Office of Environmental Services

ISSUES DOCUMENT:
Managing Mn/DOT Environmental Liability Resulting From Use of Regulated Solid Wastes in Mn/ DOT Administered Transportation Systems

Part I.

Coal Ash

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EXECUTIVE SUMMARY

The Minnesota Department of Transportation (Mn/DOT) must abide by all Minnesota and Federal environmental regulations in its administration of Minnesota's transportation systems. In practice, this requires Mn/DOT to effectively evaluate environmental hazards associated with the unrestricted use of solid wastes in Mn/DOT-administered transportation systems. Solid waste utilization has gained importance to Mn/DOT, as numerous promoters of waste utilization have sought Mn/DOT's approval for unrestricted use of a number of solid wastes that, otherwise, require disposal in regulated landfills under strictly controlled conditions. Before Mn/DOT accepts a solid waste for use in its transportation systems, it must conduct a comprehensive environmental liability evaluation to ensure that the environmental liabilities posed by the proposed waste utilization are acceptable. It is the job of Mn/DOT's Office of Environmental Services (OES) to provide the Department with environmental liability management evaluations of proposed waste utilization materials to assure that recycled solid wastes are suitable substitutions for currently used materials.

OES is considering requests to use various solid wastes in Mn/DOT administered transportation systems (for example, coal bottom ash, mercury glass from fluorescent bulbs, glass culled during source separation of municipal waste, municipal sewage sludge ash, municipal compost waste, taconite tailings and foundry sand). OES is investigating Mn/DOT's potential environmental and legal liabilities arising from such proposed waste utilization projects. OES's blend of technical and statutory expertise, pertaining specifically to transportation systems, places us in a unique position to manage legal and environmental hazards arising from waste utilization in transportation systems. It is unreasonable to expect a single agency with regulatory responsibility for every industrial system in the state to understand the nuances of how proposals to utilize solid wastes as construction materials will unfold in a transportation setting. Thus, although waste utilization proposals undergo regulatory review through permitting, OES believes regulatory permitting serves as a foundation for environmental stewardship decisions, not a ceiling.

This paper presents OES's current understanding of environmental and legal liabilities associated with the potentially extensive and unrestricted utilization of solid wastes in Mn/DOT administered transportation systems. The subject of this paper --utilization of coal bottom ash (a waste formed by coal burning power plants) -- exemplifies many of the issues that will arise in any proposal to utilize solid waste in transportation systems. The paper describes the current situation, introduces the National Research Council's (NRC) Transportation Research Board hazard assessment framework, applies the NRC framework to the use of coal bottom ash wastes as construction material and discusses environmental liability for potential impacts of these decisions.

Mn/DOT is currently evaluating a proposal to mix crushed concrete, crushed asphalt or natural aggregates with coal bottom ash to supplement Mn/DOT Class 5 aggregate. More than 800 million metric tons of coal burned annually in the United States generated approximately 75 million metric tons of coal ash, making it the fourth most abundant mineral resource in the United States and the sixth most abundant material for resource recovery. Recycling coal bottom ash (rather than disposing of it in a regulated landfill, as otherwise required), will save coal ash generators millions of dollars annually in disposal fees.

Financial incentives and a positive regulatory stance toward waste utilization encourage coal bottom ash generators to recycle these regulated solid wastes. Using coal ash as a supplement to Mn/DOT Class 5 aggregate is expected to lead to extensive use of coal bottom ash in Minnesota roads. As a responsible environmental steward and a regulated entity, Mn/DOT must not adopt this practice, until it has resolved serious environmental and legal issues. Unanswered environmental issues include:

- How to ensure that coal ash bottom wastes (otherwise disposed of, by law, as solid waste in lined, regulated landfills) will not contaminate soil and water when used in road beds that, by design, drain water from the road through the wastes to the surrounding land?
- What are the concentrations of coal bottom ash waste constituents (heavy metals, organic and radioactive substances) and how can these wastes be characterized given highly complex and variable chemistry of coal combustion residues?
- How does coal bottom ash waste toxicity compare to toxicity of construction materials that coal ash waste will replace if Mn/DOT approves its use?

Mn/DOT's environmental stewardship responsibilities require it to balance environmental protection with the interest of waste generators to make a profit center from wastes that are, otherwise, a legal and economic liability to the corporation. Thus, Mn/DOT must weigh the potential costs and benefits to the public of waste utilization.

As a regulated entity Mn/DOT abides by many environmental requirements when it constructs transportation systems. If Mn/DOT fails to meet current or future Minnesota or Federal environmental requirements for recycled wastes, it could incur unlimited CERCLA or other statutory liability. Remedial measures Mn/DOT could face range from local collection and treatment of contaminated runoff to massive removal actions. CERCLA's broad liability could result in civil or criminal prosecution directed at legally "responsible parties", i.e. the Department and individuals who authorized use of solid wastes as construction materials in Mn/DOT-administered transportation systems.

It is OES's desire that coal bottom ash and other recycled waste materials only be released to the environment after sufficient technical and legal analysis. Prior to accepting regulated solid wastes for unrestricted use, OES recommends that Mn/DOT require all relevant technical and legal issues to be identified and resolved. The proposal for utilization of coal bottom ash will serve as a precedent for how Mn/DOT evaluates all future waste utilization proposals.

The Minnesota Department of Transportation (Mn/DOT) must abide by all Minnesota and Federal environmental regulations in its administration of Minnesota's transportation systems. In practice, this requires Mn/DOT to effectively evaluate environmental hazards associated with unrestricted use of solid wastes in Mn/DOT administered transportation systems. Solid waste utilization has gained importance to Mn/DOT, as numerous promoters of waste utilization have sought Mn/DOT's approval for unrestricted use of a number of solid wastes that, otherwise, require disposal in regulated landfills under strictly controlled conditions. Before Mn/DOT accepts a solid waste for use in its transportation systems, it must conduct a comprehensive environmental liability evaluation to ensure that the environmental liabilities posed by the proposed waste utilization are acceptable. It is the job of Mn/DOT's Office of Environmental Services (OES) to provide the Department with environmental liability management evaluations of proposed waste utilization materials to assure that recycled solid wastes are suitable substitutions for currently used materials. This paper presents OES's current understanding of environmental and legal liabilities associated with the potentially extensive and unrestricted utilization of coal bottom ash, a waste formed by coal burning power plants, in transportation systems.

1. CURRENT SITUATION

Mn/DOT is currently evaluating a proposal to mix crushed concrete, crushed asphalt or natural aggregates with coal bottom ash to supplement Mn/DOT Class 5 aggregate. Recycling coal bottom ash, rather than disposing of it in a sanitary landfill or an industrial waste landfill, as otherwise required, offers coal ash generators an opportunity for an estimated annual cost savings of $1,125,000.00. This financial incentive, coupled with a positive regulatory stance toward waste utilization, makes it highly likely that generators will seek to recycle coal bottom ash wastes as a supplement to Mn/DOT Class 5 aggregate. This could lead to extensive, unrestricted use of coal bottom ash in Minnesota transportation systems.

Coal ash is the fourth most abundant mineral resource in the United States and the sixth most abundant material for resource recovery. Combustion of more than 800 million metric tons of coal in the United States annually results in approximately 75 million metric tons of solid residues. The need to deal with coal combustion residues grows more critical as coal ash wastes accumulate due to increasing demands for power and, thus more ash production. The volume of coal ash waste is also increasing due to the use of new combustion technologies that control air pollution, but generate more ash with a variety of chemical and physical compositions. In 1993, it was predicted that coal burning utilities would generate over 120 million metric tons of solid residues by the end of the century.

The United States Environmental Protection Agency (US EPA) encourages reuse of coal combustion wastes and supports state efforts to do the same. The State of Minnesota also allows certain wastes to be recycled, rather than disposed of in landfills, including some coal combustion residues. Because of the volume of coal ash, the cost of landfilling it, and the opportunity to create profitable new markets for a former liability, coal ash waste generators can be expected to exhibit great enthusiasm for waste utilization.

Environmental concern about coal combustion residues has existed for years. The primary concern, according to the Electric Power Research Institute (EPRI), is the possibility that coal combustion residues will contaminate surface and underlying waters with several inorganic constituents that may detrimentally effect plants, animals, and human health. Coal ash also contains organic and radioactive constituents of potential environmental concern.

The regulatory stance of environmental agencies toward coal ash is shifting from strict solid waste controls (i.e. disposal in regulated landfills) to a waste utilization policy. The United States Congress directed US EPA to study large-volume coal combustion wastes (fly ash, bottom ash, slag waste and flue gas emission control waste) and, by 1988, to issue a report on these wastes and a determination as to whether to deal with them as hazardous wastes under RCRA. In 1993, US EPA excluded fly ash, bottom ash, slag waste and flue gas emission control waste from hazardous waste regulation. US EPA justified the exclusion because:

- human populations were not directly exposed to contaminated groundwater supplies;
- at the time, state programs offered sufficient protection of human health; and
- potential for environmental harm was largely determined by local factors.

Since 1993, many state solid waste management programs, including Minnesota's, have adopted waste utilization policies that essentially permit unrestricted environmental release of solid wastes. Before Mn/DOT allows coal bottom ash utilization as a supplement to Mn/DOT Class 5 aggregate, it must assess the environmental and legal liabilities of utilizing coal bottom ash as a Class 5 aggregate in Mn/DOT-administered transportation systems. At a minimum, information sufficient to address the following environmental and legal issues:

- How to ensure that coal ash bottom wastes (otherwise disposed of, by law, as solid waste in lined, regulated landfills) will not contaminate soil and water when used in road beds that, by design, drain water from the road through the wastes to the surrounding land?
- What are the concentrations of coal bottom ash waste constituents (heavy metals, organic and radioactive substances) and how can these wastes be characterized given highly complex and variable chemistry of coal combustion residues?
- How does coal bottom ash waste toxicity compare to toxicity of construction materials that coal ash waste will replace if Mn/DOT approves its use?
- What impact will the utilization of coal bottom ash wastes as a supplement to Mn/DOT Class 5 aggregate have on the reconstruction or demolition of transportation systems after its engineered lifespan?
- What environmental liability protection will Mn/DOT receive regarding incorporation of coal bottom ash waste into Mn/DOT-administered transportation systems?

OES requested information to address these environmental and regulatory issues from the waste generator that proposed the use of coal bottom ash. When the information was not provided, OES undertook this issues analysis in order to address issues of environmental and legal liability, to the extent possible with information available from the open literature.

2. ENVIRONMENTAL HAZARDS ASSESSMENT

Materials used in highway construction must be assessed to ensure they pose no hazard to the natural environment or human health. As early as 1982, the National Research Council's (NRC) Transportation Research Board recognized the potential for contaminants in construction materials and activities associated with highway development to impair beneficial uses of waters receiving area drainage. The NRC recommended that transportation departments use a water quality hazard assessment to evaluate the significance of construction materials as contaminant sources and to "promote technically valid, cost-effective, yet environmentally protective evaluation and control of materials associated with highway construction," including physical effects, such as turbidity, and potential chemical impacts.

The NRC hazard assessment process mandates environmental hazard assessment by transportation departments, such as Mn/DOT, and provides a methodology for performing environmental hazard assessments. In order to make a technically valid, yet environmentally protective evaluation of the proposed use of coal bottom ash wastes as a supplement to Mn/DOT Class 5 aggregate under NRC*s methodology, Mn/DOT requires information on:

- Source and general character of coal bottom ash;

- Coal bottom ash contaminant movement by erosion and leaching;
- Coal bottom ash mode of transport;
- Environmental chemistry-fate of coal bottom ash contaminants;
- Coal bottom ash contaminant toxicity; and
- Coal bottom ash contaminant bioassay results.

Summaries of information available for each of these topics are presented below.

A. Sources and General Character of Coal Bottom Ash
Coal bottom ash accumulates in the furnace bottom in one of two forms: as a loose, dry ash or as a viscous fluid, called slag. Coal bottom ash is a granular, porous material. Compared to fly ash, bottom ash is coarser, heavier residue. Slag is black with a glassy appearance, comprised of angular particles. The coal residues that accumulate in the furnace (slag and bottom ash) are periodically flushed out of the furnace using air or water.

(1) Variability of Coal Bottom Ash Chemistry
The chemical characteristics of coal ash depend largely on geologic factors related to the coal deposit and on operating conditions at the power plant. Thus, every coal-fired plant has its own chemical ash characteristics. As a power plant changes coal sources or changes its operations, coal bottom ash is likely to exhibit different physical/chemical properties and, thus, differing propensity for environmental movement and toxic effect.

In addition to the variability inherent in the coal combustion process, the chemistry of coal ash wastes may be affected by waste handling. For example, the coal combustion literature does not always distinguish "slag" from "bottom ash". Bottom ash sometimes refers to only the loose dry ash, not slag; other times, it refers to all coarse materials that accumulate in the furnace bottom, including slag. A clear distinction between bottom ash and slag, and strict separation of these two materials, is necessary due to the different chemical properties of these materials. Similarly, coal ash slated for recycling must be strictly segregated from all other industrial wastes that may be deposited at holding sites or mixing facilities.

(2) Complexity of Coal Bottom Ash Chemistry
A large percentage of coal bottom ash is comprised of relatively inert materials, such as silicon. A large number of other elements comprise coal ash, however, in small, but potentially problematic concentrations. Table 1 shows the maximum and minimum value found for 64 elements present in bottom ash. Trace constituents in coal ash can include from 20 to 50 elements, including antimony, arsenic, barium, beryllium, boron, copper, fluorine, lead, manganese, mercury, molybdenum, nickel, selenium, tellurium, thallium, tin, titanium, uranium, vanadium, and zinc. Ash from midwestern bituminous coals generally exhibits higher trace element levels than those from western subbituminous coals, although regional differences in coal composition and coal seam variations complicate generalizations. Table 1 illustrates the tremendous variability in the concentration of many elements present in coal ash. Given the wide ranges in concentration of elements from a given coal seam or basin, a sizeable variability may be expected in experimental results characterizing ash from a single power plant.

Studies of coal ash indicate that organic contaminants may not be the only source of environmental concern. Various complex organic molecules, such as PAHs, dimethyl and monomethyl sulfate , are also among the constituents of coal ash. Oak Ridge National Laboratory analyzed the hydrocarbon and PAH content of coal fly ash, as did EPRI. EPRI found 9 mg/kg total hydrocarbon content in coal ash and hydrocarbon concentrations ranging from 500 to 900 m g/kg and PAHs ranging from <0.2 to about 37 m g/kg. See Table 2. Coal ash has also been analyzed for radionuclides. See Table 3.

B. Coal Bottom Ash Constituent Movement

Coal bottom ash constituents can move in the environment. Field studies of ash disposal ponds (Table 4) and ash disposal pits demonstrate that trace elements from coal ash can contaminate sediments, soil, surface water and groundwater. Erosion, surface water transport and groundwater transport have been identified as potential pathways for contaminant migration; leaching, however, is the most likely path by which coal bottom ash constituents in Class 5 Aggregate would become mobile, environmental contaminants. Extraction tests are a poor predictor of leaching potential under field conditions, according to EPRI, and different extraction methods yield widely differing results. Therefore, these tests cannot reliably simulate leaching under field conditions. Leaching tests do provide insight into the general patterns by which inorganic constituents leach from coal combustion residues, including bottom ash. EPRI used extraction test results to report that trace elements (As, B, Cr, Cu, Mo, Ni, and Zn) tend to dissolve more readily than other elements. Certain major elements (Ca, Na, and S) solubilize easily; others (K and Mg) dissolve more slowly; and some (Al, Si, and Fe) are released only very slowly. See Table 5.

C. Transport of Coal Bottom Ash Contaminants

As noted above, coal bottom ash constituents can move in the environment. Table 4 presents the range and average concentration of twelve elements of concern from discharges from bottom ash disposal ponds. Erosion by wind and surface water offers one mode of transport. Leaching by percolating water offers another.

Wind and water erosion can carry bottom ash constituents away as dust or suspended solids, if bottom ash aggregate piles are poorly managed on-site. Erosion of coal ash disposal piles was noted as a factor in environmental contamination at the Chisman Creek Superfund Site in York County, Virginia. Contaminants from three ash disposal pits contaminated groundwater and surface water in the Chisman Creek Watershed.

Perhaps the environmental transport mode of most concern, if coal bottom ash is used as aggregate in roads, is leaching. Coal bottom ash constituents are known to dissolve in percolating water, as discussed above. Water drainage is an important aspect of highway design. Porous materials incorporated into roadbeds allow water entering through surface cracks to drain through the roadbed and out into the surrounding environment. Promoters of coal ash utilization have suggested bottom ash for such uses, placed in a system designed to drain water through the road and into the surrounding environment, it is reasonable to expect that coal bottom ash constituents will either become entrained in the flow as particles and/or dissolve in the percolating water. By either route, contaminants will move out laterally of the roadbed into surrounding soil and surface water bodies or vertically to groundwater.

D. Environmental Chemistry-Fate of Coal Bottom Ash Contaminants

Coal bottom ash contaminants of concern include heavy metals, complex hydrocarbons and radionuclides. The environmental fate of coal ash constituents depends on the chemistry of the substances involved. The coal ash literature typically discusses elemental forms of constituents, for example, "prevalent geochemical characteristics" of ash determine its ultimate pH of leachate and thus the potential for metals to leach. Similarly, surface characteristics of ash particles appear to account for the tendency for enrichment of some trace constituents. Due to the complex and highly variable nature of coal bottom ash chemistry, this topic can only be addressed in general terms. Understanding of the behavior of coal ash contaminants in the natural subsurface environment has advanced sufficiently for EPRI to have developed a computer model (FOWL) capable of predicting the concentrations and quantities of eighteen major and trace constituents in leachates from bottom ash. FOWL applies in disposal scenarios and tracks the following coal ash constituents: Al, Ba, Ca, Cr, Mo, Si, Sr, S, As, B, Cd, Cu, Fe, Mg, Na, Ni, Se, and Zn. Future work on coal bottom ash constituent fate and transport should include an assessment of the applicability of EPRI's FOWL model to coal ash utilization projects, as well as a survey of other more recent computer models. Those promoting coal ash utilization tend to minimize environmental concern by emphasizing the relatively small amounts of potentially toxic constituents in coal ash. Studies indicate, however, that significant amounts of potentially harmful trace elements from fly ash fallout, including elevated levels of lead, cadmium, copper, zinc, mercury and manganese, accumulate in soil., In the absence of data to the contrary, it is reasonable to expect the same behavior by the same trace elements from coal bottom ash. From the soil, heavy metals can enter plant tissues that have been shown to absorb heavy metals from coal ash and, thus, the entire trophic system. Connor et al. (1976) and Gough and Erdman (1976) found selenium in lichen, grass, and sagebrush in concentration decreasing exponentially with increasing distance from two power plants in Wyoming. Se concentrations in sagebrush, grass, and lichen samples ranged from about 0.5 to 2 mg/kg (dry weight) at about 0.8 to 1.2 km from each of the plants.

Animal ingestion of plants can lead to food chain biomagnification of heavy metals. Bioaccumulation of trace elements in living tissues has been considered both with respect to the contaminated organism and its predators. Coal ash has been identified as the source of elements in bioconcentration studies. Researchers on Belews Lake, North Carolina, attribute reproductive failure of fish populations to Se entering the lake via a power plant fly ash sluice return. Although Se concentrations in the lake were not high enough to be directly toxic to fish, uptake by plankton introduced selenium into the food chain. Ultimately, it reached elevated levels in the fish of > 3 mg/kg wet weight by bioaccumulation.

The Savannah River Ecology Laboratory is currently investigating biomagnification of heavy metals up the aquatic food chain at the Department of Energy's Savannah River S. C. Site. The team recently reported finding developmental abnormalities in the animal populations exposed to elevated levels of arsenic, cadmium, selenium, strontium, and mercury linked to fly ash wastes.

Thus, despite the presence of only "trace" amounts of heavy metals in coal and coal ash, these materials have the potential to accumulate in soil and increase in concentration by food chain biomagnification. Furthermore, it is important to use bioassays to evaluate toxicity. Geochemical characteristics greatly alter the behavior of coal ash constituents, including solubility and bioavailability. Thus, even if total concentrations of elements present in coal bottom ash are within the range found in natural soils, the toxicity can be quite different.

E. Coal Bottom Ash Contaminant Toxicity

Coal bottom ash includes a wide array of potentially toxic constituents. These include fifty-six elements (Table 1), including trace constituents (antimony, arsenic, barium, beryllium, boron, copper, fluorine, lead, manganese, mercury, molybdenum, nickel, selenium, tellurium, thallium, tin, titanium, uranium, vanadium, and zinc); and, perhaps, complex hydrocarbons (Table 2) and radionuclides (Table 3). The physico-chemical properties of coal ash could pose environmental problems and have toxic effects on organisms, if coal ash utilization schemes are allowed to expose this solid waste to the environment. See Table 7. In a comprehensive review of fly ash toxicity, Roy et al. (1981) noted extensive toxic effects of coal ash leachate on fish, mollusks, eggs of fish and amphibians, and aquatic insects; and biotic community changes. The toxicity was attributed by researchers to a variety of mechanisms including direct toxicity, extreme pH effects, and asphyxiation of test animals from clogging of gills by ash particles. Ecosystem effects of a nontoxic nature have also been identified. For example, fly ash can reduce phosphorus levels in water, lowering productivity of the aquatic ecosystem.

Developmental abnormalities were recently linked to fly ash exposure by a team of ecologists at the Department of Energy's (DOE's) Savannah River, S. C. Ecology Laboratory. The researchers linked fly ash deposits to abnormally high levels of heavy metals in amphibians with resulting physical and behavioral abnormalities. The study, to be published in the Journal of Herpetology was summarized in Environmental Science and Technology. The researchers associated abnormalities in the exposed animal populations, such as oral malformations and substantial reduction of swimming performance in the affected tadpoles to elevated levels of arsenic, cadmium, selenium, strontium, and mercury in bullfrog tadpoles and softshell turtles.

(1) Elements
Many elements are extremely toxic to many organisms via a variety of mechanisms. Metals kill fish by damaging branchial apparatus. Zinc, iron, copper, cadmium, and mercury were found to act in the same way. Jones (49) corroborated these findings and extended them to all metals. Their introduction into the environment via bottom ash utilization could pose a significant environmental hazard by ingestion, dermal absorption or inhalation.

(2) Organic Molecules
Various complex organic molecules are also present in coal ash, including PAHs and other complex organic compounds. These materials are known to cause carcinogenic and mutagenic effects.

(3) Radionuclides
EPRI determined the concentrations of ten radioactive substances in coal fly ash. See Table 3. The concentration of 226Ra in bottom ash equals 1.9 pCi/g, well below the 226Ra concentration of 5 pCi/g level necessary to classify it as a hazardous waste. Other researchers have discussed potential radiation hazards from coal fired power plants. For example, radioactive emissions from such plants may exceed those from nuclear plants of a similar size. Enhanced levels of U, Th, and Ra have been documented in the soils of industrial regions. Although these levels were not a direct health hazard, researchers expressed concern over the added risk of using fly ash as a concrete additive in building materials. For example, one researcher predicted that the average human radiation dose of 100 mrad/year may increase to 130-300 mrad/year for people inhabiting buildings constructed with fly ash impregnated construction materials and calculated increases of 10 to 100 percent in leukemia, thyroid tumors, and lung carcinoma as a result.

F. Coal Ash Contaminant Bioassay Results
Bioassay work on coal ash has concentrated on fly ash toxicity and most fly ash testing has concentrated on the respiratory tract. Birge, however, conducted bioassays on precipitator collected fly ash on goldfish, readear sunfish, fowlers toad and leopard frog eggs. Exposure to undiluted effluent caused total mortality for readear sunfish and leopard frog and moderate mortality (greater than 40 percent) for goldfish and fowlers toad. Diluted effluents caused mortality in readear sunfish eggs. Fly ash has also been shown to be mutagenic by the Ames test.

3. LEGAL ASSESSMENT
As a regulated entity, the Minnesota Department of Transportation must administer Minnesota's transportation systems in compliance with all federal and state environmental regulations. Numerous environmental regulations apply to Mn/DOT's construction and management. Environmental regulations likely to pertain directly to coal bottom ash utilization, however, are:

- Resource Conservation and Recovery Act (RCRA) and related state and federal solid waste regulations, in particular the federal and state exemptions of coal ash from hazardous waste rules;
- Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) and related state and federal remediation regulations, and
- Clean Water Act (CWA) National Pollution Discharge Elimination System (NPDES) permit program.

In addition to civil penalties, criminal penalties are now available under all major federal environmental laws. Criminal provisions have been applied against government employees as vigorously as against employees of private firms. To apply criminal provisions, federal environmental statutes only require that a defendant violate the law "knowingly." The precise definition of "knowingly" is open to judicial interpretation and courts have taken it to mean simply that the defendant knew what he or she was doing, not requiring a full appreciation of the legal consequences of the action. Courts have been more likely to hold mid-level government managers criminally liable than their top-level supervisors.

A. RCRA

Coal bottom ash is exempt from state and federal hazardous waste regulations. As a non-hazardous waste, coal bottom ash is governed by RCRA Subtitle D and Amendments under the Solid Waste Disposal Act of 1984, and Minnesota's Solid Waste Rules. If discarded, therefore, coal ash residues are treated as solid wastes and US EPA, or the MPCA, may take an enforcement action if the handling or disposal of coal bottom ash presents an imminent and substantial endangerment to human health or the environment. Even if a company obtains a permit or complies with permit-by-rule requirements, US EPA, or a state with a similar statute, may force the company to take corrective action to avoid environmental harm.

B. MERLA & CERCLA

Minnesota Environmental Response and Liability Act (MERLA), section 115B.03, established liability of responsible persons for damage arising from *a release or threatened release of a hazardous substance, or a pollutant or contaminant* (emphasis added). A responsible person can be held liable for response costs, natural resource damages and damages to third parties arising from the release of hazardous substances, which include *any hazardous waste*. MERLA liability is limited to hazardous substances, however, and does not apply to coal bottom ash, which is neither a commercial chemical, designated by the FWPCA nor a hazardous air pollutant listed under the CAA, and fails to meet the MERLA definitions of "hazardous waste." Thus, MERLA's strict liability does not apply for damages caused by the release of bottom ash.

CERCLA, enacted in 1980 and revised by the Superfund Amendment and Reauthorization Act of 1986 (SARA) provides broad authority to remediate sites contaminated with hazardous substances before further damage occurs. CERCLA to impose liability against persons who are responsible for hazardous substance releases for cleanup and restitution costs and authorizes injunctive relief where an actual or threatened release poses an "imminent and substantial endangerment" to the public health or welfare of the environment. In contrast to MERLA, only petroleum substances are except from liability under Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). CERCLA defines "hazardous substance" by reference to other environmental statutes and authorizes US EPA to add other substances to the list. Thus, though coal bottom ash is exempt from RCRA hazardous waste regulations, CERCLA liability is possible for its environmental release as a hazardous substance. CERCLA has, in fact, been applied to coal ash contamination at Chisman Creek Superfund Site in York County, Virginia, where remedial action involved closure of three ash disposal pits.

C. Clean Water Act NPDES Permit Program

In 1972, the Federal Water Pollution Control Act (also referred to as the Clean Water Act (CWA)) was amended to restore and maintain the integrity of the Nation's waters through the prevention, reduction, and elimination of pollution. Like CERCLA, CWA liability can be triggered without purposeful contamination. The CWA forbids the discharge of pollutants, including oil and hazardous substances, into the waters of the United States except pursuant to a permit issued by US EPA or a state authorized to do so. The CWA applies to "navigable waters", i.e. surface waters, not groundwater. Those seeking permits for polluting activities must meet effluent limitations and employ prescribed pollution-reducing technology. The CWA states that:

> Except where an owner of operator can prove that a discharge was caused solely by (A) an act of God, (B) and act or war, (c) negligence on the part of the United States Government, or (D) and act or

omission of a third party without regard to whether such act or omission was or was not negligent, or any combination of the foregoing clauses, such owner or operator from which a hazardous substance is discharged in violation of [the CWA] shall be liable to the United States Government for the actual costs incurred for the removal of such substance.

The CWA permits point source discharges under the National Pollutant Discharge Elimination System (NPDES) permit program. Storm water permits are required under 402(p) for certain municipal and industrial storm water discharges, as well as storm water management plans for the areas covered by the permit. The NPDES program could require transportation systems to be retrofitted to prevent authorized discharges.

D. The Safe Drinking Water Act
In 1974, Congress enacted the Safe Drinking Water Act to, among other things, help protect sole source aquifers, aquifers that serve as the sole source of drinking water for a community. Under SDWA, US EPA received the authority to designate certain groundwater supplies as sole source aquifers and to review federal financially assisted projects proposed in the area to determine each project's potential to contaminate a sole source aquifer.

The GAO identified road building as a possible threat to sole source aquifers in a 1992 report to Congress. The US EPA has designated one aquifer in Minnesota as a sole source aquifer. If a federally-financed highway project planned for the region near a sole source aquifer, were reviewed by US EPA the project might be considered a potential groundwater threat because of the use of coal bottom ash and the potential for leaching of heavy metal constituents of coal bottom ash.

4. CONCLUSION
Environmental and legal liability issues must be addressed to ensure that use of coal bottom ash, including complex questions of environmental fate and transport, environmental chemistry and toxicology. Unless answered, however, the use of coal bottom ash as a construction material is a decision fraught with legal and environmental risks. As a responsible environmental steward, Mn/DOT is obligated to investigate the potential impacts of using coal bottom ash in order to ensure that stakeholders interested in disposing of these waste materials are not doing so at the expense of the greater social good. As a potentially responsible party under CERCLA, Mn/DOT and its employees may be held accountable for this decision. Applying the above information to the environmental and legal issues regarding coal bottom ash waste utilization in Mn/DOT administered transportation systems OES arrives at the following conclusions:

- No assurance was found in the technical literature that coal ash bottom wastes will not contaminate soil and water if they are used in transportation systems designed to drain water from the road through the wastes to the surrounding land. In fact, there is persuasive evidence that certain coal bottom ash waste constituents leach readily in the presence of water.
- The highly complex and variable chemistry of coal combustion residues make their characterization extremely difficult.
- The relative toxicity of coal bottom ash, as compared to toxicity of construction materials that coal ash waste will replace, is not known.
- The impact is unknown of coal bottom ash waste utilization as a supplement to Mn/DOT Class 5 aggregate on the reconstruction or demolition of transportation systems after its engineered lifespan.
- Without environmental liability protection from those who propose coal bottom ash waste utilization, Mn/DOT is open to unlimited liability under CERCLA and other applicable environmental statutes.

Table 1. Chemical Constituents of Bottom Ash

Constituent	Minimum (ppm)	Maximum (ppm)
Aluminum (Al)	**88,000.00**	**135,000.0**
Antimony (Sb)	**0.14**	**12.0**
Arsenic (1/4 as) c	**0.98**	**40.0**
Barium (Ba)	**500.00**	**4,000.0**
Beryllium (Be) c	**3.00**	**10.6**
Boron (B)	**70.00**	**300.0**
Bromine (Br)	**2.00**	**11.0**
Cadmium (Cd) c	**<0.50**	**<250.0**
Calcium (Ca)	**8,400.00**	**50,600.0**
Cerium (Ce)	**84.00**	**310.0**
Cesium(Cs) c	**7.70**	

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