A White Paper on Environmental Damage from Coal Combustion Waste:
The Cost of Poisoned Fish and Wildlife

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Summary

This paper reports the monetary cost of ecological damage from coal combustion waste (CCW) at 22 sites. Five of these cases resulted from structural failure of disposal ponds, two were caused by unpermitted discharge of ash pond effluent, two occurred at unregulated impoundments, and twelve, which includes the most costly cases, happened because of legally permitted releases allowed by the National Pollutant Discharge Elimination System (NPDES). Only one case, which was a landfill, resulted from exceedance of specified contaminant limits of an NPDES permit. The sites range from locations where historical poisoning has led to corrective actions that have greatly improved environmental conditions to those where contamination has just recently been discovered and the level of ecological damage has yet to be determined. The total cost of poisoned fish and wildlife at the surface impoundment sites is $2.31 billion (2010 dollars). This is enough money to construct 155 landfills with state-of-the-art composite liners and leachate collection systems. Evidence revealed through this study indicates that: (1) For the past 43 years, environmental damage has been a recurring theme with surface impoundment of CCW, (2) The NPDES, which was created as part of the federal Clean Water Act in 1972, has not been effective in preventing serious environmental damage from coal combustion waste, (3) EPA’s Regulatory Impact Analysis of the benefits of pollution control afforded by a RCRA Subtitle C hazardous waste designation for CCW fails to include benefits of avoided damages to natural resources, specifically, poisoned fish and wildlife, (4) Surface impoundments pose unacceptably high ecological risks regardless of location or design, and (5) Use of constructed wetlands to treat FGD wastewater may be the start of a new chapter in the CCW pollution story. Regulators should no longer ignore rigorous science and the lessons learned from multiple case examples. EPA and the United States need to show leadership on this issue by prohibiting surface impoundments, particularly since the rise in coal use in developing countries is leading to the same CCW pollution problems on a global scale.

Introduction

There has been a long history of environmental damage caused by surface impoundment of coal combustion waste (CCW). The first widely recognized case, which has become a landmark example of the ecological hazard of CCW, was the catastrophic toxic event at Belews Lake, NC, beginning in 1976. Since that time, fish and wildlife have been poisoned at numerous other locations due to pollutants leached from surface impounded CCW. A substantial amount of information useful for evaluating environmental risks and impacts of wet disposal practices has been gained. EPA has recognized some of the ecological impacts in its 2007 damage case assessment (1). However, there is also a wide range of negative economic impacts associated with ecological effects. Until now, those costs have not been tabulated. It is important for EPA
to understand the full economic and environmental implications of continued use of surface disposal in the context of its proposed regulations for CCW (2). This report summarizes the ecotoxicology of scientifically documented cases and applies principles of natural resource damage assessment (3, 4) to estimate the economic losses associated with contaminated and poisoned fish and wildlife (in 2010 dollars). This procedure includes the following value components:

Ecological – value to a healthy, self-sustaining ecosystem that supports a diverse fish and wildlife community; direct value of contaminated or lost fish and wildlife on population and community integrity

Recreational – value to sport fishing and hunting (loss of recreation, lost expenditures for gas, food, bait, tackle, ammunition, licenses, and guides), boating, swimming, and other leisure activities; avoidance of recreational activities due to health and safety issues from pollution

Real Estate – depreciated value due to stigma of environmental pollution

Aesthetic – intrinsic scenic and posterity value to non-sportsmen/recreators

Human Health – value of unconsumed fish and wildlife (negative value of contaminated fish and wildlife); impact of consumption restriction advisories; stress and anxiety of knowing ecosystem is polluted, fish and wildlife are poisoned, and public health threatened

Results of Case Study Investigations

A total of 22 cases of CCW impacts to fish and wildlife were identified in this review. Of those, five cases resulted from ash pond or FGD pond structural failures, two were caused by unpermitted discharge of ash pond effluent, two occurred at unregulated impoundments, and twelve, which includes the most costly cases, happened because of legally permitted releases allowed by the National Pollutant Discharge Elimination System (NPDES). Only one case, which was a landfill, resulted from exceedance of specified contaminant limits of an NPDES permit. The sites range from locations where historical poisoning has led to corrective actions that have greatly improved environmental conditions to those where contamination has just recently been discovered and the level of ecological damage has yet to be determined. The value of losses at these sites varies tremendously, and depends on the extent, severity, and duration of contamination. The total value of fish and wildlife losses in the 22 damage cases was $2.32 billion. A detailed analysis of each case is presented, followed by references and a summary table.
Case 1 – Belews Creek Steam Station, NC (Duke Energy)

Location of Damage: Belews Lake

Period of Damage: 1976-2006*

(*The last biological effects assessment was in 1996. It showed that poisoning of fish was still occurring and projected to continue. Selenium levels in fish tissue remained above a toxic threshold in 2006, which was the latest reporting year available.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated effluent from a coal ash disposal basin was discharged into Belews Lake. This discharge was authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. The trace element selenium bioaccumulated in aquatic food chains and caused severe poisoning and reproductive failure in fish. Of the twenty primary species of fish present, seventeen were rapidly eliminated (including all sport fish) and two were rendered sterile but persisted as adults for a few years. Extensive population and community-level impacts were sufficient to cause local extinction of species. Selenium poisoning was still evident 21 years after first being detected, and 10 years after selenium inputs to Belews Lake were markedly reduced. Concentrations of selenium in fish tissues remained above a toxic threshold (4 parts per million whole-body, dry weight, 24) in 2006, 31 years after selenium impacts first began, due to movement of the element from contaminated sediments into benthic food chains. Fish diversity and relative dominance remained substantially altered in 2004. A consumption restriction advisory for selenium contamination of fish in Belews Lake was issued by the North Carolina Department of Health and Human Services from 1993-2000.

Scientific evidence: References 5-26

Corrective Action Taken: The electric utility company began to landfill coal ash in 1986 and selenium inputs to Belews Lake were markedly reduced. However, EPA’s Toxics Release Inventory reported that there were substantial discharges of contaminants, including selenium and arsenic, to surface water in 2009, which was the latest reporting year available (5).

Monetized Value of Damage

Ecological: (A) Period of fish extirpation (1976-1986) = 11 years X pre-pollution standing crop of all species = 11 X 13,630 = 149,930 individuals per hectare X 781 hectares (half the total lake surface area) = 117,095,330 individuals lost. (B) Period of partial recovery (1987-1996) = 10 years X 25% of pre-pollution standing crop = 10 X 3,407 = 34,070 individuals per hectare X 781
hectares = 26,608,670 individuals lost. Total individuals lost X value per individual = 143,704,000 X $1.00 = $143,704,000. (C) Added damage cost from local extinction of species = aggregate value (A+B) X the % of total species represented by one species X number of extirpated species = $143,704,000 X 5% = $7,185,200 X 17 = $122,148,400 (D) Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) during initial period of partial recovery (1987-1996) = 10 years X 70% of pre-pollution standing crop = 10 X 9,576 X 781 = 74,788,560 individuals exceeding toxic threshold X $0.50 = $37,394,280. (E) Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic threshold of 4 ppm) during 1997-2006 = 10 years X 50% of pre-pollution standing crop = 10 X 6,815 X 781 = 53,225,150 individuals exceeding toxic threshold X $0.50 = $26,612,575.

Total ecological damage value = $329,859,255.00

Recreational: (A) Value of harvestable-size sport fish lost during period of extirpation = number of species X average pre-pollution standing crop per species X 50% = 8 X 1,237 X 50% = 4,948 individuals per hectare X 781 hectares = 3,864,388 X 11 years = 42,508,268 individuals X $1.00 = $42,508,268. (B) Value of harvestable-size sport fish lost during period of partial recovery = 8 X 1,237 X 10% = 989 X 781 = 772,409 X 10 years = 7,724,090 X $1.00 = $7,724,090. (C) Lost value from fishing trips not taken during period of extirpation = 14,400 angler days per year (average of 300 angler days per week X 48 weeks) X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $1,440,000 per year X 11 years = $15,840,000. (D) Lost value from fishing trips not taken during period of partial recovery = 7,200 angler days per year X $100 per day = $720,000 X 10 years = $7,200,000. (E) Lost value of other recreational trips not taken due to stigma of pollution or concerns about health and safety issues (camping, boating, swimming, etc) during 1976-1996 = 300 recreation days per week X 48 weeks = 14,400 X $100 per day inclusive of meals, gas, and gear associated with recreational activity = $1,440,000 per year X 21 years = $30,240,000. (F) Lost value of fishing and other recreational trips not taken during post-1996 years when consumption restriction advisory remained in effect (1997-2000) = 100 recreation days per week X 48 weeks = 4,800 X $100 per day = $480,000 X 4 years = $1,920,000.

Total recreational damage value = $105,432,358.00

Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of lakefront property owners (in 1990) X approximate property value X 5% depreciation X number of years fish poisoned and public health fish consumption advisories in effect = 250 X $250,000 = $62,500,000 X 5% = $3,125,000 X 25 years = $78,125,000.00
Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (1990 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = \(476,403 \times 20\% = 95,280 \times 100 = \$9,528,060\).

Human Health: (A) Value of unconsumed contaminated fish = number of angler days during the period of state-issued consumption restriction advisory (14,400 angler days per year \(\times 16\) years, 1993-2000, (22)) \(\times 4\) fish meals per angler day – number of meals allowed (limit of 1 meal per week per adult, no consumption for children (22), subtract 720 for each adult) \(\times \$7.50\) per meal = \(14,400 \times 8 = 115,200 \times 4 = 460,800 - 1,440\) (two adults and two children per family) = 459,360 \(\times \$7.50 = \$3,445,200.00\) (B) Losses due to stress and anxiety of knowing ecosystem is polluted, fish and wildlife are poisoned, and public health threatened = assuming 20% of population within 30 miles (1990 census) expresses strong negative sentiments when seeing or reading news stories describing damage = \(476,403 \times 20\% = 95,280 \times 50 = \$4,764,000\).

Total human health damage value = \$8,209,200.00

Total Case Damage Value = \$531,153,873.00

**Case 2 – Roxboro Steam Electric Plant, NC (Progress Energy)**

Location of Damage: Hyco Reservoir

Period of Damage: 1978-2005*

(*The last biological effects assessment was in 1983 and it showed massive fish reproductive failure. Fish tissue selenium remained above a toxic threshold in 2005, which was the latest reporting year available.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated effluent from coal ash disposal basins was discharged into Hyco Reservoir. These discharges were authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. The trace element selenium bioaccumulated in aquatic food chains and caused poisoning and reproductive failure in fish. Three species of sport fish (largemouth bass, striped bass, chain pickerel) were virtually eliminated and severe reductions occurred in 12 other major taxa. Extensive population and community-level impacts were sufficient to cause local extinction of species and shifts in dominance of other species. Concentrations of selenium in fish tissues remained above a toxic threshold (4 parts per million whole-body, dry weight, 24) in 2005, 31 years after depressed fish populations were first noted and 15 years after selenium inputs to Hyco Reservoir were markedly reduced, due to movement of the element from contaminated sediments into benthic food chains. A consumption restriction advisory for selenium contamination of fish in
Hyco Reservoir was issued by the North Carolina Department of Health and Human Services from 1988-2001.

Scientific Evidence: References 22, 25, 27-39

Corrective Action Taken: The electric utility company began to landfill coal ash in 1990 and selenium inputs to Hyco Reservoir were markedly reduced. However, EPA’s Toxics Release Inventory reported that there were substantial discharges of contaminants, including selenium and arsenic, to surface water in 2009, which was the latest reporting year available (27).

Monetized Value of Damage

Ecological: (A) Period of major impacts on fish (1978-1991) = 14 years X 50% of pre-pollution standing crop = 14 X 27,235 = 381,290 individuals per hectare X 880 hectares (half the total lake surface area) = 335,535,200 individuals lost. (B) Period of partial recovery (1992-1997) = 6 years X 25% of pre-pollution standing crop = 6 X 13,617 = 81,702 individuals per hectare X 880 hectares = 71,897,760 individuals lost. Total individuals lost X value per individual = 407,432,960 X $1.00 = $407,432,960. (C) Added damage cost from local extinction of species = aggregate value (A+B) X the % of total species represented by one species X number of extirpated species = $407,432,960 X 4% = $16,297,318 X 3 = $48,891,954. (D) Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) during period of partial recovery (1992-1997) = 6 years X 70% of pre-pollution standing crop = 6 X 38,129 X 880 ha = 201,321,120 individuals exceeding toxic threshold X $0.50 = $100,660,560. (E) Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic threshold of 4 ppm) during 1998-2006 = 9 years X 50% of pre-pollution standing crop = 9 X 27,235 X 880 ha = 215,701,200 individuals exceeding toxic threshold X $0.50 = $107,850,600.

Total ecological damage value = $664,836,074.00

Recreational: (A) Value of harvestable-size sport fish lost during period of major impacts = number of species X average pre-pollution standing crop per species X 50% = 8 X 1,722 X 50% = 6,888 individuals per hectare X 880 hectares = 6,061,440 X 14 years = 84,860,160 individuals X $1.00 = $84,860,160. (B) Value of harvestable-size sport fish lost during period of partial recovery = 8 X 1,722 X 10% = 1,377 X 880 = 1,211,760 X 6 years = 7,270,560 X $1.00 = $7,270,560. (C) Lost value from fishing trips not taken during period of major impacts = 9,600 angler days per year (average of 200 angler days per week X 48 weeks) X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $960,000 per year X 14 years = $13,440,000. (D) Lost value from fishing trips not taken during period of partial recovery = 4,800 angler days per year X $100 per day = $480,000 X 6 years = $2,880,000. (E) Lost value of other recreational trips not
taken due to stigma of pollution or concerns about health and safety issues (camping, boating, swimming, etc) during 1978-1997 = 200 recreation days per week X 48 weeks = 9,600 X $100 per day inclusive of meals, gas, and gear associated with recreational activity = $960,000 per year X 20 years = $19,200,000. (F) Lost value of fishing and other recreational trips not taken during post-1997 years when consumption restriction advisory remained in effect (1998-2001) = 100 recreation days per week X 48 weeks = 4,800 X $100 per day = $480,000 X 4 years = $1,920,000.

Total recreational damage value = $129,570,720.00

Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of lakefront property owners (in 1990) X approximate property value X 5% depreciation X number of years fish poisoned and public health fish consumption advisories in effect = 250 X $250,000 = $62,500,000 X 5% = $3,125,000 X 24 years = $75,000,000.00.

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (1990 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 109,925 X 20% = 21,985 X $100 = $2,198,500.

Human Health: (A) Value of unconsumed contaminated fish = number of angler days during the period of state-issued consumption restriction advisory (9,600 angler days per year X 14 years, 1988-2001, (22, 38)) X 4 fish meals per angler day – number of meals allowed (limit of 1 meal per week per adult, no consumption for children (22), subtract 720 for each adult) X $7.50 per meal = 9,600 X 14 = 134,400 X 4 = 537,600 – 1,440 (two adults and two children per family) = 536,160 X $7.50 = $4,021,200.00 (B) Losses due to stress and anxiety of knowing ecosystem is polluted, fish and wildlife are poisoned, and public health threatened = assuming 20% of population within 30 miles (1990 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 109,925 X 20% = 21,985 X $50 = $1,099,250.

Total human health damage value = $5,120,450.00

Total Case Damage Value = $876,725,744.00

Case 3 – Mayo Steam Electric Plant, NC (Progress Energy)

Location of Damage: Mayo Reservoir

Period of Damage: 2000-2007*

(*Biological effects were found in the ash basin discharge arm of the lake. Fish tissue selenium levels remained above a toxic threshold in 2007, which was the latest reporting year available.)

Source of Damage: Surface impounded coal ash
Cause and Extent of Damage: Contaminated effluent from a coal ash disposal basin was discharged into Mayo Reservoir. This discharge was authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. EPA’s Toxics Release Inventory reported that from 1998-2009, the Mayo Plant discharged 96,676 pounds of contaminants into surface water (44), and 2009 discharges were the highest of record. The resultant pollution caused reduced aquatic communities in the ash basin discharge area of the lake. The trace element selenium bioaccumulated in aquatic food chains and reached levels exceeding a toxic threshold (4 parts per million whole-body, dry weight, 24) in fish. All major sport fish (e.g., largemouth bass, bluegill, catfish) were contaminated. In 2007, concentrations of selenium in some fish samples were over twice the toxic threshold at a site 5 miles uplake of the ash basin discharge, and all fish sampled exceeded the threshold at a site 1.75 miles uplake. Those selenium levels (5-15 ppm dw) are within the range associated with impaired blood chemistry and health indicators, teratogenic deformities, and reproductive failure in the same species naturally exposed to coal ash discharges at other locations (19-20, 49-53). However, no detailed biochemical or reproductive assessment has been done for Mayo Reservoir. Since 2000, there has been an upward trend in selenium concentrations at all sampling stations. In its 2005 evaluation, the State of NC placed Mayo Reservoir in the category of “Waters with Noted Impacts” due to elevated selenium and arsenic concentrations in water and biota (47).

Scientific Evidence: References 40-47

Corrective Action Taken: As of 2003, most of the coal ash was being disposed in a landfill but EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including arsenic and mercury (selenium not reported), to surface water continued in 2009, which was the latest reporting year available (44).

Monetized Value of Damage

Ecological: (A) Value of reduction in aquatic communities = area affected X 50% of the value per hectare X percent negative change X number of years = 113 ha (10% of lake area) X $50,000 X 50% X 8 = $22,600,000. (B) Value of damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) = standing crop of fish X area affected X number of years affected X $0.50 = 34, 050 per ha (average of piedmont NC reservoirs with similar area and species composition, and the same trophic status) X 1020 ha (90% of lake area) X 2 years (2006-2007) X 0.50 = $34,731,000; for 2000-2001 = 1% of lake area affected (11 ha) = $374,550; for 2002-2003 = 10% of lake area affected (113 ha) = $3,847,650; for 2004-2005 = 50% of lake area affected (566 ha) = $19,272,300. Total ecological damage value = $80,825,500.00
Recreational: The contamination at this site is known from scientific studies and internal state and utility company reports, but has not been disclosed to the public in popular media outlets. Moreover, public access has not been restricted. Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, have not occurred.

Real Estate: Same as for recreation

Aesthetic: Same as for recreation

Human Health: Concentrations of selenium in muscle tissue of sport fish in 2006-2007 have reached consumption restriction advisory levels (10 parts per million dry weight, or 2.5 parts per million wet weight, 48). However, no advisory has been issued so associated negative human health values could not be calculated. Also, public lack of knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $80,825,500.00

Case 4 – General James M. Gavin Power Plant, OH, and John E. Amos Power Plant, WV (American Electric Power)

Location of Damage: Stingy Run and Kyger Creek OH, Little Scary Creek, WV

Period of Damage: 1974-2006*
(*The last biological effects assessment was in 1996. It showed that fish were being poisoned by fly ash effluent. Concentrations of selenium in fish from Little Scary Creek remained above a toxic threshold in 2006, which was the last reporting year available.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Ash pond discharges contaminated streams and increased the concentration of 5 trace metals (cadmium, chromium, copper, lead, zinc) and 2 metalloids (selenium, arsenic) in fish. These discharges were authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. EPA’s Toxics Release Inventory reported that from 1998-2009, the Gavin Plant discharged 265,284 pounds of contaminants into surface waters, and the Amos Plant discharged 122,770 pounds of contaminants into surface waters (54-55). Selenium bioaccumulated in aquatic food chains and fish tissues, and reached levels exceeding a toxic threshold (4 parts per million whole-body, dry weight, 24) in fish. Physiological and biological changes indicated that fish were poisoned by fly ash effluent, and that some reproductive impairment occurred, although no detailed reproduction studies were conducted at either site to quantify the levels of impairment. The numbers of mature fish in Little Scary Creek were reduced. Although fish poisoning was still occurring at the end of
scientific studies in 1996, no additional monitoring or biological assessment has been reported for Stingy Run or Kyger Creek. Concentrations of selenium in Little Scary Creek remained elevated (up to 58 ppm, dw) in 2006. Selenium in muscle tissue of sport fish sampled in 1993-2006 exceeded West Virginia consumption restriction advisory levels (10 parts per million dry weight, or 2.5 parts per million wet weight, 48). However, no advisories were issued.

Scientific Evidence: References 49-60, 220

Corrective Action Taken: The electric utility company began using a dry ash handling system at the Gavin Power Plant in 1994 to improve SO\(_2\) and particle removal from stack emissions (not in response to ecotoxicity) and selenium inputs to Stingy Run and Kyger Creek were reduced. As of 2010, some ash from the Amos Power Plant was being disposed in a landfill on the property but discharges to Little Scary Creek continued. The West Virginia Department of Environmental Protection has issued a variance in the water quality standard for Little Scary Creek, raising it from the USEPA national criterion value of 5 ug/L to a permissible level of 62 ug/L (215). This action was not approved by EPA, nor was it based on a site-specific standard development process that included supporting biological studies. EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including selenium and arsenic, to surface waters continued in 2009 at both the Gavin Plant and Amos Plant, which was the latest reporting year available (54-55).

Monetized Value of Damage

Ecological: (A) Damage to fish poisoned but not eliminated in Kyger Creek and Stingy Run = average standing crop in 25 m unit sampled X length of stream X number of years X $0.50 = 255/25 m X 40 = No./km = 10,200 X 8 km X 23 years = 1,876,000 X $0.50 = $938,400. (B) Damage to fish poisoned but not eliminated in Little Scary Creek = 10,200 X 4 km X 33 years = 1,346,400 X $0.50 = $673,200.

Total ecological damage value = $1,611,600.00

Recreational: The contamination at these sites is known from scientific studies and internal state and utility company reports, but has not been disclosed to the public in popular media outlets. Moreover, public access has not been restricted. Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, have not occurred.

Real Estate: Same as for recreational

Aesthetic: Same as for recreational
Human Health: Concentrations of selenium in muscle tissue of sport fish sampled in 1993-2006 exceeded consumption restriction advisory levels (10 parts per million dry weight, or 2.5 parts per million wet weight, 48). However, no advisory has been issued so associated negative human health values could not be calculated. Also, public lack of knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $1,611,600.00

Case 5 – Martin Lake Steam Electric Station, TX (Texas Utilities Electric)

Location of Damage: Martin Lake

Period of Damage: 1978-1997*
(*The last biological effects assessment was in 1986. It showed that the overall health and reproductive status of fish were still seriously impaired. Selenium levels in fish remained above a toxic threshold in 1997, which was the latest reporting year available.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Periodic uncontrolled, unpermitted discharges of contaminated effluent from coal ash holding ponds into Martin Lake took place from May 1978-May 1981. Fish kills occurred in 1978 and 1979. The trace element selenium bioaccumulated in aquatic food chains and caused severe tissue pathology and reproductive failure in fish. Total fish standing crop biomass was reduced by 72%. Extensive population and community-level impacts were sufficient to cause near-extinction of some species and long-term changes in the relative dominance of other species. Barn swallows nesting near the lake contained elevated concentrations of selenium and their eggs were contaminated with enough selenium to cause 20% embryo mortality. Concentrations of selenium in some fish species remained above a toxic threshold (4 parts per million whole-body, dry weight, 24) in 1997, 20 years after ash pond effluent first entered the lake and 16 years after selenium inputs were curtailed, due to movement of the element from contaminated sediments into benthic food chains. A consumption restriction advisory for selenium contamination of fish in Martin Lake was issued by the Texas Department of Health from 1992-2003.

Scientific Evidence: References 61-80, 99-100

Corrective Action Taken: Modifications in the design and operational parameters of the power plant’s wastewater disposal system were implemented in the early 1980’s to prevent uncontrolled, unpermitted discharges; selenium inputs to Martin Lake were markedly reduced. As of 2005, coal ash was being disposed in a landfill. EPA’s Toxics Release Inventory reported
that significant discharges of contaminants, including selenium, to surface waters continued at the Martin Lake plant through 2002 (61).

Monetized Value of Damage

Ecological: (A) Period of major impacts on fish (1978-1986) = 9 years X 25% of pre-pollution standing crop X number of hectares = 9 X 6,230 individuals per hectare X 1015 hectares (half the total lake surface area) = 56,911,050 individuals lost. (B) Period of partial recovery (1987-1992) = 6 years X 10% of pre-pollution standing crop X number of hectares = 6 X 2,492 = 14,952 individuals per hectare X 1015 hectares = 15,176,280 individuals lost. Total individuals lost X value per individual = 72,087,330 X $1.00 = $72,087,330. (C) Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) during period of partial recovery (1987-1992) = 6 years X 70% of pre-pollution standing crop = 6 X 17,443 X 1015 ha = 106,227,870 individuals exceeding toxic threshold X $0.50 = $53,113,935. (D) Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic threshold of 4 ppm) during 1993-1997 = 5 years X 50% of pre-pollution standing crop = 5 X 12,459 X 1015 ha = 63,229,425 individuals exceeding toxic threshold X $0.50 = $31,614,712. (E) Damage to wildlife (barn swallows) = average number of eggs per clutch X average number of nests X percentage of eggs exceeding toxic threshold (5 ppm dw) X years of major pollution = 4.5 X 95 X 10% X 15 = 641 individuals lost X $10 = $6,410.

Total ecological damage value = $156,822,387.00

Recreational: (A) Value of harvestable-size sport fish lost during period of major impacts = number of species X average pre-pollution standing crop per species X 25% = 8 X 1,125 X 25% = 2,250 individuals per hectare X 1015 hectares = 2,283,750 X 9 years = 20,553,750 individuals X $1.00 = $20,553,750. (B) Value of harvestable-size sport fish lost during period of partial recovery = 8 X 1,125 X 10% = 900 X 1015 = 913,500 X 6 years = 5,481,000 X $1.00 = $5,481,000. (C) Lost value from fishing trips not taken during period of major impacts = 9,600 angler days per year (average of 200 angler days per week X 48 weeks) X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $960,000 per year X 9 years = $8,640,000. (D) Lost value from fishing trips not taken during period of partial recovery = 4,800 angler days per year X $100 per day = $480,000 X 6 years = $2,880,000. (E) Lost value of other recreational trips not taken due to stigma of pollution or concerns about health and safety issues (camping, boating, swimming, etc) during 1978-1997 = 200 recreation days per week X 48 weeks = 9,600 X $100 per day inclusive of meals, gas, and gear associated with recreational activity = $960,000 per year X 20 years = $19,200,000. (F) Lost value of fishing and other recreational trips not taken during post-1997 years when consumption restriction advisory remained in effect (1998-2003) = 100
recreation days per week X 48 weeks = 4,800 X $100 per day = $480,000 X 6 years = $2,880,000.
Total recreational damage value = $59,634,750.00

Real Estate: Depreciated value due to stigma of environmental pollution = approximate
number of lakefront property owners (in 1990) X approximate property value X 5% depreciation
X number of years fish poisoned and public health fish consumption advisories in effect = 10 X
$250,000 = $2,500,000 X 5% = $125,000 X 26 years = $3,250,000.00.

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30
miles (1990 census) believe degradation of individual non-use values equals $100 or more for
scenic and posterity considerations = 210,001 X 20% = 42,000 X $100 = $4,200,000.

Human Health: (A) Value of unconsumed contaminated fish = number of angler days during the
period of state-issued consumption restriction advisory (9,600 angler days per year X 12 years,
1992-2003, (79-80)) X 4 fish meals per angler day – number of meals allowed (limit of 1 meal
per week per adult, no consumption for children (80), subtract 720 for each adult) X $7.50 per
meal = 9,600 X 12 = 115,200 X 4 = 460,800 – 1,440 (two adults and two children per family) =
459,360 X $7.50 = $3,445,200.00 (B) Losses due to stress and anxiety of knowing ecosystem is
polluted, fish and wildlife are poisoned, and public health threatened = assuming 20% of
population within 30 miles (1990 census) expresses strong negative sentiments when seeing or
reading news stories describing damage = 210,001 X 20% = 42,000 X $50 = $2,100,000.
Total human health damage value = $5,545,200.00

Total Case Damage Value = $229,452,337.00

Case 6 – J. Robert Welsh Power Plant, TX (American Electric Power)

Location of Damage: Welsh Reservoir

Period of Damage: 1981-2007*
(*Fish populations were reduced by 1981 but no detailed biological effects studies of fish tissue
pathology or reproductive failure were conducted. Selenium levels in fish were elevated and
remained above a toxic threshold in 1998, which was the latest reporting year available. Fish
populations continued to be reduced in 2007.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated effluent from coal ash disposal basins was
discharged into Welsh Reservoir. This discharge was authorized by permits issued through the
federal-state National Pollutant Discharge Elimination System. The resultant pollution
coincided with reduced fish communities. EPA’s Toxics Release Inventory reported that from
1998-2009, the Welsh Power Plant discharged 308,379 pounds of contaminants, including arsenic and mercury (selenium not reported), into surface waters (81). The trace element selenium bioaccumulated to levels exceeding a toxic threshold in fish tissues (4 parts per million whole-body, dry weight, 24). Total standing crop was reduced by up to 75% for some species. Analysis revealed that the levels of selenium and associated changes in fish populations were consistent with those occurring at three sister lakes (Martin Lake, TX, Hyco Reservoir, NC, Belews Lake, NC), which were also polluted by coal ash effluent during the same time period. Several fish kills were reported by Texas Parks and Wildlife Department from 1989-1999, and were attributed to elevated summer water temperatures associated with the heated discharge from Welsh Power Plant. However, the thermal tolerance limit of fish (38°C for largemouth bass and crappie, 40°C for catfish, 41°C for green sunfish, 42°C for bluegill, 82-86) was not attained in ambient areas of the reservoir and no other potential causes were examined. Metals and other pollutants in coal ash effluent are known to reduce lethal temperatures for fish and also modify their behavior in a way that would make them less likely to avoid lethal temperature zones in a heated reservoir (88-90, 96). Therefore, it is reasonable to conclude that coal ash pollution, in combination with elevated water temperature, caused the kills. Concentrations of selenium in some fish species remained above a toxic threshold in 1998, 22 years after ash pond effluent first entered the lake, and were the same as levels recorded in 1986, 12 years earlier. Fish populations were still reduced in 2007, despite changes in angler harvest regulations and artificial stocking to enhance standing crop and diversity of species. A consumption restriction advisory for selenium contamination of fish in Welsh Reservoir was issued by the Texas Department of Health from 1992-2003.

Scientific Evidence: References 81-100

Corrective Action Taken: Ash basin discharges to Welsh Reservoir were within applicable state permit limits throughout the period of damage. Some modifications in plant design and operations were done to ensure that unpermitted, uncontrolled ash basin discharges, such as those known to have occurred at a sister lake (Martin Lake) would not happen. However, as these changes did not affect permitted discharges, selenium levels in water, sediment, and fish tissues remained unchanged throughout the reporting period (1986-1998). As of 2005, some of the coal ash was being disposed in a landfill. EPA’s Toxics Release Inventory reported that substantial discharges of contaminants (selenium not reported) to surface waters continued through 2009, which was the latest reporting year available (81).

Monetized Value of Damage

Ecological: (A) Value of reduction in fish populations = pre-pollution standing crop X area affected (half the total lake surface area) X percent reduction X number of years = 43,200 X 296
X 25% X 27 = 86,313,600 individuals lost X $1.00 = $86,323,600. (B) Value of damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) = pre-pollution standing crop of fish X area affected X 25% X number of years affected X $0.50 = 43,200 X 296 X 25% X 27 = 86,313,600 individuals contaminated X $0.50 = $43,156,800.
Total ecological damage value = $129,480,800.00

Recreational: The contamination at Welsh Reservoir was known from scientific studies and internal state and utility company reports, but was not disclosed to the public in popular media outlets prior to the issuance of a fish consumption advisory for selenium in 1992. After that time, a significant impact on fishing effort was acknowledged by Texas Parks and Wildlife, which stated “a fish consumption advisory issued by TDH in 1992 has contributed to low utilization of the resource by the public” (91). Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, were calculated only for the advisory period (1992-2003). (A) Value of harvestable size sport fish lost = number of species X average pre-pollution standing crop per species X area affected (one half of total lake surface area) X 25% X number of years = 8 X 1,728 X 296 X 25% = 1,022,976 X 12 years = 12,275,712 individuals X $1.00 = $12,275,712. (B) Lost value from fishing trips not taken = 4,800 angler days per year X $100 per day = $480,000 X 12 years = $5,760,000. (C) Lost value of other recreational trips not taken due to stigma of pollution or concerns about health and safety issues (camping, boating, swimming, etc) = 4,800 recreational days per year X $100 per day X 12 years = $5,760,000
Total recreational damage value = $23,795,712.00

Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of lakefront property owners (in 1990) X approximate property value X 5% depreciation X number of years public health fish consumption advisories in effect = 20 X $250,000 = $5,000,000 X 5% = $250,000 X 12 years = $3,000,000.00.

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (1990 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 123,818 X 20% = 24,763 X $100 = $2,476,300.

Human Health: (A) Value of unconsumed contaminated fish = number of angler days during the period of state-issued consumption restriction advisory (4,800 angler days per year X 12 years, 1992-2003, (92, 98)) X 4 fish meals per angler day – number of meals allowed (limit of 1 meal per week per adult, no consumption for children (98), subtract 720 for each adult) X $7.50 per meal = 4,800 X 12 = 57,600 X 4 = 230,400 – 1,440 (two adults and two children per family) = 228,960 X $7.50 = $1,717,200 (B) Losses due to stress and anxiety of knowing ecosystem is polluted, fish and wildlife are poisoned, and public health threatened = assuming 20% of
population within 30 miles (1990 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 123,818 X 20% = 24,763 X $50 = $1,238,150.
Total human health damage value = $2,955,350.00
Total Case Damage Value = $161,708,162.00

Case 7 – Henry W. Pirkey Power Plant, TX (American Electric Power)

Location of Damage: Brandy Branch Reservoir

Period of Damage: 1987-2007*
(*Fish populations were reduced by 1987 but no detailed biological effects studies of fish tissue pathology or reproductive failure were conducted. Selenium levels in fish were elevated and remained above a toxic threshold in 1997, which was the latest reporting year available. Fish populations continued to be reduced in 2007.)

Source of Damage: Surface impounded coal ash and the power plant’s coal storage pile

Cause and Extent of Damage: Contaminated effluent from coal ash disposal basins and drainage from the plant’s coal storage pile were discharged into Brady Branch Reservoir. Discharges from the ash pond were authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. EPA’s Toxics Release Inventory reported that from 1998-2009, the Pirkey Plant discharged 49,522 pounds of contaminants, including arsenic and selenium, into surface waters (106). The trace element selenium bioaccumulated to levels exceeding a toxic threshold in fish tissues (4 parts per million whole-body, dry weight, 24). Texas Parks and Wildlife determined that during 1986-1989, average fish tissue selenium levels increased from 3.24 to 11.6 ppm dw. During 1986-2003, Texas Department of Health reviewed all data from fish monitoring over an 18-year period (1986-2003) and determined that the average concentration was 8.92 ppm dw. The levels found (8-11 ppm) are within the range associated with impaired blood chemistry and health indicators, teratogenic deformities, and reproductive failure in the same species naturally exposed to coal ash discharges at other locations (19, 50-53). However, no detailed biochemical or reproductive assessment has been done for Brandy Branch Reservoir. Changes in fish populations (reduced standing crop) were documented in a scientific study; the State concluded that those changes were due to coal ash basin discharges. Populations of some predatory sport fish (e.g., largemouth bass) continued to be reduced in 2007. A consumption restriction advisory for selenium contamination of fish in Brandy Branch Reservoir was issued by the Texas Department of Health from 1992-2003.

Scientific Evidence: References 1, 93, 99-109
Corrective Action Taken: In 1998 the power plant altered its coal storage practices to prevent discharge of stormwater runoff into the reservoir. As of 2005, some of the coal ash was being disposed in a landfill. EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including arsenic and selenium, to surface waters continued in 2009, which was the latest reporting year available (106).

Monetized Value of Damage

Ecological: (A) Value of reduction in fish populations = pre-pollution standing crop X area affected (half the total lake surface area) X percent reduction X number of years = 39,620 X 254 X 25% X 21 = 52,833,270 individuals lost X $1.00 = $52,833,270. (B) Value of damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) = pre-pollution standing crop of fish X area affected X 25% X number of years affected X $0.50 = 39,620 X 254 X 25% X 21 = 52,833,270 individuals contaminated X $0.50 = $26,416,635.
Total ecological damage value = $79,249,905.00

Recreational: The contamination at Brandy Branch Reservoir was known from scientific studies and internal state and utility company reports, but was not disclosed to the public in popular media outlets prior to the issuance of a fish consumption advisory for selenium in 1992. After that time, a significant impact on fishing effort was acknowledged by Texas Parks and Wildlife, which stated “public use of the fishery has been low due to poor fishing quality and the TDH advisory” (105). Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, were calculated only for the advisory period (1992-2003). (A) Value of harvestable size sport fish lost = number of species X average pre-pollution standing crop per species X area affected (one half of total lake surface area) X 25% X number of years = 8 X 1,307 X 254 X 25% = 663,956 X 12 years = 7,967,472 individuals X $1.00 = $7,967,472. (B) Lost value from fishing trips not taken = 4,800 angler days per year X $100 per day = $480,000 X 12 years = $5,760,000. (C) Lost value of other recreational trips not taken due to stigma of pollution or concerns about health and safety issues (camping, boating, swimming, etc) = 4,800 recreational days per year X $100 per day X 12 years = $5,760,000
Total recreational damage value = $19,487,472.00

Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of lakefront property owners (in 1990) X approximate property value X 5% depreciation X number of years public health fish consumption advisories in effect = 20 X $250,000 = $5,000,000 X 5% = $250,000 X 12 years = $3,000,000.00.
Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (1990 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 173,992 X 20% = 34,798 X $100 = $3,479,800.

Human Health: (A) Value of unconsumed contaminated fish = number of angler days during the period of state-issued consumption restriction advisory (4,800 angler days per year X 12 years, 1992-2003, (103, 108-109)) X 4 fish meals per angler day – number of meals allowed (limit of 1 meal per week per adult, no consumption for children (108), subtract 720 for each adult) X $7.50 per meal = 4,800 X 12 = 57,600 X 4 = 230,400 – 1,440 (two adults and two children per family) = 228,960 X $7.50 = $1,717,200 (B) Losses due to stress and anxiety of knowing ecosystem is polluted, fish and wildlife are poisoned, and public health threatened = assuming 20% of population within 30 miles (1990 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 173,992 X 20% = 34,798 X $50 = $1,739,900. Total human health damage value = $3,457,100.00

Total Case Damage Value = $108,674,277.00

Case 8 – Savannah River Site D-Area Power Plant, SC (US Department of Energy)

Location of Damage: Beaver Dam Creek and associated wetlands

Period of Damage: 1973-2004*
(*The last biological effects studies were in 2004. A suite of investigations from 1973-2004 showed mortality and a variety of developmental, physiological, and behavioral effects in fish and wildlife. Concentrations of trace elements remained elevated in 2004, which was the latest reporting year available.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated effluent from coal ash disposal basins was discharged into Beaver Dam Creek and associated wetlands. These discharges were authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. EPA’s Toxics Release Inventory reported that from 1998-2005, the D-Area Power Plant discharged 25,326 pounds of contaminants to surface waters (110). Concentrations of arsenic, cadmium, chromium, copper, selenium, strontium, and vanadium were elevated in alligators, turtles, snakes, fish, frogs, salamanders, toads, crayfish, rats, raccoons, birds, and clams. Selenium bioaccumulated to levels exceeding a toxic threshold in fish tissues (4 parts per million whole-body, dry weight, 24). A variety of lethal and sublethal effects were documented in the biota of this ecosystem. Populations of benthic invertebrates were reduced. Impacts to
fish included elimination of at least 5 species, fin erosion, reduced swimming performance, and reduced growth. Snakes exhibited liver pathology and elevated metabolic rate. Frogs exhibited axial and oral deformities, increased metabolic rate, reduced swimming performance and reduced predator avoidance. Adult toads had abnormal levels of sex hormones and larval toads experienced 100% mortality. Salamanders experienced an extended larval period and showed reduced recruitment. Cotton rats had a high incidence of malformed DNA strands. The interaction of multiple sublethal effects was sufficient to reduce recruitment and cause population-level impacts in frogs.

Scientific Evidence: References 110-149

Corrective Action Taken: Beginning in 2001, a vegetative cover treatment study was done to develop ways of reducing acid drainage from the ash basin (144). Since that time, the ash basin has been operated as a landfill, with permanent capping and vegetation of filled areas. Final remediation of the site is expected to begin in 2015, concurrent with closure of the coal-fired power plant (145-147). EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including mercury and lead (selenium not reported) continued in 2005, which was the latest reporting year available (110).

Monetized Value of Damage

Ecological: (A) Damage from fish eliminated in wetlands = number of species X average standing crop (estimate for unpolluted Carolina bay wetland, 143-144) X area affected X number of years = 5 X 2,500/ha X 2 ha X 32 = 800,000 individuals X $1.00 = $800,000. (B) Added damage cost from local extinction of species = value loss from (A) X the % of total species represented by one species X number of extirpated species = $800,000 X 10% = $80,000 X 5 = $400,000. (C) Damage to fish contaminated but not eliminated in wetlands (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) = number of species X average standing crop (estimate for unpolluted Carolina bay wetland, 148-149) X 90% X area affected X number of years = 5 X 2,500/ha X 0.9 X 2 ha X 32 = 720,000 individuals contaminated X $0.50 = $360,000. (D) Damage to fish in Beaver Dam Creek = length of stream affected X average standing crop per kilometer X percentage exceeding toxic effects threshold of selenium (4 ppm) X number of years affected = 5 km X 5,100 (half the standing crop of other ash-impacted streams of similar size and species composition, 46-51) X 50% X 32 = 408,000 X $0.50 = $204,000. (E) Damage to frogs from deformities = annual production of tadpoles per hectare (half the total estimated from unpolluted Carolina bay wetland, 149) X percentage deformed X area affected X number of years = 180,000 X 90% X 2 ha X 32 = 10,368,000 X $1.00 = $10,368,000. (F) Damage to toads = annual production of larvae per hectare (half the total estimated from unpolluted Carolina bay wetland, 149) X percentage mortality of larvae X area

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affected X number of years = 77,000 X 70% X 2 ha X 32 = 3,449,600 X $1.00 = $3,449,600.  (G)
Damage to salamanders = annual production of larvae per hectare (half the total estimated from unpolluted Carolina bay wetland, 149) X percentage mortality of larvae X area affected X number of years = 35,000 X 67% X 2 ha X 32 = 1,500,800 X $1.00 = $1,500,800.  (H) Value of sublethal physiological damage to fish, snakes, frogs, toads, salamanders, and crayfish = half the aggregate standing crop X area affected X number of years = 1,2,50 (fish) + 30 (snakes) + 2,500 (frogs) + 500 (toads) + 500 (salamanders) + 4,500 (crayfish) = 9,280 X 2 ha X 32 = 593,920 X $0.50 = $296,960.  (I) Value of reduction in benthic macroinvertebrate communities = area affected X 50% of the value per hectare X percent reduction X number of years = 3 ha X $50,000 X 50% X 8 = $600,000.
Total ecological damage value = $17,979,360.00

Recreational: Public access is prohibited so there is no recreational value loss.

Real Estate: There is no private ownership of property at this site.

Aesthetic: The contamination at this site is known from scientific studies and internal federal reports, but has not been disclosed to the public in popular media outlets. Therefore, it was not possible to estimate aesthetic value losses, which would be dependent on that knowledge.

Human Health: There is no consumptive use at this site. Lack of public knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $17,979,360.00

Case 9 – Gibson Generating Station, IN (Duke Energy)

Location of Damage: Gibson Lake and Cane Ridge Wildlife Management Area

Period of Damage: 1997-2010*
(*Fish populations in Gibson Lake were severely reduced by 1997 but no detailed biological effects studies of fish tissue pathology or reproductive failure have been conducted. Selenium levels in fish were elevated and remained above a toxic threshold in 2010.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated effluent from coal ash disposal basins was discharged into Gibson Lake. These discharges were exempt from regulation under the federal-state National Pollutant Discharge Elimination System because Gibson Lake is on company property and is hydrologically closed (does not discharge to state waters). Water from the reservoir was used to maintain 80 hectares of “moist soil” wetland habitat and a 25 hectare
nesting pool for endangered birds at a nearby federal wildlife management area, which also became contaminated. The trace element selenium bioaccumulated in fish to levels exceeding a toxic threshold (4 parts per million, whole-body, dry weight, 24). The levels found (9-30 ppm) are within the range associated with impaired blood chemistry and health indicators, teratogenic deformities, and reproductive failure in the same species naturally exposed to coal ash discharges at other locations (19, 50-53). However, no detailed biochemical or reproductive assessment has been done for Gibson Lake. By 1997, fish populations were severely reduced and at least eight selenium-sensitive species had disappeared from the reservoir (largemouth bass, bluegill, pumpkinseed, warmouth, longear sunfish, white crappie, black crappie, white bass). Fishery biologists with the Indiana Department of Natural Resources attributed this loss to increased water temperature associated with heated water discharges from Gibson Generating Station. However, the thermal tolerance limit of these species (e.g., 38°C for largemouth bass and crappie, 42°C for bluegill, 82-85) was not attained in ambient areas of the reservoir and no other potential causes were examined. Metals and other pollutants in coal ash effluent are known to reduce lethal temperatures for fish and also modify their behavior in a way that would make them less likely to avoid lethal temperature zones in a heated reservoir (88-90, 96). Therefore, it is reasonable to conclude that coal ash pollution, in combination with elevated water temperature, eliminated the fish. In order to reduce threats to endangered birds at Cane Ridge Wildlife Management Area, 105 hectares of wetlands and ponds on the refuge were drained, which eliminated all aquatic life. A consumption restriction advisory for selenium contamination of fish in Gibson Lake was issued by Duke Energy in 2007, and the lake was closed to fishing that same year.

Scientific Evidence: References 145-161

Corrective Action Taken: Duke Energy paid for construction of a pipeline to deliver low-selenium water pumped from the Wabash River to Cane Ridge Wildlife Management Area, which began operation in late 2008. Prior to this transfer of clean water, refuge managers drained wetlands and ponds (eliminating all aquatic life in the process), and tilled bottom soils in an effort to bury selenium-laden sediment and reduce toxic hazards to endangered birds. The utility company is converting one of its six ash ponds to a landfill by 2013 and is scheduled to close it by 2020. Other ponds still handle liquid waste.

Monetized Value of Damage

Ecological: (A) Damage to reservoir fisheries = pre-pollution standing crop per hectare X area affected X percentage reduction X number of years = 12,129 X 708 ha (half the surface area of the lake) X 50% X 14 = 60,111,324 individuals lost X $1.00 = $60,111,324. (B) Added damage cost due to local extinction of species = value loss from (A) X the % of total species represented
by one species X number of extirpated species = $60,111,324 X 5% X 8 = $24,044,529.  (C)
Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic threshold of 4 ppm) = 14 years X pre-pollution standing crop X 708 ha X 25% = 30,055,662 individuals X $0.50 = $15,027,831.  (D) Damage to Cane Ridge Wildlife Management Area = number of least tern fledglings prevented due to habitat loss or degradation X value per fledgling per Endangered Species Act violation year (different cost per fledgling for 2007 and 2008, 154) = 50 X $3,500 for 2007 = $175,000; 50 X $7,500 for 2008 = $375,000; total = $550,000.  (E) Value of destroyed aquatic life and ecosystems at Cane Ridge during management actions to reduce contamination = area destroyed X value per hectare X number of years = 105 ha X $100,000 X 2 = $21,000,000.
Total ecological damage value = $120,733,684.

Recreational:  (A) Value of harvestable-size sport fish lost at Gibson Lake during 1997-2010 = number of species X average pre-pollution standing crop per species X 50% = 8 X 860 X 50% = 3,440 individuals per hectare X 708 hectares = 2,435,520 X 14 years = 34,097,280 individuals X $1.00 = $34,097,280.  (B) Lost value from fishing trips not taken following closure of lake = 2,800 angler days per year X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $280,000 per year X 4 years = $1,120,000
Total recreational damage value = $35,217,280.00

Real Estate:  There is no public ownership of property at this site.

Aesthetic:  Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (2000 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 338,415 X 20% = 67,683 X $100 = $6,768,300.

Human Health:  (A) Value of unconsumed contaminated fish at Gibson Lake = number of angler days during the period of utility-issued consumption restriction advisory (2,800 angler days per year X 4 years, 2007-2010 (156-157) X 4 fish meals per angler day – number of meals allowed (limit of 1 meal per week per adult, 1 meal per month for children (156-157), subtract 720 for each adult, 180 for each child) X $7.50 per meal = 2,800 X 4 = 11,200 X 4 = 44,800 – (1,440 + 360) (two adults and two children per family) = 43,000 X $7.50 = $322,500  (B) Losses due to stress and anxiety of knowing ecosystem is polluted, fish and wildlife are poisoned, and public health threatened = assuming 20% of population within 30 miles (2000 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 338,415 X 20% = 67,683 X $50 = $3,384,150.
Total human health damage value = $3,706,650.00

Total Case Damage Value = $166,425,914.00
Case 10 – Oak Ridge Y-12 Steam Plant, Chestnut Ridge Operable Unit 2, TN
(US Department of Energy)

Location of Damage: McCoy Branch and Rogers Quarry

Period of Damage: 1967-2009*
(*Ash pond overflow began entering McCoy Branch in 1967. Biological monitoring studies began in 1989 and continued, periodically, through 2009. Contamination and impacts on fish populations were still evident in 2009, which was the latest reporting year available.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated slurry water in a coal ash disposal basin overflowed a retention dam and entered a steam/quarry pond ecosystem. The trace element selenium bioaccumulated in aquatic food chains and reached levels exceeding a toxic threshold in fish tissues (4 parts per million whole-body, dry weight, 24). All fish were eliminated from McCoy Branch upstream of Rogers Quarry. Fish in Rogers Quarry and Lower McCoy Branch exhibited high percentages of deformed spines, heads, and fins (up to 73% of some species were deformed). These deformities, in combination with the elevated tissue selenium concentrations found (up to 50 ppm dw) are diagnostic markers of selenium poisoning (24). Benthic macroinvertebrate communities were reduced in McCoy Branch both above and below Rogers Quarry (168). Ash pond effluent was discharged into Rogers Quarry for only one year (mid-1989 to mid 1990), yet concentrations of selenium in fish at that site remained elevated above a toxic threshold in 2009, 19 years later. Efforts to reintroduce fish to Upper McCoy Branch in the mid-1990’s were unsuccessful, but were attempted again in 2006-2009. As of 2009, two species were surviving due to stocking, banded sculpin and western blacknose dace. The ecosystem originally supported 15 fish species. Because of concerns about human health, “NO HUNTING” signs were posted along the perimeter of the coal ash pond in 1997. However, no such warnings were posted along McCoy Branch or at Rogers Quarry, which remained open for public access for both fishing and Oak Ridge Reservation game hunts that were held several times a year (177). Concentrations of selenium in muscle fillets of largemouth bass from Rogers Quarry equaled or exceeded consumption restriction advisory levels (10 parts per million dry weight, or 2.5 parts per million wet weight, 48) from 1990-2009 (178).

Scientific Evidence: References 1, 167-179

Corrective Action Taken: The ash pond was full by 1967 and no longer met its purpose of removing solids by gravitational settling. In 1989, a bypass pipe was constructed to carry ash slurry directly from the steam plant to Rogers Quarry. Disposal of ash into Rogers Quarry was discontinued in 1990, when a chemical vacuum system and a bottom ash dewatering system
were installed at the plant. Both fly ash and bottom ash were then disposed in a landfill. However, existing ash deposits were left in place and due to erosion of both the spillway and the ash itself, releases of ash into Upper McCoy Branch continued. A remedial action was conducted as part of CERCLA activities to stabilize the filled coal ash pond. McCoy Bridge Dam was renovated to hold ash and contaminated pond sediments in place and a passive treatment system (oxidation pond and constructed wetland) were added to intercept the perpetual drainage expected from the ash, with the intention of reducing contaminant loading to Upper McCoy Branch. A natural wetland which was destroyed during stabilization activities was reconstructed as part of the remedial action. Physical work was completed in March 1997. However, the selected remedy does not satisfy the statutory (CERCLA) preference for treatment, which is to permanently and significantly reduce toxicity, mobility, and volume of the contamination. The preferred outcome is not possible because treatment of the large volume of coal ash at this site was deemed “not practicable”. The ash will remain in place at the site, and surface water will receive limited treatment. Institutional controls will restrict access to the contamination and reduce risk to human health. Actions taken to isolate the ash, restrict animal access, and reduce contaminant migration to surface water should reduce risk to ecological receptors. A recurring five year review will be conducted to verify that the remedy continues to protect human health and, to the extent possible, the environment. EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including lead and mercury (selenium not reported), to surface waters continued through 2009 (179).

Monetized Value of Damage

Ecological: (A) Damage to fish in Upper McCoy Branch during period of extirpation (1967-2006) = 43 years X average standing crop of all species in Lower McCoy Branch X length of stream affected = 43 X 10,500 per km X 1 km = 451,500 individuals lost X $1.00 = $451,500. (B) Added damage cost from local extinction of species = aggregate value (A) X the % of total species represented by one species X number of extirpated species = $451,500 X 6.67% = $30,250 X 15 = $453,757. (C) Damage to fish deformed in Lower McCoy Branch = number of years X number of fish X $1.00 = 3 years (1989-1991) X 40% of standing crop X length of stream affected = 3 X 4,200 X 1 km = 12,600 X $1.00 = $12,600. (D) Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) in Lower McCoy Branch = number of years X 50% of standing crop X length of stream X $0.50 = 21 years (1989-2009) X 5,250 X 1 km X $0.50 = $55,125. (E) Damage to fish deformed in Rogers Quarry = number of years X number of fish X $1.00 = 4 years (1990-1993) X 33% of standing crop X $1.00 = 4 X 3,300 X $1.00 = 13,200 X $1.00 = $13,200. (F) Damage to fish contaminated but not eliminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) in Rogers Quarry = number of years X 50% of standing crop X area affected X $0.50 = 21 X 5,000
per hectare X 7 ha X $0.50 = $367,500. (G) Value of reduced benthic macroinvertebrate communities = area affected X 50% of the value per hectare X percent reduction X number of years = 2 ha X $50,000 X 50% X 6 = $300,000
Total ecological damage value = $1,653,682.00

Recreational: Public utilization of areas other than the coal ash pond is not restricted. Moreover, the “NO HUNTING” signs posted at the coal ash pond do not specify dangers from consumption of contaminated game animals. The contamination in McCoy Branch and Rogers Quarry is known from scientific studies and internal federal reports, but has not been disclosed to the public in popular media outlets. Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, have not occurred.

Real Estate: There is no private ownership of property at this site.

Aesthetic: The contamination at this site is known from scientific studies and internal federal reports, but has not been disclosed to the public in popular media outlets. Therefore, it is not possible to estimate aesthetic value losses, which would be dependent on that knowledge.

Human Health: Concentrations of selenium in muscle tissue of sport fish in 1990-2009 have reached consumption restriction advisory levels (10 parts per million dry weight, or 2.5 parts per million wet weight, 48). However, no advisory has been issued so associated negative human health values could not be calculated. Similarly, the “NO HUNTING” signs posted at the coal ash pond do not specify a threat from contamination. Public lack of knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $1,653,682.00

**Case 11 – Clinch River Plant, VA (American Electric Power)**

Location of Damage: Clinch River

Period of Damage: 1967-1990*
(*Faunal surveys conducted in 1974 found that the fish community remained altered. Populations of mussels remained reduced in 1990, which was the latest reporting year available prior to the initiation of restocking efforts.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: In June 1967, the dike surrounding a fly ash lagoon collapsed, releasing a slug of coal ash slurry into the Clinch River. The release lasted approximately one hour and was equivalent, in volume, to 40% of the daily flow of the river at that time. Free lime
(CaO) in the ash reacted with water in the lagoon to produce a highly alkaline (pH>12) slurry. Thus, the toxicity observed during the release was due to elevated pH rather than high concentrations of metals or other constituents. At least 217,000 fish were killed from acute toxicity in a 106 km stretch of the river. Benthic macroinvertebrates were completely eliminated for a distance of 6 km below the spill site and drastically reduced in number for 124 km below the site. Mollusks (snails and mussels) were eliminated for 18 km below the power plant. Two years after the spill, fish were completely absent for 2 km downstream and the species composition and relative abundance of fish remained altered 8 years later despite extensive stocking (126,500 individuals representing 6 species) to speed recovery. Mollusk populations remained reduced 24 years later, including several threatened and endangered species of mussels.

Scientific Evidence: References 180-191

Corrective Action Taken: The failed dike was repaired and the impoundment remained in service. As of 2005, some of the coal ash was being disposed in a landfill. EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including arsenic and barium (selenium not reported), to surface waters from the Clinch River Plant continued through 2009, which was the latest reporting year available (191).

Monetized Value of Damage

Ecological: (A) Fish killed from acute toxicity = 217,000 X $1.00 = $217,000. (B) Fish lost during 1967-1969 = standing crop X length of river affected X number of years = 15.75 individuals per linear meter X 2,000 meters X 3 = 94,500 individuals X $1.00 = $94,500. (C) Added damage cost from local extinction of species = aggregate value (A+B) X the % of total species represented by one species X number of extirpated species = $311,500 X 6.66 X 15 = $311,500. (D) Mussels killed from acute toxicity = density X length of river affected = 3 per linear meter X 18,000 m = 54,000 X $1.00 = $54,000. (E) Mussels lost during 1967-1969* = density X length of river affected X number of years = 3 per liner meter X 30,000 m X 3 = 270,000 X $1.00 = $270,000. (*Since the coal ash spill occurred prior to 1973, when the federal Endangered Species Act was enacted, no added costs of ESA penalties, which would amount to $3,500 per individual, were added to the damages for mussels). (F) Added damage cost from local extinction of species = aggregate value (D+E) X the % of total species represented by one species X number of extirpated species = $324,000 X 2.44% X 41 = $324,000. (G) Cost of lost mussels during 1970-1990 = pre-pollution density X % reduction in density X length of river affected X number of years X $1.00 = 3 per linear meter X 25% X 30,000 m X 21 X $1.00 = $472,500. (H) Value of lost (6km) and reduced (124 km) benthic macroinvertebrate communities (non-mussels) due to initial spill = area affected X 50% of the value per hectare X percent reduction X number of
years = 124 ha \times 50,000 \times 50\% \times 1 = 3,100,000.  (I) Value of reduced benthic macroinvertebrate communities after the spill due to chronic discharges = area affected \times 50\% of the value per hectare \times percent reduction \times number of years = 3 \text{ ha} \times 50,000 \times 50\% \times 2 = 150,000. 
Total ecological damage value = $4,993,500.00

Recreational:  (A) Value of harvestable-size sport fish lost during 1967-1969 = standing crop \times 20\% \times length of river affected \times number of years \times 1.00 = 15.75 \text{ individuals per linear meter} \times 20\% \times 2,000 \text{ m} \times 3 \times 1.00 = $18,900.  (B) Replacement cost of fish gained through stocking = number of fish \times 1.00 = $126,500.  (C) Lost value from fishing trips not taken during 1967-1969 due to concerns about pollution = 500 angler days per year \times 100 \text{ per day inclusive of meals, gas, bait, tackle, and licenses} = 50,000 \text{ per year} \times 3 \times 150,000.  (D) Lost value of other recreational trips not taken due to stigma of pollution or concerns about health and safety issues (camping, boating, swimming, etc) = 400 recreational days per year \times 100 \text{ per day} \times 3 \times 120,000.
Total recreational damage value = $415,400.

Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of riverfront property owners (in 1970, including 30 km downstream of spill) \times approximate property value \times 5\% depreciation \times number of years of primary pollution impact = 100 \times 250,000 = $25,000,000 \times 5\% = $1,250,000 \times 3 \times 3,750,000.00.

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20\% of population within 30 miles (1970 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 72,458 \times 20\% = 14,492 \times 100 = $1,449,200.

Human Health: (A) Value of unconsumed fish = number of angler days lost during 1967-1969 \times 4 \text{ fish meals per angler day} = 1,500 \times 4 \times 6,000 \times 7.50 \text{ per meal} = $45,000  (B) Losses due to stress and anxiety of knowing ecosystem is polluted, fish and wildlife are poisoned, and public health threatened = assuming 20\% of population within 30 miles (1970 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 72,458 \times 20\% = 14,492 \times 50 = $724,600.
Total human health damage value = $769,600.00

Total Case Damage Value = $11,377,700.00

Case 12 – Bull Run Fossil Plant, TN (Tennessee Valley Authority)

Location of Damage: Melton Hill Reservoir
Period of Damage: 1974-2010*
(*Biological effects studies showed acute toxicity of ash pond seepage to fish in 1974. Monitoring studies showed toxic levels of metals and selenium in fish in 1991-2008. Ash pond effluent and seepage discharge continued in 2010.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated effluent and seepage from coal ash settling ponds was discharged into Upper Melton Hill Reservoir. The effluent discharge was authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. EPA’s Toxics Release Inventory reported that from 1998-2009, the Bull Run Plant discharged 215,483 pounds of contaminants into Melton Hill Reservoir (192). The seepage water was acutely toxic to fish and both the seepage and effluent water contained elevated concentrations of selenium, arsenic, and heavy metals (193). Selenium concentrations were elevated to a toxic threshold (4 parts per million whole-body, dry weight, 24) in some of the fish collected in 1991-2008, and a summary report (196) concluded that the levels of arsenic and selenium in fish warranted further study. Another investigation (194) concluded that “bioaccumulation appears to confirm that exposures to high aqueous concentrations have occurred”. Melton Hill Reservoir consistently receives a poor-to-fair ecological health rating for fish and bottom life (204). Fish productivity, species diversity and abundance are lower than expected for local run-of-the-river impoundments (198-199). Poor health and low productivity have been attributed to (hypothesized but not confirmed) fluctuating water temperatures due to cold tailwater releases from an upstream reservoir (Norris Reservoir), thought to possibly affect reproductive success and growth rate of warm-water fish species. However, this explanation is tenuous since the geographic range of the “warm-water” species in question includes waters in northern states that experience far colder temperatures than Melton Hill Reservoir, with no apparent effect on reproduction or productivity (203). Although detailed physiological and reproductive studies of the effects of coal ash contaminants on fish populations in Melton Hill Reservoir have not been conducted, there are six lines of evidence pointing to long-term detrimental effects: (1) Acute waterborne toxicity in fish exposed to near-shore discharges indicates that high concentrations of coal ash contaminants are entering Melton Hill Reservoir in seepage water and ash pond effluent, which would tend to disperse and accumulate over time, (2) Concentrations of selenium in fish have reached a toxic threshold, which indicates that bioaccumulation of dispersed waterborne contaminants has occurred, (3) The fish community of Melton Hill Reservoir includes several species that are extremely sensitive to coal ash pollutants such as selenium (i.e., centrarchids). These fish could experience negative effects from chronic exposure, reflected in depressed populations, even though other measures of ecosystem health may appear normal, (4) The fish community of
Upper Melton Hill Reservoir, which is the ash pond discharge arm of the lake, received a “poor” health rating whereas other areas of the impoundment received a “fair” or “good” rating (198, 204). (5) The current state permit allows Bull Run Fossil Plant to discharge 19 million gallons of contaminated ash pond effluent into Upper Melton Hill Reservoir each day (210). The volume released is equal to the total daily municipal wastewater discharge from a city of approximately 100,000 people (207-208), and resulted in a loading of over 55,000 pounds of toxic materials to the reservoir in 2009 (selenium not inventoried, 192, 209), and (6) seepage of highly contaminated wastewater from the ash ponds into the reservoir has been a documented, chronic occurrence for the past 37 years (1974-2010, 193, 202, 206).

Scientific Evidence: References 192-211

Corrective Action Taken: Inspections dating back to 1974 indicate persistent seepage of highly contaminated ash pond water through retention dikes along the reservoir (193). These structural failures were addressed with various types of grading and patching, with limited success. As recently as 2008, problematic, uncontrolled seepage continued (200-201). A major new regrading effort was completed in 2010 (206), which included the installation of a French drain under the dike surrounding the gypsum disposal area. This action improves dike integrity by removing seepage but does not reduce the amount of contaminated water reaching Melton Hill Reservoir. Instead, the French drain collects and channels water from diffuse sources into a concentrated discharge stream, which may actually increase contaminant loading to the reservoir. EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including arsenic and zinc (selenium not reported), to surface waters from the Bull Run Plant continued through 2009, which was the latest reporting year available. Releases for 2009 (55,000 pounds) amounted to more than the previous four years combined (192).

Monetized Value of Damage

Ecological: Value of reduced fish populations = standing crop X area affected (upper third of reservoir) X percent reduction X number of years = 12,390 per ha X 738 ha X 10% X 37 = 33,832,134 individuals lost X $1.00 = $33,832,134.

Recreational: The contamination at this site is known from scientific studies and internal state and federal reports, but has not been disclosed to the public in popular media outlets. Moreover, public access has not been restricted. Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, have not occurred. (A) Value of harvestable-size sport fish lost during 1974-2010 = total individuals lost X 20% X $1.00 = 33,832,134 X 20% X $1.00 = $6,766,426.
Real Estate: The contamination at this site is known from scientific studies and internal state and federal reports, but has not been disclosed to the public in popular media outlets. Moreover, public access has not been restricted. Therefore, potential negative impacts on real estate values, which would be dependent on that knowledge, have not occurred.

Aesthetic: Same as for Real Estate

Human Health: Same as for Real Estate. Also, public lack of knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $40,598,560.00

Case 13 – J.R. Whiting Power Plant, MI (Consumers Energy)

Location of Damage: Lake Erie

Period of Damage: 1973-2002*

(*The power plant began discharging ash pond effluent in 1953 but the first contaminant monitoring study was in 1973. The last biological effects assessment was in 1984. It showed contaminated sediments, food-chain, and fish associated with reduced fish and invertebrate populations. Ash pond discharges continued unabated until 2002.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated effluent from coal ash disposal basins was discharged into Lake Erie. These discharges were authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. EPA’s Toxics Release Inventory reported that from 1998-2009, the Whiting Power Plant discharged 73,723 pounds of contaminants into Lake Erie (212,215). Selenium, arsenic, and several trace metals accumulated in sediments, benthic invertebrates and fish. Concentrations of selenium in fish food organisms were above a chronic dietary toxic level (3 parts per million, dry weight, 24). Concentrations of selenium in fish tissues reached 14 parts per million (whole-body, dry weight), which is three and one-half times a toxic threshold (4 ppm, 24). Numbers of benthic invertebrates and fish were reduced in the area near the discharge.

Scientific Evidence: References 212-217

Corrective Action Taken: The electric utility company began to landfill coal ash in 2002. Consequently, release of ash pond effluent was reduced. As of 2009, the coal ash ponds were in the process of being closed. EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including mercury and vanadium (selenium not reported), to
surface waters from the Whiting Plant continued through 2009, which was the latest reporting year available (212).

Monetized Value of Damage

Ecological: Value of reduced aquatic communities = area affected X 50% of the value per hectare X percent reduction X number of years = 2 ha X $50,000 X 50% X 30 = $1,500,000.
Total ecological damage value = $1,500,000.00

Recreational: The contamination at this site is known from scientific studies and internal state and utility company reports, but has not been disclosed to the public in popular media outlets. Moreover, public access has not been restricted. Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, have not occurred. No fish standing crop data were available from which to estimate value of harvestable-size sport fish lost.

Real Estate: Same as for Recreational

Aesthetic: Same as for Recreational

Human Health: Same as for Recreational. Also, no information was available for angler use of the affected area so it was not possible to estimate losses from unconsumed fish. Public lack of knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $1,500,000.00

Case 14 – Mitchell Power Plant, WV (American Electric Power)

Location of Damage: Connor Run Creek

Period of Damage: 2005-2010*
(*The power plant began discharging ash effluent in 1971 but no biological monitoring was conducted until 2005-2007. No biological effects studies have been done. Discharge of ash pond effluent continued unabated in 2010.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Contaminated effluent from coal ash disposal basins was discharged into Connor Run Creek, which empties into Fish Creek and then the Ohio River. These discharges were authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. EPA’s Toxics Release Inventory reported that during 1998-2009, the Mitchell Plant discharged 4,302 pounds of contaminants into surface waters
In addition to ash pond effluent, seepage through ash pond retention dikes also entered Fish Creek and the Ohio River but there has been no reported biological monitoring of these receiving waters. The trace element selenium bioaccumulated in fish to concentrations up to 30 parts per million (average = 26 ppm, 60). These levels are over 7 times the toxic threshold for fish (4 ppm whole-body, dry weight, 24), and have caused selenium poisoning and reproductive failure in sensitive species (centrarchids) in coal-ash impacted streams at other locations in West Virginia (51-53). The West Virginia Department of Environmental Protection has classified Connor Run as a fly ash influenced stream (60). Concentrations of selenium in muscle tissue of sport fish exceed West Virginia’s consumption restriction advisory levels (10 parts per million dry weight, or 2.5 parts per million wet weight, 48). However, no advisory has been issued.

Scientific Evidence: References 51-53, 60, 218-220

Corrective Action Taken: No action has been taken despite elevated selenium concentrations indicative of toxic impacts. The West Virginia Department of Environmental Protection has issued a variance in the water quality standard for Connor Run, raising it from the USEPA national criterion value of 5 ug/L to a permissible level of 62 ug/L (220). This action was not approved by EPA, nor was it based on a site-specific standard development process that included supporting biological studies. EPA’s Toxics Release Inventory reported that substantial discharges of contaminants, including barium and lead (selenium not reported), to surface waters from the Mitchell Plant continued through 2009, which was the latest reporting year available (218).

Monetized Value of Damage

Ecological: Value of fish contaminated in Connor Run = length of stream X standing crop X 100% X number of years X $0.50 = 610 m X 10.2/ m (estimated from other WV coal-ash influenced streams, 49-53) = 6,222 X 100% X 6 = 37,332 individuals X $0.50 = $18,666.

Recreational: The contamination at this site is known from internal state and utility company reports, but has not been disclosed to the public in popular media outlets. Moreover, public access has not been restricted. Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, have not occurred.

Real Estate: Same as for Recreational.

Aesthetic: Same as for Recreational
Human Health: Concentrations of selenium measured in muscle tissue of sport fish in 2005-2007 exceeded West Virginia’s consumption restriction advisory levels (10 parts per million dry weight, or 2.5 parts per million wet weight, 48). However, no advisory has been issued so associated negative human health values could not be calculated. Also, public lack of knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $18,666.00

**Case 15 – Bowen Power Plant, GA (Georgia Power)**

Location of Damage: Euharlee Creek and a tributary stream


Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: On July 28, 2002, a sinkhole developed in the coal ash disposal pond causing the release of 2.25 million gallons of ash slurry (containing 281 tons of ash) into an unnamed tributary of Euharlee Creek. Ash deposits blanketed approximately 2,500 linear feet of the stream and flowed onto adjacent private property. Approximately 80 tons of ash entered Euharlee Creek through a stormwater drainage pipe, resulting in deposition of an ash blanket up to 8 inches deep over some 1,850 square feet of the stream bottom. Two weeks after the spill, concentrations of arsenic, cadmium, chromium, copper, lead, mercury, and nickel in Euharlee Creek were found to exceed EPA’s ecological screening values, indicating a high potential for toxic impacts to aquatic life. Sediment concentrations of arsenic were measured at 14 ppm dw, a level that is over 5 times the toxic threshold. Biological sampling indicated that benthic organisms in the tributary and ash deposition zone of Euharlee Creek were either killed by contaminants or physically smothered. The resident fish community, which consisted of at least 25 species, was displaced due to the irritation of high turbidity in the ash plume as it moved through during the spill event. One month after the spill, concentrations of selenium and cadmium were elevated in crayfish, clams, mollusks, and insects at a downstream site in Euharlee Creek. A second spill occurred following a heavy rain event on September 9, 2008, when a portion of the ash stack in the Bowen Plant ash pond eroded and flowed over the ash pond dike. Approximately 40 tons of ash left plant property and flowed onto nearby residential property, and about 2 tons of ash entered Euharlee Creek. For each of the spills, the Georgia Department of Natural Resources imposed a fine for ecological damage to Euharlee Creek.

Scientific Evidence: References 221-232
Corrective Action Taken: The sinkhole in the ash pond was repaired and ash deposits in Euharlee Creek were removed by suction dredging in 2002. As of 2005, some coal ash from the Bowen Plant was being disposed in a landfill. Following the 2008 spill, ash was removed from residential properties within 30 days but was never removed from Euharlee Creek. EPA’s Toxics Release Inventory reported that separate and apart from the spills, the Bowen Plant released 210,337 pounds of contaminants into surface waters from 1998-2009 (232). There was a 20-fold increase in selenium discharges during 2007-2009 (150 to 3,200 pounds).

Monetized Value of Damage

Ecological: Value of aquatic benthic community extirpation and fish community impairment and dislocation = area affected X value per hectare X number of years = 1 hectare X $100,000 X 2 = $200,000.

Recreational: Lost value from fishing trips not taken due to stigma of pollution = 100 angler days X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $10,000.

Real Estate: Depreciated value due physical damage (ash deposition) and stigma of environmental pollution = approximate number of creekfront property owners (in 2002) X approximate property value X 5% depreciation X number of years = 10 X $250,000 = $2,500,000 X 5% X 2 = $250,000.

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (2000 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 188,557 X 20% = 37,711 X $100 = $3,771,100.

Human Health: Losses due to stress and anxiety of knowing ecosystem is polluted, property damaged, and aquatic communities are poisoned = assuming 20% of population within 30 miles (2000 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 188,557 X 20% = 37,711 X $50 = $1,885,550.

Total Case Damage Value = $6,116,650.00

Case 16 – Jim Bridger Power Plant, WY (Pacific Power)

Location of Damage: Wastewater disposal ponds

Period of Damage: 1992-2010

Source of Damage: Surface impounded Flue Gas Desulfurization (FGD) wastewater
Cause and Extent of Damage: FGD water was disposed in two large ponds comprising about 190 hectares in total surface area. The ponds were not subject to regulation under the federal-state National Pollutant Discharge Elimination System because they were on utility company property and did not discharge to state waters. The pond water contained high concentrations of dissolved salts, which formed a crust on the feathers of waterbirds that came in contact with it, destroying their insulation and buoyancy. Affected birds either died from hypothermia or drowned due to accumulation of minerals on their feathers. In addition to physical effects, the amount of salts in brain tissue was elevated above toxic levels within three hours after birds arrived on the ponds. An average of 84 birds died annually from 1992-1996, and 20 per year from 1997-2010.

Scientific Evidence: References 233-237

Corrective Action Taken: In 1992, Pacific Power was notified by the US Fish and Wildlife Service of their liabilities for wildlife damage under the Migratory Bird Treaty Act (MTBA), which prohibits killing of migratory birds. From 1992-1996, utility personnel used boats to rescue wildlife that entered the water and was unable to escape. Captured birds were cleaned of the chemical precipitate and returned to the wild. An elaborate hazing program was initiated in 1997, including loud speakers (acoustic alarm calls), pyrotechnics, chemical repellents (bird tear gas), round-the-clock radar detection/activation, and human surveillance during daylight hours to deter wildlife use. Despite these measures, some birds still utilize the FGD ponds and some die due to the salt accumulation. Moreover, resident species nest in an adjacent freshwater pond (e.g., 140 eared grebe nests documented in a site visit in 2000), some only meters away from the contaminated habitat.

Monetized Value of Damage

Ecological: (A) Value of migratory birds lost before hazing (1992-1996) = average number killed per year X number of years X value per bird = 84 X 5 X $10,000 (MBTA fine, 233) = $4,200,000.
(B) Value of migratory birds lost after hazing (1997-1998) = average number killed per year X number of years X value per bird = 20 X 2 X $10,000 (MBTA fine for 1997-1998) = $400,000.
(C) Value of migratory birds lost after hazing (1999-2010) = average number killed per year X number of years X value per bird = 20 X 12 X $15,000 (MBTA fine for 1999-2010, 237) = $3,600,000.
(D) Cost of wildlife surveillance and rescue from 1992-2010 = number of personnel X hours per day X number of days per year X number of years X cost per hour = 4 people (two 2-person teams) X 4-hr per day X 245 days (non-migration season) + 8-hr per day X 120 days (migration season) X 19 years X $25 per hour = 4 X 980 + 960 X 19 X $25 = $3,686,000.
(E) Cost of initial wildlife hazing system = material components + installation and placement + power sources = $250,000 + $120,000 + $5,000 = $375,000.
(F) Cost of operation of wildlife hazing
system = replacement of expendable components (pyrotechnics, gas, etc.) + annual skilled labor maintenance + annual skilled labor operation \( \times \) number of years = $25,000 + $60,000 + $60,000 \times 14 = $2,030,000.

Total ecological damage value = $14,291,000.

Recreational: There is no public recreational access to these sites.

Real Estate: There is no private ownership of land bordering affected waters.

Aesthetic: The contamination and mortality of waterbirds at this site is known from internal federal and utility company reports, but has received very limited disclosure to the public in popular media outlets. Therefore, it is not possible to provide a reasonable estimate of the potential negative impacts on aesthetic values, which would be dependent on that knowledge.

Human Health: Access to this site is restricted so there are no human health impacts associated with direct contact or consumptive use. Off-site movement of contaminated waterfowl, and subsequent harvesting/consumption is a possibility, but is not quantifiable with available information. Also, the public’s lack of knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $14,291,000.00

**Case 17 – Martins Creek Steam Electric Station, PA (Pennsylvania Power and Light)**

Location of Damage: Delaware River

Period of Damage: 2005-2006

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: A leak developed in one of the fly ash settling basins at the Martins Creek Station on August 23, 2005. Wooden stop logs holding back water in the 16 hectare basin breached, allowing a discharge of fly ash slurry over land through a dry creek bed and into the Delaware River. There was no gate valve or built-in control structure and it took 4 days for the utility company to stop the flow. By that time, 380 million liters of contaminated water and fly ash was released into the Delaware River, covering the bottom and banks for approximately 2.4 km downstream. Monitoring indicated that waterborne concentrations of arsenic, aluminum, copper, iron, manganese, and silver exceeded EPA water quality criteria (EPA rule doc), prompting the city of Easton, PA, the closest downstream water user, to shut down its water intake and impose water use restrictions. The levels of waterborne contaminants were also above toxicity thresholds for sensitive aquatic invertebrates (Cherry,
and 242). Immediate impacts were dramatic. At least 20 species of fish were dislocated from the spill zone and benthic invertebrates were smothered or poisoned from ash-related contaminants. In the longer term (6-12 months), suction dredging activities resuspended ash, exacerbated fish dislocation, and removed benthic invertebrates from the river bottom. Four years after the spill, concerns were expressed over possible long-term impacts to anadromous American shad...... “The shad fry that were migrating to the sea during the spill have yet to return to the Delaware to spawn. The ash may have clogged their gills, killing them by the time they reached the ocean. The effect of losing a good portion of one year’s class of shad can have a huge ripple effect for this species” (249). Although Pennsylvania Fish and Boat Commission reports show a precipitous decline in returning shad in years following the spill (250), no follow-up biological studies have been done. From August 2005-April 2006, the boating access ramp on the Delaware River at the Martins Creek site was closed to the public.

Scientific Evidence: References 238-250

Corrective Action Taken: Pennsylvania Power and Light used contractors to remove fly ash from the river bottom (suction dredge) and other impacted areas (the dry bed of Oughoughton Creek). Those efforts were completed in 2006. A new stop-log assembly made of steel-reinforced concrete was installed along with two shutoff valves. In 2007, the two coal-fired units at Martins Creek were permanently taken out of service. The ash basin was closed and covered with a geosynthetic membrane to seal it and reduce infiltration of water. Final reclamation will consist of a soil cap layer and vegetation. The Pennsylvania Department of Environmental Protection fined the utility company for polluting the Delaware River.

Monetized Value of Damage

Ecological: Value of aquatic benthic community extirpation and fish community impairment and dislocation = area affected X value per hectare X number of years = 37 hectares X $100,000 X 2 = $7,400,000.

Recreational: (A) Lost value of fishing trips not taken due to lack of public boat ramp access or stigma of pollution = 4,800 angler days per year (average of 100 angler days per week X 48 weeks) X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $480,000 per year X 2 years = $960,000. (B) Lost value of other recreational trips (boating, swimming, camping) not taken due to concerns about health and safety issues = 100 recreational days per week X 48 weeks X $100 per day = $480,000 per year X 2 years = $960,000.

Total recreational damage value = $1,920,000.
Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of riverfront property owners (in 2005) X approximate property value X 5% depreciation X number of years = 100 X $250,000 = $25,000,000 X 5% X 2 = $2,500,000.

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (2000 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 654,171 X 20% = 130,834 X $100 = $13,083,400.

Human Health: Losses due to stress and anxiety of knowing ecosystem is polluted, property damaged, and aquatic communities are dislocated and poisoned = assuming 20% of population within 30 miles (2000 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 654,171 X 20% = 130,834 X $50 = $6,541,700

Total Case Damage Value = $31,445,100.

**Case 18 – Glen Lyn Plant, VA (American Electric Power)**

Location of Damage: Adair Run

Period of Damage: 1978-1981*

(*There have been no biological effects studies since 1981 but coal waste was discharged to surface waters through 2008, according to EPA’s Toxics Release Inventory.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: From 1978-1980, effluent from a fly ash settling pond was discharged into Adair Run, a second-order tributary of the New River, under permits issued as part of the federal-state National Pollutant Discharge Elimination System. The effluent contained high pH (up to 9.5), total suspended solids (102 mg/L), cadmium (90 ug/L), chromium (70 ug/L) zinc (73 ug/L), arsenic (110 ug/L) and selenium (85 ug/L). Populations of benthic macroinvertebrates and fish were dramatically reduced during the period of ash pond discharge, as were microbial measures of aquatic ecosystem function and overall health. No biological studies were conducted on the New River or East River, which continued to receive effluent from heavy (bottom) ash disposal basins. EPA’s Toxics Release Inventory reported that 21,587 pounds of toxic contaminants were discharged into surface waters at the Glen Lyn Plant from 1998-2008 (261).

Scientific Evidence: References 251-266

Corrective Action Taken: The fly ash pond began operation in 1978, was rapidly filled, and ceased operation in 1980 due to ineffective settling of ash (not because of aquatic impacts). Fly
ash was then disposed in heavy ash ponds and a landfill on utility company property. As of 2005, the on-site landfill was nearly full and most of the ash was being hauled away for disposal at a mine site in West Virginia. In 2007, a new off-site landfill was constructed nearby in Giles County, VA. Promoted as a community development project called Cumberland Park, the landfill is located in the floodplain of the New River and is unlined because it is technically classified as a structural fill (a beneficial use designation) rather than a waste disposal landfill, and is thereby exempt from liner requirements (262). The fill raises grade by 30 feet, making it level with a nearby highway, and will provide a “prime 7+ acre building site suitable for hotel, light industry, and/or retail businesses” (264). The fill contains approximately 100,000 cubic yards of ash hauled by truck from the plant, and was completed in November 2010. Risks of long-term contamination at this site are evident. Coal ash from the Glen Lyn Plant is known to leach arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver at concentrations that are as much as 500 times the toxic threshold for aquatic life (24, 260). Ash placement began in 2008 and monitoring during 2008-2009 showed marked increases in concentrations of boron, chromium, and mercury (260, 263), suggesting that leaching of coal ash contaminants into groundwater has already begun. The New River, which is hydrologically down-gradient, lies only 100 meters away. It is classified as a “national scenic river” by the US National Park Service in recognition of its “outstandingly remarkable” fish and wildlife communities (256). EPA’s Toxics Release Inventory reported that as recently as 2008, substantial discharges of contaminants, including arsenic and barium (selenium not reported), to surface waters was occurring at the Glen Lyn Plant (261).

Monetized Value of Damage

Ecological: Value of reduced fish and benthic communities = area affected X 50% of value per hectare X percent reduction X number of years = 1 hectare X $50,000 X 80% X 4 = $160,000.

Recreational: The impacted section of Adair Run is on utility company property and there is no recreational use at this site.

Real Estate: There is no private ownership of property at this site.

Aesthetic: The contamination at this site is known from scientific studies and internal federal reports, but has not been disclosed to the public in popular media outlets. Therefore, it was not possible to estimate aesthetic value losses, which would be dependent on that knowledge.

Human Health: There is no consumptive use at this site. Lack of public knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $160,000.00
Case 19 – Columbia Energy Center, WI (Alliant Energy)

Location of Damage: Rocky Run Creek

Period of Damage: 1978-1980*
(*No biological studies were conducted in Rocky Run Creek after 1980 but direct discharges to surface water continued through 2004 according to EPA’s Toxics Release Inventory. Monitoring showed that movement of polluted groundwater beneath the ash pond was transporting contaminants into off-site wetlands in 1984. No biological studies have been conducted at these wetlands or in the Wisconsin River, which received drainage from the wetlands and Rocky Run Creek.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: Beginning in 1975, ash pond effluent was released into Rock Run Creek, a third-order tributary of the Wisconsin River, under permits issued as part of the federal-state National Pollutant Discharge Elimination System. The effluent contained high suspended solids and metals, which polluted Rocky Run Creek with cadmium, chromium, barium, aluminum and copper (arsenic and selenium were not measured). Populations of benthic macroinvertebrates and fish were dramatically reduced for at least 3.5 km downstream, as were microbial measures of aquatic ecosystem function and overall health. Some species of macroinvertebrates were totally eliminated. Crayfish exhibited markedly elevated tissue concentrations of selenium, zinc, and iron as well as impaired metabolic rates in areas below the discharge. EPA’s Toxics Release Inventory reported that from 1998-2004, the Columbia Energy Center released 5,362 pounds of contaminants into surface waters (276).

Scientific Evidence: References 267-277

Corrective Action Taken: The power plant modified its waste treatment process to improve effluent quality from the ash ponds in 1979 and some recovery of the benthic macroinvertebrate community occurred in 1980, although total numbers remained reduced and community composition was altered. As of 2010, coal ash was being disposed in a landfill, and discharges to surface water were probably reduced. However, EPA’s Toxics Release Inventory indicates that Alliant Energy did not report its releases to surface water from the Columbia site after 2005 (276). A 1984 study revealed that polluted groundwater containing elevated concentrations of boron, sodium, and sulfate was moving off-site and into wetlands adjacent to the Wisconsin River (272). Boron and sulfate are known tracers of CCW-associated groundwater pollution (273), and elevated sodium was attributed to Na₂CO₃ used to condition fly ash to enhance sulfate removal from flue gas (272). A 2004 report showed that arsenic, selenium, lead, and manganese were leaching at concentrations toxic to aquatic life (273).
Selenium, in particular, poses a high bioaccumulation hazard in wetlands (24). Although the ash ponds are now closed, they are unlined and continue to leach contaminants into groundwater (265). Collectively, this information indicates that a significant legacy pollution risk to fish and wildlife exists at the Columbia Energy Center site. The affected wetlands have been identified as a key natural resource feature of lower Rocky Run Creek and the Wisconsin River (274).

Monetized Value of Damage

Ecological: Value of reduced fish and benthic communities = area affected X 50% of value per hectare X percent reduction X number of years = 2 hectares X $50,000 X 80% X 3 = $240,000.

Recreational: The contamination of Rocky Run Creek is known from scientific studies and internal state and federal reports, but was not disclosed to the public in popular media outlets. Moreover, public access was not restricted. Therefore, potential negative impacts on recreational use, which would be dependent on that knowledge, did not occur.

Real Estate: Same as for Recreational

Aesthetic: Same as for Recreational

Human Health: Same as for Recreational. Also, lack of public knowledge of contamination prevented estimation of stress and anxiety value losses.

Total Case Damage Value = $240,000.00

Case 20 – Widows Creek Fossil Plant, AL (Tennessee Valley Authority)

Location of Damage: Widows Creek

Period of Damage: 2009-2010*
(*No biological effects studies were conducted after 2009. However, a consumption restriction advisory for mercury contamination in fish was issued in 2010.)

Source of Damage: Surface impounded flue gas desulfurization (FGD) waste and coal ash

Cause and Extent of Damage: On January 9, 2009 the cap on a discharge control pipe failed, causing an unintended release of approximately 5,000 cubic yards of FGD slurry into Widows Creek, a third-order tributary of the Tennessee River. Some of the material also made its way into the Tennessee River as well, but the volume was not estimated. The primary impact zone was a “triangle area” of relatively shallow water adjacent to a settling pond, where most of the slurry entered the creek. The waste contained elevated concentrations of metals, including mercury (282), and other trace elements such as selenium and arsenic. The spill blanketed
about 6 hectares of creek bottom, smothering and poisoning benthic macroinvertebrates (278), and dislocating the resident fish community. Concentrations of mercury were elevated above consumption advisory levels in fish (286).

Scientific Evidence: References 278-287

Corrective Action Taken: TVA undertook a cleanup action that included suction dredging of the creek bottom in the affected area. Remaining benthic organisms were removed in the process. Resuspension of contaminated sediments occurred (attempts were made to minimize downstream impacts by deploying silt fences) as well as continued dislocation of resident fish. Dredging operations were completed by the end of 2009. There was no subsequent biological monitoring of Widows Creek to determine the rate or degree of recolonization by aquatic fauna. In 2010, the Alabama Department of Public Health issued a consumption restriction advisory for mercury contaminated fish in Widows Creek in and near the “triangle area” (286). EPA’s Toxics Release Inventory reported that from 1998-2009, the Widows Creek Plant discharged 1,053,173 pounds of contaminants, including arsenic and zinc, into surface waters (selenium not reported, 287). Ash and FDG ponds are the only disposal method currently in use. Releases of effluent to the Tennessee River are permitted through the National Pollutant Discharge Elimination System. There have been no biological studies to ascertain possible chronic effects of the releases on aquatic life in Widows Creek or the Tennessee River.

Monetized Value of Damage

Ecological: Value of aquatic benthic community extirpation and fish community impairment and dislocation = area affected X value per hectare X number of years = 6 hectares X $100,000 X 1 = $600,000.

Recreational: Lost value of fishing trips not taken due to concerns about pollution = 10 angler days per week X 48 weeks X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $48,000 per year X 2 years = $96,000.

Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of creekfront property owners (in 2010) X approximate property value X 5% depreciation X number of years habitat polluted and public health fish consumption advisories in effect = 10 X $250,000 = $2.500,000 X 5% = $125,000 X 2 years = $250,000.

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (2000 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 96,791 X 20% = 19,358 X $100 = $1,935,800.
Human Health: (A) Value of unconsumed fish = number of angler days during the period of state-issued consumption restriction advisory (480 angler days per year X 1 year X 4 fish meals per angler day – number of meals allowed (limit of 1 meal per month per adult non-reproductive woman, no consumption for children and reproductive women (286), subtract 12 for each non-reproductive female adult) X $7.50 per meal = 480 X 4 = 1,920 (two adults and two children per family) – 240 = 1,680 X $7.50 = $12,600. (B) Losses due to stress and anxiety of knowing ecosystem is polluted and public health threatened = assuming 20% of population within 30 miles (2000 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 96,791 X 20% = 19,358 X $50 = $967,900. 

Total human health damage value = $980,500.00

Total Case Damage Value = $3,849,700.00

Case 21—Hatfield’s Ferry Power Station, PA (Allegheny Energy)

Location of Damage: Little Whiteley Creek and tributaries

Period of Damage: 2005-2010*

(*Untreated discharges to Little Whiteley Creek began in 1984. As of 2001, all discharges received primary treatment (settling pond) and secondary wetland treatment. Biological effects studies were conducted only in 2005; discharges continued in 2010.)

Source of Damage: Landfilled coal ash and FGD sludge

Cause and Extent of Damage: The Hatfield’s Ferry CCW landfill was permitted as a 40-acre unlined disposal site in May, 1984. Although unlined, the landfill did have an under-drain system to remove CCW leachate and groundwater from the coal ash. From 1984 until 2001, this wastewater was directed, without any treatment, to an earthen impoundment, and then discharged into an unnamed tributary of Little Whiteley Creek, which is a third-order stream that empties into the Monongahela River. Allegheny Energy began operating a passive wetland treatment system for CCW leachate in Spring 2001. The wetland treatment system was designed to remove or reduce concentrations of iron, aluminum, manganese, and total suspended solids and to control pH, but was not specifically designed to treat other problematic constituents in CCW leachate. In addition to coal ash, the landfill began receiving FGD sludge from the Hatfield Plant in 2007. Monitoring during 2002-2006 indicated that elevated concentrations of aluminum, boron, manganese, molybdenum, and thallium were being discharged from the wetland treatment system and were contaminating Little Whiteley Creek and four unnamed tributaries, all of which have designated use as warm water fishery habitat (290, 293-294). A biological study in 2005 found sharply reduced populations of benthic macroinvertebrates in locations with the highest metals concentrations (289). Some sections of
the streams exhibited “concreted bottoms” due to deposition of chemical compounds. The report concluded that conditions in these streams were indicative of “polluted water and disturbed habitat”.  

Scientific Evidence: References 288-295

Corrective Action Taken: The Pennsylvania Department of Environmental Protection (PADEP) determined that CCW leachate discharges were causing exceedances of the effluent limitations in the NPDES permit for the landfill. The PADEP issued a Consent Order and Agreement in March 2008 because of continued violations of aluminum, manganese, and thallium NPDES effluent limits from November 2003 to August 2007 associated with the wetland treatment system (there are no permit limits for selenium). As of October 2009, the landfill had been expanded by 106 acres (Phase 3) and the addition has a composite liner system designed to reduce leachate to shallow groundwater, and a lined leachate storage impoundment. The older Phase 1 and 2 sections of the landfill have been closed. Leachate from the entire landfill is still being treated using the passive wetland treatment system. The effectiveness of these measures in meeting NPDES permit limits are unclear, and will be understood only through continued chemical and biological monitoring of the Hatfield site. EPA’s Toxics Release Inventory reported a 10-fold increase in the amount of contaminants released into surface waters at the Hatfield Plant from 2002-2009 (295).

Monetized Value of Damage

Ecological: Value of reduced benthic macroinvertebrate communities = area affected X 50% of value per hectare X percent reduction X number of years = 5 hectares X $50,000 X 50% X 6 = $750,000.

Recreational: Lost value of fishing trips not taken due to concerns about pollution = 10 angler days per week X 48 weeks X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $48,000 per year X 2 years (public recognition of pollution was primarily after 2008) = $96,000.

Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of creekfront property owners (in 2010) X approximate property value X 5% depreciation X number of years habitat polluted = 3 X $250,000 = $750,000 X 5% = $37,500 X 2 years = $75,000.

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (2000 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 168,871 X 20% = 33,774 X $100 = $3,377,400.
Human Health: Losses due to stress and anxiety of knowing ecosystem is polluted and aquatic ecosystem health threatened = assuming 20% of population within 30 miles (2000 census) expresses strong negative sentiments when seeing or reading news stories describing damage = 168,871 X 20% = 33,774 X $50 = $1,688,700.

Total Case Damage Value = $5,987,100.00

**Case 22 – Kingston Fossil Plant, TN (Tennessee Valley Authority)**

Location of Damage: Upper Watts Bar reservoir

Period of Damage: 1999-2010*

(*Monitoring and toxicity studies indicated that pollution from permitted discharges was detrimentally affecting fish and invertebrates as early as 1999 but the extent and severity of impacts was not assessed. Concentrations of selenium in fish, and arsenic and selenium in sediments, remained above a toxic threshold in 2010. Long-term biological studies will continue to determine residual impacts of the 2008 ash spill on aquatic life.)

Source of Damage: Surface impounded coal ash

Cause and Extent of Damage: On December 22, 2008 an ash pond retention dam broke, releasing approximately 1.1 billion gallons (4.1 million cubic meters) of ash and slurry water. This was by far the largest spill of CCW ever recorded. About 90% of the release went into the Emory River, inundating the channel with up to 10 meters of ash for a distance of over 6 km. Ash made its way into the Clinch River, which joins with the Emory downstream, and was also found 16 km downstream in the Tennessee River, which joins with the Clinch. Together, the three rivers form the upper end of Watts Bar Reservoir. It was estimated that the initial ash flow into the Emory River contained about 3,830 tons of the 10 most toxic elements present in fly ash. The spill’s immediate impact killed approximately 5,000 fish, although unknown numbers were stranded or buried under as much as 10 meters of ash. Birds, mammals, amphibians, and reptiles were exposed to toxic ash in the spill area and sluice pond, and some were killed (306). Mussels and other benthic macroinvertebrates were smothered. At least 33 hectares of aquatic ecosystems in an embayment area were completely destroyed during the initial release (320). Eighteen days after the spill, concentrations of arsenic, barium, cadmium, lead, and selenium were elevated above state and federal water quality standards in the immediate spill zone. Levels of arsenic and selenium were elevated above toxic thresholds in river sediments for a distance of at least 4.8 km downstream, and fish tissues contained toxic concentrations of selenium (above 4 mg/kg whole-body, dry weight, 24) in this zone (303). At least 23 fish species were dislocated from a 95 hectare area around the spill and those that were collected outside that zone had ingested ash and showed signs of stress such as abrasions...
and discolored gills. Closer analysis revealed pathological changes in gill tissue consistent with toxic exposure to ash (303). Seven months following the spill, all fish collected had concentrations of selenium above a toxic threshold (303), and most were still contaminated at that level 14 months after the spill (323). Ash-laden sediments were toxic to mussels and other benthic macroinvertebrates (307). Eighteen months after the spill, concentrations of arsenic in sediment pore waters were over 10 times the toxic level for sensitive benthic invertebrates at sites 12 km downstream (297, 302, 327). Twenty-one months after the spill, a high percentage of fish exhibited symptoms of “very extreme stress [lesions, deformities, infections] which you would expect with an event like this” (333). The Tennessee Department of Health and the Tennessee Department of Environment and Conservation (TDEC) issued a recreation advisory for Watts Bar Reservoir in June 2009, warning the public against boating, swimming, and fishing in the Emory River section of the reservoir (311), and restated a consumption advisory for mercury contaminated fish (331-332). Prior to the spill, EPA’s Toxics Release Inventory reported that from 1998-2007, the Kingston Fossil Plant discharged 615,948 pounds of contaminants into surface waters (329). In 2008, the year of the spill, 2,765,700 pounds were released into surface water. In the year following the spill an additional 49,080 pounds were discharged, as the operation of the power plant continued uninterrupted. With the exception of the spill, these discharges were authorized by permits issued through the federal-state National Pollutant Discharge Elimination System. Fish tissue sampling conducted upstream of the spill zone revealed contaminant levels indicative of legacy pollution from previous, permitted discharges that took place prior to the spill (305, 310). As of October 11, 2010, the NPDES permit for the Kingston Fossil Plant did not contain effluent limits for 16 primary toxic elements, including arsenic, mercury and selenium (330), despite prior, persistent toxicity of discharges to fish and invertebrates (298). The NPDES permit for the period 2004-2008 stated that “The discharge from Outfall 002 may contain several different pollutants, the combined effect of which has a reasonable potential to be detrimental to fish and aquatic life”…….“As presented with the TVA’s permit application, fish survival [1999-2003] has been problematic in Outfall 002 and the Emory and/or Clinch River”. The permit was renewed without modification or establishment of discharge limits for the 16 primary toxic elements.

Scientific Evidence: References 296-340

Corrective Action Taken: A massive federal effort was implemented to remove ash from upland and aquatic areas (318-320, 325-326). The aquatic portion of cleanup is to be done in 3 phases: (1) suction dredging of 62 hectares of river channel and transport of ash by rail to a landfill disposal site in Alabama (completed), (2) excavation and/or dredging of 33 hectares of embayment area and on-site disposal at the Kingston Fossil Plant, and (3) excavation and/or suction dredging of 20 hectares of perimeter areas and on-site disposal at the Kingston Plant.
Phase 2 and 3 operations will continue until 2014, and TVA acknowledges that despite the effort, a large amount of ash will remain in the rivers and resuspended ash will move further downstream (325, 335). Following Phase 1 ash removal, immigration facilitated recovery of fish populations (abundance and diversity but not necessarily health) but benthic macroinvertebrates remained reduced, even in areas outside the dredge zone (326). Efforts to clean and restore upland areas have been more successful but were still incomplete as of December 2010. The ash disposal cell that failed and the adjacent ash pond are to be closed and a new disposal cell constructed to receive remaining ash from the cleanup. These efforts are projected to take up to 4 years to complete (340). Future ash generated by the power plant is to be wet sluiced from the plant to a processing area, dried and prepared for off-site disposal in a landfill (335). There has been no modification of NPDES permit requirements to address legacy and non-spill pollution issues. The Tennessee Department of Environment and Conservation fined TVA for violating state environmental laws.

Monetized Value of Damage

Ecological:  (A) Value of fish killed during initial spill = 5,000 X $1.00 = $5,000.  (B) Value of fish displaced during initial spill = standing crop per hectare (mean of 1970-1992 for Chickamauga Reservoir, 296, which is adjacent and has same ecological trophic status and species composition) X area affected – number killed X $0.50 = 29,538 X 62 ha – 5,000 X $0.50 = $1,826,356.  (C) Value of fish displaced during river dredging operations = half the standing crop per hectare X area X $0.50 = 14,769 X 62 ha X $0.50 = $457,839.  (D) Value of fish contaminated (individuals with tissue selenium exceeding toxic effects threshold of 4 ppm) during 2009-2010 = half standing crop X area X $0.50 = 14,769 X 62 ha X $0.50 = $457,839.  (E) Value of aquatic ecosystems destroyed inside Swan Pond embayment = area X value per hectare X number of years = 33 ha X $100,000 X 2 = $6,600,000.  (F) Value of benthic macroinvertebrate communities destroyed outside embayment during initial spill = area X half the value per hectare = 62 ha X $50,000 = $3,100,000.  (G) Value of benthic macroinvertebrate communities reduced during river dredging operations = area X half the value per hectare X percent reduction = 62 ha X $50,000 X 50% = $1,550,000.  (F) Value of shoreline and upland habitat destroyed (covered with ash) during initial spill = area X value per hectare X 1 year = 10 ha X $100,000 X 1 = $1,000,000.

Total ecological damage value = $14,997,034.

Recreational:  (A) Value of harvestable sport fish killed or displaced during initial spill = standing crop of harvestable fish X area X $1.00 = 1,728 per hectare X 95 ha X $1.00 = $164,160.  (B) Value of harvestable sport fish displaced during dredging operations = half the standing crop per hectare X area X $0.50 = 864 X 62 ha X $0.50 = $26,784.  (C) Lost value of fishing trips not
taken due to recreational advisory and concerns about pollution = 9600 angler days per year (average of 200 angler days per week X 48 weeks) X $100 per day inclusive of meals, gas, bait, tackle, and licenses = $960,000 per year X 2 years = $1,920,000. (D) Lost value of other recreational trips (boating, swimming, camping) not taken due to recreational advisory and concerns about health and safety issues = 200 recreational days per week X 48 weeks X $100 per day = $960,000 per year X 2 years = $1,920,000.

Total recreational value damage = $4,030,944.00

Real Estate: Depreciated value due to stigma of environmental pollution = approximate number of lakefront property owners near spill (in 2010) X approximate property value X 5% depreciation X number of years lake polluted = 100 X $250,000 = $25,000,000 X 5% = $1,250,000 X 2 years = $2,500,000 (This number does not include $46,139,375 in damages reported by TVA through July 2010 for direct impacts of ash deposited onto private property).

Aesthetic: Intrinsic value to non-sportsmen/recreators = assuming 20% of population within 30 miles (2000 census) believe degradation of individual non-use values equals $100 or more for scenic and posterity considerations = 245,307 X 20% = 49,061 X $100 = $4,906,100.

Human Health: (A) Value of unconsumed fish = number of angler days lost during 2009-2010 X 4 fish meals per angler day = 19,200 X 4 = 76,800 X $7.50 per meal = $576,000. (B) Losses due to stress and anxiety of knowing ecosystem is polluted, fish and wildlife are poisoned, and public health threatened = assuming 20% of population within 30 miles (2000 census) expresses strong negative sentiments when viewing or reading news stories describing damage = 245,307 X 20% = 49,061 X $50 = $2,453,050.

Total human health damage value = $3,029,050.00

Total Case Damage Value = $29,463,128.00

Grand Total Damage Value for all 22 Cases = $2,321,258,053.00

Discussion

Regulatory implications

Surface impoundment of CCW is widely practiced, accounting for about 21% of current disposal facilities, or some 629 impoundments (341-342). However, less than 5% of these have undergone detailed biological evaluation to determine impacts to fish and wildlife, usually following catastrophic failure of containment dams or because there was outwardly visible poisoning that triggered public demands for investigation. My synopsis here covers only a small portion of the total damage and economic costs resulting from this waste management.
technique. Yet, the value of that fraction of losses is over $2.3 billion, which is enough money to construct 155 landfills with state-of-the-art composite liners and leachate collection systems (15 million each, 343-344). The Electric Power Research Institute, the scientific arm of the coal power industry, has known the inherent environmental hazards from surface disposal of CCW for decades, and has held workshops to inform the electric utility industry about those toxic threats (345). Electric utilities themselves acknowledge the need to switch from wet to dry storage in order to protect shareholders from significant financial risks (346-347). Yet, little has changed from either an operational or regulatory perspective. Continued use of surface impoundments would be allowed by EPA under Resource Conservation and Recovery Act (RCRA) Subtitle D of its proposed regulations for CCW disposal (348). This would be a grave mistake for five reasons. First, the “D Prime” option allows continued operation of impoundments without liners, which leads to substantial pollution of groundwater, some of which can be expected to reach the surface and expose fish and wildlife to toxins (272-273, 349-350). Second, although other provisions of Subtitle D do require composite liners, it should be noted that liners are designed to protect groundwater and would have little effect on the direct surface water exposure pathway (348). That is, liners do not reduce above-ground leachate, precipitation runoff and slurry discharges that pollute surface water and poison fish and wildlife. Third, there are serious liner performance issues which indicate that groundwater protection is not assured (351-352). Therefore, exposure of fish and wildlife to contaminated groundwater that reaches the surface is a distinct possibility even at lined sites. Fourth, the possibility of structural failure has not been given adequate consideration as a serious drawback of surface impoundments. For example, in the supporting material for its proposed rule, EPA states that “The more recently documented damage cases provide evidence that current management practices can pose additional risks that EPA had not previously studied, that is, from catastrophic releases due to the structural failure of CCR surface impoundments “(348). Fifth, and perhaps most importantly, current state-administered regulatory controls would not prevent discharge of toxic CCW effluent to surface waters. For example, the National Pollutant Discharge Elimination System (NPDES), a federal-state regulatory mechanism for controlling point-source pollution (e.g., coal ash effluent), has been in effect since the enactment of the federal Clean Water Act in 1972 (353). NPDES is the principal tool that states use to address toxic industrial discharges (354). However, it did not identify or correct any of the twelve surface impoundment regulated-release CCW damage cases reviewed in this report. This is because of lack of federal oversight combined with inadequate monitoring, risk assessment, and enforcement at the state level (352, 355-356). EPA recognized these deficiencies in a recent study of steam-electric plant discharges (357) which concluded that:

“Despite current regulatory controls and wastewater treatment methods, pollutants from power plant wastewater still make their way into the environment. Many of these
pollutants, such as selenium, arsenic, mercury, total dissolved solids, and nutrients, have an impact on wildlife. The primary routes by which coal combustion wastewater impacts the environment are through discharges to surface waters, leaching to ground water, and by surface impoundments and constructed wetlands acting as attractive nuisances that increase wildlife exposure to the pollutants contained in the systems. EPA found the interaction of coal combustion wastewaters with the environment has caused a wide range of environmental effects to aquatic life.”

EPA’s own findings point out quite clearly that implementing Subtitle D would not change the flawed regulatory system that has led to pollution of surface water and toxic impacts to fish and wildlife for the past 38 years. Yet despite these revelations, EPA still put forward the Subtitle D surface impoundment disposal option for consideration by the US Office of Management and Budget, which has statutory authority to examine a proposed regulation, review cost-benefit information, and make a controlling decision on the final rule (358-360). As part of this process, EPA conducted a Regulatory Impact Analysis (RIA) for use in comparing benefits and costs of the three options in its proposed rule (Subtitle C, regulation as hazardous waste with no use of surface impoundments; Subtitle D, regulation as a non-hazardous waste with use of surface impoundments; Subtitle D Prime, continued use of unlined surface impoundments, 348, 361). That analysis shows the annualized benefits of pollution control to be much greater for Subtitle C regulation than either Subtitle D option (Table 10 in 348). However, RIA only estimated benefits of avoiding human cancer deaths, groundwater pollution, and cleanup costs of impoundment dam failure…. “RIA did not quantify or monetize several other additional benefits consisting of future avoided social costs associated with ecological and socio-economic damages. These included avoided damages to natural resources”. In order for RIA to be thorough and complete, and thus provide the most accurate information to OMB for weighing in its decision, EPA needs to add the substantial economic benefit of avoiding damages to natural resources, specifically poisoning of fish and wildlife. Based on the losses documented by scientific investigation since 1967 (which examined less than 5% of CCW surface impoundments), protection of fish and wildlife will add at least $46 million per year ($2.3 billion total cost savings spread across 50 year future period-of-analysis 2012 to 2061) to the total annualized benefit value of regulation under RCRA Subtitle C.

Emerging threat from “Green Treatment”

Although surface impoundment of CCW solids (ash) has a long and well known history of environmental problems, there is another, more insidious threat that is beginning to appear. Many coal-fired power plants have installed flue gas desulfurization (FGD) systems to reduce vapor-phase stack emissions of this key contributor to acid rain. These systems effectively
remove sulfur but they also produce a liquid waste that is highly enriched with many of the same problematic contaminants that are in fly ash slurry, notably selenium, mercury, and arsenic (362-363). At most locations, FGD wastewater must be treated in some way before being released into the environment (364). An emerging trend is to use constructed wetlands to treat raw FGD water directly, or to “polish” it after initial processing. Wetland treatment is generally viewed as an environmentally friendly “green” option that reduces the need for more costly physical or chemical methods of pollution control (364-365). Some electric utility companies have even promoted the use of FGD treatment wetlands for wildlife habitat in their public relations literature (366-368). However, selenium and other contaminants in FGD water may accumulate within the wetland to concentrations that can poison fish and wildlife. Engineering success doesn’t necessarily mean ecological success. Just because the effluent from a treatment wetland is “clean” doesn’t mean that all is well. In fact, the success of a wetland in removing pollutants can be inversely related to the biological hazard it creates. More contaminants retained may translate to more concentrated exposure of fish and wildlife (369-370). This risk can partially or wholly defeat the purpose of the wetland from the outset. Utility companies need to be aware of this inherent danger and understand its full ramifications before they consider a wetland treatment option. A wide variety of fauna will rapidly colonize treatment wetlands, even small wetland cells, and the accumulated contaminants provide a direct pathway for high exposure (371-373). It makes no difference if a wetland was created with the intent of providing wildlife habitat or is managed to keep it out........simply construct one and they will come. For example, Duke Energy quickly saw the attractiveness of their “controlled” treatment wetlands at the Belews Creek Steam Station, NC. A flock of geese consumed and destroyed vegetation plantings before they became established (374-375). A few utilities have recognized the pollution dangers and attempted to exclude wildlife with fencing or netting. However, wildlife exclusion cannot be done effectively. Fencing and netting may keep out large mammals and birds but small species will get in with little effort (e.g., frogs, toads, snakes, lizards, salamanders, turtles, crayfish, mice, rats, minnows, small birds, etc.). Moreover, contaminated insects produced in the wetland will emerge and be a source of dietary exposure to birds and other insectivorous wildlife on the outside. This is especially true for bioaccumulative contaminants in FGD wastewater, such as selenium and mercury (78, 376). The need to employ elaborate techniques such as hazing to deter wildlife usage may offset the cost savings associated with wetland treatment (235, 377). Beyond the fact that wildlife attracted to these constructed wetlands are in danger of poisoning, some species are also protected under various state and federal laws, for example, the Migratory Bird Treaty Act (MBTA). The maximum criminal penalty for electric utilities unlawfully killing a protected migratory bird is a $15,000 fine, or six months in jail, or both for each count (each dead bird, 237). There is no “allowable take” under the MBTA, killing just one bird is a violation of the Act.
The wetland owner is liable for any “take” that occurs regardless of whether or not the wetland was intended to provide wildlife habitat (378). EPA recognized this liability in its recent analysis of power plant discharges..... “constructed wetlands act as attractive nuisances that increase wildlife exposure to the pollutants contained in the systems” (357, 379). With respect to fish and wildlife health risks, FGD treatment wetlands are functionally analogous to surface impoundments used to dispose coal fly ash. Both provide pathways for bioaccumulation, exposure, and toxicity. In addition to contaminant exposure risks within the wetlands themselves, some pollutants may not be effectively removed at all, which creates toxic hazards to aquatic life in downstream receiving waters (see Case 21 – Hatfield’s Ferry). Also, over time, wetlands may become “saturated”, thereby exceeding their assimilation capacity and reducing their effectiveness in removing contaminants from FGD water (369, 379). Thus, for a variety of reasons, the promise that constructed wetlands seem to hold for treating CCW wastewater may not be realized.

Conclusions

A large body of scientific evidence from confirmed damage cases indicates that wet disposal of CCW, in any form, is not environmentally or economically prudent. In that regard, EPA’s regulatory proposal for CCW under RCRA Subtitle D, which would allow continued use of surface impoundments, is inappropriate with respect to fish and wildlife health. Moreover, going all the way back to the Belews Lake era of the 1970’s, the corrective action at problematic surface sites has been to switch to landfill disposal. Surface impoundment of CCW unnecessarily jeopardizes fish and wildlife populations, causes significant long-term environmental damage, and results in high economic costs that could be avoided or minimized if other disposal practices were used. Other experts on CCW impacts have also reviewed the technical information and reached similar conclusions (349, 373, 380). Regulators should no longer ignore rigorous science and the lessons learned from multiple case examples. EPA and the United States need to show leadership on this issue by prohibiting surface impoundments, particularly since the rise in coal use in developing countries is leading to the same CCW pollution problems on a global scale (381-384). In addition to the surface impoundment issue, there are two other fish and wildlife concerns that need further investigation from a regulatory perspective. First is the need for a full analysis of the threat posed by landfills. Unlined landfills are creating pools of polluted water underground. For example, dozens of CCW landfills have contaminated groundwater to levels that, if released to surface water, would be acutely and/or chronically toxic to aquatic life (1, 349, 385). Case 21 of this review details one such example (Hatfield’s Ferry, 386). Landfills at the Belews Creek site (Case 1) and other locations are leaching selenium at concentrations in the hundreds of parts-per-billion range, which is as high as levels in the effluent that extirpated 19 species of fish at Belews Lake in the 1970’s (387-
Moreover, there are serious questions about how well liners work (351-352, 390), which brings risks from lined landfills into consideration as well. Second is the need to evaluate risks to fish and wildlife from constructed wetlands. The recent trend of using wetlands as a “green” way to treat FGD wastewater may be the start of a new chapter in the CCW pollution story.

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Table 1. Summary of fish and wildlife damage cases from disposal of coal combustion waste.

<table>
<thead>
<tr>
<th>Case</th>
<th>Location</th>
<th>CCW Disposal Method</th>
<th>Cause of Water Pollution</th>
<th>Damage Value ($US)</th>
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<tbody>
<tr>
<td>1</td>
<td>Belews Lake, NC</td>
<td>Impoundment</td>
<td>NPDES permitted releases</td>
<td>531,153,873</td>
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<td>Hyco Reservoir, NC</td>
<td>Impoundment</td>
<td>NPDES permitted releases</td>
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<td>Impoundment</td>
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<td>4</td>
<td>Gavin, OH/Amos, WV</td>
<td>Impoundment</td>
<td>NPDES permitted releases</td>
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<td>Martin Lake, TX</td>
<td>Impoundment</td>
<td>Unpermitted discharge</td>
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<td>NPDES permitted releases</td>
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<td>Clinch River, VA</td>
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Total ...... $ 2,321,258,053.00