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Hydrologic Protections within the Federal Surface Mine Control and Reclamation Act

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Introduction

On August 3, 1977, President Jimmy Carter signed into law the Surface Mine Control and Reclamation Act (SMCRA). This law was an outgrowth of decades-long rising concern over the damage resulting from the increasing reliance on strip mining as the preferred, and more economic, method for coal extraction. State-by-state efforts to reduce the environmental damage of strip mining had produced limited success, largely due to inter-State competition for coalmines. Were a state to structure a law to be rigorously effective, companies could move operations to another state with lower standards and lower associated mining costs. The competition among the states produced the classic race-to-the-bottom that characterizes attempts to rein in environmental damage with regulation on anything less than a national basis. SMCRA was developed as a means of leveling the regulatory playing field across the nation with a bar high enough to prevent at least the worst impacts of surface mining.

The early to mid-1970s was a time of significant environmental legislation implementing regulation on the national level. In addition to SMCRA, major federal legislation included the Clean Air Act (1970, 1977), the Clean Water Act (1972), and the Resource Conservation and Recovery Act (1976). Common to the design of each of these programs was that an individual state would implement a program conforming to the federal program and, upon approval of the state program, become the designated authority for the federal legislation. SMCRA, however, came from a separate mold in many respects than did the other laws, and is, or should be, the best of the lot.

One of the features that most distinguishes SMCRA from other environmental programs is SMCRA's embrace of citizen enforcement. Perhaps because of historical problems from state management of mining practices, the authors of SMCRA were concerned about the diligence or enthusiasm with which the federal mining law might be implemented or enforced by reluctant state agencies. In practice, as well as theory, a state agency that unenthusiastically interpreted and enforced SMCRA could precipitate comparable attitudes in competitive states, triggering another race-to-the-bottom for the industry. SMCRA was written with the explicit inclusion of the citizenry as an additional enforcement authority. Citizens do not have to rely solely on the state, as the designated program authority, to ensure that the law is properly implemented and enforced. If citizens observe non-compliance by a mine, they can compel the state to investigate and to enforce regulations. Citizens have the right to initiate and participate in site visits and inspections. If the state does not implement the law, citizens have the right to take the state to court to compel it to do so. And, because of the explicit inclusion of provisions of citizen enforcement in SMCRA, judicial deference to an agency policy or decision is rightly less under SMCRA than under the other environmental programs.

Another difference between SMCRA and other contemporary environmental programs is the relative lack of reliance by SMCRA on prescriptive activities and requirements and a greater reliance on proscribed conditions and activities. As a result, when properly implemented, SMCRA produces a mine permit that has a mining and reclamation plan that is custom-fit to the permit area and site conditions and that ensures that this mine with this design for this location will meet the performance requirements of SMCRA. SMCRA thus puts greater obligation and responsibility on an operator; one design doesn't fit all mines. It also puts greater obligation and responsibility on the regulatory agency; each mining and reclamation plan is necessarily unique and simply checking the boxes in a requirement matrix is not enough.

Finally, SMCRA is unusual in that it acknowledges that the regulated activity – surface mining – inherently will do damage. You just don't make an omelet without breaking eggs. The statute is designed to limit that damage; minimize it when possible and remediate it when necessary. Further, SMCRA appreciates that with respect to hydrology – ground- and surface water – impacts extend beyond the mine and that no mine is an island. A mine may be adjacent to other mines, up- and down stream of other mines, above and below other mines, and earlier and later than other mines. So, as a final elegance, SMCRA imposes an additional obligation on the regulatory agency. The agency cannot issue a permit for a mine until it has determined that the off-permit hydrologic impacts of the proposed mine, cumulatively with all other past, current, and anticipated future mining, will not exceed acceptable levels. This determination is the cumulative hydrologic impact assessment, or CHIA, that is required prior to approval of every permit application.

Proscribing issuance of a mine permit unless finding that the cumulative off-permit hydrologic impacts of all mining in the area are within acceptable levels puts special emphasis on hydrology in SMCRA. In much of the remainder of this report, I will discuss that special emphasis, and how it allows SMCRA to work. Hopefully the discussion will not only clarify how and why SMCRA can work, but also share the sense of elegance I feel for this well-written statute.

Lastly, I will offer some general comments based upon my decades of work in hydrogeology and with SMCRA issues and permits. It is unfortunate, but, while SMCRA is elegantly designed and carefully crafted, it does not always work as well as it could and should. These comments are less a catalog of agency-specific criticisms and more examples of where and how non-citizen enforcement choices undercut SMCRA's inherent power.

SMCRA's Approach to Protection of Hydrology near and at the Mine Site

Regulations associated with most federal environmental legislation tend to be very complex and detailed, often controlling minutia. The regulations not only specify what must be accomplished, but also, in great detail, how it will be accomplished. The *how to* is typically developed from stakeholder input through some combination of science, economics, technology, negotiation, compromise, and/or fiat. The results are regulations that are easily, but mechanically, enforced. They are also frequently inflexible and can lock in protocols, technologies and standards that through the decades become recognized as ineffective, outdated, or non-protective. Changes to one set of regulations can produce inconsistencies that propagate through other regulations.[1]

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[1] The reevaluation of the toxicity of arsenic in the CWA is an example. The original maximum contaminant level (MCL) for arsenic was 50 micrograms/liter (ug/L). Contemporaneously, RCRA defined solid wastes that leached contaminants at concentrations 100-times their respective MCLs as *hazardous* by characteristic (toxicity). *I.e.*, the toxic threshold for arsenic leaching in RCRA was defined as 5000 ug/L. The USEPA subsequently determined the original arsenic MCL was insufficiently protective of human health and it was redefined as 10 ug/L. However, the recognition of the higher toxicity of arsenic in the CWA did not propagate to RCRA, where the hazardous threshold for arsenic in a solid waste remains at 5000 ug/L, now 500-times the MCL, instead of the original concept of 100-times the MCL.

SMCRA takes a fundamentally different approach. Rather than prescribing in detail how to achieve its objectives, SMCRA mandates the performance to be met and provides a framework that allows the company and the regulatory agency to develop the site-specific knowledge base and mine plan that will achieve that performance.

With respect to hydrology, SMCRA is designed by Congress to implement two principal mandates to protect the hydrology at a mine site. These limit the levels of damage allowed inside and outside the immediate area of mining:

- damage to the prevailing hydrologic balance at each mine site and in associated offsite areas must be minimized[2]
- material damage to the hydrologic balance outside each permit area must be prevented[3]

Key to these mandates is the meaning of *hydrologic balance*. *Hydrologic balance* is defined 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 ground and surface water storage.[4]

There is a closely related concept that is used in SMCRA, the *hydrologic regime*. *Hydrologic regime* is defined as

> the entire state of water movement in a given area. It is a function of the climate and includes the phenomena by which water first occurs as atmospheric water vapor, passes into a liquid or solid form, falls as precipitation, moves along or into the ground surface, and returns to the atmosphere as vapor by means of evaporation and transpiration.[5]

The hydrologic regime is a subset of the hydrologic balance. It is the dynamic relationships among atmosphere, precipitation, run-off and infiltration, soil moisture, and moisture losses to plants and the atmosphere. It does not include the surface water quality elements of the hydrologic balance nor groundwater quantity, flow and discharge.

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[2] 30 U.S.C. § 1265(b)(10)
[3] 30 U.S.C. § 1260(b)(3)
[4] 30 C.F.R. § 701.5 *Hydrologic balance*
[5] 30 C.F.R. § 701.5 *Hydrologic regime*

The fundamental hydrologic protections under SMCRA are not simply extended to a stream, or to streams. They are not simply extended to a water well, a public water supply system, a stock tank, or an aquifer. They are not simply extended to the quantity or flow rate of water, or just to the quality of ground- or surface water. The fundamental hydrologic protections under SMCRA are extended to all of those, and more. The protections are also extended to the exchanges among and changes to each and all, and not as defined at just an instant, but as they change dynamically. The authors of SMCRA understood that water is constantly moving and constantly changing and that damage anywhere along the path or cycle impacts everything along that path or cycle. It is the *relationship* – the balance – that must be protected. It requires an integrated understanding developed through the science of hydrogeology.

Implementing the Mandates in SMCRA

Achieving the principal mandates of SMCRA – minimizing damage to the hydrologic balance inside the permit area and preventing material damage outside the permit boundary – is a non-trivial but readily accomplishable task. The basic mechanisms and tools for doing so are enumerated in SMCRA and provide a logical set of steps to allow the law work.

The first step is the characterization of the prevailing hydrologic balance, as it exists pre-mining, so one knows what is being protected. The second step is to evaluate the mining plan to ascertain how the mining is going to change the hydrologic balance and determine what will be the probable hydrologic consequences of mining. The third step is to develop a hydrologic reclamation plan that ameliorates the impacts of mining to the point that damage to the hydrologic balance is expected to comply with SMCRA limitations. The fourth step is a monitoring plan that will track the changes due to mining to verify the projections of the probable hydrologic consequences, to demonstrate the efficacy of the hydrologic reclamation plan, and to allow timely intervention if things aren't going as planned.

The operator performs these first four steps as part of the permit application. There is a fifth step that must be performed as part of the approval process by the regulatory agency. The agency assesses the cumulative hydrologic impacts from this mine and from other mines. The permit application must be denied unless the agency finds in writing that the cumulative impacts of this mine and all other mining will prevent material damage to the hydrologic balance outside the permit area.

Each of these steps is described in more detail below. It is fundamental to the success of this approach to appreciate that these four steps are not independent. Each builds upon the preceding step, and final success is dependent upon each step being done correctly. The estimation of the probable hydrologic consequences of the mining plan to the pre-mining hydrologic balance is inherently flawed if the hydrologic balance is not fully characterized. A hydrologic reclamation plan designed to ameliorate the wrong probable hydrologic consequences will be ineffective. And, a monitoring program that is not looking for the right problems at the right places and at the right times, doesn't work. To work as designed in SMCRA, it all starts with the characterization of the hydrologic balance.

Characterization of the Hydrologic Balance

The definition of hydrologic balance indicates that its characterization requires that multiple, separate hydrologic units must be characterized with respect to water quality and quantity. It also indicates that the hydrologic units are not to be characterized in isolation from each other and not simply as a snapshot in time. Rather, the dynamic relationship among the units and patterns of flow among them must be characterized.

The definition is supplemented in the regulations with specific requirements for minimum characterization. Key sections of the regulations that pertain to characterization of the hydrologic balance include 30 C.F.R. §§ 780.18 Reclamation plan: General requirements; 780.21 Hydrologic information; and 780.22 Geologic information.

The hydrologic balance is required to be characterized under pre-mining (baseline) conditions with an inventory of hydrologic units that comprise the hydrologic balance, seasonal variation of water quality and quantity within each such unit and of the transfers of water among the units. In addition to these characterization requirements, an inventory must be built of all uses, *i.e.*, wells, springs, stream diversions, seeps, etc., of water resources from units comprising the hydrologic balance and the rates of withdrawal and consumption by those users.

Some of the characterization can be done at the earth's surface. Hydrologic units such as drainage basins, streams and rivers, lakes, or reservoirs are all surface water features and require no invasive procedures to describe or characterize them. They can be directly observed and measured. Other hydrologic units, such as soil zones and aquifers, are below the surface and can only be characterized by drilling holes, installing wells or piezometers, and/or excavating.

Characterization of individual units of the hydrologic balance is fairly straight forward with respect to quality and quantity. Sampling and analyzing the water from a hydrologic unit determines water quality of that unit at the time it was sampled. The flow rate of a stream or river is measured to characterize its quantity at any one point at one time. For streams or rivers that are long or variable across the permit and affected areas, multiple measurements may be necessary to fully characterize them. The volume of water in a lake or reservoir characterizes its quantity. For both confined and unconfined aquifers, water elevations in wells are needed to characterize water quantity in the aquifer. In addition, the thickness, area and porosity of the aquifer are needed to characterize the quantity of water within it. For aquifers with broad extent across the permit and affected areas, multiple characterization locations are needed.

In developing the program for characterization of the hydrologic balance, it is important to be certain that each unit of the balance is individually characterized. From those individual characterizations, the relationships that comprise the hydrologic balance can be determined. For example, water discharging from a spring and water in a deep aquifer are both groundwater. But, they may not be, and often are not, groundwater from the same hydrologic unit. Each should be characterized (quality, quantity, flow patterns and rates, and seasonal variations of all those things) individually. It is not appropriate, for example, to average water quality from separate hydrologic units as part of the characterization. Doing so masks the actual water quality of each unit. Not only might such averaging erroneously assign higher contaminant levels to a unit with demonstrably clean water, it will assign erroneously lower contamination to the water of the other unit. Further, since pre-mining water quality strongly influences the choice of damage criteria, averaging of data may afford a clean water supply inappropriately lax quality standards.

The obligation to characterize the hydrologic balance sufficiently to determine its seasonal variation adds a time element to obligations of the operator. Since SMCRA does not provide a regulatory definition for seasonal variation, common understanding of seasonal variation should apply. Virtually all areas mined for coal in the United States experience four distinct seasons over the course of a year. These four seasons are each distinct in their climatologic patterns and their relationships to preceding and following seasons. That is, it is not possible to generate the one season's characteristics from those of another season through some kind of symmetry of the annual cycle. To capture variations of hydrologic conditions under seasonal variation, then, requires data collected each of the four seasons over the course of at least a whole year.

SMCRA specifies in its performance requirement to minimize damage within the permit area that the concern is damage to the *prevailing* hydrologic balance. That is, the baseline and seasonal variations used for characterization of the hydrologic balance must be representative of typical or normal hydrologic conditions. Baseline and seasonal variation data collected from a period of distinctly atypical weather conditions, such as a severe drought or an unusually wet year, is not sufficient for characterization purposes.

The mandate to characterize seasonal variation has an additional nuance for surface water units of the hydrologic balance. Groundwater conditions generally vary slowly; seasonal variations of the annual cycles are typically the highest frequency variations naturally occurring. Surface water flows and, to a lesser extent, discharge patterns from some springs, are subject to episodic flow variations that occur over a much shorter period than annually or seasonally. Such variations are primarily related to precipitation events or periods of snowmelt that occur locally and/or upstream of the point of observation. Isolating the seasonal variations from a flow pattern that superimposes long- and short-term events requires that the observation interval be shorter than the duration of the short-term events in the record. Thus, whereas seasonal groundwater variations can reasonably be observed with monthly observations, identifying the seasonal variations in stream flow requires higher frequency measuring, such as daily, to distinguish seasonal from precipitation-generated variations.

The final mandate for characterization of the baseline hydrologic balance is that flows within and between units of the hydrologic balance be characterized, including characterization of seasonal variations of those flows. Flows within any single unit of the hydrologic balance are readily identified. Surface water flows downhill. Topographic maps that are required in the permit application provide the flow direction of surface water and direct flow measurements determine the rate of flow. Groundwater flows downgradient; *i.e.*, from areas of high potential (or head) to areas of low potential. Within any given aquifer, water elevation data collected for baseline characterization are used to generate the head (potentiometric) maps that are required in the permit application. Potentiometric maps provide the direction of flow, if any, within a given aquifer. The rates of flow can be derived from those maps and measures or estimates of the hydraulic conductivity and porosity of the aquifer.

Characterizing the flows between units of the hydrologic balance is more difficult but readily possible if the data described above have been adequately collected. Flow from one aquifer into another is established using the head maps that were generated to determine flow within each aquifer. If the head (potential) in an aquifer is greater than that in an aquifer above or below it, vertical flow is toward the aquifer with lower head. If the head is lower than that in an overlying or underlying aquifer, vertical flow is into the aquifer from the aquifer with higher head. The rate of flow between aquifers requires some measurement or knowledge of the conductivity of the rock or soil layers between the aquifers.

Similarly, if the head in an aquifer that underlies a stream is lower than the elevation of the stream, the flow will be from the stream toward the aquifer and surface water will infiltrate to groundwater. Conversely, if the stream is at lower elevation than the head in the aquifer, groundwater will discharge from the aquifer into the stream. The relationship between the head in an aquifer and the elevation of a stream can change along the course of the stream. The relationship between the head in the aquifer and the elevation of a stream can also vary seasonally.

If the head in an aquifer is higher than the elevation of the surface of the ground, any flow from the aquifer will be toward the ground surface. Localized discharge for such water will be seeps or springs, and the flow rates from such features is a measure of the exchange from one element of the hydrologic balance (an aquifer) to another (surface water). When heads in the aquifer change seasonally, so will the rates, or even existence, of spring discharge.

Those reaches of a stream where groundwater discharges to the stream, progressively adding to the stream flow, are called *gaining* reaches. Those reaches where the stream discharges to groundwater, progressively subtracting from the stream flow, are called *losing* reaches. Multiple measurements of flow along the course of a stream allow identification of gaining and loosing reaches, which, in turn, identify areas where groundwater is transferring to surface water and where surface water is transferring to groundwater, respectively. Identifying and locating these types of transfers are an integral part of characterizing the hydrologic balance.

The activities and processes described above are minimum requirements of SMCRA for characterization of the hydrologic balance. This characterization describes the conditions that set the ultimate performance requirements of SMCRA; *i.e.*, that damage to the characterized hydrologic balance be minimized at the mine site and associated off-site areas and that material damage to the hydrologic balance be prevented outside the permit area. If the characterization of the hydrologic balance is not properly done, SMCRA cannot work as designed.

Probable Hydrologic Consequences

SMCRA requires that the operator determine the probable impacts of the proposed mining operations on the pre-mining hydrologic balance. This mandate is stated in the statute with the requirement that each permit application contain the following:

> a determination of the probable hydrologic consequences of the mining and reclamation operations, both on and off the mine site, 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 . . . (30 U.S.C. 30 U.S.C. § 1257(b)(11)

The statutory mandate is addressed in the regulations requiring a determination of probable hydrologic consequence with similar language, but including explicit ties to and reliance upon the characterization of the hydrologic balance:

> (1) The application shall contain a determination of the probable hydrologic consequences (PHC) of the proposed operation upon the quality and quantity of surface and ground water under seasonal flow conditions for the proposed permit and adjacent areas.
>
> (2) The PHC determination shall be based on baseline hydrologic, geologic and other information collected for the permit application and may include data statistically representative of the site.
>
> (3) The PHC determination shall include findings on: . . . (30 C.F.R. § 780.21(f))

The determination of the PHC that is required of each permit application is essentially a projection of the new hydrologic balance that will exist if the mining plan is approved. It necessarily must determine the hydrologic consequences during active mining, during the period of reclamation, and into the future, as a new equilibrium is reached for the post-mining hydrologic balance. As with the characterization of the pre-mining hydrologic balance, the PHC must include projections of changes to surface water quality and quantity, changes to groundwater quality and quantity, changes to transfer of water among units of the hydrologic balance, as well as the changes to seasonal variations of each.

One major contrast of the determination of the PHC and the characterization of the hydrologic balance is the transient nature of many of the hydrologic consequences of implementing the mining plan. The characterization of the prevailing hydrologic balance is an attempt to define conditions of the pre-mining hydrologic balance, a system that is in dynamic equilibrium. The pre-mining hydrologic balance is not static; it varies seasonally and it varies from year to year. But, it is presumed to vary about a central, prevailing condition. Post-mining, a new hydrologic balance will eventually exist that also has seasonal and year-to-year variations about a new central, prevailing condition. The PHC is in part meant to be an estimation of the differences between those hydrologic balances.

However, prior to that new hydrologic balance, there are the other hydrologic conditions that will exist while the mining is ongoing and during the transition from mining conditions to the eventual post-mining hydrologic balance. To be complete, the determination of the PHC that is required by SMCRA should include determinations of the PHC at the time of mining, the reclamation period, the transition period, and the final post-mining hydrologic balance. Without a determination of the PHC under each of those conditions, a determination cannot be made that the proposed mining will, at all stages, minimize damage in the permit and affected areas and prevent material damage outside the permit area.

It should be clear that a defensible determination of the PHC requires a thorough and defensible characterization of the hydrologic balance as a first step. If the characterization of the hydrologic balance is incomplete or in error, it is not possible to correctly predict the consequences of the mining plan on the hydrologic balance during and after mining. And, if consequences of mining on the hydrologic balance are unknown, there can be no valid determination that the damage levels to the hydrologic balance comply with the performance requirements of SMCRA.

Hydrologic Reclamation Plan

SMCRA further contemplates that things can go wrong with the hydrologic balance even if the balance is properly characterized, the mine plan is appropriate, the hydrologic consequences are well determined and there is a monitoring plan that is properly designed and operated. As a check and feedback to the SMCRA hydrologic protections, SMCRA requires a hydrologic reclamation plan:

> The application shall include a plan, with maps and descriptions, indicating how the relevant requirements of part 816, including §§816.41 to 816.43, will be met. The plan shall be specific to the local hydrologic conditions. It shall contain the steps to be taken during mining and reclamation through bond release to minimize disturbances to the hydrologic balance within the permit and adjacent areas; to prevent material damage outside the permit area; to meet applicable Federal and State water quality laws and regulations; and to protect the rights of present water users. The plan shall include the measures to be taken to: Avoid acid or toxic drainage; prevent, to the extent possible using the best technology currently available, additional contributions of suspended solids to streamflow; provide water-treatment facilities when needed; control drainage; restore approximate premining recharge capacity and protect or replace rights of present water users.

> The plan shall specifically address and [*sic*] potential adverse hydrologic consequences identified in the PHC determination prepared under paragraph (f) of this section and shall include preventive and remedial measures. (30 C.F.R. § 780.21(h))

The purpose of the hydrologic reclamation plan is two-fold. First it requires the mining plan include efforts to specifically address any probable hydrologic consequences of this mine that may have unacceptable adverse impacts, *i.e.*, to reduce those impacts to acceptable levels.[6] Second, the hydrologic reclamation plan will include preventative and remedial measures to be implemented in the event unacceptable hydrologic consequences develop in spite of the initial reclamation plans. Thus, through the hydrologic reclamation plan, the back-up plan is already in place in the event the monitoring program identifies existing or developing problems that were not expected.

As with each of the other SMCRA provisions protecting the hydrology of an area to be mined, the hydrologic reclamation plan is not designed and does not operate in a vacuum. It modifies the mining plan based upon the PHC determined from the characterization of the hydrologic balance. If the characterization of the hydrologic balance is inadequate and/or the PHC is inadequate so will be the hydrologic reclamation plan.

Monitoring Program

The determination of the PHC is not accepted as factual statements of future conditions under SMCRA. SMCRA regulations require a monitoring program to assess the changes to the hydrologic balance that actually occur during mining and reclamation. The monitoring program must address all aspects of the hydrologic balance[7]; ground- and surface water quantity and quality, flow directions and rates, and transfers among the various units of the hydrologic balance. The monitoring must be capable of detecting or projecting harm, if it occurs, and trigger remedial action. The monitoring program is to include a description of how the

[6] 30 C.F.R. § 780.21(h) is one of the places in SMCRA regulations where there is an alternative wording of the first hydrologic performance requirement. This section requires minimization of damage to the hydrologic balance "within the permit area" rather than "at each mine site and in associated offsite areas," as is used at 30 U.S.C. § 1265(b)(10).

[7] 30 C.F.R. § 780.21(i)(1) and (j)(2)

monitoring data will be evaluated and what criteria will be used to accomplish these requirements.

It is axiomatic that a monitoring program can be successful only if it monitors at relevant locations for relevant parameters at relevant times. A properly designed performance-monitoring program is, therefore, designed to test the understanding developed by the determinations of the PHC. Because the hydrologic conditions and the monitoring purposes of hydrologic characterization and performance monitoring are so different, it is seldom, if ever, appropriate to use the same monitoring program for both baseline characterization and mine performance. Verifying the predicted hydrologic consequences requires monitoring at locations and times when consequences are predicted. For example, if there are predictions of head decline outside the permit area due to mine dewatering and to eventual head recovery at some point after reclamation, verification requires monitoring head levels outside the permit area during mining and sufficiently long after mining to establish the degree of predicted head loss and recovery are accurate. Similarly, if a predicted hydrologic consequence of head recovery in the mine is that spoil water will migrate from the mine and degrade groundwater to some degree, verification requires monitoring occur subsequent to the start of outward migration of spoil water from the mine.

The monitoring plan is more than a system to detect unacceptable damage caused by mining and thereby trigger remediation. No permit can be approved if the probable consequence of mining and reclamation is unacceptable damage. Therefore the monitoring plan also fundamentally serves as a verification of the PHC determination. If the monitoring results confirm the accuracy, or conservatism, of the PHC determination, there will be no unacceptable damage that would trigger remediation. If, however, the monitoring results indicate the PHC determination under-projected the impacts of mining, that insight allows intervention prior to unacceptable damage ever occurring. Intervention is particularly relevant for consequences outside the permit area, where SMCRA mandates that material damage be prevented, not just detected and remediated.

The proper design of a performance-monitoring program is partially dependent upon a valid determination of the PHC. If the PHC determination leads to monitoring in the wrong locations or at the wrong times, the monitoring program cannot be effective. Since a valid PHC determination is highly dependent upon a valid determination of the pre-mining hydrologic balance, the monitoring program is similarly dependent upon that initial characterization.

Cumulative Hydrologic Impact Assessment (CHIA)

The hydrologic protections afforded by SMCRA in defense of ground- and surface water does not stop with the permit application and the determinations by the applicant. SMCRA places upon the regulatory authority the onus of determining that the hydrological impacts of this proposed mine, cumulatively with the impacts of all other mines in an area of overlapping impacts, prevent material damage to the hydrologic balance outside the permit area. This cumulative assessment is provided in the regulations as follows:

> The regulatory authority shall provide an assessment of the probable cumulative hydrologic impacts (CHIA) of the proposed operation and all anticipated mining upon surface- and ground-water systems in the cumulative impact area. The CHIA shall be sufficient to determine, for purposes of permit approval, whether the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area. The regulatory authority may allow the applicant to submit data and analyses relevant to the CHIA with the permit application. (30 C.F.R. § 780.21(g)(1))

Further:

> No permit application . . . shall be approved unless the application affirmatively demonstrates and the regulatory authority finds, in writing, on the basis of information set forth in the application or from information otherwise available that is documented in the approval, the following:
> . . .
>> (e) The regulatory authority has made an assessment of the probable cumulative impacts of all anticipated coal mining on the hydrologic balance in the cumulative impact area and has determined that the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area. (30 C.F.R. § 773.15(e))

Although the regulatory authority must make a cumulative assessment and find in writing that the proposed operation is designed to prevent material damage to the hydrologic balance outside the permit area, it is important to understand that the CHIA is not necessarily an independent review or assessment. The regulatory authority may rely on analyses and information submitted by the permit applicant to reach its finding. In some jurisdictions, the regulatory authority charges the permit applicant with authoring the CHIA and simply reviews the operator-authored CHIA to reach the required findings. Thus, poor characterization of the hydrologic balance and/or PHC can propagate throughout the process and compromise even the CHIA.

Material Damage Criteria

Material damage to the hydrologic balance is not a defined term in SMCRA or in its regulations. SMCRA does establish a relationship between SMCRA and other federal laws protecting hydrologic resources:

> Nothing in [SMCRA] shall be construed as superseding, amending, modifying, or repealing . . . The Federal Water Pollution Control Act, the State laws enacted pursuant thereto, or other Federal laws relating to preservation of water quality.[8]

So, certainly, mining regulation under SMCRA cannot be allowed to perceive material damage to mean contamination limits higher than the limits of the Clean Water Act. But beyond that limit, SMCRA leaves the determination of material damage to the regulatory authority.

The lack at the federal level of a program-wide definition of material damage is not an oversight; it is deliberate. For example, there is not a single value for the concentration of boron that makes sense across the country. The same is true for sulfate or selenium. Absolute nation-wide standards probably wouldn't work and probably aren't appropriate. The authors of SMCRA deferred to the individual regulatory authorities to define material damage, whether program-wide, site-by-site, as a numerical standard, as a narrative standard, or some combinations.

What was not deferred to the individual regulatory authorities was the latitude to not define material damage. Logic dictates that no valid coal mining permit can be issued without

[8] 30 U.S.C. § 1292(a)(3)

definition of material damage. The regulatory authority cannot rationally find that material damage to the hydrologic balance outside the permit area will be cumulatively prevented if the authority does not first define what constitutes material damage. Similarly, the operator cannot assert an operations plan or a reclamation plan will prevent material damage outside the permit area if material damage has not been defined.[9] SMCRA functionally requires a definition of material damage for compliance with and enforcement of the law. The onus of developing that definition is put upon the regulatory authority.

Miscellaneous Protections

There are several provisions in SMCRA that provide special protections for hydrologic settings or conditions that do not exist everywhere. Although not universally applicable, these protections are treated with essentially the same rubric sequence of hydrologic characterization, probable hydrologic consequences, hydrologic monitoring program, hydrologic reclamation plan, and the CHIA.

Alluvial Valley Floors

Alluvial Valley Floors (AVF) are geographic areas defined by specific geology, landforms, hydrologic properties and potential resource use. Specifically, AVF is defined as follows:

> the unconsolidated stream-laid deposits holding streams with water availability sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by unconcentrated runoff or slope wash, together with talus, or other mass-movement accumulations, and windblown deposits.[10]

AVF designation, and its higher levels of hydrologic protection, is applicable only west of the 100th Meridian due the importance of AVF to farming that relies upon irrigation. The higher

[9] Nor would it be a good business decision to do so. The priorities of regulatory authorities can change over time. An implicit standard of “we’ll know it when we see it” may change halfway through a mining operation, leaving the operator badly exposed.
[10] 30 C.F.R. § 701.5 *Alluvial valley floors*

levels of hydrologic protection derive from a designation of a stream and valley as an AVF are as follows:

> Permit applicants who propose to conduct surface coal mining and reclamation operations within a valley holding a stream or in a location where the permit area or adjacent area includes any stream, in the arid and semiarid regions of the United States, as an initial step in the permit process, may request the regulatory authority to make an alluvial valley floor determination with respect to that valley floor. The applicant shall demonstrate and the regulatory authority shall determine, based on either available data or field studies submitted by the applicant, or a combination of available data and field studies, the presence or absence of an alluvial valley floor. Studies shall include sufficiently detailed geologic, hydrologic, land use, soils, and vegetation data and analysis to demonstrate the probable existence of an alluvial valley floor in the area. The regulatory authority may require additional data collection and analysis or other supporting documents, maps, and illustrations in order to make the determination.[11]

If an area is determined to be an AVF, surface mining operations and reclamation requirements are significantly more restrictive than for general operations and reclamation. Specifically, in addition to mandates related to the hydrologic balance, mining must protect the essential hydrologic functions of the AVF and reclamation must be able to restore those functions if it is impaired. *Essential hydrologic functions* is defined as follows:

> the role of an alluvial valley floor in collecting, storing, regulating, and making the natural flow of surface or ground water, or both, usefully available for agricultural activities by reason of the valley floor's topographic position, the landscape, and the physical properties of its underlying materials. A combination of these functions provides a water supply during extended periods of low precipitation.[12]

A designation of an area as an AVF does not preclude surface mining, but the standards make it unlikely. Unless the company can identify an applicable statutory exclusion, the basic requirements to mine are as follows:

> No permit or permit revision application for surface coal mining and reclamation operations on lands located west of the 100th meridian west longitude shall be approved by the regulatory authority unless the application demonstrates and the regulatory authority finds in writing, on the basis of information set forth in the application, that—

[11] 30 C.F.R. § 785.19(a) (1)
[12] 30 C.F.R. § 701.5 *Essential hydrologic functions*

> (i) The proposed operations will not interrupt, discontinue, or preclude farming on an alluvial valley floor;
>
> (ii) The proposed operations will not materially damage the quantity or quality of water in surface and underground water systems that supply alluvial valley floors; and
>
> (iii) The proposed operations will comply with part 822 [SPECIAL PERMANENT PROGRAM PERFORMANCE STANDARDS—OPERATIONS IN ALLUVIAL VALLEY FLOORS] of this chapter and the other applicable requirements of the Act and the regulatory program.[13]

Intermittent and Perennial Streams

SMCRA defines three levels of streams: ephemeral, intermittent and perennial. The streams are largely defined upon the hydrologic function they serve and their hydrologic relationship to groundwater. Their hydrologic protection varies depending upon the hydrologic relationship to ground water.

Ephemeral streams support flow only in direct response to precipitation or snowmelt; they never receive a contribution to flow from groundwater. Since the natural function of an ephemeral stream is simply to convey surface water runoff, operations may mine through them and restore the function of surface water conveyance by topographic restoration as part of reclamation.

A perennial stream flows throughout the year. It is defined in SMCRA as

> a stream or part of a stream that flows continuously during all of the calendar year as a result of ground-water discharge or surface runoff. The term does not include *intermittent stream* or *ephemeral stream.*[14]

Hydrologically, an intermittent stream is dry part of the year, flows in direct response to precipitation or snowmelt, and part of the year receives base flow from groundwater discharge. SMCRA uses a version of the hydrologic definition and adds a definition using a threshold drainage area, beyond which a stream is intermittent whether or not its flow is supported

[13] 30 C.F.R. § 785.19(e) (2)
[14] 30 C.F.R. § 701.5 *Perennial stream*

episodically by discharge of groundwater. Specifically, in SMCRA, an intermittent stream is defined as follows:

> (a) A stream or reach of a stream that drains a watershed of at least one square mile, or
>
> (b) A stream or reach of a stream that is below the local water table for at least some part of the year, and obtains its flow from both surface runoff and ground water discharge.[15]

A close examination of these definitions establishes that collectively they neither describe the universe of all streams nor prevent one stream from meeting the definitions of more than one SMCRA stream type. Problems with the definitions notwithstanding, SMCRA does confer upon intermittent and perennial streams a significantly higher level of protection than is conferred upon ephemeral streams. Whereas an ephemeral stream may be simply mined through, the mine boundary cannot come with 100 feet of an intermittent or perennial stream[16] without complying with the special protections of the stream buffer rule.[17]

In the case of intermittent streams, the detail and efficacy of the characterization of the hydrologic balance is absolutely critical for obtaining available protections under SMCRA. The definition of *intermittent stream* relies upon determining the nature of water transfer between groundwater and a stream throughout the year. If the characterization of the hydrologic balance is insufficient to document groundwater discharge to the stream during part of the year, the valuable protection is lost to the stream.

Water Source Replacement

If someone's source of water is diminished in quantity or quality as a result of mining, the operator is required to replace that water resource.[18] The loss of water may or may not be compliant with the limits imposed on damage to the hydrologic balance. Either way, such loss of

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[15] 30 C.F.R. § 701.5 *Intermittent stream*
[16] 30 C.F.R. § 780.28
[17] 30 C.F.R. § 816.57 Hydrologic balance: Activities in or adjacent to perennial or intermittent streams.
[18] 30 U.S.C. § 1307(b)

water is clearly damage to that individual, and SMCRA requires that such person be made whole.

The water replacement requirement is not, however, an alternative available to the operator in lieu of complying with the requirements to minimize damage to the hydrologic balance within the permit area and prevent material damage to the hydrologic balance outside the permit area. In listing the items that must be addressed in the hydrologic reclamation plan, the regulations unambiguously require both protection of the hydrologic balance and protecting or replacing the rights of present water users.[19]

Discussion

SMCRA is an exceptional law in its expectations, its objectives, and its design. It works substantially better than how things were before it was passed, but it does not work nearly as well as it should. As anticipated by its authors, the delegated regulatory authorities often do not have the will or the interest or the resources to fully enforce the law and the regulations. Citizen enforcement authority can, and does, help, but resources and experience are too limited to be as effective as it should be.

Hydrologic protections within SMCRA are many and well thought out. However, their benefits are handicapped by ineffectual implementation at the start of the process, *i.e.*, the permit application. A careful review of the permit application, then, can serve as an initial focal point for improving the implementation of SMCRA. Some of the practices I personally have noticed across the years that lead to poor applications, and, therefore, poor implementation of SMCRA, follow.

[19] 30 C.F.R. § 780.21(h), and as quoted above.

Characterization of the Hydrologic Balance

The characterization of the hydrologic balance is too frequently inadequate, sometimes grossly so. Baseline data collection is generally too limited geographically, geologically, in duration and in frequency. The greatest missing understanding of the hydrologic balance is from the failure to characterize the interconnected flows among individual elements of the balance. As a result of the inadequate characterization, only a ghost of the hydrologic balance is seen; with not enough detail to protect it. Examples include

- State programs do not always require at least a full year of observation of ground- and surface water.
- State programs do not always require surface water flow data be collected at a frequency that allows the seasonal variation of stream flow to be isolated from shorter duration events that are due to precipitation and snow-melt runoff.[20]
- Spring discharge represents one of the readily visible transfers between hydrologic units – the discharge of groundwater to surface water. Seldom do states require a full inventory of spring discharges; typically only those being used are inventoried, and, often, there is no requirement, or little attempt, to characterize seasonal variation.[21]
- Stream flow typically is monitored only at permit boundaries for a stream crossing a permit area and only where a stream leaves a permit area for a stream arising on the permit. Except for the identification of perennial flow in perennial streams, this limited spatial monitoring precludes collecting the data to characterize any exchanges between the surface water hydrologic unit and any groundwater hydrologic unit(s), as required by SMCRA.
- Solely permit-boundary monitoring of stream flow also precludes characterizing whether, when, and where a stream exhibits intermittent flow; and is, therefore, afforded the additional protections of the stream buffer rule discussed earlier in this paper.[22]

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[20] No state in which I have worked requires daily flow data be collected routinely for characterization of seasonal variations of stream flow in permit applications. Some applications in some states do contain daily data, but such data are related to data that were collected for other purposes and that are incorporated into the permit application. Examples of such data include USGS gauging station data, data collected for AVF determination and characterization, and data existing on already impaired streams for purposes of establishing TMDLs under the CWA.

[21] In one Ohio permit application, the applicant's consulting firm explicitly stated, in detail, in its hydrology report that the once-a-month sampling of spring flow discharges they had performed were simply 'snapshots' and could not be used to characterize seasonal variation of spring flows. In spite of the obvious and acknowledged deficiency, the regulatory agency approved the permit and the agency's hearing board upheld the approval on appeal.

[22] In a recent appeal of a permit in Illinois in which I participated, the hydrogeologist of the regulatory agency testified that the hydrologic characteristic of the stream was irrelevant to the determination of whether or not it is intermittent. He testified that Illinois had never used that part of the definition; it only used the drainage area criterion to determine intermittent streams. The regulatory authority perceived the definition as offering the state program a choice to use either (a) or (b) as the definition. (The definition of intermittent stream is quoted above.)

- Inappropriately 'lumping' or averaging of data that are collected from different hydrologic units is often allowed. Doing so will compromise characterization of the hydrologic balance. This is particularly common with groundwater data, where waters from different aquifers are averaged for purposes of statistically characterizing 'groundwater', or spring discharges from shallow soil zones are lumped with deep bedrock aquifer.

Probable Hydrologic Consequences

There are errors as well with developing the PHC. At a most fundamental level, if the hydrologic balance is not sufficiently understood, one is lost trying to identify the probable consequences of the proposed mining and reclamation plans on the hydrologic balance. Because characterizations of the hydrologic balance are so commonly inadequate, almost all PHC determinations are inherently handicapped.

A common inadequacy in permit applications is the lack of detail of the PHC. In most mine permit applications I have reviewed, regardless of the regulatory programs, the identified hydrologic consequences are generalized projections. The timing, duration, and/or magnitude of a consequence have no specific, quantitative determination. It is not enough to predict that groundwater quality may degrade as a result of mining. How badly will it degrade and when? In what hydrologic unit(s) will it degrade? Where does the degraded water flow during mining, during reclamation, and in the new hydrologic equilibrium after mining? Will it degrade inside the permit area only, or also outside the permit area?

The lack of detail in determining the PHC is not simply an issue of accuracy and completeness, although those are required before a permit may be issued.[23] The lack of detail does not allow operator to design the hydrologic reclamation plan to intervene at a place and time and with a technology that minimizes damage to the hydrologic balance inside the permit area and that prevents material damage outside the permit area, if monitoring should show that the expected PHC are underestimated. Such lack also precludes the ability of the operator to design a

An administrative law judge in an appeal determined that the definition meant that the stream was intermittent if either (a) or (b) was met.

[23] 30 C.F.R. § 773.15(a)

monitoring plan that is compliant with SMCRA. For example, if there are no quantified PHC, the monitoring data cannot support a determination that the PHC are or are not likely realistic and that the mine will or will not remain in compliance.

Hydrologic Reclamation Plans

My experience suggests that the first objective of the hydrologic reclamation plan is met, to the extent possible. That is, the hydrologic reclamation plan does consider the PHC and discusses how the mining plan will address those potential consequences to appropriately limit damage to the hydrologic balance inside and outside the permit area. However, due to the common inadequacies of the PHC and the underlying characterization of the hydrologic balance, this portion of the hydrologic reclamation plan is frequently so generic as to be boilerplate text equally applicable to any mine anywhere; only the names and acreages need be changed.

My experience also indicates that the second objective is never met. I have never seen a permit application that meaningfully includes preemptive triggers and preventative and/or remedial measures to implement in the event unacceptable hydrologic impacts are developing, beyond those predicted in the PHC.

Hydrologic Monitoring Plans

Deficiencies in hydrologic monitoring programs are inevitable when there are inadequacies in characterization of the hydrologic balance, the PHC, and the hydrologic reclamation plans. My experience indicates that there are also systematic problems that exist beyond problems that result from interdependencies with other parts of SMCRA. These problems exist in virtually every mine application I have reviewed, regardless of the regulatory authority. Among the problems are the following:

- The hydrologic monitoring plans use the same monitoring system as was used for the hydrologic characterization and baseline data collection.[24]

[24] This fails to recognize that the hydrologic monitoring system must monitor the performance of the mine and its impacts on the new hydrologic balance(s) that will exist during mining, reclamation, and post-mining. During- and post-mining conditions must define where and when monitoring by the hydrologic monitoring plan is needed.

- The plans fail to monitor at the frequencies or for the durations that are meaningful.[25] [26]
- The plans do not describe how the data will be used.[27]
- The plans do not provide the thresholds, limits, trends or narrative criteria that will be used to ensure that the mine is and will remain in compliance.[28]

Material Damage

Material damage is a concept that is poorly managed under state SMCRA programs. It is managed differently in each state and sometimes inconsistently within a state. It has been and is a litigation target, and, I suspect it will be years before it is fully resolved.

At the federal level, it is, or at least was, more clearly managed. The federal Office of Surface Mining Reclamation and Enforcement (OSM) issued a draft guidance for the development of material damage criteria. That guidance is clearly predicated on complete and accurate determinations of the hydrologic balance, the probable hydrologic consequences, a site-specific hydrologic reclamation plan, and a meaningful hydrologic monitoring program. With those elements, the guidance showed how to determine appropriate material damage criteria for this geologic area (possibly statewide, but not necessarily) and how to define the monitoring criteria that would allow this mine plan at this mine site to prevent material damage off the permit area.

[25] As with characterization monitoring, performance monitoring must be capable of assessing the hydrologic balance, since damages to the hydrologic balance are the performance criteria. This necessarily includes monitoring seasonal variation and transfers among various hydrologic units. I.e., Monitoring groundwater annually or once every three years cannot determine seasonal variations. Baseflow contribution to a stream cannot be determined by annual, quarterly, or monthly measurements of stream flow. Yet, these are parts of the hydrologic monitoring plans for the Rosebud mining complex in MT.

[26] Monitoring groundwater at the perimeter of a mine is a ubiquitous element of hydrologic monitoring programs. This monitoring is expected to cease once reclamation bonds are released. Such monitoring is virtually always measuring water moving from outside the permit area into the mined area; outward migration will only occur after the mine pits have reached the new, post-mining hydrologic equilibrium potentially decades after bond release.

[27] A perfunctory assertion that ‘the data will be compared to baseline data’ is not sufficient.

[28] A perfunctory assertion that ‘if a violation or material damage is observed, remedial measures may be required,’ is not sufficient. Compliance requires that damages to the hydrologic balance be minimized and prevented, inside and outside the permit area, respectively. To comply with SMCRA, the monitoring program must allow operator response in time to prevent the violation, not simply react to it. The criteria that will allow the preventative response(s) are to be provided.

In lieu of dealing with material damage as a performance requirement, and its prevention as a – the – principal mandate of SMCRA, state programs largely avoid or ignore it. In my opinion, no state in which I have worked comes close to implementing the OSM guidance.[29] States do, however, substitute the water source replacement obligation for material damage criteria. Such substitution often propagates backward from the approval documents (including the CHIA) through the SMCRA elements discussed is this paper to even the characterization of the hydrologic balance.

Ultimately, with this substitution, the characterization of the hydrologic balance becomes simply the inventory of water users. Spring discharge is significant only respect to the portion of the flow that is being used. AVF is reduced to only those lands/sediments currently being used for irrigation, not those capable of being used.[30] Material damage to surface water quantity will be prevented because current water rights will be available from the river.[31] Enforcing only the replacement provision at the expense of the protection provisions ignores the fundamental SMCRA obligation to protect the entire hydrologic balance itself, not just someone's use of a part of it.

Summary

As previously noted, SMCRA is an exceptional law in its expectations, its objectives, and its design. In the thirty-seven years since it's passage, the environmental damage done by surface mining has declined substantially. That said, environmental problems still persist with surface coal mining. The hydrologic problems that persist as a result surface mining, however, are not the result of inadequacies within SMCRA or its regulations. While SMCRA is elegantly designed and carefully crafted, it is not implemented as well as it could be and should be to protect hydrology.

[29] I was involved in a permit appeal hearing recently in Utah at which a state employee identified the OSM draft guidance for CHIAs as a document recognized as authoritative and relied upon by Utah.

[30] OSM also produced a draft guidance for AVF determination that makes it clear the federal position at the time of publication was that it was capability, not use, that was controlling for AVF determination.

[31] This is a finding of the WY Department of Environmental Quality CHIA for Youngs Creek Mine.

Regulatory agencies of both federal and state programs undercut the inherent power of SMCRA statute and regulations through poor implementation and lax enforcement. Inadequate implementation is most notable in the issuance of permits underlain by inadequate and incomplete permit applications and insufficient and/or inappropriate agency findings. Lax enforcement is the result of agency enforcement of the inadequate permit rather than enforcement of the law and regulations.

The primary mandate of SMCRA for hydrologic protection is two-fold; that damage to the hydrologic balance be minimized within the permit area and that material damage to the hydrologic balance be prevented outside the permit area. The key inadequacy of SMCRA permit applications with respect to hydrologic issues is inadequate characterization of the hydrologic balance. Inadequate characterization of the hydrologic balance propagates deficiencies throughout the thoughtfully structured interdependencies of the permit application, *i.e.*, the determination of probable hydrologic consequences, the hydrologic reclamation plan, and the hydrologic monitoring plans.

The key deficiency of agency findings that are required for permit approval is the inadequacy, to the point of avoidance, of determinations of the material damage criteria that apply to the mine and the cumulative impact area. Compliance with the mandate to prevent material damage outside the permit area is quite simply impossible if material damage to the hydrologic balance is not defined. It is analogous to a traffic authority asserting it will control speeding without either setting or posting speed limits. The failure to define criteria for material damage is compounded by the substitution of the requirement to replace source water for the requirement to prevent material damage to the hydrologic balance. Doing so extends the analogy to an assertion that one need not control speeding if one enforces parking regulations.

The failure to characterize the hydrologic balance in the permit application and the failure to establish material damage criteria to protect it are intimately related. Together they eviscerate the ability to enforce the key SMCRA mandate to protect hydrology while mining. The result is environmental damage to hydrologic resources that could be avoided and should be avoided. And, it is damage that would be avoided if SMCRA were fully implemented.