STREAM PROTECTION IN PENNSYLVANIA

IN THE CONTEXT OF UNDERGROUND COAL MINING

Prepared for:

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CITIZENS COAL COUNCIL

Since its formation in 1989, the Citizens Coal Council (CCC) has been working to protect people, land, and water from the harm caused by coal mining throughout the United States. Its mission is *"To inform, empower, and work for and with communities affected by the mining, processing, and use of coal."* CCC seeks to address the core problem in the coalfields: the unequal distribution of power between the coal industry and citizens. It serves as a watchdog of the coal industry and the government agencies that oversee mining. It provides a forum for the exchange of ideas and the development of strategic alliances among coalfield leaders and citizens. CCC monitors national regulations, policies, and legal decisions, and serves as a vehicle for bringing coal-related issues before national policymakers. Aimee Erickson is the *Executive Director* of CCC, and she can be reached at aimee@citizenscoalcouncil.org

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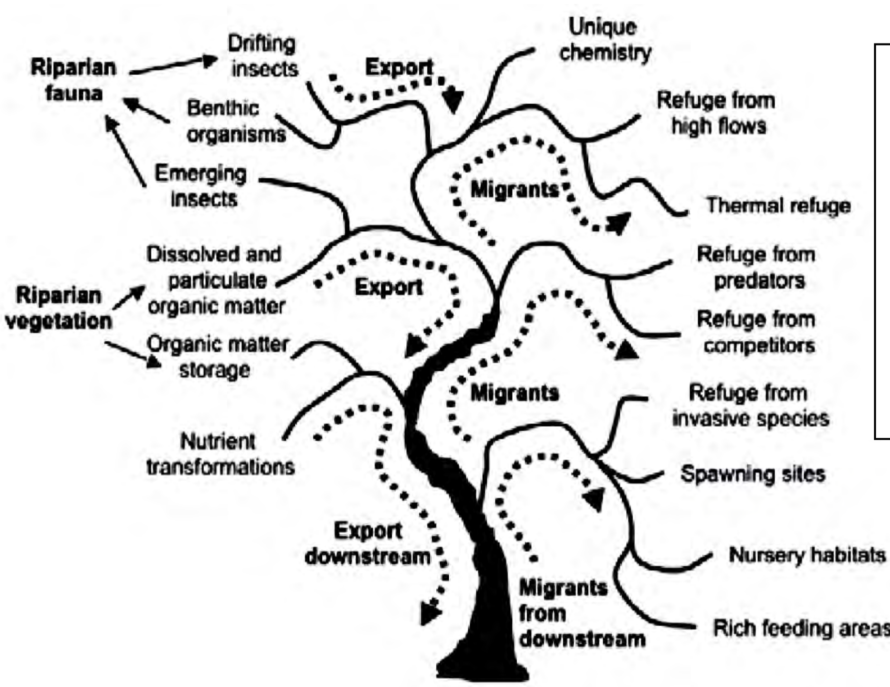
1 INTRODUCTION

This report examines the effects that underground coal mining has on streams and discusses legislative and regulatory efforts in Pennsylvania to protect streams from adverse effects. It begins by focusing on the basic elements that constitute a stream, including its structure and functions. Next is a discussion of the nature of underground coal mining and the ways in which different mining methods adversely affect streams. Then it discusses the various laws and regulatory requirements that have been adopted with respect to stream protection and reviews their effectiveness. Finally, a review is provided of the success of attempts to restore damaged streams, both generally and in the specific context of coal mining activities.

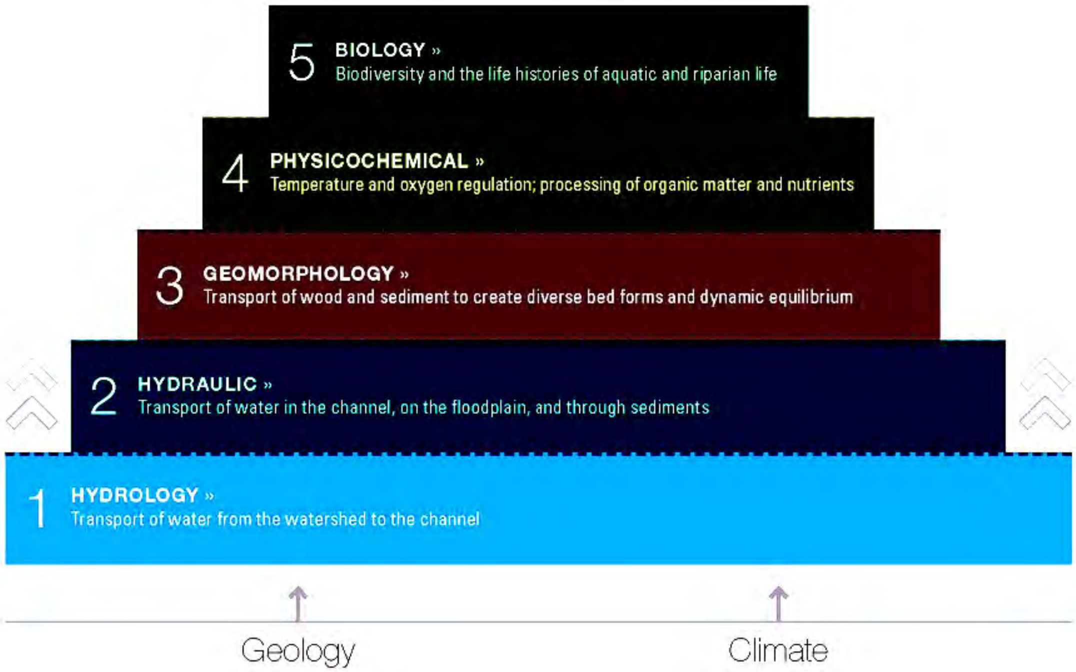
2 THE NATURE OF STREAMS

A stream is much more than simply a conduit for water. A stream is a complex, interconnected system of living and non-living components (see graphic below). A stream has both structural elements and functional elements. Structurally, a stream consists of a bed, banks, channel, and floodplain area. Streams are three-dimensional features which both affect, and are affected by, their surrounding areas. Fish and other aquatic organisms typically live in the stream and depend on adjacent areas for inputs of organic matter and energy. A stream is a dynamic system, typically with sections of slow flow (pools) and sections of fast flow (riffles). Sediment, pebbles, rocks, tree leaves and branches, and other organic and inorganic matter are transported by the stream, which themselves cause changes in the shape, flow, and meander pattern of the stream and greatly affect the kinds of aquatic organisms that inhabit the system.



Factors that contribute to the biological importance of headwater streams in river networks (Meyer *et al. 2007).* Attributes on the right benefit species unique to headwaters and also make headwaters essential seasonal habitats for migrants from downstream. On the left are biological contributions of headwater ecosystems to riparian and downstream ecosystems.

Harman *et al.* (2012) have classified stream functions into a hierarchy of five categories (see figure below).



Within this hierarchical framework, higher-level functions are supported by lower-level functions, like a pyramid. For example, hydraulic functions (#2) cannot occur without hydrologic functions (#1), and so on. Hydrology is the foundation of the pyramid because water contributed from the watershed, including from precipitation and groundwater, strongly affects the higher-level stream functions. Simply put, without water, there is no stream, no channel formation, and no aquatic ecosystem.

Pennsylvania Department of Environmental Protection (PADEP) mining regulations (see Section 4 below) acknowledge the complexity of streams and their inclusion within the broader system known as the hydrologic balance. At 25 *Pa. Code* 89.5, the underground coal mining regulations define "hydrologic balance" as:

> The relationship between the quality and quantity of water inflow to, water outflow from and water storage in a hydrologic unit such as a drainage basin, aquifer, soil zone, lake or reservoir. It encompasses the dynamic relationships among precipitation, runoff, evaporation and changes in groundwater and surface water storage.

Streams sometimes are distinguished on the basis of flow and are classified as being perennial, intermittent, or ephemeral. The flow in a stream can come from one or more sources: direct precipitation, surface runoff, and/or groundwater inflow. Perennial streams typically have flowing water year-round during most years, with significant groundwater inflow. In their natural state, perennial streams tend to support a great number and diversity of aquatic organisms. Intermittent streams will have continuously flowing water during the wetter times of the year (typically winter-spring) but can be dry during certain periods, especially during the summer season. While surface flow may not always be apparent, many intermittent streams maintain some flow or wetness just beneath the surface. Ephemeral streams typically flow only in response to precipitation or snowmelt and lack the groundwater contribution found in intermittent or perennial streams.

Stream characteristics and functions change from headwaters (upper elevations of a watershed) to permanent large rivers to tidal estuaries. Streams in the headwaters contribute flow to streams further down. Many headwater streams are ephemeral or intermittent; some are fed by permanent springs. Small headwater streams make up most of the stream-miles in a watershed (up to 80%), and scientific literature unequivocally demonstrates that streams, individually or cumulatively, exert a strong influence on the integrity of downstream waters (USEPA 2015, Alexander *et al.* 2007, Clarke *et al*. 2005, Freeman *et al*. 2007, Kaplan *et al*. 2008, Meyer *et al*. 2003, Meyer *et al.* 2007).

According to the latest surface water quality assessment, Pennsylvania has an estimated 86,000 miles of identified rivers and streams (PADEP 2017). This is the greatest mileage of streams of the 48 conterminous United States (USEPA 2013, Carlisle *et al*. 2013). Because many intermittent and small headwater streams are not shown on available maps (such as USGS quadrangles and the National Hydrography Database, upon which the PADEP estimate was derived), the actual number of stream miles in Pennsylvania subject to formal protection is significantly higher.

According to PADEP's 2017 assessment, 84,372 miles of streams and rivers have been assessed in Pennsylvania for aquatic life use. Of that total, 64,223 miles (76%) are listed as "attaining" their designated aquatic life use; the others are considered "impaired" by pollutants or other impacts from human activities. The two largest sources of water quality impairment for aquatic life use are agriculture (6,421 miles) and abandoned mine drainage (5,595 miles).

3 MINING AND ITS EFFECTS ON STREAMS[1]

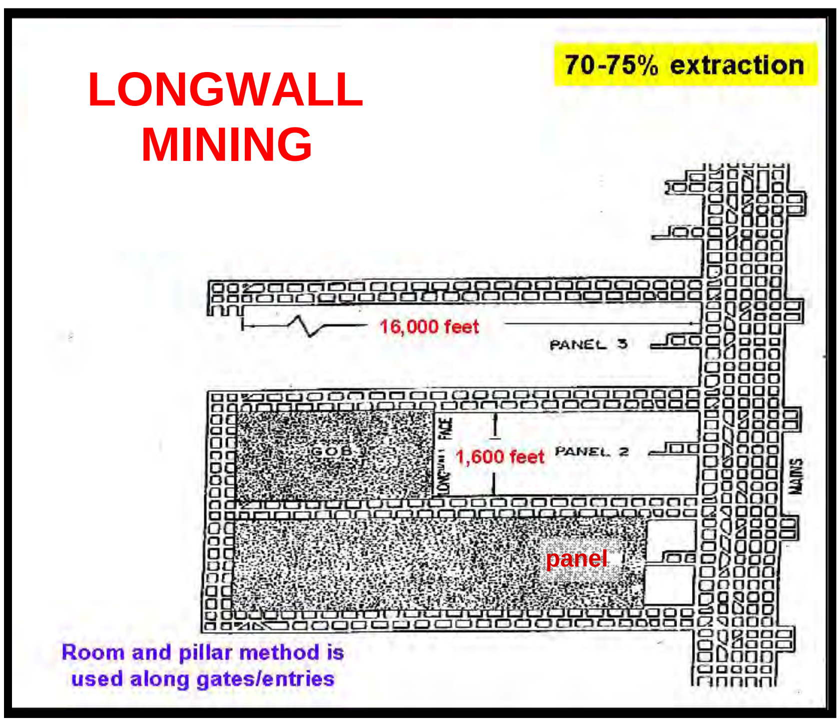
Coal mining long has played an important role in the history, economy, and culture of Pennsylvania. Underground (as opposed to surface) mining of coal in the Commonwealth is the oldest and most productive method (Edmunds 2002). For more than 200 years most underground coal mining in Pennsylvania was done using the traditional room-and-pillar method, which extracts about 40%-60% of the coal in an area, but leaves enough coal in place (in the pillars) to support the mine roof and prevent surface subsidence. Room-and-pillar mining has been practiced in Pennsylvania since the late 1700s (PADEP 2014b), and continues to be used profitably today. It does not cause surface subsidence, at least not intentionally and not if the mine is properly designed and operated to preserve roof support. All underground coal mines in Pennsylvania rely upon room-and-pillar mining methods to some extent, and more than 70% use such methods exclusively.

[1] A 1994 amendment of the Pennsylvania underground bituminous coal mining law (known as "Act 54"; see also Section 4 below) requires the PADEP to prepare, every five years, an analysis of the effects of underground coal mining on subsidence of surface structures, features, and water resources. There have been four such 5-year "Act 54 Reports" to date, covering the period from 1993 through 2013. The most recent Act 54 Report (for 2008-2013) was released in late December 2014 [PADEP 2014b]. Most of the data presented herein are derived from those reports.

Historically, the principal impact to streams from underground coal mining was acid mine drainage (AMD). Mine drainage is formed when pyrite, an iron sulfide mineral in coal, is exposed to and reacts with air and water to form sulfuric acid and dissolved iron. The acidic (low pH) runoff further dissolves other heavy metals such as copper, lead, and mercury which leach into groundwater or surface waters. Regulation and treatment of discharges has largely eliminated AMD.

Prior to the advent of longwall mining another underground mining method, known as retreat mining or pillar removal mining, was sometimes used to extract a higher percentage of coal (60% to 70%) than could be produced by traditional room-and-pillar mining. Retreat mining was used to selectively remove pillars of coal that had been left in place in completed sections of a room-and-pillar mine. The removal of the support pillars, however, often resulted in the collapse of the overburden (rock above the mine) and in the weakening of adjacent pillars, causing surface subsidence to occur, often at unpredictable times. Retreat mining is still practiced in about 10% of Pennsylvania underground mines. Mine engineering has advanced sufficiently that subsidence is generally avoided.

In the 1970s, longwall mining first was introduced into southwestern Pennsylvania from Europe. It was promoted as a high-extraction mining method that was safer and more predictable than retreat mining. Using longwall methods, up to 75% of the coal in an area can be removed. It starts out using traditional room-and-pillar methods to develop access "gates" and entryways around the perimeter of a large rectangular "panel". It then removes all of the coal from within the panel itself (see figure at right).



Surface subsidence is an intrinsic part of longwall mining because there is no surface support except in the narrow gates between the panels, which currently are about 230 to 260 feet wide. The size of a longwall panel, in particular its width, is an important factor in a mine's productivity but also in the magnitude of resulting subsidence. More than 30 years ago a Bureau of Mines analysis (Jeran and Barton 1985) found that subsidence deformation increases significantly as longwall panel width increases in proportion to coal seam depth.

Longwall panel widths have increased significantly over time. In its most recent five-year Act 54 Report on the effects of underground bituminous coal mining subsidence, the PADEP noted:

> "The average size of longwall panels has increased nearly four-fold since the method's introduction in Pennsylvania around 1970, from about 400-ft in width originally to as much as 1,560-ft currently." (PADEP 2014b: page XI-3)

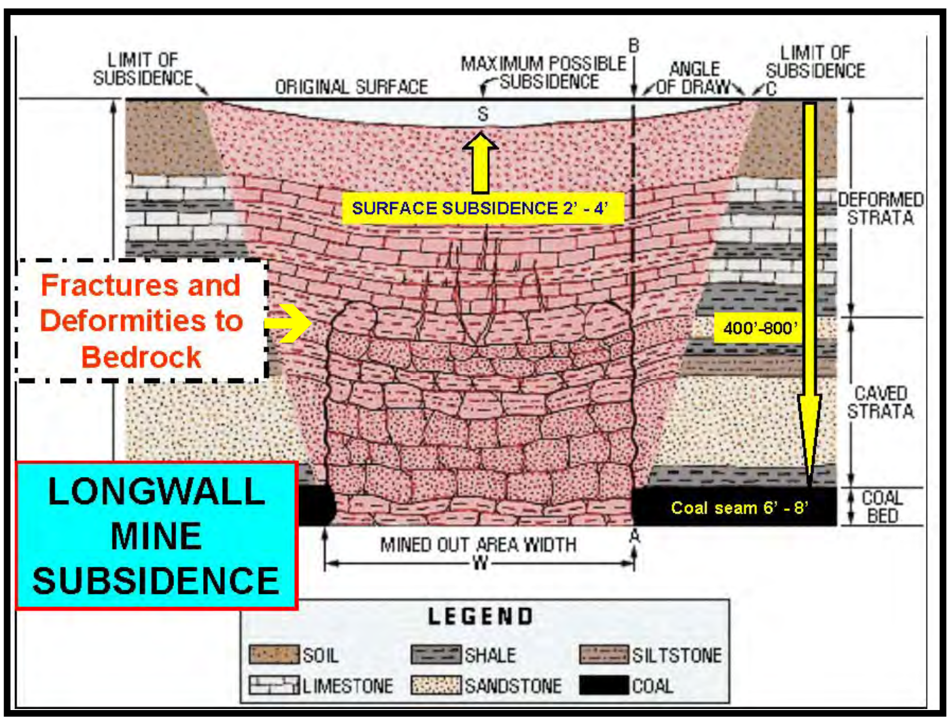
As a general rule, the **critical width** (Lc) of a longwall panel is defined as:

Lc = W/H

(where W = panel width and H = depth of cover)

A subsidence basin can form when W/H exceeds 0.25; for example if a panel is 400 feet wide at 1,000 feet below the surface it has a W/H ratio of 0.25. If the panel is any wider at that depth, some subsidence will occur (PADEP 2011).

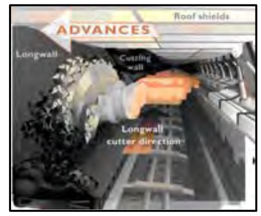
The greatest vertical surface subsidence generally occurs above the center of a panel, and decreases towards the edges nearest the gates and entries. Maximum subsidence potential is realized when the W/H ratio exceeds 1.0. At ratios greater than 1.0, a panel is considered "supercritical"; below 1.0, it is "subcritical" (PADEP 2011). Thus, at 1,000 feet below the surface, maximum subsidence will be experienced whenever a panel is more than 1,000 feet wide. During the 2008-2013 period studied by PADEP (2014b) longwall mining was conducted at an average depth of 783 feet, but most longwall panels mined during the period were wider than 1,000 feet, and several of the mines active during the period had panels wider than 1,500 feet. Thus, most of the current longwall mining is "supercritical".



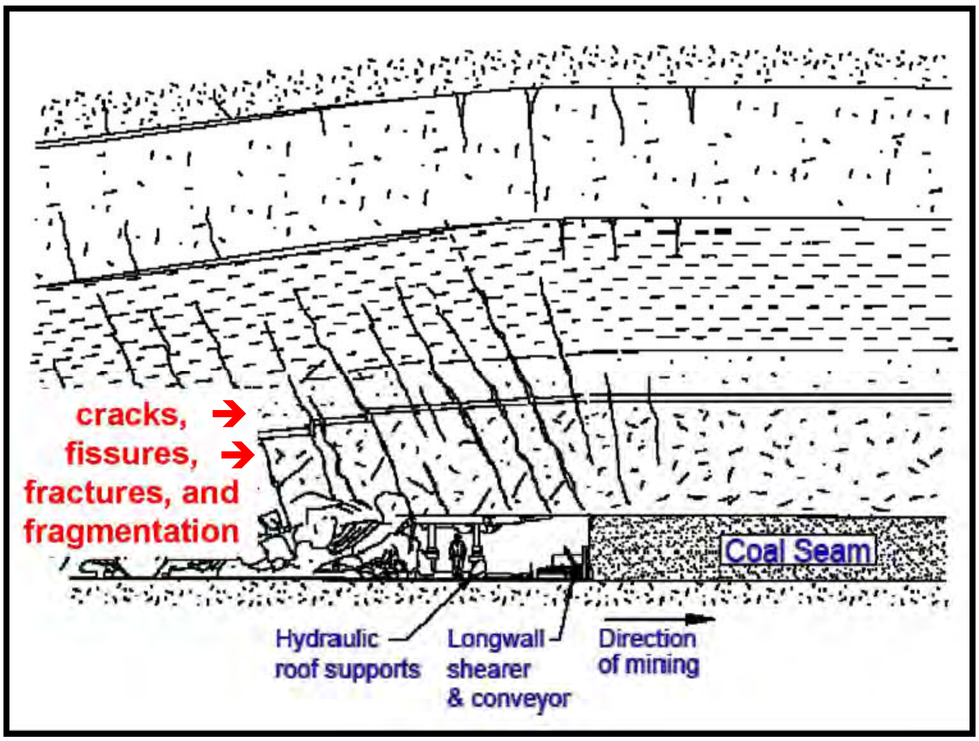
Maximum subsidence is a function of the extracted seam thickness [mining height], width of the individual panel with respect to the depth of the mine, and thickness of the overburden.

The subsidence factor is the ratio of maximum surface subsidence to the seam mining height and often is expressed as a percentage. For example, if 7 feet of subsidence occurred at the ground surface over a mine panel with a 10-foot mining height, then the subsidence factor would be 70 percent. The subsidence factor will increase with increasing panel width, and it then levels off when both the previous and new panel widths exceed the critical width, which typically occurs in a range of from approximately 1.0 to 1.4 times the depth. The maximum surface subsidence (S_{max}) over a longwall panel develops when panel width reaches and exceeds the critical width (USDOI-BLM 2009, Page C-7).

Large hydraulic supports hold the roof in place where coal is being sliced from the seam face (right). As the longwall operation advances, the supports are moved, allowing the roof to collapse into the void behind the supports. The resultant fracturing and settlement of the rocks progresses upward through the overlying strata, causing sagging and bending of the near-surface rocks and subsidence of the ground above, as shown in the figure below (Mine Subsidence Engineering Consultants 2007).



Longwall shearer at face of seam



While vertical displacement is the most obvious surface effect of subsidence, other factors are also at work. When the area above a longwall panel collapses into the created void, it exerts significant strain, tension, and compression on the overlying strata that changes as the longwall face advances. Tilt, horizontal displacement, curvature, and strain are the terms normally used to define the types of the ground surface movements that occur as the longwall mining advances. Structures or other features located on the surface at the positions of maximum curvature and strain generally suffer the greatest impact. A given point on the surface may be subjected to a series of subsidence waves as coal is extracted from adjacent panels, and as the angles of draw over each panel overlap. The duration of impacts will depend upon the position of the point relative to each of the subsidence troughs that are formed.

Longwall mine subsidence most often impacts streams in one of two ways: flow loss or pooling. According to a US Fish and Wildlife Service report on longwall mining impacts in southwestern Pennsylvania (2004), the following types of hydrologic effects can be expected from longwall mining subsidence:

> Subsidence often fractures overlying rock strata and can translate into varying effects at the earth's surface depending on the depth and width of the panel, geology of the overburden, mining height, number of panels, and mining face location (Shultz 1988). At the surface, subsidence may fracture relatively impermeable layers of rock or clay that previously diverted groundwater to hillside seeps, and first and second order stream channels. Springs may go dry; stream bottoms may fracture, thereby causing the stream to go dry; or the stream bottom may sink relative to unsubsided reaches (Northwestern University 1997; Booth *et al.* 1998; Hobba 1981).

On the PADEP Mining Program website the following description is provided regarding the potential subsidence impacts on streams and surface waters:

> The impacts of underground mining on surface waters can range from no noticeable impact to appreciable diminution, ponding, and/or diversion. The formation of subsidence-induced cracks, surface depressions, and/or sinkholes at the bottom of, or adjacent to, surface water bodies, such as streams, ponds, and lakes can lead to complete or partial loss of water due to leakage to the underlying strata. The resultant changes in surface slope can adversely impact drainage along irrigated fields, canals, sewers, and natural streams (Bhattacharya and Singh, 1985).

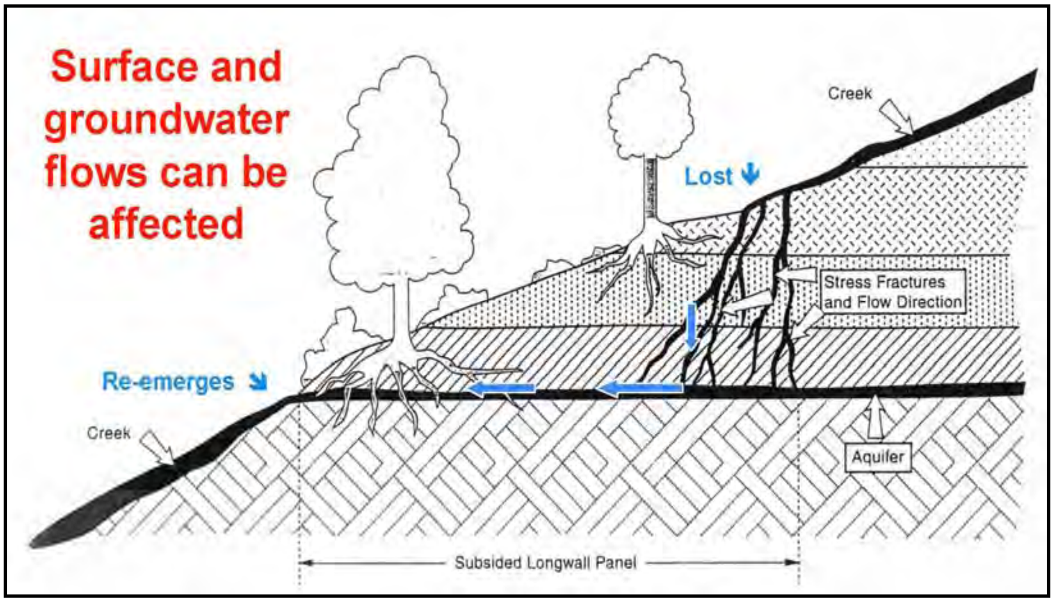
Pooling occurs because the land surface above a longwall panel subsides irregularly. In the center of the panel the surface may drop as much as several feet vertically, but the subsidence is less in areas closer to the gates and entries along the perimeter of the panel which are designed to not subside at all so as to protect the miners. When a stream overlying a longwall-mined area extends across several panels, its flow can become blocked by the unsubsided gates which then form a series of dams. When a section of a formerly free-flowing stream becomes pooled in this way, it collects sediment, loses oxygen, becomes warmer, and prevents the movement of fish and the transport of organic matter. All of these changes have a substantial and negative effect on the biological and chemical properties of the stream. The typical "fix" for pooling is to cut through the unsubsided gate so it matches the lowered elevation of the streambed on either side. However, the latest Act 54 Report noted that it takes on average 682 days (1.9 years) for mine operators just to *begin* efforts to restore streams impacted by pooling (PADEP 2014b). The time required for actual biological recovery of pooled streams has not been documented.

Flow loss in streams occurs when cracks and fissures created by the longwall mining extend all the way to the surface. Hydrologic impacts at and near the ground surface due to longwall mining are described thus by Callaghan, Brady, Chisholm, and Sames (2000):

> One important aspect of overburden movement, relative to the potential of high-extraction mining to impact surface waters, is the formation of surface extension zone fractures. An extension zone forms at panel edges and at the traveling panel face and is most pronounced

near the surface. Surface extension zone fractures are typically 50 to 100 feet deep. This near-surface zone of increased permeability and storativity can result in shallow aquifer and surface water impacts even where overburden to seam ratios are considerable and there is no direct avenue for drainage to the mine.

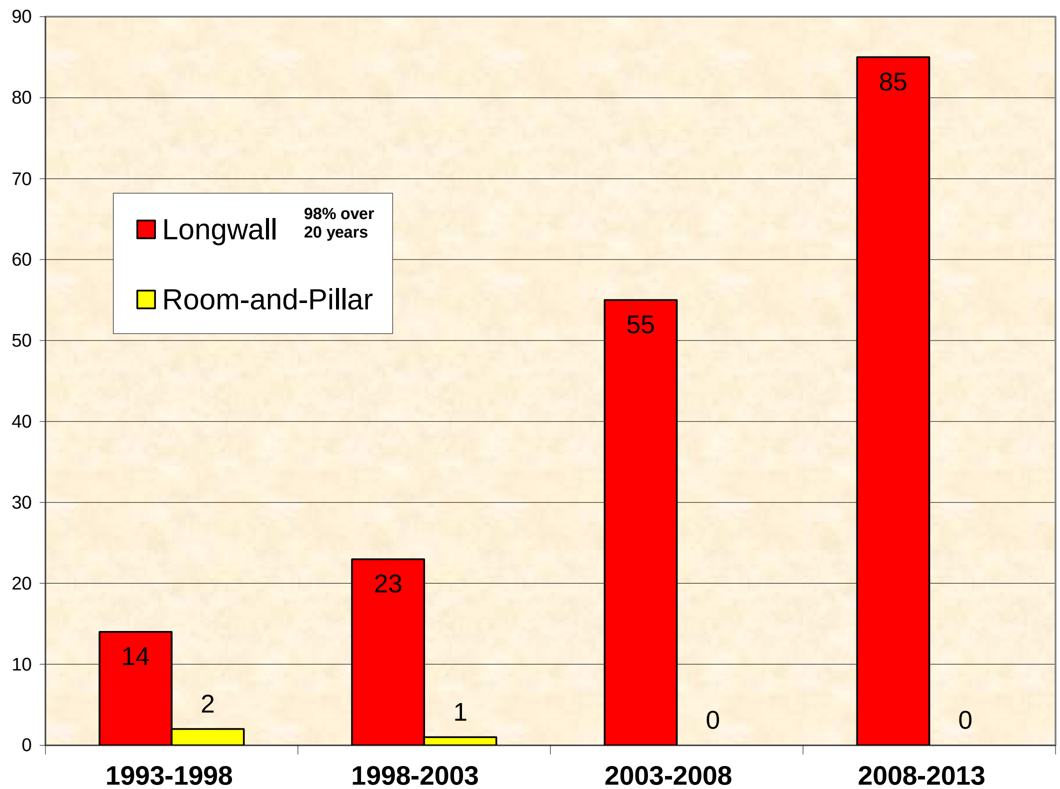
The sudden appearance of faults and fractures extending from the mined-out coal seam to the surface can induce a drastic change in hydrology of immense consequence to surface landowners, to streams, seeps, springs, wetlands, and groundwater, and to the organisms dependent on water resources. Subsidence involves physical changes (heaved streambed, pooling, or flow loss) which cause physical and chemical changes in the stream (increased sediment loads, increased temperature, higher conductivity, lower dissolved oxygen) and which also induce biological effects such as changes in the fish and macroinvertebrate communities (decrease in the numbers and types of species, loss of native species, increase in invasive species).



Streams dewatered by longwall mines can re-emerge at some point downstream. However, where such dewatering was studied in Marshall County, West Virginia, re-emergence was not sufficient for full recovery, resulting in 50% permanent stream loss (Stout, 2003; Stout 2004). Comparable data have not been collected in Pennsylvania, and such details are given little consideration in the PADEP five-year Act 54 Reports. The ecosystem services that headwater streams provide to adjoining ecosystems are permanently lost when headwater streams are dewatered by longwall mining (Stout and Cassidy 2006).

Subsidence-related flow loss represents a much more significant impact to a stream than pooling. When pooling occurs because streamflow becomes impeded behind an unsubsided gate, the water still is present. Restoration of pre-subsidence flow typically can be achieved in a pooled stream by cutting through the unsubsided area. By contrast, flow loss occurs in a stream when mine subsidence has caused heaving of the streambed, and cracks and fissures drain water not only from the stream itself but also from adjacent wetlands, springs, and groundwater. Restoration of a stream that has suffered flow loss is more challenging technically because not only must the damaged streambed be physically repaired, but its various interconnected hydrologic inputs must somehow be replaced.

The Act 54 Reports have tracked the *number* of stream impact incidents associated with underground coal mines in Pennsylvania, but few details about the impacts or their outcomes. Fully 98% of underground mine-related stream impacts documented by PADEP during the last 20 years have been associated with longwall mines[2]. Two patterns are evident from the graphs below. First, in each of the four 5-year Act 54 Report periods, longwall mines were overwhelmingly responsible for stream impacts. Second, the number of recognized stream impacts has been increasing steadily.



NUMBER OF REPORTED STREAM IMPACTS FROM UNDERGROUND BITUMINOUS MINES BY ACT 54 REPORT PERIOD

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[2] Although very few stream impacts have been reported in Pennsylvania from room-and-pillar mines, that does not necessarily mean such impacts have not occurred more frequently. The PADEP Mining Program does not require applicants for room-and-pillar mines which are more than 100 feet below ground to provide detailed inventory and monitoring data on stream flow and biological conditions overlying their proposed operations. An absence of data is not the same as an absence of impacts.

4 LEGAL AND REGULATORY PROTECTIONS FOR STREAMS

The Clean Streams Law

As mentioned above, coal has played an important role in Pennsylvania's heritage and economy for a long time. The regulation of coal extraction, and attempts to balance its economic potential with its adverse environmental effects, also have a long history. The Pennsylvania Clean Streams Law[3] (CSL) was adopted in 1937. By that time, more than 100 years of coal mining had polluted many Commonwealth streams by acid mine drainage. One of the primary objectives of the Clean Streams Law was to address past impacts from coal mining and prevent future mine-related stream pollution:

> "...regulating the operation of mines and regulating the impact of mining upon water quality, supply and quantity..."

The Pennsylvania CSL preceded by 11 years the original federal Clean Water Act, which was adopted in 1948 and at the time was called the Water Pollution Control Act[4]. Both the PA Clean Streams Law and the federal Clean Water Act (CWA) recognize the importance of clean water to public health and welfare, and their underlying regulations seek to protect the uses and functions of waterways. Unlike the federal CWA, Pennsylvania's Clean Streams Law protects groundwater as well as surface waters.

Sections of the CSL specifically address mines and mining activities. According to CSL Article III, Section 315(c) [Operation of Mines]:

> *The application for a permit to operate a mine shall include a determination of the probable hydrologic consequences of the operation, both on and off the site of the operation, with respect to the hydrologic regime, quantity and quality of water in surface and ground water systems including the dissolved and suspended solids under seasonal flow conditions and the collection of sufficient data for the site of the operations and surrounding areas so that an assessment can be made by the department of the probable cumulative impacts of all anticipated mining in the area upon the hydrology of the area and particularly upon water availability.*

The Pennsylvania Environmental Hearing Board has found that significant hydrologic changes (such as pooling or flow loss) fit within the definition of "pollution" under the Clean Streams Law just as surely as a discharge containing high levels of acid, iron, sulfur, nitrogen, phosphorus, or other traditional pollutants[5]. Applicability of the CSL to hydrologic changes is of particular importance in the context of longwall mining.

BMSLCA

The Bituminous Mine Subsidence and Land Conservation Act (BMSLCA) was the original Pennsylvania underground coal mining law. It was enacted in 1966, and was in effect for 28

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[3] The Clean Streams Law, Act of June 22, 1937, P.L.1987 as amended, 35 P.S. § 691.1
[4] Water Pollution Control Act of 1948, P.L. 80-845, 62 Stat. 1155
[5] Oley Township v. DEP and Wissahickon Spring Water, Inc., 1996 EHB 1098.

years until it was amended in 1994 by Act 54 (see below). Under BMSLCA, damage to most surface structures built prior to 1966 was prohibited. In adopting this law Pennsylvania was leading the nation in its early acknowledgment of, and attempts to prevent, surface damages from underground coal mining, although the BMSLCA did not specifically address streams or surface waters. This law repeatedly was challenged by the mining industry unsuccessfully through the courts.

Act 54

When it was passed in 1994, Act 54 removed the BMSCLA prohibition on surface damage and specifically allowed damages to (A) structures and (B) water supplies, but with the intention that damages were to be addressed. *How* damages were to be addressed differed between the two features. Under Act 54, damage to structures was to be repaired, but financial compensation also was allowed. Damaged water supplies were to be repaired or replaced, and only as a last resort was financial compensation to be allowed.

> Section 9.1(d) of *Act 54* states:
>
> ***Nothing in this act shall be construed to amend, modify or otherwise supersede standards related to prevailing hydrologic balance .... nor any standard contained in*** *the act of June 22, 1937 (P.L. 1987, No. 394), known as "****The Clean Streams Law," or any regulation promulgated thereunder*** *by the Environmental Quality Board.* [BOLD ADDED]

Even though Act 54 specifically states that it does not supersede the Clean Streams Law (box above), the allowance of damages inexplicably has also been applied by the PADEP Mining Program to streams and other natural features. Thus, under PADEP's implementation of Act 54, longwall mines presented a new threat to waterways --- the disruption of flow.

Streams as Water Supplies per Act 54

A water supply is commonly thought of as drinking water, or perhaps more broadly as water used in the home for not only drinking, but also cooking, washing, and other domestic purposes. Such water typically comes either from a well, spring, or cistern, or from a public water supplier. Under Act 54, however, the term "water supply" encompasses many other things, including streams.

Section 5.1(a)(3) of Act 54 defines "water supply" as follows:

> For the purposes of this section, the term **"water supply"** shall include any existing **source of water** used
>
> for **domestic**, **commercial**, **industrial** or **recreational** purposes or
>
> for **agricultural** uses, including use or consumption of water to maintain the health and productivity of animals used or to be used in agricultural production and the watering of lands on a periodic or permanent basis by a constructed or manufactured system in place on the effective date of this act to provide irrigation for agricultural production of plants and crops at levels of productivity or yield historically experienced by such plants or crops within a particular geographic area, or

which **serves any public building or any noncommercial structure** customarily used by the public, including, but not limited to, churches, schools and hospitals.

[format adjusted and boldface added for emphasis]

Thus, under Act 54 a protected water supply includes not only waters used domestically for consumption or other purposes, but also waters used for commercial, industrial, or recreational purposes, for agricultural uses (including for irrigation or livestock), and in public and quasi-public buildings. Some of these water supplies could be streams, such as those from which water is drawn to irrigate lands or feed livestock, or those used for fishing, swimming, or other recreational purposes.

Under Act 54, streams clearly are meant to benefit from two levels of protection: (1) in accordance with all the statutory and regulatory provisions of the Clean Streams Law, and (2) as water supplies. The CSL protections signify that both the water quality of streams and the quantity of their streamflow are to be maintained and protected from discharges and land development activities, including mining. One of the basic protected uses of all streams in the Commonwealth is for water supply [25 *Pa. Code* 93.4(a)], and Act 54 imposes specific requirements on mine operators who may, or actually do, damage a "water supply".

Sections 5.1 through 5.3 of Act 54 address the restoration or replacement of water supplies damaged by underground mining activities. Mine operators are presumed liable for damage to any water supply within the 35-degree Rebuttable Presumption Zone. For every damaged water supply, mine operators are supposed to provide a temporary replacement water supply within 24 hours and a permanent replacement within three years. If a permanent alternate water supply is not provided within three years, the mine operator may enter into an agreement with the landowner to provide compensation, purchase the damaged property, or pay the difference between the value of the property before and after the water supply was damaged.

The inclusion of streams in the PADEP definition of "water supply" (per Act 54 and the mining regulations) goes beyond the minimum federal (Office of Surface Mining Reclamation and Enforcement, or OSMRE) requirements which focus exclusively on drinking (potable) water. With respect to drinking water, however, to the extent that an agreement between a mine operator and a landowner allows anything other than an actual replacement water supply, it would not comport with the federal underground coal mining requirement "*to promptly replace any drinking, residential, or domestic water supply*[6]". In practice, agreements that provide financial compensation instead of actual replacement often are regarded as pertaining to structure damages (for the damage to the well) rather than as water supply damages.

The OSMRE typically would not be concerned about the PADEP handling of damage to a "water supply" that involves a stream used for any purpose other than drinking, since that provision of Act 54 and the State program is beyond the minimum federal requirements which

[6] Regulations of the Office of Surface Mining Reclamation and Enforcement at §817.41(j) in accordance with the Surface Mining Control and Reclamation Act of 1977 (SMCRA)

focus on (drinking) water supplies. However, the PADEP's expanded definition of "water supply" is part of the State Mining Program *approved* by OSMRE, so any Pennsylvania water supply requirements (whether for drinking water or recreational streams) must be applied. In practice, however, the PADEP Mining Program provisions regarding water supplies almost exclusively have been applied to *drinking* water supplies, and not to *streams* which otherwise fit the definition of, or are used as, water supplies.

As noted above, Act 54 allows voluntary agreements between a mine operator and a landowner with respect to an affected water supply, typically as a last resort. Under a voluntary agreement, a landowner and the mine operator can agree that an alternative arrangement (something other than replacement) be implemented for the loss of a water supply. To the extent that such an agreement were to be made regarding a damaged water supply that is a stream, that agreement might not be legally binding insofar as there exist other protected "uses" of the stream that might not be replaced under the arrangement. Furthermore, beyond the landowner and the mine operator, there are other interests to be considered (such as those of the State and downstream users) in preserving the stream as a water of the Commonwealth for the benefit of all people, including future generations.

Streams as Water Supplies per PADEP Regulations

The exact same definition of "water supply" as is found in Act 54 also is found in the 25 *Pa. Code* Chapter 89 regulations (Underground Mining of Coal and Coal Preparation Facilities). By both definitions, any stream that is *used* as a source of water for domestic, commercial, industrial, recreational, or agricultural purposes is a "water supply".

All water supplies above or within 1,000 feet of a proposed mine are supposed to be inventoried as part of a mine permit application. The inventory is to be used to determine whether a water supply has been damaged and as a standard for restoration if necessary. The PADEP regulations at §89.145a address standards for replacement of damaged water supplies. Those regulations, and the associated sections of a mine permit application in Module 8, focus largely on *drinking* water supplies (*i.e*., wells and springs); streams associated with one or more water supply uses appear to have been ignored. For example, the premining water supply survey is supposed to include a physical description of the water supply, "...*including the depth and diameter of the well, length of casing and description of the treatment and distribution systems*"; similarly, hydrogeologic data are to be provided "...*such as the static water level and yield determination*" [§89.145a(a)(1)]. Section 8.3 in the permit application elicits data on "*all wells and springs that serve as water supplies*"; Section 8.7 elicits data on "*public water supplies*", and Section 8.16 notes that for sampling of water supply quality, the "[p]*remining sampling should also address other regulated safe drinking parameters that are likely to be present in the water supply*."

The PADEP regulations at 25 *Pa. Code* Chapter 93 (Water Quality Standards) appear to be even more inclusive regarding streams as "water supplies". The Chapter 93 regulations were established under the authority of the Clean Streams Law to "preserve and improve" the quality of surface waters of the Commonwealth. As identified at §93.4, there are ten basic water uses that apply to <u>all</u> streams in the Commonwealth. Five of the ten Statewide water uses are characterized as "water supply" uses (box at right), and include: potable water supply, industrial water supply, livestock water supply, wildlife water supply, and irrigation. Chapter 93 also establishes certain additional designated uses for aquatic life on a stream-by-stream basis; that is, all streams are protected at the minimum aquatic life use of WWF (warm water fishes), but some streams have been assigned a higher aquatic life use (cold water fishes, trout stocking fishes, or migratory fishes), and some have been afforded "Special Protection" (high quality and exceptional value waters). While some higher designated uses can be degraded to a degree under certain circumstances authorized by PADEP, these ten Statewide uses provide the base standard to which all surface waters are required to be protected per §93.4(a).

> **§ 93.4. Statewide water uses.**
>
> (a) *Statewide water uses*. Except when otherwise specified in law or regulation, the uses set forth in Table 2 apply to all surface waters. These uses shall be protected in accordance with this chapter, Chapter 96 (relating to water quality standards implementation) and other applicable State and Federal laws and regulations.
>
> **TABLE 2**

Symbol	*Use*
	Aquatic Life
WWF	Warm Water Fishes
	Water Supply
PWS	Potable Water Supply
IWS	Industrial Water Supply
LWS	Livestock Water Supply
AWS	Wildlife Water Supply
IRS	Irrigation
	Recreation
B	Boating
F	Fishing
WC	Water Contact Sports
E	Esthetics

The requirement at §93.4(a) does not prioritize the ten uses but specifically states that *all* of the listed uses *shall be protected*. The lists in §93.9 of each named waterway in the Commonwealth by major drainage basin includes a column for "water uses protected". That column indicates the specific water quality criteria that apply to the waterway (whether it be the minimum statewide uses, or a higher use). That column also indicates where specific exceptions have been allowed on a stream-by-stream or segment-by-segment basis. Thus for example, all streams statewide are protected for potable water supply (PWS); however, for a very few streams the PWS use has been specifically deleted (*e.g.*, Quigley Creek in the Allegheny River basin, §93.9u).

As the PADEP Bureau of Water Quality Management pointed out in an internal review of its regulations during 1995:

> *Subsection 93.4(a) specifies the water uses that are to be protected statewide, including a potable water supply use for every stream in the Commonwealth whether or not it is an existing or known projected use. The current language results in the application of instream water quality criteria to protect a potable water use, even though it does not presently occur and is not projected to occur.*

That same explanation was repeated more recently in the PADEP Water Quality Antidegradation Implementation Guidance (Technical Guidance Document #391-0300-002, adopted 29 November 2003). The TGD 391-0300-002 discussion on page 6 ("*How are existing uses different from designated uses*?") states:

> *A designated use, on the other hand, may constitute the regulatory goal that the Environmental Quality Board (EQB) promulgates for a surface water, regardless of whether the water has actually attained such a use. For example, **all Pennsylvania waters are designated for use as public*** [sic, likely meant "potable" per §93.4(a)]

water supplies *although that use may not be actually attained in all waters.*
[boldface added for emphasis]

Accordingly, each of the ten statewide uses listed in Table 2 of §93.4(a) [box above] deserves equal and complete protection. Inasmuch as all streams in Pennsylvania are protected for five water supply uses, the "water supply" protections and requirements prescribed in Act 54 apply to all streams whether or not any person or animal presently is drinking from those streams.

The underground mine requirements for a premining inventory of streams generally are discussed apart from the requirements for inventory of wells, springs, and other *drinking* water supplies. Nevertheless, Mine Application Form 8.4A (General Stream Inventory) includes a column for identifying each stream's "uses", a list of which is provided at the bottom of the form (see box at right). These 12 uses are similar to, but not the same as, those applicable to streams in accordance with the lists at §93.3 and §93.4(a), yet they are nowhere listed in the Chapter 89 mining regulations.

Uses	
1 = Cold Water	7 = Livestock Water Supply
2 = Trout Stocked Fishery	8 = Boating, Navigation
3 = Warm Water Fishery	9 = Swimming
4 = Potable Water Supply	10 = Irrigation
5 = Industrial Water Supply	11 = Recreational Fishery
6 = Wildlife water Supply	12 = Waterfowl habitat

List of potential stream uses, Mine Form 8.4A

The main takeaway message of the above discussion is that the water supply use of streams is formally and widely recognized in various Pennsylvania laws and regulations. With respect to Act 54, damage to and the need for restoration of water supplies is addressed specifically. However, the PADEP Mining Program has failed to fully apply the Act 54 provisions and protections for water supplies to those water supplies which are streams.

PADEP Technical Guidance Documents

Currently, perennial and intermittent streams are protected equally from underground coal mine-related damages, and protected streams are identified on the basis of their ability to support two or more taxa of streambed macroinvertebrates. For many years, however, the PADEP Mining Program only protected perennial streams from adverse impacts associated with underground mines, and based their identification on continuous year-round flow.

During November 1997 PADEP first adopted a Technical Guidance Document (TGD) on stream protection, identifying measures to be taken by underground coal mine operators to minimize stream flow loss (PADEP 1997). As its title implied, TGD 563-2000-655 "Perennial Stream Protection" applied only to perennial streams. Although it was adopted more than 3 years after Act 54 was enacted, it does not appear that this TGD was meant to clarify how the Department believed it should protect streams under Act 54. The 1997 TGD nowhere makes mention of Act 54, although it claims to seek to protect perennial streams in accordance with applicable statutory and regulatory (specifically 25 *Pa. Code* Chapters 89 and 93) requirements.

The 1997 TGD offered numerous ways for a mine operator to demonstrate that a stream was *not* perennial, and thus would not be protected under the TGD. One way was to submit photographs that the stream had ever gone dry, and photographs taken during periods of extreme weather events such as a drought were not excluded as evidence. As a result, many streams that should have been protected were not.

Despite whatever the mining regulations (or technical guidance) may say, permanent stream flow is not a requirement for regulatory jurisdiction in Pennsylvania pursuant to the Clean Streams Law (or the federal Clean Water Act). The CSL definition of regulated waters is broad, and it includes even tiny rivulets and artificial channels such as ditches. The full definition is as follows:

> "Waters of the Commonwealth" shall be construed to include any and all rivers, streams, creeks, rivulets, impoundments, ditches, water courses, storm sewers, lakes, dammed water, ponds, springs and all other bodies or channels of conveyance of surface and underground water, or parts thereof, whether natural or artificial, within or on the boundaries of this Commonwealth. [From Section 1. Definitions in The Act of Jun. 22, 1937, P.L. 1987, No. 394 Cl. 32]

The 1997 Technical Guidance Document was revised on 8 October 2005. The TGD number (563-2000-655) remained the same, but the title was changed to "Surface Water Protection" to reflect the fact that its scope had expanded to include more than just perennial streams (PADEP 2005). The revised TGD included detailed methods for identifying and assessing streams and wetlands, for determining whether and when mining-induced changes have caused adverse effects, and for determining whether and when a mine-damaged stream has recovered or been restored to its normal premining range of conditions. The 2005 TGD was possibly the most significant change for stream protection that the PADEP Mining Program has adopted since the enactment of Act 54 in 1994.

One of the more important aspects of the 2005 TGD was a new protocol to be used for delineating and characterizing “protected” stream segments subject to the new guidance. In particular, a stream subject to regulation was specifically defined by its ability to support aquatic macroinvertebrates (per 25 *Pa. Code* 89.5) rather than just by continuous year-round flow. The 2005 TGD required mine permit applicants to conduct premining bioassessments on streams proposed to be undermined by longwall mining methods. The TGD required mine applicants to identify and distinguish "biologically diverse" stream segments from "biologically variable" stream segments, but both are to be protected and restored if damaged. The premining bioassessments conducted under the TGD provide very detailed information about the physical, chemical, and biological conditions of the subject streams, which establishes a good baseline standard that can be used A) to determine whether an adverse effect has occurred, and if so B) to evaluate whether stream restoration actions have been successful.

Like all Technical Guidance Documents, the 2005 TGD on surface water protection does not have the same legal authority as do regulations or laws themselves. The TGD itself is qualified by the following standard disclaimer:

> Nothing in the policies or procedures [outlined in this guidance] shall affect regulatory requirements. The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of DEP to give the rules in these policies that weight or deference.

That said, the TGD represents the Department's best guidance on how an applicant can comply with the laws and regulations. Apparently no applicant is *required* to follow the directives of a TGD, but an applicant should expect to justify how and why it may choose to deviate from it.

Current longwall mine permit files include many very detailed premining stream bioassessment reports, each typically hundreds of pages long. These data represent considerable information that rarely if ever was developed or provided to the Department prior to the 2005 TGD. To the Department's credit, it has been firm in applying at least some of the TGD directives consistently (more so for streams than for wetlands).

There is no reference in the 2005 TGD to any section of the application for an underground coal mine permit. In September 2008, nearly three full years after the 2005 TGD first became effective, changes in the underground mine permit application Modules for the first time made specific reference to the 2005 TGD, notably in Module 6 (Environmental Resource Maps), Module 8 (Hydrology), and Module 15 (Streams/Wetlands). The integration of the TGD requirements into the permit application requirements for longwall mines was a positive, if not timely, outcome.

Protection of Streams' "Existing Uses" per Pa. Code Chapter 93

While it is encouraging that premining bioassessments are being conducted on streams by applicants, and that they routinely are being provided to the PADEP, the potential for those data to provide greater stream protection is not being fully utilized. "Existing use" protection is required to be provided for a waterbody segment whenever PADEP takes a final action on a permit application potentially affecting its quality. In accordance with §93.4c(a)(1):

> (i) Existing use protection shall be provided when the Department’s evaluation of information (including data gathered at the Department’s own initiative, data contained in a petition to change a designated use submitted to the Environmental Quality Board pursuant to §93.4d(a), or data considered in the context of a Department permit or approval action) indicates that a surface water has attained an existing use.
>
> and
>
> (iv) The Department will make a final determination of existing use protection for the surface water as part of the final approval action.

The last point in the box above is repeated in the introductory remarks by PADEP in its 2005 TGD (page 6):

> *The Department is required to make a final determination of existing use protection for surface waters as part of the permit or approval process.* [underline added]

A stream's existing use may be, and often is, different from its designated use. A designated use is one that has been assigned to a stream on the basis of best available information, which may or may not include actual in-stream sampling data, and it is the result of a formal rulemaking process. An existing use, on the other hand, is based on actual in-stream data collected and analyzed in accordance with prescribed sampling methods and protocols. Any stream found to have attained a use higher (better) than its designated use subsequent to 28 November 1975 is required to be protected at that higher (existing use) level and cannot be downgraded.

The premining macroinvertebrate data now being compiled for underground coal mine permit applications sufficiently characterize the aquatic community to identify not only whether streams are attaining their "designated" uses, but also whether they are likely to be attaining higher "existing" uses. Those data could and should be used, at minimum, to create a "short list" of streams that deserve further investigation by the Department to make a final determination regarding their existing uses and if found to be higher, to protect them at that higher use prior to approving any mining permit. This final step, unfortunately, is not taken by the PADEP Mining Program. As stated by Joel Koricich during his February 2016 deposition in an Environmental Hearing Board case (Docket 2014-072) in response to the question: "How does the Department verify the existing uses of streams within the permit area?":

> *We have tools available to us, resources available to us, that identifies* [sic] *stream uses. Primarily we use a computer program known as eMap which outlines designated and existing uses.*

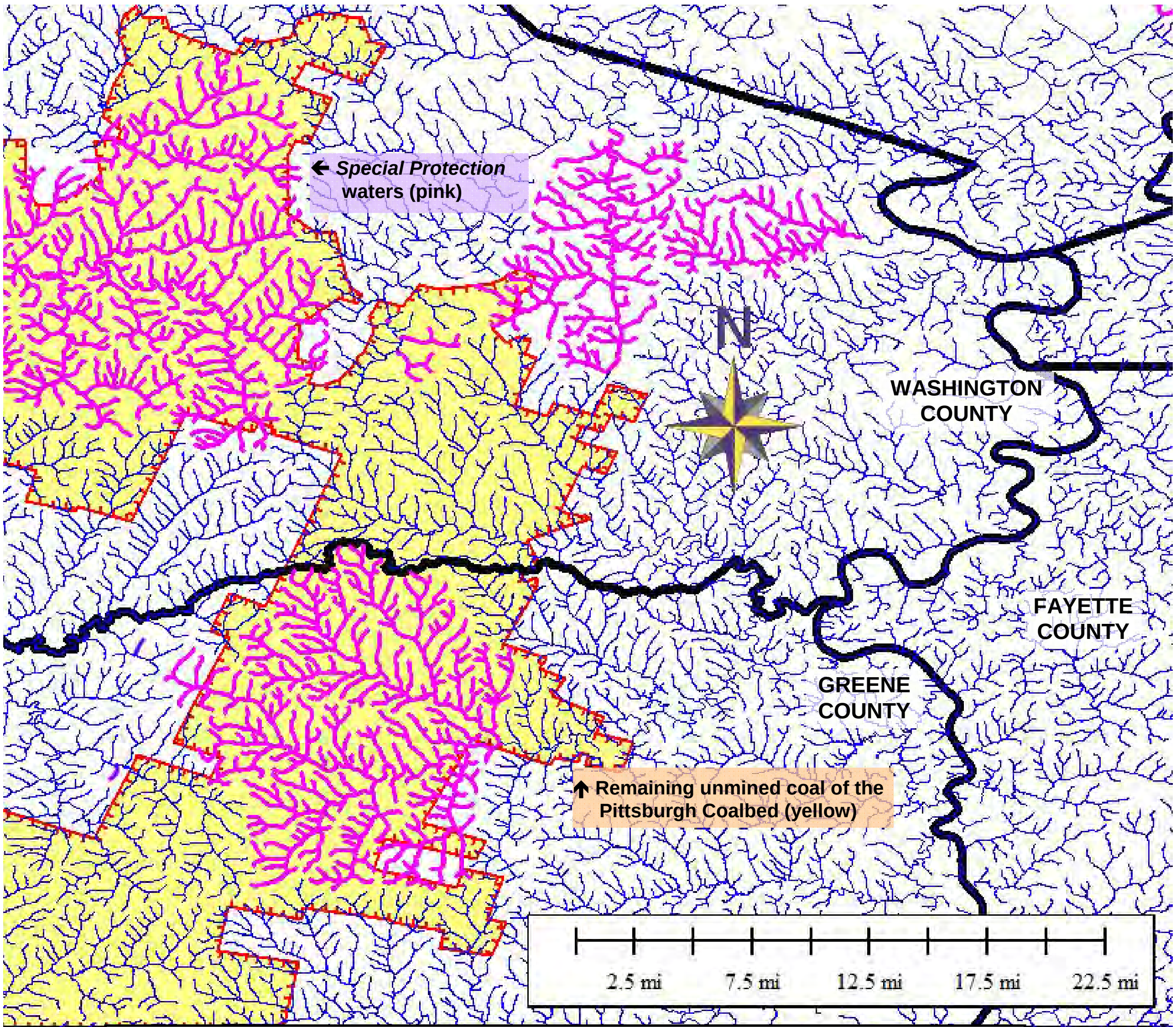
In other words, the Department does not rely on recent, actual in-stream data analyzed for the streams within the subject mine permit area, data that specifically are being collected by the mine permit applicant in accordance with the PADEP 2005 TGD. Instead the Department relies on its eMap mapping of two lists: the Chapter 93 list of *designated* stream uses assigned to streams many years ago (uses which in most cases were not based on actual in-stream data), and a separate online list of *existing* stream uses[7] for those few streams that the Department more recently has conducted formal stream assessments, but which typically do not include any streams in a mine permit area. The failure of the PADEP Mining Program to use the data they have collected from mine applicants to make the required existing use determinations of streams to be undermined prior to issuing permits has been pointed out repeatedly (Schmid & Company, Inc. 2010a, 2010b, 2011, 2014, 2015, 2016).

Special Protection Waters per Pa. Code Chapter 93

The uses assigned to the very best streams in Pennsylvania are Exceptional Value (EV) and High Quality (HQ). In accordance with the State's water quality standards, EV and HQ streams collectively are known as “Special Protection” waters. The Pennsylvania antidegradation program ostensibly provides more stringent levels of protection for such waters in accordance with 25 *Pa. Code* §93.4a. Throughout the Commonwealth, only 4% of all streams have been recognized as qualifying as Exceptional Value, and an additional 27% are recognized as High Quality (DRN 2011). Direct discharges to Special Protection waters require more detailed review and an NPDES (National Pollutant Discharge and Elimination System) permit. The potential subsidence impacts to Special Protection waters, however,

[7] http://www.dep.pa.gov/Business/Water/CleanWater/WaterQuality/Pages/ExistingUse.aspx

are afforded no different consideration in either the PADEP mine application forms or its permit review (Schmid & Company, Inc. 2010a). Although most streams that have been undermined have not been formally assessed as Special Protection waters, those that are so designated overlie slightly more than half of the as-yet unmined Pittsburgh seam in Washington and Greene Counties, which is the focus of all Pennsylvania longwall mining (see figure below). As non-Special Protection watersheds become depleted of easily minable coal, longwall operators increasingly are moving their operations into these Special Protection watersheds.

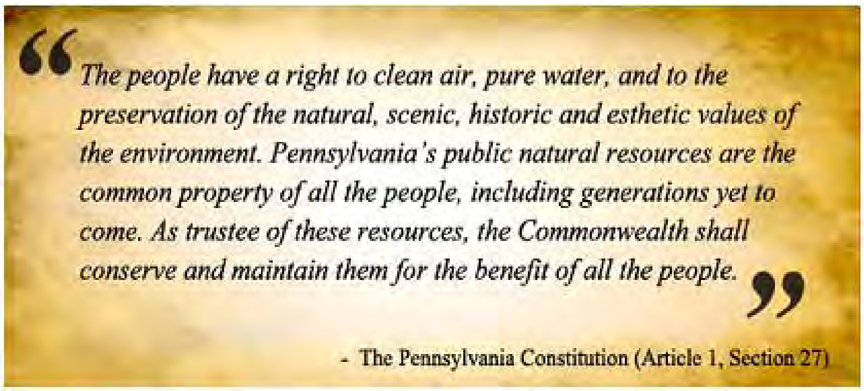


The latest Act 54 Report (PADEP 2014b) estimated that it will take about 37 more years to extract the remaining unmined coal in the Pittsburgh seam (yellow) in Greene and Washington Counties. To date, areas recognized as Special Protection waters (pink) have largely been avoided, but they comprise slightly more than half of the unmined area.

Constitutional Protection for Streams

The legislative and regulatory bases for protecting the water supply and other uses of all streams clearly are supported by the Pennsylvania Constitution. Amended in 1971, the Constitution's enumeration of rights declares that pure water is one such right of all the citizens of the Commonwealth, including future generations of citizens, which the PADEP has a trustee responsibility to conserve and maintain.

On 18 May 1971, after approval by a constitutional convention followed by unanimous adoption by both houses in two successive sessions of the General Assembly, Pennsylvania voters, by a four-to-one margin, ratified what is now Article I, Section 27 of the State constitution (below).



In his 162-page plurality opinion written in a 2013 decision of the Pennsylvania Supreme Court[8], Chief Justice Ronald Castille noted that Article I, Section 27 of the Pennsylvania Constitution was drafted in part to correct abuses inflicted on the environment by past coal mining.

A majority of the Pennsylvania Supreme Court, in its 20 June 2017 decision[9], reaffirmed and extended its *Robinson Township* decision regarding the Commonwealth's trusteeship duty under Article I, Section 27 of the Pennsylvania Constitution.

In a decision issued on 15 August 2017 (Docket No. 2014-072-B), the Pennsylvania Environmental Hearing Board (EHB) declared that "*impairment of a stream by the impacts of longwall mining violates the Clean Streams Law and the Mine Subsidence Act and their regulations*". Further, the EHB found that the PADEP violated its regulations, laws, and Article I, Section 27 of the Constitution by issuing a permit for a longwall mine revision where stream damage was predicted to be so severe from both the longwall mining itself and the proposed restoration activities that the existing uses of the streams would be adversely affected.

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[8] *Robinson Township et al. v. Commonwealth et al.*, Nos. 63 MAP 2012, 64 MAP 2012, 72 MAP 2012, 73 MAP 2012, 2013 WL 6687290 (Pa. Dec. 19, 2013). http://www.pacourts.us/assets/opinions/Supreme/out/J-127A-D-2012oajc.pdf

[9] *Pennsylvania Environmental Defense Foundation v. Commonwealth*, No. 10 MAP 2015, 2017 WL 2645417 (Pa. June 20, 2017) http://caselaw.findlaw.com/pa-supreme-court/1865162.html

5 STREAM RESTORATION SUCCESS POST-MINING

As noted above, acid mine drainage historically was the principal coal mining-related problem for streams. Coal mine operators today are required to treat mining discharges and predict whether post-mining pollution is likely. Through advances in predictive science, less than 2 percent of the permits issued today result in a post-mining discharge[10]. New technologies, including alkaline treatment and special handling of acid producing materials, are being studied in order to help address the remaining 2 percent.

The larger coal mining issue relating to streams today involves the effect of undermining (particularly using the longwall method) on streamflow. It is essential to understand the natural, premining flow of a stream in order to determine whether undermining has any effect on it, and then to provide a baseline for restoration efforts. One requirement of the 2005 TGD that is not being utilized to its full potential involves stream flow monitoring. According to the 2005 TGD (and also Section 8.9 of the underground mine application Module 8), operators of longwall mines with the potential to cause flow loss in an overlying stream must monitor the flow in that stream. The permit application must include monthly measurements of streamflow during at least 2 years prior to undermining. The application also must include a plan for more detailed stream flow monitoring once mining is underway.

Detailed stream flow measurements are supposed to be made weekly and then daily by longwall mine operators beginning 6 months before they undermine a stream and continuing at least 6 months after the stream has been undermined. The loophole in this requirement is that the detailed monitoring data are only required to be *collected* by the operator; they are not required to be *provided* to the Department. In past times it may have been impractical for the Department to keep reams and reams of monitoring paperwork in their offices. But now that most data files are assembled and stored electronically, there is no valid reason for PADEP *not* to require operators to provide this crucial information digitally.

The weekly and daily stream flow monitoring data, if they are being faithfully collected for every stream being undermined by longwall methods, provide a wealth of real-time information about when, where, and how streamflow is affected by longwall mines. When combined with other mine-specific information such as depth of cover, longwall panel dimensions, and local geology, as well as precipitation records, those flow data could be used to create models for predicting the hydrologic effects of longwall mining, both at individual mines as well as regionally. This is not simply a good idea, it actually is *required* by PADEP regulation. For decades 25 *Pa. Code* 89.35 has stated that, for every underground coal mining operation:

> "*the operation plan shall include a prediction of the probable hydrological consequences of the proposed underground mining activities upon the quantity and quality of groundwater and surface water within the proposed permit [area], adjacent [areas] and general areas under seasonal flow conditions...*"

[10] PADEP abstract summary of PASDA GIS mapping of "Coal Mining Operations, 2017" http://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=271

Despite this clear regulatory requirement, and more than a decade of collecting detailed streamflow records above approved longwall mine panels, specific predictions of which undermined streams are likely to experience significant flow loss are not being made. Either mine operators are unable to make such predictions, or they are reluctant to admit to likely adverse stream impacts. In either case, whether unanticipated or anticipated, streams are being impacted and the mine operators are not being held accountable.

According to TGD 563-2000-655, if a stream is adversely affected as a result of underground coal mining, both its flow and biological conditions must be successfully returned to premining conditions in order for it to be considered restored (PADEP 2005). As the PADEP Act 54 Reports demonstrate, attempts to successfully restore premining conditions to streams damaged by longwall subsidence typically require many years, if they can be restored at all.

As noted above, there are two principal types of streamflow damage that longwall mine subsidence can cause to overlying streams: pooling and flow loss. Pooling occurs when the land above a longwall panel subsides, but the land above the gate does not, causing water to become dammed up behind the gate. The typical "fix" for pooling is to cut through the unsubsided gate so it matches the lowered elevation of the streambed on either side. Restoring flow in this way is fairly straight-forward, but as noted above it can take as much as two years before such restoration activities are even begun. The full duration of time between pooling impacts and actual biological recovery has not been documented.

In accordance with the 2005 TGD, if an operator uses mitigation measures that are technologically and economically feasible for five years and cannot fully restore a damaged stream, the effort can be abandoned in favor of alternative compensatory mitigation. In its latest Act 54 Report the PADEP reported that at least 6 streams that had been dewatered during the 2003-2008 period had met that condition (could not be restored despite employing mitigation measures that were technologically and economically feasible) and thus were determined (in letters dated 27 December 2012 from PADEP to the mine operator) to have been irreparably damaged by longwall mining. In those six instances, no alternative mitigation has yet been proposed, much less implemented or deemed successful, so it remains unclear how the PADEP intends to address these situations.

The art of post-mining stream restoration still is in its infancy, and to date does not have a documented record of success, particularly in the high-gradient streams typical in the coalfields of Appalachia. As pointed out in PADEP's latest five-year Act 54 Report:

> "While mining companies are generally either able to repair, replace, or financially compensate for damages to structures, the ability to repair damage to streams remains largely unknown." (PADEP 2014b, page V-7)

Numerous studies have demonstrated a lack of success in fully restoring the biological condition of streams once they have been damaged by either coal mining or other activities (Doyle and Shields 2012, Palmer *et al*. 2010, Pond *et al.* 2008, Carr *et al*. 2005, Stout 2004). This is the case even when the physical conditions of the streams have been restored.

Experience shows that stream restoration efforts are seldom successful in replacing lost functions and values. According to Doyle and Shields (2012), who examined "available and robust peer-reviewed literature":

> The balance of published evidence suggests that current practices of stream restoration – in terms of scale and technique – cannot be assumed to provide demonstrable physical, chemical, or biological functional improvements.

In examining streams in central Appalachia, Stout (2004) found essentially the same thing for streams damaged by longwall mining. He determined that there is "*no indication that the physical, chemical, or biological nature of longwall mine-impacted streams recover over time*." Similarly a recent evaluation of 434 stream mitigation projects associated with surface mining in Appalachia found that most did not meet Clean Water Act objectives to replace lost or degraded stream ecosystems and their functions. Even after 5 years of monitoring, fully 97% of the projects reported suboptimal or marginal habitat (Palmer and Hondula 2014).

Researchers with the Academy of Natural Sciences of Drexel University assembled a database of 1,501 separate records for 70 stream restoration projects completed in Pennsylvania through 2002. They analyzed the differences between the ecological condition of restored sites and paired reference reaches. They found that the restored sites consistently scored lower in riparian habitat quality as well as the biotic integrity of both periphyton (*i.e*., attached algae) and benthic macroinvertebrate assemblages. They concluded that their results clearly demonstrate that at the present time these stream reaches continue to exhibit the types of impaired conditions that originally made them candidates for restoration (Srivastava *et al*. 2003).

The conclusion of each of these studies seems to be that stream restoration as currently practiced in the Pennsylvania coalfields is not likely to compensate for the destructive impacts of mining and other activities. If irreparable damage to streams cannot be accurately predicted, and the likelihood of full restoration of the uses and functions of damaged streams is low, the only prudent course of action is to curtail full-extraction mining beneath streams.

6 SUMMARY AND CONCLUSIONS

Underground coal mining can affect the quality and quantity of streams and other surface water resources. Historically, the principal impact on Pennsylvania streams from mining was related to unregulated discharges of acid mine drainage. Current permit requirements make such discharges rare, although legacy AMD pollution continues to be a problem. Today, the largest threat to streams from modern underground coal mines in Pennsylvania relates to subsidence, which can alter the hydrology of streams and other water resources and affect their biological condition. For more than 20 years the PADEP has been required to compile and analyze information on the effects of subsidence on surface structures, features, and water resources.

Two different methods of extracting coal underground currently are used in Pennsylvania: room-and-pillar and longwall. The room-and-pillar mining method, which has been used to extract coal in the Commonwealth for more than two centuries, still is widely and profitably practiced. Longwall mining, introduced in the 1970s, is more automated, more productive, and more profitable. It also is more damaging. In its four Act 54-mandated five-year reports prepared to date, the PADEP has documented that stream damages are almost exclusively associated with the longwall mining method, of which subsidence is an intrinsic component. Properly designed room-and-pillar mines do not result in surface subsidence or the associated damages to water resources.

Longwall mining does not always result in permanent stream damage. The location and extent of subsidence-related stream damages from longwall mines, however, are not being accurately predicted despite clear regulatory requirements to do so. Efforts by mine operators to restore damaged streams to their premining conditions typically extend over many years. Evaluations of the effectiveness of stream restoration efforts largely have been hindered by a lack of adequate premining baseline data. In 2012, the PADEP formally determined that six streams were irreparably damaged after years of attempted restoration proved to be unsuccessful. Pennsylvania courts have determined that certain stream damage from longwall mining methods violates PADEP regulations, Pennsylvania laws, and the State Constitution.

For several centuries Pennsylvania has enjoyed the economic benefits of coal extraction, but also has suffered from its adverse environmental impacts. The PADEP has a trustee responsibility to conserve and maintain the public natural resources of the Commonwealth, including its streams, for the benefit of all the people. Coal mining and stream protection are not mutually exclusive concepts. Going forward, the PADEP must ensure that all approved coal mining is conducted so as to avoid significant and irreparable damage to the waters of this Commonwealth.

7 AUTHORSHIP AND ACKNOWLEDGEMENTS

This report was prepared on behalf of the Citizens Coal Council by Stephen P. Kunz with the assistance of James A. Schmid. Both are senior ecologists with Schmid & Company, Inc. Mr. Kunz has been a consulting ecologist since receiving a degree in human ecology from Rutgers University in 1977. Dr. Schmid is a biogeographer with more than 40 years of experience in ecological consulting. Both Mr. Kunz and Dr. Schmid are certified as *Senior Ecologists* by the Ecological Society of America and as *Professional Wetland Scientists* by the Society of Wetland Scientists.

Mr. Kunz and Dr. Schmid offer outstanding credentials as experts in ecology, wetlands, environmental regulation, and impact assessment. They have analyzed the environmental impacts of many kinds of proposed development activities in many states, including coal mining facilities, industrial facilities, transportation facilities, and commercial and residential developments. They have prepared environmental inventories and written Environmental Impact Statements under contract to various federal, State, and local government agencies, and a diverse array of private sector entities. Regarding the regulation of underground coal mining, they have reviewed and provided public comments on proposed new regulations, revisions to existing regulations, technical guidance documents, and permit application forms and procedures, both at the State and federal levels. They also have reviewed and assessed specific coal mine permit applications. Regarding Pennsylvania Act 54, they have reviewed and provided formal comments on all four of the five-year assessments and associated documents. They have been engaged with the PADEP Citizens Advisory Council on Act 54 issues for more than a decade.

A society is defined not only by what it creates, but by what it refuses to destroy.
— John C. Sawhill

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