AMD INVENTORY IN WV

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ABSTRACT

Recent sampling and aquatic habitat evaluation by many entities has indicated that despite a long history of negative influence by acid mine drainage, many streams and rivers in West Virginia are improving in quality. AMD continues to negatively impact streams in many areas of the state, but a combined effort industry, state, and federal concerns to control AMD at active mine sites, bond forfeitures, and abandoned mine lands has resulted in improved fisheries and restored water uses. Effective chemical treatment and watershed improvement efforts utilizing passive technologies have been the primary cause of this trend. Active mine sites, bond forfeiture sites, and AML projects dealing with AMD are inventoried for location and extent. Trends in AMD affected watersheds are presented.

INTRODUCTION

For many years at this symposium and at other venues, much discussion has been made about the extent, nature, and solution for acid mine drainage (AMD). Acid mine drainage research began prior to this century (Gleason 1976). Evaluation of the efficacy of acid mine drainage abatement measures is difficult.. Even empirical analytical data may not reflect the actual measure of success of a mitigative endeavor. Most technical papers present a substantial amount of analytical data at a specific site prior to and after the water quality mitigation effort. However, the real indicator of mine drainage mitigation is restored or preserved habitat and water uses in receiving streams.

I should like to present an overview of the AMD problem in West Virginia. Rather than explore the technical intricacies of AMD formation and mitigation, l would rather discuss the extent, nature, and trends of AMD in the Mountain State. Several sources of information have developed in the last few years which, for the first time, give us the opportunity to understand where we have been and are going in this long journey toward controlling this most serious water pollution problem in our state.

LOCATION AND EXTENT

There are two good reference sources that document AMD in WV. The WV Division of Environmental Protection (WVDEP) Office of Water Resources (OWR) annually compiles a {(303(d)} list of streams affected by acid mine drainage. Both a priority (17 of 51 priority streams in 1996 are affected by mine drainage) list and a non-priority list (469 streams in 1996) are generated on the basis of analytical and benthic investigation (Bennett 1997). The USEPA Region 111 office in Wheeling compiled a Geographic Information System (GIS) database of streams with AMD impacted fisheries in 1995 which graphically presents mild to toxic AMD influence (USEPA 1995). This database defined two levels of impact. Severe impacts were denoted "no fish" as characterized by state fisheries biologists. Less severely impacted streams where reduced number of species or reduced productivity were denoted "some fish". The WVDEP OWR lists indicate all mine drainage impacts (including alkaline metal drainage, high solids, and other negative influences) while the USEPA graphic is limited to AMD only.

As seen from these sources detailing where habitat and water use is compromised by AMD, it is obvious that AMD in WV is serious and widespread. It is important to recognize, that despite serious, chronic AMD problems in several watersheds, beyond a few small tributaries, West Virginia does not export acidity beyond its borders. All major rivers leaving WV, including those listed and shown as impacted by AMD, are now generally net alkaline (STORET, 1997). Further, they are generally improving in quality for a number of reasons.

ORIGIN

Mining operations in West Virginia are classified into three legal categories. Operations which completed operations prior to the Federal law (SMCRA) in 1977 constitute Abandoned Mine Lands (AML eligible). Operations since SMCRA are actively permitted or completed(released). Sites where the permit was revoked and bonds forfeited comprise the third category.

Water quality associated with mining operations is not so easily classified. The origin of water discharges is not always clear. The quality of mine discharges is affected by a host of variables, including seasonal and geochemical influences. Attempts to define the mine drainage problem in West Virginia have generally involved an estimation of acid load by analyzing affected streams. Another approach, and certainly the most valuable (and difficult), would be to inventory individual discharges (point sources) identified as water quality concerns.

Such an inventory commenced in 1981 when WVDEP's Office of AML&R began collecting water quality information in its problem area descriptions of **Abandoned Mine Lands.** Earlier attempts to identify problem mine drainage by other state agencies (including WVDNR Water Resources Division) were noted in this evaluation (WVDNR 1973, 1979, 1981..85).

In 1988, AML&R's Special Reclamation Program began collecting water quality information at all sites where bonds were **forfeited** since SMCRA. This AMD-BF inventory is updated regularly and prioritized yearly to implement mitigation of water quality at revoked sites (Faulkner 1996).

In 1994, the first inventory of water quality problems at **active mine sites** was prepared by WVDEP (WVDEP 1995). This inventory was updated and refined in late 1996 (Faulkner 1997).

AML SITES

The inventory of this first category is fairly complete. Water quality at AML sites has been collected by WVDEP over the past several years at sites where land reclamation was a high priority. Until recent changes in SMCRA, AML&R concentrated on dangerous land configurations and hazards rather than water quality. The inventory of abandoned mine drainage affected areas in West Virginia waters was first developed pursuant to Section 208 of the Federal Clean Water Act (Public Law 95-217, et. seq.) and Title IV of SMCRA (Public Law 95-87). The studies were conducted by WVDNR Water Resources Division in the Monongahela River Basin from 1981 to 1985.

Since then, WVDEP has revisited many of these sites and has implemented passive treatment including backfilling and regrading, soil amendments and sealants, in-stream limestone sand, limestone rotary drums, open limestone channels (OLC), anoxic limestone drains (ALD), wetlands, and alkaline producing systems of various designs (Skousen 1996). Monitoring of these mitigation efforts and other intense monitoring at other sites will soon join bond forfeitures and active mine sites in WVDEP's Geographic Information System.

BOND FORFEITURES

The responsibility of meeting effluent limits and minimizing impact to the receiving streams rests completely with the permit holder. Should the permit be revoked, WVDEP implements water quality mitigation at the site on a watershed and priority approach. Waterquality improvement efforts at selected sites are also considered on a cost-benefit and watershed approach.

WVDEP's Office Special Reclamation Program has inventoried all bond forfeitures since SMCRA to determine water quality impacts and design and remedy sites with water quality issues. Less than 100 sites have detectable impact to their receiving stream. Since 1985, the Special Reclamation Program, funded through securities forfeitures, civil penalties and coal taxes, expended over $6.9 million in chemical treatment of acid mine drainage from four bond forfeiture sites. Since 1988, over $2.2 million has been spent on water quality investigation (over 900 sites) and design of AMD abatement at bond forfeiture sites. An additional $2.3 million construction work has been implemented to mitigate water quality problems at 75 of these sites. Careful monitoring indicates backfilling and regrading often improve water quality at acid emanating sites by reducing acidity or flow or both (Faulkner 1994). Developing passive technologies similar to those mentioned previously as well as diversion wells and alkaline additions have been employed with measurable success.

ACTIVE MINES

Coal has been mined in WV since the late 1700's. Active mining exacerbates the natural production of acidity from pyrite rich coal seams and strata by allowing acid producing materials to come in contact with water and oxygen (Skousen 1996). Coal operators employ diverse chemical and physical means to reduce acidity at active and reclaimed mines, and reclaim hundreds of acres of old mines each year by remining (Hedin 1997). To meet effluent limits of pH > 6, and to reduce metal concentrations to NPDES limits, operators often introduce strong chemical neutralizers with excess alkalinity that mask the effects of contiguous or adjacent AML acid sources.

In 1994, WVDEP inspectors collected raw (untreated) mine related drainages at actively permitted sites where water quality was a concern and performed field analyses. Inspectors reviewed all sites at the final discharge point to ensure compliance with the effluent limits established under the NPDES program. This exercise was repeated in 1996 except water samples were collected for laboratory analysis. Flow was estimated using the best available means. Samples for field analysis were collected at the source or at a collection point prior to chemical, biological, or physical treatment.

The Acid Mine Drainage (AMD) Inventory included all sites where water quality was a concern to the inspector. This included sites where effluent limits were not being met for any established parameter, not just pH < 6.0, or acidity > alkalinity. The title is a misnomer, and the resulting document should be referred to as the "Active Mine Water Quality Inventory" or hereafter "Inventory".

There are currently over 16,800 outlets permitted at coal mine operations by the NPDES program in West Virginia. WVDEP inspectors identified 890 sources to these outlets (5%) as water quality concerns in 1994. This number had changed to 816 in 1996. Inspectors added 107 new sources to the inventory in 1996. Since 1994, 9 sources had improved in water quality sufficient to allow final release. Fifty five (55) others had improved in quality such that they were no longer of concern, had been eliminated by regrading, or were determined to be of AML origin. Permits containing 35 sources were revoked, and 34 duplicate sources were eliminated from the inventory. In 1996, only 563 of the 816 sources exhibited a measurable flow (> I gpm). This represents the total number of sources now being considered.

Fairmont (Region 1) had approximately I /3 of the water quality concerns in 1994. Philippi (Region 11) had a large portion of the 1994 sources of concern, and many of these sources had relatively high flows, representing approximately I /3 of the flow causing concern. Oak Hill (111) had a relatively high number of sources troubling its inspectors, but they generally had lower flows than those in northern WV. While both have a number of large deep mines with high flows, many of those in southern West Virginia exhibit good water quality. Similarly, while Welch (IV) had only a few sources in 1994, some of these had fairly high flows. Region IV's (Logan) flows were similar to Fairmont in that outlet number and flow volume constituted similar portions of the total for the state in 1994.

Changes in flow distribution since 1994 are unremarkable. Total flow for the state actually decreased nearly 4500 8pm. This is due to several factors, but largely to the season of the sampling (July, 1994 vs. October, 1996).

It is important to realize that deep mine drainage dominates the flow (64% in 1994 and 72% in 1996), while representing only a modest portion of sources (22% in 1994 and 20% in 1996). Further, while only approximately 4% of the sources represented actively pumped water, this flow constituted 20% to 25% of the total problem flow volume.

While specific sources could be identified and presented graphically by latitude and longitude (GIS format), a fair idea of distribution is seen when sources and flows are listed by county. It is not surprising that two counties with large Underground mine complexes (Grant and Monongalia) dominate over 1/3 of the total flow. Adding Tucker and Harrison Counties increases the percentage to half the state total. While Preston County reported a sizable number (7- 10%) of sources, they represented only a small portion (2%) of the total flow. This may be due to the rather large number of surface mine sites with poor water quality and relatively low flows. A similar trend is seen in Nicholas County. Conversely, McDowell County had only 1 % of the sources, but the large deep mines dominating that county returned approximately 10% of the flow for the state.

The 1996 data indicate that 37% of the sources representing 50% the total flow of concern is alkaline (pH >6 and acidity < 1). Further, nearly half (47%) of the 1996 sources representing over 55% of the total flow are not strongly acid (pH >5.0).

If metals are considered, about 17% of the pH neutral sources of concern have the potential (untreated) to discharge elevated (above the usual effluent limit of 2 ppm) manganese concentrations. This represents approximately 1/5 the problem drainage. When manganese is the only parameter of concern, (pH >5.9, Fe <3, Mn >2), about 7% of the sources (or 9% of the flow) are being treated for manganese only. WVDEP is presently evaluating the efficacy of this specialized treatment since elevated pH may be more detrimental than moderate concentrations of manganese.

A substantial portion (14% in 1994; 18% in 1996) of the raw water sources exhibited neutral to alkaline pH (>5.9) and iron concentrations greater than general effluent limits (3 ppm). This represented 26% to 31 % of the flow. Large deep mines with circumneutral pH and elevated iron concentrations constitute a large portion of the water quality problem in the state. More sites exhibit elevated iron at pH >5.9 than in the range of 4.9< pH <5.9. A surprisingly small number of sites cause only pH concern.

The origin of water at the Untreated (raw) sampling location is often unknown. WVDEP inspectors have the benefit of historic knowledge at most sites, particularly with the information assembled for the permit and adjacent permitted sites. Many subject drainages were suspected to be influenced by more than one source. Over a third of the drainage of concern is influenced by either surface runoff, seepage, or refuse. Over two thirds is influenced by underground works.

Operators appear to have control over the quantity of flow at a relatively few (4%) of the sources, but these pump manipulated discharges constitute a large portion (20% in 1994, 25% in 1996) of the total flow.

Mine operators employ a host of treatment strategies for managing water quality. The most primitive treatment method; soda ash briquettes in a hopper or ditchline, was employed upstream of approximately one quarter of the sites where water quality was a concern in 1994. These sources constituted less than 10% of the total flow. This is no surprise, since operators have historically used this method on low volume, mild, or intermittent flows. This number reduced substantially in 1996. Caustic soda dominated the number of sites where water was chemically treated in 1994. While 36% of the sources received caustic soda in 1994, this represented only 26% of the flow. Conversely, 18% of the sites used lime of some composition to treat 48% of the total flow that year. Obviously several large deep mine and refuse complexes with capital intensive central treatment plants and very large flows dominate the chemical treatment arena. Anhydrous ammonia was used at a large number of sites and was responsible for a respectable portion (16%) of the water receiving chemical treatment in 1994. Calcium oxide is being dispensed at a growing number of sites, and is replacing lime and ammonia at many sites due to its economic advantage and low toxicity. Many lime plants (typically capital intensive) have converted to calcium oxide. A few sites meet effluent limits by employing passive technologies such as anoxic limestone drains or wetlands, but many more stay in compliance by the effects of dilution or physical retention. A common observation of those experienced in water quality management is that each drainage and treatment scenario is unique, and several treatment strategies may be in use at a single site (Hilton 1993).

A more meaningful examination of treatment strategies is possible when chemical analyses are available (1996). The product of acidity or metals concentrations and flow can be expressed in load as tons of metals or acidity per year. Because many sites use a variety or combination of chemicals depending on flow volume or quality, temperature, availability, or a host of other factors, loads and flow cannot be summed, and the entire matrix must be viewed as non-cumulative. For the total treated drainage, similar flow volumes are addressed with lime, calcium oxide, and caustic, yet lime-treated sources constitute a higher acid load. Calcium oxide appears to be the chemical of choice for high iron concentrations, and caustic is used frequently at sites with high manganese concentrations. Only one pumped source was listed as using calcium oxide, and only 2 sites dispensed ammonia at pumped sources. Of the 816 sources in 1996, 632 received chemical treatment at least occasionally, representing 76,590 8pm. Of the total 872 sources in 1994, 764 received chemical treatment at least occasionally, representing 83,850 8pm. Several sites were revoked during this period, but the untreated discharge of only two, (T&T and Omega), represented significant threats to the environment such that the State continued treatment. Others have been addressed with passive efforts including backfilling and constructed wetlands, alkaline addition, and limestone drains. Similarly, many active sites achieved effluent limits by passive technologies. Passive strategies, including constructed mitigation structures or encouraging dilution or retention, were employed at 184 sources dealing with over 12,000 8pm.

Using historic state expenditures as a standard, industry spends at least $30 million per year neutralizing acidity in West Virginia. Capital intensive, high volume plants designed to deal with large alkaline flows laden with iron and difficult manganese sites suggest the total bill to industry exceeds $60 million.

In 1996, inspectors estimated 269 sources (33% of 816) representing 66,000 8pm (73% of 89,325) would have a significant impact on the receiving stream if untreated. These estimates are actually less than 1994 figures (308 sources with approximately the same total flow).

If treatment is not effective, violations are issued and efficacy is achieved or the permit is revoked. Several sites are not eligible for bond release solely on the basis of poor water quality. Inspectors were asked to comment on the likelihood that water quality would prevent release of securities held for the permit. In 1994, inspectors estimated that 395 of the 516 permits of concern would be affected in this manner. In 1996, inspectors estimated 345 permits representing 62,736 8pm would not be released because of poor water quality. Obviously. the acid mine drainage arena is fairly static.

If a pie chart were to be constructed assigning portions of the total acid load to each of these three categories, it would look like this:

1. Active Mine sites (neutralized)	60,000 tons/year
2. Bond Forfeiture Sites (some neutralized)	14,000 tons/year
3. Abandoned Mine Lands (some neutralized by 1 above)	200,000 tons/year

Coal operators reduce the acidity of their problem discharges to zero. In fact, additional alkalinity is usually introduced to effluent waters to ensure compliance and/or for the precipitation of regulated metals (iron, manganese, and aluminum). The most serious bond forfeitures in environmentally sensitive watersheds are being successfully ameliorated by chemical treatment or by passive means. Additionally, direct and indirect water quality benefits from AML&R efforts have been realized in most AMD affected watersheds. Over $12 million has been spent directly on AMD at AML projects in West Virginia to date. Projects totaling another $6 million have been designed, and another $12 million are being planned.

TRENDS

POTOMAC RIVER BASIN NORTH BRANCH

Only two bond forfeiture sites with water quality problems are located within the Potomac watershed. Passive amelioration was designed for Allison Engineering after reconnaissance. This site is being further explored by AML&R as part of a comprehensive project with the US Army Corps of Engineers and other agencies. AML&R has completed an ambitious passive system (Bismark Strip) contiguous to the bond forfeiture site. Passive system construction is underway at the other bond forfeiture site in the watershed. Extensive limestone dosers operated by the Maryland Department of the Environment have restored the North Branch upstream of Jennings Randolph Lake (Mills 1996). Abram Creek still adversely affects this valuable "world class" trout fishery. Expenditures to characterize these two sites have been beneficial to the many agencies involved in this aggressive, successful remediation project. AML&R work at another affected tributary to the Potomac, Piney Swamp Run, is being planned.

MONONGAHELA RIVER BASIN

The Monongahela River prior to SMCRA was characterized as having chemical quality of broad variation. Most streams and headwaters were good to very good quality for most purposes. The West Fork and lower portions of the Monongahela required extensive treatment because of the mineralized qualities of water. The Monongahela was severely impacted by the West Fork, somewhat by the Tygart, and deteriorated to Point Marion...with an annual acid load of 80,000 tons. The Cheat, Middle Fork, and Buckhannon were of good quality. Today, the Monongahela River exhibits net alkalinity with average pH >6.3. The Monongahela River from its formation of the West Fork and Tygart at Fairmont has improved dramatically, largely as a result of mine reclamation and industry efforts. Ten bond forfeitures with poor water quality have been addressed with passive treatment systems on this section of the Monongahela River. Fisheries Biologists now characterize the Monongahela as good quality with an excellent fishery and expect it to improve as AMD reductions in the Tygart increase alkalinity. The Opekiska Pool is now the most intensely used bass tournament site in WV.

WEST FORK RIVER

The West Fork has been impacted by AMD for many years. In 1973, it was the predominant negative influence on the Monongahela River. Largely due to uncelebrated AML &R and industry efforts, the West Fork is now alkaline (still with problem metals, specifically iron) with a good fishery. Its major influence in summer months is now the higher flow as dictated by the new Stonewall Jackson Lake. Creation of the lake directly reduced acid loads by inundating at least one problem acid source. This has helped improve the fishery. Only two problem bond forfeiture sites remain in the West Fork watershed. One has an undetectable influence on its receiving stream, and the drainage from the other has been improved dramatically by passive technologies. Many land reclamation efforts by AML&R and Special Reclamation and remining by industry have indirectly improved water quality by reducing acid loads. Older work through WVDNR on Elk Crk. of this watershed helped restore this fishery several years ago.

TYGART VALLEY RIVER SUB-BASIN

The Tygart River was characterized in 1982 in an Abandoned Mine Drainage Assessment. Nearly 60% the acidity of the river originated in the lower Tygart including Three Forks Creek, Sandy Creek, and Fords Run. One quarter the load came from the middle Tygart (Roaring Ck. and Grassy Run), and the balance (15%) of the acid load came from the Middle Fork River. The upper Tygart is relatively unaffected by mining and the Buckhannon generally contributes neither alkalinity or acidity to the Tygart.

TYGART VALLEY RIVER

The Tygart Valley River supports an excellent fishery upstream of Grassy Run. At this point, the number of smallmouth bass > 12" decreases from 10/acre to I /acre downstream of the acid tributary. During critical low flow periods since the drought of 1988, AML&R has prevented certain fish kills and reduced the impacts of this acid tributary and Roaring Creek by pumping highly alkaline water from the underground limestone quarry west of Elkins and chemical treatment at Grassy Run. The Stream Restoration Program is performing additional reconnaissance of other problem tributaries of the Tygart while developing the feasibility of ameliorating top priority Grassy Run. Cost-sharing with the Army Corps is available to WVDEP in this endeavor. Hopefully, this will accomplish what EPA's predecessors started in the 1960's (Borek 1991) and AML reclamation continued in the 1980's. Tygart Lake has improved in alkalinity since the mid-1970's and is supporting a remarkably good fishery despite threatened tributaries including Sandy Creek. Chemical treatment at F&M on Sandy Creek protects the fishery in Tygart Lake. Downstream of the lake, the Tygart receives very negative influences from Three Forks Creek. Several bond forfeitures and AML sites in this tributary produce copious amounts of acidity. The lake output must be increased to counteract this influence during low flow and peak runoff conditions. From the dam, the Tygart supports a viable but threatened muskie fishery for 20 miles to the Monongahela. Fords Run downstream of the confluence of the Buckhannon is a high priority to help restore this fishery upstream of Tygart Lake.

Thirteen bond forfeiture sites with poor water quality are located in the Tygart River watershed. All have been backfilled, and the F & M complex continues to receive chemical treatment. Other sites have been addressed with passive treatment. Substantial land reclamation by AML&R has indirectly improved drainage in this area.

MIDDLE FORK RIVER

The Middle Fork River constitutes a fairly small watershed, heavily impacted by mining, yet salvageable. There had been acid problems in the watershed as early as 1957, and trout stocking ceased in 1973. Beginning in 1991, Special Reclamation began a comprehensive study of the primary problem areas, Kittle Flats and Whitman Flats. These two problem areas produce the bulk of acidity in the Middle Fork River. Upstream of their drainage (Cassity Fork), the Middle Fork is lightly buffered, with adverse influences from acidic precipitation. Prior to the organization of the Stream Restoration Committee and AML delineation, Special Reclamation installed an alkaline recharge zone and wetland in 1991, an anoxic limestone drain in 1993, and another anoxic limestone drain and de-watering trenches in 1994 at a total cost of over $900,000. Following this site work, and pilot in-stream limestone sand application, a dramatic change was observed in acidity loads in the Middle Fork River. With subsequent in-stream limestone sand treatment in 1993-95, (Zurbuch 1996) and amelioration of the only two other problem bond forfeitures in the watershed (Pierce Contour and Parkland Mining) and aggressive passive treatment systemsand reclamation at two large AML sites (Whitman Flats and 10/15), the Middle Fork River had recovered significantly such that trout were again stocked in February, 1997. With annual maintenance (limestone sand), and future AML&R efforts at Camp Mahonegan and Kittle Flats, the Middle Fork will continue to improve as a smallmouth bass fishery and seasonal put-and-take trout fishery in its warm water lower portion and support trout in its cooler upper reachesyear-round.

BUCKHANNON RIVER

The Buckhannon River has been characterized as a "threatened" fishery. It is an excellent fishery today, particularly for muskie, and is being preserved due to the efforts of industry and the Alton Project's extensive chemical treatment program. Other than the Alton Project, Special Reclamation has backfilled those revoked sites with poor water quality. I his was sufficient to dramatically reduce acidity at most sites. Additional passive work at the portion of the Pierce complex that drains to the Buckhannon have also helped preserve water uses in this watershed. The positive contribution of the effects of land reclamation by AML&R are undocumented.

CHEAT RIVER SUB-BASIN * LOWER CHEAT RIVER

In 1973, the Monongahela River was characterized as 'exhibiting a high acid load as it entered Pennsylvania", and was "neutralized by the Cheat River which of good chemical quality with the lowest iron and manganese values in the entire Monongahela River Basin"(WVDNR 1973). This trend has reversed since that time. The Monongahela River has improved dramatically, largely due to the efforts of the coal industry. Mining in the Cheat in the mid 1970's increased the acidity loads present from earlier mining. The WVDNR and WVDEP in cooperation with the US Andy Corps of Engineers initiated a flood control and environmental enhancement study of the Cheat, Tygart, and North Branch of the Potomac Rivers in 1995. The study is in the reconnaissance and feasibility stage, and is focused on restoration of stream uses, particularly sport fisheries. Many highly acidic tributaries of the Cheat are resultant of non-point sources of AMD or are not good candidates for many existing passive technologies because of the intensity of the problem or lack of suitable field locations for ameliorative efforts. In-stream limestone sand application is a possibility at some of the tributaries.

This has caused the Stream Restoration Committee to change its initial focus from The worst sites" to affixable" tributaries of the Cheat such as Big Sandy and Little Sandy Creek (Cherry Run #3 and Webster Refuse Projects by AML&R) and its smaller tributaries such as Sovern Run {inventoried by National Mine Land Reclamation Center (/ticker 1999)~. The Cheat is severely impacted aesthetically and biologically in its lower reaches from Kingwood to Cheat Lake by AML sites and bond forfeiture sites. WVDEP operates a chemical treatment facility at the most severe bond forfeiture site, (T&T). Several AML&R water quality projects have been initiated in the Lower Cheat watershed including Masontown #4 and Martin Creek Refuse. WVDNR with the help of industry has placed limestone sand in the South Fork of Greens Run with good results. Industry has also implemented passive mitigation at abandoned sites (Titchenell 1996). At bond forfeiture sites, some form of passive amelioration effort including regrading and backfilling, alkaline recharge zones and ALDs, wetlands and Open limestone Channels have been installed at all 24 problem sites. Additional water quality work is being considered at backfilled sites. Remarkably, Cheat Lake is supporting an improving bass fishery, and discharges from Cheat Dam average net alkaline with pH values generally > 6.5. The Cheat representsa major challenge but cooperative efforts by many interests provide hope this resource will be improved (Vukovich & Adolfson 19971.

BLACKWATER RIVER

There are no problem bond forfeiture sites on the Blackwater River. In September' 1994, a $1 million limestone drum / closer station was completed upstream of the first (mine drainage) acid tributary which has restored the Blackwater from Davis to the North Fork to an excellent trout fishery. AML AMD sources to the North Fork have been addressed with passive systems, (Albert and Douglas Highwalls) as well as the Pierce site and Beaver Creek watershed work which have improved the Blackwater to its confluence with Dry Fork. Metal loads havebeen reduced by 40%, and future fish surveys should confirm fishermen's reports of a developing trout fishery in this river that has been devoid of fish for many years. This has also had a positive influence on the Cheat River downstream.

LITTLE KANAWHA RIVER SYSTEM

Only three problem bond forfeiture sites exist in this relatively unaffected watershed. None of the sites impair their receiving stream. AML&R completed a massive land reclaimation project on Bear Run which has certainly reduced sediment loads in this watershed.

KANAWHA RIVER BASIN * KANAWHA RIVER

Five bond forfeiture sites located near the Kanawha mainstem exhibited fairly benign influence on the alkaline Kanawha. All are backfilled and regraded (two at state expense) and Open Limestone Channels have been implemented at three sites. A prominent tributary, Paint Creek, can likely become the next in-stream limestone sand success story. Once isolated AMI) sources further upstream are neutralized, this stream will benefit from terrific access and visibility from the WV Turnpike. Numerous old mining scars have been restored along this major highway in the lastfew years by industry and the AML&R program.

POCATALICO RIVER

A single problem bond forfeiture site is located in this small, but damaged watershed. Much of the problem is AML related. Backfilling the site reduced the acid load to where there is no serious detriment to the receiving stream, which is grossly polluted by abandoned Sequences..

ELK RIVER

Only a few tributaries of the Elk River were identified as acid mine drainage Impacted" in the 303(d) list. Thirteen bond forfeiture sites with water quality problems have been identified. All have nominalto undetectable impact to the receiving stream. Many have been addressed with passive treatment technology during regrading operations. Buffalo Creek presents tremendous potential if chronic AML sites in this very lightly buffered watershed can be mitigated. Aluminum poses a significant threat.

COAL RIVER

Only one problem bond forfeiture site is located in the Coal River watershed. Innovative modifications of the ALD using concrete tanks were fairly successful in reducing the acid load whileproviding valuable insights to this fledgling technology. Backfilling this site reduced the loadings dramatically. AML&R has reclaimed numerous sites in this watershed, and industry has assisted in improving physical habitat in Pond Fork and other tributaries.

NEW RIVER

Six bond forfeitures sites with water quality problems are located in the New River watershed, which is generally of good quality with only isolated acid mine drainage influences. All have been at least partly backfilled with additional passive systems implemented. The effects of land reclamation at the Summerlee AML&R project are undocumented. The Stream Restoration Program has inventoried Dunloup Creek for potential improvement. Several isolated AML AMD sources continue to impact tributaries.

GAULEY RIVER

The Gauley is generally of very good quality, but isolated intensely acid tributaries have been identified. Thirteen sites have been addressed with backfilling and passive treatment systems, including the first anoxic limestone drains constructed in West Virginia. Documentation of this effort improved the understanding of this new technology dramatically. At the most severely impacted watershed in this system, (Greendale) industry has assumed chemical treatment responsibility andis implementing additional passive systems that build on the aggressive earlier work of the Special Reclamation Program. The Meadow River exhibits several severe AMD sources which are treated by industry.

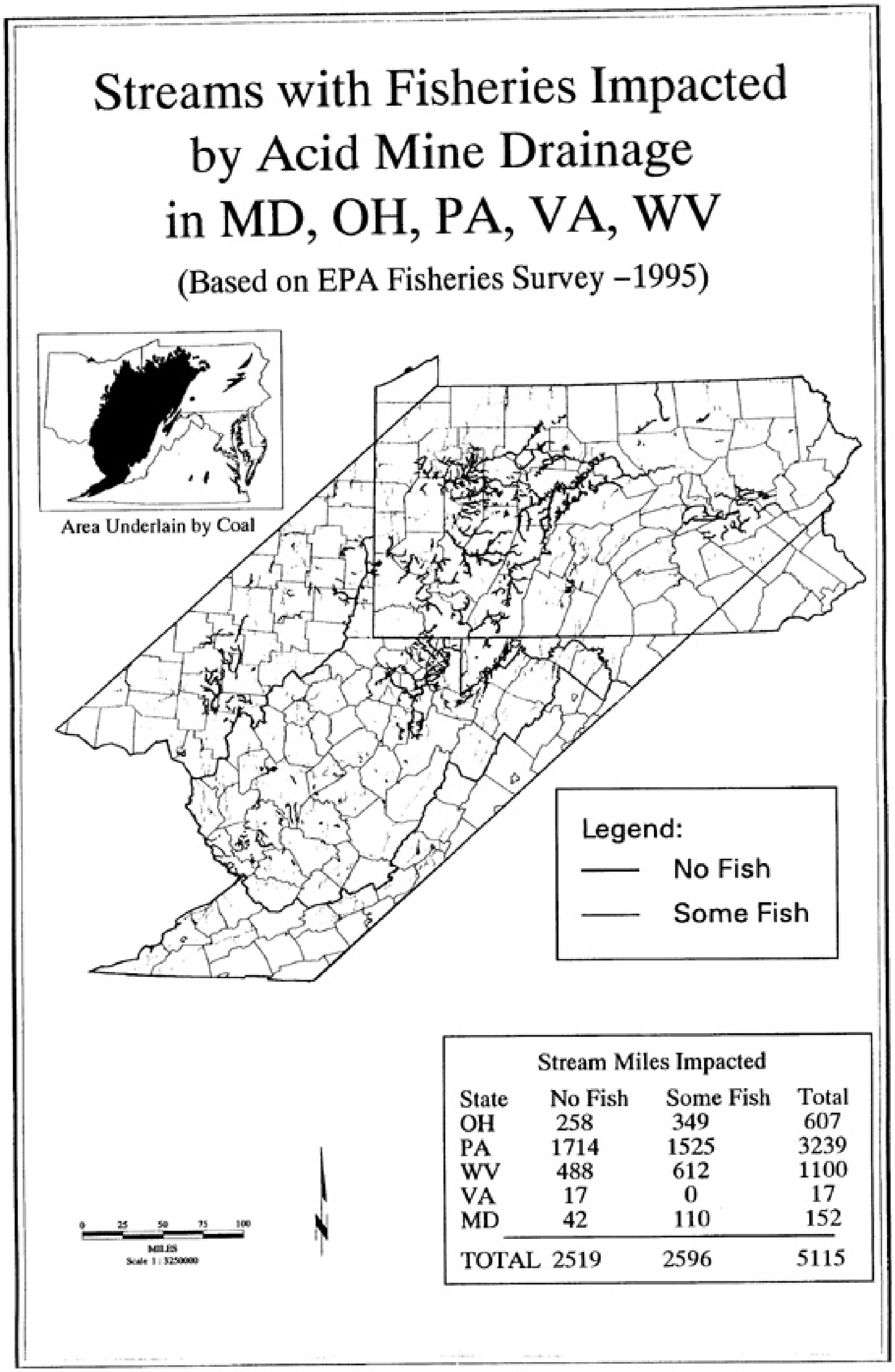
GUYANDOTTE RIVER BASIN

The Guyandotte is also impacted by acid mine drainage in isolated areas. The river is dominantly alkaline, but has endured chronic sediment and suspended solids pollution from extensive mining. Seven bond forfeitures on affected tributaries exhibit a range of mild to intensely acid discharges, but flows are low, with no significant impact to the receiving stream. Where not limitedby areal constraints, backfilling and regrading has been accompanied by the installation of passive technologies. Significant land AML&R reclamation in the watershed has certainly reducedthe metals and acidity concentrations from problem sites.

BIG SANDY / TUG RIVER BASIN

Only one problem bond forfeiture site has been identified in this relatively unaffected watershed. The tributary receiving drainage from this site is influenced by substantial AMI. drainage as well. Other than characterizing the discharge and its effects, no work has been done at this site. Few acidsources exist in this watershed, but isolated acid discharges in Mingo and Logan Counties cause diminution of water quality and diminish fisheries.

Trends are obvious - acid mine drainage affected waters in West Virginia are improving as the result of conscientious active mining and aggressive, innovative work by industry and government sponsored efforts.



State	No Fish	Some Fish	Total
OH	258	349	607
PA	1714	1525	3239
WV	488	612	1100
VA	17	0	17
MD	42	110	152
TOTAL	2519	2596	5115

ACTIVE MINE SITES WITH WATER QUALITY PROBLEMS IN WV

QUALITY OF SOURCES (w/flow >1 gpm):

				SOURCE FLOW							
				1994		**1996**		**1994**		**1996**	
	pH	Fe	Mn	sources	%	sources	%	gpm	%	gpm	%
alkaline drainage	>5.9			219	25%	208	37%	31,918	34%	44,199	50%
weak acid drainage	>5.0			333	38%	263	47%	40,324	43%	49,361	55%

alkaline manganese	>5.9		>2	146	17%	99	18%		16,556	18%	17,482	20%
alkaline iron	>5.9	>3		118	14%	99	18%		24,073	26%	28,098	31%
pH only problem	<6.0	<3	<2	48	6%	34	6%		2,049	2%	4,017	4%
alk-sl. acid w/ iron	>4.9	3-5		39	4%	23	4%		9,570	10%	9,814	11%
alk-sl. acid w/ iron	>4.9	5-10		147	17%	35	6%		16,913	18%	4,845	5%
alk-sl. acid w/ iron	>4 9	> 10		11	1 %	74	13%		4,635	5%	19,776	22%
alk-sl. acid w/ Mn	>4.9		<2	94	11%	126	22%		16,182	17%	27,283	31%
lk-sl. acid w/ Mn	>4.9		2-4	82	9o/o	54	10%		12,598	13%	12,121	14%
alk-sl. acid w/ Mn	>4.9		>4	157	18%	91	16%	~	11,544	12%	10,404	12%
alk-sl. acid w/ Mn	>4.9		>20	2	0%	5	1 %		203	0%	116	0%
discharging:				872		563			93,760		89,269	

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SOURCE OR INFLUENCES ON WQ OF DRAINAGE:

	1994		**1996**			**~ 1994**		**1996**	
	sources	%	sources	%	"	gpm	%	gpm	%
PITWATER	47	5%	48	6%	~	7,237	8%	5,815	7%
SURFACE RUNOFF	207	24%	231	28%	~	29,679	32%	32,280	36%
SEEPAGE	382	44%	385	47%	~	32,349	35%	29,742	33%
REFUSE	205	24%	204	25%	~	34,178	36%	35,226	39%
UNDERGROUND	192	22%	166	20%	~	60,063	64%	63,923	72%
OTHER	86	10%	69	8%	~	5,436	6%	2,206	2%
# OUTLETS TOTAL gpm	872		816		~	93,760		89,325	

Note: WQ at many sources is influenced by more than one category; percentages are based on unique sources and their flow.

TREATMENT STRATEGIES:

	1994		**1996**			**~ 1994**		**1996**	
	sources	%	sources	%	~	gpm	%	gpm	%
CAUSTIC (NaOH)	315	36%	305	37%	~	23,974	26%	27,840	31%
SODA ASH (NaCO3)	222	25%	180	22%	~	5,059	5%	6,945	8%
LIME (exe. CaO)	156	18%	121	15%	~	45,140	48%	26,086	29%
CALCIUM OXIDE (CaO)	51	6%	79	10%	-	1,766	2%	26,205	29%
AMMONIA (NH_3)	124	14%	110	13%	~	15,120	16%	10,877	12%
PASSIVE	26	3%	70	9%	~	432	0%	2,094	2%
OTHER	14	2%	22	3%	~	8,532	9%	8,764	10%
NONE	68	8%	92	11 %	_	951	1 %	1,877	2%
# UNIQUE OUTLETS	872		816		~	93,760		89,325	

Note: Treatment at many sources is influenced by more than one chemical. percentages are based on unique sources and their flow.

LOAD IN TONS PER YEAR and how ameliorated at the 563 sources discharging in 1996:

563 sources		80	65	267	87sources
TOTAL	Total	lime	CaO	caustic	ammonia treatment
gpm	89269	26078	26204	27828	10871gallons per minute
acid load	60646	35975	21604	31284	6579tons per year
iron load	20287	6764	12287	6196	1433tons per year
Mnload	1235	359	434	596	179tons per year

DISTRIBUTION OF OUTLETS BY REGION:

REGION	OFFICE	94 source	94 % total	96 source	SOURCE 96 % total	FLOW - 94 gpm	94 % total	96 gpm	96 % total
1	Fairmont	253	29%	200	25%~	30,945	33%	35,006	39%
2	Philippi	183	21 %	193	24%~	30,624	33%	26,213	29%
3	Oak Hill	270	31 %	230	28%~	8,793	9%	7,411	8%
4	Welch	32	4%	34	4%~	10,070	11 %	9,574	11 %
5	Logan	134	15%	159	19%~	13,328	14%	11,121	12%
Total		872		816	~		93,760	89,325	

ACTIVE MINE SITES WITH WATER QUALITY PROBLEMS IN WV

QUALITY OF SOURCES (w/flow >1 gpm):

				SOURCE				FLOW			
				1994		1996		1994		1996	
	pH	Fe	Mn	sources	%	sources	%	gpm	%	gpm	%
alkaline drainage	>5.9			219	25%	208	37%	31,918	34%	44,199	50%
weak acid drainage	>5.0			333	38%	263	47%	40,324	43%	49,361	55%
alkaline manganese	>5.9		>2	146	17%	99	18%	16,556	18%	17,482	20%
alkaline iron	>5.9	>3		118	14%	99	18%	24,073	26%	28,098	31%
pH only problem	<6.0	<3	<2	48	6%	34	6%	2,049	2%	4,017	4%
alk-sl. acid w/ iron	>4.9	3-5		39	4%	23	4%	9,570	10%	9,814	11%
alk-sl. acid w/ iron	>4.9	5-10		147	17%	35	6%	16,913	18%	4,845	5%
alk-sl. acid w/ iron	>4.9	>10		11	1%	74	13%	4,635	5%	19,776	22%
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	1994		1996		1994		1996	
	sources	%	sources	%	gpm	%	gpm	%
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# OUTLETS, TOTAL gpm	872		816		93,760		89,325	

Note: WQ at many sources is influenced by more than one category; percentages are based on unique sources and their flow.

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	1994		1996		1994		1996	
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NONE	68	8%	92	11%	951	1%	1,877	2%
# UNIQUE OUTLETS	872		816		93,760		89,325	

Note: Treatment at many sources is influenced by more than one chemical. percentages are based on unique sources and their flow.

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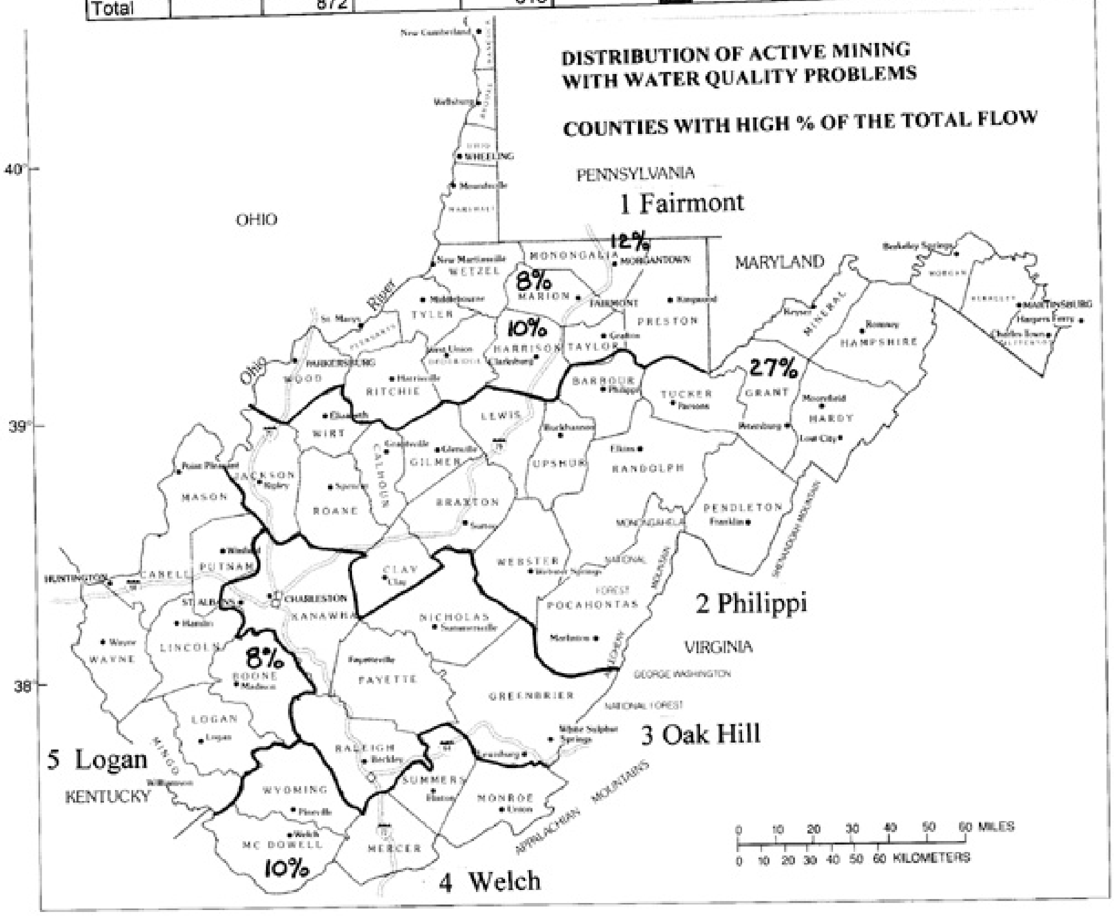
5	Logan	134	15%	159	19%	13,328	14%	11,121	12%
Total		872		816		93,760		89,325	



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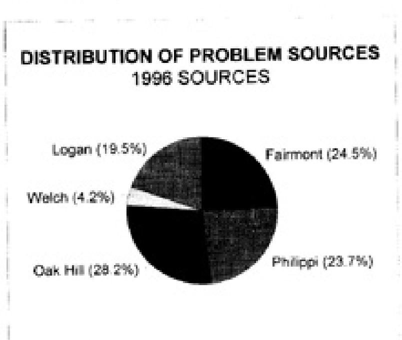

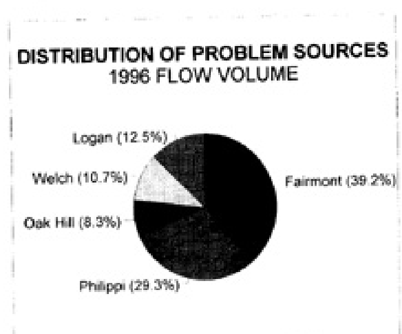

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