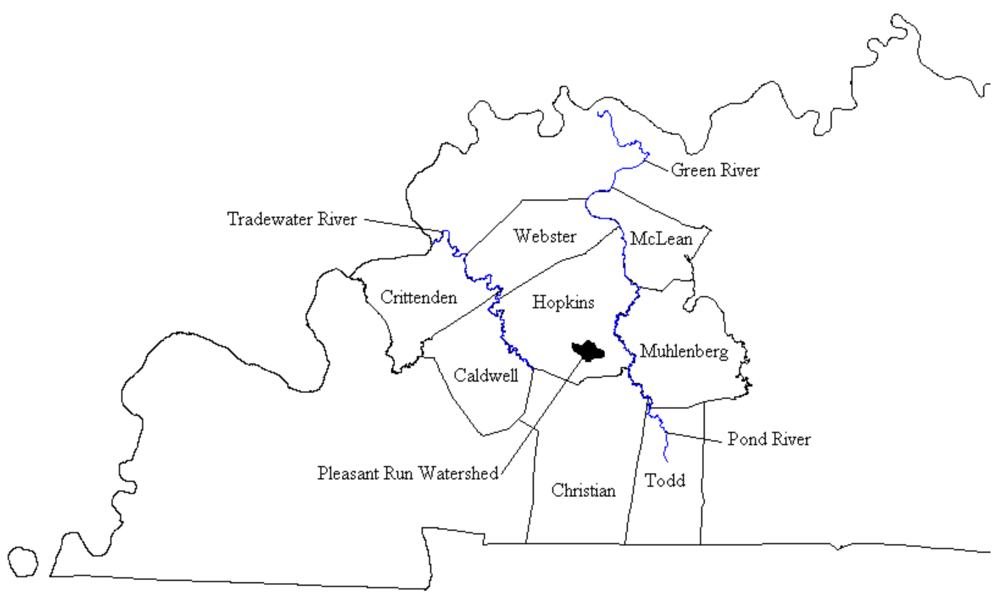


Figure 1. Location of the Pleasant Run Watershed

Hydrologic Information

Pleasant Run, a third order stream, originates in central Hopkins County and flows east to discharge into Drakes Creek 13.9 km (8.6 miles) upstream from its confluence with the Pond River (Figure 2). The Pond River and the Mud River discharge into the Green River, which carries the runoff northward into the Ohio River.

Pleasant Run's mainstem is approximately 12.7 km (7.9 miles) long and drains an area of 8054.5 acres (12.59 square miles). The average gradient is 35.5 feet per mile. Elevations for Pleasant Run range from 214 m (700 ft) above mean sea level (msl) in the headwaters to 122 m (400 ft) above msl at the mouth. Like most of the smaller watersheds, many of the tributary streams are intermittent.

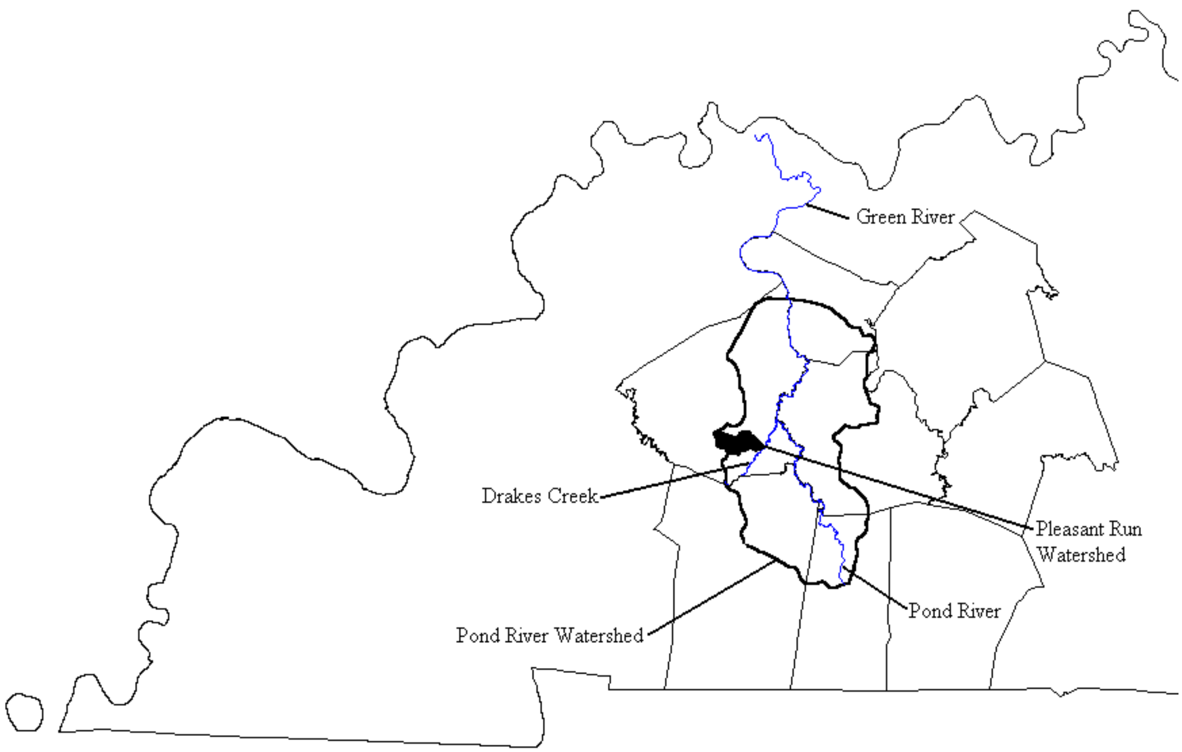


Figure 2. Pond River Watershed, 8-digit HUC 05110006.

Geologic Information

The Pleasant Run watershed is in the Western Coal field physiographic region. The surface bedrock is of Pennsylvanian age. Formations of the Pennsylvanian age are mostly sandstone, siltstone, coal, and interbedded limestone and shale; alluvial deposits of siltstone and crossbedded sand or sandstone underlie the extensive lowland areas (USDA, 1977). The relief of the Pleasant Run watershed ranges from nearly level to steep. Gently sloping to steep soils are found in the uplands and nearly level soils are found on the floodplain.

Landuse Information

Coal, oil, and natural gas are among the natural resources of Hopkins County. The Pleasant Run watershed contains two main landuses: resource extraction (mining and disturbed land area) and agriculture.

Soils Information

The Pleasant Run watershed consists of acidic silt loam. The soils near the mouth of Pleasant Run are materials washed from loess, sandstone, and shale, formed in acidic alluvium. At the headwaters, the subsurface consists of weathered acidic sandstone and shale covered by a thin layer of loess.

Mining History

Mining activities in the Pleasant Run Watershed have occurred since 1970. A list of the various mining permits that have been issued for Pleasant Run is provided in Table 1. Mining 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). An explanation of the permit numbering system is provided in Appendix A (at the back of the report).

Table 1. Recent Mining Permits in the Pleasant Run Watershed

Permit	Beginning Date	Release Date	Permitted Area (ac)	Disturbed Area (ac)*	Associated Company
2036-69	6/29/70	10/31/72	10	Not in SMIS	S&W Coal Co.
2036-70	1/9/71	5/19/80	15	Not in SMIS	Weskol Mining Co., Inc.
2628-71	12/15/71	1/11/73	21	Not in SMIS	Bedford Coal Co.
2808-72	1/30/73	9/30/81	0	14	Hamby Mining Co.
3646-74	1/14/75	-	2	3	Otis Bennet Coal Co.
2839-73	1/23/74	-	70	18	Cyclone Coal Corp.
3142-73	5/20/74	-	20	7	W&H Mining Co.
3272-74	8/19/74	8/17/82	0	16	Wiser Coal Co
3390-74	10/11/74	7/7/77	10	Not in SMIS	Jim Whitaker & Son
3589-74	12/9/74	1/3/84	0	20	Sextet Mining Co.
5508-76	3/10/77	-	20	20	B&H Coal Co.
5735-76	5/20/77	3/7/83	94	33	Valley Mining Co.
254-0343	9/20/77	9/20/81	49	44	TK Jessup Inc.
054-0005	10/3/78	10/03/80	36	36	TK Jessup Inc.
054-0049	7/12/79	7/12/81	15	15	Crook & Hardwick Mining Co.
054-0116	8/28/81	8/28/83	84.4	10 - RC	Margarita Fuels Inc.
054-0118	9/10/81	9/10/83	6	5	BEM Co.
054-0136	5/17/82	5/17/84	99.96	0 - RC	Bituminous Resources Inc.
054-0157	7/13/82	7/13/84	126.8	100 - RC	Charolais Corporation
454-0116	4/27/84	4/27/89	93.8	50 - RC	Margarita Fuels Inc.
454-0136	7/9/84	7/9/94	258	250 - RC	Bituminous Resources Inc.
854-0065	11/5/84	11/5/86	1.55	2 - FF	H&H Mining Co.
854-0164	5/7/92	7/9/94	187.6	187.6 - RC	Charolais Corp.

* SMIS = Surface Mining Information System
RC = Permits Completely Released (Reclaimed)
FF = Final Forfeiture

All permits are secured through reclamation bonds. A reclamation bond is a financial document submitted to the Office of Surface Mining 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 Office of Surface Mining) 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 postmining 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.

Monitoring History

The waters of Pleasant Run were monitored as early as 1978 by the DOW as reported in The Effects of Coal Mining Activities on the Water Quality of Streams in the Western and Eastern Coalfields of Kentucky, published in 1981 by the Kentucky Department for Natural Resources and Environmental Protection as part of an agreement with the Division of Abandoned Lands. The DOW sampled the three unnamed tributaries to Pleasant Run on April 26, 1978. The three streams had pH values of 4.3, 3.5, and 3.2.

The degradation of Pleasant Run is the consequence of acid mine drainage in the watershed as noted by the DOW. In 1970, the first permit was issued to conduct mining operations in the Pleasant Run watershed. Table 1 lists the historical permits that have been opened and released in the Pleasant Run watershed.

Additional monitoring has been performed more recently in the Pleasant Run watershed as permits were granted to mining companies. Several sampling stations were established to monitor the water quality characteristics of the tributaries and mainstem of Pleasant Run in association with mining permits numbers 454-0136, opened in 1984 and 854-0164, opened in 1992. The locations of the sampling stations are shown in Figure 3. A summary of the historic pH readings at these sites is shown in Table 2. As can be seen from the table, most pH readings were well below 6.0.

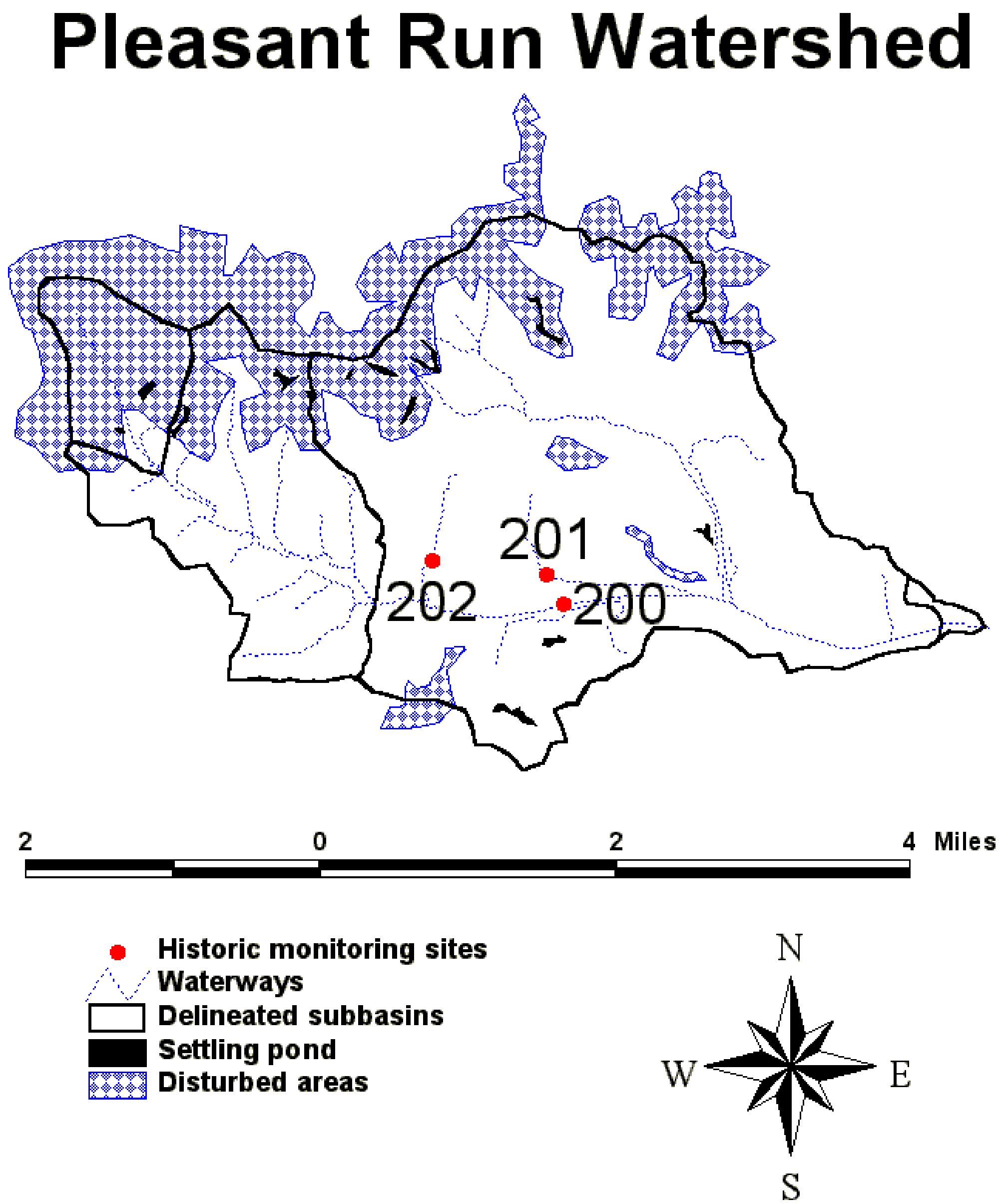


Figure 3. Mining operations and historic sampling sites in the Pleasant Run Watershed

Table 2: Historic Monitoring Data

Date	Station 200		Station 201		Station 202	
	Flow (cfs)	pH	Flow (cfs)	pH	Flow (cfs)	pH
5/12/82	1.2	2.96	0.29	2.76	-	-
6/3/82	3.6	3.09	1.7	3.07	0.29	3.87
7/27/82	0.71	3.00	-	-	-	-
8/13/82	0.16	3.00	-	-	-	-
9/3/82	2.76	2.80	0.75	2.57	-	-
2/19/88	0.1	4.30	0.1	4.50	-	-
3/31/88	1.76	2.33	0.29	2.48	-	-
9/12/88	0.21	3.25	-	-	-	-
12/20/88	0.5	3.68	0.2	3.72	-	-
3/30/89	2.9	3.60	0.17	4.77	-	-
7/18/89	0.4	3.07	0.01	3.28	-	-
8/7/90	0.625	3.53	-	-	-	-
11/20/90	0.18	3.19	-	-	-	-
8/29/91	0.22	2.85	0.17	3.18	-	-
12/16/91	175	3.50	-	-	-	-
1/13/92	3500	3.40	300	3.65	-	-
4/14/92	2.23	3.15	0.55	3.50	-	-
9/11/92	0.22	3.15	0.01	2.80	-	-
12/1/92	0.557	3.35	0.557	3.55	0.0011	6.60
1/5/93	11.14	3.90	2.23	5.25	-	-
6/28/93	2.22	3.05	0.17	3.05	-	-
9/20/93	0.18	4.94	0.14	4.68	-	-
1/31/94	3.33	4.47	1.11	4.61	-	-
3/21/94	5.55	2.74	0.11	3.10	-	-
4/21/94	2.22	3.02	0.09	3.28	-	-
12/27/94	1.11	3.13	0.9	3.98	-	-
9/11/95	0.25	3.85	0.01	6.55	-	-

In 1997, the Division of Water (DOW) conducted a survey of streams in the Western Kentucky CoalFields, including Pleasant Run. The DOW reported a high level of pH impairment, citing acid mine drainage as the principal source. A pH of 2.9 was recorded on July 3, 1997. Based on these readings, the stream was listed as First Priority on the Kentucky 303(d) list of streams not meeting their designated uses. Pleasant Run does not support the designated uses of aquatic life and swimming.

AML Projects

Three AML projects have been performed in the Pleasant Run drainage area: Pleasant Run, Pleasant Run II and Pleasant Run - Area 5. The projects were conducted in 1986 - 1987 at a combined cost of approximately $2.6 million and resulted in the reclamation of 274 acres. The work involved covering coal refuse, grading strip mine spoil, eliminating impoundments, and establishing a vegetated cover for the project areas.

There has been mining activity in the watershed since the 1920's, first by Norton Coal Company, then followed by Peabody Coal in the 1940's and 1950's. Considerable additional mining activity was conducted from the 1970's through the early 1990's.

Problem Definition

The 1996 and subsequent 303(d) lists of waters for Kentucky (Ky. Dept. for Environmental Protection DOW, 1996, 1998, and 2003) indicate 7.9 miles of Pleasant Run, from the headwaters to the confluence with the Pond River in Hopkins County, does not meet its designated use for contact recreation (swimming) and for aquatic life because of low pH. The Pleasant Run watershed provides a classic example of impairment caused by acid mine drainage (AMD). Bituminous coal mine drainage, like that found in the Pleasant Run watershed, generally contains very concentrated sulfuric acid and may contain high concentrations of metals, especially iron, manganese, and aluminum.

Acid mine drainage can (1) ruin domestic and industrial water supplies, (2) decimate aquatic life and (3) cause waters to be unsuitable for swimming (primary contact recreation). In addition to these problems, a depressed pH interferes with the natural stream self-purification processes. At low pH levels, the iron associated with AMD is soluble. However, in downstream reaches where the pH begins to improve, most of the ferric sulfate [$Fe_2(SO_4)_3$] is hydrolyzed to essentially insoluble iron hydroxide [$Fe(OH)_3$]. The stream bottom can become covered with a sterile orange or yellow-brown iron hydroxide deposit that is deleterious to benthic algae, invertebrates, and fish.

The sulfuric acid in AMD is formed by the oxidation of sulfur contained in the coal and/or the rock or clay found above and below the coal seams. Most of the sulfur in the unexposed coal is found in a pyritic form as iron pyrite and marcasite (both having the chemical composition FeS_2).

In the process of mining, the iron sulfide (FeS_2) is uncovered and exposed to the oxidizing action of oxygen in the air (O_2), water, and sulfur-oxidizing bacteria. The end products of the reaction are as follows:

$$4\ FeS_2 + 14\ O_2 + 4\ H_20 + \text{bacteria} \rightarrow 4\ Fe + SO_4 + 4\ H_2SO_4 \qquad (1)$$

The subsequent oxidation of ferrous iron and acid solution to ferric iron is generally slow. The reaction may be represented as:

$$4\ FeSO_4 + O_2 + 2\ H_2SO_4 \rightarrow 2\ Fe_2(SO_4)_3 + 2\ H_2O \qquad (2)$$

As the ferric acid solution is further diluted and neutralized in a receiving stream and the pH rises, the ferric iron [Fe^{3+} or $Fe_2(SO_4)_3$] hydrolyses and ferric hydroxide [$Fe(OH)_3$] may precipitate according to the reaction:

$$2\ Fe_2(SO_4)_3 + 12\ H_2O \rightarrow 4\ Fe(OH)_3 + 6\ H_2SO_4 \qquad (3)$$

The brownish yellow ferric hydroxide ($Fe(OH)_3$) may remain suspended in the stream even when it is no longer acidic. Although the brownish, yellow staining of the stream-banks and water doesn't cause the low pH, it does indicate that there has been production of sulfuric acid. The overall stoichiometric relationship is shown in equation (4):

$$4\ FeS_2 + 15\ O_2 + 14\ H_2O \longleftrightarrow 8\ H_2SO_4 + 4\ Fe(OH)_3 \tag{4}$$

Reaction (4) indicates that a net of 4 moles of H+ are liberated for each mole of pyrite (FeS_2) oxidized, making this one of the most acidic weathering reactions known.

Target Identification

The endpoint or goal of the TMDL is to achieve a pH concentration (and associated load in lbs/day) that allows for the sustainability of aquatic life and swimming uses in these stream reaches. The chronic pH criterion to protect Warm Water Aquatic Habitat Use in Kentucky requires that the pH remain not less than 6.0 or more than 9.0 (Title 401, Kentucky Administrative Regulations, Chapter 5:031). For a watershed impacted by AMD, the focus will be on meeting a pH of 6. In the case of violations caused by non-point sources on small intermittent streams, such standards must be evaluated based on an appropriate critical exceedance frequency (return interval) as opposed to a critical period or flow (e.g. 7Q10). For pH violations on such streams, the Kentucky DOW has determined that the maximum daily mean flow having a 3-year exceedance frequency be used for setting the appropriate TMDL and associated load reduction. In cases where the load and the resultant target indicator (i.e. pH) are directly proportional to discharge (flow rate), the exceedance frequency of the associated discharge can be directly related to the exceedance frequency of the target value (e.g. pH). As a result, the critical daily discharge and associated critical load may be obtained as a function of a specified flow exceedance frequency (e.g. 3 years).

In some watersheds, however, as is the case of the Pleasant Run watershed (see Figures 8-10), it has been observed that the ion load tends to increase as a function of flow, reach a maximum, and then decrease as the flow increases. It is hypothesized that these results reflect two competing physical processes. At lower flows and as a result of a first flush effect, it is hypothesized that ion loads are initially leached out of the spoil areas resulting in increasing ion loads. A maximum value of ion load is reached, and as the runoff volumes increase, it is hypothesized that the ion load in the spoil areas become depleted and therefore reduced because of flow dilution in the stream. As a result, ion load increases with increasing flow, reaches a maximum, and then decreases as flow continues to increase. Based on the observed data, a conservative estimate of the resulting maximum ion loads can now be obtained by selecting the maximum observed ion load at each station.

Source Assessment

Point Source Loads

At the time of the study, there are no permitted point source loads contributing to the existing pH violations in the watershed.

Non-Point Source Loads

Previous monitoring has been performed in the Pleasant Run watershed in conjunction with mining permits. The historic pH readings at these sites as recorded in Table 2 indicate severe impairment to the Pleasant Run waters.

In order to provide a more recent characterization of the pH levels in the watershed, the University of Kentucky (as part of the study contract with the KDOW) subcontracted with Murray State University to collect additional data from the watershed at the sites shown in Figure 4. A summary of the results obtained from these sites is shown in Table 3. Both data sets (Tables 2 and 3) indicate significant pH degradation in the watershed and serve as a basis for the development of a TMDL. Two additional sites (sites 2 and 3 for which the data are not shown) that were sampled by Murray State personnel were dropped because of a limited flow occurring at those two locations.

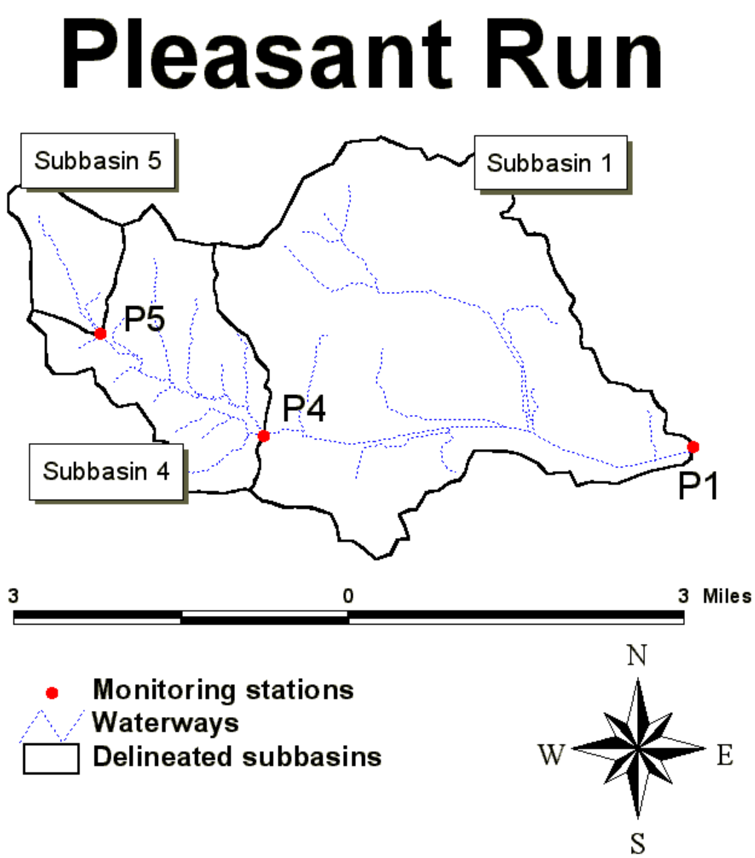


Figure 4. Sampling sites monitored by Murray State personnel

Table 3. Murray State Sample Results

	Site 1 (P1 at River Mile 0.3)		Site 4 (P4 at River Mile 4.4)		Site 5 (P5 at River Mile 6.6)	
Date	Flow Rate (cfs)	pH	Flow Rate (cfs)	pH	Flow Rate (cfs)	pH
11/14/99	1	3.2	0.6	2.6	1.2	2.5
1/13/00	34	3.2	5.8	3	1.1	3.1
2/4/00	16	3.6	1.4	3.1	0.7	3.1
2/19/00	163	5.6	30.7	4	1.5	3.5
2/27/00	48	4.7	15.6	4	1.4	3.6
3/5/00	1	2.8	4.7	2.5	1.3	2.5
4/28/00	11	3.6	12.6	3.3	2.1	3.3
5/5/00	10	4.3	14	3.4	1.8	3.1

Model Development

The magnitude of the associated hydrogen ion load in a water column (in terms of activity) can be determined by measuring the pH of the water. The relationship between hydrogen load and pH can be expressed as follows:

$$\{H_3O^+\} = 10^{-pH} \quad \text{or more commonly} \quad \{ H^+ \} = 10^{-pH} \qquad (5)$$

where pH is the negative log of the H^+ ion activity in mol/L. To convert between the measured activity $\{H^+\}$ and the actual molar concentration $[H^+]$, the activity is divided by an activity coefficient, γ.

$$[H^+] = \{H^+\}/\gamma \qquad (6)$$

The activity coefficient γ is dependent on the ionic strength μ of the source water under consideration. The ionic strength of a given source water can be approximated by estimating the TDS (total dissolved solids in mg/liter or ppm) and applying the following relationship:

$$\mu = (2.5 * 10^{-5}) * TDS \qquad (7)$$

In the absence of actual measured values of TDS, a conservative estimate of TDS for Acid Mine Drainage can be obtained using the cumulative probability distribution of typical terrestrial waters (Figure 5) with an associated conservative probability of exceedance of 95%.

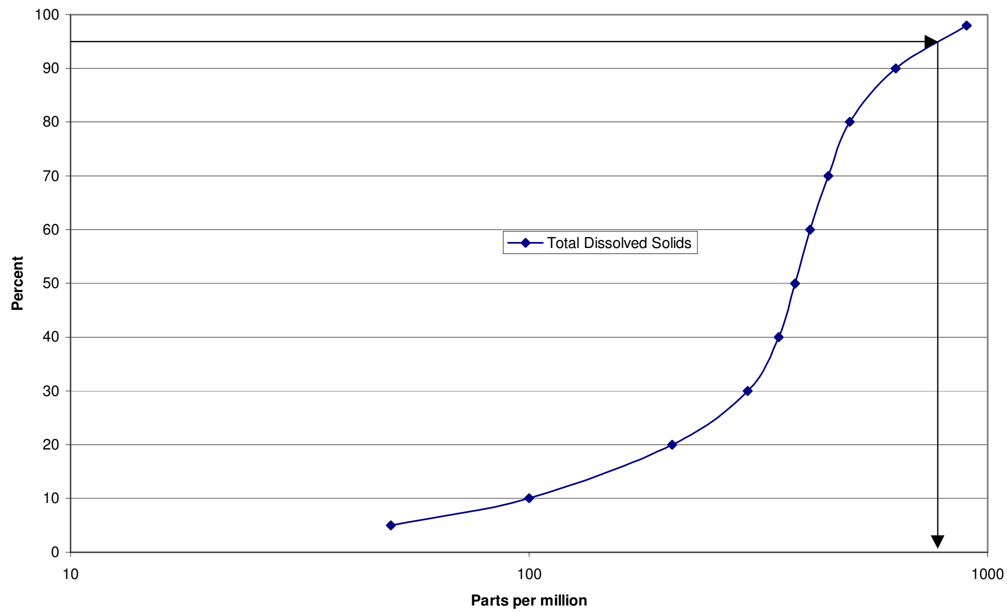


Figure 5: Distribution function of total dissolved solids concentration for terrestrial waters (Snoeyink, 1980)

Use of Figure 5 along with an exceedance probability of 95% yields a TDS value of approximately 900 ppm. Substitution of a TDS concentration of 900 ppm into equation 7 yields an ionic strength of 0.0225. Ionic strength can be converted to an associated activity coefficient using the functional relationship shown in Figure 6. Use of an ionic strength of 0.0225 yields an activity coefficient of 0.89.

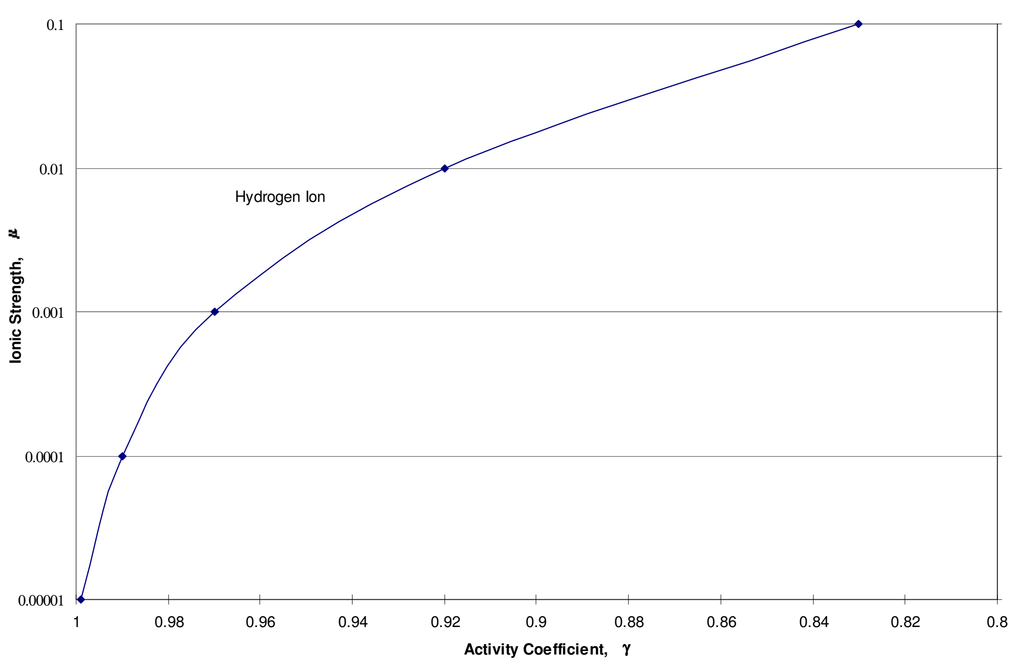


Figure 6: Activity coefficients of H+ as a function of ionic strength (Snoeyink, 1980)

The atomic weight of hydrogen is 1 gram per mole so the concentration of hydrogen ions in mol/L is also the concentration in g/L. Multiplying the concentration of hydrogen ions by the average flow rate for a given day results in a hydrogen ion load for that day in grams/day. As a result, for any given flow rate, there is a maximum ion load that the stream can assimilate before a minimum pH value of 6.0 is violated. Thus for any given day a TMDL may be calculated for that day using the average daily flow and a minimum pH standard of 6 units.

Hydrogen Loading Sample Calculation

In order to demonstrate the hydrogen loading conversion procedure, use the following monitoring data:

- Critical discharge (Q) = 34.0 cfs
- Measured pH = 6.0

The pH can be converted to a mole/liter measurement (i.e. moles [H^+]/liter) by applying the following relationship:

$$pH = -\log \{H^+\}$$

The resulting moles of hydrogen is the anti-log of -6.0, which is 0.000001 moles/liter. The units need to be converted into grams/cubic ft. This is accomplished by applying the following conversion factors:

- There is one gram per mole of Hydrogen.
- 1 liter = 0.035314667 cubic feet

(0.000001 moles/liter)*(1 gram/mole)*(1liter/0.035314667 ft^3) = 0.0000283168 g/ft^3

The goal is to achieve a loading rate in terms of g/day, or lbs/day. If the amount of hydrogen in grams/cubic foot is multiplied by the given flow rate in cubic feet/second and a conversion factor of 86,400 s/day, then the load is computed as:

(0.0000283168 g/ft^3)*(34.0 ft^3/s)*(86400s/1day) = 83.18 g/day, or .18 lbs/day

Assuming an activity correction factor of 0.89, the final load is 93.46 g/day, or .21 lbs/day:

83.18 g/day / 0.89 = 93.46 g/day, or .21 lbs/day

This load is based on a pH of 6.0. The pH determination is based on a logarithmic scale such that as the pH decreases by one unit the number of moles per liter of hydrogen increases by 10. This obviously has a significant effect on the load and subsequent load reduction needed to attain a pH of 6.0. Using the Q = 34.0 cfs, the load reduction needed to attain a pH of 6.0 if the observed pH is 5.0 is 1.85 lbs/day. For an observed pH of 4.0 the reduction needed is 20.40 lbs/day.

Because pH and equivalent hydrogen ion load can be related as a function of discharge (flow) and ionic strength, a functional relationship can be developed between discharge and the associated ion loading for a given pH value. By specifying a minimum pH value (e.g. 6) and a minimum activity correction factor (e.g. 0.89), an envelope of maximum ion loads may be obtained as a function of discharge (see Figure 7). This figure thus provides a basis for establishing the maximum ion load for a given discharge.

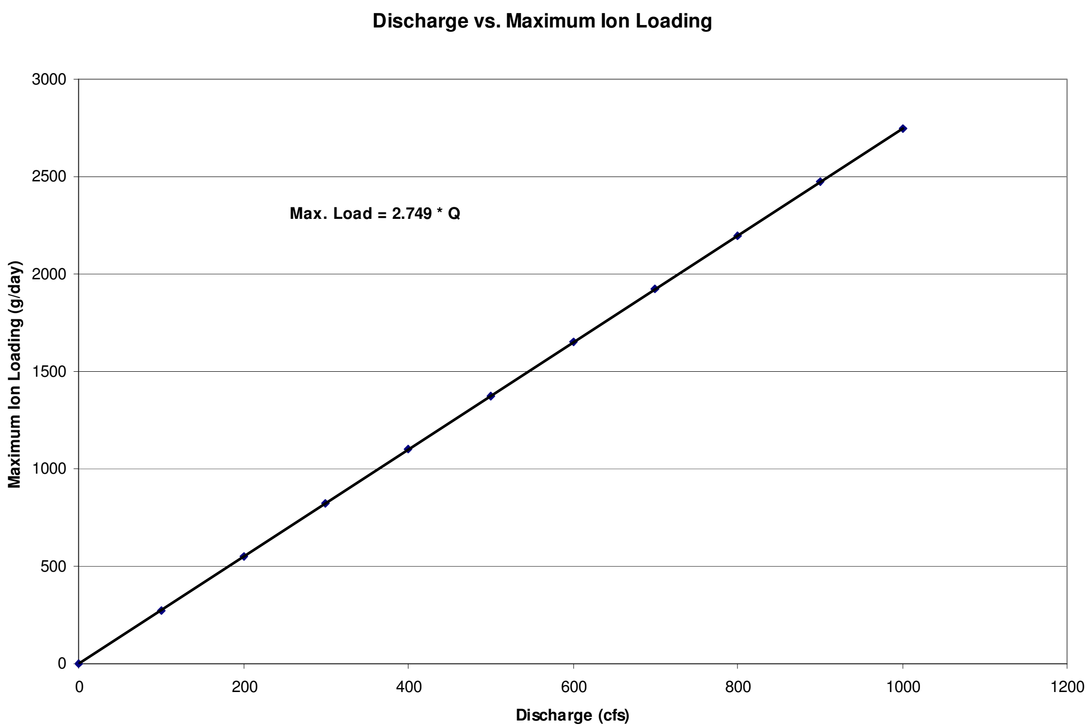


Figure 7. Relation between discharge and maximum ion loading for a pH of 6.0

Once a TMDL is developed for a watershed, the associated load reduction must be spatially allocated. One way to accomplish this objective is through unit load reductions as associated with different land uses within the watershed. The impacts of such reductions on the associated water quality standard can then be verified through mathematical simulation. Alternatively, separate TMDLs (and associated load reductions) can be developed for individual subbasins within the watershed. In the current study, separate TMDLs and associated load reductions were developed for each of the subbasins identified in Figure 4. Attainment of the individual load reductions should then meet the TMDL requirement for the complete watershed.

Based on a physical inspection of the watershed, it is hypothesized that the degradation of the pH in the stream is directly related to oxidation of sulfur that occurs as runoff flows over the spoil areas associated with previous mining activities in the basin. Plots of ion loads versus flows from the three monitoring stations shown in Figure 4 are shown in Figures 8-10.

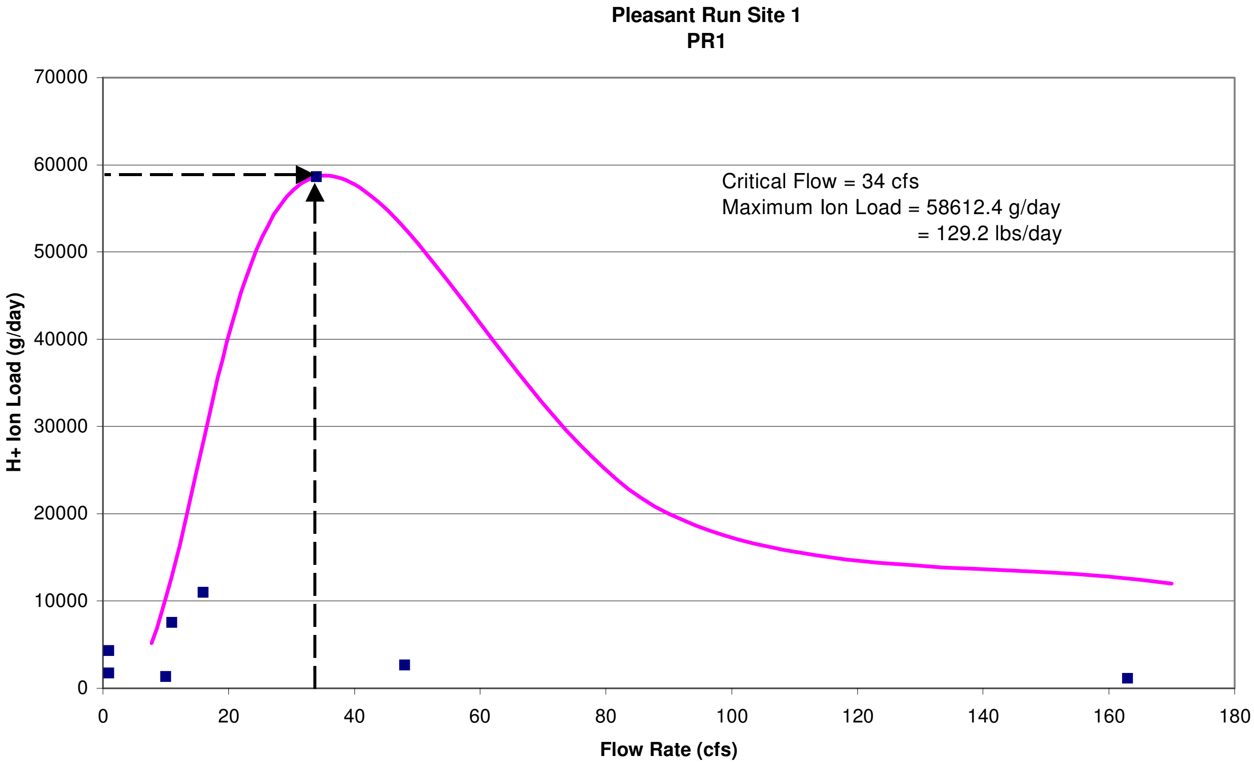


Figure 8. Relation between flow and ion load for site 1

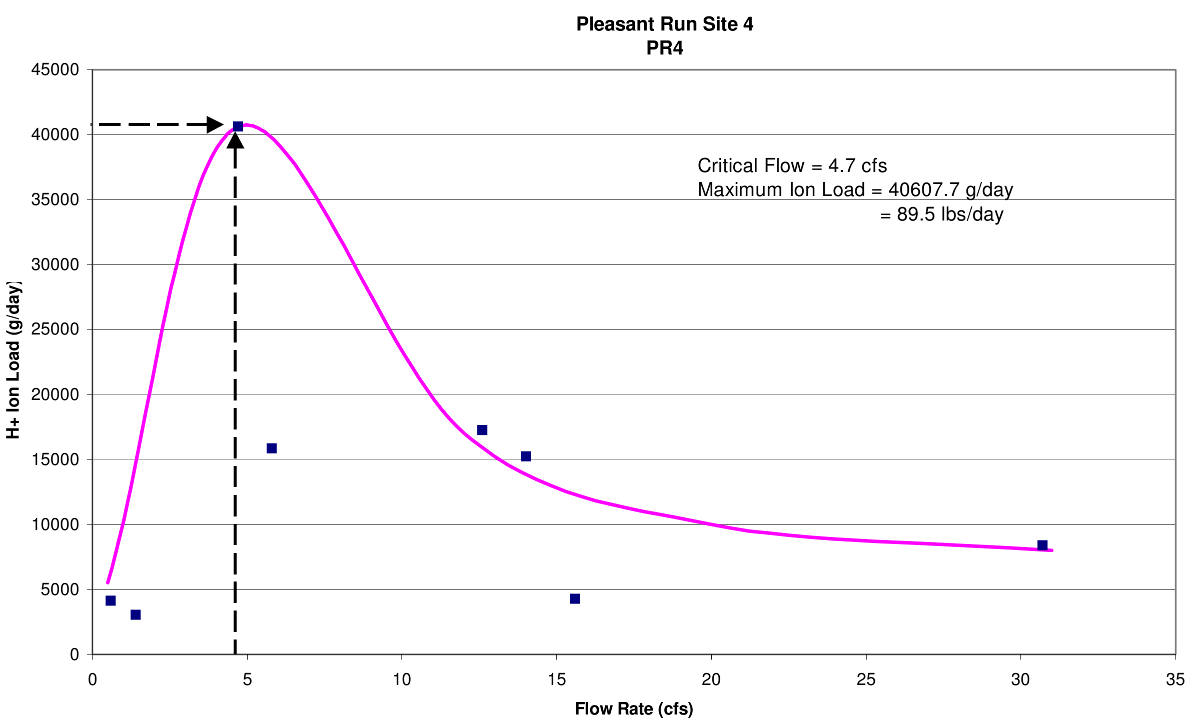


Figure 9. Relation between flow and ion load for site 4

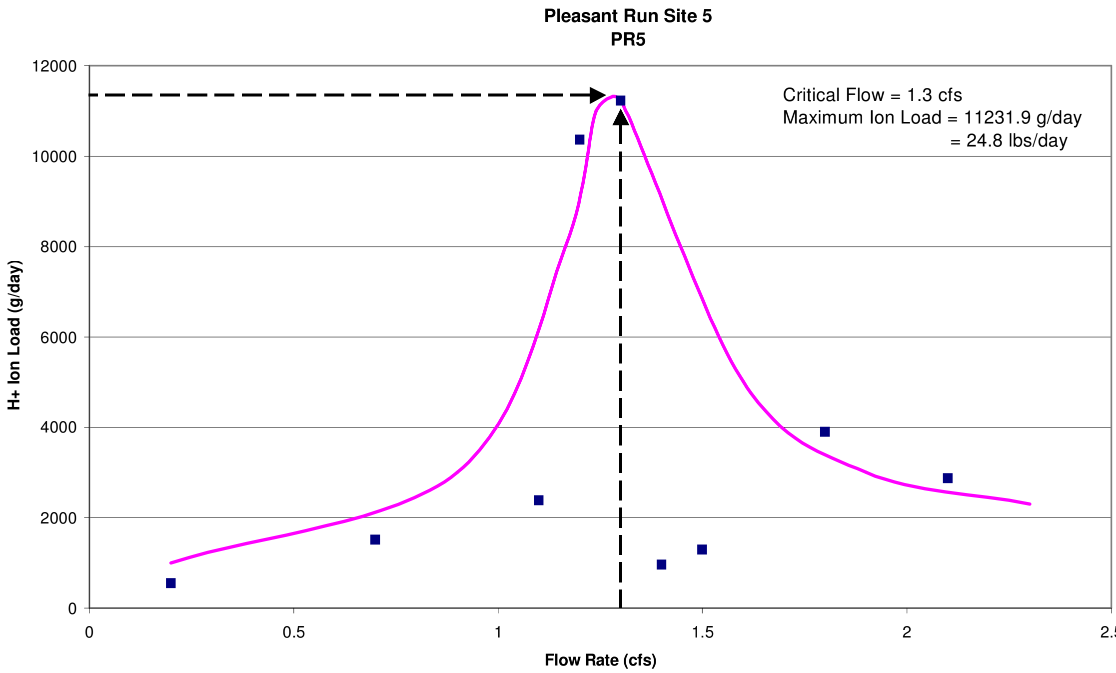


Figure 10. Relation between flow and ion load for site 5

TMDL Development

Theory

The Total Maximum Daily Load (TMDL) is a term used to describe the maximum amount of a pollutant a stream can assimilate without violating water quality standards and includes a margin of safety. The units of a load measurement are mass of pollutant per unit time (i.e. mg/hr, lbs/day). In the case of pH there is no associated mass unit (pH is measured in Standard Units).

Total maximum daily loads (TMDLs) are comprised of the sum of individual waste load allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels for a given watershed. The sum of these components may not result in exceedance of water quality standards (WQSs) for that watershed. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \text{Sum (WLAs)} + \text{Sum (LAs)} + \text{MOS} \qquad (8)$$

Waste Load Allocations

At the time the study was conducted, there were no point source discharges in the watershed. Therefore, the current Waste Load allocation (WLA) is zero. Of particular note is that there is currently one active Kentucky Pollutant Discharge Elimination

System (KPDES) permit in the Pleasant Run Watershed. The permit (KY0067121) is issued to Charolais Corporation. Mining has not been initiated under this permit so there is still no point source discharge to any stream in the Pleasant Run watershed. The KPDES permit includes an outfall that will receive flow from an area of 5 acres. The discharge from the permitted outfall will enter an unnamed tributary to Pleasant Run that drains to the site at P4. This KPDES permit will expire on May 31, 2005. At the time of reissuance of the KPDES permit, the discharge from the one outfall or any proposed new outfalls draining to streams in the Pleasant Run Watershed would need to meet the criteria for new and reissued permits as described in the Fact Sheet (an end-of-pipe pH of 7.0 to 9.0). As mentioned in the Fact Sheet, the Hydrogen ion load associated with a pH of 7.0 is insignificant (effectively zero). A pH of 7.0 represents a neutral state between an acidic and a non-acidic condition. As such, a discharge having a pH of 7.0 to 9.0 standard units will not cause or contribute to the existing impairment.

As mentioned in the Fact Sheet, new and reissued permits with effluent limits requiring a minimum pH of 7.0, and new remining permits with modified effluent limits, essentially represent no net change in conditions in the subwatershed with respect to pH, therefore, the waste load allocation will be assigned a value of zero and the total allowable hydrogen ion load within the watershed will be attributed to the load allocation category.

Load Allocations

Because there were no active mining areas (no point source discharges) during the study period, the loads for the Pleasant Run Watershed were assumed to be directly related to acid mine drainage as a result of water leaching from abandoned mines. The average daily flow is assumed to be represented by the flow corresponding to the maximum value of ion load (which is termed the critical flow). Predicted maximum daily loads for each subbasin within the watershed can be obtained using the maximum observed ion loads shown in Figures 8-10.

Summary of Waste Load and Load Allocations

The total waste load and load allocation (the TMDL) for the Pleasant Run watershed is assumed to be an explicit function of the average daily flow in the stream and an associated pH standard of 6 units. New permits would not cause or contribute to the existing impairment and remining permits would be exempt from the TMDL requirements. Therefore, no load will be provided for the WLA category. The entire value of the TMDL will therefore be assigned to the load allocation (LA). Because the WLA will be assigned a value of zero, the LA represents the total allowable hydrogen ion load within the watershed.

Margin of Safety

The margin of safety (MOS) is part of the TMDL development process (Section 303(d)(1)(C) of the Clean Water Act). There are two basic methods for incorporating the MOS (USEPA, 1991a):

1) Implicitly incorporate the MOS using conservative model assumptions to develop allocations, or
2) Explicitly specify a portion of the total TMDL as the MOS using the remainder for allocations.

In the current TMDL, the MOS is incorporated implicitly through the properties of water chemistry that determine the relationship between pH and hydrogen ion concentration and through the use of the maximum observed ion loads at each station as the basis of the TMDL load reduction. In an electrically neutral solution (such as all natural systems), the activity coefficient (γ in eqn. 6) is assumed to be equal to 1.0, meaning that there is no quantitative difference between activity and molar concentration. In the case of AMD there obviously exists the possibility of additional ions in the water column that may affect the relationship between the measured activity and the associated ion load. Therefore, taking a conservative approach, a minimum activity correction factor of 0.89 is assumed. This means that for all values of pH the calculated hydrogen ion concentration is assumed to be higher than would normally be calculated under the assumption of a nominal activity correction factor. Overestimation of the potential loading rate requires a greater reduction and thus allows for an implicitly defined margin of safety. Finally, all pH degradation below the minimum threshold of 6 is assumed to be totally attributable to acid mine drainage. As a result, any load reductions for the watershed will be made irrespective of any natural background sources and thus provide a further conservative reduction strategy.

TMDL Determination

The TMDL for a given stream segment may be determined on the basis of a critical discharge and the use of Figure 7. These values are then converted to lbs/day. In determining the TMDLs for stations P1, P4, and P5 (Figure 4), the flow values corresponding to the maximum observed ion load for each station were used as the critical discharge. The critical discharge at site P1 and P4 (Figures 8 and 9) must be adjusted by mass balance to account for flow entering that subbasin from upstream. The values in Table 4 reflect that adjustment. Using these discharges, the TMDLs in Table 4 were obtained.

Table 4. Incremental Critical Flow and Corresponding TMDL (lbs/day)

Subbasin	Incremental Flow Rate (cfs)	Incremental TMDL (lbs/day)
1	29.30	0.178
4	3.40	0.020
5	1.30	0.008

Predicted Load

As indicated previously, the maximum hydrogen ion loads for each site may be obtained from Figures 8-10. Using the data, the total predicted maximum loads were calculated (Table 5).

Table 5. Incremental Critical Flow and Corresponding Predicted Ion Loads (lbs/day)

Subbasin	Critical Flow (cfs)	Predicted Load (lbs/day)
1	29.30	39.69
4	3.40	64.76
5	1.30	24.76

Note again that a mass balance application must be performed to find the incremental load for Subbasins 1 and 4. For example, the incremental load at Subbasin 4 is found by subtracting the cumulative load at Subbasin 5 (24.76 lbs/day) from the cumulative load at Subbasin 4 (89.52). A similar approach is used to calculate the incremental load for Subbasin 1 (129.21 lbs/day - 89.52 lbs/day = 39.69 lbs/day).

Load Reduction Allocation

Translation of the TMDL in Table 4 into associated daily load reductions for each site may be accomplished by subtracting the incremental TMDL from the incremental predicted load for each of the subbasins. This approach allocates the total load reduction for Pleasant Run (site P1) between each of the contributing sites in the watershed, so that the entire watershed is rehabilitated and the pH is improved throughout the stream network. Application of this approach yields the values in Table 6.

Table 6. TMDL Summary and Reductions Needed for Pleasant Run

Total TMDL for Pleasant Run = 0.207 lbs H+ Ions/day				
	Critical Incremental Flow Rate (cfs)	Incremental TMDL for a pH of 6.0 (lbs/day)	Predicted Maximum Incremental Load (lbs/day)	Incremental Reduction Needed (lbs/day)
Subbasin 1	29.30	0.178	39.69	39.52
Subbasin 4	3.40	0.020	64.76	64.74
Subbasin 5	1.30	0.008	24.76	24.75
Total	34.00	0.207	129.22	129.01

Permitting

New and Reissued Permitting in the Pleasant Run Watershed

All of the streams in the watershed are considered to be impaired as a result of disturbance throughout the watershed from past mining activities.

New permits (except for new remining permits) and reissued permits for discharges to streams in the Pleasant Run watershed could be allowed anywhere in the watershed, contingent upon the end-of-pipe pH being permitted at a range of 7.0 to 9.0 standard units. Water quality standards state that for meeting the designated uses of aquatic life and swimming, the pH value should not be less the 6.0, nor greater than 9.0. This range of 6.0 to 9.0 for pH is generally the value assigned for end-of-pipe effluent limits. However, because a stream impairment exists (low pH), new discharges can not cause or contribute to an existing impairment. A pH of 7.0 represents a neutral state between an acidic and a non-acidic condition. As such, a discharge having a pH of 7.0 to 9.0 standard units will not cause or contribute to the existing impairment. The discharge will not cause an impairment because the effluent discharge has a pH greater than 6.0 standard units. The discharge will not contribute to the existing impairment because a pH of 7.0 represents a neutral condition with respect to acidity and effectively represents a background condition. The hydrogen ion load associated with a pH of 7.0 is insignificant (effectively zero) and therefore does not represent a contribution to the existing impairment. As such, new and reissued permits having an effluent limit pH of 7.0 to 9.0 would not be assigned a hydrogen ion load as part of a Waste Load Allocation.

There is only one active Kentucky Pollutant Discharge Elimination System (KPDES) permit in the Pleasant Run Watershed. The permit (KY0067121) is issued to Centennial Resources, Incorporated. The KPDES permit is for a portion (5 acres) of the subwatershed that drains to the site at P4. The KPDES permit will expire on May 31, 2005. At the time of reissuance of the KPDES permit, any discharge points draining to streams in the Pleasant Run Watershed would need to meet the above criteria (an end-of-pipe pH of 7.0 to 9.0).

Remining Permits

New remining permits may be approved on a case-by-case basis where streams are impaired because of low pH from abandoned mines. Permit approval is contingent on reclamation of the site after remining activities are completed. During remining, existing conditions of the water coming from the site must be maintained or improved. Reclamation of the site is the ultimate goal, but water quality standards (pH of 6.0 to 9.0 standard units) may not necessarily be met in the interim if the Commonwealth issues a variance to the permittee as defined by 401 Kentucky Administrative Regulation (KAR) 5:029. In instances where the Commonwealth issues a variance for a remining activity consistent with this regulation, hydrogen ion loads from this remining activity are allowed to exceed the waste load allocation. The variance allows an exception to the applicable water quality standard as well as the TMDL.

Remining therefore constitutes a means whereby a previously disturbed and unreclaimed area can be reclaimed. The authority for remining is defined in Section 301(p) of the Federal Clean Water Act; Chapter 33, Section 1331(p) of the U.S. Code – Annotated (the Rahall Amendment to the Federal Clean Water Act); and the Kentucky Administrative Regulations (401 KAR 5:029 and 5:040).

The eventual reclamation of the remining site should result in a reduction of the overall ion load (specifically the nonpoint source load) of the subbasin where the remining was done. The reclamation should also result in an improved stream condition (increased pH) because a previously disturbed and unreclaimed area will be reclaimed. Follow-up, in-stream monitoring would need to be done at the subbasin outfall to determine the effect of reclamation activities (following remining) on the overall ion load coming from the subbasin. This constitutes a phased TMDL, where a remedial measure (reclamation at the end of remining) would then need to be followed by in-stream monitoring to see how well the remedial measure did in improving the low pH condition for that subbasin.

Distribution of Load

Because new permits (pH 7.0 to 9.0) would not cause or contribute to the existing impairment and remining permits would be exempt from the TMDL requirements, no load has been provided for the waste load allocation category. Therefore, the table below allocates all of the load to the load allocation category. New and reissued permits having a minimum pH of 7.0, and new remining permits essentially represent no net change in conditions in the subwatershed with respect to pH.

Table 7. Waste Load and Load Allocation for Each Subbasin in the Pleasant Run Watershed

	Critical Flow Rate (cfs)	TMDL for pH = 6.0 (lbs/day)	Waste Load Allocation (lbs/day)	Load Allocation (lbs/day)
Subbasin 1	29.30	0.178	0.000	0.178
Subbasin 4	3.40	0.020	0.000	0.020
Subbasin 5	1.30	0.008	0.000	0.008

Implementation/Remediation Strategy

Remediation of pH-impaired streams as a result of current mining operations is the responsibility of the mine operator. The Kentucky Division of Field Services of the Kentucky Department of Surface Mining Reclamation and Enforcement (DSMRE) is responsible for enforcing the Surface Mining Control and Reclamation Act of 1977 (SMCRA). No governmental entity bears the responsibility to remediate pH-impaired streams as a result of pre-law mining operations or mining operations associated with forfeited reclamation bonds. The Kentucky Division of Abandoned Mine Lands

(KDAML) is charged with performing reclamation to address the impacts from pre-law mine sites in accordance with priorities established in SMCRA. SMCRA sets environmental problems as third in priority in the list of AML problem types. Just recently, 319 funding (specifically Clean Water Action Plan funds) has been awarded to the KDAML, which is part of the DSMRE. This grant is the Homestead Refuse Reclamation Project and includes reclamation of most of the area above site P5 that lies to the west of Pleasant Run (the western slope). The project also includes reclamation in the eastern portion of the adjacent watershed to the west of Pleasant Run, which is the Fox Run watershed. Therefore, the project area includes the eastern slope of the upper Fox Creek watershed, the western slope of the Pleasant Run watershed upstream from site P5, and the ridgeline between the two watersheds. The project involves a 92-acre area. The total cost of the reclamation project is $1.26 Million, of which 60% is federal funds and 40% is supplied by the KDAML. Also, three AML projects have been performed in the Pleasant Run drainage area: Pleasant Run, Pleasant Run II and Pleasant Run - Area 5. The projects were conducted in 1986 - 1987 at a combined cost of approximately $2.6 million and resulted in the reclamation of 274 acres. The work involved covering coal refuse, grading strip mine spoil, eliminating impoundments, and establishing a vegetated cover for the project areas.

Reclamation activities are underway at other locations within the state where water quality is affected by acid mine drainage (AMD). The success of the reclamation activities in these watersheds was to be evaluated before developing remediation strategies for other watersheds affected by AMD. The DAML developed a reclamation project in response to documented sedimentation and flooding problems in the nearby Brier Creek Watershed. The project included reclamation of approximately 120 acres of barren or poorly vegetated areas affected by past strip mining. The project also entailed six acres of channel restoration to minimize sedimentation caused by erosion. The restoration of streams included construction of ditches and PVC coated gabion baskets utilized as velocity reducers and energy dissipaters; bale silt checks and silt trap dugouts were also utilized for sediment control. The reclamation project consisted of 67 acres of gradework to remove erosion gullies, redistribute sediment deposits, and prepare a surface to receive a soil cover. The area under consideration received a two foot soil cover layer, taken from 20 acres of watershed area designated for borrow. Gradework areas were treated with an application of agricultural limestone to neutralize acidic conditions and all areas were revegetated using a combination of seedbed preparation, agricultural limestone, fertilizer, seed, mulch, and crimping. The agricultural limestone provided a variety of particle sizes so that it dissolved at different rates and mobilized under a range of flow conditions. The strategy employed at Brier Creek is similar in some respects to a project that is currently underway on Rock Creek and a tributary, White Oak Creek in McCreary County, Kentucky. This 12-acre project is part of the Kentucky Clean Water Action Plan. It involves the removal of coal refuse from the banks of Rock Creek, the establishment of a vegetative cover on other refuse areas in the watershed, and the application of limestone sand at selected locations to neutralize the effects of AMD.

The total cost for the Brier Creek project was $913,000.00 (i.e. $7600/acre) while the total cost of the Rock Creek project is estimated to be approximately $650,000 (i.e. $54,200/acre). For 2001, the total federal KDAML budget allocation was approximately $17 million. However the bulk of these funds were used to support priority 1 (extreme danger of adverse effects to public health, safety, welfare, and property) and priority 2 (adverse effects to public health, safety, and welfare) projects. Based on the cost of current remediation efforts, it would appear that a significant increase in federal funding to AML projects, particularly priority 3 projects, would be required in order for the AML program to play a significant part in meeting the TMDL implementation requirement associated with pH impaired streams in the state of Kentucky.

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APPENDIX A: MINING 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 issues after May 3, 1978. The first three numbers indicate the location of the mine by county and the timing of the original permit issuance. (Ex. Hopkins County = 54).

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. Ex. 254 (Hopkins)

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. Ex. 454 or 654 (Hopkins)

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. Ex. 854 (Hopkins)

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	Flourspar