# Step 1: Understanding Coal Mine Drainage

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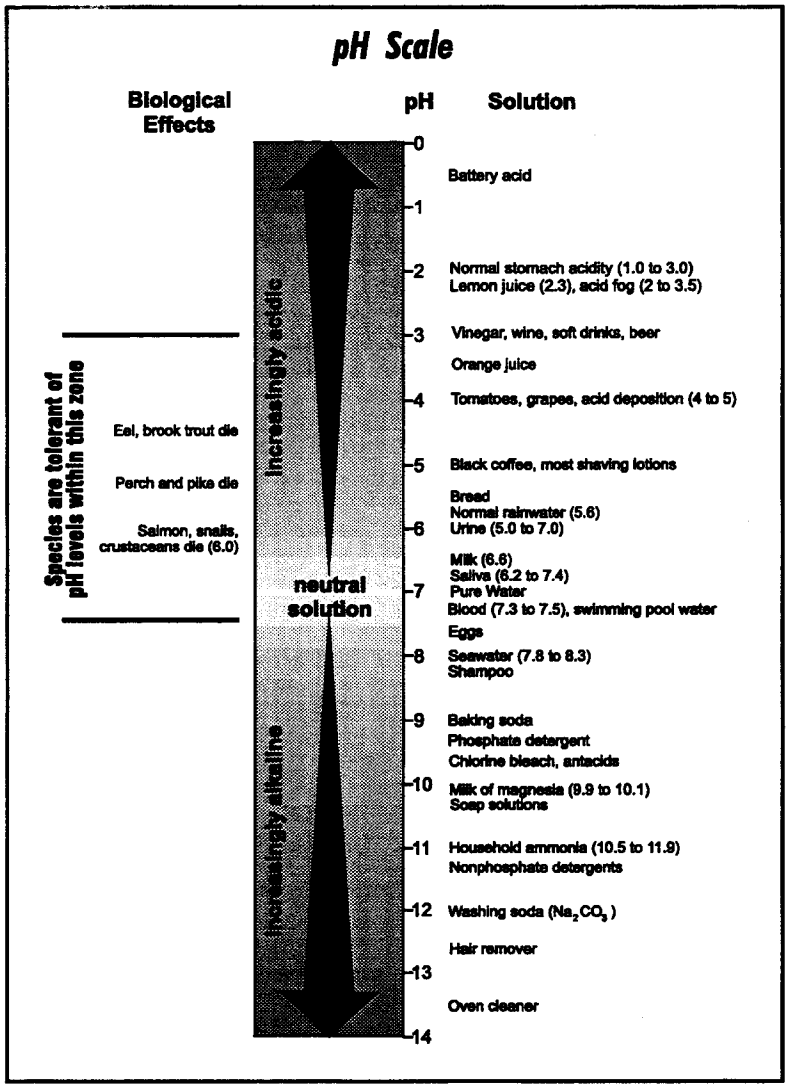
## DEFINING COAL MINE DRAINAGE

Coal Mine Drainage (CMD) from abandoned mines is water which is affected by passage through, or alteration by, coal or abandoned coal mine environments. CMD can have acceptable water quality, but often it is contaminated. Contaminated CMD can lower water quality and impair aquatic life, and is most often characterized by one or more of the four major components:

- Low pH (high acidity), i.e., acid mine drainage (AMD)
- High metal concentrations
- Elevated sulfate levels
- Excessive suspended solids and/or siltation

### *Low pH (high acidity)*

The majority of CMD problems result from surface water contact with the unreclaimed waste rock and other earthen materials or from the seepage or drainage of ground water which has con-




tacted the coal or rock strata remaining in an underground mine. If the water becomes acidic, it is referred to as "acid mine drainage" (AMD). Acid is a contaminant of primary concern since it can leach toxic concentrations of metals from rocks at mine sites.

Acids in streams are a problem because they can corrode metal pipes and structures, break down concrete, and kill or stunt plants and other aquatic life-forms. Acidic surface waters or runoff can also break down metallic compounds of iron, sulfur, manganese, and aluminum found in nearby rock or earthen waste piles.

### Where does the acid come from?

Acid solutions form when surface or ground water comes into contact with acidic material, mostly pyrite, commonly found in mine rocks, earthen refuse piles, or underground mine works and/or auger holes. The iron-sulfide mineral pyrite is often found near subsurface coal seams along with compounds containing manganese, aluminum, and other metals. In the presence of oxygen, ordinary rain water or ground water can react with the sulfur to form sulfuric acid.

## Chemical Formula to Form Contaminated CMD

*A simplified version of the chemical process that forms contaminated CMD is shown below.*

*Pyrite (iron sulfide) + oxygen + water react to create sulfuric acid + iron hydroxide (yellow boy)*

Acid concentrations in CMD can reach levels that are more than 10,000 times higher than neutral waters, presenting a powerful leaching agent that can dissolve significant amounts of metal compounds and leach additional acid from rocks and earthen wastes commonly found at most mine sites.

## High Metal Concentrations

Layers of rock and earth above the coal removed during mining commonly contain traces of iron, manganese, and aluminum and can also contain other heavy metals. These metals can be dissolved from mining sites through the action of acid runoff, as described above, or can be washed into streams as sediment. Many metals, though common, can be toxic to fish and other aquatic organisms when they are present in high dissolved concentrations. Dissolved iron and iron precipitate, for example, can kill the aquatic biota that fish feed on, thus reducing the overall fish population. Iron precipitate can also clog the gill structures of fish which will eventually lead to their death

as well. In addition, precipitation of iron in the stream channel can also wipe out the aquatic food chains and adversely affect fish populations.

### Elevated Sulfate Levels

As pyrite wastes are chemically broken down, a sulfate compound is produced in runoff waters. Sulfates can bond with water molecules to form sulfuric acid or can attach to calcium atoms to form a gypsum sludge. Elevated sulfate levels are often found in CMD discharges.

### Excessive Silt and Suspended Solids

Most people think contaminated CMD results from chemical reactions in streams, but a significant threat to water quality and aquatic organisms comes from eroding soils at abandoned mining sites. Tiny fly nymphs, insect larvae, and other organisms that form the base of aquatic food chains can be wiped out by heavy accumulations of soil and mine waste particles that wash into streams after rain events. Suspended silt particles can clog the gills of fish and smother eggs on the stream bottom. Streams and rivers muddied by silt and other suspended solids also mean higher costs at municipal and industrial water treatment plants and accelerated sedimentation in reservoirs.

### What Do These Colors Mean?

***White:*** *High dissolved aluminum concentrations are deposited as a whitish powder as the aluminum is oxidized back into solid form.*

***Black:*** *Oxidized manganese appears as a dark or black stain on creek rocks*

***Orange/Yellow:*** *Oxidized iron has an orangish, rusty color. Ferric (iron) hydroxide gives CMD-contaminated streams and seeps their characteristic rusty, yellow-orange appearance. Nicknamed "yellow boy," the substance forms after iron is leached from iron sulfide wastes contained in rocks at mining sites.*

#### Oven Run

*Oven Run, located in Pennsylvania's Shade Township, is one of several tributaries that discharge CMD into Stoneycreek River. Stoneycreek River flows north from Somerset County to "The Point" in Johnstown, where it joins the Little Conemaugh to form the Conemaugh River. Millions of tons of coal were removed from mines in the Oven Run watershed during past decades, and CMD problems were significant. The estimated flow of CMD at one site alone exceeded 700,000 gallons per day (gpd). Degradation from Oven Run and other tributaries severely impacted aquatic life at Stonycreek River's downstream locations, which did not support the thriving trout fishery found above the CMD sites.*

#### Mill Creek

*Mill Creek drains a watershed that covers nearly 60 square miles within Clarion and Jefferson Counties in western Pennsylvania. The Main stem of Mill Creek is approximately 15 miles long, with the upper two-thirds of the channel and some tributaries supporting a viable population of native brook trout. The lower third of the main stem, from the confluence with Clarion River to a point about six miles upstream, had been so badly polluted by acid mine drainage over a 50-year period that most aquatic life had disappeared. Little Mill Creek, which empties into the lower third of Mill Creek, is the largest tributary and primary contributor of CMD. Ten CMD discharges were identified in the Little Mill Creek watershed.*

# PRE-1977 MINING PRACTICES AND THE FORMATION OF CONTAMINATED CMD

Knowing how the coal was mined can provide you with clues as to where to look for the sources of contamination. All past mining approaches sought to remove coal from beneath sometimes thick layers of soil and rock called overburden. Many of the various coal-mining practices exposed the sulfur-containing rocks and minerals to the weather, and in some cases, to groundwater flow.

There were and continue to be two approaches to mining: removing the overburden to get at the coal (surface or strip mining) or extracting the coal while leaving the overlying material in place (underground or auger mining). Underground mining has accounted for approximately 70 percent of the Appalachian mining production in the past. Surface (or strip) mining, underground mining, and augering were all common to the Appalachian region.

*It has been estimated that 70 percent of the existing acid drainage in Appalachia is the result of past underground mining operations (1969 ARC report).*

## Surface Mining

Surface mining was practiced where coal beds were at or near the surface of eroded hillsides. Operators removed the overburden with various excavating equipment to expose the coal outcrops. The amount of material disturbed by this technique depended on the thickness and quality of coal being mined, but in most situations, resulted in more than just the near surface zone. The overburden fill is left in the area and if located along drainage zones, can become a source for acid formation if sulfur-containing materials are present and exposed to water.

## Auger Mining

Auger mining is the process of drilling out coal seams from a vertical highwall with a large auger. This practice often accompanies the contour mining process. Augers could penetrate horizontally more than 200 feet into a seam, removing as much as 60 percent of the coal. Waste material brought out with the coal was sometimes placed back into the auger holes to prevent subsidence and tension cracks at the surface. Auger holes can be a source of contaminated drainage if rain percolates through the overlying layers and seeps into the holes.

## Underground Mining

Removing coal through a process of tunneling through the relatively soft coal beds is among one of the oldest, and still most

common, mining practice. In this practice (also called deep mining), vertical, horizontal, and/or entire sloping mine works were constructed to provide access to the coal seam and to remove dust and recharge fresh air supplies. Many old, abandoned underground mines are honeycombed with miles of tunnels, capable of collecting huge amounts of water. As this water passes through the overburden and the maze of tunnels in the coal, it can react with the various acid-forming materials (if present) and create strong concentrations of acid.

## RESOURCE INFORMATION


Appalachian Clean Streams Initiative. Office of Surface Mining. n.d. *Appalachian Clean Streams Initiative: A Plan to Clean Up Streams Polluted by Acid Drainage*. Brochure explains what AMD is, how it can be eliminated, and discusses the mission of the Appalachian Clean Streams Initiative.

*Focusing on the Problem of Mining Wastes: An Introduction to Acid Mine Drainage*. Durkin, T.V., and J.G. Herrmann. Reprint from EPA Seminar Publication No. EPA/625/R-95/007, Managing Environmental Problems at Inactive and Abandoned Metals Mine Sites. Obtained from Internet: http:www.info-mine.com/technomine/enviromine/publicat/amdintro.html.

Office of Surface Mining's WWW Home Page is accessible through the internet at http://www.osmre.gov. OSM, 1951 Constitution Avenue, Washington D.C. 20240; (202) 208-2782.

Robertson GeoConsultants, Inc., hosts an online technical discussion group on mining and related environmental issues. It can be accessed by e-mailing listproc@info-mine.com. An informative web site hosted by the group can be accessed at http://www.info-mine.com/technomine/enviromine/wetlands/welcome.htm.

Stoneycreek-Conemaugh River Improvement Project (SCRIP) of Pennsylvania maintains a homepage on the Internet at http://ctcnet.net/scrip. This site contains a rich variety of information on CMD and links to other resources on the World Wide Web.

U.S. Department of Agriculture Natural Resources Conservation Service. See county listings for local offices.

U.S. Department of Energy, Morgantown Energy Technology Center, 3610 Collins Ferry Road, P.O. Box 880, Morgantown, WV 26507-0880; Robert Bedick 304/285-4505.

U.S. Environmental Protection Agency Region 3 (Maryland, Virginia, Pennsylvania, West Virginia) is at (215) 597-3429; 841 Chestnut Building, Philadelphia, PA 19107.

U.S. Environmental Protection Agency Region 4 (Kentucky, Tennessee, North Carolina, Georgia) at (404) 347-2126; 61 Forsyth Street, Atlanta, GA 30303.

U.S. Environmental Protection Agency Region 5 (Ohio) is at (312) 886-0209; 77 West Jackson Blvd., Chicago, IL 60604.U.S.

U.S. Department of the Interior, Office of Surface Mining, 1951 Constitution Avenue, Washington D.C. 20240; (202) 208-2782.

U.S. Forest Service. *User Guide to Solid - Mining and Reclamation in the West.* Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, UT. Gen. Tech. Report. INT-68, SEAM; 1979.