Chapter 2: The Environmental Effects of Strip Mining

THE ENVIRONMENTAL EFFECTS OF STRIP MINING

All mining operations have a disruptive effect on the environment, but the sheer volume of material involved in strip mining makes the impact on the environment especially acute. Surface mining (another name for "strip mining") can severely erode the soil or reduce its fertility; pollute waters or drain underground water reserves; scar or alter the landscape; damage roads, homes, and other structures; and destroy wildlife. The dust and particles from mining roads, stockpiles, and lands disturbed by mining are a significant source of air pollution. In order to participate effectively in controlling the abuses of strip mining, it is important to understand the basic techniques of surface mining and the types of environmental damage that can result.

The Mechanics of Strip Mining

This section describes the five main types of surface coal mining techniques: area mining, open pit mining, contour mining, auger mining, and mountaintop removal. Underground mining is also considered in this section. Terrain, economics, and custom generally dictate which technique an operator chooses.

All surface or strip mining first removes the overlying vegetation, soil and underground rock layers in order to expose and extract coal from an underground seam or coal deposit. Responsible surface mining attempts to limit the side effects of this removal through several basic steps:

1. First, the surface vegetation (trees, bushes, etc.) under which the coal seam lies is scalped or removed.
2. Next, the operator removes the topsoil, usually by bulldozers or scrapers and loaders. The operator either stockpiles the topsoil for later use or spreads it over an area that already has been mined.
3. The exposed overburden is then usually drilled and blasted, and removed by bulldozers, shovels, bucketwheel excavators, or draglines, depending on the amount of overburden and the type of mining.
4. After removing the overburden, the exposed coal seam is usually fractured by blasting.
5. The operator then loads the fractured coal onto trucks or conveyor belts and hauls it away.
6. Next, the operator dumps the overburden or spoil that was removed during the mining process on a previously mined area and grades and compacts it. (Special handling may be necessary if any of the overburden contains toxic materials, such as acid or alkaline producing materials.)
7. Any excess overburden that remains after the mined area is completely backfilled (Eastern mines generally have substantial excess spoil) is deposited in a fill.
8. Finally, the operator redistributes the topsoil and seeds and revegetates the mined area.
While these basic steps are relatively consistent, the environmental impacts of the five main techniques vary significantly.

**Area Mining**

Area mining is the technique most often employed in the flat or gently rolling countryside of the Midwest and western United States. Area mines excavate large rectangular pits, developed in a series of parallel strips or cuts which may extend several hundred yards in width and more than a mile in length. Following scalping of the vegetation and topsoil removal, area mining begins with an initial rectangular cut (called the box cut).

*Area strip mining with concurrent reclamation.*

The operator places spoil from the box cut on the side away from the direction in which mining will progress. In large mines, huge stripping shovels or *draglines* remove the overburden. After extracting the coal from the first cut, the operator makes a second, parallel cut. The operator places the overburden from the second cut into the trench created by the first cut and grades and compacts the spoil. The backfilled pit is then covered with topsoil and seeded. This process continues along parallel strips of land so long as the ratio between the overburden and the coal seam, called the *stripping ratio*, makes it economically feasible to recover coal. Mining may cease in a particular area, for example, where the coal seam becomes thinner or where the seam dips further below the surface.

When the operator reaches the last cut, the only spoil remaining to fill this cut is the overburden from the initial or box cut. Yet, since the box cut spoil may lie several miles from the last cut, the operator generally finds it cheaper not to truck the box cut spoil to the last cut. Instead, he may decide to establish a permanent water impoundment in the last cut. These *last cut lakes* are commonplace in the coal regions of the Midwest but may pose environmental and land use problems. A later section of this handbook describes strategies for challenging these last cut lakes.

**Open Pit Mining**

Open pit mining is similar to area mining. The technique is common in the western United States (and other parts of the world) where very thick — 50 to 100 foot — coal seams exist. Open pit mines are usually large operations. Production levels may exceed 10 million tons of coal per year.

The thick coal seams found at these large mines ensure that the amount of land disturbed for each ton of coal produced is much smaller than for most Eastern and Midwestern mines. Nonetheless, the sheer size and capacity of these mines necessitates substantial surface disturbance. In open pit mining, the operator first removes the overburden to uncover the coal seam. The overburden may be placed on adjacent, undisturbed land, or it may be transported by belt or rail to the other end of the same mine or to an exhausted mine that needs to be backfilled. Typically, several different pits, at various stages of development or reclamation, are being worked at any given time on a single site.

Large machines remove the overburden in successive layers until the coal seam is reached. The operator then extracts the coal and transports it to a power plant or to a rail line for shipment to a power plant. Next, the operator backfills the pit with previously extracted overburden and grades it. Topsoil that either has been saved or transported from the ongoing operation is spread over the spoil, and the area is seeded.
The thin overburden and thick coal seams that are frequently encountered with open pit mines may result in insufficient spoil material to reclaim the mined land. SMCRA provides an exemption from the "approximate original contour" or AOC requirement for operators confronting this situation.[1]

**Contour Mining**

The contour method is used almost exclusively in the steep Appalachian region of the United States, where coal seams outcrop from the sides of hills or mountains. Contour mining makes cuts on the slope where the coal seam is located, to remove first the overburden and then the coal itself. Overburden from adjacent cuts is used to fill previous cuts. The operator continues making cuts until the ratio of overburden to coal becomes uneconomical. The operation then continues along the contour of the mountain until the coal resources, or the operator's resources, are exhausted.

Contour mining uses small earth-moving equipment such as power shovels, backhoes and bulldozers — similar to equipment used for many other kinds of construction activities. Contour mining is therefore a favorite technique of small, often undercapitalized operators in Appalachia. Persons in the construction business, for example, can easily move in and out of the mining business as market conditions change.

In contrast to open pit operators, contour operators frequently have too much spoil after mining is completed. This results from a phenomenon called the *swell factor*. When overburden is removed it breaks up and loses some of the compaction that occurred over the thousands of years that it laid undisturbed. Even after replacement and mechanical compaction, the volume of the material increases by up to 25%.[2] The pits left after extracting the relatively thin coal seams of the East are often not large enough to hold this added volume. As a result, most contour miners must dispose of their excess spoil in another fill or disposal area. The most common disposal areas are at the heads of valleys, called *valley fills* or *head of hollow fills*. The construction of a fill means that additional land beyond that required for mining must be disturbed in order to accommodate that mining. The harmful effects of valley fills are discussed further under the section on mountaintop removal.

**Auger Mining**

Auger mining usually takes place in conjunction with a contour mining operation. Once the contour operator reaches the point where the height of the highwall makes it uneconomical to remove further overburden, the operator may choose to extract further coal, before beginning reclamation, by drilling into the face of the highwall with a mining auger. Large diameter drill bits, which can be broken into relatively small lengths, may bore as much as 200 feet into a coal seam, thereby extracting as much as 60 percent of the coal resources. Because auger mining removes support for the materials above it, care must be taken to fill the auger holes after extracting the coal. Failure to fill auger holes may cause tension cracks and other problems on the surface.

**Mountaintop Removal**

The final method of surface coal extraction to be described here is aptly called mountaintop removal. Using this technique, operators remove entire mountaintops to reach the coal seam lying underneath it. Mountaintop removal requires more capital and engineering skill than the contour mining method, but it allows the operator to extract virtually the entire coal seam. Mountaintop removal, which is used increasingly in Appalachia, became possible only after technology evolved and the economics of mining changed to allow
greater stripping ratios. Today it is economical to remove as much as 1,000 feet of mountain to reach a sizable coal seam.[3]

Mountaintop removal is a controversial mining method that generates an enormous amount of spoil, and unlike every other technique, none of the mined area is backfilled. What used to be the top of the mountain becomes a large, flat plateau. Because steep mountain grades make restoring the natural contour of the landscape impossible, SMCRA provides an exception to the normal rule that post-mining land must be restored to its approximate original contour.[4] Typically, the operator places the spoil in a fill in an adjacent valley or hollow. The massive fills constructed in Appalachia appear generally stable. Fewer than twenty slope movements have been reported out of the more than 6,800 fills built from 1985 to 2003.[5] However, the fills bury streams that flow through Appalachian valleys,[6] and the deforested mine sites cause flooding, even after revegetation efforts are complete. Rivers and streams are polluted. The mining process itself causes dust, noise, and fires. Subsidence cracks the foundations of nearby houses and disrupts the operation of nearby wells.[7] The change in topography is startling.[8]

Mountaintop removal mining has an immeasurable effect on wildlife.[9] The areas most suitable for mountain top removal fills are the narrow, V-shaped, steep-sided hollows that are sometimes inhabited by endangered or rare animal and plant species. Streams buried by mountaintop spoil or polluted by heavy metals contain endangered and threatened aquatic species. Fish migration routes are cut off. Of course, removal of mountaintops may also damage the aesthetic quality of an area.

Mountaintop removal mining is occurring more and more frequently, and citizens’ efforts to stop it through litigation have proven largely unsuccessful.[10] [11] During the debate over SMCRA, citizen groups in Appalachia tried to persuade Congress to ban mountaintop removal completely. After heated discussions, Congress allowed the technique, but only under special conditions which are described later in this handbook.

Underground Mining

Despite its title, SMCRA's provisions apply not only to surface mining, but also to the surface effects of underground mining.[12] As a percentage of all coal mining, underground coal mining has been declining for many years, but in 2007 it still accounted for approximately 31 percent of coal mining, as compared with 69 percent surface mining.[13] An underground coal mine usually begins much like a contour mine, with a cut into the side of a hill. Indeed, many abandoned surface mines serve as the face for the underground mine. The bench created by the cut often houses the mine office and equipment storage. Several portals are usually dug into the coal seam at the base of the highwall. These portals serve both as entryways for the mine and for ventilation.

Underground mining can take various forms. Traditionally, operators used a room-and-pillar method whereby large pillars of coal were left in place to hold up the roof and protect the miners. In retreat mining, operators return to the mine after it was otherwise completed to rob the pillars, or extract the coal pillars and allow the roof to subside while retreating toward the coal portals.

In recent years, the majority of underground mines have moved to a process called longwall mining. In contrast to more traditional techniques, longwall mining uses powerful coal extraction machinery and hydraulic lifts to remove the entire coal seam during the initial mining operation. A cutting machine shaves coal from the face of the seam while hydraulic lifts support the roof near the working face. When the hydraulic lifts move forward, the unsupported overburden collapses behind it, causing the ground surface to subside. This collapsing of the surface
above the mine is called **planned subsidence**. Because of the nature of the machinery that is used, longwall mining is only practical where the coal seam is of relatively uniform thickness.

Unless the mine workings have been backfilled to support the overburden, any surface area lying above a spot where coal has been mined by underground methods may subside at any time in the future. Sinkholes from room-and-pillar mining develop unpredictably 20 to 50 years after mining takes place. The advantage of planned subsidence is that the damage occurs relatively soon after mining occurs, and the operator is readily available to mitigate any damage that results. Nonetheless, the environmental effects of planned subsidence may be unacceptable in certain circumstances. For example, structures above the mining, including buildings, roads and pipelines can be seriously damaged. Also, subsidence cracks may drain or dewater streams, ponds, wells and groundwater aquifers above the coal seam. These events can cause an irreversible adverse impact on the hydrologic balance.

Despite these problems, SMCRA does not forbid mining methods that involve planned subsidence. It does, however, set standards to control subsidence and other forms of surface damage caused by underground mining.

### Environmental Effects

Unless proper precautions are taken, any of these mining techniques will significantly harm the environment. The older mining areas of Appalachia testify daily to this reality. In Appalachia alone, thousands of square miles of mountainous terrain have been scarred by strip mining and left unreclaimed. For 25 years, operators simply pushed overburden downslope from the mountain mines, causing landslides, erosion, sedimentation, and flooding. The remaining unstable highwalls, often 100 feet high, crumble and erode, disrupting drainage patterns and causing massive water pollution.

Erosion increases dramatically when the protective plant cover is removed and the remaining soil is not stabilized. Studies show that water flows from selected mines carry sediment loads up to 1,000 times greater than flows from unmined areas.[14] In a 1979 analysis, the **Department of the Interior found gullies greater than one foot in depth on more than 400,000 acres of mined land.**[15] High sediment loads and erosion also increase the likelihood and severity of floods, fill lakes and ponds, degrade water supplies, increase water treatment costs, and adversely affect the breeding and feeding of certain fish.

**Not all strip mining damage is as dramatic** as mutilated mountainsides with highwalls exceeding 100 feet. SMCRA has helped eliminate many of these more obvious abuses. But long-term damage to the soil, water and wildlife continues despite Congress' efforts to control it.

### Damage to Land Resources

Long-term damage to soil resources from strip mining may be masked when intensive, short-term land management gives a false impression that reclamation has been successful. Strip mining eliminates existing vegetation and alters the soil profile, or the natural soil layers. Mining disturbs and may even destroy the beneficial micro-organisms in the topsoil. Soil also may be damaged if reclamation operations mix the topsoil with subsoils, diluting matter in the surface soil.

Strip mining also may degrade the productive capacity of adjacent land. Spoil placed on adjacent land that has not been properly prepared may erode and thereby cover topsoil or introduce toxic materials to the soil.
Mining also may alter the natural topography of the area in ways that prevent a return to the previous land use, such as farming. Returning the soil from the mined area to full productivity is especially important in the Midwest, where some of the world's most prime farmland is now being mined for the coal that lies beneath it.

In the western United States the arid or semiarid conditions of that region may increase the damage to soils caused by mining. Once the natural vegetation is removed, erosion may increase dramatically. One of the most persistent problems at western mines is establishing a "diverse, effective, and permanent vegetative cover... capable of self-regeneration and plant succession at least equal...to the natural vegetation of the area,"[16] Native vegetation in the West has adapted to the arid climate to provide maximum soil stability during drought periods. Moreover, diverse native species provide forage for animals throughout the year. But because revegetation using native species is often difficult and expensive, many operators choose non-native species, which stabilize the soil over the short-term. Often, however, these species are not suited for forage and they may not be capable of long-term self-regeneration as required by SMCRA.

**Water Resource Damage**

Irresponsible strip mining can pollute streams and disrupt water supplies. SMCRA was intended to prevent these problems. Sometimes water pollution is easy to spot. Clear water often turns reddish-orange if it contains a high concentration of iron. However, other types of pollution are harder to detect. A highly acidic stream may look no different than a clean one unless you notice that it has no fish in it.

Water discharged from strip or underground mines must meet pollution standards for four major pollutants: pH, iron (inapplicable during rainstorms and during the reclamation phase), manganese and suspended solids (i.e., sediment). Let's briefly look at each of the major pollutants and problems they cause:

- **pH** — pH is a measure of the relative acidity of liquids. A pH of 7 is considered neutral. Liquid with a pH below 7 is acidic; liquid with a pH above 7 is alkaline. Each number on the pH scale represents a 10-fold increase or decrease in acidity. Thus, a pH of 3 describes a liquid that is 10 times as acidic as a liquid with a pH of 4.[17]

  The law requires that the pH of water released from a mine be between 6 and 9.[18] Although the more common problem associated with mining operations is acid drainage (low pH), alkaline drainage (high pH) is less common but can also cause problems. Alkaline mine drainage or runoff is most common in the West, where alkaline overburden may be exposed to water during mining. Acid drainage is typically caused when pyrite (fool's gold) or marcasite in the overburden is exposed to air and water during the mining process. Rainwater mixes with the pyrite to form sulfuric acid which is washed into streams and ponds below the mine.

  Acid is one of the most damaging pollutants. It kills fish and other aquatic life, eats away metal structures, destroys concrete, increases the cost of water treatment for power plants and municipal water supplies, and renders water unfit for recreational use. Acid also may leach-out highly toxic metals or cause them to be released from soils. These toxic substances kill aquatic life and can contaminate water supplies causing serious adverse human health effects. Thousands upon thousands of miles of streams have been degraded by acid mine drainage and runoff. Exposed acid material may continue to leach acid for 800 to 3,000 years.

- **Iron** — (Iron hydroxide, sometimes called "yellow boy") Increased amounts of iron in streams which result from mining activity can be toxic to aquatic life and contribute to the "hardness" of water.

- **Manganese**[19] — Manganese is a metal that is soluble in acid once it has been unearthed by mining activity. It pollutes water supplies and corrodes other metals.
- **Suspended solids**[20] — Also referred to as “TSS” (Total Suspended Solids) or sediment, suspended solids are solid material, both mineral and organic, that has been moved from its place of origin by air, water, ice, or gravity. Removing vegetation, blasting the overburden and using heavy equipment create erosion and introduce sediment into streams. Sediment loads are particularly high in mountainous and hilly terrains. Suspended solids reduce light penetration in water and alter a waterway’s temperature. Fish production is hindered; spawning grounds are destroyed. Sediment increases the burden on treatment plants, and streams filled with sediment lose some of their capacity to carry runoff following storms, thus making the stream more prone to flooding. A sediment-laden stream flow can fill up a reservoir and severely reduce its useful life span. Finally, sediment may act as a carrier for other pollutants such as pesticides, heavy metals and bacteria.

A mining operation that discharges or deposits overburden or spoil into a body of water, including streams and wetlands, must obtain a permit under section 404 of the Clean Water Act (CWA). Section 404 regulates any discharge of any dredged or fill material, including overburden from mining activities as well as material deposited in a water body for construction purposes. A permit under SMCRA does not release a mining operation from the obligation to obtain a CWA section 404 permit.

Section 404 applies to all “navigable waters” in the United States, which until recently the Army Corps of Engineers (“COE”) has defined to include almost any river, lake, stream, pond, wetland, or other body of water, including some streams that may not flow year round.[21] Section 404 requires that the mining operator provide alternative proposals evaluating the discharge effects of overburden disposal on different streams within the permit boundary.[22] It also requires that the discharge of fill does not jeopardize threatened or endangered species, [23] does not violate state or federal water quality standards,[24] and does not contribute to the significant degradation of waters of the United States.[25] Clean Water Act permit requirements are discussed further in Chapter 5.

Mining activity can also affect the quantity and quality of groundwater supplies. In many coal fields, the coal beds themselves serve as aquifers — underground supplies of water. The water in these aquifers flows — although when compared to surface water streams, groundwater flows at a very slow rate. The fact that groundwater flows, however, allows it to recharge or replenish many surface water systems. Surface mining operations will necessarily cut through the coal aquifer and also any aquifer above the coal seam that is being mined. Blasting activity and subsidence from underground mining may break up the impermeable layers of rock that hold water in these aquifers, even where the overburden is not being extracted.

These aquifers may be the source of water for many wells. Flow patterns in such aquifers may be changed, thereby adversely affecting water pressure in wells. Portions of aquifers and surface systems may be dewatered, reducing the availability of water for other uses, and perhaps interfering with prior existing water rights. Even where water losses from existing aquifers do not affect other users, disposal of excess water from those aquifers may cause environmental damage.

It has yet to be demonstrated that a groundwater system destroyed by mining can be permanently restructured. If not conducted properly, coal development — especially in the West — may leave behind barren landscapes vulnerable to continual erosion and disrupted groundwater systems. As a result, the value of these areas for agriculture and other uses may be greatly diminished.

**Wildlife Damage**

Wildlife often suffers severely as a result of strip mining. In the short term, all species are either destroyed or displaced from the area of the mine itself. Mining also may have adverse, long-term impacts on wildlife, including impairment of its habitat or native environment. Many animal species cannot adjust to the changes brought on by
the land disturbance involved in coal mining. In cases where an important habitat (such as a primary breeding ground) is destroyed, the species may be eliminated. Unique habitats like cliffs, caves, and old-growth forests may be impossible to restore.[26] Larger mines, such as those in the West, may disrupt migration routes and critical winter range for large game animals.

As previously noted, strip mining exposes heavy metals and compounds that can alter the pH or acid balance of runoff and leach into streams. Such pollution can impair the habitat of fish and other aquatic species, thereby reducing population levels. Even where species survive, toxic materials can lower reproduction and growth rates. Strip mining also causes increased turbidity and siltation of streams and ponds, greater variation in stream flow levels and water temperature, and stream dewatering, all of which contribute to the endangerment of aquatic species.[27]

When fill material is replaced following a strip mining operation, it is heavily compacted to prevent it from eroding or sliding. As a result, easily-planted grasses out-compete tree seedlings, whose growth is slowed by the compacted soil, and complete reforestation is unlikely. More effective reclamation techniques now exist and must be promoted.[28]

The Appalachian Mountains, where northern and southern species converge, contain an incredible diversity of unique plants and animals. Appalachian ecoregions are home to one of the richest salamander populations in the world as well as increasingly rare forest types, all of which are threatened by the region’s heavy mining activity.[29]

Proper compliance with SMCRA’s reclamation requirements can help minimize the environmental harm associated with strip mining. Reclaimed land can reconnect fragmented wildlife habitats, and properly replaced soil can encourage re-growth of high-value trees like the American Chestnut. According to the U.S. Fish and Wildlife Service (FWS), SMCRA effectively protects endangered species through provisions designed to minimize direct impacts on wildlife[30]-- but only when properly enforced. The indirect impacts, or “incidental take,” such as increased human access to endangered species created by mining roads, long-term changes in land use, and invasions by new species, are impossible to quantify.[31]

Furthermore, FWS’s proclamation that SMCRA can adequately protect endangered species from the dangers of coal mining is now under attack. Conservation groups are petitioning FWS and the Office of Surface Mining Reclamation and Enforcement (OSM), demanding that more effective measures be taken to protect at-risk species.[32]

More than 31.5 billion tons of coal has been mined under SMCRA as of July 2009.[33] The chapters that follow describe the major provisions of SMCRA and the opportunities for citizens to ensure that the law is fully implemented and enforced.