TO: Commissioners of the Alabama Surface Mining Commission: Mr. Rene' Williams, Chairman; Mr. John Stevens, Vice-Chairman; Mr. Jack Bergsieker; Mr. Bobby Humphrey; Mr. Richard C. Lopez; Mr. Russell Alan Runyan; and Mr. Steven A. Thomas

Staff members of the Alabama Surface Mining Commission: Dr. Randall C. Johnson, Director; Ann Miles, Executive Secretary; Carla D. Lightsey, Chief - Division of SMCR; and G. Milton McCarthy, Jr., Legal Division milton.mccarthy@asmc.alabama.gov

FROM: Dr. Emily S. Bernhardt, Associate Professor, Department of Biology and the Nicholas School of the Environment, Duke University

Dr. Margaret A. Palmer, Director, National Socio-Environmental Synthesis Center and Professor, Department of Entomology, University of Maryland

Dr. Michael Hendryx, Professor of Applied Health Science, Indiana University

RE: SMCRA Lands Unsuitable for Coal Mining Petition

CC: Nelson Brooke, Black Warrior Riverkeeper

We appreciate this opportunity to share with the Alabama Surface Mining Commission our expertise on the impacts of surface coal mining on water quality and ecological health. We have researched this issue extensively over the last five years, and published numerous papers on the topic. We have also each been involved in multiple court cases as well as briefings of both state agency and U.S. congressional staff. Our work has been concentrated in central Appalachia, but our findings are applicable to any surface coalmines in which coal residues and rock overburden are placed directly within stream channel networks, where coal derived sulfuric acid and soluble metals can be leached into surface waters. We include our professional resumes as an attachment to this letter to provide proof of our expertise.

All of the accumulating body of research on this topic demonstrates that **surface coal mining leads to severe, persistent and far-reaching degradation of water quality and biodiversity.** This conclusion is solidly grounded in the growing literature on this topic and has been demonstrated in our own empirical work and published papers. We provide a brief summary of the most relevant publications as an attachment to this letter along with complete copies of each of those publications for your reference (APPENDIX 1).

The basic problem of surface coal mining is that it leaves behind coal residues mixed with overburden, with all of this mineral material having vastly increased reactive surface areas exposed to air and water. As rainfall percolates through this regarded and filled material it picks up the sulfuric acid, selenium, soluble iron, manganese from the coal and weathers tremendous quantities of buffering ions from the surrounding bed material. While the resulting leachate may not be acidic due to internal buffering, it is saltier and laden with a variety of trace metals that can be harmful for organisms and which entail more extensive treatment to comply with drinking water standards. Because surface mines continue to export these saline, metal rich waters for decades post reclamation (see US EPA 2011, Lindberg et al. 2011, Bernhardt et al. 2012), each new mine contributes more salts and metals on top of the already elevated background concentrations derived from historic mines. The impacts of surface mines thus accumulate in a highly predictable manner as a function of the total extent of surface mines.

Despite our extensive collective experience regarding permit applications in the coalfields of West Virginia and Kentucky, the Shepherd's Bend mine is the first mining permit application that we have seen immediately adjacent to a public drinking water supply. Given the extensive literature linking surface coal mining to a variety of human health problems with enormous associated public health costs (*see attached summary of this literature,* APPENDIX 2) such activity seems particularly ill advised.

We understand that the Surface Mining Commissions recently denied a request to designate a 40,000 acre portion of the Mulberry Fork watershed as "lands unsuitable for coal mining" to protect the drinking water supply for 200,000 residents of Birmingham, Alabama. In their petition, two very important issues are raised (see p. 7)

> *"The first is, despite the extensive coal mining that has occurred in the area both currently and historically, there has never been a comprehensive study of the cumulative impacts of mining on source drinking water in the Mulberry Fork, nor any meaningful consideration of how the operations of two (or even more) additional mines will further contribute to these impacts. Just as importantly, there have never been any scientific studies of how concentrated coal mining along the Mulberry Fork may affect the health of those who live nearby or who rely on this intake for their drinking water."*

We wholeheartedly support these critical points. In the absence of such study, we would urge the commission to consider that recent efforts to complete this type of analysis in the coalfields of Central Appalachia have discovered that the impacts of surface coal mining are far more damaging and far more long-lasting than permit applicants would have one believe.

Having read the May 2013 document in support of this decision, entitled **Inventory of Environmental, Economic and Coal Resources and Data for Evaluation of a Petition to Designate Lands Adjacent to the Mulberry Fork of the Black Warrior River as Unsuitable for Coal Minin** it appears that the commission's decision rests on several key conclusions in the absence of the data necessary to draw those conclusions. Although considerable energy was invested in preparing this report, it does not appear to represent a serious effort to address the important questions being posed which are: <u>How are existing surface mines (both active and reclaimed) altering the water quality at the water intake point?</u> and, <u>How will new mining activity in the contested area further alter water quality?</u> There cannot be any question that these proposed new coalmines will add mining derived pollution to the Mulberry Fork, as that is the inevitable result of rainfall on active and reclaimed coal mines and filled valleys alongside rivers. The question before the commission should be the extent and the impact of that inevitable pollution increase.

We urge you to reconsider and reevaluate the following key statements in light of available evidence.

The authors state on p. 17 *"It can be seen from previous mining in this area as well as the overburden data that the overburden material does not contain acid-or toxic forming material that can lead to water quality problems."* This statement is not attached to any citation or any reference to data, and no reference is made to the acid or toxic forming material of the coal residue itself. In the decision document (Table 2 and figures 1,) it is clear that for multiple locations within the watershed, the <u>average</u> iron, manganese and lead concentrations regularly exceed DWS limits, strong evidence that coal derived pollutants are being generated and making their way into surface waters.

On p.22, the authors state *"Generally pre-mining data will show lower conductivity than during mining data. Specific Conductance is a measure of water's ability to conduct an electrical current. It can be used for approximating the total dissolved solids content of water by testing the capacity to carry an electrical current (U.S. Geological Survey- "Water Science School Glossary of Terms").* ***Post mining water quality trends show a decrease in conductivity over time****."* (emphasis added). No evidence is provided in support of the statement that post mining water quality conductivity declines through time. If true, this conclusion would contradict recent published research on the topic. Because this flies in the face of what has been recently reported (US EPA 2011, Lindberg et al. 2011, Bernhardt et al. 2012) such a statement requires empirical support. No data are shown and no citations are provided in support of this statement.

The same critique can be leveled at the next paragraph on p. 22 where the authors state *"The iron concentrations from surface water sites are generally less than 1.00 mg/l, and mostly under 0.5 mg/l except for two sites on P-3860. The iron concentrations were high prior to, and during mining, however the concentrations have significantly decreased since reclamation activities have been implemented at this mine."* Again, this is inconsistent with recent reports from central Appalachia and requires some empirical proof.

A major point in the decision document is that the number of exceedances for Fe, Mn and SO4 are similar between mined and unmined streams. The study authors declare that the "unmined" stream category included some sites downstream of a reclaimed surface mine. Since it has been shown that mining pollution from surface mines can persist without decline for decades these sites should be eliminated from the comparison. If all the exceedances reported for the unmined watersheds are from sites impacted by reclaimed mines then the analysis is flawed. It is also disingenuous to compare the frequency of exceedances rather than the absolute concentrations of these pollutants of interest.

The reporting of water chemistry analyses from streams within the lands unacceptable for mining (LUM) area are not accompanied by any description of their watersheds and thus it is difficult to draw strong conclusions from these data. It is clear from the NPDES permit reporting that there is significant mining derived pollution entering streams, as the conductivity data reported for these streams (beginning p. 265 of the Inventory document) range between 173-3124 uMhos cm^{-1}, while reference stream locations in the state are typically much lower (95% CI 91 ± 4.5 uMhos cm^{-1})[1]. This sort of comparison between state reference streams and pollutants of concern really ought to be done comprehensively within the Mulberry Fork basin.

In light of these critiques, we would reiterate the petitioners' request for a thorough analysis of existing data. Although a large amount of water quality data is presented in the Inventory document and Decision document the accompanying analysis is incomplete. It would be the work of only a day or two to map the chemical records from EPA and state databases onto the maps of mining for the watershed and to determine the extent to which mining derived pollutants like sulfate, iron, manganese, selenium and mining pollutant indicators such as elevated conductivity and alkalinity are predictable from the extent of upstream mining. Such an analysis would provide the simplest and best tool for evaluating the impact of expanding the mining footprint in the Mulberry Fork river and would be far more useful than the current simple comparisons between mined and unmined watersheds. The absence of such an obvious analysis, which could easily assess the impact of mining in the basin, is troubling. It is clear that the water intake in question (BBWB) is already frequently exceeding standards for both Al and Mn (Table 5, decision document). It is highly likely that the frequency and duration of exceedance will increase with additional mining immediately adjacent to the intake. It is also likely that additional constituents will become problematic, as higher Sulfates and Fe concentrations are likely to occur based on reported data from mined watersheds showing frequent high values of both constituents (Table 6, decision document).

In short, extensive research conducted in the central Appalachians makes it very clear that there are good reasons to be concerned about the water quality implications of surface coalmines. Without similar research and evidence to the contrary, the citizens and managers of Alabama would be prudent to assume that the same trends apply. The limited time and evidence available to us in the preparation of this comment give us no reason to conclude that the coal mines of Alabama are having markedly different impacts than the coal mines of West Virginia or Kentucky.

Submitted respectfully.
Emily S. Bernhardt, Ph.D.,
Michael Hendryx, Ph.D.
Margaret A. Palmer, Ph.D.

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[1] Based on data provided to ESB on Friday, February 14th from Lynn Sisk of the Alabama Department of Environmental Mangement.. Data are accessible through this web portal http://www.waterqualitydata.us/

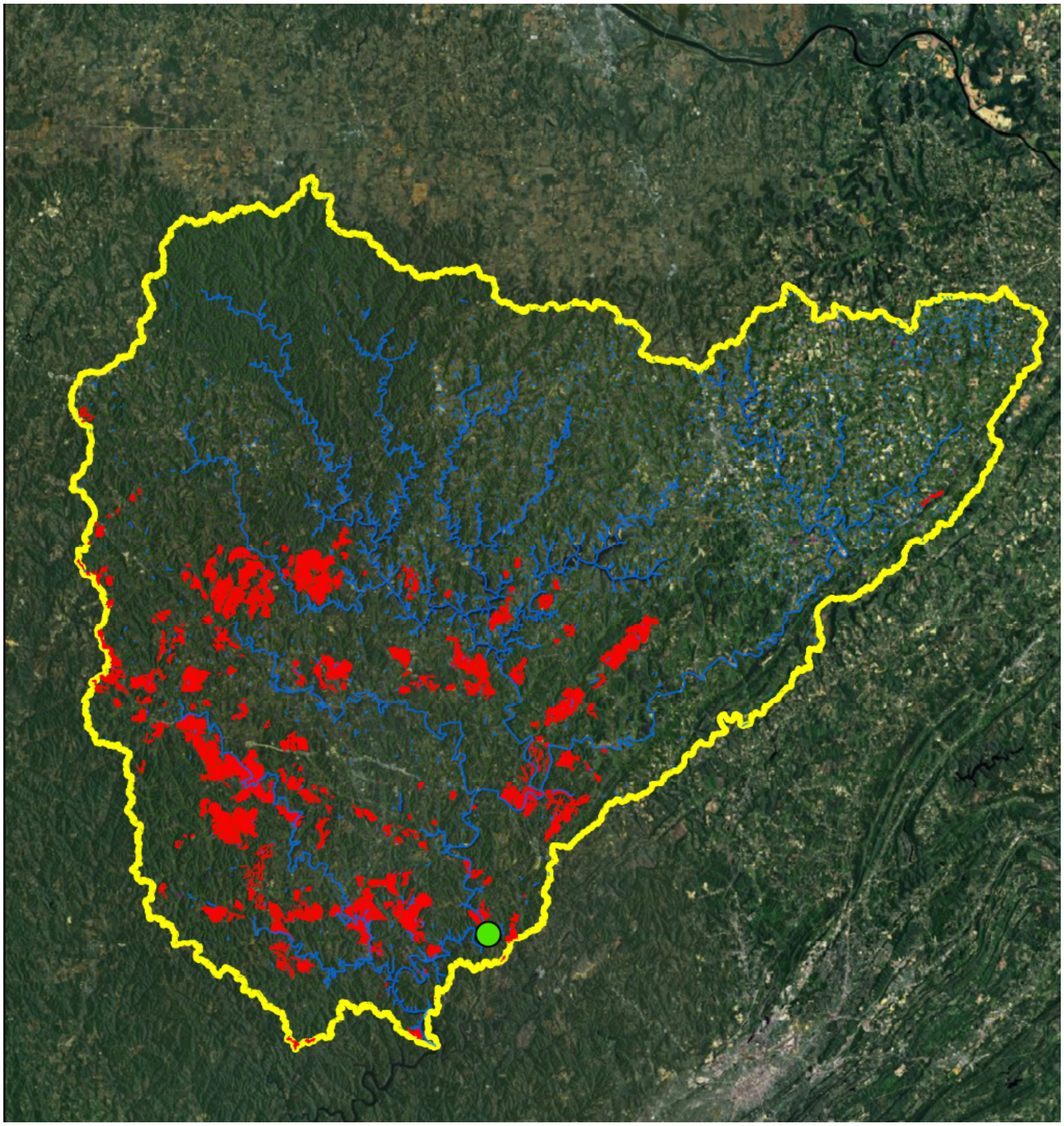

Figure 1 A map of the Mulberry Fork watershed (delineated in yellow) showing the stream network (in blue) and permitted surface mines (in red). The water intake station in question is indicated by the green dot. We estimate the area of the watershed to be 2369 mi^2 with mine permits encompassing 113 mi^2 (or ~5%) of the watershed area. Permit maps were obtained directly from the Alabama Surface Mining Commission (http://www.surface-mining.state.al.us/page3.html). Watershed boundaries and stream maps were obtained from the National Hydrography Database.

Attachment 1: A summary of recent research on surface coal mining impacts on surface water quality and biota

Literature Synthesis:

- The first comprehensive report on the effects of surface coal mining together with stream filling was the UE EPA's 2005 Environmental Impact Statement. Despite limited prior research on the topic, US EPA and USGS researchers clearly documented higher conductivity and sulfate concentrations in streamwaters directly downstream of mountaintop mines. The report found as well that streams with high conductivity and high sulfate concentrations almost never supported sensitive stream macroinvertebrates and that there was a consistent negative relationship between conductivity and a variety of commonly used biological indicators of water quality.

- *(Palmer et al. 2010 Science)* Our analysis of state records found that WV streams with high sulfate concentrations were also many times more likely to have high concentrations of a variety of trace elements including selenium, a contaminant with significant biological toxicity. In previous reports (especially the 2005 Environmental Impact Statement) sulfate concentrations above 50 mg L^{-1} were acknowledged to result from coal mining, so in this study we used sulfate as a proxy for mining impacts. This short review paper also highlighted new and important research documenting significant public health problems in surface coal mining counties in the region (see list of papers on this topic below).

- The weight of evidence documenting the harmful effects of surface coal mining on surface waters has accumulated through time with increased ability to map and monitor surface mining impacts and monitoring of stream water quality and biota. *In 2011*, we prepared a comprehensive literature review paper on the subject of the effect of mountaintop mining on aquatic ecosystems of the Central Appalachians (Bernhardt and Palmer 2011). We concluded that paper as follows:

  "In summary, the environmental impacts of MTVFs in the Central Appalachians are severe, large scale, and long lasting. In addition to the permanent burial and loss of headwater streams directly impacted by mining, many additional river miles are being degraded by the cumulative impacts of altered flows and increased pollutant from both past and present mining activities in the region. Whether or not individual component ions within mining-derived runoff reach streamwater concentrations that are individually lethal or toxic to aquatic life, the cumulative effect of elevated concentrations of multiple contaminants is clearly associated with a substantial reduction in water quality and biological integrity in streams and rivers below mine sites. All research to date indicates that conductivity is a robust measure of the cumulative or additive impacts of the elevated concentrations of multiple chemical stressors from mine sites that lead to biological impairment of streams. Each constituent pollutant increases conductivity and they may have additive or multiplicative ecological impacts. To

date, mitigation practices and restoration efforts have not been effective in ameliorating water pollution from MTVF sites. Furthermore, efforts to reclaim vegetation and restore the full diversity of plant species in mined watersheds have not proved successful to date."

- Later that same year, the USEPA published a comprehensive report on the environmental impacts of surface mining (US EPA 2011). Their report relied on both published literature and analysis of government agency datasets. Their conclusions mirrored our own. The major conclusions of the report are summarized below:
    - **Section 8.2.1 Loss of Headwater Resources**– more than 1900km of mid-Appalachian streams has been lost through burial
    - **Section 8.2.2 Impacts on Water Quality**- Effluent waters below valley fills were often alkaline and high in conductivity due to high concentrations of SO42−, HCO3−, Ca2+, and Mg^{2+}. Selenium and iron concentrations were elevated below mines, with more than half of surveyed sites exceeding the chronic AWQC for selenium.
    - **Section 8.2.3 Toxicity Impacts on Aquatic Organisms -** Se concentrations reported from waters in the study area were high enough to warrant concern. Other toxicants were also high enough to warrant further investigation. Fe and Mn deposits have been observed on macroinvertebrates. Ni and Zn concentrations in sediments are higher than empirical screening level values.
    - **Section 8.2.4 Impacts on Aquatic Ecosystems**– all surveys reported degraded biological conditions downstream of surface coal mines, with both fish and macroinvertebrate communities being affected.
    - **Section 8.2.5 Cumulative Impacts of Multiple Mining Operations**– the EPA concluded that there had been too little work on cumulative impacts, but cited a paper by Johnson et al. (2010) which found that conductivity in large streams could be accurately predicted by the conductivity of tributaries – suggesting that conductivity levels accumulate in concert with an increasing proportion of mining.
    - **Section 8.2.6 Effectiveness of Mining Reclamation and Mitigation Efforts** The results of the water quality studies indicate that reclamation efforts partially controlled the amount of soil erosion and fine sediments transported downstream. However, there is no evidence that reclamation efforts altered or reduced the ions or toxic chemicals downstream of valley fills. Ion concentrations have either remained constant or increased over time.

- (Lindberg et al. 2011 Proceedings of the National Academy of Sciences)
  Since 2010, Bernhardt together with a team of researchers from Duke University has been intensively monitoring water quality in the Mud River as if flows upstream of and then through the Hobet Mine complex. We find that while conductivity is consistent with state reference streams and Se concentrations are below detection upstream of the mine, the first mining impacted tributary raises the

conductivity of the Mud River above 500 µS and Se concentrations frequently exceed the toxicity threshold of 5 µg/L below this confluence. By the time the 8th mining impacted tributary enters the Mud River at the downstream end of the Hobet mine complex, conductivity is always >1000 uS and Se concentrations are 2-4X the toxicity threshold. Several of the tributaries to the Mud River are actively mined, and, contrary to suggestions that mining practices have significantly improved, we find through monthly sampling of these tributaries that they always have Se concentrations > 5 µg L^{-1} and conductivity >500µS. As a result the amount of surface mining (both past and present) within the watershed explains nearly all of the increase in streamwater conductivity, sulfate, selenium and a host of trace elements concentrations as you move downstream in the Mud River.

- *(Bernhardt et al. 2012* Environmental Science and Technology reports our first estimate of the cumulative impacts of surface coal mining on freshwaters throughout heavily mined southern West Virginia. Using detailed maps of surface mining activity throughout southern WV since the mid 1970's together with location-specific water quality and biological data from the WVDEP, Bernhardt and colleagues found that the amount of mining in a streams watershed was the single best predictor of surface water conductivity, sulfate concentrations, calcium concentrations and magnesium concentrations. This variation in stream conductivity or underlying ion concentrations explains nearly half of the observed variation in the number of sensitive species of stream insects found across WV streams. Generalized additive models were used to estimate the amount of watershed mining, stream ionic strength, or sulfate concentrations beyond which biological impairment (based on state biocriteria) is likely. We fi nd this threshold is reached once surface coal mines occupy >5.4% of their contributing watershed area, ionic strength exceeds 308 **µ** S cm−1 , or sulfate concentrations exceed 50 mg L−1 . Signifi cant losses of many intolerant macroinvertebrate taxa occur when as little as 2.2% of contributing catchments are mined.

References Cited (all are attached for your reference):

Bernhardt, E. S., B. D. Lutz, R. S. King. C. A. Carter, J. P. Fay, D. Campagna, J. Amos. 2012. How many mountains can we mine? In review. Examining the cumulative impact of surface mining on freshwater ecosystems of the Central Appalachians. Environmental Science and Technology

Lindberg. T.T., E.S. Bernhardt, R. Bier, A. Helton, R. Merola, A.Vengosh, R.T. Di Giulio. 2011. Cumulative impacts of mountaintop mining on an Appalachian watershed. Proceedings of the National Academy of Sciences.

Bernhardt, E.S. and M.A. Palmer. 2011. Impacts of mountaintop mining and valley fill operations on aquatic ecosystems of the central Appalachians. Annual Review of Conservation and the Environment. Annals of the New York Academy of Sciences. 1223: 39-57.

Palmer, M.A., E.S. Bernhardt, W.H. Schlesinger, K.N. Eshleman, E. Foufoula-Georgiou, M.S. Hendryx, A.D. Lemly, G.E. Likens, O.L. Loucks, M.E. Power, P.S. White, and P.R. Wilcock. 2010. Environmental and Human Health Consequences of Mountaintop Removal Mining. Science 327:148-149.

U.S. EPA. 2005. Mountaintop Mining / Valley Fills in Appalachia. Final Programmatic Environmental Impact Statement.. EPA 9-03-R-05002.

U.S. EPA. The Effects of Mountaintop Mines and Valley Fills on Aquatic Ecosystems of the Central Appalachian Coalfields (2011 Final). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-09/138F, 2011.

Attachment 2: **Summaries of articles showing public health consequences of Appalachian coal mining**
(As of March 2013)
Prepared by Michael Hendryx, PhD

Executive Summary

Coal mining in Appalachia, especially in mountaintop mining areas of West Virginia and other central Appalachia areas, is associated with a set of serious public health problems, including:

- Higher cancer rates
- Higher heart and lung disease rates
- Higher kidney disease rates
- Higher rates of birth defects
- Higher levels of impaired functioning due to health problems

Data also show that the economic costs of health problems in Appalachian coal mining areas are more than 5 times greater than the economic benefits from mining.

These health problems are partly due to disadvantages in mining areas such as poverty and smoking. However, the pattern of results shows that:

- Health problems are present after statistical adjustment for age, smoking, obesity, poverty, education, availability of doctors, and other risks
- Health problems are most severe in areas where amounts of mining are greatest
- Health problems in mountaintop mining areas are worsening in more recent years versus earlier years
- Health problems are present for men, women and children and reflect more than occupational exposure.

Dust collected from residential areas near mountaintop mining has been analyzed in the lab. The dust contains primarily silica, sulfur, and organic carbon, with small amounts of aluminum, iron, and many other trace elements. This evidence indicates that the elevated dust originates from the surface mining sites. Laboratory animals that inhale MTM dust show impaired vascular function.

Most recently, environmental data from mountaintop mining communities show evidence that air and water quality are impaired in mining communities; and that the specific forms of impairment are consistent with mountaintop mining activity (e.g. dust in communities contains high levels of silica that seem to result from overburden removal.) Dust collected from mountaintop mining communities has been shown to be toxic to animal tissues. These studies have not yet been published but are going through the peer-review process.

Studies that directly measure environmental exposures for individual persons with biological impacts for those same persons have not yet been conducted. However, the overall pattern of results from this research, and from research conducted by other scientists, strongly suggests that mountaintop mining is destructive of local environments in ways that impair human health.

Summaries of research studies showing public health consequences of Appalachian coal mining
(As of March 2013)

1) Hospitalization Patterns Associated with Appalachian Coal Mining
In this study, researchers explored the relationship between quantity of coal mined in counties and hospitalizations for "coal exposure sensitive" ailments (those linked with coal mining in previous research) and "coal exposure insensitive" ailments (those that had not been shown to be associated with coal mining). After controlling for other risk-factors they found that hospitalization for Chronic Pulmonary Obstructive Disease (COPD) and high blood pressure, both coal exposure sensitive conditions, were linked with quantity of coal mined. The odds for a COPD hospitalization increased 1% for each 1462 tons of coal mined, and the odds for a high blood pressure hospitalization increased 1% for each 1873 tons of coal mined.

2) Relations between Health Indicators and Residential Proximity to Coal Mining in West Virginia
In this large survey study of West Virginia residents, researchers examined the relationship between amounts of coal mined in an area, levels of self-reported health, and rates of chronic disease conditions for residents. High levels of coal production were found to be associated with worse health status and with higher rates of cardiopulmonary disease, chronic obstructive pulmonary disease, high blood pressure, lung disease, and kidney disease.

3) Mortality Rates in Appalachian Coal Mining Counties: 24 Years behind the Nation
Appalachia has higher rates of death than the rest of the country, and this study investigated whether this trend was linked with the high rates of coal mining in this region. It found that coal mining areas do indeed have higher mortality rates than both other Appalachian counties and the rest of the country. The association between coal mining and higher mortality rates remained even after controlling for other risk factors such as smoking, poverty, education, rural-urban setting, and race/ethnicity. Mortality rates present currently in mining counties lag 24 years behind the rates found in non-mining counties.

4) Lung Cancer Mortality is Elevated in Coal-Mining Areas of Appalachia
Researchers in this study examined nationwide data to test whether living in coal-mining areas of Appalachia contributed to the higher rates of lung cancer deaths observed in Appalachia relative to the rest of the nation. Results show that lung cancer death rates for the years 2000—2004 are indeed higher in areas of heavy Appalachian coal mining even after controlling for smoking, poverty, education, age, sex, race and other risk factors. Higher mortality may be partly the result of exposure to environmental pollution associated with the coal-mining industry.

5) Mortality from Heart, Respiratory, and Kidney Disease in Coal Mining Areas of Appalachia

This study compared the mortality rates from heart, respiratory, and kidney disease in four groups of counties: Appalachian counties with more than 4 million tons of coal mined from 2000 to 2004; Appalachian counties with mining at less than 4 million tons; non-Appalachian counties with coal mining; and other non-coal mining counties across the nation. For both males and females, mortality rates in Appalachian counties with the highest level of coal mining were significantly higher relative to non-mining areas for chronic heart, respiratory and kidney disease, but were not higher for acute forms of illness.

6) Mortality in Appalachian Coal Mining Regions: the Value of Statistical Life Lost

Value of statistical life (VSL) is an estimate of the monetary value that society places on an abstract (or statistical) human life. VSL estimates are used to help decide how to allocate limited resources in order to maximize benefit to society, and are usually derived from studies on how much people are willing to pay to avoid risks to their life and health. This study found that, after other risk factors were controlled for, 2,347 to 2,889 yearly excess deaths are associated with living in an area in Appalachia with coal mining. Corresponding VSL estimates (which ranged from to $10.923 to $13.492 billion) exceeded the economic contributions of the coal mining industry. When the data was analyzed without controlling for other risk factors these numbers were much higher (8,840- 10,923 excess deaths, translating to VSL estimates of $41.283 to $51.010 billion.) The best point estimate for the mortality cost of Appalachian coal mining was $42 billion, while the benefits of coal mining for Appalachia totaled only $8 billion.

7) Higher Coronary Heart Disease and Heart Attack Morbidity in Appalachian Coal Mining Regions

This study tested whether self-reported cardiovascular disease rates were higher in Appalachian coal mining counties compared to other Appalachian counties and counties outside Appalachia with and without coal mining. Reported rates of cardiovascular disease, angina or coronary heart disease and heart attack were found to be significantly higher in Appalachian coal mining counties than in other counties. This trend was present among both men and women and held true even when other relevant risk factors, such as age and smoking rates, were controlled for. Cardiovascular diseases have been linked to both air and water contamination in ways consistent with toxicants found in coal and coal processing.

8) A Geographical Information System-Based Analysis of Cancer Mortality and Population Exposure to Coal Mining Activities in West Virginia, United States of America

This study used Geographical Information Systems (GIS) techniques to determine whether there is a link between how close people live to coal mining activities and cancer mortality rates. The results obtained from these techniques were contrasted with those from earlier similar studies examining the relationship between tons of coal mined per county and county cancer mortality rates. The GIS techniques yielded a stronger association between coal mining and cancer death rates, even after controlling for smoking and age, suggesting that where people live in proximity to mining, not just the county they live in, contributes to cancer mortality.

9) Mountaintop Mining Consequences
This article, published in *Science*, discusses and summarizes the growing scientific evidence for the negative impacts of mountaintop mining with valley fill (MTM/VF). In this practice, upper elevation forests are cleared and stripped of topsoil, and explosives are used to break up rocks to get at buried coal. Extra rock is pushed into neighboring valleys, where it buries existing streams. Analyses of current studies and new water-quality data from West Virginia streams reveal that MTM/VF causes serious damage to the environment that cannot be repaired. Published studies also suggest strongly that human health is being negatively affected by such activities.

10) Residence in Coal-Mining Areas and Low Birth-Weight Outcomes
This study investigated whether mothers living in coal-mining areas were at greater risk for giving birth to babies with low birth-weights. After adjusting for other factors that influence birth-weight, there was a 16% higher risk of a low birth weight infant in areas with high mining levels, and a 14% higher risk in areas with lower mining levels, as compared to areas with no mining.

11) A Comparative Analysis of Health-Related Quality of Life for Residents of U.S. Counties with and without Coal Mining
This study compared health-related quality of life (HRQOL) in mining and non-mining counties in and out of Appalachia. Residents of coal-mining counties reported significantly fewer healthy days for both physical and mental health and poorer self-rated health, as compared to U.S. non-mining counties, but disparities were greatest for people living in Appalachian coal mining areas.

12) Learning Outcomes among Students in Relation to West Virginia Coal Mining: an Environmental "Riskscape" Approach
To evaluate the impact of coal mining environment on the cognitive development of West Virginia children, this study examined pass rates on standardized school performance tests in counties in West Virginia with and without coal mining. Pass rates for children in schools in coal-mining counties versus non-coal mining counties were significantly lower in all subject areas. Lower pass rates were partly related to socioeconomic disadvantage, but remained significantly lower after controlling for county high school education rates, percent of low-income students, percent of highly qualified teachers, number of students tested, and county smoking rates.

13) Ecological Integrity Streams Related to Human Cancer Mortality Rates
Ecological integrity refers to a balanced community of organisms with healthy composition, diversity, and functional organization. This study explored the relationship between the ecological integrity of streams and human health. It found that lower ecological integrity corresponded with higher overall rates of human cancer death and higher mortality rates from digestive, respiratory, urinary, and breast cancer. Coal mining was also linked with higher cancer mortality and low levels of environmental integrity.

14) Full Cost Accounting for the Life Cycle of Coal
This paper examines and summarizes the enormous body of research and information on the harmful impact that the stages of the life-cycle of coal- extraction, transport, processing, and combustion- have on health and the environment. It also considers the costs of such damages, which are assumed by the U.S. public rather than coal companies and amount to a third to over one-half of a trillion dollars annually. Accounting for the damages conservatively doubles to triples the price of electricity from coal per kWh generated, making wind, solar, and other forms of non-fossil fuel power generation, along with investments in efficiency and electricity conservation methods, economically competitive.

15) Health-Related Quality of Life among Central Appalachian Residents in Mountaintop Mining Counties
Researchers in this study evaluated the health-related quality of life of residents in mountaintop mining counties of Appalachia relative to residents of counties with other types of mining and with no mining. People living in mountaintop mining counties reported significantly more days of activity limitation (e.g. work loss days), poor physical and mental health, and poor self-rated health compared to residents of the other two types of counties. Results were similar among males and females and among people of different ages. On average people in mountaintop mining areas experience four extra years of poor lifetime health compared to non-mining residents.

16) Poverty and Mortality Disparities in Central Appalachia: Mountaintop Mining and Environmental Justice
This study investigated whether people in mountaintop coal mining areas in Appalachia experience greater rates of death and poverty as compared to inhabitants of other mining areas or non-mining areas. The answer was yes: mountaintop mining areas had significantly higher mortality rates, total poverty rates, and child poverty rates every year (2000-2007) in comparison with other counties in the same states. For example, the child poverty rate in 2007 was about 35% in mountaintop mining areas compared to 21% in non-mining areas.

17) Chronic Cardiovascular Disease Mortality in Mountaintop Mining Areas of Central Appalachian States
This study looked at whether chronic cardiovascular disease (CVD) death rates are higher among people living in mountaintop mining (MTM) areas than among those in mining and non-mining areas, and whether there is a relationship between rates of MTM surface mining and CVD death levels. CVD mortality rates in MTM areas were found to be significantly higher than those of other areas, and the greater the amount of surface mining in an area, the higher the CVD death rates.

18) The Association between Mountaintop Mining and Birth Defects among Live Births in Central Appalachia, 1996–2003
In this study birth defect rates in mountaintop coal mining areas in central Appalachia were examined and compared to rates of birth defects in other coal mining areas and in non-mining areas of central Appalachia. After controlling for relevant risk factors there

were 26% more birth defects in communities with mountaintop mining, as compared to non-mining communities. In earlier years (1996-1999) the increased risk was 13% higher, and grew more pronounced in recent years (2000-2003) to 42% higher. The mountaintop mining effect was most pronounced for defects of the cardiovascular and respiratory system, where the rate in more recent years was 181% higher than in non-mining areas.

19) Self-Reported Cancer Rates in Two Rural Areas of West Virginia with and without Mountaintop Coal Mining
Researchers in this study conducted door-to-door health interviews in one rural mountaintop mining area and in one rural non-mining area of West Virginia in order to compare cancer rates in the two communities. Self-reported cancer rates were two times higher in the mining versus the non-mining area after controlling for respondent age, sex, smoking, occupational history, and family cancer history, indicating that mountaintop mining is linked to increased community cancer risk.

20) Cancer Mortality Rates in Appalachian Mountaintop Mining Areas.
Researchers examined the association between cancer mortality rates in three types of counties in central Appalachia: those with mountaintop coal mining (MTM), those with other surface or underground mining, or those with no coal mining. County-level analyses examined the association between age-adjusted cancer mortality rates and MTM mining for two periods of time: 1999-2002 and 2003-2007. County-level covariates included smoking, health care access, adult obesity, poverty, and education. Mortality rates for leukemia and for lung, colon, and bladder cancer in MTM counties were significantly greater than those in non-mining areas in 2003-2007 (lung cancer mortality rates were also significantly greater than non-mining areas in 1999-2002). Kidney cancer mortality rates in MTM areas were marginally significantly greater ($p < .06$) than those in non-mining counties in 2003-2007. In conclusion, mortality rates from lung, colon, bladder, and kidney cancer and leukemia are significantly associated with MTM mining areas (vs. non-mining counties) in 2003-2007. Results may indicate either that exposures to water and air pollutants from MTM activity have accumulated, or that contamination in MTM counties may have worsened in more recent years in conjunction with increases in the extent of this activity.

21) Adult tooth loss for residents of US coal mining and Appalachian counties.
The authors compared rates of tooth loss between adult residents of Appalachian coal mining areas and other areas of the nation after control for covariate risks. Residents of Appalachian coal mining counties showed significantly elevated odds for any tooth loss, and for greater tooth loss measured by a 4-level tooth-loss severity scale. Greater risk of tooth loss among adult residents of Appalachian coal mining areas is present and is not explained by differences in reported receipt of dental care, fluoridation rates, supply of dentists or other behavioral or socioeconomic risks. Possible contributing factors include mining-specific disparities related to access, behavior or environmental exposures.

22) Public Drinking Water Violations in Mountaintop Coal Mining Areas of West Virginia, USA

Researchers analyzed the U.S. Environmental Protection Agency's Safe Drinking Water Information System to examine the number and type of public water treatment violations in West Virginia for the years 2001–2009. Violations were compared between three groups of water treatment facilities: those in counties with mountaintop coal mining (n = 161 facilities), coal mining other than mountaintop mining (n = 184 facilities), and with no coal mining (n = 137 facilities). Adjusting statistically for system size and water source, there were 73.0 violations per system in MTM areas, 16.7 violations per system in other mining areas, and 10.2 violations per system in non-mining areas. Excess violations in MTM counties were most often related to failure to conduct required sampling for organic compounds. Complete sampling and reporting of public drinking water quality in MTM areas is needed.

23) Air pollution particulate matter collected from an Appalachian mountaintop mining site induces microvascular dysfunction

Samples of ambient dust were collected from outside residential areas near mountaintop mining. The dust was analyzed for composition and used in a laboratory animal study. The dust consisted largely of sulfur (38% by weight) and silicon (24%). Rats received a dose of 300 µg of dust into their respiratory systems. The dust impaired normal microvascular function; such impairment is known to be a risk in the development of cardiovascular disease.

24) Personal and family health in rural areas of Kentucky with and without mountaintop coal mining

A community-based participatory research study was implemented to collect information from residents on health conditions and symptoms for themselves and other household members in a rural mountaintop mining area compared to a rural non-mining area of eastern Kentucky. A door-to-door health interview collected data from 952 adults. Adjusting for covariates, significantly poorer health conditions were observed in the mountaintop mining community on: self-rated health status, illness symptoms across multiple organ systems, lifetime and current asthma, COPD, and hypertension. Respondents in mountaintop mining communities were also significantly more likely to report that household members had experienced serious illness, or had died from cancer in the past five years.

<u>List of peer-reviewed studies showing public health problems in Appalachian coal mining areas, as of August 2012, in chronological order:</u>

1. Hendryx M, Ahern M, Nurkiewicz T. Hospitalization patterns associated with Appalachian coal mining. *Journal of Toxicology and Environmental Health Part A,* 2007, 70, 2064-2070.
2. Hendryx M, Ahern M. Relations between health indicators and residential proximity to coal mining in West Virginia. *American Journal of Public Health*, 2008, 98, 669-671.
3. Hendryx M. Mortality rates in Appalachian coal mining counties: 24 years behind the nation. *Environmental Justice*, 2008, 1, 5-11.

4. Hendryx M, O'Donnell K, Horn K. Lung cancer mortality is elevated in coal mining areas of Appalachia. *Lung Cancer*, 2008, 62, 1-7.

5. Hendryx M. Mortality from heart, respiratory and kidney disease in coal mining areas of Appalachia. *International Archives of Occupational and Environmental Health*, 2009, 82, 243-249.

6. Hendryx M, Ahern M. Mortality in Appalachian coal mining regions: the value of statistical life lost. *Public Health Reports*, 2009, 124, 541-550.

7. Hendryx M, Zullig K. Higher coronary heart disease and heart attack morbidity in Appalachian coal mining regions. *Preventive Medicine*, 2009, 49, 355-359.

8. Hendryx M, Fedorko E, Anesetti-Rothermel A. A geographical information system-based analysis of cancer mortality and population exposure to coal mining activities in West Virginia, United States of America. *Geospatial Health*, 2010, 4, 243-256.

9. Palmer MA, Bernhardt ES, Schlesinger WH, Eshleman KN, Foufoula-Georgiou E, Hendryx MS, Lemly AD, Likens GE, Loucks OL, Power ME, White PS, Wilcock PR. Consequences of mountaintop mining. *Science*, 2010, 327, 148-149.

10. Ahern M, Mullett M, MacKay K, Hamilton C. Residence in coal-mining areas and low-birth-weight outcomes. *Maternal and Child Health Journal*, 2010, epub ahead of print.

11. Zullig KJ, Hendryx M. A comparative analysis of health-related quality of life (HRQOL) for residents of US counties with and without coal mining. *Public Health Reports*, 2010, 125, 548-555.

12. Cain L, Hendryx M. Learning outcomes among students in relation to West Virginia coal mining: an environmental "riskscape" approach. *Environmental Justice*, 2010, 3, 71-77.

13. Hitt NP, Hendryx M. Ecological integrity of streams related to human cancer mortality rates. *EcoHealth*, 2010, 7, 91-104.

14. Epstein PR, Buonocore JJ, Eckerle K, Hendryx M, Stout BM, Heinberg R, Clapp RW, May B, Reinhart NL, Ahern MM, Doshi SK, Glustrom L. Full cost accounting for the life cycle of coal. *Annals of the New York Academy of Sciences,* 2011, 1219, 73-98.

15. Zullig K, Hendryx M. Health-related quality of life among central Appalachian residents in mountaintop mining counties. *American Journal of Public Health*, 2011, 101, 848-853.

16. Hendryx M. Poverty and mortality disparities in central Appalachia: mountaintop mining and environmental justice. *Journal of Health Disparities Research and Practice*, 2011, 4(3), 50-59.

17. Ahern M, Hendryx M, Conley J, Fedorko E, Ducatman A, Zullig K. The association between mountaintop mining and birth defects among live births in Central Appalachia, 1996-2003. *Environmental Research*, 2011, 111, 838-846.

18. Esch L, Hendryx M. Chronic cardiovascular disease mortality in mountaintop mining areas of central Appalachian states. *Journal of Rural Health*, 2011, 27, 350-357.

19. Hendryx M, Wolfe L, Luo J, Webb, B. Self-reported cancer rates in two rural areas of West Virginia with and without mountaintop coal mining. *Journal of Community Health*, 2012, 37, 320-327.

20. Ahern M, Hendryx M. Cancer mortality rates in Appalachian mountaintop mining areas. *Journal of Occupational and Environmental Science*, 2012, 1(2), 63-70.

21. Hendryx M, Ducatman AM, Zullig KJ, Ahern MM, Crout R. Adult tooth loss for residents of US coal mining and Appalachian counties. *Community Dentistry and Oral Epidemiology*, 2012, 40, 488-497..

22. Hendryx M, Fulk F, McGinley A. Public drinking water violations in mountaintop coal mining areas of West Virginia, USA. *Water Quality, Exposure and Health*, 2012, 4, 169-175.

23. Knuckles TL, Stapleton PA, Minarchick VC, Esch L, McCawley M, Hendryx M, Nurkiewicz TR. Air pollution particulate matter collected from an Appalachian mountaintop mining site induces microvascular dysfunction. *Microcirculation*, in press.

24. Hendryx M. Personal and family health in rural areas of Kentucky with and without mountaintop coal mining. *Journal of Rural Health*, in press.