



Federal Register

**Monday,
June 21, 2010**

Part II

Environmental Protection Agency

**40 CFR Parts 257, 261, 264 et al.
Hazardous and Solid Waste Management
System; Identification and Listing of
Special Wastes; Disposal of Coal
Combustion Residuals From Electric
Utilities; Proposed Rule**



Characterization of Coal Combustion Residues from Electric Utilities – Leaching and Characterization Data



Coal Combustion Waste Damage Case Assessments

**U.S. Environmental Protection Agency
Office of Solid Waste**

July 9, 2007

With the exception of the documents listed below, the documents referenced throughout this assessment are available from the docket to the Notice of Data Availability on the Disposal of Coal Combustion Wastes in Landfills and Surface Impoundments at www.regulations.gov, docket ID EPA-HQ-RCRA-2006-0796, through internet links provided, or from other identified sources.

1. Application of Don Frame Trucking, Inc. Petitioner for a Judgment Pursuant to Article 78 of the CPLR against the New York State Department of Environmental Conservation Respondent; Supreme Court of the State of New York County of Chautauqua (July 22, 1988). Order G11278.
2. Selenium Posting on Hyco Lake Rescinded, North Carolina Department of Health and Human Services (NCDHHS), August 2001.
3. Feasibility Study for the Y-12 Chestnut Ridge Operable Unit 2 Filled Coal Ash Pond, Oak Ridge, Tennessee. DOE/OR/02-1259&D1. August 1994.
4. Final Site Investigation Report on Groundwater Contamination, Township of Pines, Porter County, Indiana. December 2002.
5. Texas Bureau of Health (TBH). 1992. Fish Advisory: Brandy Branch Reservoir. May 1992.
6. Texas Commission on Environmental Quality (TCEQ). 2003. Improving Water Quality in Brandy Branch Reservoir; One TMDL for Selenium. February 2003.
7. Report: Sulfate Investigation, Miamiview Landfill, Hamilton County, Ohio. Prepared for the Cincinnati Gas & Electric Company by Dames & Moore. December 13, 1994. Available in the docket titled Availability of Report to Congress on Fossil Fuel Combustion: Request for Comments and Announcement of Public Hearing, EPA-HQ-RCRA-1999-0022-0632.

Table of Contents

	Description	Page
I.	Summary.....	2
II.	Proven Damage Cases.....	12
1.	Salem Acres Site, Massachusetts.....	13
2.	City of Beverly/Vitale Brothers Fly Ash Pit, Massachusetts.....	14
3.	Don Frame Trucking, Inc. Fly Ash Landfill, New York.....	15
4.	Virginia Electric Power Co. (VEPCO) Possum Point, VA.....	16
5.	PEPCO Morgantown Generating Station Faulkner Off-site Disposal Facility, Maryland.....	17
6.	Virginia Power Yorktown Power Station Chisman Creek Disposal Site, Virginia.....	17
7.	Hyco Lake, Roxboro, North Carolina.....	19
8.	Georgia Power Company, Plant Bowen, Cartersville, GA.....	19
9.	Department of Energy - Oak Ridge Y-12 Plant Chestnut Ridge Operable Unit 2.....	20
10.	South Carolina Electric & Gas Canadys Plant, South Carolina.....	24
11.	Belews Lake, North Carolina.....	25
12.	U.S. Department of Energy Savannah River Project, South Carolina.....	25
13.	Dairyland Power Cooperative E.J. Stoneman Generating Station Ash Disposal Pond, Wisconsin.....	26
14.	WEPCO Highway 59 Landfill, Wisconsin.....	27
15.	Alliant (formerly Wisconsin Power & Light) Nelson Dewey Ash Disposal Facility, Wisconsin.....	27
16.	WEPCO Cedar-Sauk Landfill, Wisconsin.....	28
17.	Wisconsin Electric Power Co. (WEPCO) Port Washington Facility, Wisconsin.....	29
18.	Lansing Board of Water & Light (LBWL) North Lansing Landfill, Michigan.....	30
19.	Northern Indiana Public Service Corp. (NIPSCO) Yard 520 Landfill Site (Brown's Landfill) Township of Pines, Porter County, IN.....	32
20.	Brandy Branch Reservoir, Texas.....	33
21.	Southwestern Electric Power Company Welsh Reservoir, Texas.....	34
22.	Texas Utilities Electric Martin Lake Reservoir, Texas.....	34
23.	Basin Electric Power Cooperative W.J. Neal Station Surface Impoundment, North Dakota.....	35
24.	Cooperative Power Association/United Power Coal Creek Station Surface Impoundments, North Dakota.....	36
III.	Potential Damage Cases.....	38
25.	K.R. Rezendes South Main Street Ash Landfill, Freetown, Massachusetts.....	38
26.	New England Power, Brayton Point, Massachusetts.....	39
27.	AES Creative Resources Weber Ash Disposal Site, New York.....	40

	Description	Page
28.	Central Hudson Gas and Electric Corporation Danskammer Waste Management Facility, New York.....	40
29.	C. R. Huntley Flyash Landfill, New York.....	40
30.	Elrama Plant, Pennsylvania.....	41
31.	Tennessee Valley Authority - Bull Run Steam Plant, Oak Ridge, Tennessee.....	41
32.	Tennessee Valley Authority Widows Creek Fossil Fuel Plant, Alabama.....	41
33.	Tennessee Valley Authority Colbert Fossil Fuel Plant, Alabama.....	42
34.	Duke Power Allen Steam Generating Plant, North Carolina.....	42
35.	Cinergy East Bend Scrubber Sludge Landfill, Kentucky.....	43
36.	Florida Power and Light Lansing Smith Plant, Florida.....	43
37.	Florida Power and Light Port Everglades Plant, Florida.....	44
38.	Florida Power and Light Riviera Plant.....	44
39.	Florida Power and Light P.L. Bartow Plant.....	44
40.	Commonwealth Edison Powerton Plant - Mahoney Landfill, Pekin, Tazewell County, Illinois.....	45
41.	Xcel Energy/Southern Minnesota Municipal Power Agency - Sherburne County (Sherco) Generating Plant Becker, Minnesota.....	45
42.	Alliant Rock River Ash Disposal Facility, Wisconsin.....	46
43.	Michigan City Site, Michigan City, Indiana.....	46
44.	Bailly Generating Station, Indiana.....	47
45.	Alliant Edgewater 1-4 Ash Disposal Site, Wisconsin.....	47
46.	Wisconsin Power Supply Co. (WPSC) Pulliam Ash Disposal Site, Wisconsin.....	48
47.	Central Illinois Light Co. Duck Creek Station, Illinois.....	48
48.	Illinois Power Co. Hennepin Power Station, Illinois.....	48
49.	Illinois Power Co. Havanna Power Plant, Illinois.....	49
50.	Dairyland Power Alma On-site Fly Ash Landfill, Wisconsin.....	49
51.	Dairyland Power Alma Off-site Fly Ash Landfill, Wisconsin.....	50
52.	Illinois Power Vermillion Power Station, Illinois.....	50
53.	Central Illinois Public Service Company Hutsonville Power Station, Illinois.....	51
54.	Illinois Power Company Wood River Power Station, Illinois.....	51
55.	R.M. Schahfer Generating Station, IN.....	51
56.	Coffeen/White & Brewer Trucking Fly Ash Landfill, Illinois.....	52
57.	Southern Indiana Gas and Electric Company (SIGECO) A.B Brown Generating Station, Indiana.....	52
58.	Cincinnati Gas & Electric Co. Miamiview Landfill, Ohio.....	52
59.	Indiana Power & Light Petersburg Generating Station, Indiana.....	53
60.	Hoosier Energy Mermon Generating Station Coal Combustion Waste Landfill, Indiana.....	53
61.	Cinergy W.C. Beckjord Station, Ohio.....	53
62.	Lemberger Landfill, Wisconsin.....	54
63.	Conesville Fixed FGD Sludge Landfill, Ohio.....	54
64.	Muscatine County Landfill, Iowa.....	56
65.	Dave Johnston Power Plant, Wyoming.....	56
66.	Montana-Dakota Utilities R.M. Heskett Station, North Dakota.....	56
67.	Arizona Public Service Co. Cholla Steam Electric Generating Station, Arizona.....	57

	Description	Page
IV.	Rejected Damage Cases.....	59
68.	American Coal Corporation #5 Landfill.....	59
69.	Cardinal PFBC Monofill.....	59
70.	Cardinal Fly Ash Reservoir II Impoundment.....	59
71.	Clinch River, Virginia.....	60
72.	Copicut Road.....	60
73.	Dixie Caverns County Landfill, Virginia.....	60
74.	Gavin Impoundments.....	61
75.	Kyger Creek Power Plant Impoundments.....	61
76.	Lake Erie, Ohio.....	61
77.	Muskingum River Power Plant Impoundments.....	62
78.	Muskogee Environmental Fly Ash Disposal Site, Oklahoma.....	62
79.	Public Service Co Fly Ash Disposal Site, Oklahoma.....	63
80.	Star Coal Company #6 Landfill.....	63
81.	Star Coal Company #14 Landfill.....	63
82.	Stuart Station Impoundments.....	63
83.	Thompson Landfill, Michigan.....	64
84.	Turris Coal Company Elkhart Mine, Illinois.....	64
85.	Western Farmers Electrical Fly Ash Site, Oklahoma.....	64

List of Tables

	Description	Page
Table 1.	Eleven Damage Cases Cited in the May 2000 Regulatory Determination.....	3
Table 2.	Fossil Fuel Combustion (FFC) Damage Case Resolution, excluding minefills.....	8
Table 3.	Oak Ridge Y-12 Plant Chestnut Ridge Operable Unit 2 Surface and Ground Water Monitoring Programs.....	21

Summary of Coal Combustion Waste Damage Case Assessments

I. Summary

Under the Bevill Amendment for the "special waste" categories of the Solid Waste Disposal Act, EPA was statutorily required to examine "documented cases in which danger to human health or the environment has been proved" from the disposal of coal combustion wastes. The criteria used to determine whether danger to human health and the environment has been proven are described in detail in the May 2000 Regulatory Determination at 65 FR 32224. For the May 2000 Regulatory Determination for Wastes from the Combustion of Fossil Fuels (Regulatory Determination), the Agency determined there were approximately 300 CCW landfills and 300 CCW surface impoundments used by 440 coal fired utilities.

In comments on the March 1999 Report to Congress on Wastes from the Combustion of Fossil Fuels, public interest groups identified 59 cases in which they alleged damage to human health or the environment had been caused by fossil fuel combustion wastes¹. The Agency reviewed each of the cases. That review resulted in identifying nine of the 11 damage cases cited in the May 2000 Regulatory Determination² (see Table 1 below for complete listing of the 11 proven damage cases³). Of the remaining 50 cases, 25 were classified as "potential" damage cases as

¹ Letter from the Hoosier Environmental Council to the RCRA Docket Information Center regarding the CCW RTC, June 11, 1999, Letter from the Hoosier Environmental Council and the Citizens Coal Council to the RCRA Docket Information Center regarding the CCW RTC, June 14, 1999 and Letter from the Hoosier Environmental Council, et. al., to Dennis Ruddy regarding the CCW RTC, September 24, 1999.

² Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

³ Per the May 2000 Regulatory Determination, 65 FR 32224 (http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2000_register&docid=fr22my00-22.pdf) and Section 1.4.4 of the 1999 Report to Congress (http://www.epa.gov/epaoswer/other/fossil/volume_2.pdf), proven damage cases are those with (i) documented exceedances of primary MCLs or other health-based standards measured in ground water at sufficient distance from the waste management unit to indicate that hazardous constituents have migrated to the extent that they could cause human health concerns, and/or (ii) where a scientific study demonstrates there is documented evidence of another type of damage to human health or the environment (e.g., ecological damage), and/or (iii) where there has been an administrative ruling or court decision with an explicit finding of specific damage to human health or the environment. In cases of co-management of CCWs with other industrial waste types, CCWs must be clearly implicated in the reported damage.

The May 2000 Regulatory Determination falls short of providing a comprehensive definition of the review criteria ("test of proof") for assessing the validity of damage case allegations; it only discusses the review criteria in response to public comments on the review process of the Cement Kiln Dust (CKD) proposed rule, and focuses only on the location of the exceedance point with respect to the source term (32224 CFR 65):

"Proven damage cases were those with documented MCL exceedances that were measured in ground water at a sufficient distance from the waste management unit to indicate that hazardous constituents had migrated to the extent that they could cause human health concerns."

The "test of proof" criteria were fully defined on pp. 3-4 of the *Technical Background Document to the Report to Congress on Remaining Waste from Fossil Fuel Combustion: Potential Damage Cases* (1999):

defined in the Regulatory Determination⁴ and five cases were determined to be not applicable to the Regulatory Determination. Four of these five cases could not be linked to coal combustion wastes and the other was at a coal mine, which is outside the scope of this NODA. Of the remaining 20 cases, one damage case was the result of wastes other than coal combustion wastes; one was not considered because it was an illegal, unpermitted dump; and 18 cases were indeterminate due to insufficient information⁵.

Table 1. Eleven Damage Cases Cited in the May 2000 Regulatory Determination

Damage Case	Wastes Present	Event	Criteria (Test of Proof)	Comment
Coal-Fired Utility Comanaged Wastes				
Chisman Creek (VA)	Coal ash and petroleum coke landfill.	Se primary MCL exceedance; V, Se, and sulfate in residential drinking water wells.	Scientific ⁶ /Admini strative ⁷	Was put on NPL. EPA required remediation: new water supply to nearby residents, capping disposal area, ground water treatment, relocation of surface water tributary; other possible sources of contamination.

http://www.epa.gov/epaoswer/other/fossil/fic2_397.pdf. This language, in turn, is derived from the 1993 *Report to Congress on Cement Kiln Dust Waste*: <http://www.epa.gov/epaoswer/other/ckd/cement2.htm>.

According to the 1993 CKD Report to Congress (Chapter Five), Section 8002(o)(4) of RCRA requires that EPA's study of CKD waste examine "documented cases in which danger to human health or the environment has been proved." In order to address this requirement, EPA defined danger to human health to include both acute and chronic effects (e.g., directly observed health effects such as elevated blood lead levels or loss of life) associated with management of CKD waste. Danger to the environment includes the following types of impacts: (1) Significant impairment of natural resources; (2) Ecological effects resulting in degradation of the structure or function of natural ecosystems and habitats; and (3) Effects on wildlife resulting in damage to terrestrial or aquatic fauna.

⁴ Per the May 2000 Regulatory Determination, 65 FR 3224, potential damage cases are those with (1) documented exceedances of primary MCLs or other health-based standards only directly beneath or in very close proximity to the waste source, and/or (2) documented exceedances of secondary MCLs or other health-based standards on-site or off-site.

⁵ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

⁶ Where a scientific study demonstrates there is documented evidence of damage to human health or the environment other than ground water contamination (e.g., ecological damage).

⁷ Where there has been an administrative ruling by a state or federal agency, or court decision with an explicit finding of specific damage to human health or the environment [e.g., listing on EPA's National Priorities List (NPL)].

Damage Case	Wastes Present	Event	Criteria (Test of Proof)	Comment
Faulkner Offsite Disposal Facility (MD)	Coal ash and pyritic mill rejects.	Low pH; exceedance of State standard; landfill and collection pond seepage and discharges resulted in plant and fish impacts to adjacent wetlands.	Scientific/Administrative	State required remediation included pond liners, landfill cover, and sequestration of pyrites.
DPC – Old E.J. Stoneman Ash Pond (WI)	Coal ash, demineralizer regenerant, other water treatment wastes.	Cd and Cr primary MCL exceedance; 'gross contamination' by pond cited by State – Elevated levels of Zn and sulfate; Boron near 5 mg/L in private drinking water well.	Administrative	State required Closure plan and relocation of town water supply well.
Basin Electric W.J. Neal Station (ND)	Coal ash and sludge; comanaged wastes probable.	Cr exceeded state standard and other metals detected at elevated levels in downgradient sediments and ground water.	Administrative (limited information available)	State required the site closed and capped, NFRAP (No Further Remedial Action Planned).
VEPCO – Possum Point (VA)	Coal ash, pyrites, oil ash, water treatment wastes, and boiler cleaning wastes	Cd primary MCL exceedance in ground water; ground water contaminated with Cd and Ni, attributed to pyrites and oil ash.	Administrative	Response included sequestration of oil ash, pyrites, and metal cleaning wastes to separate lined units.
WEPCO Hwy 59 Ash Landfill (WI)	Coal ash and mill rejects; other comanaged wastes probable.	Boron exceedance of state standard in down gradient ground water; elevated levels of As, Fe, Se, Mn, sulfate in private drinking water wells.	Scientific / Administrative	State required additional monitoring for problem/damage assessment.
Alliant Nelson Dewey (WI)	Coal ash, comanaged wastes.	Boron exceedance of state standard in down gradient ground water; elevated levels of As, Se, Fl, sulfate in ground water.	Administrative	State required company to investigate and assess problem; remedial action change to dry ash handling and modify landfill cover to reduce infiltration.

Damage Case	Wastes Present	Event	Criteria (Test of Proof)	Comment
Coal Creek Station (ND)	Coal ash, comanaged wastes.	Se and As exceedance of primary MCL in ground water on site; elevated sulfate and chloride levels in down gradient ground water.	Administrative	Impacted shallow ground water aquifer. State required additional impoundment liners.
Non-Utility Coal Combustion Waste Sites				
Salem Acres (MA)	Large volume; many other wastes present including municipal solid waste and industrial solid waste.	PAHs, VOCs, PCBs, metals including As and Cr; in soils, surface-waters, and ground water.	Administrative (on NPL) ⁸	Contribution of FFC wastes to damage not separable from other wastes. Remedial measures taken including excavation, treatment, removal of sludges and soils.
Lemberger Landfill, Inc. ⁹ (WI)	Comanaged wastes; many other materials including municipal solid waste; adjacent site contains industrial solid waste.	Elevated levels of As, Cr, and Pb onsite, VOCs, PCBs. VOCs in private water wells initiated action.	Administrative (on NPL) ¹⁰	Contribution of FFC wastes to damage not separable from other wastes.
Don Frame Trucking Fly Ash Landfill (NY)	Coal ash, other materials.	Pb exceedance of primary MCL action level in down gradient ground water; elevated levels of Mn, sulfate, TDS in a water supply well.	Administrative	State required remedial action: site closure landfill cover; post-closure care and monitoring.

Soon after the publication of the Regulatory Determination, the Agency conducted a reevaluation of the damage cases identified in the Regulatory Determination, including the 11 proven damage

8

http://yosemite.epa.gov/r1/npl_pad.nsf/f52fa5c31fa8f5c885256adc0050b631/C8A4A5BEC0121F048525691F0063F6F3?OpenDocument

⁹ Reclassified as a potential damage case. See Section III., Potential Damage Cases. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

¹⁰ <http://www.epa.gov/superfund/sites/npl/nar735.htm>

cases, the four additional ecological damage cases¹¹ which were identified in comments on the 1999 Report to Congress, the illegal disposal case, and the two potential damage cases attributed to non-utility coal combustion waste in the 1999 Report to Congress. As a result of this review, one of the cases identified in the Regulatory Determination as an ecological damage case, and the case identified as an illegal disposal case were reclassified as proven damage cases due to contamination of ground water from the disposal of CCW in sand and gravel pits and another site, the Lemberger Landfill, was reclassified as a potential damage case¹².

In October 2000, the Agency began collecting additional information from its own experience, from state agencies, and from commenters to clarify the details of the 18 previously indeterminate cases, which were included as part of the 59 cases identified by the public interest groups in their comments on the March 1999 Report to Congress. After analyzing this additional information, EPA classified three of the 18 cases as proven damage cases, nine as potential damage cases, and six as cases without documented evidence of proven or potential damage or where the damage could not be clearly attributed to CCW. Two of the three proven damage cases involved management of CCW in sand and gravel pits and the third - a surface impoundment¹³.

Finally, in February 2002, environmental- and citizen-organizations submitted to the Agency 16 alleged cases of damage¹⁴. Some of these cases had been submitted to EPA previously and evaluated for the 1999 Report to Congress. The Agency evaluated ten of the 16 cases¹⁵; one case was not evaluated because it involves minefilling of CCW, which, while under the scope of the 2000 Regulatory Determination, is outside the scope of this NODA that deals exclusively with surface disposal. The other five cases were not evaluated because they involved allegations with little or no supporting information. Of the ten cases evaluated, one case has been categorized as a proven damage case with documented off-site damages to ground water, while six cases were categorized as potential damage cases due to on-site exceedances of primary or secondary MCLs¹⁶. Another damage case was determined to be a proven ecological damage case as a result of documented impacts to fish and other wildlife on-site; this case also has been categorized as a potential (human health) damage case due to documented exceedances of primary and secondary MCLs attributable to an inactive CCW surface impoundment detected in on-site monitoring wells. Finally, one case was rejected because monitoring data for the site

¹¹ Ecological damages are damages to mammals, amphibians, fish, benthic layer organisms and plants.

¹² Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

¹³ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

¹⁴ Letter from the Hoosier Environmental Council, et. al., to Dennis Ruddy regarding the CCW RTC, September 24, 1999.

¹⁵ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

¹⁶ See Potential DCs, Section III of this document.

revealed no exceedances of primary or secondary MCLs attributable to coal combustion waste placement at the site, while another site is an oil burning facility and, therefore, is not covered by the May 2000 Regulatory Determination¹⁷.

In August 2005, another damage case was recorded when a dam confining a surface impoundment in eastern Pennsylvania failed. This damage case resulted in discharge of coal-ash contaminated water into the Delaware River and concomitant pollution of ground water when an unlined surface impoundment was temporarily used to divert the ash from the breached impoundment. Other than obtaining verification of the event from state authorities, the Agency did not conduct an independent evaluation of this case¹⁸.

In summary, EPA gathered or received information on 135 possible damage cases and has evaluated 85 of these cases. Six of the 50 cases that were not evaluated were minefills and outside the scope of this NODA. The remaining 44 cases that were not evaluated involved allegations with little or no supporting information. (See Table 2: Fossil Fuel Combustion (FFC) Damage Case Resolution, excluding minefills)

Of the 85 cases evaluated, EPA determined that 24 were proven cases of damage¹⁹. Sixteen were determined to be proven damages to ground water and eight were determined to be proven damages to surface water. Four of the proven damages to ground water were from unlined landfills, five were from unlined surface impoundments, one was due to a liner failure at a surface impoundment, and the remaining six were from unlined sand and gravel pits. Another 43 cases were determined to be potential damages to ground water or surface water. Four of the potential damage cases were attributable to oil combustion wastes. The remaining 18 alleged damage cases were not considered to be proven or potential damage cases; they were, therefore, rejected due to either (1) lack of any evidence of damage or (2) lack of evidence that damages were uniquely associated with CCW²⁰.

Of the 16 proven cases of damages to ground water, the Agency has been able to confirm that corrective actions have been completed in six cases and are ongoing in nine cases. The Agency has not received information regarding the one remaining case. Corrective actions measures at these CCW management units vary depending on site specific circumstances and include formal closure of the unit, capping, the installation of new liners, ground water treatment, ground water monitoring, and combinations of these measures.

¹⁷ Status of Alleged Damage Cases Submitted by HEC, et. al., to Dennis Ruddy, February, 2002.

¹⁸ PA DEP Press Release, December 27, 2005.

¹⁹ See Proven Damage Cases, Section II of this document. In addition to the documents previously cited, additional discussions of proven damages can be found in the Memorandum from SAIC to Dennis Ruddy regarding Additional Information Regarding Fossil Fuel Combustion Waste Damage Cases, April 20, 2000; and Ecological Assessment of Ash Deposition and Removal, Euharlee Creek, Georgia Power Bowen Plant.

²⁰ See Rejected Cases Excluding Minefills, Section IV of this document.

Table 2. Fossil Fuel Combustion (FFC) Damage Case Resolution, excluding minefills
(Updated 2/03/05)

Occurrence	State	Final Proven	Final Potential	Final Rejected	Indeterminate	Not re-evaluated	Non-FFC	Sand & Gravel Pit	Non-Utility	Oil Comb. Waste	Eco-Damage
TVA Widows Creek	AL		X								
TVA Colbert Plant	AL		X								
Arizona Public Serv Cholla Station	AZ		X								
Comanche, PSCC	CO				X						
Pierce Site	CT				X						
Hunts Brook Watershed (3 sites)	CT				X						
FP&L - Lansing Smith Plant (part 1)	FL		X								
TECO Big Bend Electric Plant	FL										
TECO Polk Power Station	FL										
FP&L Port Everglades (EPRI #6)	FL		X (oil)							X	
FP&L Riviera (EPRI #10)	FL		X (oil)							X	
FPC P.L. Bartow (EPRI #66)	FL		X (oil)							X	
Georgia Power Bowen	GA	X									
Muscatine County	IA		X								
American Coal Corp. #5 CCR Landfill	IA			X							
Star Coal Co. #6 CCR Landfill	IA			X							
Star Coal Co. #14 CCR Landfill	IA			X							
Powerton Plant	IL		X					X			
Central IL Light Duck Creek	IL		X								
Power Hennepin Station	IL		X								
IL Power Havana Plant	IL		X								
IL Power - Vermilion	IL		X								
Cent. IL PSC - Hutsonville Station	IL		X								
IL Power - Wood River	IL		X								
Coleen, White, Brewer Ash Landfill	IL		X								
Turris Coal Company Elkhart Mine	IL			X							
Michigan City Site	IN		X								
Bailey Station	IN		X								
RM Schaffer Station (Schahfer)	IN		X								
SIGECO - AB Brown	IN		X								
IP&L - Petersburg Station	IN		X								
Hoosier Energy Merom Landfill	IN		X								
Yard 520 Landfill Pines	IN	X									
Indiana-Kentucky Electric Clifty Creek Station	IN				X						
Cinergy/Cinn. G&E - East Bend/Boon County - FGD	KY		X								
LG&E Mill Creek Plant	KY				X						
LG&E Cane Run Plant	KY				X						
Salem Acres	MA	X									
Vitale Fly Ash Pit	MA	X						X			
Rezendes Ash Landfill (South Main Street Site/Freetown)	MA		X					X			
Copicut Road Monofill, Freetown	MA			X				X			
SE Salem Harbor, Salem	MA				X						
Brayton Point (EPRI #27)	MA		X (oil)							X	

Table 2. Fossil Fuel Combustion (FFC) Damage Case Resolution, excluding minefills
(Updated 2/03/05)

Occurrence	State	Final Proven	Final Potential	Final Rejected	Indeterminate	Not re-evaluated	Non-FFC	Sand & Gravel Pit	Non-Utility	Oil Comb. Waste	Eco-Damage
PEPCO Faulkner	MD	X									
Constellation Energy Crofton	MD				X						
Brandywine Disposal Site	MD				X						
Lansing Board P&L - N. Lansing Landfill	MI	X						X			
Thompson Landfill	MI			X							
Motor Wheel, Inc	MI							X			
Dagget Sand & Gravel, Inc	MI				X			X			
Sherburne County Plant	MN		X								
Colstrip Power Plant	MT										
Hyco Lake (CP&L Roxboro)	NC	X									X
Belews Lake	NC	X									X
Duke Power - Allen Plant	NC		X								
Ecusta Ash Monofill	NC					X			X		
BASF Industrial Landfill	NC					X			X		
Neal Station BESI	ND	X									
Coop Power & United Power - Coal Creek	ND	X									
Montana-Dakota - Heskett Station	ND		X								
Stanton Site, United Power	ND				X						
Leland Olds Site, Basin Electric	ND				X						
Don Frame Trucking	NY	X									
AES Creative Weber Site	NY		X								
Central Hudson G&E - Danskammer Site	NY		X								
C.R. Huntley Ash Landfill	NY		X								
Cinergy/Cinn. G&E - Miamiview Landfill	OH		X					X			
Cinergy/Cinn. G&E - Beckjord Station	OH		X								
Muskingum River Power Plant Impoundments	OH			X							
Cardinal Fly Ash Reservoir II Impoundment	OH			X							
Cardinal PFBC Monofill	OH			X							
Stuart Station Monofill	OH			X							
Gavin Impoundments	OH			X							
Kyger Creek Power Plant Impoundments	OH			X							
Lake Erie	OH			X							X
Conesville FGD Landfill (part 1)	OH		X								
Tristate Asphalt Flyash Landfill	OH				X						
Muskogee Env. Ash Site	OK			X							
Western Farmers Ash Site	OK			X							
Public Service Ash Site	OK			X							
Fort Gibson Fly Ash Monofill	OK				X						
Grand River Dam Authority	OK				X						
IMCO	OK				X						
Elrama Plant	PA		X								
Hatsfield Ferry Power Plant, Greene County	PA				X						
Zullinger Quarry	PA				X						

**Table 2. Fossil Fuel Combustion (FFC) Damage Case Resolution, excluding minefills
(Updated 2/03/05)**

Occurrence	State	Final Proven	Final Potential	Final Rejected	Indeterminate	Not re-evaluated	Non-FFC	Sand & Gravel Pit	Non-Utility	Oil Comb. Waste	Eco-Damage
Veterans Quarry, Domino Salvage	PA				X						
Shawville Site, Penelec	PA				X						
Montour Ash Disposal Area	PA				X						
SC Elec & Gas Canadys Plant	SC	X									
Savannah Riv. Project	SC	X									X
SCE&G McMeekin Station	SC				X						
Chestnut Ridge Y-12 Steam Plant Operable Unit 2	TN	X									X
TVA Bull Run Steam Plant	TN		X								
Brandy Branch Reservoir	TX	X									X
Welsh Reservoir	TX	X									X
Martin Creek Reservoir	TX	X									X
JT Deely Power Plant, San Antonio Public Services	TX				X						
VEPCO Possum Pt (Virginia Power)	VA	X								OCW & CCW	
VEPCO Chisman (Virginia Power)	VA	X						X			
Clinch River (part 1)	VA			X							X
Dixie Caverns Landfill	VA			X			X				
Chesterfield, Virginia Power	VA				X						
Georgia Pacific Industrial Waste Landfill, Big Island	VA					X			X		
Dairyland Power Stoneman (Old E.J. Stoneman)	WI	X									
WEPCO Hwy 59	WI	X						X			
Alliant Nelson Dewey	WI	X									
WEPCO Cedar Sauk Landfill (part 1)	WI	X						X			
WEPCO Port Washington	WI	X						X			
Alliant Rock River	WI		X								
Alliant Edgewater 1-4	WI		X								
Wisconsin Power Pulliam Ash	WI		X								
Dairyland Power Alma On-site Landfill	WI		X								
Dairyland Power Alma Off-site Landfill	WI		X								
Lemberger Landfill	WI		X					X			
Genoa #3, Dairyland Power Cooperative (DPC)	WI				X						
Old Columbia, WPL	WI				X						
Oak Creek, WEPCO	WI				X						
New Columbia, WPL	WI				X						
Locks Mill Landfill	WI					X			X		
Biron On-site Landfill	WI					X			X		
Kraft Division Off-site Landfill	WI					X			X		
Niagara of Wisconsin Paper Corporation Flyash Landfill	WI					X			X		
RPC Landfill #1	WI					X			X		
RPC Landfill #2	WI					X			X		
RPC Pine Lake Landfill	WI					X			X		
Ward Paper Company Landfill	WI					X			X		
Sasant Prairie, WEPCO	WI				X						
Dave Johnston Power Plant	WY		X								

Proven Coal Combustion Waste Damage Cases

II. Proven Damage Cases

Per the 2000 Regulatory Determination, 65 FR 32224 and the *Technical Background Document to the Report to Congress on Remaining Waste from Fossil Fuel Combustion: Potential Damage Cases* (1999), classifying damage to groundwater as a proven damage case requires the satisfaction of at least one of the following "tests of proof"²¹:

- 1) Scientific investigation: Damages that are found to exist as part of the findings of a scientific study. Such studies should include both formal investigations supporting litigation or a state enforcement action, and the results of technical tests (such as monitoring of wells). Scientific studies must demonstrate that damages are significant in terms of impacts on human health or the environment. For example, information on contamination of drinking water aquifer must indicate that contaminant levels exceed drinking water standards.
- (2) Administrative ruling. Damages are found to exist through a formal administrative ruling, such as the conclusions of a site report by a field inspector, or through existence of an enforcement that cited specific health or environmental damages.
- (3) Court decision. Damages are found to exist through the ruling of a court or through an out-of-court settlement.
- (4) As a practical matter, EPA employed a fourth criterion in determining whether damages are proven: available information needed to clearly implicate fossil fuel combustion wastes in the damage observed.

The above definition does not limit proven damage cases only to those sites with a primary MCL exceedance(s) in ground water distant from the waste management unit. A case still may be considered proven under the scientific investigation test if a scientific study demonstrates there is

²¹ The May 2000 Regulatory Determination falls short of providing a comprehensive definition of the review criteria ("test of proof") for assessing the validity of damage case allegations; it only discusses the review criteria in response to public comments on the review process of the Cement Kiln Dust (CKD) proposed rule, and focuses only on the location of the exceedance point with respect to the source term (32224 CFR 65):

"Proven damage cases were those with documented MCL exceedances that were measured in ground water at a sufficient distance from the waste management unit to indicate that hazardous constituents had migrated to the extent that they could cause human health concerns."

The "test of proof" criteria were fully defined on pp. 3-4 of the *Technical Background Document to the Report to Congress on Remaining Waste from Fossil Fuel Combustion: Potential Damage Cases* (1999): http://www.epa.gov/epaoswer/other/fossil/ffc2_397.pdf. This language, in turn, is derived from the 1993 *Report to Congress on Cement Kiln Dust Waste*: <http://www.epa.gov/epaoswer/other/ckd/cement2.htm>.

According to the 1993 CKD Report to Congress (Chapter Five), Section 8002(o)(4) of RCRA requires that EPA's study of CKD waste examine "documented cases in which danger to human health or the environment has been proved." In order to address this requirement, EPA defined danger to human health to include both acute and chronic effects (e.g., directly observed health effects such as elevated blood lead levels or loss of life) associated with management of CKD waste. Danger to the environment includes the following types of impacts: (1) Significant impairment of natural resources; (2) Ecological effects resulting in degradation of the structure or function of natural ecosystems and habitats; and (3) Effects on wildlife resulting in damage to terrestrial or aquatic fauna.

documented evidence of another type of damage to human health or the environment (e.g., ecological damage).

1. Salem Acres Site, Massachusetts²²

History: Fly ash disposal occurred at this site from at least 1952 to 1969. The site was originally contaminated by fly ash, sewage sludge, tannery waste and materials from a landfill on the site. The contamination was confined to the southernmost 13 acres of the 235 acre parcel and consisted of polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins/furans, volatile organic compounds (VOCs), chromium, arsenic, beryllium, vanadium and thallium.

EPA proposed adding the Salem Acres site to the NPL on October 15, 1984, and added it to the final list on June 10, 1986²³. On May 26, 1987, EPA signed a Consent Order with the South Essex Sewerage District (SESD) to perform the studies to examine the nature and extent of contamination and present technical options for cleanup. In December 1993, EPA signed a Consent Decree with the SESD to clean up the lagoons. The EPA also signed a separate Consent Decree with the Massachusetts Electric Company to clean up the fly ash pile on site. In October 1994, the EPA signed a Consent Order with DiBase Salem Realty Trust, the owner of the property and remaining party, to clean up the landfill and three debris piles.

Cleanup of the site was addressed in two stages: initial actions and a long-term remedial phase focusing on cleanup of the entire site. In 1987, lagoon water was removed and disposed of, the slurry wall at the disposal areas was capped and a fence was installed. In 1988, EPA covered the sludge pits with a high density polyethylene synthetic cap, removed the liquid wastes from the disposal pits to an off-site storage facility, and constructed concrete cut-off walls to prevent further releases into the wetlands. In 1990, repairs were made to a monitoring well and a security fence on site, and signs were posted to further restrict access.

The South Essex Sewerage District completed an investigation into the nature and extent of the soil and sludge contamination in early 1993. The investigation defined the contaminants of concern and recommended alternatives for final cleanup. Ground water at the site and adjacent wetlands demonstrated only minor contamination and therefore, no further remedial actions were planned. EPA selected a final remedy for the site, including sludge-fixation with fly ash and other substances such as cement and soil, as necessary and disposed of off-site to a secured landfill. A contingent remedy includes the installation of an EPA-approved cap. In 1995, the fly ash area and "old landfill" on site were excavated and the contaminated material was taken off site to a municipal landfill. Final site restoration of these areas occurred in 1996. The sludge lagoon cleanup was completed in the fall of 1997 and final site restoration was completed in the

²² Memorandum from SAIC to Dennis Ruddy regarding Additional Information Regarding Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

²³

http://yosemite.epa.gov/r1/npl_pad.nsf/f52fa5c31fa8f5c885256adc0050b631/C8A4A5BEC0121F048525691F0063F6F37?OpenDocument

spring of 1998. In the summer of 1999, fly ash was removed from the wetland adjacent to the former fly ash pile. The wetland was restored at this time. The site was officially deleted from the National Priorities List (NPL) effective July 23, 2001²⁴. The site now allows for unrestricted land use.

Basis for Consideration as a Proven Damage Case: The criteria for classifying this site as a proven damage case were (1) Scientific – Arsenic and chromium exceeded (health-based) primary MCLs, and (2) Administrative – The site has been placed on the NPL list, and EPA signed a Consent Order with the owner to clean up the lagoons.

2. City of Beverly/Vitale Brothers Fly Ash Pit, Massachusetts²⁵

History: This site is an abandoned gravel and sand mine that was used as an unpermitted landfill from the 1950's until the mid-1970s. The site was operated by the Vitale Brothers until 1980, when the City of Beverly Conservation Commission gained ownership because of failure to pay property taxes. On the site, the Vitale Brothers accepted and disposed saltwater-quenched fly ash from New England Power Company along with other wastes. Leaking underground storage tanks containing petroleum products were also located at the site. In 1973, fly ash at the site eroded into a nearby swamp and a stream that is a tributary to a surface drinking water supply. The erosion created a damming effect and resulted in flooding of neighboring property. In 1988, surface water sampling of the stream revealed levels of iron and manganese significantly greater than upstream levels. Additionally, there were complaints of fugitive dust from the site from neighbors located 500 feet away. Air sampling on one occasion in 1988 revealed arsenic concentrations of 2 parts per billion. Finally, 1988 ground water sampling found arsenic and selenium in excess of their primary MCLs and aluminum, iron, and manganese in excess of secondary MCLs. According to the State, fly ash is the suspected source of contamination in all of these media.

Fly ash is disposed at the site at depths from 14 to 36 feet. Not only is the site unlined, but ground water depth at the site is between 10 and 21 feet, indicating the likelihood of direct contact with fly ash. Fly ash also is observed to be present at the surface of the site with no cover or other surface runoff, erosion, or fugitive dust controls. Finally, the site is located in close proximity to a wetland and a surface water body.

The site has a long history of noncompliance with local and State laws and regulations. Following the completion of a Comprehensive Site Assessment and Risk Characterization in preparation for potential remedial action under Massachusetts regulations for the assessment and cleanup of hazardous waste sites, the fly ash was removed and the site was redesigned with special attention to protecting the adjacent water courses from erosion²⁶. The Vitale Flyash site

²⁴ Ibid

²⁵ Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

²⁶ http://www.erosioncontrol.com/ecm_0603_erosion.html

submitted a site closure report February 1, 2007, and a preliminary screening of the site closure report is underway²⁷.

Basis for Consideration as a Proven Damage Case: This case was not counted as a proven damage case in the 1999 Regulatory Determination because it was a case of illegal disposal not representative of historical or current disposal practices. The case, however, otherwise meets the criteria for a proven damage case for the following reasons: (1) Scientific – (i) selenium and arsenic exceeded (health-based) primary MCLs, and (ii) there is evidence of contamination of nearby wetlands and surface waters; and (2) Administrative - the facility was the subject of several citations and the State has enforced remedial actions.

3. Don Frame Trucking, Inc. Fly Ash Landfill, New York²⁸

History: This solid waste management facility had been used for disposal of fly ash, bottom ash, and other material including yard sweepings generated by the Niagara Mohawk Power Corporation's Dunkirk Steam Station. The age of the facility was not identified in the materials provided. The available monitoring data for this facility include quarterly water quality analysis and various miscellaneous data collected at the facility from March 1989 through September 1998. These data show down-gradient levels of lead greater than the primary MCL Action Level. These exceedances occurred in 1989 and 1996. The data also document elevations from background of sulfate, total dissolved solids, and manganese, including levels of manganese in a water supply well greater than the secondary MCL.

As a result of the contamination, Don Frame Trucking recommended to the New York State Department of Environmental Conservation (NYSDEC) that the affected water supply well should immediately be connected to a public water supply. Also, on September 16, 1988, Don Frame Trucking, Inc. was directed to cease receiving the aforementioned wastes at the facility no later than October 15, 1988, in accordance with the standards contained in 6 NYCRR Part 360.²⁹ The site was divided into five separate sections. The NYSDEC directed Don Frame Trucking, Inc. to place two feet of a "final cover" over Section I. The soil should have a coefficient of permeability of 1×10^{-5} cm/sec. NYSDEC directed Section II to be covered with 18 inches of clay cover with a coefficient of permeability of 1×10^{-7} in two shifts. Once the permeability was tested and considered acceptable, NYSDEC directed Don Frame Trucking, Inc. to place six additional inches of topsoil over the clay cover and then seed and mulch the section. Eighteen inches of clay with a coefficient of permeability of 1×10^{-7} was also directed to be placed on Sections III, IV, and V, followed by reseeding and mulching. Don Frame Trucking, Inc. was instructed to finish all remediation procedures by October 15, 1988, and then provide

²⁷ MADEP tracking number 3-00230; email message from Patricia Donahue, MADEP, July 9, 2007.

²⁸ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

²⁹ Application of Don Frame Trucking, Inc. Petitioner for a Judgment Pursuant to Article 78 of the CPLR against the New York State Department of Environmental Conservation Respondent; Supreme Court of the State of New York County of Chautauqua (July 22, 1988). Order G11278.

certification by a licensed professional engineer that the facility was closed in accordance with the rules and regulations as stipulated by the NYSDEC by October 21, 1988. Post-closure ground water and surface water monitoring and maintenance were also expected to continue for 30 years after final closure of the entire facility.

Basis for Consideration as a Proven Damage Case: (1) Scientific - The lead levels found in down-gradient wells exceed the primary MCL Action Level; (2) Administrative - The State has required remedial action as a result of the contamination; and (3) Court order - The owner was directed, by the Supreme Court of the State of New York County of Chautauqua (July 22, 1988), to cease receiving the aforementioned wastes at the facility no later than October 15, 1988.

4. Virginia Electric Power Co. (VEPCO) Possum Point, VA³⁰

History: EPA identified this site as a proven damage case in the March 1999 Report to Congress. It is described in detail in the Report and supporting technical background documents in the rulemaking docket.

The technical background document³¹ states: "One additional documented damage case is the Virginia Electric and Power Company (VEPCO) Possum Point Site, described in the 1993 Regulatory Determination. This is an active facility with 40-acre unlined ash ponds with solids dredged to 80-acre lined ponds. These ponds received coal ash, pyrites, water treatment wastes, boiler cleaning wastes, and oil ash. Ground water monitoring found cadmium at concentrations 3.6 times and nickel, at 26.4 times the primary MCLs. Monitoring for vanadium was conducted but no results were given. The elevated concentrations were attributed to the pyrites and oil ash. These wastes, along with metal cleaning wastes, were ordered sequestered to separate lined units."

The 1999 Report to Congress³² states: "**Possum Point, Virginia** (described in the 1993 Supplemental Analysis). At this site, oil ash, pyrites, boiler chemical cleaning wastes, coal fly ash, and coal bottom ash were comanaged in an unlined pond, with solids dredged to a second pond. Levels of cadmium above 0.01 mg/L were recorded prior to 1986 (the primary MCL is 0.005 mg/L). After that time, remedial actions were undertaken to segregate wastes (oil ash and low volume wastes were believed to be the source of contamination). Following this action, cadmium concentrations were below 0.01 mg/L."

Basis for Consideration as a Proven Damage Case: Based on evidence on exceedances of cadmium and nickel, the State pursued an Administrative Action by requiring the removal of the waste, thus qualifying it as a proven damage case.

³⁰ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

³¹ Technical Background Document For the Report to Congress On Remaining Wastes from Fossil Fuel Combustion: Potential Damage Cases, March 15, 1999 (http://www.epa.gov/epaoswer/other/fossil/tfc2_397.pdf)

³² http://www.epa.gov/epaoswer/other/fossil/volume_2.pdf

5. PEPSCO Morgantown Generating Station Faulkner Off-site Disposal Facility, Maryland³³

History: Landfills at this site manage fly ash, bottom ash, and pyrites from the Morgantown Generating Station starting in 1970. Unlined settling ponds also are used at the site to manage stormwater runoff and leachate from the ash disposal area. In 1991, the State found that water quality was degraded in the underlying aquifer and that ground water contamination had migrated to nearby surface waters (including a stream and a wetland area). The impacts included vegetative damages, orange staining from iron precipitation, and low pH. Because of the ground water migration, the operator was cited for unpermitted discharges to surface water. The low pH impacts are believed to have resulted from pyrite oxidation. The low pH may also have contributed to the migration of other contaminants. Additionally, ground water beneath the facility is shallow. Documentation shows the water table is very close to the bottom of the ash disposal area at the down-gradient end of the facility and well above the base of the settling ponds used to manage stormwater runoff and leachate from the ash disposal area.

Remedial measures at the site included closure and capping of older units, installation of liners in newer units, installation of a slurry wall to prevent ground water migration, and sequestration of pyrites. EPA identified this site as a proven damage case in the March 1999 Report to Congress. It is described in detail in the Report and supporting technical background documents in the rulemaking docket.

Basis for Consideration as a proven Damage Case: EPA has categorized this case as a proven damage case for the following reasons: (1) Scientific - Ground water contamination migrated off-site; and (2) Administrative - The State required remedial action.

6. Virginia Power Yorktown Power Station Chisman Creek Disposal Site, Virginia³⁴

History: This site consists of three parcels of land that cover 27 acres. Between 1957 and 1974, abandoned sand and gravel pits at the site received fly ash from the combustion of coal and petroleum coke at the Yorktown Power Station. Disposal at the site ended in 1974 when Virginia Power began burning oil at the Yorktown plant. In 1980, nearby shallow residential wells became contaminated with vanadium and selenium. Water in the wells turned green and contained selenium above the primary MCL and sulfate above the secondary MCL. Investigations in response to the discolored drinking water found heavy metal contamination in the ground water around the fly ash disposal areas, in onsite ponds, and in the sediments of Chisman Creek and its tributaries. Arsenic, beryllium, chromium, copper, molybdenum, nickel, vanadium, and selenium were detected above background levels.

³³ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

³⁴ Ibid. Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

The contamination at the site's vicinity was caused by the combination of several factors: (i) The facility was operated with no dust or erosion controls; (ii) The facility is unlined and located in close proximity to drinking water wells, and ground water at the site was very shallow and possibly in contact with disposed waste.; (iii) A surface water tributary passed through or near the disposal areas.

In September 1983, EPA added the site to the National Priorities List (NPL)³⁵ under the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA). Cleanup began in late 1986 and was conducted in two parts. The first part addressed the fly ash pits and contaminated ground water and included the following steps:

- Extension of public water to 55 homes with contaminated well water,
- Capping the disposal pits with soil (2 pits) or compacted clay (1 pit) overlain with topsoil and vegetative growth,
- Ground water and leachate collection for treatment and to lower the water table beneath the pits, and
- Post-closure monitoring.

The second part addressed the onsite ponds, a freshwater tributary stream, and the Chisman Creek estuary and included the following steps:

- Relocation of a 600-foot portion of the tributary to minimize contact with the fly ash disposal areas,
- Diversion of surface runoff, and
- Long-term monitoring for the ponds, tributary, and estuary.

Construction of all cleanup components was completed on December 21, 1990. The site has been redeveloped as a public park. Following the completion (in December 2006) of its third five-year review of the site, EPA determined that the remedial action at Operable Unit 1 is protective in the short term because the extent of the vanadium contamination in the shallow ground water aquifer is not presently known. EPA is presently working with Virginia Power to determine the extent of the vanadium contamination and to amend the restriction to make sure it provides the necessary assurance that it will be protective over time.

Basis for Consideration as a Proven Damage Case: EPA identified this site as a proven damage case in the March 1999 Report to Congress. It is described in detail in the Report and supporting technical background documents in the rulemaking docket. EPA has categorized this case as a proven damage case for the following reasons: (1) Scientific – (i) Drinking water wells contained selenium above the (health-based) primary MCL and (ii) There is evidence of surface water and sediment contamination; and (2) Administrative - The site was remediated under CERCLA.

³⁵ <http://epa.gov/ce3hwynd/npl/VAD980712913.htm>

7. Hyco Lake, Roxboro, North Carolina³⁶

History: This case was originally identified by a public interest group in a table alleging selenium contamination, and a selenium fish consumption advisory³⁷.

Hyco Lake was constructed in 1964 as a cooling water source for the CP&L Roxboro Steam Electric Plant. The lake received discharges from the plant's ash-settling ponds containing high levels of selenium. The selenium accumulated in the fish in the lake, affecting reproduction and causing declines in fish populations in the late 1970s and 1980s. The North Carolina Department of Health and Human Services issued a fish consumption advisory in 1988³⁸.

In 1990, CP&L installed a dry ash handling system to meet new permit limits for selenium. To determine the effectiveness of the new handling system, the Department of Water Quality is requiring long-term monitoring of the lake. Based on the results of fish tissue sampling, the fish consumption advisory has been rescinded in stages starting in 1994³⁹. It was completely rescinded in August, 2001⁴⁰.

Basis for Consideration as a Proven Damage Case: This case is categorized as a proven ecological damage case for the following reasons: (1) Scientific - declines in fish populations were observed (1970s & 1980s); (2) Administrative - The State concluded that the impacts were attributable to the ash ponds, and issued a fish consumption advisory as a result of the contamination.

8. Georgia Power Company, Plant Bowen, Cartersville, GA⁴¹

History: This unlined CCW management unit was put in service in 1968. On July 28, 2002, a sinkhole developed in the (coal) ash pond of the Georgia Power Company - Plant Bowen Facility (coal-fired generating facility). The sinkhole ultimately reached four acres and a depth of thirty

³⁶ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

³⁷ Letter from the Hoosier Environmental Council to the RCRA Docket Information Center regarding comments on the May 2000 Regulatory Determination, September 19, 2000.

³⁸ Selenium Posting on Hyco Lake Rescinded, North Carolina Department of Health and Human Services (NCDHHS), August 2001.

³⁹ Roanoke River Basinwide Water Quality Plan, Section B, Chapter 5: Roanoke River Subbasin 03-02-05, North Carolina Department of Environment and Natural Resources (NCDENR), July 2001. Available at http://h2o.enr.state.nc.us/basinwide/roanoke/2001/2001_Roanoke_wq_management_plan.htm

⁴⁰ Selenium Posting on Hyco Lake Rescinded, North Carolina Department of Health and Human Services (NCDHHS), August 2001.

⁴¹ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007. Ecological Assessment of Ash Deposition and Removal, Euharlee Creek, Georgia Power Bowen Plant, available in the docket to the CCW NODA (EPA-HQ-RCRA-2006-0796).

feet. The integrity of the ash pond dikes did not appear to be compromised. The company estimated that 2.25 million gallons of ash/water mixture was released to an unnamed tributary of the Euharlee Creek, containing 281 tons of ash. Georgia's Department of Natural Resources alleges an unpermitted discharge of water containing approximately 80 tons of ash slurry entered Euharlee Creek through a stormwater drainage pipe resulting in a temporary degradation of public waters.

Georgia Department of Natural Resources issued a consent order on November 20, 2002. The order contained the following provisions:

- Fine of \$31,250 was imposed;
- Company to perform ecological impact study of the ash discharge into Euharlee Creek and recommend remedial action;
- Company to submit proposed dredging plan if necessitated by impact study;
- Company to submit report on actions taken to fill sinkhole and grout fissures under the dike;
- Company to perform geological engineering assessment of the ash pond stability and recommend corrective actions to address future sinkhole development;
- Company to submit a revised ash water management plan;
- Georgia EPD approved corrective action plans shall be implemented; and
- Company shall submit interim progress report and final schedule for completion of implementation of corrective action plans.

Basis for Consideration as a Proven Damage Case: (1) Scientific - unpermitted discharge of water containing ash slurry into the Euharlee Creek resulting in a temporary degradation of public waters; and (2) Administrative - Georgia Department of Natural Resources issued a consent order requiring, among others, a fine and corrective action.

**9. Department of Energy - Oak Ridge Y-12 Plant Chestnut Ridge Operable Unit 2
DOE Oak Ridge Reservation, Oak Ridge, Tennessee⁴²**

History: This case was originally identified by public commenters in a table that alleged aluminum, arsenic, iron, and selenium contamination, as well as fish deformities and a region of a stream where no fish are found⁴³.

Chestnut Ridge Operable Unit (OU) 2 consists of Upper McCoy Branch, the Filled Coal Ash Pond (FCAP), and the area surrounding the sluice channel formerly associated with coal ash disposal in the FCAP. Upper McCoy Branch runs from the top of Chestnut Ridge across the FCAP into Rogers Quarry. The FCAP is an 8.5 acre area. The sluice channel area extends approximately 1,000 feet from the crest of Chestnut Ridge to the edge of the FCAP.

⁴² Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

⁴³ Letter from HEC et. al., to Dennis Ruddy, February, 2002.

The FCAP is an ash retention impoundment used to dispose of coal ash slurry from the Y-12 steam plant. It was constructed in 1955 by building an earthen dam across a northern tributary of Upper McCoy Branch, and was designed to hold 20 years of ash. By July of 1967, the impoundment was filled to within four feet of the top of the earthen dam. Once the impoundment was no longer able to retain the ash solids, the slurry was released directly into Upper McCoy Branch through direct flow over the earthen dam. In 1967 and 1968, Upper McCoy Branch was diverted into Rogers Quarry. Between 1967 and 1989, the ash slurry flowed directly from the FCAP into Upper McCoy Branch and then into Rogers Quarry. In 1989, a bypass pipe was constructed to carry the 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 are now disposed in a landfill. Existing ash deposits were left in place. Erosion of both the spillway and the ash itself has occurred, leading to releases of ash into Upper McCoy Branch⁴⁴.

In the mid-1980s, the Y-12 plant began investigation and ground water monitoring at a number of locations within its boundaries, as required under RCRA and by the Tennessee Department of Environmental Conservation (TDEC). The entire Oak Ridge Reservation was placed on the NPL in 1989. CERCLA requires all sites under investigation to complete a remedial investigation to determine the nature and extent of contamination, evaluate the risks to public health and the environment, and determine remedial action goals. The Remedial Investigation for OU conducted in two phases. Phase I was conducted by CH2M Hill in the Upper McCoy Branch zone. Phase II was conducted by CDM Federal in the FCAP and sluice area zones. Both investigations consisted of surface and ground water, soil, and ash sampling. The table below shows a summary of the results of the monitoring programs⁴⁵.

**Table 3. Oak Ridge Y-12 Plant Chestnut Ridge Operable Unit 2
Surface and Ground Water Monitoring Programs**

Monitoring type	Monitoring location	Constituents with exceedances of ambient/reference/background concentrations	Constituents with exceedance of MCLs or SMCLs
Surface Water	Upper McCoy Branch (Phase I)	Al, Fe, Cu	Al, As, Fe, Mn
	Upper McCoy Branch (Phase II)	Al, As, Ca, Mn, K, Na	Al, As, Mn
	FCAP Pond Water	Al, As, Ba, Ca, Cr, Cu, Fe, Pb, Mg, Mn, K, Na, V, Zn	Al, As, Fe, Mn

⁴⁴ Feasibility Study for the Y-12 Chestnut Ridge Operable Unit 2 Filled Coal Ash Pond, Oak Ridge, Tennessee. DOE/OR/02-1259&D1. August 1994.

⁴⁵ Ibid.

Monitoring type	Monitoring location	Constituents with exceedances of ambient/reference/background concentrations	Constituents with exceedance of MCLs or SMCLs
	Spring Water	Al, As, Ba, Ca, Pb, Mn, Hg, K, V, Zn	Al, As, Fe, Pb, Mn
Ground Water	Upper McCoy Branch (Phase I)	Al, Ba, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Se, Zn	Al, Fe, Mn
	Upper McCoy Branch (Phase II)	information not provided	Mn
	Sluice Channel Area	information not provided	Mn
Soil	Near Upper McCoy Branch (Phase II)	Al, As, Ba, Fe, Mn, K, Na	Not applicable
	Near FCAP	Al, As, K, Na	Not applicable
Ash	Entire Site	No background data	Not applicable

Biological monitoring has also been conducted at the site as part of a RCRA Facility Investigation (RFI) required by the 1984 Hazardous and Solid Waste Amendments to RCRA, and as part of the Phase I Remedial Investigation. The biological monitoring conducted for the RFI included toxicity testing, bioaccumulation studies, fish community assessments, and a benthic macro-invertebrate community assessment. Biological monitoring for the Phase I RI consisted of toxicity testing, a benthic macro-invertebrate assessment, a soil (ash) invertebrate survey, and bioaccumulation studies⁴⁶.

The conclusions for the RFI biological monitoring programs were as follows:

- Toxicity testing: The results of the toxicity testing did not show significant evidence for toxic conditions in Upper McCoy Branch.
- Bioaccumulation studies:
 - Concentrations of selenium, arsenic, and possibly thallium were elevated in largemouth bass from Rogers Quarry, relative to bass from another nearby site;
 - Arsenic exceeded screening criteria;
 - Some fish from Rogers Quarry had deformed bony structures (these effects were not described in literature as effects of arsenic or selenium); and
 - Bioaccumulation was not indicated in Upper McCoy Branch discharge

⁴⁶ Ibid.

- Fish community assessment: The results indicate that Upper McCoy Branch is under severe stress:
 - No fish populations were found above Rogers Quarry; and
 - Downstream sunfish populations had high percentages of deformed heads and eroded fins.
- Benthic Macro-invertebrate Community Assessment: The results were indicative of moderate stress. The stress appears to be habitat alteration as a result of ash deposition within the stream channel and possibly leaching of potential toxicants from the ash.

The conclusions for the RI biological monitoring programs were as follows:

- Toxicity testing: The results did not show toxic conditions in Upper McCoy Branch.
- Benthic Macro-invertebrate Assessment: The results exhibited no strong evidence of impact at Upper McCoy Branch. There were some differences in July samples, which could be due to natural variations between the two locations, or could be due to low flow conditions increasing concentrations of contaminants from the ash.
- Soil (ash) Invertebrate Study: No invertebrates were found in samples from the sluice channel area or the FCAP, indicating this is not a possible pathway for contamination of the food chain.
- Bioaccumulation Studies:
 - Vegetation: The results show that selenium uptake into plants is a possible source of exposure to soil invertebrates and small mammals.
 - Small mammals: The study found higher concentrations of arsenic, selenium and lead in animals from the FCAP than in animals from a reference site.

A remedial action was conducted to stabilize the filled coal ash pond, McCoy Bridge dam holding contaminated pond sediments in place. A wetland, removed during stabilization activities, was re-constructed as part of the remedial action. Physical work was completed in March 1997. The remedial action report was approved in May 1997⁴⁷.

Basis for Consideration as a Proven Damage Case: This case has been categorized as a proven ecological damage case based on scientific documentation of impacts to fish and other wildlife on-site. This case has also been categorized as a potential (human health) damage case based on (1) Scientific basis - Exceedances of primary and secondary MCLs were detected in on-site monitoring locations, and (2) Administrative grounds - Federal RCRA and the Tennessee Department of Environmental Conservation (TDEC) requirements, including placement of the entire Oak Ridge Reservation on the NPL.

⁴⁷ <http://www.epa.gov/region4/waste/npl/npltn/oakridtn.htm>

10. South Carolina Electric & Gas Canadys Plant, South Carolina⁴⁸

History: This facility is a coal-fired power plant located along the Edisto River approximately 10 miles south of St. George, South Carolina. Ash from the power plant is mixed with water and managed in an ash storage pond. The facility operated an unlined, 80-acre ash pond from 1974 to 1989. A new, 95-acre ash pond lined with a bentonite slurry wall began operation in 1989.

Since 1982, arsenic has consistently been found in monitoring wells surrounding the old ash pond at levels above the MCL. Nickel also has occasionally been found above a State standard in a single monitoring well adjacent to the old ash pond. Because of these results, DHEC required the facility to delineate the extent of the contamination surrounding the old ash pond. The contamination was found to extend beyond the original property boundary of the facility, but the operator was allowed to buy neighboring property under State policy at the time. The investigation also showed that the contamination was not reaching the Edisto River and that its vertical extent was limited by a confining geologic unit 15 to 30 feet below the property. The facility is currently deactivating the old ash pond, with ash being removed and sold to a cement company. DHEC concluded that further migration of contaminants was not likely given the ground water conditions and the ongoing deactivation. In 1996, therefore, DHEC approved a mixing zone with ongoing monitoring around the old ash pond. The mixing zone establishes a compliance boundary around the old ash pond. Arsenic concentrations above the MCL are permitted within the mixing zone, but not at or outside of the compliance boundary.

The new ash pond extends beyond the compliance boundary of the old ash pond. Sampling in May 2000 found arsenic above its MCL at, and external to, the compliance boundary in wells that are adjacent to the new ash pond. Resampling in June 2000 confirmed the noncompliance. The facility's engineering contractor and DHEC suspect this arsenic contamination is associated with a separate plume originating from the new ash pond. DHEC suspects improper anchoring or a breach of the slurry wall surrounding the new ash pond. Based on a geophysical investigation, the facility's engineering contractor concluded that the slurry wall appears to have failed in various locations, allowing multiple seeps. The contractor noted that drought-like conditions during the preceding three years have caused a site-wide decrease in the water table. The increase in potentiometric head between the new ash pond and the falling water table may be a contributing factor to the breaches in the slurry wall. The facility has proposed additional monitoring to delineate the extent of the new arsenic plume and an extension of the compliance boundary to encompass the new ash pond. The facility also is evaluating possible corrective action alternatives for repairing or replacing the slurry wall. The extent of the new plume has not yet been fully delineated and DHEC has not yet determined what response may be required of the facility.

This site was initially classified as indeterminate because there was no information on the extent of the contamination (on-site or off-site), quantitative data on whether arsenic levels exceeded State standards, or confirmation that the contamination was attributable to fossil fuel combustion waste. In a follow-up assessment conducted after the Regulatory Determination, a representative

⁴⁸ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

from South Carolina's Department of Health and Environmental Control (DHEC) confirmed that there is arsenic contamination attributable to two coal combustion waste (CCW) management units at this site. According to the DHEC contact, it is unlikely that there are any ground water supply wells or other human exposure points in the vicinity of the facility. Furthermore, ground water supply wells in the region typically are drilled beneath the underlying confining geologic unit.

Basis for Consideration as a Proven Damage Case: Scientific - There are exceedances of the health-based standard for arsenic at this site. While there are no known human exposure points nearby, some recent exceedances have been detected outside an established regulatory boundary.

11. Belews Lake, North Carolina⁴⁹

History: This Lake was impounded in the early 1970s to serve as a cooling reservoir for a large coal-fired power plant. Fly ash produced by the power plant was disposed in a settling basin, which released selenium-laden effluent in return flows to the Lake. Due to the selenium contamination, 16 of the 20 fish species originally present in the reservoir were entirely eliminated, including all the primary sport fish. The pattern of selenium contamination from the plant and fish impacts persisted from 1974 to 1985. In late 1985, under mandates from the State of North Carolina, the power company changed operations for fly ash disposal, and selenium-laden effluent no longer entered the Lake.

A fish advisory was issued for selenium in 1993 which was rescinded December 31, 2000⁵⁰.

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven ecological damage case for the following reasons: (1) Scientific evidence of extensive impacts on fish populations due to direct discharge to a surface water body, and (2) Administrative - The State required changes in operating practices to mitigate the contamination.

12. U.S. Department of Energy Savannah River Project, South Carolina⁵¹

History: The Savannah River Project commenced operations and disposal of ash in 1952. At this site, a coal-fired power plant sluices fly ash to a series of open settling basins. A continuous flow of sluice water exits the basins, overflows, and enters a swamp that in turn discharges to Beaver Dam Creek. Observations of bullfrogs of all developmental stages in the settling basins and swamp suggest that the mixture of pollutants that characterize the site does not prevent

⁴⁹ Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

⁵⁰ <http://134.67.99.49/scripts/esrimap.dll?Name=Listing&Cmd=Name/Query&Left=-178.215026855469&Right=-52.6202812194824&Top=83.1083221435547&Bottom=-14.3755550384521&shp=3­=6&idChoice=3&loc=on&NameZoom=NC%20-%20Belews%20Lake>

⁵¹ Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

completion of the life cycle. However, bullfrog tadpoles inhabiting the site have oral deformities and impaired swimming and predator avoidance abilities. There also is evidence of metabolic impacts on water snakes inhabiting the site.

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven ecological damage case for the following reasons: (1) Scientific evidence of impacts on several species in a nearby wetland caused by releases from the ash settling ponds.

13. Dairyland Power Cooperative E.J. Stoneman Generating Station Ash Disposal Pond, Wisconsin⁵²

History: This facility is an unlined pond that managed ash, demineralizer regenerant, and sand filter backwash from the 1950's until 1987. During the facility's operating life, ground water monitoring of on-site wells around the pond found cadmium and chromium in excess of primary MCLs and sulfate, manganese, iron, and zinc in excess of secondary MCLs. Nearby private drinking water wells showed levels of sulfate and boron elevated from background. As a result, the State concluded that other constituents could reach the drinking water wells in the future.⁵³ Because of the evidence of ground water contamination and because the facility violated State location standards, the State denied the operator's proposal to continue operation of the pond. The State also required the operator to close the facility and provide alternative drinking water to the affected residences. The history of contamination also led the State to require a new landfill on the site to be constructed with a double liner and leachate collection.

In addition to being unlined, the unconsolidated soils beneath the site consist of highly permeable sand and gravel (estimated permeability of 10^{-2} cm/sec). The pond was located close to the Mississippi River, in violation of the State's requirement for 300 feet of separation from navigable rivers. The proximity to the river caused variable water table levels and periods of ground water mounding, during which the depth of ground water beneath the unit was very shallow (possibly as low as 1 foot). Finally, the pond was located closer to 15 water supply wells than allowed by State standards.

Basis for Consideration as a Proven Damage Case: EPA identified this site as a proven damage case in the March 1999 Report to Congress. It is described in detail in the Report and supporting technical background documents in the rulemaking docket. EPA has categorized this case as a proven damage case for the following reasons: (1) Scientific - Cadmium and chromium exceeded (health-based) primary MCLs, and contamination migrated to nearby, private drinking water wells; and (2) Administrative - The State required closure of the facility.

⁵² Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

⁵³ More recent monitoring data confirm this conclusion, with cadmium exceeding the primary MCL and iron and manganese exceeding secondary MCLs in the drinking water wells.

14. WEPCO Highway 59 Landfill, Wisconsin⁵⁴

History: This site is located in an old sand and gravel pit and received fly ash and bottom ash between 1969 and 1978. Ground water monitoring between 1988 and 1998 found sulfate, boron, manganese, chloride, and iron above the State's Enforcement Standards (ES) and arsenic above the State's Preventive Action Level (PAL) in nearby private wells. Other down-gradient monitoring wells showed sulfate, boron, iron, and manganese in excess of the ES and selenium and chloride in excess of PALs. State agency staff considered this site one of the most seriously affected coal ash sites in the State. The State required a continuation of monitoring at this closed facility in 1982 and an investigation into ground water contamination in 1994.

The facility is unlined and the soil underlying the site consists of fine to coarse sands and gravel with minor amounts of silt and clay and is believed to be relatively permeable. The original sand and gravel pit included an area of standing water. The presence of the standing water is attributed to the elevation of the ground water table exceeding the base of the pit in this area. Waste was disposed directly into this area to a depth of 5 to 10 feet below the water table. (Note also that the facility is located in close proximity to a wetland, although there is no documentation of impact to flora in the wetland.)

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven damage case of the following reasons: (1) Scientific - Although the boron standard was not health-based at the time of the exceedances, the boron levels reported for the facility would have exceeded the State's recently promulgated health-based ES for boron; and contamination from the facility appears to have migrated to off-site private wells; and (2) Administrative - As a result of the various PAL and ES exceedances, the State required a ground water investigation.

15. Alliant (formerly Wisconsin Power & Light) Nelson Dewey Ash Disposal Facility, Wisconsin⁵⁵

History: This facility was originally constructed in the early 1960's as a series of settling basins for sluiced ash and permitted by the State in 1979. Waste disposal at the site resulted in exceedances of the State's Preventative Action Levels (PALs) for arsenic, selenium, sulfate, boron, and fluoride. These exceedances occurred within the design management zone of the facility. Waste disposal also has resulted in exceedances of the State's Enforcement Standards (ES) for boron, fluoride, and sulfate outside the design management zone of the facility. As a result of these exceedances, the State required an investigation of ground water contamination in 1993. In 1996, the facility began converting to dry ash management and covering/closing phases of the facility.

⁵⁴ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

⁵⁵ Ibid.

Soil underlying the site consists of unconsolidated glacial outwash deposits of relatively high permeability (estimated between 10^{-2} and 10^{-5} cm/sec). The facility is not only unlined, but was originally designed to allow sluiced liquids to infiltrate to ground water, with direct discharge to surface water occurring only occasionally. For much of their life, the basins operated with a relatively high hydraulic head. In fact, in 1986, the facility began using direct discharge to reduce the hydraulic head in response to PAL exceedances for sulfate. This combination of conditions resulted in a ground water mound beneath the ash disposal area. While depth to ground water at the site is generally approximately 10 feet, the height of the ground water mound was estimated at 5 to 8 feet, resulting in an estimated effective depth to ground water of only 2 to 5 feet underneath the disposal area.

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven damage case for the following reasons: (1) Scientific - Although the boron standard was not health-based at the time of the exceedances, the boron levels reported for the facility would have exceeded the State's recently promulgated health-based ES for boron; and (2) Administrative - As a result of the various PAL and ES exceedances, the State required a ground water investigation, and the facility took action to remediate ground water contamination and prevent further contamination.

16. WEPCO Cedar-Sauk Landfill, Wisconsin⁵⁶

History: This facility is an abandoned sand and gravel pit that received coal combustion waste from the WEPCO Port Washington Power Plant from 1969 to 1979. After closure of the facility, ground water monitoring revealed exceedances of the primary MCL for selenium, the State standard for boron, and the secondary MCL for sulfate. Vegetative damage resulting from boron uptake also was observed in a nearby wetland. Presumably, this damage is the result of ground water migration to the wetland. As a result, the State required installation of relief wells to confine and remediate the contamination plume and installation of an upgraded cover at the site. The facility is not only unlined, but was constructed over shallow ground water⁵⁷ in highly permeable (10^{-3} to 10^{-2} cm/sec) media. Some time after closure, the water table rose, saturating portions of the ash fill. Furthermore, the original soil cover installed at closure -- less than 2 feet in places -- was found to be insufficient. Finally, the site was located in close proximity to a wetland.

EPA identified this site in its original 1988 Report to Congress on Wastes from the Combustion of Fossil Fuels by Electric Utility Power Plants and analyzed it further in the supplemental analysis conducted for its 1993 Regulatory Determination⁵⁸. This case was not counted as a

⁵⁶ Ibid.

⁵⁷ Quantitative data on the original depth to ground water are not available, but documentation on the site reports that the water table was near the base of the original pit.

⁵⁸ Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste. U.S. EPA., July 30, 1993. Available from the docket for the 1993 Regulatory Determination for Fossil Fuel Combustion. (Part 1), EPA-HQ-RCRA-1993-0042-1642.

proven damage case in the 1999 Report to Congress, however, because there was no evidence of comanagement of low-volume wastes at the site.

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven damage case for the following reasons: (1) Scientific - Selenium in ground water exceeded the (health-based) primary MCL, and there was clear evidence of vegetative damage; and (2) Administrative - The State required remedial action.

17. Wisconsin Electric Power Co. (WEPCO) Port Washington Facility, Wisconsin⁵⁹

History: Originally, the commenters identified this Wisconsin site in a table that alleged fly ash contaminated several drinking water wells with boron and selenium. Following a preliminary evaluation by the EPA, this site was initially classified as indeterminate because (i) the commenters did not identify the source of the information, and (ii) No quantitative data or further information about this site was available.

In the course of reassessment conducted following the Regulatory Determination, a copy of the original Water Well Journal article cited by the commenters was obtained from the National Ground Water Association (NGWA). The article presented instances in which boron and selenium concentrations exceeded standards in a well located down-gradient of the CCW disposal site. Contact was established with Wisconsin Department of Natural Resources (DNR) Waste Management Program. The DNR representative reported that the site affects a residential, private water well supply. He located the well at about 250 feet south of an old quarry that was filled to 40-60 feet in depth with fly ash from the Wisconsin Electric Power Company. The power company placed fly ash in the quarry from 1948-1971, so the ash had been there at least 20 years prior to the contamination described by the article.

In lieu of providing up-gradient well monitoring data, the DNR representative stated with certainty that in his best professional judgment the boron levels reported for the well are not naturally occurring. He also is confident that the contaminants come from the quarry because of the proximity to the monitoring well. He added that boron is characteristic of coal ash and that geologically there is no naturally-occurring source in that area of Wisconsin that would produce boron levels that high. However, he was not aware that a boron standard existed at the time of the exceedances. He reiterated that the selenium concentration exceeds the selenium standard reported in the article. Based on today's standard of 50ug/L, the levels of selenium reported would not be considered a compliance problem.

Based on the information provided by the State, contamination from this facility appears to have migrated to off-site private wells. Documentation to confirm this analysis was received in the form of a laboratory report from the State Laboratory of Hygiene. Samples collected at the John & Dolly Keating Port Washington Sample Tap Pit (an off-site drinking water well) showed very high concentrations of boron. Although the State did not have a health-based standard for boron at the time of the exceedances, the boron levels reported for the facility would have exceeded the State's recently promulgated health-based enforcement standard for boron. Samples collected

⁵⁹ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

also showed elevated selenium concentrations, but the levels detected would not exceed the current primary MCL.

Basis for Consideration as a Proven Damage Case: This case is categorized as a proven damage case based on a scientific observation - The off-site exceedance of a health-based standard for selenium, caused by the fact that the site is an unlined former sand and gravel quarry and is in close proximity to drinking water wells.

18. Lansing Board of Water & Light (LBWL) North Lansing Landfill, Michigan⁶⁰

History: The North Lansing Landfill (NLL), a former gravel quarry pit, was licensed in 1974 for disposal of inert fill materials including soil, concrete, and brick. From 1980 to 1997, the NLL was used for disposal of coal ash from the Lansing Board of Water and Light (LBWL) electric and steam generating plants. The NLL has three disposal areas, two of which were used for coal ash disposal. Filling of Area I ceased in 1988 and a temporary cover was placed over the ash. Area III was the active disposal area from 1988 to January 1997. A temporary cover was placed over Area III in September 1998 and grass was planted on this cover. Area II was not actively used for disposal, although some ash has washed into this area. Since 1992, Area II has usually contained standing water from on- and off-site storm water runoff.

Among the damages that commenters alleged existed at this site were down-gradient selenium and arsenic exceeding their MCLs and down-gradient sulfate greater than "allowable water quality standards." The commenters also stated that an adjacent municipal well field is "threatened."

The site owner claimed that sulfate contamination is due to wastes other than fly ash in the landfill or else is due to off-site sources. The Michigan Department of Environmental Quality (MDEQ) confirmed in writing that ground water contamination had occurred at this historic landfill, which was constructed before current State regulations were in place. The site was eventually closed because the inadequate control of contamination violated current regulatory requirements. According to the letter, the NLL was forced to take remedial action to address the contamination.

This site was initially classified as indeterminate because (i) the documents and quantitative data supporting the alleged damages were not available; (ii) information was needed to positively identify the source of the contamination; and (iii) more information was needed to describe the extent of ground water contamination and to establish whether this contamination extends off-site.

In an effort to reassess this alleged damage case, EPA's contractor contacted MDEQ and found that this site was in the process of a Remedial Investigation (RI) and Feasibility Study (FS). The following information is based on the RI Report, published in May 1999 and revised in December 1999.

⁶⁰ Ibid.

There are two aquifers beneath the NLL. The upper aquifer is highly permeable, but is not used for drinking water. The lower aquifer (the Saginaw), however, supplies the City of Lansing with drinking water. Fill underlying the ash has lower hydraulic conductivity than the underlying aquifer, but does not constitute a liner. The underlying fill has settled in places and the water table has risen, so that lower portions of the ash are now saturated in Areas I and III. The standing water in Area II has merged with ground water, forming a mound in the water table. According to the Lansing Board of Water and Light North Lansing Landfill Remedial Investigation Report (the RI Report), this mounding effect likely extends laterally into the ash, thereby increasing the saturated ash thickness, and consequently the volume of ash subject to leaching in Areas I and III. Because of the rise in the water table, the facility no longer meets the State's requirement for a 4-foot isolation distance between wastes and ground water. Moreover, in mid- to late-1993, abrupt increases were observed in sulfate and selenium concentrations in an on-site monitoring well. As a result, LBWL was required to perform a remedial investigation and feasibility study. The RI Report concluded that the timing of the increase in contamination indicated that leachate released from the saturated fly ash was the source of the contamination.

The objectives of the RI included characterization of site conditions, definition of the nature and extent of ground water impacts, and estimation of future migration. This analysis is complicated by the presence of other known or potential sources of ground water contamination both up-gradient and down-gradient of the NLL site. Therefore, the remedial investigation used statistical comparisons (i.e., tolerance intervals calculated from up-gradient and background monitoring data) to delineate ground water impacts from the NLL. Ground water concentrations were compared to Michigan's Part 201 criteria. The Part 201 standards for ground water identify contaminant concentrations that are safe for long-term, daily consumption. The investigation's statistical analysis, modeling results, and conclusions form the basis for the analysis of the NLL as a damage case.

For a variety of reasons, the RI Report concluded that boron, iron, pH, strontium, selenium, and sulfate are of little concern. The RI Report concluded that the constituents of the most concern are lithium, manganese, and potassium. Based on statistical analysis and consideration of site-specific factors, however, the following cannot be conclusively linked to the NLL: boron, iron, pH, and sulfate. Of the remaining contaminants of concern:

- Lithium appears to be attributable to the NLL and concentrations are above health-based standards off-site;
- Manganese contamination on-site appears to be attributable to the NLL and concentrations are above non-health based-standards. (Note that off-site concentrations of manganese also are above non-health-based standards, but do not appear to be attributable to the NLL);
- Potassium appears to be attributable to the NLL, but has no regulatory standard;
- Selenium appears to be attributable to the NLL and concentrations are above health-based standards on-site, but not off-site;
- Strontium appears, based on statistics, to be attributable to the NLL, but concentrations are below health based standards.

Basis for Consideration as a Proven Damage Case: This site was classified as a proven damage case based on a scientific observation of off-site exceedances of the State's health-based standard

for lithium. The exceedance was caused by the fact that the site is an unlined former gravel quarry with an elevated ground water table leading to ground water contact.

19. Northern Indiana Public Service Corp. (NIPSCO) Yard 520 Landfill Site (Brown's Landfill) Township of Pines, Porter County, IN⁶¹

History: NIPSCO's Bailly and Michigan City power plants have deposited an estimated 1 million tons of fly ash in the Town of Pines since 1983. Fly ash was buried in the landfill and used as construction fill in the town. The ash is pervasive on site, visible in roads and driveways⁶².

Pines is located near the Indiana Dunes National Lakeshore, about 2 miles south of Lake Michigan. This is a region of sand dune ridges which separate low-lying, poorly drained wetland areas. The soil is very sandy, unconsolidated, highly-acidic, and with a high organic content. These sands overlie a less permeable clay-rich unit. The ground water flows in a northerly direction from the Yard 520 landfill toward the town⁶³.

In April 2000, Indiana DEM received a complaint from a Pines resident that water from her private well tasted foul. IDEM conducted sampling and found residential wells contaminated with elevated levels of benzene, arsenic, manganese, and VOCs including benzene. In 2001, EPA's Superfund program conducted a preliminary assessment and site investigation, and found elevated levels of MTBE, boron, manganese, and molybdenum. In January 2002, IDEM recommended the site for EPA's National Priorities List⁶⁴.

Additional site investigations indicate that the Pines Yard 520 Landfill site is the likely source of contamination of residential water wells, caused by leaching of heavy metals (manganese, boron, molybdenum, arsenic, lead) from fly ash that was buried in the landfill and used as construction fill. The presence of elevated levels of contaminants that are not associated with coal ash, such as volatile organic compounds (VOCs) and MTBE, indicate that there are additional sources of contamination that are not related to coal ash⁶⁵.

EPA and the responsible parties signed an Administrative Order of Consent effective January 2003 to cover costs of connecting the affected areas to Michigan City's water system (USEPA 2003a). In April 2004, EPA and IDEM negotiated an Administrative Order of Consent with the

⁶¹ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

⁶² Tim Drexler, Remedial Project Manager, telephone communications with Bonnie Robinson, USEPA. June 5, 2003.

⁶³ Final Site Investigation Report on Ground water Contamination, Township of Pines, Porter County, Indiana. December 2002.

⁶⁴ EPA Announces Investigation Results at Pines Site (Fact Sheet). January 2003.

⁶⁵ Final Site Investigation Report on Ground water Contamination, Township of Pines, Porter County, Indiana. December 2002.

responsible parties for continued work at the site⁶⁶. In January 2004, the Hoosier Environmental Council, Inc. filed a complaint for declaratory and injunctive relief against NISOURCE, the parent company of NIPSCO (U.S. District Court).

Basis for Consideration as a Proven Damage Case: This site was classified as a proven damage case based on (1) Scientific evidence for boron, molybdenum, arsenic and lead exceeding health-based standards in water wells away from the Pines Yard 520 Landfill site, and (2) Administrative Orders of consent signed between the EPA and IDEM with responsible parties for continued work at the site.

20. Brandy Branch Reservoir, Texas⁶⁷

History: This case was originally identified by a public interest group in a table alleging selenium and chromium contamination, and a selenium fish consumption advisory⁶⁸.

The Brandy Branch Reservoir is a power plant cooling reservoir built in 1983 for Southwestern Electric Power Company's Pirkey Power Plant. The cooling reservoir received discharges from ash ponds containing elevated levels of selenium, resulting in increased selenium concentrations in fish from the reservoir. From 1986 to 1989, the Texas Parks and Wildlife Department reported that average selenium concentrations in fish from the Brandy Branch Reservoir increased from 0.81 to 2.29ppm⁶⁹. In 1992, the Texas Department of Health (TDH) issued a fish consumption advisory for the reservoir⁷⁰.

The advisory recommended that adults consume no more than eight ounces of fish from the reservoir per week; children seven years and older - no more than four ounces/week; and children under six and pregnant women or women who may become pregnant should not consume any fish from the reservoir. In 1996 and 1997, TDH collected 17 fish from the reservoir. Selenium concentrations in these fish ranged between 0.46 and 1.79ppm, with an average concentration of 0.87ppm (ATSDR 1998).

A total maximum daily load (TMDL) project has been initiated by the Texas Commission on Environmental Quality (TCEQ) to determine the necessary steps to improve water quality in Brandy Branch reservoir. The project involved a fish sampling and analysis program and a

⁶⁶ <http://www.epa.gov/region5/sites/pines/>

⁶⁷ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

⁶⁸ Letter from the Hoosier Environmental Council to the RCRA Docket Information Center regarding comments on the May 2000 Regulatory Determination, September 19, 2000.

⁶⁹ Agency for Toxic Substances and Disease Registry (ATSDR), 1998. Health Consultation: Brandy Branch Reservoir, Marshall, Harrison County, Texas. September 1998. Available at http://www.atsdr.cdc.gov/HAC/PHA/marshall/mar_toc.html.

⁷⁰ Texas Bureau of Health (TBH), 1992. Fish Advisory: Brandy Branch Reservoir. May 1992.

human health risk assessment, and was completed in August 2003⁷¹. Based on its findings, The Texas Commissioner of Health fish advisory was lifted in March 2004⁷².

Basis for Consideration as a Proven Damage Case: This case is categorized as a proven ecological damage case for the following reasons: (1) Observations of impacts on fish populations were confirmed by scientific study, based on which the State concluded that the impacts were attributable to the ash ponds; and (2) Administrative - The State issued a fish consumption advisory as a result of the contamination.

21. Southwestern Electric Power Company Welsh Reservoir, Texas⁷³

History: This Lake was constructed in 1976 to serve as a cooling reservoir for a power plant and receives discharges from an open ash settling pond system. The Texas Parks and Wildlife Department's (TPWDs) monitoring program documents elevated levels of selenium and other metals in fish. In 1992 the Texas Commissioner of Health issued a fish consumption advisory for selenium similar to the one issued for the Brandy Branch Reservoir described above⁷⁴. The TPWD's report concludes that "discharges from the open ash settling ponds may be a source for the elevated levels of selenium in fish." The Texas Commissioner of Health fish advisory was lifted in March 2004⁷⁵.

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven ecological damage case for the following reasons: (1) the State concluded that, based on scientific evidence, selenium accumulation in fish may be attributable to the ash settling ponds; and (2) Administrative - The State has issued a fish consumption advisory as a result of the contamination.

22. Texas Utilities Electric Martin Lake Reservoir, Texas⁷⁶

History: This Lake was constructed in 1974 to serve as a cooling reservoir for a power plant and was the site of a series of major fish kills in 1978 and 1979. Investigations determined that unpermitted discharges from ash settling ponds resulted in elevated levels of selenium in the

⁷¹ Texas Commission on Environmental Quality (TCEQ). 2003. Improving Water Quality in Brandy Branch Reservoir; One TMDL for Selenium. February 2003.

⁷² Assessing the Fish Consumption Use, Water Quality in Brandy Branch Reservoir, TCEQ, March 2004.

⁷³ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

⁷⁴ <http://www.tceq.state.tx.us/implementation/water/tmdl/14-welshreservoir.html>

⁷⁵ Assessing the Fish Consumption Use, Water Quality in Welsh Reservoir, TCEQ, March 2004.

⁷⁶ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

water and fish. The State's monitoring program continues to document elevated levels of selenium and other metals in fish at the Lake. The Texas Commissioner of Health issued a fish consumption advisory for this Lake similar to the one issued for the Brandy Branch Reservoir described above in 1992⁷⁷. There also is evidence of elevated selenium concentrations in birds nesting near the Lake. The Texas Commissioner of Health fish advisory was lifted October 14, 2004⁷⁸.

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven ecological damage case for the following reasons: (1) Scientifically based evidence of adverse effects on wildlife - impacts on fish populations were observed, and the State concluded that the impacts were attributable to the ash setting ponds; and (2) Administrative - The State has issued a fish consumption advisory as a result of the contamination.

23. Basin Electric Power Cooperative W.J. Neal Station Surface Impoundment, North Dakota⁷⁹

History: This site was an unlined, 44-acre surface impoundment that received fly ash and scrubber sludge from a coal-fired power plant, along with other wastes (including ash from the combustion of sunflower seed hulls), from the 1950's until the late 1980's. Sampling in 1982 found chromium at 8.15 parts per million in the pond sediment and in excess of the primary MCL in down-gradient ground water. The State issued a special use disposal permit to allow disposal to continue, but required a continuation of monitoring and began negotiations for closure of the site. The facility was closed between 1989 and 1990, when the impoundment sediments were consolidated to a 22-acre area and capped. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the site underwent a preliminary assessment (PA) in 1990 and a site inspection (SI) in 1995. The PA found sediments in a marshy area adjacent to the closed facility with antimony, arsenic, chromium, manganese, selenium, and sodium elevated above background. The PA also found arsenic in excess of the primary MCL and aluminum in excess of the secondary MCL in down-gradient ground water. The SI found arsenic elevated above background in the marsh sediments and in surface water passing through the wetland. The SI also found cadmium and lead in excess of primary MCLs and zinc in excess of the secondary MCL in a public water supply well. The SI concluded that releases had occurred from the surface impoundment to ground water and surface water.

Soils underlying the facility are characterized by one source as relatively permeable (10^{-4} cm/sec). Regionally, the surficial aquifer varies in depth from 3 to 25 feet below the surface. While a precise mapping of the water table at the site is not available, the SI characterizes ground water beneath the closed, unlined impoundment as "very shallow." Other information in the literature confirms this and possibly suggests ground water may directly contact the disposed material, specifically:

⁷⁷ <http://www.tceq.state.tx.us/implementation/water/tmdl/12-martincreekreservoir.html>

⁷⁸ Assessing the Fish Consumption Use, Water Quality in Martin Creek Reservoir, TCEQ, March 2004.

⁷⁹ Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

- Depth to water in the monitoring wells surrounding the facility ranges from 5.5 to 16 feet, while the depth of the ash fill is estimated at approximately 10 feet.
- According to the PA, regionally, “many lakes and potholes represent “windows” into the water table ...” and an on-site pond located directly up-gradient and adjacent to the disposal area may be “a surface expression of the ground water onsite.”

Additionally, the site was operated without any control of surface waters from the impoundment. A tributary to the marsh and a nearby creek formerly flowed through the ash disposal areas. Even as late as 1989, surface water ran directly off the site from the surface impoundment dike into the marsh. This direct discharge was not documented as being permitted under State or Federal regulations.

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven damage case for the following reasons: (1) Scientific investigation - Several constituents have exceeded their (health-based) primary MCLs in down-gradient ground water, and the site inspection found documentation of releases to ground water and surface water from the site; and (2) Administrative - The State required closure of the facility.

24. Cooperative Power Association/United Power Coal Creek Station Surface Impoundments, North Dakota⁸⁰

History: This site includes a number of evaporation ponds and ash storage/disposal ponds that were constructed in 1978 and 1979. The ponds were originally lined but developed severe leaks in the late 1970's. The ponds are operated as a zero discharge facility. While quantitative data on the depth to ground water are not available, documentation from the State agency indicates that the ponds were constructed “directly over and adjacent to” the Weller Slough Aquifer, suggesting the presence of shallow ground water. Ground water monitoring at the site showed arsenic in excess of the primary MCL in 1987 and selenium in excess of the primary MCL in 1992 and 1993. Down-gradient monitoring data also have shown sulfate and chloride above secondary MCLs and elevated levels of boron. In the facility's 1990 permit application, the State required relining of the ponds with a composite liner.

Basis for Consideration as a Proven Damage Case: EPA has categorized this case as a proven damage case for the following reasons: (1) Scientific evidence - Arsenic and selenium exceeded (health-based) primary MCLs, and (2) Administrative - The State required remedial action.

⁸⁰ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

Potential Coal Combustion Waste Damage Cases

III. Potential Damage Cases

According to 65 FR 32224, "Potential damage cases were those with documented MCL exceedences that were measured in ground water beneath or close to the waste source. In these cases, the documented exceedences had not been demonstrated at a sufficient distance from the waste management unit to indicate that waste constituents had migrated to the extent that they could cause human health concerns. State regulations typically use a compliance procedure that relies on measurement at a receptor site or in ground water at a point beyond the waste boundary (e.g., 150 meters)." In addition, groundwater contamination would be considered as a potential damage case also where there are documented exceedences of secondary MCLs or other non-health based standards on-site or off-site.

25. K.R. Rezendes South Main Street Ash Landfill, Freetown, Massachusetts⁸¹

History: This case was originally identified through contacts with State regulators.

This site consists of an ash monofill located in a former sand and gravel quarry located in Freetown, Massachusetts. The landfill began operation in 1976 and has an area of approximately 35 acres. It was originally approved as a 14-acre monofill by the Freetown Board of Health and by permit from the MADEP. The Board of Health granted approval for the remaining 21 acres in 1990, and approved a request for expansion to within 250 feet of Assonet Bay in 1993. The final permit for the site was issued by MADEP in 1994.

The site accepted ash from PG&E's Salem Harbor (approximately 250,000 tons/year) and Brayton Point Plants (approximately 140,000 tons/year). According to PG&E estimates, a total of 2,500,000 tons of ash have been disposed at the K.R. Rezendes South Main Street Ash Landfill.

Ground water monitoring at the site has detected levels of selenium above the primary MCL. Elevated levels of sulfates, total dissolved solids, manganese, iron, and aluminum have also been detected at the site, although levels are below the relevant secondary MCLs. All of the monitoring wells at the site are located on-site. There are no down-gradient drinking water sources, because the landfill is adjacent to a down-gradient water body (Assonet Bay), which is not used as a drinking water source due to its brackish water.

In early 2001, MADEP required modifications to the ground water monitoring program, including:

- Increase in sampling from annual to semi-annual;
- Semi-annual surface water sampling;
- Evaluation of wells to ensure the wells yield representative samples;
- Installation of additional monitoring wells; and

⁸¹ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

- Evaluation of ground water discharge to the adjacent Assonet Bay.

Operations at the landfill ended in 2001 as the result of a bylaw passed by the Town of Freetown. The bylaw bans the disposal of coal combustion wastes within the town. It was appealed by the landfill operator and PG&E, but upheld by the State Attorney General.

Basis for Consideration as a Potential Damage Case: This case has been categorized as a potential damage case for the following reasons: (1) Scientific - Selenium exceeded its primary MCL in on-site monitoring wells; and (2) Administrative - The State required modification to the site's ground water monitoring program.

26. New England Power, Brayton Point, Massachusetts⁸²

History: Associated with the largest coal- and oil- powered generating station in New England, this is one of nine sites managing oil combustion wastes that have ground water contamination identified for the 1999 Report to Congress. Seven of the nine, including this site, were documented in EPRI's oil ash report; the two other sites were found in the 1993 Regulatory Determination and in RCRA Corrective Action records. Most of the nine sites evaluated were solid settling basins, while one site had a landfill and a second site had a solids disposal pond. At each of the nine sites, the waste management unit was found to negatively impact ground water in one of the following ways: (1) at least one constituent was found in down-gradient ground water monitoring wells above its MCL, but was not present in up-gradient wells above its MCL, or (2) a constituent exceeded its MCL both up-gradient and down-gradient, but the down-gradient concentrations were noticeably higher than the up-gradient concentrations. These constituents most often include manganese and nickel. Other parameters (including arsenic, cadmium, chromium, selenium, silver, and zinc) exceeded their MCL in down-gradient wells at only one of the sites. Although vanadium does not have an MCL, the parameter was found in ground water down-gradient of waste management units.

At several of the sites reviewed, EPA found that the waste management unit very likely contributes to the contamination of constituents, such as manganese, nickel, and vanadium, into ground water. Many of these sites are located next to the ocean or other large bodies of water where such releases can be diluted and no drinking water wells would be located between the management unit and the surface water. EPA did not find any cases of drinking water contamination or other environmental damages resulting from these releases. Additionally, most or all unlined units are operated under state permit allowing exceedances of ground water standards close to the management unit, but which must be met outside the zone of discharge.

Basis for Consideration as a Potential Damage Case: This case has been categorized as a potential damage case for the following reasons: exceedance of one or more MCL standards

⁸² Technical Background Document for the Report to Congress on Remaining Wastes from Fossil Fuel Combustion: Potential Damage Cases, March 15, 1999 (http://www.epa.gov/epaoswer/other/fossil/ffc2_397.pdf), Status of Alleged Damage Cases Submitted by HEC, et. al., to Dennis Ruddy, February, 2002. Brayton Point Administrative Consent Order (ACO-BO-00-2002, undated), Brayton Point Administrative Consent Order Timetable, August 22, 2006.

down flow from the plant's unlined wastewater treatment basins that does not impact drinking water wells offsite.

27. AES Creative Resources Weber Ash Disposal Site, New York⁸³

History: Monitoring data at this site from between 1991 and 1998 show levels of sulfate, total dissolved solids, manganese, iron, aluminum, and pH in down-gradient wells in excess of their secondary MCLs. There is no information available on the location of these wells relative to the waste management units.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site: sulfate, total dissolved solids, manganese, iron, aluminum, and pH, are of non-health-based standards. Therefore, this case is a potential damage case.

28. Central Hudson Gas and Electric Corporation Danskammer Waste Management Facility, New York⁸⁴

History: There were exceedances of State non-health-based standards for sulfate, sulfide, total dissolved solids, turbidity, iron, magnesium, manganese, sodium, boron, and pH attributable to CCW at the site. It is unclear whether the exceedances of health-based standards were attributable to CCW.

Basis for Consideration as a Potential Damage Case: The contamination at the site: sulfate, sulfide, total dissolved solids, turbidity, iron, magnesium, manganese, sodium, boron, and pH did not appear likely to threaten human health or the environment. Therefore, this case was determined to be a potential damage case.

29. C. R. Huntley Flyash Landfill, New York⁸⁵

History: There were exceedances of State health-based standards for arsenic and non-health-based standards for iron, manganese, sulfate, and total dissolved solids at this site's down-gradient wells. While there also were exceedances in up-gradient wells, there was statistical evidence of significant increases over up-gradient concentrations for several of these constituents. In addition, the State regulatory agency and the site contractor identified some of these constituents as potential indicators of leachate.

⁸³ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

⁸⁴ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

⁸⁵ Ibid.

Basis for Consideration as a Potential Damage Case: All of the exceedances were in wells located on-site, close to the waste management unit. Therefore, this case was determined to be a potential damage case.

30. Elrama Plant, Pennsylvania⁸⁶

History: EPA identified this site in its original 1988 Report to Congress on Wastes from the Combustion of Fossil Fuels by Electric Utility Power Plants. It is described in detail in that document. In the 1988 Report, EPA found concentrations of cadmium in down-gradient wells above the primary MCL; the highest concentrations were found in the well closest to the landfill. EPA concluded that coal combustion wastes have been a source of contamination at the site, but also concluded that exceedances for many contaminants were probably due to concurrent contamination from acid mine drainage.

Basis for Consideration as a Potential Damage Case: While levels of cadmium exceed the primary MCL, the contamination appears to be at least partially attributable to sources other than coal combustion wastes. Therefore, this case is a potential damage case.

31. Tennessee Valley Authority - Bull Run Steam Plant, Oak Ridge, Tennessee⁸⁷

Basis for Consideration as a Potential Damage Case: This case was categorized as a potential damage case for the following reasons: (1) exceedances of the secondary MCLs for aluminum, calcium, iron, and sulfate were detected in on-site surface water; (2) a toxicity study indicates the potential for ecological impacts; and (3) these impacts appear to be directly attributable to CCW management.

32. Tennessee Valley Authority Widows Creek Fossil Fuel Plant, Alabama⁸⁸

History: Monitoring data at this site show lead in excess of the primary MCL Action Level. This exceedance, however, occurred in an on-site well that appears to be opposite the direction of ground water flow. Still, in a 1993 memorandum, the Alabama Department of Environmental Management (ADEM) expressed concern with this exceedance and elevated levels of cadmium and chromium (which did not exceed their primary MCLs) in this well and recommended that corrective action measures be established.

Basis for Consideration as a Potential Damage Case: While the ADEM has expressed concern with on-site contamination and recommended that corrective action measures be established,

⁸⁶ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

⁸⁷ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

⁸⁸ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

there is no evidence available of off-site migration of contaminants. Therefore, this case is a potential damage case.

33. Tennessee Valley Authority Colbert Fossil Fuel Plant, Alabama⁸⁹

History: Only limited information on this site was available from the commenters. The commenters' summary of monitoring data shows no exceedances of primary MCLs in ground water at the site. The only primary MCL exceedances (for sulfate, chromium and selenium) reported by the commenters are found in a well installed within the saturated ash of the surface impoundment. A 1998 letter from the facility owner to the ADEM, however, does indicate some exceedances of primary MCLs in on-site wells that the owner proposes to eliminate from its sampling program. The only constituent identified in this letter is cadmium. The commenters report that ADEM believes ground water contamination has resulted from the disposal of coal combustion wastes at this facility. An ADEM geologist also reported to the commenters that the disposal area has been subject to collapse into a karst sinkhole.

Basis for Consideration as a Potential Damage Case: While some primary MCL exceedances (for sulfate, chromium and selenium) appear to have occurred in on-site wells, there is no evidence available of off-site migration of contaminants. Therefore, this case is a potential damage case.

34. Duke Power Allen Steam Generating Plant, North Carolina⁹⁰

History: The Allen Plant of Duke Power Company was included in a study of waste disposal at coal-fired power plants conducted by Arthur D. Little, Inc (ADL) in 1985. ADL conducted ground water sampling in 18 monitoring wells installed on-site, detecting exceedances of manganese and iron, both secondary water quality standards.

Contact was made with North Carolina Department of Environment and Natural Resources (DENR). According to those contacted, the State has only surface water discharge information for this facility. There is no record of ground water monitoring at the facility, and no indication that violations or enforcement actions occurred at the facility. A permit check determined that ground water monitoring at the site is not required by the facility permit. There is no indication that any ground water samples have been tested since the 1985 study.

Basis for Consideration as a Potential Damage Case: According to the 1985 data, there were documented exceedances of manganese and iron, non-health-based standards, in wells downstream from the waste management unit. Therefore, this site is categorized as a potential damage case.

⁸⁹ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. TVA Colbert ground water data, undated.

⁹⁰ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003. Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

35. Cinergy East Bend Scrubber Sludge Landfill, Kentucky⁹¹

History: Commenters identified this site in a table that alleged an estimated 300 tons of sulfate per year is leaking into the Ohio River from this site. This site was initially classified as indeterminate because the commenters did not identify the source of the information and no quantitative data or further information about this site was available.

Subsequently, additional information was obtained through the Kentucky Department of Environmental Protection (DEP). According to the DEP, there were on-site exceedances of non-health-based standards for total dissolved solids, iron, and sulfate at this site. The State has taken regulatory action based on these exceedances.

Basis for Consideration as a Potential Damage Case: Based on the on-site exceedances of non-health-based standards for total dissolved solids, iron, and sulfate at this site, and subsequent State regulatory action based on these exceedances, this case is a potential damage case.

36. Florida Power and Light Lansing Smith Plant, Florida⁹²

History: EPA initially identified this site in the supplemental analysis conducted for its 1993 Regulatory Determination⁹³. As a result of this analysis, EPA rejected this site as a damage case because there was no evidence that coal combustion wastes were comanaged with low-volume wastes at this site. A subsequent evaluation of the information for this site indicates that there were documented exceedances of primary drinking water standards for cadmium, chromium and fluoride and secondary drinking water standards for sulfate, chloride, manganese and iron in on-site ground water attributable to CCW.

Basis for Consideration as a Potential Damage Case: This site has been reclassified as a potential damage case Based on documented exceedances of primary drinking water standards for cadmium, chromium and fluoride and secondary drinking water standards for sulfate, chloride, manganese and iron in on-site ground water attributable to CCW.

⁹¹ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

⁹² Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Status of Alleged Damage Cases Submitted by HEC, et. al., to Dennis Ruddy, February, 2002. Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

⁹³ Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste. U.S. EPA. July 30, 1993. Available from the docket for the 1993 Regulatory Determination for Fossil Fuel Combustion (Part I), EPA-HQ-RCRA-1993-0042-1642.

37. Florida Power and Light Port Everglades Plant, Florida⁹⁴

History: This is one of nine sites managing oil combustion wastes that have ground water contamination identified for the 1999 Report to Congress. Seven of the nine, including this site, were documented in EPRI's oil ash report; the two other sites were found in the 1993 Regulatory Determination and in RCRA Corrective Action records. Most of the nine sites evaluated were solid settling basins, while one site had a landfill and a second site had a solids disposal pond. At each of the nine sites, the waste management unit was found to negatively impact ground water in one of the following ways: (1) at least one constituent was found in down-gradient ground water monitoring wells above its MCL, but was not present in up-gradient wells above its MCL, or (2) a constituent exceeded its MCL both up-gradient and down-gradient, but the down-gradient concentrations were noticeably higher than the up-gradient concentrations. These constituents most often include manganese and nickel. Other parameters (including arsenic, cadmium, chromium, selenium, silver, and zinc) exceeded their MCL in down-gradient wells at only one of the sites. Although vanadium does not have an MCL, the parameter was found in ground water down-gradient of waste management units.

At several of the sites reviewed, EPA found that the waste management unit very likely contributes to the contamination of constituents, such as manganese, nickel, and vanadium, into ground water. Many of these sites are located next to the ocean or other large bodies of water where such releases can be diluted and no drinking water wells would be located between the management unit and the surface water. EPA did not find any cases of drinking water contamination or other environmental damages resulting from these releases. Additionally, most or all unlined units are operated under state permit allowing exceedances of ground water standards close to the management unit, but which must be met outside the zone of discharge.

Basis for Consideration as a Potential Damage Case: This case has been categorized as a potential damage case for the following reasons: exceedance of one or more MCL standards down flow from the plant's disposal facility that does not impact drinking water wells offsite.

38. Florida Power and Light Riviera Plant⁹⁵

See the preceding description for the Port Everglades Plant.

39. Florida Power and Light P.L. Bartow Plant⁹⁶

See the preceding description for the Port Everglades Plant.

⁹⁴ Technical Background Document for the Report to Congress on Remaining Wastes from Fossil Fuel Combustion: Potential Damage Cases, March 15, 1999 (http://www.epa.gov/epaoswer/other/fossil/ffc2_397.pdf).

⁹⁵ Ibid.

⁹⁶ Ibid.

40. Commonwealth Edison Powerton Plant - Mahoney Landfill, Pekin, Tazewell County, Illinois⁹⁷

History: This case was originally identified during the review of candidate damage cases for the 1988 Report to Congress on Wastes from the Combustion of Coal by Electric Utility Power Plants. Although it was rejected as a proven damage case in EPA's 1993 Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste (EPA 1993), this case was re-examined in light of EPA's subsequently developed criteria for categorizing cases as "potential" damage cases.

There were exceedances of primary MCLs for cadmium, lead, and nitrate and secondary MCLs for iron, manganese, and sulfate in ground water and surface water at the site. The exceedances of secondary MCLs in ground water appear attributable to management of CCW.

Basis for Consideration as a Potential Damage Case: All the reported exceedances that are attributable to management of CCW are for constituents with non-health-based standards and are located in on-site wells. Therefore, this case was categorized as a potential damage case.

41. Xcel Energy/Southern Minnesota Municipal Power Agency - Sherburne County (Sherco) Generating Plant Becker, Minnesota⁹⁸

History: This case was originally identified during the review of candidate damage cases for the 1988 Report to Congress on Wastes from the Combustion of Coal by Electric Utility Power Plants. Although it was rejected as a proven damage case in EPA's 1993 Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste (EPA 1993), this case was re-examined in light of EPA's subsequently developed criteria for categorizing cases as "potential" damage cases.

There were exceedances of primary MCLs for arsenic, cadmium, chromium, fluoride, lead, and nitrate and secondary MCLs for chloride, copper, iron, manganese, sulfate, and zinc at the site, at least some of which appear attributable to management of CCW. While a scientific study indicated the potential for future increases in contamination, more recent data were not available.

Basis for Consideration as a Potential Damage Case: The reported exceedances of both primary and secondary MCLs were located in on-site wells and the potential for off-site migration of contamination may be limited. Therefore, this case was categorized as a potential damage case.

⁹⁷ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

⁹⁸ Ibid.

42. Alliant Rock River Ash Disposal Facility, Wisconsin⁹⁹

History: Monitoring data at this site show down-gradient levels of arsenic and mercury that would exceed the Wisconsin Department of Natural Resources (WDNRs) drinking water enforcement standard (ES) levels (equivalent to primary MCLs). The data also show down-gradient levels of sulfate and iron that would exceed their ES levels (equivalent to secondary MCLs for these constituents). According to information provided by WDNR, however, the site has no down-gradient ES points of standards application due to its proximity to the Rock River (i.e., all wells are within the design management zone of the landfill). Thus, the State considers the preventive action limit (PAL) exceedances, not ES exceedances. The preventive action limit represents a lesser concentration of the substance than the enforcement standard¹⁰⁰. In 1996, as a result of the PAL exceedances for sulfate and iron, WDNR required the company to begin submitting biennial ground water reports evaluating causes and trends relating to the continued PAL exceedances. Ongoing monitoring at the site includes indicator parameters and iron.

Basis for Consideration as a Potential Damage Case: Whereas the levels of arsenic and mercury in down-gradient wells exceed health-based enforcement standards, these exceedances are within the design management zone of the landfill and there is no evidence available of off-site migration of contaminants. Therefore, this case was determined to be a potential damage case.

43. Michigan City Site, Michigan City, Indiana¹⁰¹

History: EPA identified this site in its original 1988 Report to Congress on Wastes from the Combustion of Fossil Fuels by Electric Utility Power Plants. It is described in detail in that document. In the 1988 Report, EPA concluded that ash ponds at the site are responsible for arsenic concentrations above the primary Maximum Contaminant Limit (MCL). EPA also concluded, however, that effects on ground water appeared to be limited to areas within the facility boundaries.

Basis for Consideration as a Potential Damage Case: While levels of arsenic found on-site exceed the primary MCL, there was no evidence available of off-site migration of contaminants. Therefore, this case is a potential damage case.

⁹⁹ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹⁰⁰ The PAL is either 10%, 20%, or 50% of the enforcement standard as specified by statute based on the health-related characteristics of the particular substance. Ten percent is used for cancer-causing substances, 20% for substances with other health effects and 50% for substances having aesthetic or other public-welfare concerns.

¹⁰¹ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

44. Bailly Generating Station, Indiana¹⁰²

History: EPA identified this site in its original 1988 Report to Congress on Wastes from the Combustion of Fossil Fuels by Electric Utility Power Plants. The site is identified as the “Bailly Site, Dune Acres, Indiana” and described in detail in that document. In the 1988 Report, EPA concluded that leachate from ash disposal ponds was the most probable contributor to concentrations of arsenic and lead that were found above the primary MCL and primary MCL Action Level, respectively, in on-site, down-gradient wells. EPA also observed, however, that cadmium was the only constituent whose down-gradient off-site concentration exceeded the primary MCL. Elevated cadmium concentrations also were found in samples taken from the background well, leading EPA to conclude that the elevated down-gradient concentrations of cadmium may not have been caused by leachate from the coal ash.

Basis for Consideration as a Potential Damage Case: While levels of arsenic and lead found on-site exceed health-based standards, the only off-site exceedances of health-based standards (for cadmium) are not shown to be attributable to coal combustion waste. Therefore, this case is a potential damage case.

45. Alliant Edgewater 1-4 Ash Disposal Site, Wisconsin¹⁰³

History: Monitoring data at the site show down-gradient levels of boron that exceed WDNR’s health-based ES level¹⁰⁴. Additional data shows that private water supply wells have shown ES exceedances for sulfate and iron (equivalent to secondary MCLs for these contaminants) and PAL exceedances for chloride. As a result of these exceedances, WDNR required a series of investigations from 1988 to 1997. The investigations found that cessation of ash sluicing and capping of the landfill had effectively controlled the contamination of ground water and no additional remedial actions were required. Ongoing monitoring at the site (including monitoring of the private wells) includes boron, sulfate, and arsenic. Previous monitoring included selenium, iron, fluoride, and chloride.

Basis for Consideration as a Potential Damage Case: The level of boron found down-gradient exceeds a health-based standard. It is unclear, however, whether this exceedance is in an off-site monitoring location. The exceedances found in off-site private wells are for constituents without health-based standards. Therefore, this case is a potential damage case.

¹⁰² Ibid.

¹⁰³ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹⁰⁴ As of January 1, 2000, Wisconsin elevated boron to the status of a human health-related parameter.

46. Wisconsin Power Supply Co. (WPSC) Pulliam Ash Disposal Site, Wisconsin¹⁰⁵

History: Monitoring data at this site showed down-gradient levels of sulfate and manganese that would exceed WDNR's ES levels (equivalent to secondary MCLs for these constituents) and levels of iron that exceed WDNR's PAL. According to information provided, however, the site had no down-gradient ES points of standards application (i.e., all wells are within the design management zone of the landfill). Thus, the State would consider the sulfate and manganese exceedances to be PAL, not ES, exceedances. Further review by WDNR found an inadequate monitoring network at the facility. Therefore, in 1994, WDNR required an investigation of the ground water contamination and an upgrade of the monitoring network. Ongoing monitoring at the site includes indicator parameters plus boron, selenium, manganese, and iron.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate, manganese and iron, are within the design management zone of the landfill and are for constituents without health-based standards. Therefore, this case is a potential damage case.

47. Central Illinois Light Co. Duck Creek Station, Illinois¹⁰⁶

History: Monitoring data at this site from April 1999 showed levels of sulfate, total dissolved solids, chloride, manganese, and iron in excess of their secondary MCLs. There is no clear indication of down-gradient wells or whether these wells are on-site or off-site.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate, total dissolved solids, chloride, manganese and iron, are of non-health-based standards. Therefore, this case is a potential damage case.

48. Illinois Power Co. Hennepin Power Station, Illinois¹⁰⁷

History: Monitoring data at this site from between 1997 and 1999 showed levels of sulfate and total dissolved solids in down-gradient wells in excess of their secondary MCLs. There is no information available on the location of these wells relative to the waste management units. There is no monitoring data for metals at this site.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate and total dissolved solids, are of non-health-based standards. Therefore, this case is a potential damage case.

¹⁰⁵ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹⁰⁶ Ibid.

¹⁰⁷ Ibid.

49. Illinois Power Co. Havana Power Plant, Illinois¹⁰⁸

History: Monitoring data at this site between 1997 and 1999 showed levels of manganese down-gradient of the south ash impoundment in excess of the secondary MCL. The data also show levels of sulfate down-gradient of the east ash impoundment greater than up-gradient levels, but within the secondary MCL. There is no information available on the location of the monitoring wells relative to the waste management units.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, manganese and sulfate, are of non-health-based standards. Therefore, this case is a potential damage case.

50. Dairyland Power Alma On-site Fly Ash Landfill, Wisconsin¹⁰⁹

History: EPA initially identified this site in the supplemental analysis conducted for its 1993 Regulatory Determination¹¹⁰. This analysis, along with additional information submitted by commenters, shows down-gradient levels of sulfate and manganese that would exceed WDNR's ES levels (equivalent to secondary MCLs for these constituents). According to information provided by WDNR, however, there are no ES points of standards application at the site (i.e., all wells are within the design management zone of the landfill). Thus, the State considers these exceedances PAL, not ES exceedances. In 1975, WDNR issued an administrative order as a result of an inspection that disclosed a number of operational and locational problems at the facility. Among other things, the order required submission of a closure plan and an in-field conditions report. The closure plan was approved in 1981 and included ground water monitoring. In 1986, the Department required the company to install additional monitoring wells and to monitor seven private water supply wells for two rounds of monitoring. Ongoing monitoring at the site includes indicator parameters plus manganese and boron.

Basis for Consideration as a Potential Damage Case: While the State has taken regulatory action at this site, the action appears to be based on operational and locational problems, not evidence of contamination. The exceedances found at the site, sulfate and manganese, are of non-health-based standards. Therefore, this case is a potential damage case.

¹⁰⁸ Ibid.

¹⁰⁹ Ibid.

¹¹⁰ Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste. U.S. EPA. July 30, 1993. Available from the docket for the 1993 Regulatory Determination for Fossil Fuel Combustion (Part 1), EPA-HQ-RCRA-1993-0042-1642.

51. Dairyland Power Alma Off-site Fly Ash Landfill, Wisconsin¹¹¹

History: EPA initially identified this site in the supplemental analysis conducted for its 1993 Regulatory Determination¹¹². This analysis, along with additional information submitted by commenters, shows down-gradient levels of sulfate and manganese that would be in excess of WDNR's ES levels (equivalent to secondary MCLs for these constituents). The monitoring data also show levels of boron that exceed WDNR's PAL. According to information provided by WDNR, however, the sulfate and manganese exceedances were not found at ES points of application; they were found in an on-site well within the design management zone of the landfill. Thus, the State considers the exceedances PAL, not ES, exceedances. None of the ES wells for the site have shown exceedances. Because of the PAL exceedances and a proposal by the owner to expand the ash disposal area, WDNR required an analysis of the performance of the existing landfill along with an upgraded liner system and other design improvements for the new facility on the site. Ongoing monitoring at the site includes indicator parameters plus iron and boron, although the company has monitored some wells for a list of metals as part of the siting for the expansion.

Basis for Consideration as a Potential Damage Case: While the State has taken regulatory action at the site, the exceedances found at this site, sulfate and manganese, are within the design management zone of the landfill and are for constituents without health-based standards. Therefore, this case is a potential damage case.

52. Illinois Power Vermillion Power Station, Illinois¹¹³

History: Monitoring data at this site showed levels of sulfate and total dissolved solids in down-gradient wells in excess of their secondary MCLs. No monitoring data for metals, trace elements, or organics were available.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate and total dissolved solids, are of non-health-based standards. Therefore, this case is a potential damage case.

¹¹¹ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹¹² Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste. U.S. EPA. July 30, 1993. Available from the docket for the 1993 Regulatory Determination for Fossil Fuel Combustion (Part 1), EPA-HQ-RCRA-1993-0042-1642.

¹¹³ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

53. Central Illinois Public Service Company Hutsonville Power Station, Illinois¹¹⁴

History: Monitoring data at this site showed levels of sulfate, total dissolved solids, and manganese in excess of their secondary MCLs. These exceedances were in wells that were presumed by the commenters to be down-gradient. There is no clear indication of down-gradient wells or whether these wells are on-site or off-site. No monitoring data for metals, trace elements, or organics were available.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate, total dissolved solids and manganese, are of non-health-based standards. Therefore, this case is a potential damage case.

54. Illinois Power Company Wood River Power Station, Illinois¹¹⁵

History: Monitoring data at this site showed levels of sulfate, total dissolved solids, chloride, manganese, and iron in excess of their secondary MCLs. It is unclear from the information provided whether these exceedances were observed in wells close to the waste management unit boundaries or in more distant wells. All of the monitoring wells, however, appear to be within the property boundary. There is insufficient information to designate wells at this site as up-gradient or down-gradient.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate, total dissolved solids, chloride, manganese and iron, are of non-health-based standards. Therefore, this case is a potential damage case.

55. R.M. Schahfer Generating Station, IN¹¹⁶

History: EPA initially identified this site in the supplemental analysis conducted for its 1993 Regulatory Determination¹¹⁷. This analysis, along with additional information submitted by commenters, showed down-gradient levels of sulfate in excess of its secondary MCL. EPA concluded in the supplemental analysis that other pollutant exceedances at the site appeared to be outliers or were for up-gradient wells only.

Basis for Consideration as a Potential Damage Case: The sulfate exceedances found at this site are of non-health-based standards. Therefore, this case is a potential damage case.

¹¹⁴ Ibid.

¹¹⁵ Ibid.

¹¹⁶ Ibid.

¹¹⁷ Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste. U.S. EPA. July 30, 1993. Available from the docket for the 1993 Regulatory Determination for Fossil Fuel Combustion (Part 1), EPA-HQ-RCRA-1993-0042-1642.

56. Coffeen/White & Brewer Trucking Fly Ash Landfill, Illinois¹¹⁸

History: Monitoring data at this site showed levels of sulfate, total dissolved solids, and manganese in down-gradient wells in excess of their secondary MCLs. Two of the three wells for which the commenters provided data appear to be located directly underneath the landfill area. A May 18, 1995 memorandum from the Illinois Environmental Protection Agency (IEPA) documents areas of dead or distressed grass on-site, apparently due to ground water seepage.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate, total dissolved solids and manganese, are of non-health-based standards. Therefore, this case is a potential damage case.

57. Southern Indiana Gas and Electric Company (SIGECO) A.B Brown Generating Station, Indiana¹¹⁹

History: EPA initially identified this site in the supplemental analysis conducted for its 1993 Regulatory Determination¹²⁰. This analysis, along with additional information submitted by commenters, shows down-gradient levels of sulfate, total dissolved solids, chloride, and pH in excess of their secondary MCLs.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate, total dissolved solids, chloride and pH, are of non-health-based standards. Therefore, this case is a potential damage case.

58. Cincinnati Gas & Electric Co. Miamiview Landfill, Ohio¹²¹

History: Monitoring data at this site from 1994 show levels of sulfate in excess of its secondary MCL. This exceedance was identified in a well near the boundary of the landfill. An investigation of the site estimates that the sulfate plume extends to an area approximately 400 feet south of the site¹²². No data are available for other constituents for the site.

¹¹⁸ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹¹⁹ Ibid.

¹²⁰ Supplemental Analysis of Potential Risks to Human Health and the Environment from Large-Volume Coal Combustion Waste. U.S. EPA. July 30, 1993. Available from the docket for the 1993 Regulatory Determination for Fossil Fuel Combustion (Part 1), EPA-HQ-RCRA-1993-0042-1642.

¹²¹ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹²² Report: Sulfate Investigation, Miamiview Landfill, Hamilton County, Ohio. Prepared for the Cincinnati Gas & Electric Company by Dames & Moore. December 13, 1994. Available in the docket titled Availability of Report to Congress on Fossil Fuel Combustion: Request for Comments and Announcement of Public Hearing, EPA-HQ-RCRA-1999-0022-0632.

Basis for Consideration as a Potential Damage Case: The sulfate exceedances found at this site are of non-health-based standards. Therefore, this case is a potential damage case.

59. Indiana Power & Light Petersburg Generating Station, Indiana¹²³

History: Monitoring data at this site showed levels of sulfate and total dissolved solids in down-gradient wells in excess of their secondary MCLs. There is no information available on the location of these wells relative to the waste management units.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate and total dissolved solids, are of non-health-based standards. Therefore, this case is a potential damage case.

60. Hoosier Energy Mermon Generating Station Coal Combustion Waste Landfill, Indiana¹²⁴

History: The historical exceedances of health-based standards (primary MCLs for barium, chromium, cadmium, and lead and secondary MCLs for sulfate and chloride) at this site are correlated with up-gradient exceedances and occur in on-site wells.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, primary MCLs for barium, chromium, cadmium, and lead and secondary MCLs for sulfate and chloride, are all confined to on-site wells. . Therefore, this case is a potential damage case.

61. Cinergy W.C. Beckjord Station, Ohio¹²⁵

History: There were exceedances of non-health-based standards (secondary MCL for sulfate) and a single exceedance of a health-based standard (primary MCL for selenium) at this site. There was no evidence available of off-site migration. A public water supply well within the property boundary was shut down and can no longer be used as a drinking water supply as a direct or indirect result of the contamination due to exceedance of sulfate.

Basis for Consideration as a Potential Damage Case: While a public water supply well within the property boundary was shut down, the contaminant of concern (sulfate) in the water supply well does not have a health-based standard. Therefore, this case is a potential damage case.

¹²³ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹²⁴ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

¹²⁵ Ibid.

62. Lemberger Landfill, Wisconsin¹²⁶

History: The 21-acre Lemberger Landfill, Inc. site is located in Manitowoc County. The Township of Franklin used the site, an old gravel pit, as an open dump from 1940 to 1970. Lemberger Landfill, Inc. operated the site as a sanitary landfill under a license from the Wisconsin Department of Natural Resources (WDNR) from 1969 to 1976. From 1976 to 1977, the Wettencamp and Brunner Excavating Company transported fly ash from Manitowoc Public Utilities to the Lemberger facility. An estimated 1,750 to 2,500 cubic yards of fly ash were disposed of monthly. Past WDNR inspections showed that Lemberger used fly ash and bottom ash as cover, instead of burying them along with the refuse.

Damages at the site include the seepage of landfill leachate onto adjacent property. Ground water at the site is contaminated with volatile organic compound (VOC) and inorganic constituents including arsenic, barium, chromium, cadmium, and lead. VOCs were present in residential wells in the vicinity of the site, according to monitoring conducted by the State in 1984 and 1985; and a river near the site also is impacted by VOCs, cadmium and lead. A group of potentially responsible parties (PRPs) entered into a consent decree (CD) with U.S. EPA in 1992 to perform design and remedy implementation activities. Construction was completed in September 1996. The five-year review of September 2000 identified that the groundwater extraction system was not capturing the entire contaminant plume. In order to correct this problem, modifications to the groundwater extraction system were constructed in winter 2001.

On June 15, 2006, U.S. EPA and WDNR approved the PRP's workplan for the monitored natural attenuation pilot study and gave approval to shut down the groundwater pump and treat system. The pump and treat system was shut down on August 1, 2006¹²⁷.

Basis for Consideration as a Potential Damage Case: Because the available documentation does not clearly implicate, or rule out, coal combustion waste as a source of the contamination, this case is a potential damage case.

63. Conesville Fixed FGD Sludge Landfill, Ohio¹²⁸

History: EPA identified this site in its original 1988 Report to Congress on Wastes from the Combustion of Fossil Fuels by Electric Utility Power Plants. Ground water monitoring data are described in detail in the report.

¹²⁶ Memorandum from SAIC to Dennis Ruddy regarding Additional Information Regarding Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

¹²⁷ <http://www.epa.gov/R5Super/npl/wisconsin/WID980901243.htm>

¹²⁸ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

Thirty-four monitoring wells were installed (two up-gradient) to monitor the effectiveness of a Poz-O-Tec fixation process (fluidized gas desulfurization (FGD) sludge mixed with fly ash and lime) to stabilize and thus immobilize potential contaminants. The stabilized FGD sludge was deposited next to the fly ash pond.

Two sets of samples were collected, one between February 27 and April 12, 1979 and the other between December 4, 1979 and July 10, 1980. Samples from the first set of data contained lead concentrations which exceeded the primary drinking water standard (PDWS) in two on-site wells and three off-site wells. Samples from on-site wells in the first set of data also showed increases above background levels in the secondary drinking water standards (SDWS) of calcium, magnesium, total dissolved solids (TDS), sulfate and iron.

In the second set of data, samples from on-site wells showed increases in calcium, magnesium, TDS and sulfate relative to the first set of data. Exceedances of the PDWS for arsenic, cadmium, chromium and selenium were found in on-site wells and exceedances of the PDWS for chromium were found in off-site wells. Lead was not detected in any of the second set of samples.

Elevated levels of selenium were detected in up-gradient wells in both the first and second sets of samples suggesting that selenium is originating from indigenous sediments rather than coal combustion wastes. The only constituents that appeared to be migrating off-site were lead in the first set of sampling and chromium in the second set of sampling.

Based on data collected, there appeared to be a temporal change in ground water quality at this site, and potential adverse impacts from constituents migrating off-site appeared to be limited. While the data indicated that lead and chromium appeared to be migrating off-site, EPA rejected this site as a damage case due to apparent limited potential adverse impacts. Subsequent to the March 2000 Regulatory Determination, this site was reevaluated and rejected as a damage case because there was no evidence that coal combustion wastes were managed with low-volume wastes at this site so the site was not covered by that Regulatory Determination¹²⁹. Since then, the Agency has learned that the site receives various types of coal combustion wastes, including fly ash, and is covered by the March 2000 Regulatory Determination.

Basis for Consideration as a Potential Damage Case: Based on the on-site ground water contamination of the cited secondary drinking water standards (calcium, magnesium, total dissolved solids, sulfate and iron), and of primary drinking water standards (arsenic, cadmium, chromium and selenium) and the limited potential for the off-site migration of contaminants, this site has been reclassified as a potential damage case.

¹²⁹ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

64. Muscatine County Landfill, Iowa¹³⁰

History: It is not clear, based on the available data, if the currently active facility was constructed on the same site as the older, closed landfill. However, the issue of whether or not the sites are the same does not affect the analysis here, because the available data for the active site do not cover the constituents of concern (sulfate and selenium) for the older site. Further research is unlikely to find any additional information about the old facility. Therefore, conclusions about this site are based on the limited historical data.

Basis for Consideration as a Potential Damage Case: The exceedances of non-health-based standards (secondary MCL for sulfate) and possibly a single health-based standard (primary MCL for selenium) at this site are in wells located on-site, close to the waste management unit. Therefore, this case is a potential damage case.

65. Dave Johnston Power Plant, Wyoming¹³¹

History: Exceedances of the primary MCL for cadmium and the secondary MCLs for manganese and sulfate were observed in ground water up-gradient and down-gradient of the site. Interpretations of sampling results were difficult to make because other potential sources of contamination exist, such as other waste disposal areas at the site; contaminants naturally occurring in the soil which is highly mineralized around the Johnston site; and uncertainties with regard to what degree leachate from the two landfills had reached the down-gradient wells.

Basis for Consideration as a Potential Damage Case: Whereas exceedances of the primary MCL (cadmium) and the secondary MCLs (manganese and sulfate) were observed in ground water down-gradient of the site, the natural occurrence of mineralization products in the local soils and possible and other potential sources of contamination. Therefore, this case is a potential damage case.

66. Montana-Dakota Utilities R.M. Heskett Station, North Dakota¹³²

History: Monitoring data at this site from 1998 show levels of sulfate and boron immediately down-gradient of an old ash pile in excess of the secondary MCL. According to the NDDOH, the State required the company "... to install ground water monitoring wells and implement a closure plan. Since that time, the site has been effectively closed and is currently revegetated

¹³⁰ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

¹³¹ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

¹³² Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

with a good stand of growth. The ground water monitoring data indicate that impact to ground water has been reduced since closure of the site¹³³.

Basis for Consideration as a Potential Damage Case: While the State has taken regulatory action at this site, the sulfate and boron exceedances found are of non-health-based standards. Therefore, this case is a potential damage case.

67. Arizona Public Service Co. Cholla Steam Electric Generating Station, Arizona¹³⁴

History: Monitoring data at this site show levels of sulfate, total dissolved solids, chloride, and fluoride in excess of their secondary MCLs. These exceedances are found in a well located directly at the foot of the fly ash pond. The affected aquifer has "naturally poor water quality," but no background or up-gradient data are available. The commenters use a comparison to distant alluvial ground water to implicate pond leachate as a source of contamination. The commenters also allege that construction of the waste management units has caused naturally poor quality water from upper aquifers to contaminate the pristine lower aquifer, regardless of leachate contamination.

Basis for Consideration as a Potential Damage Case: The exceedances found at this site, sulfate, total dissolved solids, chloride and fluoride, are of non-health-based standards and are in a well directly at the foot of a waste management unit. Therefore, this case is a potential damage case.

¹³³ Attachment B to the letter from the Honsier Environmental Council to Dennis Ruddy regarding damage case sites, November 11, 1999, Document ID # EPA-HQ-RCRA-1999-0022-1235 in the docket titled Comments In Response To The April 28, 1999 Federal Register Availability Of Report To Congress On Fossil Fuel Combustion: Request For Comments And Announcement Of Public Hearing, Attachment B: Report On R.M. Heskett Station. The Report On R.M. Heskett Station is accessible at: <http://www.hecweb.org/ProgramsandInitiatives/CCW/heskett.pdf>

¹³⁴ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

**Rejected Coal Combustion Waste
Damage Cases
(Excluding Minefills)**

IV. Rejected Damage Cases

The following alleged damage cases were rejected due to either (1) lack of any evidence of damage or (2) lack of evidence that damages were uniquely associated with CCW.

68. American Coal Corporation #5 Landfill¹³⁵

No information available

69. Cardinal PFBC Monofill¹³⁶

According to Ohio EPA representatives, the Cardinal PFBC Monofill is used for the disposal of bed ash from the Ohio Power Cardinal Power Plant. The monofill was constructed on top of the closed Fly Ash Reservoir I Impoundment. The State has ground water monitoring data for the site, but the representatives could not confirm the presence of any suspected impacts. The data do not show any exceedences of primary or secondary MCLs. Furthermore, according to the State's hydrogeologists, interpretation of the data is occluded by mining impacts in the area. There are no exceedences of primary or secondary MCLs at this site. Therefore, this site is categorized as a case without documented evidence of proven or potential damage to human health or the environment.

70. Cardinal Fly Ash Reservoir II Impoundment¹³⁷

According to Ohio EPA representatives, the Cardinal Fly Ash Reservoir II Impoundment is used for the disposal of fly ash from the Ohio Power Cardinal Power Plant. The State has ground water monitoring data for the site, but the representatives could not confirm the presence of any suspected impacts. The data do not show any exceedences of primary or secondary MCLs. Furthermore, according to the State's hydrogeologists, interpretation of the data is occluded by mining impacts in the area. There are no exceedences of primary or secondary MCLs at this site. Therefore, this site is categorized as a case without documented evidence of proven or potential damage to human health or the environment.

¹³⁵ Memorandum from SAIC to Dennis Ruddy regarding Revised Identification of New Candidate Damage Cases, December 7, 2001.

¹³⁶ Ibid.

¹³⁷ Ibid.

71. Clinch River, Virginia¹³⁸

EPA identified this site in its original 1988 Report to Congress on Wastes from the Combustion of Fossil Fuels by Electric Utility Power Plants. It is described in detail in that document. EPA concluded that this site represented a proven damage case for purposes of the 1993 Regulatory Determination. In conducting its analysis for the 1999 Report to Congress, however, EPA concluded that there was no evidence of comanagement at this site. EPA therefore rejected this site as a damage case for purposes of the 1999 Report to Congress.¹³⁹

72. Copicut Road¹⁴⁰

Monitoring results do not document any exceedances of federal or state standards (Ruddy 2001), except for pH. The ground water pH was below (more acidic than) its minimum secondary MCL both prior to and during placement (PG&E undated). Because acidic ground water was present prior to ash placement, this exceedance cannot be attributed to ash placement. Monitoring data for the site reveal no exceedances of primary or secondary MCLs attributable to coal combustion waste placement at the site. Therefore, this case is categorized as a case without documented evidence of proven or potential damage to human health or the environment.¹⁴¹

73. Dixie Caverns County Landfill, Virginia¹⁴²

Dixie Caverns Landfill was operated by Roanoke County, Virginia, as a disposal site for municipal refuse, solvents, and fly ash. When the landfill was closed in 1976, it was not capped and an intermittent stream on the site flowed through a large drum pile and the fly ash pile and emptied into the Roanoke River, approximately two miles southeast of the landfill. There was also a sludge disposal pit on site. The contaminants identified on site include lead, cadmium, zinc, silver, iron, benzene, substituted benzene, chlorinated ethane, and polynuclear aromatic hydrocarbons (PAHs). Based on review of the materials provided by the commenters, it is apparent that the fly ash disposed at the site is emission control dust from an electric arc furnace,

¹³⁸ Letter from the Hoosier Environmental Council to the RCRA Docket Information Center regarding the CCW RTC, June 11, 1999, Letter from the Hoosier Environmental Council and the Citizens Coal Council to the RCRA Docket Information Center regarding the CCW RTC, June 14, 1999 and Letter from the Hoosier Environmental Council, et. al., to Dennis Ruddy regarding the CCW RTC, September 24, 1999.

¹³⁹ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000. Memorandum from SAIC to Dennis Ruddy regarding Review of Causative Factors for Coal Combustion Waste Damage Cases, November 29, 2000.

¹⁴⁰ Letter from HEC, et. al., to Dennis Ruddy, February, 2002.

¹⁴¹ Compendium of nineteen alleged coal combustion wastes damage cases, May 3, 2007.

¹⁴² Letter from the Hoosier Environmental Council and the Citizens Coal Council to the RCRA Docket Information Center regarding the CCW RTC, June 14, 1999 and Letter from the Hoosier Environmental Council, et. al., to Dennis Ruddy regarding the CCW RTC, September 24, 1999.

not fossil fuel combustion waste. This site did not receive fossil fuel combustion waste and therefore is not applicable.¹⁴³

74. Gavin Impoundments¹⁴⁴

According to Ohio EPA representatives, the Gavin Plant ash ponds are used for the disposal of ash from the Ohio Power Gavin Plant. The fly ash pond is no longer receiving ash, but has not yet been closed. The facility has not conducted ground water monitoring, but has submitted a ground water monitoring plan and will be required to monitor as part of their closure activities for the fly ash pond. The bottom ash pond is still receiving wastes. There is no ground water monitoring for the bottom ash pond. The representatives could not confirm the presence of any suspected impacts and the State has not undertaken any regulatory action at the site. There is no evidence of damage at this site. Therefore, this site is categorized as a case without documented evidence of proven or potential damage to human health or the environment.

75. Kyger Creek Power Plant Impoundments¹⁴⁵

According to Ohio EPA representatives, the Kyger Creek Plant surface impoundments are used for the disposal of ash from the Ohio Valley Electric Kyger Creek Power Plant. Bottom ash is disposed of in the bottom ash pond, although most of the facility's bottom ash is used by Black Beauty, an on-site company which sells products containing bottom ash. While there is no ground water monitoring around the bottom ash pond, Ohio EPA staff are unaware of any issues related to this pond.

76. Lake Erie, Ohio¹⁴⁶

Commenters provided a study of trace element concentrations in sediments, surface water, and biota in proximity to an ash disposal basin along the shore of Lake Erie. The study noted that sediment concentrations in the proximity of the basin had the potential for adverse effects on benthos (*oligochaetes*) and fish in early life stages. In addition, the study observed changes in fish behavior (e.g., possibly due to avoidance) near the basins. The study findings, however, do not conclusively implicate coal combustion waste as the source of the observed behavioral changes. There is insufficient evidence to confirm that fossil fuel combustion wastes are the source of contamination in this case.

¹⁴³ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹⁴⁴ Memorandum from SAIC to Dennis Ruddy regarding Revised Identification of New Candidate Damage Cases, December 7, 2001.

¹⁴⁵ Ibid.

¹⁴⁶ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

77. Muskingum River Power Plant Impoundments¹⁴⁷

According to Ohio EPA representatives, the Ohio Power Muskingum River Power Plant disposes of bottom ash in ponds located next to the plant. The representatives confirmed that there are no monitoring wells at the site. They indicated, however, that elevated levels of iron and manganese have been detected in facility production wells. These observations have led the State's hydrogeologists to suspect that there might be some impacts from the bottom ash ponds. The representatives, however, stated that the levels of iron and manganese detected are below the relevant secondary MCLs. Because there are no exceedances of primary or secondary MCLs at this site, the evidence is not sufficient to categorize this case as a proven or potential damage case under EPA's definitions. Therefore, this site is categorized as a case without documented evidence of proven or potential damage to human health or the environment.

The fly ash pond originally consisted of two ponds in series. One of the ponds has recently been closed and capped, while the other continues to accept waste. At the time that the fly ash pond was closed, the facility installed ground water monitoring wells around the perimeter of the entire fly ash disposal area and five years of monitoring data now are available. According to the Ohio EPA representatives, monitoring has detected some statistically "out of range" values for iron, manganese, and TDS. These observations have led the State's hydrogeologists to suspect that there might be some impacts from the fly ash ponds. The representatives, however, stated that the levels detected are below the relevant secondary MCLs. Because there are no exceedances of primary or secondary MCLs at this site, the evidence is not sufficient to categorize this case as a proven or potential damage case under EPA's definitions. Therefore, this site is categorized as a case without documented evidence of proven or potential damage to human health or the environment.

78. Muskogee Environmental Fly Ash Disposal Site, Oklahoma¹⁴⁸

Commenters provided a printout from the Superfund Archive identifying this site as a Superfund site. The information provided, however, does not identify the constituents of concern, the reason for inclusion of this site in the Superfund database, or otherwise indicate that any contamination at this site is associated with fossil fuel combustion wastes. There is insufficient information available to identify the extent and nature of damages present and attribute them to fossil fuel combustion wastes.¹⁴⁹

¹⁴⁷ Ibid.

¹⁴⁸ Letter from the Hoosier Environmental Council, et. al., to Dennis Ruddy regarding the CCW RTC, September 24, 1999.

¹⁴⁹ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

79. Public Service Co Fly Ash Disposal Site, Oklahoma¹⁵⁰

Commenters provided a printout from the Superfund Archive identifying this site as a Superfund site. The information provided, however, does not identify the constituents of concern, the reason for inclusion of this site in the Superfund database, or otherwise indicate that any contamination at this site is associated with fossil fuel combustion wastes. There is insufficient information available to identify the extent and nature of damages present and attribute them to fossil fuel combustion wastes.¹⁵¹

80. Star Coal Company #6 Landfill¹⁵²

No information available

81. Star Coal Company #14 Landfill¹⁵³

No information available

82. Stuart Station Impoundments¹⁵⁴

According to Ohio EPA representatives, the Stuart Station ash ponds are used for the disposal of ash from the Dayton Power & Light Stuart Station. The State has ground water monitoring data for wells near the ash ponds and older data from facility production wells. According to the State's hydrogeologists, the facility relocated their production wellfield due to ground water quality impacts of "undetermined origin." The monitoring data also show a statistical increase over background concentrations. The specific constituents showing increases were not identified, but there are no exceedances of primary or secondary MCLs at the site, according to the Ohio EPA representatives. The State's hydrogeologists also indicated that the impacts observed may be either from the ash ponds or from coal piles located in the area. Because there are no exceedances of primary or secondary MCLs at this site, the evidence is not sufficient to categorize this case as a proven or potential damage case under EPA's definitions. Therefore, this site is categorized as a case without documented evidence of proven or potential damage to human health or the environment.

¹⁵⁰ Letter from the Hoosier Environmental Council, et. al., to Dennis Ruddy regarding the CCW RTC, September 24, 1999.

¹⁵¹ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

¹⁵² Memorandum from SAIC to Dennis Ruddy regarding Revised Identification of New Candidate Damage Cases, December 7, 2001.

¹⁵³ Ibid.

¹⁵⁴ Ibid.

83. Thompson Landfill, Michigan¹⁵⁵

This site is an abandoned landfill. Commenters cited a MDEQ study that allegedly shows arsenic greater than Michigan “cleanup criteria” attributable to the landfill. This document and quantitative data supporting the alleged damages were not available. Recent information from the MDEQ, however, confirms that ground water contamination is present and that the site is being remediated. There is no information on whether wastes other than coal combustion wastes might be present that could contribute to the contamination. There is no information on whether the alleged contamination extends off-site. There is insufficient information available to identify the extent of ground water contamination, or to positively identify the source of the contamination.¹⁵⁶

84. Turris Coal Company Elkhart Mine, Illinois¹⁵⁷

This site is an underground mine that disposes of coal processing waste and coal combustion waste in a diked surface lagoon. Commenters provided monitoring data showing exceedances of the secondary MCLs for sulfate, chloride, and total dissolved solids in a single well at the site. The data for this well also show an increase in these concentrations since the placement of coal combustion waste began. The other wells at the site do not show similar exceedances or trends. There is no quantitative data on the presence of other constituents at the site. There is insufficient data on hydrogeology at the site, the location of coal combustion waste placement at the site, or on activities other than coal combustion waste placement at the site to conclude that the impacts identified are due to coal combustion waste placement. Although there is some quantitative evidence of contamination, the available data are limited to a small number of constituents. There also is insufficient information to identify the extent of the contamination or confirm the source of the contamination.¹⁵⁸

85. Western Farmers Electrical Fly Ash Site, Oklahoma¹⁵⁹

Commenters provided a printout from the Superfund Archive identifying this site as a Superfund site. The information provided, however, does not identify the constituents of concern, the reason for inclusion of this site in the Superfund database, or otherwise indicate that any

¹⁵⁵ Letter from the Hoosier Environmental Council, et. al., to Dennis Ruddy regarding the CCW RTC, September 24, 1999.

¹⁵⁶ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

¹⁵⁷ Memorandum from SAIC to Dennis Ruddy regarding Rationale and Conclusions Regarding Commenter-Identified Fossil Fuel Combustion Waste Damage Cases, April 20, 2000.

¹⁵⁸ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

¹⁵⁹ Letter from the Hoosier Environmental Council, et. al., to Dennis Ruddy regarding the CCW RTC, September 24, 1999.

contamination at this site is associated with fossil fuel combustion wastes. There is insufficient information available to identify the extent and nature of damages present and attribute them to fossil fuel combustion wastes.¹⁶⁰

¹⁶⁰ Memorandum from SAIC to Dennis Ruddy regarding Final Revised Report on Resolution of 18 Previously Indeterminate Candidate Damage Cases, March 5, 2003.

SUBCHAPTER 2L - GROUNDWATER CLASSIFICATION AND STANDARDS

SECTION .0100 - GENERAL CONSIDERATIONS

15A NCAC 02L .0101 AUTHORIZATION

(a) N.C. General Statute 143-214.1 directs that the Commission develop and adopt after proper study a series of classifications and standards which will be appropriate for the purpose of classifying each of the waters of the state in such a way as to promote the policy and purposes of the act. Pursuant to this statute, the rules in this Subchapter establish a series of classifications and water quality standards applicable to the groundwaters of the state.

(b) These rules are applicable to all activities or actions, intentional or accidental, which contribute to the degradation of groundwater quality, regardless of any permit issued by a governmental agency authorizing such action or activity except an innocent landowner who is a bona fide purchaser of property which contains a source of groundwater contamination, who purchased such property without knowledge or a reasonable basis for knowing that groundwater contamination had occurred, or a person whose interest or ownership in the property is based or derived from a security interest in the property, shall not be considered a responsible party.

*History Note: Authority G.S. 143-214.1; 143-214.2; 143-215.3(a)(1); 143B-282;
Eff. June 10, 1979;
Amended Eff. August 1, 1989; July 1, 1988; September 1, 1984; December 30, 1983.*

15A NCAC 02L .0102 DEFINITIONS

The definition of any word or phrase used in these Rules shall be the same as given in G.S. 143-212 and G.S. 143-213 except that the following words and phrases shall have the following meanings:

- (1) "Bedrock" means any consolidated rock encountered in the place in which it was formed or deposited and which cannot be readily excavated without the use of explosives or power equipment.
- (2) "Commission" means the Environmental Management Commission as organized under G.S. 143B.
- (3) "Compliance boundary" means a boundary around a disposal system at and beyond which groundwater quality standards may not be exceeded and only applies to facilities which have received a permit issued under the authority of G.S. 143-215.1 or G.S. 130A.
- (4) "Contaminant" means any substance occurring in groundwater in concentrations which exceed the groundwater quality standards specified in Rule .0202 of this Subchapter.
- (5) "Corrective action plan" means a plan for eliminating sources of groundwater contamination or for achieving groundwater quality restoration or both.
- (6) "Director" means Director of the Division of Environmental Management.
- (7) "Division" means the Division of Environmental Management.
- (8) "Exposure pathway" means a course taken by a contaminant by way of a transport medium after its release to the environment.
- (9) "Free product" means a non-aqueous phase liquid which may be present within the saturated zone or in surface water.
- (10) "Fresh groundwaters" means those groundwaters having a chloride concentration equal to or less than 250 milligrams per liter.
- (11) "Groundwaters" means those waters occurring in the subsurface under saturated conditions.
- (12) "Hazardous substance" means any substance as defined by Section 101(14) of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA).
- (13) "Licensed geologist" means a person who has been duly licensed as a geologist in accordance with the requirements of G.S. 89E.
- (14) "Natural remediation" means those natural processes acting to restore groundwater quality, including dilution, filtration, sorption, ion-exchange, chemical transformation and biodegradation.
- (15) "Practical Quantitation Limit" means the lowest concentration of a given material that can be reliably achieved among laboratories within specified limits of precision and accuracy by a given analytical method during routine laboratory analysis.
- (16) "Natural conditions" means the physical, biological, chemical and radiological conditions which occur naturally.
- (17) "Potable waters" means those waters suitable for drinking by humans.

- (18) "Professional Engineer" means a person who has been duly registered and licensed as a professional engineer in accordance with the requirements of G.S. 89C.
- (19) "Receptor" means any human, plant, animal, or structure which is, or has the potential to be, adversely effected by the release or migration of contaminants. Any well constructed for the purpose of monitoring groundwater and contaminant concentrations shall not be considered a receptor.
- (20) "Review boundary" means a boundary around a permitted disposal facility, midway between a waste boundary and a compliance boundary at which groundwater monitoring is required.
- (21) "Saline groundwaters" means those groundwaters having a chloride concentration of more than 250 mg/l.
- (22) "Saturated zone" means that part of the subsurface below the water table in which all the interconnected voids are filled with water under pressure at or greater than atmospheric. It does not include the capillary fringe.
- (23) "Standards" means groundwater quality standards as specified in Rule .0202 of this Subchapter.
- (24) "Suitable for drinking" means a quality of water which does not contain substances in concentrations which, either singularly or in combination if ingested into the human body, may cause death, disease, behavioral abnormalities, congenital defects, genetic mutations, or result in an incremental lifetime cancer risk in excess of 1×10^{-6} , or render the water unacceptable due to aesthetic qualities, including taste, odor or appearance.
- (25) "Time of travel" means the time required for contaminants in groundwater to move a unit distance.
- (26) "Waste boundary" means the perimeter of the permitted waste disposal area.
- (27) "Water table" means the surface of the saturated zone below which all interconnected voids are filled with water and at which the pressure is atmospheric.

History Note: Authority G.S. 143-214.1; 143-215; 143B-282;
 Eff. June 10, 1979.
 Amended Eff. October 1, 1993; August 1, 1989; July 1, 1988; March 1, 1985.

15A NCAC 02L .0103 POLICY

(a) The rules established in this Subchapter are intended to maintain and preserve the quality of the groundwaters, prevent and abate pollution and contamination of the waters of the state, protect public health, and permit management of the groundwaters for their best usage by the citizens of North Carolina. It is the policy of the Commission that the best usage of the groundwaters of the state is as a source of drinking water. These groundwaters generally are a potable source of drinking water without the necessity of significant treatment. It is the intent of these Rules to protect the overall high quality of North Carolina's groundwaters to the level established by the standards and to enhance and restore the quality of degraded groundwaters where feasible and necessary to protect human health and the environment, or to ensure their suitability as a future source of drinking water.

(b) It is the intention of the Commission to protect all groundwaters to a level of quality at least as high as that required under the standards established in Rule .0202 of this Subchapter. In keeping with the policy of the Commission to protect, maintain, and enhance groundwater quality within the State of North Carolina, the Commission will not approve any disposal system subject to the provisions of G.S. 143-215.1 which would result in:

- (1) the significant degradation of groundwaters which have existing quality that is better than the assigned standard, unless such degradation is found to be in the best interests of the citizens of North Carolina based upon the projected economic benefits of the facility and a determination that public health will be protected, or
- (2) a violation of a groundwater quality standard beyond a designated compliance boundary, or
- (3) the impairment of existing groundwater uses or increased risk to the health or safety of the public due to the operation of a waste disposal system.

(c) Violations of standards resulting from groundwater withdrawals which are in compliance with water use permits issued pursuant to G.S. 143-215.15, shall not be subject to the corrective action requirements of Rule .0106 of this Subchapter.

(d) No person shall conduct or cause to be conducted, any activity which causes the concentration of any substance to exceed that specified in Rule .0202 of this Subchapter, except as authorized by the rules of this Subchapter.

(e) Work that is within the scope of the practice of geology and engineering, performed pursuant to the requirements of this Subchapter, which involves site assessment, the interpretation of subsurface geologic conditions, preparation of conceptual corrective action plans or any work requiring detailed technical knowledge of site conditions which is submitted to the Director, shall be performed by persons, firms or professional corporations who are duly licensed to offer geological or engineering services by the appropriate occupational licensing board or are exempted from such licensing by G.S. 89E-6.

Work which involves design of remedial systems or specialized construction techniques shall be performed by persons, firms or professional corporations who are duly licensed to offer engineering services. Corporations that are authorized by law to perform engineering or geological services and are exempt from the Professional Corporation Act, G.S. 55B, may perform these services.

History Note: Authority G.S. 143-214; 143-214.1; 143-214.2; 143-215.3(e); 143-215.3(a)(1); 143B-282; Eff. June 10, 1979; Amended Eff. August 1, 1989; July 1, 1988; September 1, 1984; December 30, 1983; RRC Objection Eff. September 17, 1993, due to lack of necessity for Paragraph (e); Amended Eff. November 4, 1993.

15A NCAC 02L .0104 RESTRICTED DESIGNATION (RS)

(a) The RS designation serves as a warning that groundwater so designated may not be suitable for use as a drinking water supply without treatment. The designation is temporary and will be removed by the Director upon a determination that the quality of the groundwater so designated has been restored to the level of the applicable standards or when the groundwaters have been reclassified by the Commission. The Director is authorized to designate GA or GSA groundwaters as RS under any of the following circumstances:

- (1) Where, as a result of man's activities, groundwaters have been contaminated and the Director has approved a corrective action plan, or termination of corrective action, that will not result in the immediate restoration of such groundwaters to the standards established under this Subchapter.
 - (2) Where a statutory variance has been granted as provided in Rule .0113 of this Subchapter.
- (b) Groundwaters occurring within an area defined by a compliance boundary in a waste disposal permit are deemed to be designated RS.
- (c) The boundary of a designated RS area may be approximated in the absence of analytical data sufficient to define the dimension of the area. The boundary shall be located at least 250 feet away from the predicted edge of the contaminant plume, and shall include any areas into which the contamination is expected to migrate.
- (d) In areas designated RS, the person responsible for groundwater contamination shall establish and implement a groundwater monitoring system sufficient to detect changes in groundwater quality within the RS designated area. Monitoring shall be quarterly for the first year and may be reduced to semi-annually thereafter until the applicable standards have been achieved. If during the monitoring period, contaminant concentrations increase, additional remedial action or monitoring pursuant to these Rules may be required.
- (e) The applicant for an RS designation shall also provide written verification that all property owners within and adjacent to the proposed RS area have been notified of the requested RS designation.
- (f) The Division shall provide public notice of the intent to designate any groundwater RS in accordance with the following requirements:

- (1) Notice shall be published at least 30 days prior to any proposed final action in accordance with G.S. 143-215.4. In addition, notice shall be provided to all property owners identified pursuant to Paragraph (e) of this Rule and to the local County Health Director and the chief administrative officer of the political jurisdiction(s) in which the contamination occurs.
- (2) The notice shall contain the following information:
 - (A) name, address, and phone number of the agency issuing the public notice;
 - (B) the location and extent of the designated area;
 - (C) the county title number, county tax identification number, or the property tax book and page identifiers;
 - (D) a brief description of the action or actions which resulted in the degradation of groundwater in the area;
 - (E) actions or intended actions taken to restore groundwater quality;
 - (F) the significance of the RS designation;
 - (G) conditions applicable to removal of the RS designation;
 - (H) address and phone number of a Division contact from whom interested parties may obtain further information.
- (3) The Director shall consider all requests for a public hearing, and if he determines that there is significant public interest he shall issue public notice and hold a public hearing in accordance with G.S. 143-215.4(b) and Rule .0113(e) of this Section.

- (4) These requirements shall not apply to groundwaters defined in Paragraph (b) of this Rule.

History Note: Authority G.S. 143-214.1; 143-215.3(a)(1); 143B-282(2);
Eff. June 10, 1979;
Amended Eff. October 1, 1993; December 1, 1989; August 1, 1989; December 30, 1983.

15A NCAC 02L .0105 ADOPTION BY REFERENCE

History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Repealed Eff. August 1, 1989.

15A NCAC 02L .0106 CORRECTIVE ACTION

(a) Where groundwater quality has been degraded, the goal of any required corrective action shall be restoration to the level of the standards, or as closely thereto as is economically and technologically feasible as determined by the Department in accordance with this Rule. In all cases involving requests to the Secretary, as defined in 15A NCAC 02C .0102, for approval of corrective action plans, or termination of corrective action, the responsibility for providing all information required by this Rule lies with the person(s) making the request.

(b) Any person conducting or controlling an activity that results in the discharge of a waste or hazardous substance or oil to the groundwaters of the State, or in proximity thereto, shall take action upon discovery to terminate and control the discharge, mitigate any hazards resulting from exposure to the pollutants and notify the Department, as defined in 15A NCAC 02C .0102, of the discharge.

(c) Any person conducting or controlling an activity that has not been permitted by the Department and that results in an increase in the concentration of a substance in excess of the standard, other than agricultural operations, shall:

- (1) within 24 hours of discovery of the violation, notify the Department of the activity that has resulted in the increase and the contaminant concentration levels;
- (2) respond in accordance with Paragraph (f) of this Rule;
- (3) submit a report to the Secretary assessing the cause, significance, and extent of the violation; and
- (4) implement an approved corrective action plan for restoration of groundwater quality in accordance with a schedule established by the Secretary. In establishing a schedule, the Secretary shall consider a schedule proposed by the person submitting the plan. A report shall be made to the Health Director of the county or counties in which the contamination occurs in accordance with the requirements of Rule .0114(a) in this Section.

Any activity not permitted pursuant to G.S. 143-215.1 or G.S. 130A-294 shall, for the purpose of this Rule, be deemed not permitted by the Department and subject to the provisions of this Paragraph.

(d) Any person conducting or controlling an activity that is conducted under the authority of a permit initially issued by the Department on or after December 30, 1983 pursuant to G.S. 143-215.1 or G.S. 130A-294 and that results in an increase in concentration of a substance in excess of the standards:

- (1) at or beyond a review boundary: the person shall demonstrate, through predictive calculations or modeling, that natural site conditions, facility design and operational controls will prevent a violation of standards at the compliance boundary. Alternately, the person may submit a plan for alteration of existing site conditions, facility design, or operational controls that will prevent a violation at the compliance boundary, and implement that plan upon its approval by the Secretary.
- (2) at or beyond a compliance boundary: the person shall respond in accordance with Paragraph (f) of this Rule, assess the cause, significance and extent of the violation of standards and submit the results of the investigation, and a plan and proposed schedule for corrective action to the Secretary. The permittee shall implement the plan as approved by and in accordance with a schedule established by the Secretary. In establishing a schedule the Secretary shall consider any schedule proposed by the permittee, the scope of the project, the extent of contamination, and the corrective action being proposed.

(e) Any person conducting or controlling an activity that is conducted under the authority of a permit initially issued by the Department prior to December 30, 1983 pursuant to G.S. 143-215.1 or G.S. 130A-294, and that results in an increase in concentration of a substance in excess of the standards at or beyond the compliance boundary specified in the permit, shall:

- (1) within 24 hours of discovery of the violation, notify the Department of the activity that has resulted in the increase and the contaminant concentration levels;
- (2) respond in accordance with Paragraph (f) of this Rule;

- (3) submit a report to the Secretary assessing the cause, significance and extent of the violation; and
 - (4) implement an approved corrective action plan for restoration of groundwater quality at or beyond the compliance boundary, in accordance with a schedule established by the Secretary. In establishing a schedule the Secretary shall consider any schedule proposed by the person submitting the plan. A report shall be made to the Health Director of the county or counties where the contamination occurs in accordance with the requirements of Rule .0114(a) in this Section.
- (f) Initial response required to be conducted prior to or concurrent with the assessment required in Paragraphs (c), (d), or (e) of this Rule shall include:
- (1) Prevention of fire, explosion, or the spread of noxious fumes;
 - (2) Abatement, containment, or control of the migration of contaminants;
 - (3) Removal, treatment, or control of any primary pollution source such as buried waste, waste stockpiles, or surficial accumulations of free products;
 - (4) Removal, treatment, or control of secondary pollution sources that would be potential continuing sources of pollutants to the groundwaters, such as contaminated soils and non-aqueous phase liquids. Contaminated soils that threaten the quality of groundwaters shall be treated, contained, or disposed of in accordance with rules in this Chapter and in 15A NCAC 13 applicable to such activities. The treatment or disposal of contaminated soils shall be conducted in a manner that will not result in a violation of standards or North Carolina Hazardous Waste Management rules.
- (g) The site assessment conducted pursuant to the requirements of Paragraphs (c), (d), or (e) of this Rule, shall include:
- (1) The source and cause of contamination;
 - (2) Any imminent hazards to public health and safety, as defined in G.S. 130A-2, and any actions taken to mitigate them in accordance with Paragraph (f) of this Rule;
 - (3) All receptors and significant exposure pathways;
 - (4) The horizontal and vertical extent of soil and groundwater contamination and all significant factors affecting contaminant transport; and
 - (5) Geological and hydrogeological features influencing the movement, chemical, and physical character of the contaminants.
- Reports of site assessments shall be submitted to the Department as soon as practicable or in accordance with a schedule established by the Secretary. In establishing a schedule the Secretary shall consider a proposal by the person submitting the report.
- (h) Corrective action plans for restoration of groundwater quality, submitted pursuant to Paragraphs (c), (d), and (e) of this Rule shall include:
- (1) A description of the proposed corrective action and reasons for its selection;
 - (2) Specific plans, including engineering details where applicable, for restoring groundwater quality;
 - (3) A schedule for the implementation and operation of the proposed plan; and
 - (4) A monitoring plan for evaluating the effectiveness of the proposed corrective action and the movement of the contaminant plume.
- (i) In the evaluation of corrective action plans, the Secretary shall consider the extent of any violations, the extent of any threat to human health or safety, the extent of damage or potential adverse impact to the environment, technology available to accomplish restoration, the potential for degradation of the contaminants in the environment, the time and costs estimated to achieve groundwater quality restoration, and the public and economic benefits to be derived from groundwater quality restoration.
- (j) A corrective action plan prepared pursuant to Paragraphs (c), (d), or (e) of this Rule shall be implemented using a remedial technology demonstrated to provide the most effective means, taking into consideration geological and hydrogeological conditions at the contaminated site, for restoration of groundwater quality to the level of the standards. Corrective action plans prepared pursuant to Paragraphs (c) or (e) of this Rule may request an exception as provided in Paragraphs (k), (l), (m), (r), and (s) of this Rule.
- (k) Any person required to implement an approved corrective action plan for a site subject to Paragraphs (c) or (e) of this Rule may request that the Secretary approve such a plan without requiring groundwater remediation to the standards. A request submitted to the Secretary under this Paragraph shall include a description of site-specific conditions, including information on the availability of public water supplies for the affected area; the technical basis for the request; and any other information requested by the Secretary to evaluate the request in accordance with Subparagraphs (1) through (7) of this Paragraph. The person making the request shall demonstrate:
- (1) that all sources of contamination and free product have been removed or controlled pursuant to Paragraph (f) of this Rule;

- (2) that the time and direction of contaminant travel can be predicted with reasonable certainty;
- (3) that contaminants have not and will not migrate onto adjacent properties, or that:
 - (A) such properties are served by an existing public water supply system dependent on surface waters or hydraulically isolated groundwater; or
 - (B) the owners of such properties have consented in writing to the request;
- (4) that the standards specified in Rule .0202 of this Subchapter will be met at a location no closer than one year time of travel upgradient of an existing or foreseeable receptor, based on travel time and the natural attenuation capacity of subsurface materials or on a physical barrier to groundwater migration that exists or will be installed by the person making the request;
- (5) that, if the contaminant plume is expected to intercept surface waters, the groundwater discharge will not possess contaminant concentrations that would result in violations of standards for surface waters contained in 15A NCAC 02B .0200;
- (6) that public notice of the request has been provided in accordance with Rule .0114(b) of this Section; and
- (7) that the proposed corrective action plan would be consistent with all other environmental laws.

(l) Any person required to implement an approved corrective action plan for a site subject to Paragraphs (c) or (e) of this Rule may request that the Secretary approve such a plan based upon natural processes of degradation and attenuation of contaminants. A request submitted to the Secretary under this Paragraph shall include a description of site-specific conditions, including written documentation of projected groundwater use in the contaminated area based on current state or local government planning efforts; the technical basis for the request; and any other information requested by the Secretary to evaluate the request in accordance with Subparagraphs (1) through (10) of this Paragraph. The person making the request shall demonstrate:

- (1) that all sources of contamination and free product have been removed or controlled pursuant to Paragraph (f) of this Rule;
- (2) that the contaminant has the capacity to degrade or attenuate under the site-specific conditions;
- (3) that the time and direction of contaminant travel can be predicted based on subsurface conditions and the contaminant's physical and chemical properties;
- (4) that contaminant migration will not result in any violation of applicable groundwater standards at any existing or foreseeable receptor;
- (5) that contaminants have not and will not migrate onto adjacent properties, or that:
 - (A) such properties are served by an existing public water supply system dependent on surface waters or hydraulically isolated groundwater; or
 - (B) the owners of such properties have consented in writing to the request;
- (6) that, if the contaminant plume is expected to intercept surface waters, the groundwater discharge will not possess contaminant concentrations that would result in violations of standards for surface waters contained in 15A NCAC 02B .0200;
- (7) that the person making the request will put in place a groundwater monitoring program that, based on subsurface conditions and the physical and chemical properties of the contaminant, will accurately track the degradation and attenuation of contaminants and contaminant by-products within and down gradient of the plume and to detect contaminants and contaminant by-products prior to their reaching any existing or foreseeable receptor at least one year's time of travel upgradient of the receptor and no greater than the distance the groundwater at the contaminated site is predicted to travel in five years;
- (8) that all necessary access agreements needed to monitor groundwater quality pursuant to Subparagraph (7) of this Paragraph have been or can be obtained;
- (9) that public notice of the request has been provided in accordance with Rule .0114(b) of this Section; and
- (10) that the proposed corrective action plan would be consistent with all other environmental laws.

(m) The Department or any person required to implement an approved corrective action plan for a site subject to Paragraphs (c) or (e) of this Rule may request that the Secretary approve termination of corrective action.

- (1) A request submitted to the Secretary under this Paragraph shall include:
 - (A) a discussion of the duration of the corrective action, the total project cost, projected annual cost for continuance and evaluation of the success of the corrective action;
 - (B) an evaluation of alternate treatment technologies that could result in further reduction of contaminant levels, projected capital, and annual operating costs for each technology; and
 - (C) the effects, including health and safety impacts, on groundwater users if contaminant levels remain at levels existing at the time corrective action is terminated.
- (2) In addition, the person making the request shall demonstrate:

- (A) that continuation of corrective action would not result in a significant reduction in the concentration of contaminants. This demonstration shall show the duration and degree of success of existing remedial efforts to attain standards. For the purpose of this Part, a "significant reduction" is demonstrated by showing that the asymptotic slope of the contaminants curve of decontamination is less than a ratio of 1:40 over a term of one year based on quarterly sampling;
 - (B) that contaminants have not and will not migrate onto adjacent properties, or that:
 - (i) such properties are served by an existing public water supply system dependent on surface waters or hydraulically isolated groundwater; or
 - (ii) the owners of such properties have consented in writing to the request;
 - (C) that, if the contaminant plumes are expected to intercept surface waters, the groundwater discharge will not possess contaminant concentrations that would result in violations of standards for surface waters contained in 15A NCAC 02B .0200;
 - (D) that public notice of the request has been provided in accordance with Rule .0114(b) of this Section; and
 - (E) that the proposed termination would be consistent with all other environmental laws.
- (3) The Secretary shall not authorize termination of corrective action for any area that, at the time the request is made, has been identified by a state or local groundwater use planning process for resource development.
- (4) The Secretary may authorize the termination of corrective action, or amend the corrective action plan after considering all the information in the request. In making the authorization, the Secretary shall consider health and safety impacts on all existing and foreseeable receptors and the impacts the contaminated plume may have if it reaches them. Upon termination of corrective action, the Secretary shall require implementation of a groundwater monitoring program that, based on subsurface conditions and the physical and chemical properties of the contaminants, will accurately track the degradation and attenuation of contaminants at a location of no less than one year's predicted time of travel upgradient of any existing or foreseeable receptor. The monitoring program shall remain in effect until there is sufficient evidence that the contaminant concentrations have been reduced to the level of the standards. For the purpose of this Part, "sufficient evidence" means that sampling and analyses demonstrate that contaminant concentrations have been reduced to the level of the standards on multiple sampling events.
- (n) Upon a determination by the Secretary that continued corrective action would result in no significant reduction in contaminant concentrations, and the contaminated groundwaters can be rendered potable by treatment using technologies that are in use in other applications and shown to be effective for removal of contaminants, the Secretary may designate the remaining area of degraded groundwater RS. Where the remaining degraded groundwaters cannot be made potable by such treatment, the Secretary may consider a request for reclassification of the groundwater to a GC classification as outlined in Rule .0201 of this Subchapter.
- (o) If at any time the Secretary determines that a new technology is available that would remediate the contaminated groundwater to the standards specified in Rule .0202 of this Subchapter, the Secretary may require the responsible party to evaluate the economic and technological feasibility of implementing the new technology in an active groundwater corrective action plan in accordance with a schedule established by the Secretary. The Secretary's determination to utilize new technology at any site or for any particular constituent shall include a consideration of the factors in Paragraph (h) of this Rule.
- (p) Where standards are exceeded as a result of the application of pesticides or other agricultural chemicals, the Secretary shall request the Pesticide Board or the Department of Agriculture and Consumer Services to assist the Department in determining the cause of the violation. If the violation is determined to have resulted from the use of pesticides, the Secretary shall request the Pesticide Board to take appropriate regulatory action to control the use of the chemical or chemicals responsible for, or contributing to, such violations, or to discontinue their use.
- (q) The approval pursuant to this Rule of any corrective action plan, or modification or termination thereof, that permits the migration of a contaminant onto adjacent property, shall not affect any private right of action by any party that may be affected by that contamination.
- (r) If a discharge or release is not governed by the rules in Section .0400 of this Subchapter and the increase in the concentration of a substance in excess of the standard resulted in whole or in part from a release from a commercial or noncommercial underground storage tank as defined in G.S. 143-215.94A, any person required to implement an approved corrective action plan pursuant to this Rule and seeking reimbursement for the Commercial or Noncommercial Leaking Petroleum Underground Storage Tank Cleanup Funds shall implement a corrective action plan meeting the requirements of Paragraph (k) or (l) of this Rule unless the person demonstrates to the Secretary that:

- (1) contamination resulting from the discharge cannot qualify for approval of a plan based on the requirements of the Paragraphs; or
 - (2) the cost of making such a demonstration would exceed the cost of implementing a corrective action plan submitted pursuant to Paragraph (c) of this Rule.
- (s) If a discharge or release is not governed by the rules in Section .0400 of this Subchapter and the increase in the concentration of a substance in excess of the standard resulted in whole or in part from a release from a commercial or noncommercial underground storage tank as defined in G.S. 143-215.94A, the Secretary may require any person implementing or operating a previously approved corrective action plan pursuant to this Rule to:
- (1) develop and implement a corrective action plan meeting the requirements of Paragraphs (k) and (l) of this Rule; or
 - (2) seek discontinuance of corrective action pursuant to Paragraph (m) of this Rule.

History Note: Authority G.S. 143-215.1; 143-215.3; 143-215.94A; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Eff. August 1, 1989; Amended Eff. October 1, 1993; September 1, 1992; Temporary Amendment Eff. January 2, 1998; January 2, 1996; Amended Eff. July 1, 2016; October 29, 1998.

15A NCAC 02L .0107 COMPLIANCE BOUNDARY

- (a) For disposal systems individually permitted prior to December 30, 1983, the compliance boundary is established at a horizontal distance of 500 feet from the waste boundary or at the property boundary, whichever is closer to the source.
- (b) For disposal systems individually permitted on or after December 30, 1983, a compliance boundary shall be established 250 feet from the waste boundary, or 50 feet within the property boundary, whichever point is closer to the source.
- (c) The boundary shall be established by the Director, or his designee at the time of permit issuance. Any sale or transfer of property which affects a compliance boundary shall be reported immediately to the Director, or his designee. For disposal systems which are not governed by Paragraphs (e) or (f) of this Rule, the compliance boundary affected by the sale or transfer of property will be re-established consistent with Paragraphs (a) or (b) of this Rule, whichever is applicable.
- (d) Except as provided in Paragraph (g) of this Rule, no water supply wells shall be constructed or operated within the compliance boundary of a disposal system individually permitted or repermitted after January 1, 1993.
- (e) Except as provided in Paragraph (g) of this Rule, a permittee shall not transfer land within an established compliance boundary of a disposal system permitted or repermitted after January 1, 1993 unless:
 - (1) the land transferred is serviced by a community water system as defined in 15A NCAC 18C, the source of which is located outside the compliance boundary; and
 - (2) the deed transferring the property:
 - (A) contains notice of the permit, including the permit number, a description of the type of permit, and the name, address and telephone number of the permitting agency; and
 - (B) contains a restrictive covenant running with the land and in favor of the permittee and the State, as a third party beneficiary, which prohibits the construction and operation of water supply wells within the compliance boundary; and
 - (C) contains a restrictive covenant running with the land and in favor of the permittee and the State, as a third party beneficiary, which grants the right to the permittee and the State to enter on such property within the compliance boundary for groundwater monitoring and remediation purposes.
- (f) Except as provided in Paragraph (g) of this Rule, if at the time a permit is issued or reissued after January 1, 1993, the permittee is not the owner of the land within the compliance boundary, it shall be a condition of the permit issued or renewed that the landowner of the land within the compliance boundary, if other than the permittee, execute and file in the Register of Deeds in the county in which the land is located, an easement running with the land which:
 - (1) contains:
 - (A) either a notice of the permit, including the permit number, a description of the type of permit, and the name, address and telephone number of the permitting agency; or
 - (B) a reference to a notice of the permit with book and page number of its recordation if such notice is required to be filed by statute;
 - (2) prohibits the construction and operation of water supply wells within the compliance boundary; and
 - (3) reserves the right to the permittee and the State to enter on such property within the compliance boundary for groundwater monitoring and remediation purposes. The easement may be terminated by the Director

when its purpose has been fulfilled or the need for the easement no longer exists. Under those conditions the Director shall, upon request by the landowner, file a document terminating the easement with the appropriate Register of Deeds.

(g) The requirements of Paragraphs (d), (e) and (f) of this Rule are not applicable to ground adsorption treatment systems serving four or fewer single family dwellings or multiunit dwellings of four or fewer units.

(h) The boundary shall form a vertical plane extending from the water table to the maximum depth of saturation.

(i) For ground absorption sewage treatment and disposal systems which are permitted under 15A NCAC 18A .1900, the compliance boundary shall be established at the property boundary.

(j) Penalties authorized pursuant to G.S. 143-215.6A(a)(1) will not be assessed for violations of standards within a compliance boundary unless the violations are the result of violations of permit conditions or negligence in the management of the facility.

(k) The Director shall require:

- (1) that permits for all activities governed by G.S. 143-215.1 be written to protect the quality of groundwater established by applicable standards, at the compliance boundary;
- (2) that necessary groundwater quality monitoring shall be conducted within the compliance boundary; and
- (3) that a violation of standards within the compliance boundary resulting from activities conducted by the permitted facility be remedied through clean-up, recovery, containment, or other response when any of the following conditions occur:
 - (A) a violation of any standard in adjoining classified groundwaters occurs or can be reasonably predicted to occur considering hydrogeologic conditions, modeling, or other available evidence;
 - (B) an imminent hazard or threat to the public health or safety exists; or
 - (C) a violation of any standard in groundwater occurring in the bedrock other than limestones found in the Coastal Plain sediments, unless it can be demonstrated that the violation will not adversely affect, or have the potential to adversely affect a water supply well.

History Note: Authority G.S. 143-215.1(b); 143-215.3(a)(1); 143B-282;
Eff. August 1, 1989;
Amended Eff. October 1, 1993; November 2, 1992.

15A NCAC 02L .0108 REVIEW BOUNDARY

A review boundary is established around any disposal system midway between the compliance boundary and the waste boundary. When the concentration of any substance equals or exceeds the standard at the review boundary as determined by monitoring, the permittee shall take action in accordance with the provisions of Rule .0106(c)(2)(A) of this Subchapter.

History Note: Authority G.S. 143-215.1(b); 143-215.3(a)(1); 143B-282;
Eff. August 1, 1989.

15A NCAC 02L .0109 DELEGATION

(a) The Director is delegated the authority to enter into consent special orders under G.S. 143-215.2 for violations of the standards except when a public meeting is required as provided in 15A NCAC 2H .1203.

(b) The Director is delegated the authority to prepare a proposed special order to be issued by the Commission without the consent of the person affected and to notify the affected person of that proposed order and of the procedure set out in G.S. 150B-23 to contest the proposed special order.

(c) The Director, or his designee shall give public notice of proposed consent special orders as specified in 15A NCAC 2H .1203.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.3(a)(4);
Eff. August 1, 1989;
Amended Eff. October 1, 1993; October 1, 1990.

15A NCAC 02L .0110 MONITORING

(a) Except where exempted by statute or this Subchapter, any person who causes, permits or has control over any discharge of waste, or groundwater cleanup program, shall install and implement a monitoring system, at such locations, and in such detail, as the Director, or his designee may require to evaluate the effects of the discharge upon the waters of the state, including the effect of any actions taken to restore groundwater quality, as well as the efficiency of any treatment facility. The monitoring

plan shall be prepared under the responsible charge of a Professional Engineer or Licensed Geologist and bear the seal of the same.

(b) Monitoring systems shall be constructed in a manner that will not result in the contamination of adjacent groundwaters of a higher quality.

(c) Monitoring shall be conducted and results reported in a manner and at a frequency specified by the Director, or his designee.

History Note: Authority G.S. 143-215.1(b); 143-215.3(a)(1); 143-215.65; 143-215.66; 143B-282;
Eff. August 1, 1989;
Amended Eff. October 1, 1993.

15A NCAC 02L .0111 REPORTS

(a) Any person subject to the requirements for corrective action specified in Rule .0106 of this Section shall submit to the Director, in such detail as the Director may require, a written report that describes:

- (1) the results of the investigation specified in Paragraphs (c) and (d) of Rule .0106 of this Section, including but not limited to:
 - (A) a description of the sampling procedures followed and methods of chemical analyses used; and
 - (B) all technical data utilized in support of any conclusions drawn or determinations made.
- (2) the results of the predictive calculations or modeling, including a copy of the calculations or model runs and all supporting technical data, used in the demonstration required in Paragraph (d) of Rule .0106 of this Section; and
- (3) the proposed methodology and timetable associated with the corrective action for those situations identified in Paragraphs (c) and (d) of Rule .0106 of this Section.

(b) The report shall be prepared under the responsible charge of a Professional Engineer or Licensed Geologist and bear the seal of the same as specified in Rule .0106(d) of this Section.

History Note: Authority G.S. 143-215.1(b); 143-215.3(a)(1); 143-215.65; 143B-282;
Eff. August 1, 1989;
Amended Eff. October 1, 1993.

15A NCAC 02L .0112 ANALYTICAL PROCEDURES

Tests or analytical procedures to determine compliance or noncompliance with the standards established in Rule .0202 of this Subchapter will be in accordance with:

- (1) The most sensitive of the following methods or procedures for substances where the standard is at or above the method detection limit value:
 - (a) The most recent version of Standard Methods for the Examination of Water and Wastewater, published jointly by American Public Health Association, American Water Works Association and Water Pollution Control Federation;
 - (b) Methods for Chemical Analysis of Water and Waste, 1979, U.S. Environmental Protection Agency publication number EPA-600/4-79-020, as revised March 1983;
 - (c) Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods, 3rd Edition, 1986, U.S. Environmental Protection Agency publication number SW-846;
 - (d) Test Procedures for the Analysis of Pollutants Under the Clean Water Act, Federal Register Vol. 49, No. 209, 40 CFR Part 136, October 26, 1984;
 - (e) Methods or procedures approved by letter from the Director upon application by the regulated source; or
- (2) A method or procedure approved by the Director for substances where the standard is less than the method detection limit value.

History Note: Authority G.S. 143-215.3(a)(1); 143B-282;
Eff. August 1, 1989;
Amended Eff. October 1, 1993.

15A NCAC 02L .0113 VARIANCE

(a) The Commission, on its own initiative or pursuant to a request under G.S. 143-215.3(e), may grant variances to the rules of this Subchapter.

(b) Requests for variances are filed by letter from the applicant to the Environmental Management Commission. The application shall be mailed to the chairman of the Commission in care of the Director, Division of Environmental Management, Post Office Box 29535, Raleigh, N.C. 27626-0535.

(c) The application shall contain the following information:

- (1) Applications filed by counties or municipalities must include a resolution of the County Board of Commissioners or the governing board of the municipality requesting the variance.
- (2) A description of the past, existing or proposed activities or operations that have or would result in a discharge of contaminants to the groundwaters.
- (3) Description of the proposed area for which a variance is requested. A detailed location map, showing the orientation of the facility, potential for groundwater contaminant migration, as well as the area covered by the variance request, with reference to at least two geographic references (numbered roads, named streams/rivers, etc.) must be included.
- (4) Supporting information to establish that the variance will not endanger the public health and safety, including health and environmental effects from exposure to groundwater contaminants. (Location of wells and other water supply sources including details of well construction within 1/2 mile of site must be shown on a map).
- (5) Supporting information to establish that requirements of this Rule cannot be achieved by providing the best available technology economically reasonable. This information must identify specific technology considered, and the costs of implementing the technology and the impact of the costs on the applicant.
- (6) Supporting information to establish that compliance would produce serious financial hardship on the applicant.
- (7) Supporting information that compliance would produce serious financial hardship without equal or greater public benefit.
- (8) A copy of any Special Order that was issued in connection with contaminants in the proposed area and supporting information that applicant has complied with the Special Order.
- (9) A list of the names and addresses of any property owners within the proposed area of the variance as well as any property owners adjacent to the site covered by the variance.

(d) Upon receipt of the application, the Director will review it for completeness and request additional information if necessary. When the application is complete, the Director shall give public notice of the application and schedule the matter for a public hearing in accordance with G.S. 143-215.4(b) and the procedures set out in Paragraph (e) of this Rule.

(e) Notice of Public Hearing:

- (1) Notice of public hearing on any variance application shall be circulated in the geographical areas of the proposed variance by the Director at least 30 days prior to the date of the hearing:
 - (A) by publishing the notice one time in a newspaper having general circulation in said county;
 - (B) by mailing to the North Carolina Department of Environment, Health, and Natural Resources, Division of Environmental Health and appropriate local health agency;
 - (C) by mailing to any other federal, state or local agency upon request;
 - (D) by mailing to the local governmental unit or units having jurisdiction over the geographic area covered by the variance;
 - (E) by mailing to any property owner within the proposed area of the variance, as well as any property owners adjacent to the site covered by the variance; and
 - (F) by mailing to any person or group upon request.
- (2) The contents of public notice of any hearing shall include at least the following:
 - (A) name, address, and phone number of agency holding the public hearing;
 - (B) name and address of each applicant whose application will be considered at the meeting;
 - (C) brief summary of the variance request;
 - (D) geographic description of a proposed area for which a variance is requested;
 - (E) brief description of activities or operations which have or will result in the discharge of contaminants to the groundwaters described in the variance application;
 - (F) a brief reference to the public notice issued for each variance application;
 - (G) information regarding the time and location for the hearing;
 - (H) the purpose of the hearing;

- (I) address and phone number of premises at which interested persons may obtain further information, request a copy of each application, and inspect and copy forms and related documents; and
 - (J) a brief description of the nature of the hearing including the rules and procedures to be followed. The notice shall also state that additional information is on file with the Director and may be inspected at any time during normal working hours. Copies of the information on file will be made available upon request and payment of cost or reproduction.
- (f) All comments received within 30 days following the date of the public hearing shall be made part of the application file and shall be considered by the Commission prior to taking final action on the application.
- (g) In determining whether to grant a variance, the Commission shall consider whether the applicant has complied with any Special Order, or Special Order by Consent issued under G.S. 143-215.2.
- (h) If the Commission's final decision is unacceptable, the applicant may file a petition for a contested case in accordance with Chapter 150B of the General Statutes. If the petition is not filed within 60 days, the decision on the variance shall be final and binding.
- (i) A variance shall not operate as a defense to an action at law based upon a public or private nuisance theory or any other cause of action.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.3(a)(3); 143-215.3(a)(4); 143-215.3(e); 143-215.4;
Eff. August 1, 1989;
Amended Eff. October 1, 1993.

15A NCAC 02L .0114 NOTIFICATION REQUIREMENTS

(a) Any person subject to the requirements of Rule .0106(c) of this Section shall submit to the local Health Director, and the chief administrative officer of the political jurisdictions in which the groundwater contamination has occurred, a report that describes:

- (1) The area extent of the contaminant plume;
- (2) The chemical constituents in the groundwater which exceed the standards described in Rule .0202 of this Subchapter;
- (3) Actions taken and intended to mitigate threats to human health;
- (4) The location of any wells installed for the purpose of monitoring the contaminant plume and the frequency of sampling.

The report described in this Rule shall be submitted no later than five working days after submittal of the completed report assessing the cause, significance and extent of the violation as required by Rule .0106(c).

(b) Any person who submits a request under Rule .0106(k), (l), or (m) of this Section shall notify the local Health Director and the chief administrative officer of the political jurisdictions in which the contaminant plume occurs, and all property owners and occupants within or contiguous to the area underlain by the contaminant plume, and under the areas where it is expected to migrate, of the nature of the request and reasons supporting it. Notification shall be made by certified mail concurrent with the submittal of the request to the Director. A final decision by the Director shall be postponed for a period of 30 days following receipt of the request so that the Director may consider comments submitted by individuals interested in the request.

(c) Any person whose request under Rule .0106(k), (l), or (m) of this Section is granted by the Director shall notify parties specified in Paragraph (b) of this Rule of the Director's decision. Notification shall be made by certified mail within 30 days of receipt of the Director's decision.

History Note: Authority G.S. 143-214.1; 143-215.3(a)(1); 143B-282(2)b;
Eff. October 1, 1993.

15A NCAC 02L .0115 RISK-BASED ASSESSMENT AND CORRECTIVE ACTION FOR PETROLEUM UNDERGROUND STORAGE TANKS

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V;
143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1;
Temporary Adoption Eff. January 2, 1998;
Eff. October 29, 1998;
Recodified to 15A NCAC 02L .0400 Eff. December 1, 2005.

SECTION .0200 - CLASSIFICATIONS AND GROUNDWATER QUALITY STANDARDS

15A NCAC 02L .0201 GROUNDWATER CLASSIFICATIONS

The classifications which may be assigned to the groundwaters will be those specified in the following series of classifications:

- (1) Class GA groundwaters; usage and occurrence:
 - (a) Best Usage. Existing or potential source of drinking water supply for humans.
 - (b) Conditions Related to Best Usage. This class is intended for those groundwaters in which chloride concentrations are equal to or less than 250 mg/l, and which are considered suitable for drinking in their natural state, but which may require treatment to improve quality related to natural conditions.
 - (c) Occurrence. In the saturated zone.
- (2) Class GSA groundwaters; usage and occurrence:
 - (a) Best Usage. Existing or potential source of water supply for potable mineral water and conversion to fresh waters.
 - (b) Conditions Related to Best Usage. This class is intended for those groundwaters in which the chloride concentrations due to natural conditions is in excess of 250 mg/l, but which otherwise may be considered suitable for use as potable water after treatment to reduce concentrations of naturally occurring substances.
 - (c) Occurrence. In the saturated zone.
- (3) Class GC groundwaters; usage and occurrence:
 - (a) Best Usage. The best usage of GC groundwaters is as a source of water supply for purposes other than drinking, including other domestic uses by humans.
 - (b) Conditions Related to Best Usage. This class includes those groundwaters that do not meet the quality criteria for GA or GSA groundwaters and for which efforts to improve groundwater quality would not be technologically feasible, or not in the best interest of the public. Continued consumption of waters of this class by humans could result in adverse health affects.
 - (c) Occurrence. Groundwaters of this class may be defined by the Commission pursuant to Section .0300 of this Subchapter on a case by case basis.

*History Note: Authority G.S. 143-214.1; 143B-282(2);
Eff. June 10, 1979;
Amended Eff. October 1, 1993; August 1, 1989; September 1, 1984; December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0202 GROUNDWATER QUALITY STANDARDS

(a) The groundwater quality standards for the protection of the groundwaters of the state are those specified in this Rule. They are the maximum allowable concentrations resulting from any discharge of contaminants to the land or waters of the state, which may be tolerated without creating a threat to human health or which would otherwise render the groundwater unsuitable for its intended best usage.

(b) The groundwater quality standards for contaminants specified in Paragraphs (h) and (i) of this Rule are as listed, except that:

- (1) Where the standard for a substance is less than the practical quantitation limit, the detection of that substance at or above the practical quantitation limit constitutes a violation of the standard.
- (2) Where two or more substances exist in combination, the Director shall consider the effects of chemical interactions as determined by the Division of Public Health and may establish maximum concentrations at values less than those established in accordance with Paragraphs (c), (h), or (i) of this Rule. In the absence of information to the contrary, in accordance with Paragraph (d) of this Rule, the carcinogenic risks associated with carcinogens present shall be considered additive and the toxic effects associated with non-carcinogens present shall also be considered additive.
- (3) Where naturally occurring substances exceed the established standard, the standard shall be the naturally occurring concentration as determined by the Director.

- (4) Where the groundwater standard for a substance is greater than the Maximum Contaminant Level (MCL), the Director shall apply the MCL as the groundwater standard at any private drinking water well or public water system well that may be impacted.
- (c) Except for tracers used in concentrations which have been determined by the Division of Public Health to be protective of human health, and the use of which has been permitted by the Division, substances which are not naturally occurring and for which no standard is specified shall not be permitted in concentrations at or above the practical quantitation limit in Class GA or Class GSA groundwaters. Any person may petition the Director to establish an interim maximum allowable concentration for a substance for which a standard has not been established under this Rule. The petitioner shall submit relevant toxicological and epidemiological data, study results, and calculations necessary to establish a standard in accordance with Paragraph (d) of this Rule. Within three months after the establishment of an interim maximum allowable concentration for a substance by the Director, the Director shall initiate action to consider adoption of a standard for that substance.
- (d) Except as provided in Paragraph (f) of this Rule, groundwater quality standards for substances in Class GA and Class GSA groundwaters are established as the least of:
- (1) Systemic threshold concentration calculated as follows: $[\text{Reference Dose (mg/kg/day)} \times 70 \text{ kg (adult body weight)} \times \text{Relative Source Contribution (.10 for inorganics; .20 for organics)}] / [2 \text{ liters/day (avg. water consumption)}]$;
 - (2) Concentration which corresponds to an incremental lifetime cancer risk of 1×10^{-6} ;
 - (3) Taste threshold limit value;
 - (4) Odor threshold limit value;
 - (5) Maximum contaminant level; or
 - (6) National secondary drinking water standard.
- (e) The following references, in order of preference, shall be used in establishing concentrations of substances which correspond to levels described in Paragraph (d) of this Rule.
- (1) Integrated Risk Information System (U.S. EPA).
 - (2) Health Advisories (U.S. EPA Office of Drinking Water).
 - (3) Other health risk assessment data published by the U.S. EPA.
 - (4) Other relevant, published health risk assessment data, and scientifically valid peer-reviewed published toxicological data.
- (f) The Commission may establish groundwater standards less stringent than existing maximum contaminant levels or national secondary drinking water standards if it finds, after public notice and opportunity for hearing, that:
- (1) more recent data published in the EPA health references listed in Paragraph (e) of this Rule results in a standard which is protective of public health, taste threshold, or odor threshold;
 - (2) the standard will not endanger the public health and safety, including health and environmental effects from exposure to groundwater contaminants; and
 - (3) compliance with a standard based on the maximum contaminant level or national secondary drinking water standard would produce serious hardship without equal or greater public benefit.
- (g) Groundwater quality standards specified in Paragraphs (h) and (i) of this Rule and interim maximum allowable concentrations established pursuant to Paragraph (c) of this Rule shall be reviewed by the Director on a triennial basis. Appropriate modifications to established standards shall be made in accordance with the procedure prescribed in Paragraph (d) of this Rule where modifications are considered appropriate based on data published subsequent to the previous review.
- (h) Class GA Standards. Unless otherwise indicated, the standard refers to the total concentration in micrograms per liter of any constituent in a dissolved, colloidal or particulate form which is mobile in groundwater. This does not apply to sediment or other particulate matter which is preserved in a groundwater sample as a result of well construction or sampling procedures. The Class GA standards are:
- (1) Acenaphthene: 80;
 - (2) Acenaphthylene: 200;
 - (3) Acetone: 6 mg/L;
 - (4) Acrylamide: 0.008;
 - (5) Anthracene: 2 mg/L;
 - (6) Arsenic: 10;
 - (7) Atrazine and chlorotriazine metabolites: 3;
 - (8) Barium: 700;
 - (9) Benzene: 1;
 - (10) Benzo(a)anthracene (benz(a)anthracene): 0.05;
 - (11) Benzo(b)fluoranthene: 0.05;

- (12) Benzo(k)fluoranthene: 0.5;
- (13) Benzoic acid: 30 mg/L;
- (14) Benzo(g,h,i)perylene: 200;
- (15) Benzo(a)pyrene: 0.005;
- (16) Bis(chloroethyl)ether: 0.03;
- (17) Bis(2-ethylhexyl) phthalate (di(2-ethylhexyl) phthalate): 3;
- (18) Boron: 700;
- (19) Bromodichloromethane: 0.6;
- (20) Bromoform (tribromomethane): 4;
- (21) n-Butylbenzene: 70;
- (22) sec-Butylbenzene: 70;
- (23) tert-Butylbenzene: 70;
- (24) Butylbenzyl phthalate: 1 mg/L;
- (25) Cadmium: 2;
- (26) Caprolactam: 4 mg/L;
- (27) Carbofuran: 40;
- (28) Carbon disulfide: 700;
- (29) Carbon tetrachloride: 0.3;
- (30) Chlordane: 0.1;
- (31) Chloride: 250 mg/L;
- (32) Chlorobenzene: 50;
- (33) Chloroethane: 3,000;
- (34) Chloroform (trichloromethane): 70;
- (35) Chloromethane (methyl chloride): 3;
- (36) 2-Chlorophenol: 0.4;
- (37) 2-Chlorotoluene (o-chlorotoluene): 100;
- (38) Chromium: 10;
- (39) Chrysene: 5;
- (40) Coliform organisms (total): 1 per 100 mL;
- (41) Color: 15 color units;
- (42) Copper: 1 mg/L;
- (43) Cyanide (free cyanide): 70;
- (44) 2, 4-D (2,4-dichlorophenoxy acetic acid): 70;
- (45) DDD: 0.1;
- (46) DDT: 0.1;
- (47) Dibenz(a,h)anthracene: 0.005;
- (48) Dibromochloromethane: 0.4;
- (49) 1,2-Dibromo-3-chloropropane: 0.04;
- (50) Dibutyl (or di-n-butyl) phthalate: 700;
- (51) 1,2-Dichlorobenzene (orthodichlorobenzene): 20;
- (52) 1,3-Dichlorobenzene (metadichlorobenzene): 200;
- (53) 1,4-Dichlorobenzene (paradichlorobenzene): 6;
- (54) Dichlorodifluoromethane (Freon-12; Halon): 1 mg/L;
- (55) 1,1-Dichloroethane: 6;
- (56) 1,2-Dichloroethane (ethylene dichloride): 0.4;
- (57) 1,2-Dichloroethene (cis): 70;
- (58) 1,2-Dichloroethene (trans): 100;
- (59) 1,1-Dichloroethylene (vinylidene chloride): 350;
- (60) 1,2-Dichloropropane: 0.6;
- (61) 1,3-Dichloropropene (cis and trans isomers): 0.4;
- (62) Dieldrin: 0.002;
- (63) Diethylphthalate: 6 mg/L;
- (64) 2,4-Dimethylphenol (m-xenol): 100;
- (65) Di-n-octyl phthalate: 100;
- (66) 1,4-Dioxane (p-dioxane): 3;

- (67) Dioxin (2,3,7,8-TCDD): 0.0002 ng/L;
- (68) 1,1– Diphenyl (1,1,-biphenyl): 400;
- (69) Dissolved solids (total): 500 mg/L;
- (70) Disulfoton: 0.3;
- (71) Diundecyl phthalate (Santicizer 711): 100;
- (72) Endosulfan: 40;
- (73) Endrin, total (includes endrin, endrin aldehyde and endrin ketone): 2;
- (74) Epichlorohydrin: 4;
- (75) Ethyl acetate: 3 mg/L;
- (76) Ethylbenzene: 600;
- (77) Ethylene dibromide (1,2-dibromoethane): 0.02;
- (78) Ethylene glycol: 10 mg/L;
- (79) Fluoranthene: 300;
- (80) Fluorene: 300;
- (81) Fluoride: 2 mg/L;
- (82) Foaming agents: 500;
- (83) Formaldehyde: 600;
- (84) Gross alpha (adjusted) particle activity (excluding radium-226 and uranium): 15 pCi/L;
- (85) Heptachlor: 0.008;
- (86) Heptachlor epoxide: 0.004;
- (87) Heptane: 400;
- (88) Hexachlorobenzene (perchlorobenzene): 0.02;
- (89) Hexachlorobutadiene: 0.4;
- (90) Hexachlorocyclohexane isomers (technical grade): 0.02;
- (91) n-Hexane: 400;
- (92) Indeno(1,2,3-cd)pyrene: 0.05;
- (93) Iron: 300;
- (94) Isophorone: 40;
- (95) Isopropylbenzene: 70;
- (96) Isopropyl ether: 70;
- (97) Lead: 15;
- (98) Lindane (gamma hexachlorocyclohexane): 0.03;
- (99) Manganese: 50;
- (100) Mercury: 1;
- (101) Methanol: 4 mg/L;
- (102) Methoxychlor: 40;
- (103) Methylene chloride (dichloromethane): 5;
- (104) Methyl ethyl ketone (2-butanone): 4 mg/L;
- (105) 2-Methylnaphthalene: 30;
- (106) 3-Methylphenol (m-cresol): 400;
- (107) 4-Methylphenol (p-cresol): 40;
- (108) Methyl tert-butyl ether (MTBE): 20;
- (109) Naphthalene: 6;
- (110) Nickel: 100;
- (111) Nitrate (as N): 10 mg/L;
- (112) Nitrite (as N): 1 mg/L;
- (113) N-nitrosodimethylamine: 0.0007;
- (114) Oxamyl: 200;
- (115) Pentachlorophenol: 0.3;
- (116) Petroleum aliphatic carbon fraction class (C5 - C8): 400;
- (117) Petroleum aliphatic carbon fraction class (C9 - C18): 700;
- (118) Petroleum aliphatic carbon fraction class (C19 - C36): 10 mg/L;
- (119) Petroleum aromatics carbon fraction class (C9 - C22): 200;
- (120) pH: 6.5 - 8.5;
- (121) Phenanthrene: 200;

- (122) Phenol: 30;
 - (123) Phorate: 1;
 - (124) n-Propylbenzene: 70;
 - (125) Pyrene: 200;
 - (126) Selenium: 20;
 - (127) Silver: 20;
 - (128) Simazine: 4;
 - (129) Styrene: 70;
 - (130) Sulfate: 250 mg/L;
 - (131) 1,1,2,2-Tetrachloroethane: 0.2;
 - (132) Tetrachloroethylene (perchloroethylene; PCE): 0.7;
 - (133) 2,3,4,6-Tetrachlorophenol: 200;
 - (134) Toluene: 600;
 - (135) Toxaphene: 0.03;
 - (136) 2,4,5-TP (Silvex): 50;
 - (137) 1,2,4-Trichlorobenzene: 70;
 - (138) 1,1,1-Trichloroethane: 200;
 - (139) Trichloroethylene (TCE): 3;
 - (140) Trichlorofluoromethane: 2 mg/L;
 - (141) 1,2,3-Trichloropropane: 0.005;
 - (142) 1,2,4-Trimethylbenzene: 400;
 - (143) 1,3,5-Trimethylbenzene: 400;
 - (144) 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113): 200 mg/L;
 - (145) Vinyl chloride: 0.03;
 - (146) Xylenes (o-, m-, and p-): 500; and
 - (147) Zinc: 1 mg/L.
- (i) Class GSA Standards. The standards for this class are the same as those for Class GA except as follows:
- (1) chloride: allowable increase not to exceed 100 percent of the natural quality concentration; and
 - (2) dissolved solids (total): 1000 mg/L.
- (j) Class GC Standards.
- (1) The concentrations of substances that, at the time of classification, exceed the standards applicable to Class GA or GSA groundwaters shall not be caused to increase, nor shall the concentrations of other substances be caused to exceed the GA or GSA standards as a result of further disposal of contaminants to or beneath the surface of the land within the boundary of the area classified GC.
 - (2) The concentrations of substances that, at the time of classification, exceed the standards applicable to GA or GSA groundwaters shall not be caused to migrate as a result of activities within the boundary of the GC classification, so as to violate the groundwater or surface water quality standards in adjoining waters of a different class.
 - (3) Concentrations of specific substances, that exceed the established standard at the time of classification, are listed in Section .0300 of this Subchapter.

History Note: Authority G.S. 143-214.1; 143B-282(a)(2);
 Eff. June 10, 1979;
 Amended Eff. November 1, 1994; October 1, 1993; September 1, 1992; August 1, 1989;
 Temporary Amendment Eff. June 30, 2002;
 Amended Eff. August 1, 2002;
 Temporary Amendment Expired February 9, 2003;
 Amended Eff. April 1, 2013; January 1, 2010; April 1, 2005;
 Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.

SECTION .0300 - ASSIGNMENT OF UNDERGROUND WATER CLASSIFICATIONS

15A NCAC 02L .0301 CLASSIFICATIONS: GENERAL

(a) Schedule of Classifications. The classifications are based on the quality, occurrence and existing or contemplated best usage of the groundwaters as established in Section .0200 of this Subchapter and are assigned statewide except where supplemented or supplanted by specific classification assignments by major river basins.

(b) Classifications and Water Quality Standards. The classifications and standards assigned to the groundwaters are denoted by the letters GA, GSA, or GC. These classifications refer to the classifications and standards established by Rule .0201 of this Subchapter.

History Note: Authority G.S. 143-214.1; 143B-282(2);
Eff. December 30, 1983;
Amended Eff. August 1, 1989;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.

15A NCAC 02L .0302 STATEWIDE

The classifications assigned to the groundwaters located within the boundaries or under the extraterritorial jurisdiction of the State of North Carolina are:

- (1) Class GA Waters. Those groundwaters in the state naturally containing 250 mg/l or less of chloride are classified GA.
- (2) Class GSA Waters. Those groundwaters in the state naturally containing greater than 250 mg/l chloride are classified GSA.
- (3) Class GC Waters. Those groundwaters assigned the classification GC in Rules .0303 - .0318 of this Section.

History Note: Authority G.S. 143-214.1; 143B-282(2);
Eff. December 30, 1983;
Amended Eff. August 1, 1989;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.

15A NCAC 02L .0303 BROAD RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.

15A NCAC 02L .0304 CAPE FEAR RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.

15A NCAC 02L .0305 CATAWBA RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.

15A NCAC 02L .0306 CHOWAN RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.

15A NCAC 02L .0307 FRENCH BROAD RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0308 HIWASSEE RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0309 LITTLE TENNESSEE RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0310 SAVANNAH RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0311 LUMBER RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0312 NEUSE RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0313 NEW-WATAUGA RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0314 PASQUOTANK RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0315 ROANOKE RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0316 TAR PAMLICO RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0317 WHITE OAK RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0318 YADKIN-PEE DEE RIVER BASIN

No classification assignments other than those specified in Rule .0302 are made for the river basin.

*History Note: Authority G.S. 143-214.1;
Eff. December 30, 1983;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

15A NCAC 02L .0319 RECLASSIFICATION

The groundwater classifications as assigned may be revised by the Commission following public notice and subsequent public hearing. Changes may be to a higher or lower classification. Reclassification requests may be submitted to the Director.

*History Note: Authority G.S. 143-214.1; 143-215.3(e); 143B-282(2);
Eff. December 30, 1983;
Amended Eff. August 1, 1989;
Pursuant to G.S. 150B-21.3A, rule is necessary without substantive public interest Eff. March 6, 2018.*

**SECTION .0400 - RISK-BASED ASSESSMENT AND CORRECTIVE ACTION FOR PETROLEUM
UNDERGROUND STORAGE TANKS****15A NCAC 02L .0401 PURPOSE**

- (a) The purpose of this Section is to establish procedures for risk-based assessment and corrective action sufficient to:
- (1) protect human health and the environment;
 - (2) abate and control contamination of the waters of the State as deemed necessary to protect human health and the environment;
 - (3) permit management of the State's groundwaters to protect their designated current usage and potential future uses;
 - (4) provide for anticipated future uses of the State's groundwater;
 - (5) recognize the diversity of contaminants, the State's geology and the characteristics of each individual site; and
 - (6) accomplish these goals in a cost-efficient manner to assure the best use of the limited resources available to address groundwater pollution within the State.
- (b) Section .0100 of this Subchapter shall apply to this Section unless specifically excluded.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648,s. 1;
Recodified from 15A NCAC 02L .0115(a);
Amended Eff. December 1, 2005;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0402 DEFINITIONS

The definitions as set out in Rule .0102 of this Subchapter shall apply to this Section.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648,s. 1;
Eff. December 1, 2005;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0403 RULE APPLICATION

This Section shall apply to any discharge or release from a "commercial underground storage tank" or a "noncommercial underground storage tank," as those terms are defined in G.S. 143-215.94A, that is reported on or after January 2, 1998. The requirements of this Section shall apply to the owner and operator of the underground storage tank from which the discharge or release occurred, a landowner seeking reimbursement from the Commercial Leaking Underground Storage Tank Fund or the Noncommercial Leaking Underground Storage Tank Fund under G.S. 143-215.94E, and any other person responsible for the assessment or cleanup of a discharge or release from an underground storage tank, including any person who has conducted or controlled an activity that results in the discharge or release of petroleum or petroleum products as defined in G.S. 143-215.94A(10) to the groundwaters of the State or in proximity thereto; these persons shall be collectively referred to for purposes of this Section as the "responsible party." This Section shall be applied in a manner consistent with the rules found in 15A NCAC 02N in order to assure that the State's requirements regarding assessment and cleanup from underground storage tanks are no less stringent than Federal requirements.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648,s. 1;
Recodified from 15A NCAC 02L .0115(b);
Amended Eff. December 1, 2005;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0404 REQUIRED INITIAL ABATEMENT ACTIONS BY RESPONSIBLE PARTY

- (a) Upon a discharge or release of petroleum from a commercial underground storage tank the responsible party shall:
- (1) take action to prevent all further discharge or release of petroleum from the underground storage tank; identify and mitigate all fire, explosion, and vapor hazards; remove any free product; and comply with the requirements of 15A NCAC 02N .0601 through .0604, .0701 through .0703, and .0705 within 24 hours of discovery;
 - (2) incorporate the requirements of 15A NCAC 02N .0704 into the submittal required under Subparagraph (3) of this Paragraph or the limited site assessment report required under Rule .0405 of this Section, whichever is applicable. The submittals shall constitute compliance with the reporting requirements of 15A NCAC 02N .0704(b); and
 - (3) submit within 90 days of the discovery of the discharge or release a soil contamination report containing information sufficient to show that remaining unsaturated soil in the side walls and at the base of the excavation does not contain contaminant levels that exceed either the "soil-to-groundwater" or the residential maximum soil contaminant concentrations established by the Department pursuant to Rule .0411 of this Section, whichever is lower. If the showing is made, the discharge or release shall be classified as low risk by the Department as defined in Rules .0406 and .0407 of this Section.
- (b) Upon a discharge or release of petroleum from a noncommercial underground storage tank the responsible party shall:
- (1) take necessary actions to protect public health, safety, and welfare and the environment, including actions to prevent all further discharge or release of petroleum from the noncommercial underground storage tank; identify and mitigate all fire, explosion, and vapor hazards; and report the release within 24 hours of discovery, in compliance with G.S. 143-215.83(a), G.S. 143-215.84(a), G.S. 143-215.85(b), and G.S. 143-215.94E; and

- (2) provide or otherwise make available any information required by the Department to determine the site risk as described in Rules .0405, .0406, and .0407 of this Section.
- (c) The Department shall notify the responsible party for a discharge or release of petroleum from a noncommercial underground storage tank that no cleanup, no further cleanup, or no further action shall be required without additional soil remediation pursuant to Rule .0408 of this Section if the site is determined by the Department to be low risk. This classification is based on information provided to the Department that:
 - (1) describes the source and type of the petroleum release, site-specific risk factors, and risk factors present in the surrounding area as defined in Rules .0406 and .0407 of this Section;
 - (2) demonstrates that no remaining risk factors are present that are likely to be affected per G.S. 143-215.94V(b); or
 - (3) documents that soils remaining onsite do not contain contaminant levels that exceed either the "soil-to-groundwater" or the residential maximum soil contaminant concentrations established by the Department pursuant to Rule .0411 of this Section, whichever is lower.

The Department shall reclassify the site as high risk, as defined in Rule .0406(1) of this Section, upon receipt of new information related to site conditions indicating that the discharge or release from a noncommercial underground storage tank poses an unacceptable risk or a potentially unacceptable risk to human health or the environment, as described in Rule .0407 of this Section.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(c)(1)-(3); Amended Eff. December 1, 2005; Temporary Amendment Eff. September 29, 2017; Readopted Eff. June 1, 2019.

15A NCAC 02L .0405 REQUIREMENTS FOR LIMITED SITE ASSESSMENT

- (a) If the required showing for a commercial underground storage tank cannot be made or if the Department determines that a release from a noncommercial underground storage tank represents an unacceptable risk under Rule .0404 of this Section, the responsible party shall submit within 120 days of the discovery of the discharge or release, a report containing information needed by the Department to classify the level of risk to human health and the environment posed by a discharge or release under Rule .0406 of this Section.
- (b) The responsible party may submit a written request for an extension to the 120 day deadline set forth in Paragraph (a) of this Rule to the Department for the Department's consideration prior to the deadline. The request for deadline extension by the responsible party shall demonstrate that the extension, if granted by the Department, would not increase the risk posed by the release. When considering a request from a responsible party for additional time to submit the report, the Department shall consider the following:
 - (1) the extent to which the request for additional time is due to factors outside of the control of the responsible party;
 - (2) the previous history of the person submitting the report in complying with deadlines established under the Commission's rules;
 - (3) the technical complications associated with assessing the extent of contamination at the site or identifying potential receptors; and
 - (4) the necessity for action to eliminate an imminent threat to public health or the environment.
- (c) The report shall include:
 - (1) a location map, based on a USGS topographic map, showing the radius of 1500 feet from the source area of a confirmed release or discharge and depicting all water supply wells, surface waters, and designated wellhead protection areas as defined in 42 U.S.C. 300h-7(e) within the 1500-foot radius. 42 U.S.C. 300h-7(e), is incorporated by reference including subsequent amendments and editions. Copies may be obtained at no cost from the U.S. Government Bookstore's website at <http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap6A-subchapXII-partC-sec300h-7.htm>. The material is available for inspection at the Department of Environmental Quality, UST Section, 217 West Jones Street, Raleigh, NC 27603. For purposes of this Section, "source area" means the point of release or discharge from the underground storage tank system;
 - (2) a determination of whether the source area of the discharge or release is within a designated wellhead protection area as defined in 42 U.S.C. 300h-7(e);

- (3) if the discharge or release is in the Coastal Plain physiographic region as designated on a map entitled "Geology of North Carolina" published by the Department in 1985, incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the Department's website at <https://deq.nc.gov/about/divisions/energy-mineral-land-resources/north-carolina-geological-survey/ncgs-maps/1985-geologic-map-of-nc>, a determination of whether the source area of the discharge or release is located in an area in which there is recharge to an unconfined or semi-confined deeper aquifer that is being used or may be used as a source of drinking water;
- (4) a determination of whether vapors from the discharge or release pose a threat of explosion due to the accumulation of vapors in a confined space or pose any other serious threat to public health, public safety, or the environment;
- (5) scaled site maps showing the location of the following that are on or adjacent to the property where the source is located:
 - (A) site boundaries;
 - (B) roads;
 - (C) buildings;
 - (D) basements;
 - (E) floor and storm drains;
 - (F) subsurface utilities;
 - (G) septic tanks and leach fields;
 - (H) underground and aboveground storage tank systems;
 - (I) monitoring wells;
 - (J) water supply wells;
 - (K) surface water bodies and other drainage features;
 - (L) borings; and
 - (M) the sampling points;
- (6) the results from a limited site assessment that shall include:
 - (A) the analytical results from soil samples collected during the construction of a monitoring well installed in the source area of each confirmed discharge or release from a noncommercial or commercial underground storage tank and either the analytical results of a groundwater sample collected from the well or, if free product is present in the well, the amount of free product in the well. The soil samples shall be collected every five feet in the unsaturated zone unless a water table is encountered at or greater than a depth of 25 feet from land surface in which case soil samples shall be collected every 10 feet in the unsaturated zone. The soil samples shall be collected from suspected worst-case locations exhibiting visible contamination or elevated levels of volatile organic compounds in the borehole;
 - (B) if any constituent in the groundwater sample from the source area monitoring well installed in accordance with Part (A) of this Subparagraph, for a site meeting the high risk classification in Rule .0406(1) of this Section, exceeds the standards or interim standards established in Rule .0202 of this Subchapter by a factor of 10 and is a discharge or release from a commercial underground storage tank, the analytical results from a groundwater sample collected from each of three additional monitoring wells or, if free product is present in any of the wells, the amount of free product in such well. The three additional monitoring wells shall be installed as follows: one upgradient of the source of contamination and two downgradient of the source of contamination. The monitoring wells installed upgradient and downgradient of the source of contamination shall be located such that groundwater flow direction can be determined; and
 - (C) potentiometric data from all required wells;
- (7) the availability of public water supplies and the identification of properties served by the public water supplies within 1500 feet of the source area of a confirmed discharge or release;
- (8) the land use, including zoning if applicable, within 1500 feet of the source area of a confirmed discharge or release;
- (9) a discussion of site-specific conditions or possible actions that could result in lowering the risk classification assigned to the release. The discussion shall be based on information known or required to be obtained under this Paragraph; and

- (10) names and current addresses of all owners and operators of the underground storage tank systems for which a discharge or release is confirmed, the owners of the land upon which such systems are located, and all potentially affected real property owners.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(c)(4); Amended Eff. December 1, 2005; Temporary Amendment Eff. September 29, 2017; Readopted Eff. June 1, 2019.

15A NCAC 02L .0406 DISCHARGE OR RELEASE CLASSIFICATIONS

The Department shall classify the risk of each known discharge or release as high, intermediate, or low risk unless the discharge or release has been classified under Rule .0404(a)(3) or (c) of this Section. For purposes of this Section:

- (1) "High risk" means that:
 - (a) a water supply well, including one used for non-drinking purposes, has been contaminated by a release or discharge;
 - (b) a water supply well used for drinking water is located within 1000 feet of the source area of a confirmed discharge or release from a commercial underground storage tank or a noncommercial underground storage tank of 1100 gallons or less in capacity used for storing motor fuel for noncommercial purposes;
 - (c) a water supply well not used for drinking water is located within 250 feet of the source area of a confirmed discharge or release from a commercial underground storage tank or a noncommercial underground storage tank of 1100 gallons or less in capacity used for storing motor fuel for noncommercial purposes;
 - (d) the groundwater within 500 feet of the source area of a confirmed discharge or release from a commercial underground storage tank or a noncommercial underground storage tank of 1100 gallons or less in capacity used for storing motor fuel for noncommercial purposes has the potential for future use in that there is no source of water supply other than the groundwater;
 - (e) a water supply well, including one used for non-drinking purposes, is located within 150 feet of the source area of a confirmed discharge or release from a noncommercial underground storage tank storing heating oil for consumptive use on the premises;
 - (f) the vapors from a discharge or release pose a serious threat of explosion due to accumulation of the vapors in a confined space; or
 - (g) a discharge or release poses an imminent danger to public health, public safety, or the environment.
- (2) "Intermediate risk" means that:
 - (a) surface water is located within 500 feet of the source area of a confirmed discharge or release from a commercial underground storage tank and the maximum groundwater contaminant concentration exceeds the applicable surface water quality standards and criteria found in 15A NCAC 02B .0200 by a factor of 10;
 - (b) in the Coastal Plain physiographic region as designated on a map entitled "Geology of North Carolina" published by the Department in 1985, the source area of a confirmed discharge or release from a commercial underground storage tank is located in an area in which there is recharge to an unconfined or semi-confined deeper aquifer that the Department determines is being used or may be used as a source of drinking water;
 - (c) the source area of a confirmed discharge or release from a commercial underground storage tank is within a designated wellhead protection area, as defined in 42 U.S.C. 300h-7(e);
 - (d) the levels of groundwater contamination associated with a confirmed discharge or release from a commercial underground storage tank for any contaminant except ethylene dibromide, benzene, and alkane and aromatic carbon fraction classes exceed 50 percent of the solubility of the contaminant at 25 degrees Celsius or 1,000 times the groundwater standard or interim standard established in Rule .0202 of this Subchapter, whichever is lower; or
 - (e) the levels of groundwater contamination associated with a confirmed discharge or release from a commercial underground storage tank for ethylene dibromide and benzene exceed 1,000 times the

federal drinking water standard set out in 40 CFR 141. 40 CFR 141 is incorporated by reference including subsequent amendments and editions. Copies may be obtained at no cost from the U.S. Government Bookstore's website at <https://www.gpo.gov/fdsys/pkg/CFR-2015-title40-vol23/pdf/CFR-2015-title40-vol23-part141.pdf>. The material is available for inspection at the Department of Environmental Quality, UST Section, 217 West Jones Street, Raleigh, NC 27603.

- (3) "Low risk" means that:
 - (a) the risk posed does not fall within the high risk category for any underground storage tank, or within the intermediate risk category for a commercial underground storage tank; or
 - (b) based on review of site-specific information, limited assessment, or interim corrective actions, the discharge or release poses no significant risk to human health or the environment.

If the criteria for more than one risk category applies, the discharge or release shall be classified at the highest risk level identified in Rule .0407 of this Section.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(d); Amended Eff. December 1, 2005; Temporary Amendment Eff. September 29, 2017; Readopted Eff. June 1, 2019.

15A NCAC 02L .0407 RECLASSIFICATION OF RISK LEVELS

(a) Each responsible party shall have the continuing obligation to notify the Department of any changes that may affect the level of risk assigned to a discharge or release by the Department if the change is known or should be known by the responsible party, including changes in zoning of real property, use of real property, or the use of groundwater that has been contaminated or is expected to be contaminated by the discharge or release.

(b) The Department shall reclassify the risk posed by a release if warranted by further information concerning the potential exposure of receptors to the discharge or release or upon receipt of new information concerning changed conditions at the site. After initial classification of the discharge or release, the Department may require limited assessment, interim corrective action, or other actions that the Department believes will result in a lower risk classification.

(c) If the risk posed by a discharge or release is determined by the Department to be high risk, the responsible party shall comply with the assessment and cleanup requirements of Rule .0106(c), (g), and (h) of this Subchapter and 15A NCAC 02N .0706 and .0707. The goal of a required corrective action for groundwater contamination shall be restoration to the level of the groundwater standards set forth in Rule .0202 of this Subchapter, or as closely thereto as is economically and technologically feasible. In a corrective action plan submitted pursuant to this Paragraph, natural attenuation shall be used to the maximum extent possible, when the benefits of its use do not increase the risk to the environment and human health. If the responsible party demonstrates that natural attenuation prevents the further migration of the plume, the Department may approve a groundwater monitoring plan.

(d) If the risk posed by a discharge or release is determined by the Department to be an intermediate risk, the responsible party shall comply with the assessment requirements of Rule .0106(c) and (g) of this Subchapter and 15A NCAC 02N .0706. As part of the comprehensive site assessment, the responsible party shall evaluate, based on site-specific conditions, whether the release poses a significant risk to human health or the environment. If the Department determines, based on the site-specific conditions, that the discharge or release does not pose a significant threat to human health or the environment, the site shall be reclassified as a low risk site. If the site is not reclassified, the responsible party shall, at the direction of the Department, submit a groundwater monitoring plan or a corrective action plan, or a combination thereof, meeting the cleanup standards of this Paragraph and containing the information required in Rule .0106(h) of this Subchapter and 15A NCAC 02N .0707. Discharges or releases that are classified as intermediate risk shall be remediated, at a minimum, to a cleanup level of 50 percent of the solubility of the contaminant at 25 degrees Celsius or 1,000 times the groundwater standard or interim standard established in Rule .0202 of this Subchapter, whichever is lower, for any groundwater contaminant except ethylene dibromide, benzene and alkane and aromatic carbon fraction classes. Ethylene dibromide and benzene shall be remediated to a cleanup level of 1,000 times the federal drinking water standard as referenced in 15A NCAC 18C .1518 incorporated by reference including subsequent amendments and editions, and available free of charge at <http://reports.oah.state.nc.us/ncac/title 15a - environmental quality/chapter 18 - environmental health/subchapter c/15a ncac 18c .1518.pdf>. Additionally, if a corrective action plan or groundwater monitoring plan is required under this Paragraph, the responsible party shall demonstrate that the groundwater cleanup levels are sufficient to prevent a violation of:

- (1) the rules contained in 15A NCAC 02B;

- (2) the standards contained in Rule .0202 of this Subchapter in a deep aquifer as described in Rule .0406(2)(b) of this Section; and
- (3) the standards contained in Rule .0202 of this Subchapter at a location no closer than one year time of travel upgradient of a well within a designated wellhead protection area, based on travel time and the natural attenuation capacity of the subsurface materials or on a physical barrier to groundwater migration that exists or will be installed by the person making the request.

In any corrective action plan submitted pursuant to this Paragraph, natural attenuation shall be used to the maximum extent possible, if the benefits of its use do not increase the risk to the environment and human health.

(e) If the risk posed by a discharge or release is determined to be a low risk, the Department shall notify the responsible party that no cleanup, no further cleanup, or no further action is required by the Department unless the Department later determines that the discharge or release poses an unacceptable risk or a potentially unacceptable risk to human health or the environment. No notification shall be issued pursuant to this Paragraph, however, until the responsible party has:

- (1) completed soil remediation pursuant to Rule .0408 of this Section or as closely thereto as economically or technologically feasible;
- (2) submitted proof of public notification, if required pursuant to Rule .0409(b) of this Section; and
- (3) recorded all required land-use restrictions pursuant to G.S. 143B-279.9 and 143B-279.11.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(e)-(h); Amended Eff. December 1, 2005; Readopted Eff. June 1, 2019.

15A NCAC 02L .0408 ASSESSMENT AND REMEDIATION PROCEDURES

Assessment and remediation of soil contamination shall be addressed as follows:

- (1) At the time that the Department determines the risk posed by the discharge or release, the Department shall also determine, based on site-specific information, whether the site is "residential" or "industrial/commercial." For the purposes of this Section, a site is presumed residential, but may be classified as industrial/commercial if the Department determines based on site-specific information that exposure to the soil contamination is limited in time due to the use of the site and does not involve exposure to children. For the purposes of this Paragraph, "site" means both the property upon which the discharge or release occurred and any property upon which soil has been affected by the discharge or release.
- (2) For a discharge or release from a commercial underground storage tank, or for a discharge or release from a noncommercial underground storage tank classified by the Department as high risk, the responsible party shall submit a report to the Department assessing the vertical and horizontal extent of soil contamination in excess of the lower of:
 - (a) the residential or industrial/commercial maximum soil contaminant concentration, whichever is applicable, that has been established by the Department pursuant to Rule .0411 of this Section; or
 - (b) the "soil-to-groundwater" maximum soil contaminant concentration that has been established by the Department pursuant to Rule .0411 of this Section.
- (3) For a discharge or release from a commercial underground storage tank classified by the Department as low risk, the responsible party shall submit a report demonstrating that soil contamination has been remediated to either the residential or industrial/commercial maximum soil contaminant concentration established by the Department pursuant to Rule .0411 of this Section, whichever is applicable.
- (4) For a discharge or release classified by the Department as high or intermediate risk, the responsible party shall submit a report demonstrating that soil contamination has been remediated to the lower of:
 - (a) the residential or industrial/commercial maximum soil contaminant concentration, whichever is applicable, that has been established by the Department pursuant to Rule .0411 of this Section; or
 - (b) the "soil-to-groundwater" maximum soil contaminant concentration that has been established by the Department pursuant to Rule .0411 of this Section.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(i);

*Amended Eff. December 1, 2005;
Temporary Amendment Eff. September 29, 2017;
Readopted Eff. June 1, 2019.*

15A NCAC 02L .0409 NOTIFICATION REQUIREMENTS

(a) A responsible party who submits a corrective action plan that proposes natural attenuation, to cleanup groundwater contamination to a standard other than a standard as set forth in Rule .0202 of this Subchapter, or to cleanup soil other than to the standard for residential use or soil-to-groundwater contaminant concentration established pursuant to this Section, whichever is lowest, shall give notice to:

- (1) the local Health Director and the chief administrative officer of each political jurisdiction in which the contamination occurs;
- (2) all property owners and occupants within or contiguous to the area containing the contamination; and
- (3) all property owners and occupants within or contiguous to the area where the contamination is expected to migrate.

The notice shall describe the nature of the plan and the reasons supporting it. Notification shall be made by certified mail concurrent with the submittal of the corrective action plan. Approval of the corrective action plan by the Department shall be postponed for a period of 60 days following receipt of the request so that the Department may receive and consider comments. The responsible party shall, within 30 days, provide the Department with a copy of the notice and proof of receipt of each required notice or of refusal by the addressee to accept delivery of a required notice. If notice by certified mail to occupants under this Paragraph is impractical, the responsible party shall give notice as provided in G.S. 1A-1, Rule 4(j) or 4(j1). If notice is made to occupants by posting, the responsible party shall provide the Department with a copy of the posted notice and a description of the manner in which such posted notice was given.

(b) A responsible party who receives a notice from the Department pursuant to Rule .0404(c) or .0407(e) of this Section for a discharge or release that has not been remediated to the groundwater standards or interim standards established in Rule .0202 of this Subchapter or to the lower of the residential or soil-to-groundwater contaminant concentrations established under Rule .0411 of this Section, shall, within 30 days of the receipt of such notice, provide a copy of the notice to:

- (1) the local Health Director and the chief administrative officer of each political jurisdiction in which the contamination occurs;
- (2) all property owners and occupants within or contiguous to the area containing the contamination; and
- (3) all property owners and occupants within or contiguous to the area where the contamination is expected to migrate.

Notification shall be made by certified mail. The responsible party shall, within 60 days of receipt of the original notice from the Department, provide the Department with proof of receipt of the copy of the notice or of refusal by the addressee to accept delivery of the copy of the notice. If notice by certified mail to occupants under this Paragraph is impractical, the responsible party shall give notice as provided in G.S. 1A-1, Rule 4(j) or 4(j1). If notice is made to occupants by posting, the responsible party shall provide the Department with a description of the manner in which the posted notice was given.

*History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1;
Recodified from 15A NCAC 02L .0115(j) and (k);
Amended Eff. December 1, 2005;
Temporary Amendment Eff. September 29, 2017;
Readopted Eff. June 1, 2019.*

15A NCAC 02L .0410 DEPARTMENTAL LISTING OF DISCHARGES OR RELEASES

The Department shall maintain in each of the Department's regional offices a list of all petroleum underground storage tank discharges or releases discovered and reported to the Department within the region on or after the effective date of this Section and all petroleum underground storage tank discharges or releases for which notification was issued under Rule .0407(e) of this Section by the Department on or after the effective date of this Section.

*History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1;
Recodified from 15A NCAC 02L .0115(l);
Amended Eff. December 1, 2005;
Readopted Eff. June 1, 2019.*

15A NCAC 02L .0411 ESTABLISHING MAXIMUM SOIL CONTAMINATION CONCENTRATIONS

The Department shall publish on the Department website and annually revise maximum soil contaminant concentrations to be used as soil cleanup levels for contamination from petroleum underground storage tank systems. The Department shall establish maximum soil contaminant concentrations for residential, industrial/commercial, and soil-to-groundwater exposures as follows:

- (1) The following equations and references shall be used in establishing residential maximum soil contaminant concentrations. Equation 1 shall be used for each contaminant with an EPA carcinogenic classification of A, B1, B2, C, D or E. Equation 2 shall be used for each contaminant with an EPA carcinogenic classification of A, B1, B2 or C. The maximum soil contaminant concentration shall be the lower of the concentrations derived from Equations 1 and 2.
 - (a) Equation 1: Non-cancer Risk-based Residential Ingestion Concentration

$$\text{Soil mg/kg} = [0.2 \times \text{oral chronic reference dose} \times \text{body weight, age 1 to 6} \times \text{averaging time noncarcinogens}] / [\text{exposure frequency} \times \text{exposure duration, age 1 to 6} \times (\text{soil ingestion rate, age 1 to 6} / 10^6 \text{ mg/kg})]$$
 - (b) Equation 2: Cancer Risk-based Residential Ingestion Concentration

$$\text{Soil mg/kg} = [\text{target cancer risk of } 10^{-6} \times \text{averaging time carcinogens}] / [\text{exposure frequency} \times (\text{soil ingestion factor, age adjusted} / 10^6 \text{ mg/kg}) \times \text{oral cancer slope factor}]$$

The age adjusted soil ingestion factor shall be calculated by: $[(\text{exposure duration, age 1 to 6} \times \text{soil ingestion rate, age 1 to 6}) / (\text{body weight, age 1 to 6})] + [((\text{exposure duration, total} - \text{exposure duration, age 1 to 6}) \times \text{soil ingestion, adult}) / (\text{body weight, adult})]$.
 - (c) The exposure factors selected in calculating the residential maximum soil contaminant concentrations shall be within the recommended ranges specified in the following references or the most recent version of these references:
 - (i) EPA, 2011. Exposure Factors Handbook, incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Environmental Protection Agency website at <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252>;
 - (ii) EPA, 1991. Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual (Part B, Development of Risk Based Preliminary Remediation Goals), incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Environmental Protection Agency website at <https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-b>;
 - (iii) EPA. Regional Screening Level Generic Tables (RSL) and User's Guide, incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Environmental Protection Agency website at <https://www.epa.gov/risk/regional-screening-levels-rsls>; and
 - (iv) EPA, 2018. Region 4 Human Health Risk Assessment Supplemental Guidance, incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Environmental Protection Agency website at https://www.epa.gov/sites/production/files/2018-03/documents/hhra_regional_supplemental_guidance_report-march-2018_update.pdf.
 - (d) The following references or the most recent version of these references, in order of preference, shall be used to obtain oral chronic reference doses and oral cancer slope factors:
 - (i) EPA. Integrated Risk Information System (IRIS) Computer Database, incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Environmental Protection Agency website at <https://www.epa.gov/iris>;
 - (ii) EPA. Health Effects Assessment Summary Tables (HEAST), incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Environmental Protection Agency website at <https://epa-heast.ornl.gov>;
 - (iii) EPA. Regional Screening Level Generic Tables (RSL) and User's Guide;
 - (iv) EPA, 2018. Region 4 Human Health Risk Assessment Supplemental Guidance; and

- (v) Other scientifically valid peer-reviewed published health risk assessment data, and scientifically valid peer-reviewed published toxicological data.
- (2) The following equations and references shall be used in establishing industrial/commercial maximum soil contaminant concentrations. Equation 1 shall be used for each contaminant with an EPA carcinogenic classification of A, B1, B2, C, D or E. Equation 2 shall be used for each contaminant with an EPA carcinogenic classification of A, B1, B2 or C. The maximum soil contaminant concentration shall be the lower of the concentrations derived from Equations 1 and 2.
- (a) Equation 1: Non-cancer Risk-based Industrial/Commercial Ingestion Concentration

$$\text{Soil mg/kg} = [0.2 \times \text{oral chronic reference dose} \times \text{body weight, adult} \times \text{averaging time noncarcinogens}] / [\text{exposure frequency} \times \text{exposure duration, adult} \times (\text{soil ingestion rate, adult} / 10^6 \text{ mg/kg}) \times \text{fraction of contaminated soil ingested}].$$
- (b) Equation 2: Cancer Risk-based Industrial/Commercial Ingestion Concentration

$$\text{Soil mg/kg} = [\text{target cancer risk of } 10^{-6} \times \text{body weight, adult} \times \text{averaging time carcinogens}] / [\text{exposure frequency} \times \text{exposure duration, adult} \times (\text{soil ingestion rate, adult} / 10^6 \text{ mg/kg}) \times \text{fraction of contaminated soil ingested} \times \text{oral cancer slope factor}].$$
- (c) The exposure factors selected in calculating the industrial/commercial maximum soil contaminant concentrations shall be within the recommended ranges specified in the following references or the most recent version of these references:
- (i) EPA, 2011. Exposure Factors Handbook;
 - (ii) EPA, 1991. Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual (Part B, Development of Risk Based Preliminary Remediation Goals);
 - (iii) EPA. Regional Screening Level Generic Tables (RSL) and User's Guide; and
 - (iv) EPA, 2018. Region 4 Human Health Risk Assessment Supplemental Guidance.
- (d) The following references or the most recent version of these references, in order of preference, shall be used to obtain oral chronic reference doses and oral cancer slope factors:
- (i) EPA. Integrated Risk Information System (IRIS) Computer Database;
 - (ii) EPA. Health Effects Assessment Summary Tables (HEAST);
 - (iii) EPA. Regional Screening Level Generic Tables (RSL) and User's Guide;
 - (iv) EPA, 2018. Region 4 Human Health Risk Assessment Supplemental Guidance; and
 - (v) Other scientifically valid peer-reviewed published health risk assessment data, and scientifically valid peer-reviewed published toxicological data.
- (3) The following equations and references shall be used in establishing the soil-to-groundwater maximum contaminant concentrations:
- (a) Organic Constituents:

$$\text{Soil mg/kg} = \text{groundwater standard or interim standard} \times [(.02 \times \text{soil organic carbon-water partition coefficient}) + 4 + (1.733 \times 41 \times \text{Henry's Law Constant (atm.-m}^3/\text{mole)})].$$
- (i) If no groundwater standard or interim standard has been established under Rule .0202 of this Subchapter, the practical quantitation limit shall be used in lieu of a standard to calculate the soil-to-groundwater maximum contaminant concentrations.
 - (ii) The following references or the most recent version of these references, in order of preference, shall be used to obtain soil organic carbon-water partition coefficients and Henry's Law Constants:
 - (A) EPA. Superfund Chemical Data Matrix (SCDM), incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Environmental Protection Agency website at <https://www.epa.gov/superfund/superfund-chemical-data-matrix-scdm>;
 - (B) EPA, 1991. Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual (Part A), incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Environmental Protection Agency website at <https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part/>; it is Volume I of the three-volume set called Risk Assessment Guidance for Superfund;

- (C) Agency for Toxic Substances and Disease Registry, "Toxicological Profile for [individual chemical]," incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Agency for Toxic substances and Disease Registry website at <https://www.atsdr.cdc.gov/substances/index.asp>;
 - (D) Montgomery, J.H., 2007. Groundwater Chemicals Desk Reference. CRC Press. This document is incorporated by reference including subsequent amendments and editions, and may be obtained for a charge of two hundred ninety six dollars (\$296.00) at <https://www.crcpress.com/Groundwater-Chemicals-Desk-Reference/Montgomery/p/book/9780849392764/> or a copy may be reviewed at the Division of Waste Management, Underground Storage Tank Section office at 217 West Jones Street, Raleigh, N.C. 27603; and
 - (E) Other scientifically valid peer-reviewed published data.
- (b) Inorganic Constituents:
- Soil mg/kg = groundwater standard or interim standard x [(20 x soil-water partition coefficient for pH of 5.5) + 4 + (1.733 x 41 x Henry's Law Constant (atm.-m3/mole))].
- (i) If no groundwater standard or interim standard has been established under Rule .0202 of this Subchapter, the practical quantitation limit shall be used in lieu of a standard to calculate the soil-to-groundwater maximum contaminant concentrations.
 - (ii) The following references or the most recent version of these references, in order of preference, shall be used to obtain soil-water partition coefficients and Henry's Law Constants:
 - (A) EPA. Superfund Chemical Data Matrix (SCDM);
 - (B) Baes, C.F., III, R.D. Sharp, A.L. Sjoreen, and R.W. Shor, 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture. Oak Ridge National Laboratory, incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the United States Nuclear Regulatory Commission website at <https://www.nrc.gov>;
 - (C) Agency for Toxic Substances and Disease Registry, "Toxicological Profile for [individual chemical];" and
 - (D) Other scientifically valid peer-reviewed published data.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(m); Amended Eff. December 1, 2005; Readopted Eff. June 1, 2019.

15A NCAC 02L .0412 ANALYTICAL PROCEDURES FOR SOIL SAMPLES

- (a) Analytical procedures for soil samples required under this Section shall be methods accepted by the US EPA as suitable for determining the presence and concentration of petroleum hydrocarbons for the type of petroleum released.
- (b) Soil samples collected, including the most contaminated sample, shall be analyzed as follows in order to determine the risks of the constituents of contamination:
 - (1) soil samples collected from a discharge or release of low boiling point fuels, including gasoline, aviation gasoline, and gasohol, shall be analyzed for volatile organic compounds and additives, including isopropyl ether and methyl tertiary butyl ether, using EPA Method 8260;
 - (2) soil samples collected from a discharge or release of high boiling point fuels, including kerosene, diesel, varsol, mineral spirits, naphtha, jet fuels, and fuel oil no. 2, shall be analyzed for volatile organic compounds using EPA Method 8260 and semivolatile organic compounds using EPA Method 8270;
 - (3) soil samples collected from a discharge or release of heavy fuels shall be analyzed for semivolatile organic compounds using EPA Method 8270;
 - (4) soil samples collected from a discharge or release of used and waste oil shall be analyzed for volatile organic compounds using EPA Method 8260, semivolatile organic compounds using EPA Method 8270,

- polychlorinated biphenyls using EPA Method 8080, and chromium and lead using procedures specified in Subparagraph (6) of this Paragraph;
- (5) soil samples collected from a discharge or release subject to this Section shall be analyzed for alkane and aromatic carbon fraction classes using methods approved by the Director under 15A NCAC 02H .0805(a)(1);
 - (6) analytical methods specified in Subparagraphs (1), (2), (3), and (4) of this Paragraph shall be performed as specified in the following references or the most recent version of these references: Test Methods for Evaluating Solid Wastes:Physical/Chemical Methods, November 1990, U.S. Environmental Protection Agency publication number SW-846, is incorporated by reference and may be purchased for a cost of three hundred sixty seven dollars (\$367.00) from the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, DC 20402; or in accordance with other methods or procedures approved by the Director under 15A NCAC 02H .0805(a)(1);
 - (7) other EPA-approved analytical methods may be used if the methods include the same constituents as the analytical methods specified in Subparagraphs (1), (2), (3), and (4) of this Paragraph and meet the detection limits of the analytical methods specified in Subparagraphs (1), (2), (3), and (4) of this Paragraph; and
 - (8) metals and acid extractable organic compounds shall be eliminated from analyses of soil samples collected pursuant to this Section if these compounds are not detected in soil samples collected during the construction of the source area monitoring well required under Rule .0405 of this Section.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1;
 Recodified from 15A NCAC 02L .0115(n);
 Amended Eff. December 1, 2005;
 Readopted Eff. June 1, 2019.

15A NCAC 02L .0413 ANALYTICAL PROCEDURES FOR GROUNDWATER SAMPLES

(a) Analytical procedures for groundwater samples required under this Section shall be methods accepted by the US EPA as suitable for determining the presence and concentration of petroleum hydrocarbons for the type of petroleum released.

(b) Groundwater samples, including the most contaminated sample, shall be analyzed as follows in order to determine the risks of the constituents of contamination:

- (1) groundwater samples collected from a discharge or release of low boiling point fuels, including gasoline, aviation gasoline, and gasohol, shall be analyzed for volatile organic compounds, including xylenes, isopropyl ether, and methyl tertiary butyl ether, using Standard Method 6200B or EPA Methods 601 and 602. Samples shall also be analyzed for ethylene dibromide using EPA Method 504.1 and lead using Standard Method 3030C preparation. 3030C metals preparation, using a 0.45 micron filter, shall be completed within 72 hours of sample collection;
- (2) groundwater samples collected from a discharge or release of high boiling point fuels, including kerosene, diesel, varsol, mineral spirits, naphtha, jet fuels, and fuel oil no. 2, shall be analyzed for volatile organic compounds using EPA Method 602 and semivolatile organic compounds plus the 10 largest non-target peaks identified using EPA Method 625;
- (3) groundwater samples collected from a discharge or release of heavy fuels shall be analyzed for semivolatile organic compounds plus the 10 largest non-target peaks identified using EPA Method 625;
- (4) groundwater samples collected from a discharge or release of used or waste oil shall be analyzed for volatile organic compounds using Standard Method 6200B, semivolatile organic compounds plus the 10 largest non-target peaks identified using EPA Method 625, and chromium and lead using Standard Method 3030C preparation. 3030C metals preparation, using a 0.45 micron filter, shall be completed within 72 hours of sample collection;
- (5) groundwater samples collected from a discharge or release subject to this Section shall be analyzed for alkane and aromatic carbon fraction classes using methods approved by the Director under 15A NCAC 02H .0805(a)(1);
- (6) analytical methods specified in Subparagraphs (1), (2), (3) and (4) of this Paragraph shall be performed as specified in the following references or the most recent version of these references:
 - (A) Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act, 40 CFR Part 136, is incorporated by reference and may be obtained electronically free of charge

from the United States Environmental Protection Agency website at <https://www.epa.gov/cwa-methods>;

- (B) Standard Methods for the Examination of Water and Wastewater, published jointly by American Public Health Association, American Water Works Association and Water Pollution Control Federation, is incorporated by reference and is available for purchase from the American Water Works Association (AWWA), 6666 West Quincy Avenue, Denver, CO 80235 for a charge of one hundred sixty dollars (\$160.00) for the 18th Edition, one hundred eighty dollars (\$180.00) for the 19th Edition, and two hundred dollars (\$200.00) for the 20th Edition; or
- (C) in accordance with methods or procedures approved by the Director under 15A NCAC 02H .0805(a)(1);
- (7) other EPA-approved analytical methods may be used if the methods include the same constituents as the analytical methods specified in Subparagraphs (1), (2), (3), and (4) of this Paragraph and meet the detection limits of the analytical methods specified in Subparagraphs (1), (2), (3), and (4) of this Paragraph; and
- (8) metals and acid extractable organic compounds shall be eliminated from analyses of groundwater samples collected pursuant to this Section if these compounds are not detected in the groundwater sample collected from the source area monitoring well installed pursuant to Rule .0405 of this Section.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(o); Amended Eff. December 1, 2005; Readopted Eff. June 1, 2019.

15A NCAC 02L .0414 REQUIRED LABORATORY CERTIFICATION

In accordance with 15A NCAC 02H .0804, laboratories shall obtain North Carolina Division of Water Resources laboratory certification for parameters that are required to be reported to the State in compliance with the State's surface water, groundwater, and pretreatment rules.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(p); Amended Eff. December 1, 2005; Readopted Eff. June 1, 2019.

15A NCAC 02L .0415 DISCHARGES OR RELEASES FROM OTHER SOURCES

This Section shall not relieve any person responsible for assessment or cleanup of contamination from a source other than a commercial or noncommercial underground storage tank from its obligation to assess and clean up contamination resulting from the discharge or releases.

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(q); Amended Eff. December 1, 2005; Readopted Eff. June 1, 2019.

15A NCAC 02L .0416 ELIGIBILITY OF SITES TO CONTINUE REMEDIATION UNDER RULES EXISTING BEFORE THE EFFECTIVE DATE OF 15A NCAC 02L .0115

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1; Recodified from 15A NCAC 02L .0115(r); Amended Eff. December 1, 2005; Expired Eff. April 1, 2018 pursuant to G.S. 150B-21.3A.

15A NCAC 02L .0417 ESTABLISHING CLEANUP REQUIREMENTS FOR SITES ELIGIBLE TO CONTINUE REMEDIATION UNDER RULES EXISTING BEFORE THE EFFECTIVE DATE OF 15A NCAC 02L .0115

History Note: Authority G.S. 143-215.2; 143-215.3(a)(1); 143-215.94A; 143-215.94E; 143-215.94T; 143-215.94V; 143B-282; 1995 (Reg. Sess. 1996) c. 648, s. 1;
Recodified from 15A NCAC 02L .0115(s);
Amended Eff. December 1, 2005;
Expired Eff. April 1, 2018 pursuant to G.S. 150B-21.3A.

SECTION .0500 – RISK-BASED ASSESSMENT AND CORRECTIVE ACTION FOR PETROLEUM RELEASES FROM ABOVEGROUND STORAGE TANKS AND SOURCES

15A NCAC 02L .0501 PURPOSE

- (a) The purpose of this Section is to establish procedures for risk-based assessment and corrective action sufficient to:
- (1) protect human health and the environment;
 - (2) abate and control contamination of the waters of the State as deemed necessary to protect human health and the environment;
 - (3) permit management of the State's groundwaters to protect their designated current usage and potential future uses;
 - (4) provide for anticipated future uses of the State's groundwater;
 - (5) recognize the diversity of contaminants, the State's geology, and the characteristics of each individual site; and
 - (6) accomplish these goals in a cost-efficient manner to assure the best use of the limited resources available to address groundwater pollution within the State.
- (b) Section .0100 of this Subchapter shall apply to this Section unless specifically excluded.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0502 DEFINITIONS

The definitions as set out in Rule .0102 of this Subchapter and the following definitions shall apply throughout this Section:

- (1) "Aboveground storage tank" or "AST" means any one or a combination of tanks, including pipes connected thereto, that is used to contain an accumulation of petroleum.
- (2) "AST system" means an aboveground storage tank, connected piping, ancillary equipment, and containment system, if any.
- (3) "Discharge" includes any emission, spillage, leakage, pumping, pouring, emptying, or dumping of oil into groundwater or surface water or upon land in such proximity to such water that it is likely to reach the water and any discharge upon land which is intentional, knowing, or willful.
- (4) "Non-UST" means as defined in G.S. 143-215.104AA(g) and excludes underground storage tank releases governed by G.S. 143-215.94V.
- (5) "Operator" means any person in control of or having responsibility for the daily operation of the AST system.
- (6) "Owner" means any person who owns a petroleum aboveground storage tank or other non-UST petroleum tank, stationary or mobile, used for storage, use, dispensing, or transport.
- (7) "Person" means an individual, trust, firm, joint stock company, Federal agency, corporation, state, municipality, commission, political subdivision of a state, or any interstate body. "Person" also includes a consortium, a joint venture, a commercial entity, and the United States Government.
- (8) "Petroleum" or "petroleum products" means as defined in G.S. 143-215.94A(10).
- (9) "Release" means any spilling, leaking, emitting, discharging, escaping, leaching, or disposing into groundwater, surface water, or surface or subsurface soils.
- (10) "Tank" means a device used to contain an accumulation of petroleum and constructed of non-earthen materials, such as concrete, steel, or plastic, that provides structural support.

History Note: Authority G.S. 143-212(4); 143-215.3(a)(1); 143-215.77; 143-215.84; 143-215.104AA; 143B-282;

*Eff. March 1, 2016;
Readopted Eff. June 1, 2019.*

15A NCAC 02L .0503 RULE APPLICATION

The requirements of this Section shall apply to the owner and operator of a petroleum aboveground storage tank or other non-UST petroleum tank, stationary or mobile, from which a discharge or release occurred and to any person determined to be responsible for assessment and cleanup of a discharge or release from a non-UST petroleum source, including any person who has conducted or controlled an activity that results in the discharge or release of petroleum or petroleum products (as defined in G.S. 143-215.94A(10)) to the groundwaters of the State or in proximity thereto. These persons shall be collectively referred to as the "responsible party" for purposes of this Section.

*History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.*

15A NCAC 02L .0504 REQUIRED INITIAL RESPONSE AND ABATEMENT ACTIONS BY RESPONSIBLE PARTY

Upon a discharge or release of petroleum from a non-UST petroleum source the responsible party shall:

- (1) take actions to prevent all further discharge or release of petroleum from the non-UST petroleum source; identify and mitigate all fire, explosion, or vapor hazard; and report the release within 24 hours of discovery, in compliance with G.S. 143-215.83(a), 84(a), and 85(b);
- (2) perform initial abatement actions to measure for the presence of a release where contamination is most likely to be present; confirm the source of the release; investigate to determine the possible presence of free product; begin free product removal; and to continue to monitor and mitigate all additional fire, explosion, or vapor hazards posed by vapors or by free product; and submit a report to the Department of Environmental Quality, UST Section, Regional Office Supervisor in accordance with 15A NCAC 02B .0309 and .0311, within 20 days after release confirmation summarizing these initial abatement actions;
- (3) remove contaminated soil that would act as a continuing source of contamination to groundwater. For a new release, no further action shall be necessary if:
 - (a) initial abatement actions involving control and removal of contaminated materials are initiated within 48 hours from discovery and before contaminated materials begin to impact groundwater; and
 - (b) analysis, in accordance with the approved methods in Rule .0412 of this Subchapter, of representative samples of remaining soils shows concentrations:
 - (i) at or below the more stringent of the soil-to-groundwater concentration value and the residential maximum soil contamination concentration value; or
 - (ii) using other EPA-approved analytical methods in accordance with Rule .0412(b)(7) of this Subchapter, concentration values below the more stringent of the soil-to-groundwater concentration alkane and aromatic carbon fraction class values and the residential maximum soil contamination concentration alkane and aromatic carbon fraction class values;

For new releases, if the abatement actions cannot be initiated within 48 hours of discovery or if soil concentrations remain above the values in this Paragraph, the responsible party shall conduct all activities under Items (1) through (5) of this Rule;
- (4) conduct initial site assessment, assembling information about the site and the nature of the release, including the following:
 - (a) a site history and site characterization, including data on nature and estimated quantity of release and data from available sources and site investigations concerning surrounding populations, water quality, use, and approximate locations of wells, surface water bodies, and subsurface structures potentially affected by the release, subsurface soil conditions, locations of subsurface utilities, climatological conditions, and land use;
 - (b) the results of free product investigations and free product removal, if applicable;
 - (c) the results of groundwater and surface water investigations, if applicable;
 - (d) a summary of initial response and abatement actions; and

- (5) submit as required in Item (2) of this Rule, within 90 days of the discovery of the discharge or release:
 - (a) an initial assessment and abatement report as required in Item (4) of this Rule;
 - (b) soil assessment information sufficient to show that remaining unsaturated soil in the side walls and at the base of the excavation does not contain contaminant levels that exceed either the soil-to-groundwater or the residential maximum soil contaminant concentrations established by the Department pursuant to Rule .0511 of this Section, whichever is lower; and
 - (c) documentation to show that neither bedrock nor groundwater was encountered in the excavation or, if groundwater was encountered, that contaminant concentrations in groundwater were equal to or less than the groundwater quality standards established in Rule .0202 of this Subchapter. If such showing is made, the discharge or release shall be classified as low risk by the Department.

*History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
 Eff. March 1, 2016;
 Readopted Eff. June 1, 2019.*

15A NCAC 02L .0505 REQUIREMENTS FOR LIMITED SITE ASSESSMENT

(a) If the required showing cannot be made by the responsible party under Rule .0504 of this Section, the responsible party shall submit within 120 days of the discovery of the discharge or release, a report as required in Rule .0504 of this Section, containing information needed by the Department to classify the level of risk to human health and the environment posed by a discharge or release under Rule .0506 of this Section.

(b) The responsible party may submit a written request an extension to the 120 day deadline set forth in Paragraph (a) of this Rule to the Department for the Department's consideration prior to the deadline. The request for deadline extension by the responsible party shall demonstrate that the extension, if granted by the Department, would not increase the risk posed by the release. When considering a request from a responsible party for additional time to submit the report, the Department shall consider the following:

- (1) the extent to which the request for additional time is due to factors outside of the control of the responsible party;
 - (2) the previous history of the person submitting the report in complying with deadlines established under the Commission's rules;
 - (3) the technical complications associated with assessing the extent of contamination at the site or identifying potential receptors; and
 - (4) the necessity for action to eliminate an imminent threat to public health or the environment.
- (c) The report shall include:
- (1) a location map, based on a USGS topographic map, showing the radius of 1500 feet from the source area of a confirmed release or discharge and depicting all water supply wells, surface waters, and designated "wellhead protection areas" as defined in 42 U.S.C. 300h-7(e) within the 1500-foot radius. 42 U.S.C. 300h-7(e), is incorporated by reference including subsequent amendments and editions. Copies may be obtained at no cost from the U.S. Government Bookstore's website at <http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap6A-subchapXII-partC-sec300h-7.htm>. The material is available for inspection at the Department of Environmental Quality, UST Section, 217 West Jones Street, Raleigh, NC 27603. For purposes of this Section, "source area" means point of release or discharge from the non-UST petroleum source, or if the point of release cannot be determined precisely, "source area" means the area of highest contaminant concentrations;
 - (2) a determination of whether the source area of the discharge or release is within a designated "wellhead protection area" as defined in 42 U.S.C. 300h-7(e);
 - (3) if the discharge or release is in the Coastal Plain physiographic region as designated on a map entitled "Geology of North Carolina" published by the Department in 1985, incorporated by reference including subsequent amendments or editions and may be obtained electronically free of charge from the Department's website at <https://deq.nc.gov/about/divisions/energy-mineral-land-resources/north-carolina-geological-survey/ncgs-maps/1985-geologic-map-of-nc>, a determination of whether the source area of the discharge or release is located in an area in which there is recharge to an unconfined or semi-confined deeper aquifer that is being used or may be used as a source of drinking water;
 - (4) a determination of whether vapors from the discharge or release pose a threat of explosion due to the accumulation of vapors in a confined space; pose a risk to public health from exposure; or pose any other threat to public health, public safety, or the environment;

- (5) scaled site maps showing the location of the following that are on or adjacent to the property where the source is located:
 - (A) site boundaries;
 - (B) roads;
 - (C) buildings;
 - (D) basements;
 - (E) floor and storm drains;
 - (F) subsurface utilities;
 - (G) septic tanks and leach fields;
 - (H) underground and aboveground storage tank systems;
 - (I) monitoring wells;
 - (J) water supply wells;
 - (K) surface water bodies and other drainage features;
 - (L) borings; and
 - (M) the sampling points;
- (6) the results from a limited site assessment that shall include the following actions:
 - (A) determine the presence, the lateral and vertical extent, and the maximum concentration levels of soil and, if possible, groundwater contamination and free product accumulations;
 - (B) install monitoring wells constructed in accordance with 15A NCAC 02C .0108 within the area of maximum soil or groundwater contamination to determine the groundwater flow direction and maximum concentrations of dissolved groundwater contaminants or accumulations of free product. During well construction, the responsible party shall collect and analyze soil samples that represent the suspected highest contaminant-level locations by exhibiting visible contamination or elevated levels of volatile organic compounds from successive locations at five-foot depth intervals in the boreholes of each monitoring well within the unsaturated zone; collect potentiometric data from each monitoring well; and collect and analyze groundwater or measure the amount of free product, if present, in each monitoring well;
- (7) the availability of public water supplies and the identification of properties served by the public water supplies within 1500 feet of the source area of a confirmed discharge or release;
- (8) the land use, including zoning if applicable, within 1500 feet of the source area of a confirmed discharge or release;
- (9) a discussion of site-specific conditions or possible actions that may result in lowering the risk classification assigned to the release. Such discussion shall be based on information known or required to be obtained under this Item; and
- (10) names and current addresses of all responsible parties for all petroleum sources for which a discharge or release is confirmed, the owners of the land upon which such petroleum sources are located, and all potentially affected real property owners. Documentation of ownership of ASTs or other sources and of the property upon which a source is located shall be provided.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
 Eff. March 1, 2016;
 Readopted Eff. June 1, 2019.

15A NCAC 02L .0506 DISCHARGE OR RELEASE CLASSIFICATIONS

The Department shall classify the risk of each known discharge or release as high, intermediate, or low risk, unless the discharge or release has been classified under Rule .0504 of this Section. For purposes of this Section:

- (1) "High risk" means that:
 - (a) a water supply well, including one used for non-drinking purposes, has been contaminated by a release or discharge;
 - (b) a water supply well used for drinking water is located within 1000 feet of the source area of a confirmed discharge or release;
 - (c) a water supply well not used for drinking water is located within 250 feet of the source area of a confirmed discharge or release;
 - (d) the groundwater within 500 feet of the source area of a confirmed discharge or release has the potential for future use in that there is no source of water supply other than the groundwater;

- (e) the vapors from a discharge or release pose a serious threat of explosion due to accumulation of the vapors in a confined space or pose a risk to public health from exposure; or
 - (f) a discharge or release poses an imminent danger to public health, public safety, or the environment.
- (2) "Intermediate risk" means that:
- (a) surface water is located within 500 feet of the source area of a confirmed discharge or release and the maximum groundwater contaminant concentration exceeds the applicable surface water quality standards and criteria found in 15A NCAC 02B .0200 by a factor of 10;
 - (b) in the Coastal Plain physiographic region as designated on a map entitled "Geology of North Carolina" published by the Department in 1985, the source area of a confirmed discharge or release is located in an area in which there is recharge to an unconfined or semi-confined deeper aquifer that the Department determines is being used or may be used as a source of drinking water;
 - (c) the source area of a confirmed discharge or release is within a designated wellhead protection area, as defined in 42 U.S.C. 300h-7(e);
 - (d) the levels of groundwater contamination for any contaminant except ethylene dibromide, benzene, and alkane and aromatic carbon fraction classes exceed 50 percent of the solubility of the contaminant at 25 degrees Celsius or 1,000 times the groundwater standard or interim standard established in Rule .0202 of this Subchapter, whichever is lower; or
 - (e) the levels of groundwater contamination for ethylene dibromide and benzene exceed 1,000 times the federal drinking water standard as referenced in 15A NCAC 18C .1518, incorporated by reference including subsequent amendments and editions and is available free of charge at <http://reports.oah.state.nc.us/ncac/title 15a - environmental quality/chapter 18 - environmental health/subchapter c/15a ncac 18c .1518.pdf>.
- (3) "Low risk" means that:
- (a) the risk posed does not fall within the high or intermediate risk categories; or
 - (b) based on review of site-specific information, limited assessment, or interim corrective actions, the discharge or release poses no significant risk to human health or the environment.

If the criteria for more than one risk category applies, the discharge or release shall be classified at the highest risk level identified in Rule .0507 of this Section.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
 Eff. March 1, 2016;
 Readopted Eff. June 1, 2019.

15A NCAC 02L .0507 RECLASSIFICATION OF RISK LEVELS

- (a) Each responsible party shall have the continuing obligation to notify the Department of any changes that may affect the level of risk assigned to a discharge or release by the Department if the change is known or should be known by the responsible party, including changes in zoning of real property, use of real property, or the use of groundwater that has been contaminated or is expected to be contaminated by the discharge or release.
- (b) The Department shall reclassify the risk posed by a release if warranted by further information concerning the potential exposure of receptors to the discharge or release or upon receipt of new information concerning changed conditions at the site. After initial classification of the discharge or release, the Department may require limited assessment, interim corrective action, or other actions that the Department believes will result in a lower risk classification.
- (c) Remediation of sites with off-site migration shall be subject to the provisions of G.S. 143-215.104AA.
- (d) If the risk posed by a discharge or release is determined by the Department to be high risk, the responsible party shall comply with the assessment and cleanup requirements of Rule .0106(c), (g), and (h) of this Subchapter. The goal of a required corrective action for groundwater contamination shall be restoration to the level of the groundwater standards set forth in Rule .0202 of this Subchapter, or as closely thereto as is economically and technologically feasible. In a corrective action plan submitted pursuant to this Paragraph, natural attenuation may be used when the benefits of its use do not increase the risk to the environment and human health. If the responsible party demonstrates that natural attenuation prevents the further migration of the plume, the Department may approve a groundwater monitoring plan.
- (e) If the risk posed by a discharge or release is determined by the Department to be an intermediate risk, the responsible party shall comply with the assessment requirements of Rule .0106(c) and (g) of this Subchapter. As part of the comprehensive site assessment, the responsible party shall evaluate, based on site specific conditions, whether the release

poses a significant risk to human health or the environment. If the Department determines, based on the site-specific conditions, that the discharge or release does not pose a significant threat to human health or the environment, the site shall be reclassified as a low risk site. If the site is not reclassified, the responsible party shall, at the direction of the Department, submit a groundwater monitoring plan or a corrective action plan, or a combination thereof, meeting the cleanup standards of this Paragraph and containing the information required in Rule .0106(h) of this Subchapter. Discharges or releases that are classified as intermediate risk shall be remediated, at a minimum, to a cleanup level of 50 percent of the solubility of the contaminant at 25 degrees Celsius or 1,000 times the groundwater standard or interim standard established in Rule .0202 of this Subchapter, whichever is lower, for any groundwater contaminant except ethylene dibromide, benzene, and alkane and aromatic carbon fraction classes. Ethylene dibromide and benzene shall be remediated to a cleanup level of 1,000 times the federal drinking water standard as referenced in 15A NCAC 18C .1518, incorporated by reference including subsequent amendments and editions and available free of charge at <http://reports.oah.state.nc.us/ncac/title 15a - environmental quality/chapter 18 - environmental health/subchapter c/15a ncac 18c .1518.pdf>. Additionally, if a corrective action plan or groundwater monitoring plan is required under this Paragraph, the responsible party shall demonstrate that the groundwater cleanup levels are sufficient to prevent a violation of:

- (1) the rules contained in 15A NCAC 02B;
- (2) the standards contained in Rule .0202 of this Subchapter in a deep aquifer as described in Rule .0506(2)(b) of this Section; and
- (3) the standards contained in Rule .0202 of this Subchapter at a location no closer than one year time of travel upgradient of a well within a designated wellhead protection area, based on travel time and the natural attenuation capacity of the subsurface materials or on a physical barrier to groundwater migration that exists or will be installed by the person making the request.

In any corrective action plan submitted pursuant to this Paragraph, natural attenuation may be used if the benefits of its use does not increase the risk to the environment and human health and shall not increase the costs of the corrective action.

(f) If the risk posed by a discharge or release is determined to be a low risk, the Department shall notify the responsible party that no cleanup, no further cleanup, or no further action is required by the Department, unless the Department later determines that the discharge or release poses an unacceptable risk or a potentially unacceptable risk to human health or the environment.

No notification shall be issued pursuant to this Paragraph, however, until the responsible party has:

- (1) completed soil remediation pursuant to Rule .0508 of this Section or as closely thereto as economically or technologically feasible;
- (2) submitted proof of public notification, if required pursuant to Rule .0409(b) of this Section;
- (3) recorded all required land-use restrictions pursuant to G.S. 143B-279.9 and 143B-279.11; and
- (4) paid any applicable statutorily authorized fees.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Amended Eff. March 1, 2017;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0508 ASSESSMENT AND REMEDIATION PROCEDURES

Assessment and remediation of soil contamination shall be addressed as follows:

- (1) At the time that the Department determines the risk posed by the discharge or release, the Department shall also determine, based on site-specific information, whether the site is "residential" or "industrial/commercial." For the purposes of this Section, a site is presumed residential, but may be classified as industrial/commercial if the Department determines based on site-specific information that exposure to the soil contamination is limited in time due to the use of the site and does not involve exposure to children. For the purposes of this Item, "site" means both the property upon which the discharge or release occurred and any property upon that soil has been affected by the discharge or release.
- (2) For a discharge or release the responsible party shall submit a report to the Department assessing the vertical and horizontal extent of soil contamination.
- (3) For a discharge or release classified by the Department as low risk, the responsible party shall submit a report demonstrating that soil contamination has been remediated to either the residential or industrial/commercial maximum soil contaminant concentration established by the Department pursuant to Rule .0511 of this Section, whichever is applicable.
- (4) For a discharge or release classified by the Department as high or intermediate risk, the responsible party shall submit a report demonstrating that soil contamination has been remediated to the lower of:

- (a) the residential or industrial/commercial maximum soil contaminant concentration, whichever is applicable, that has been established by the Department pursuant to Rule .0511 of this Section; or
- (b) the "soil-to-groundwater" maximum soil contaminant concentration that has been established by the Department pursuant to Rule .0511 of this Section.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0509 NOTIFICATION REQUIREMENTS

(a) A responsible party who submits a corrective action plan that proposes natural attenuation, to cleanup groundwater contamination to a standard other than a standard as set forth in Rule .0202 of this Subchapter, or to cleanup soil other than to the standard for residential use or soil-to-groundwater contaminant concentration established pursuant to this Section, whichever is lowest, shall give notice to:

- (1) the local Health Director and the chief administrative officer of each political jurisdiction in which the contamination occurs;
- (2) all property owners and occupants within or contiguous to the area containing the contamination; and
- (3) all property owners and occupants within or contiguous to the area where the contamination is expected to migrate.

The notice shall describe the nature of the plan and the reasons supporting it. Notification shall be made by certified mail concurrent with the submittal of the corrective action plan. Approval of the corrective action plan by the Department shall be postponed for a period of 30 days following receipt of the request so that the Department may receive and consider comments. The responsible party shall, within 60 days, provide the Department with a copy of the notice and proof of receipt of each required notice or of refusal by the addressee to accept delivery of a required notice. If notice by certified mail to occupants under this Paragraph is impractical, the responsible party shall give notice as provided in G.S. 1A-1, Rule 4(j) or 4(j1). If notice is made to occupants by posting, the responsible party shall provide the Department with a copy of the posted notice and a description of the manner in which such posted notice was given.

(b) A responsible party who receives a notice pursuant to Rule .0507(e) of this Section for a discharge or release that has not been remediated to the groundwater standards or interim standards established in Rule .0202 of this Subchapter or to the lower of the residential or soil-to-groundwater contaminant concentrations established under Rule .0511 of this Section, shall, within 30 days of the receipt of such notice, provide a copy of the notice to:

- (1) the local Health Director and the chief administrative officer of each political jurisdiction in which the contamination occurs;
- (2) all property owners and occupants within or contiguous to the area containing contamination; and
- (3) all property owners and occupants within or contiguous to the area where the contamination is expected to migrate.

Notification shall be made by certified mail. The responsible party shall, within 60 days, provide the Department with proof of receipt of the copy of the notice or of refusal by the addressee to accept delivery of the copy of the notice. If notice by certified mail to occupants under this Paragraph is impractical, the responsible party shall give notice as provided in G.S. 1A-1, Rule 4(j) or 4(j1). If notice is made to occupants by posting, the responsible party shall provide the Department with a description of the manner in which such posted notice was given.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0510 DEPARTMENTAL LISTING OF DISCHARGES OR RELEASES

The Department shall maintain in each of the Department's regional offices a list of all non-UST petroleum discharges or releases discovered and reported to the Department within the region.

History Note: Authority G.S. 143-215.3(a)(1); 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0511 ESTABLISHING MAXIMUM SOIL CONTAMINATION CONCENTRATIONS

For the purposes of risk-based assessment and remediation for non-UST petroleum releases, establishment of maximum soil contamination concentrations shall be in accordance with Rule .0411 of this Subchapter.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0512 ANALYTICAL PROCEDURES FOR SOIL SAMPLES

For the purposes of risk-based assessment and remediation for non-UST petroleum releases, analytical procedures for soil samples shall be in accordance with Rule .0412 of this Subchapter.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0513 ANALYTICAL PROCEDURES FOR GROUNDWATER SAMPLES

For the purposes of risk-based assessment and remediation for non-UST petroleum releases, analytical procedures for groundwater samples shall be in accordance with Rule .0413 of this Subchapter.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0514 REQUIRED LABORATORY CERTIFICATION

In accordance with 15A NCAC 02H .0804, laboratories shall obtain North Carolina Division of Water Resources laboratory certification for parameters that are required to be reported to the State in compliance with the State's surface water, groundwater, and pretreatment rules.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.

15A NCAC 02L .0515 DISCHARGES OR RELEASES FROM OTHER SOURCES

This Section shall not relieve any person responsible for assessment or cleanup of contamination from a source other than a non-UST petroleum release from its obligation to assess and clean up contamination resulting from the discharge or releases.

History Note: Authority G.S. 143-215.3(a)(1); 143-215.84; 143-215.104AA; 143B-282;
Eff. March 1, 2016;
Readopted Eff. June 1, 2019.



United States
Environmental Protection
Agency

Drinking Water Health Advisory for Manganese

**Drinking Water Health Advisory
for Manganese**

Prepared by:

U.S. Environmental Protection Agency
Office of Water (4304T)
Health and Ecological Criteria Division
Washington, DC 20460

<http://www.epa.gov/safewater/>

EPA-822-R-04-003
January, 2004

January 2004

OFFICIAL COPY

Feb 18 2020

Acknowledgments

This document was prepared under the U.S. EPA Contract Number 68-C-02-009. Lead Scientist, Julie Du, Ph.D., Health and Ecological Criteria Division, Office of Science and Technology, Office of Water, U. S. Environmental Protection Agency.

CONTENTS

ABBREVIATIONS	ii
FOREWORD	iii
EXECUTIVE SUMMARY	1
1.0 INTRODUCTION	3
2.0 MANGANESE IN THE ENVIRONMENT	3
2.1 Water	4
2.2 Soil	4
2.3 Air	5
2.4 Food	5
2.5 Environmental Fate	7
2.6 Summary	8
3.0 CHEMICAL AND PHYSICAL PROPERTIES	8
Organoleptic Properties	8
4.0 TOXICOKINETICS	9
4.1 Absorption	9
4.2 Distribution	11
4.3 Metabolism	12
4.4 Excretion	12
5.0 HEALTH EFFECTS DATA	12
5.1 Human Studies	13
5.1.1 Short-term Exposure Studies	13
5.1.2 Long-term Exposure Studies	14
5.2 Animal Studies	20
5.2.1 Short-term Exposure Studies	20
5.2.2 Long-term Exposure Studies	22
6.0 QUANTIFICATION OF TOXICOLOGICAL EFFECTS	27
Limitations of Using Rodent Data In Assessing Neurotoxicity of Manganese	27
Dose Response and Risk Characterization	28
Determination of Health Advisories	29
7.0 ANALYTICAL METHODS AND TREATMENT TECHNOLOGY	33
8.0 OTHER CRITERIA, GUIDANCE AND STANDARDS	34
9.0 REFERENCES	36

ABBREVIATIONS

ALS	Amyotrophic lateral sclerosis
CDC	Centers for Disease Control and Prevention
CJD	Creutzfeldt-Jakob Disease
g	gram
kg	kilogram
IOM	Institute of Medicine
L	liter
m ³	cubic meters
mg	milligram
mL	milliliter
mM	millimolar
Mn	manganese
min	minute
mmol	millimole
MMT	methylcyclopentadienyl manganese tricarbonyl
MND	motor neuron disease
NTP	National Toxicology Program
OST	Office of Science and Technology
OW	Office of Water
ppm	parts per million
PWS	public water system
RfD	Reference Dose
SDWA	Safe Drinking Water Act
SMCL	secondary maximum contaminant level
UCM	unregulated contaminant monitoring
µg	microgram
µmol	micromole

FOREWORD

The Drinking Water Health Advisory Program, sponsored by the Health and Ecological Criteria Division of the Office of Science and Technology (OST), Office of Water (OW), provides information on the health and organoleptic (color, taste, odor, etc.) effects of contaminants in drinking water. This Drinking Water Health Advisory contains Health Advisories as well as aesthetic properties (e.g., taste, odor, color) of manganese in drinking water.

A Drinking Water Health Advisory is not an enforceable standard for action. This Health Advisory describes nonregulatory concentrations of the contaminant in water that are expected to be without adverse effects on both health and aesthetics. Health Advisories serve as technical guidance to assist Federal, State, and local officials responsible for protecting public health when emergency spills or contamination situations occur. They are not to be construed as legally enforceable Federal standards. They are subject to change as new information becomes available. This draft supersedes any previous draft advisories for this chemical.

This Document is based, in part, on the Health Effects Support Document for Manganese (U.S. EPA, 2003a), the ATSDR's final Toxicological Profile for Manganese (ATSDR, 2000), and the Institute of Medicine's Dietary Reference Intakes for Manganese (IOM, 2002). The sections on analytical method and treatment technology are based on the Contaminant Candidate List Preliminary Regulatory Determination Support Document for Manganese (U.S. EPA, 2001).

EXECUTIVE SUMMARY

The EPA Office of Water is issuing this health advisory to provide guidance to communities that may be exposed to drinking water contaminated with high manganese (Mn) concentrations. The advisory provides guidance on the concentrations below which potential health and organoleptic problems would unlikely occur. This Drinking Water Health Advisory does not mandate a standard for action; rather it provides practical guidelines for addressing Mn contamination problems. The advisory provides an analysis of the current health hazard information and information on the organoleptic (i.e., taste and odor) associated with Mn-contaminated water, because organoleptic problems will affect consumer acceptance of water resources.

Manganese is a naturally-occurring element that can be found ubiquitously in the air, soil, and water. Manganese is an essential nutrient for humans and animals. Adverse health effects can be caused by inadequate intake or over exposure. Manganese deficiency in humans is thought to be rare because manganese is present in many common foods.

The greatest exposure to manganese is usually from food. Adults consume between 0.7 and 10.9 mg/day in the diet, with even higher intakes being associated with vegetarian diets (Freeland-Graves et al., 1987; Greger, 1999; Schroeder et al., 1966).

Manganese intake from drinking water is normally substantially lower than intake from food. At the median drinking-water level of 10 : g/L determined in the National Inorganic and Radionuclide Survey (NIRS), the intake of manganese from drinking water would be 20 : g/day for an adult, assuming a daily water intake of 2 L. Exposure to manganese from air is generally several orders of magnitude less than that from the diet, typically around 0.04 ng/day on average (U.S. EPA, 1990), although this can vary substantially depending on proximity to a manganese source.

Although manganese is an essential nutrient at low doses, chronic exposure to high doses may be harmful. The health effects from over-exposure of manganese are dependent on the route of exposure, the chemical form, the age at exposure, and an individual's nutritional status. Regardless, the nervous system has been determined to be the primary target organ with neurological effects generally observed. Many of the reports of adverse effects from manganese exposures in humans are from inhalation exposures in occupational settings.

Although there are substantial data supporting the neurological effects of *inhaled* manganese in both humans and animals, there are few data for the association between *oral* exposure to manganese and toxic effects. For example, several epidemiological studies (Kondakis et al., 1989; He et al., 1994) associate adverse neurological effects with exposure to manganese from drinking water; however, due to a lack of qualitative and quantitative details of the exposure scenario, these studies cannot be used for quantitative assessment. On the other hand, rodents do not provide a good experimental model for manganese neurotoxicity. Therefore, the assessment in this document focuses more on what is believed to be a safe oral intake of manganese for the general human population. Finally, it is important to emphasize that

individual requirements for, as well as adverse reactions to, manganese may be highly variable. The lifetime health advisory derived from the reference dose is estimated to be an intake for the general population that is not associated with adverse health effects; this is not meant to imply that intakes above the reference dose are necessarily associated with toxicity. Some individuals may, in fact, consume a diet that contributes more than 10 mg Mn/day without any cause for concern.

There were no studies found that reported exposure to elevated inorganic manganese with cancer in humans. Cancer studies in animals have provided equivocal results. Therefore, there are little data to suggest that inorganic manganese is carcinogenic.

As an element, manganese cannot go through metabolic transformation, but it can exist in many oxidative states and can be converted from one oxidative state to another within the body. Manganese is almost entirely excreted in the feces, only a small proportion being eliminated in the urine (Davis and Greger, 1992). Fecal manganese is comprised of unabsorbed dietary manganese and manganese excreted in bile.

Groups possibly sensitive to manganese would be those who absorb greater amounts of manganese or those who excrete less. These would include the very young (who may absorb more and excrete less), the elderly, and those with liver disease (with impaired biliary excretion).

In order to enhance consumer acceptance of water resources, this advisory recommends reducing manganese concentrations to or below 0.050 mg/L, the EPA's Secondary Maximum Contaminant Level (SMCL) for Mn. The SMCL is based on staining and taste considerations. It is not a federally enforceable regulation, but is intended as a guideline for States. States may establish higher or lower levels depending on the local conditions, such as unavailability of alternate water sources or other compelling factors, provided that public health and welfare are not adversely affected. The lifetime health advisory value of 0.3 mg/L will protect against concerns of potential neurological effects. In addition, this document provides a One-day and 10-day HA of 1 mg/L for acute exposure. However, it is advised that for infants younger than 6 months, the lifetime HA of 0.3 mg/L be used even for an acute exposure of 10 days, because of the concerns for differences in manganese content in human milk and formula and the possibility of a higher absorption and lower excretion in young infants.

1.0 INTRODUCTION

Manganese is a naturally-occurring element that can be found ubiquitously in the air, soil, and water. Manganese is also an essential nutrient for humans and animals (Leach and Harris, 1997; U.S. EPA, 2003a). Adverse health effects can be caused by inadequate intake or over exposure (See a review by Keen et al., 1999 and Keen et al., 2000). The main exposure of humans to manganese is from ingestion of food. Manganese deficiency in humans appears to be rare because manganese is present in many common foods. Manganese is essential to the proper functioning of both humans and other animals as it is required by many cellular enzymes (e.g., manganese superoxide dismutase, pyruvate carboxylase) and can serve to activate many others (e.g., kinases, decarboxylases, transferases, hydrolases, etc.; Hurley et al., 1984; Wedler, 1994; WHO, 2002).

Although manganese is an essential nutrient at low doses, chronic exposure to high doses may be harmful. There are substantial data supporting the neurological effects of *inhaled* manganese in both humans and animals, however, there are little data for the association between *oral* exposure to manganese and toxic effects.

There is a need for EPA to issue a health advisory to provide guidance to communities on the concentrations for avoiding health and organoleptic problems. This Drinking Water Health Advisory does not mandate a standard for action; rather it provides practical guidelines for addressing Mn contamination problems. The advisory provides an analysis of the current health hazard and organoleptic (i.e., taste and odor) information associated with Mn-contaminated water, because organoleptic problems will affect consumer acceptance of water resources.

Uses

Manganese is used principally in the manufacture of iron and steel alloys, manganese compounds, and as an ingredient in various products (ATSDR, 2000; IPCS, 1999). Manganese dioxide and other manganese compounds are used in products such as batteries, glass, and fireworks. Potassium permanganate is used as an oxidant for cleaning, bleaching, and disinfection purposes (ATSDR, 2000; HSDB, 2001). Potassium and manganese greensands are used in some locations for potable water treatment (ATSDR, 2000). Methylcyclopentadienyl manganese tricarbonyl (MMT), an organic manganese compound, is used as an octane-enhancing agent in unleaded gasoline in Canada, the United States, Europe, Asia, and South America (Lynam et al., 1999). Other manganese compounds are used in fertilizers, varnish, fungicides, and as livestock feeding supplements (HSDB, 2001).

2.0 MANGANESE IN THE ENVIRONMENT

Manganese is one of the most abundant metals on the earth's surface, making up approximately 0.1% of the earth's crust. Manganese is not found naturally in its pure (elemental) form, but is a component of over 100 minerals (ATSDR, 2000).

2.1 Water

Manganese is naturally occurring in many surface and ground water sources and in soils that may erode into these waters. However, human activities are also responsible for much of the manganese contamination in water in some areas.

Ambient manganese concentrations in sea water have been reported to range from 0.4 to 10 : g/L (ATSDR, 2000), with an average of about 2 : g/L (Barceloux, 1999). Levels in freshwater typically range from 1 to 200 : g/L (Barceloux, 1999). ATSDR reported that a U.S. river water survey found dissolved manganese levels of less than 11 to more than 51 : g/L (ATSDR, 2000). The United States Geological Survey's National Ambient Water Quality Assessment (NAWQA) has gathered limited data since 1991 on representative study basins around the U.S. This report indicates a median manganese level of 16 : g/L in surface waters, with 99th percentile concentrations of 400 to 800 : g/L (Leahy and Thompson, 1994; USGS, 2001). Higher levels in aerobic waters are usually associated with industrial pollution.

Overall, the detection frequency of manganese in U.S. ground water is high (approximately 70% of sites assayed have measurable manganese levels) due to the ubiquity of manganese in soil and rock, but the levels detected in ground water are generally below levels of public health concern (U.S. EPA 2003a). Similarly, manganese is detected in about 97% of surface water sites (at levels far below those likely to cause health effects) and universally in sediments and aquatic biota tissues (at levels which suggest that it does not bioaccumulate; U.S. EPA 2003a).

Between 1984 and 1986, the National Inorganic and Radionuclide Survey (NIRS) collected data from 989 U.S. community public water systems (PWSs) served by ground water in 49 states and found that 68% of the ground water PWSs reported detectable levels of manganese, with a median concentration of 10 : g/L. Supplemental survey data from PWSs supplied by surface waters in five states reported occurrence ranges similar to those of ground water PWSs.

2.2 Soil

Manganese constitutes approximately 0.1% of the earth's crust, and is a naturally occurring component of nearly all soils (ATSDR, 2000). Natural levels of manganese range from less than 2 to 7,000 ppm, with a geometric mean concentration of 330 ppm (Shacklette and Boerngen, 1984). The estimated arithmetic mean concentration is 550 ppm. Accumulation of manganese occurs in the subsoil rather than on the soil surface (ATSDR, 2000). An estimated 60–90% of soil manganese is associated with the sand fraction (WHO, 1981, as cited in ATSDR, 2000).

No published reports quantify exposure to manganese associated with soil ingestion. Assuming a concentration range of < 2 to 7,000 mg/kg soil and average ingestion of 50 mg soil/day, the average manganese intake of a 70-kg adult would be <0.0014 to 5 : g/kg-day. The corresponding intake for a 10-kg child consuming 100 mg of soil/day would be <0.02 to 70 : g/kg-day (U.S. EPA, 2003a).

2.3 Air

Air levels of manganese compounds vary widely depending on the proximity of point sources such as ferroalloy production facilities, coke ovens, or power plants. Average ambient levels near industrial sources have been reported to range from 220 to 300 nanograms of manganese per cubic meter (ng Mn/m^3), while levels in urban and rural areas without point sources have been reported to range from 10 to 70 ng Mn/m^3 (Barceloux, 1999). Existing data indicate that little difference is found between ambient manganese levels in areas where MMT is used in the gasoline and areas where MMT is not used (Lynam et al., 1999). The U.S. EPA estimated 40 ng Mn/m^3 as an average annual background concentration in urban areas based on measurements in 102 U.S. cities (U.S. EPA, 1990).

2.4 Food

Manganese is found in a variety of foods including many nuts, grains, fruits, legumes, tea, leafy vegetables, infant formulas, and some meat and fish. Food is the most important source of manganese exposure in the general population (ATSDR, 2000; IOM, 2002; U.S. EPA, 2003a).

Heavy tea drinkers may have a higher manganese intake than the general population. An average cup of tea may contain 0.4 to 1.3 mg manganese (ATSDR, 2000). In addition to dietary sources, approximately 12% of the adult population of the U.S. consumed manganese supplements in 1986 (Moss et al., 1989). The median amount of manganese in these dietary supplements was determined to be 2.4 mg/day, similar to the amount of the element consumed in the diet (based on survey information from the Third National Health and Nutrition Estimation Survey; IOM, 2002).

Freeland-Graves et al. (1987) have suggested a daily intake range of 3.5 to 7 mg Mn/day for adults based on a review of human studies. After reviewing dietary surveys, Greger (1999) presented a range for average intakes from adult Western and vegetarian diets of 0.7 to 10.9 mg Mn/day.

Infant formulas contain 50 to 300 : g/L manganese (Collipp et al., 1983), compared to human milk which contains approximately 3.5 to 15 : g/L manganese (ATSDR, 2000; U.S. EPA, 1997). Assuming an intake of 742 millilitres (mL) of breast milk/day (U.S. EPA, 1996a), a breast-fed infant would have an estimated daily manganese intake of 2.6 to 11.1 : g/day. An infant consuming the same volume of infant formula would have an estimated daily manganese intake of 37.1 to 223 : g/day. Assuming an average weight of 6 kg for an infant of age 6 months, the weight-adjusted average daily intake would range from 0.4 to 1.85 : g/kg-day for breast-fed infants. The corresponding weight-adjusted intake for a formula-fed infant would be 6.2 to 37.2 : g/kg-day. Given the high manganese content of milk-based formula, the underexposure of infants to manganese appears less probable than their overexposure (Davidsson et al., 1989a; Dörner et al., 1987; Keen et al., 1986). Once solid foods are introduced, however, the contribution of manganese intake from milk becomes less significant.

In addition to concentration, an important consideration for determining human exposure to manganese from food is bioavailability (Kies, 1994). Several factors can influence the degree to which manganese in foods is absorbed following ingestion. These include intake of dietary fiber, oxalic acids, tannins, and phytic acids, which tend to decrease manganese absorption (Gibson, 1994; U.S. EPA, 2003a), as well as possibly sex-specific iron status (low iron can result in increased manganese absorption; Finley, 1999 while high levels of iron can inhibit manganese uptake). In addition, the status of the GI tract (e.g., the presence of material in the GI tract - fed vs fasted) also affects bioavailability.

Manganese Intake

Adequate Intake (AI) values have been determined for manganese by the Food and Nutrition Board of the Institute of Medicine as follows: 3 : g/day for infants 0-6 months, 0.6 mg/day for infants 7-12 months, 1.2 mg/day for children 1-3 years, 1.5 mg/day for children 4-8 years, 1.9 mg/day for boys 9-13 years, 2.2 mg/day for boys 14-18 years, 1.6 mg/day for girls 9-18 years, 2.3 mg/day for men 19 years or older, 1.8 mg/day for women 19 years or older, 2 mg/day during pregnancy, and 2.6 mg/day during lactation (IOM, 2002).

Adequate Manganese Intakes for Men, Women and Children

Age Group	Males	Females
Infants, 0-6 months	3 : g/day	3 : g/day
Infants, 7-12 months	0.6 mg/day	0.6 mg/day
Children, 1-3 years	1.2 mg/day	1.2 mg/day
Children, 4-8 years	1.5 mg/day	1.5 mg/day
Boys, 9-13 years	1.9 mg/day	--
Boys, 14-18 years	2.2 mg/day	--
Girls, 9-18 years	--	1.6 mg/day
Adults, \$19 years	2.3 mg/day	1.8 mg/day
Women, pregnant (lactating)	--	2 mg/day (2.6 mg/day)

According to IOM, the AI for infants (newborn to 6 months) was set based on “an average manganese concentration of 0.0035 mg/L in human milk” and an average milk consumption of 0.78 L/day. As indicated previously, the manganese concentration in human milk varies. For example, ATSDR (2000) listed a manganese concentration in human milk ranging from 0.003 to 0.01 mg/L, and U.S. EPA (1997), from 0.007 to 0.015 mg/L. Assuming an intake of 0.78 liters milk per day, an infant (0 to 6 months) would ingest 0.003 to 0.012 mg Mn/day from human milk (using the minimum and maximum values in the two concentration ranges); the AI set by the IOM (i.e., 0.003 mg/day) is at the lower end of this range.

Tolerable Upper Intake

The IOM (2002) also set a tolerable upper intake level of 11 mg/day for adults, based on a recent review (Greger, 1999) which stated that the average manganese intake for adults eating typical Western and vegetarian diets in various surveys ranged from 0.7 to 10.9 mg Mn/day. Davis and Greger (1992) reported that women given daily supplements of 15 mg manganese (as an amino acid-chelated manganese supplement) for 90 days experienced no effects other than a significant increase in lymphocyte manganese-dependent superoxide dismutase, a “biomarker” that increases in direct relation to manganese exposure (Greger 1998, 1999). There are insufficient data to set tolerable upper intakes for infants or children.

2.5 Environmental Fate

Manganese compounds may be present in the atmosphere as suspended particulates resulting from industrial emissions, soil erosion, volcanic emissions, application of manganese-containing pesticides, and the burning of MMT-containing gasoline (IPCS, 1999). Early analysis of emissions suggested that manganese from combustion of MMT is emitted primarily as manganese tetroxide (Mn_3O_4 ; Ter Haar et al., 1975, as cited in ATSDR, 2000). However, more recent testing suggests that when very low levels of MMT are combusted (i.e., concentrations comparable to the currently allowed levels), manganese is emitted primarily as manganese phosphate and sulfate. The reported formal charge of the emitted manganese is +2.2, with a mass median aerodynamic diameter of 1 to 2 microns (Ethyl Corporation, 1997, as cited in Lynam et al., 1999). Uncombusted MMT rapidly decomposes to manganese oxide, carbon dioxide, and organic compounds in the atmosphere and has a half-life of only a few seconds in the presence of sunlight (Lynam et al., 1999; Zayed et al., 1999). Because particle size is small, atmospheric manganese distribution can be widespread. These particles will eventually settle out into surface waters or onto soils via the process of dry deposition. Little information is available on the chemical reactions of atmospheric manganese, but it is expected to react with sulfur and nitrogen dioxide. The half-life of manganese in air is only a few days (ATSDR, 2000).

The primary sources for surface and ground water releases are industrial facility effluent discharge, landfill and soil leaching, and underground injection. Manganese, in the form of potassium permanganate, may be used in drinking water treatment to oxidize and remove iron, manganese, and other contaminants (ANSI/NSF, 2000). Transport and partitioning of manganese in water is dependent on the solubility of the manganese form. In surface waters, manganese occurs in both dissolved and suspended forms, depending on such factors as pH, anions present, and oxidation-reduction potential (ATSDR, 2000). Often, manganese in water will settle into suspended sediments. Anaerobic groundwater often contains elevated levels of dissolved manganese. The divalent form (Mn^{2+}) predominates in most water at pH 4–7, but more highly oxidized forms may occur at higher pH values or result from microbial oxidation (ATSDR, 2000). It can bioaccumulate in lower organisms (e.g., phytoplankton, algae, mollusks, and some fish), but not in higher organisms, and biomagnification in food-chains is not expected to be significant (ATSDR, 2000). Little information is available on the biodegradation of manganese-containing compounds in water, but factors such as pH and temperature are important for microbial activities.

Approximately 91% of environmental manganese is released to soil. The main source of this release is land disposal of manganese-containing wastes. The ability of manganese compounds to adsorb to soils and sediments is contingent upon the cation exchange capacity and organic content of the soil or sediment. Adsorption can vary widely based on differences in these two factors. Oxidative microbial activity may increase the precipitation of manganese minerals and increase the dissolution of manganese in subsurface environments.

2.6 Summary

The greatest exposure to manganese is usually from food. Adults consume between 0.7 and 10.9 mg/day in the diet, with even higher intakes being associated with vegetarian diets (Freeland-Graves et al., 1987; Greger, 1999.; Schroeder et al., 1966) or the consumption of large amounts of tea.

Manganese intake from drinking water is normally substantially lower than intake from food. At the median drinking-water level of 10 : g/L determined in the National Inorganic and Radionuclide Survey (NIRS), the intake of manganese would be 20 : g/day for an adult, assuming a daily water intake of 2 L. Exposure to manganese from air is generally several orders of magnitude less than that from the diet, typically around 0.04 ng/day on average (U.S. EPA, 1990), although this can vary substantially depending on proximity to a manganese source.

3.0 CHEMICAL AND PHYSICAL PROPERTIES

Manganese can exist in multiple oxidative states; the most environmentally and biologically important manganese compounds are those that contain Mn^{2+} , Mn^{4+} , and Mn^{7+} (U.S. EPA, 1994). The physical and chemical properties of different manganese compounds vary substantially, as demonstrated in Table 1 on the next page.

ORGANOLEPTIC PROPERTIES

At concentrations exceeding 0.1 milligrams per litre (mg/L), the manganese ion imparts an undesirable taste to beverages and stains plumbing fixtures and laundry (Griffin, 1960). When manganese (II) compounds in solution undergo oxidation, manganese precipitates, resulting in encrustation problems. At concentrations as low as 0.02 mg/L, manganese can form coatings on water pipes that may later slough off as a black precipitate (Bean, 1974). The U. S. and a number of other countries have set secondary standards of 0.05 mg/L for manganese. This is an aesthetic level above which problems with discoloration may occur.

Table 1.
Chemical and Physical Properties of Manganese and Common Manganese Compounds

	Mn	MnCl ₂	Mn ₃ O ₄	MnO ₂	KMnO ₄
CAS No.	7439-96-5	2145-07-3	1317-35-7	479-93-7	7722-64-7
Valance	0	+2	+2 and +3	+4	+7
Molecular Weight	54.9	125.8	228.8	86.9	158
Synonyms	Elemental manganese	Manganese dichloride; Manganese chloride; Manganese (II) chloride	Manganese oxide; Manganese (II,III) oxide; Manganese tetroxide	Manganese dioxide; Black dioxide; Cement black; Manganese peroxide; Manganese (IV) oxide	Potassium permanganate; permanganic acid, potassium salt
Physical State (25°C)	Solid	Solid	Solid	Solid	Solid
Boiling Point (°C)	1962	1190	—	—	—
Melting Point (°C)	1244	650	1564	535 (loses oxygen)	240
Density (g/cm ³)	7.4	2.98	4.86	5.026	2.703
Vapor Pressure (20°C)	1.9	—	—	—	—
Water Solubility (g/100 mL)	Decomposes	723 (25°C)	insoluble	insoluble	63.8 (20°C)
Log Octanol/Water Partition – Coefficient (Log K _{ow})	—	—	—	—	—
Taste Threshold	—	—	—	—	—
Odor Threshold (air)	—	—	—	—	—
Conversion Factor	—	—	—	—	—

— No data available.

4.0 TOXICOKINETICS

The absorption, distribution, metabolism and excretion of manganese in the body are reviewed, discussed, and summarized in Greger (1999), Kies (1994), U.S. EPA (1984; 1993; 2003a), and ATSDR (2000). Age, chemical species, dose, route of exposure, and dietary conditions all affect manganese absorption and retention (Lönnerdal et al., 1987). Uptake of dietary manganese appears to be influenced by several dose-dependent processes: biliary excretion, intestinal absorption, and intestinal elimination.

4.1 Absorption

Manganese speciation and the route of exposure affects its absorption (Andersen et al., 1999; Tjälve et al., 1996). Thomson et al. (1971) and Gibbons et al. (1976) reported that the divalent form of manganese is absorbed most efficiently. However, as Bales et al. (1987) reported, the efficiency of absorption also varies for different manganese salts with manganese

chloride more efficiently absorbed than the sulfate or acetate salts. Recent studies show that significant differences exist in the amounts of manganese that are absorbed across different exposure routes, with inhaled manganese being absorbed more rapidly and to a greater extent than ingested manganese (Roels et al., 1997; Tjälve et al., 1996). Very little manganese is absorbed through the skin. Absorption of manganese via inhalation, intratracheal instillation, or intravenous infusion bypasses the control processes of the gastrointestinal tract. Absorption from inhalation exposure is mainly a function of particle size with smaller particles reaching the lower airways where they can be absorbed and larger particles deposited in the upper airways where they are subject to possible mucociliary transport to the throat followed by entrance into the gastrointestinal tract.

From animal experiments, it is known that inhaled manganese (even the insoluble MnO_2) is transported in a retrograde direction from the olfactory epithelium to the striatum of the brain (Gianutsos et al., 1997; Roels et al., 1997). During its uptake through the olfactory nerve endings (Bench et al., 2001; Brenneman et al., 2000; Tjälve et al., 1996; Vitarella et al., 2000) it may damage the astrocytes (Henriksson and Tjälve, 2000). After peroral uptake, manganese, like all other metals, is filtered from the blood by the choroid plexus (Ingersoll et al., 1995; Zheng et al., 1991). The retrograde transport of manganese through the olfactory epithelium directly into certain regions of the central nervous system or the brain could explain why the safe dose following inhalation exposure is much lower than after oral ingestion (Wang et al., 1989). The following sections discuss absorption of manganese following oral exposure only.

Absorption of manganese across the gastrointestinal tract is regulated by normal physiological processes to help maintain manganese homeostasis. Manganese absorbed in the divalent form from the gut via the portal blood is complexed with plasma proteins that are efficiently removed by the liver. A 7-week study in which 7 adult males ingested high-fiber diets containing 12.0 to 17.7 mg Mn/day (0.17 to 0.25 mg/kg-day) found that an average of $7.7\% \pm 6.3\%$ of the manganese was absorbed during weeks 5 to 7, with no measurable net retention of manganese (Schwartz et al., 1986). Similarly, an average absorption of $8.4\% \pm 4.7\%$ was observed in 7 adults ingesting infant formula containing manganese (Sandström et al., 1986).

Manganese retention may be greater for young animals and infants (Keen et al., 1986) due to the fact that the biliary system, the primary route of excretion, is not completely developed in human infants (Lönnerdal, 1994). Keen et al. (1986) demonstrated a strong effect of age on intestinal manganese uptake and retention. Sprague-Dawley rat pups were fasted overnight and then intubated with 0.5 mL of human milk containing 0.005 mg $^{54}\text{Mn}/\text{mL}$. Manganese retention was highest ($\geq 80\%$) in pups less than 15 days old. In older pups (16-19 days old), the average retention was 40%. Lönnerdal et al. (1987) showed that manganese uptake from brush border membranes was higher in 14-day-old rats than in 18-day-old rats. Although Rehnberg et al. (1985) found that younger animals had a slower distal intestinal transit time than older animals (potentially contributing to a higher proportional uptake), Bell et al. (1989) showed that the uptake rate was similar in pre- and post-weanling animals, suggesting that age-dependent differences in manganese retention were not due to immature intestinal transport mechanisms. Fechter (1999) determined that neonatal mice are unable to maintain manganese homeostasis until 17-18 days of age. When considered together, these data indicate that human infants, at

certain ages, may not have developed the capacity to completely excrete manganese following ingestion.

Davidsson et al. (1989b) studied whole-body retention of ^{54}Mn in adult humans after intake of radiolabeled infant formula. These authors observed reproducible retention figures at day 10, after repeated administrations of the labeled formula to six subjects. Absorption ranged from 0.8-16%, with a mean value of $5.9 \pm 4.8\%$. This range corresponds to a 20-fold difference between the highest and lowest values. Retention at day 10 ranged from 0.6-9.2%, with a mean value of $2.9 \pm 1.8\%$, when measured in 14 healthy individuals. These results suggest substantial variation in absorption between individuals.

The absorption of manganese is closely linked to iron absorption; iron-deficient diets lead to an increased absorption of both iron and manganese (Finley, 1999; Sandström et al., 1986; Thomson et al., 1971). Rehnberg et al. (1982) administered dietary Mn_3O_4 (450, 1,150, or 4,000 ppm Mn) to young rats. These authors amended the basal diets with varying levels of iron, and demonstrated that iron deficiency promoted the intestinal absorption of manganese. Conversely, manganese absorption was inhibited by large amounts of dietary iron. Absorption is also related inversely to the level of calcium in the diet (Lutz et al., 1993; McDermott and Kies, 1987; Kies, 1994; Schroeder et al., 1966). Johnson et al. (1991) studied the absorption of radiolabeled manganese from various plant foods in adult men and women and reported that the absorption values ranged from 1.4 to 5.5% and were significantly lower than the mean values of 7.8 to 10.2% from controls (MnCl_2 dissolved in water). Certain constituents of tea, such as tannins, can result in reduced manganese absorption (Freeland-Graves and Llanes, 1994). Other factors can also influence the degree to which manganese in foods is absorbed upon ingestion. These include intake of dietary fiber, oxalic acids, and phytic acids as well as contents in the gut, which tend to decrease manganese absorption (Gibson, 1994; U.S. EPA, 2003a).

4.2 Distribution

Manganese is present in all tissues of the body, the highest levels usually being found in the liver, kidney, pancreas, and adrenals (Sumino et al., 1975; Tipton and Cook, 1963). Intermediate concentrations occur in the brain, heart and lungs (ATSDR, 2000), with accumulations preferential in certain regions of the brain in infants and young animals (Kontur and Fechter, 1988; Zlotkin and Buchanan, 1986). The lowest concentrations of manganese are observed in bone and fat. Some data suggest that tissues rich in mitochondria (for example, liver, kidney, and pancreas) contain higher levels of manganese (Kato, 1963; Maynard and Cotzias, 1955).

After absorption into the blood system by routes other than the gastrointestinal tract, manganese is apparently oxidized, and the trivalent manganese binds to transferrin. Transferrin-bound trivalent manganese is not as readily removed by the liver, as are protein complexes with divalent manganese. Thus, manganese delivered by routes other than the gastrointestinal tract would be available for uptake into tissues for a longer period of time than the orally administered manganese, leading to quantitative differences in tissue uptake (Andersen et al., 1999).

Factors that may alter tissue distribution include co-exposure to other metals (Shukla and Chandra, 1987) and the chemical form (Gianutsos et al., 1985). Age may also be a factor. Animal studies have shown that manganese crosses the blood-brain barrier in neonates at a rate four times higher than that in adults (Mena, 1974).

4.3 Metabolism

As a metallic element, manganese does not undergo metabolic conversion to other products. However, manganese has the potential to exist in several oxidation states in biological systems. Circumstantial evidence from the study of manganese-containing enzymes and from electron spin trapping experiments suggests that manganese undergoes conversion from Mn(II) to Mn(III) within the body (ATSDR, 2000). The conversion from Mn(II) to Mn(III) appears to be catalyzed by the α -globulin protein ceruloplasmin (Andersen et al., 1999).

A small fraction of absorbed manganese is present as the free ion. However, manganese readily forms complexes with a variety of organic and inorganic ligands. The complexes formed include 1) low molecular weight complexes with bicarbonate, citrate or other ligands; 2) an exchangeable complex with albumin; and 3) tightly bound complexes with proteins such as transferrin and α_2 -macroglobulin. In addition, manganese can assume a structural role in metalloproteins such as mitochondrial superoxide dismutase, pyruvate decarboxylase, and liver arginase. Manganese also plays a catalytic or regulatory role in enzymatic reactions involving select hydrolases, dehydrogenases, kinases, decarboxylases and transferases.

4.4 Excretion

Manganese is almost entirely eliminated in the feces, with only a small proportion (0.1-2%) being excreted in the urine (Davis and Greger, 1992). Fecal manganese is comprised of unabsorbed dietary manganese plus manganese excreted in bile. In humans, elimination is biphasic, with half-lives of 13 and 37 days (Davidsson et al., 1989b; Sandström et al., 1986). Sweat, hair and the milk of lactating mothers also contribute to excretion (Roels et al., 1992).

5.0 HEALTH EFFECTS DATA

Manganese is an essential element for many living organisms, including humans. It is necessary for proper functioning of some enzymes (manganese superoxide dismutase) and for the activation of others (kinases, decarboxylases, etc.). Adverse health effects can be caused by inadequate intake or over exposure. Manganese deficiency in humans appears to be rare because manganese is present in many common foods. Animals experimentally maintained on manganese-deficient diets exhibit impaired growth, skeletal abnormalities, reproductive deficits, ataxia of the newborn, and defects in lipid and carbohydrate metabolism (Keen et al., 1999; Hurley and Keen, 1987; U.S. EPA, 1984).

The health effects from over-exposure of manganese are dependent on the route of exposure, the chemical form, the age at exposure, and an individual's nutritional status.

Irrespective of the exposure route, the nervous system has been determined to be the primary target with neurological effects generally observed.

5.1 Human Studies

Humans are exposed to inorganic manganese compounds in food and water, but there are few reports of adverse effects in humans from ingesting excess manganese. Most human studies reporting adverse effects are of inhalation exposure. There is conclusive evidence from occupational studies in humans that inhalation exposure to high levels of manganese compounds can lead to a disabling syndrome of neurological effects referred to as “manganism.” Although it is typical for symptoms to occur after several years of exposure, some individuals may begin to show signs after 1-3 months of exposure (Rodier, 1955).

5.1.1 Short-term Exposure Studies

Neurological

Kawamura et al. (1941) reported health effects resulting from the ingestion of manganese-contaminated well water for an estimated 2-3 months by 25 individuals. The source of contamination was identified as leachate from approximately 400 dry cell batteries buried near the drinking water well. The concentration of manganese in the well water was analyzed 7 weeks after the first case appeared and was determined at that time to be ~14 mg Mn/L (as Mn_3O_4). However, when re-analyzed 1 month later, the levels were decreased about half. Therefore, the actual exposure was probably to drinking water containing ~28 mg Mn/L or higher. Assuming a daily water intake of 2 L, with a minimum of 2 mg Mn from food, a dose of at least 58 mg Mn/day is estimated. This exposure level is quite uncertain and it is estimated that it is around 25-30 times the level considered to be safe and adequate by the Food and Nutrition Board of the Institute of Medicine (IOM, 2002).

Health effects reported by Kawamura et al. (1941) included lethargy, increased muscle tonus, tremor and mental disturbances. Out of 25 people examined, 15 had symptoms. Five cases were considered severe, 2 cases were categorized as moderate, and 8 cases were described as mild. The most severe symptoms were observed in the elderly. Younger people were less affected, and symptoms of intoxication were completely absent in young children (age 1 to 6 years). Three deaths occurred, including one from suicide. Upon autopsy, the concentration of manganese in the brain of one person was found to be 2 to 3 times higher than concentrations measured in two unexposed individuals (controls). Extreme macroscopic and microscopic changes were seen in the brain tissue, especially in the globus pallidus. Although there were also elevated levels of zinc in the well water, the authors concluded that the zinc appeared to have no relation to the observed symptoms or tissue pathology. This conclusion was largely based on the observation of morphological changes in the corpus striatum, which are characteristic of manganese poisoning, but are not a feature of zinc poisoning.

While toxicity in the Kawamura et al. (1941) study is attributed to manganese, several

aspects of the observed health effects are inconsistent with traits of manganism observed in humans following chronic inhalation exposure. Inconsistencies include the rapid onset of symptoms and rapid progression of the disease. Two adults who came to tend the members of one family developed symptoms within 2 to 3 weeks. The course of the disease was very rapid, progressing in one case from initial symptoms to death in 3 days. Some survivors recovered prior to significant decreases in the manganese concentration of the well water which resulted when the dry-cell batteries were removed from the site. This pattern contrasts with the longer latency period and irreversible damage caused by inhalation exposure to manganese (as observed in several occupational exposure studies; ATSDR, 2000). These observations may represent differences in the pharmacokinetics of ingested versus inhaled manganese, but there is little information to support this conclusion. Although the individuals in the Kawamura et al. (1941) study were clearly exposed to high levels of manganese, it is possible that additional factors contributed to the observed effects (ATSDR, 2000; U.S. EPA, 1993).

Symptoms resembling Parkinson's disease have also been noted in an individual who ingested 1.8 mg/kg-day potassium permanganate for 4 weeks (Bleich et al., 1999; Holzgraefe et al., 1986). The symptoms occurred 9 months after the exposure.

5.1.2 Long-term Exposure Studies

Neurological

The neurological effects of inhaled manganese have been well documented in humans chronically exposed to elevated levels in the workplace (ATSDR, 2000; Canavan et al., 1934; Cook et al., 1974; Roels et al., 1999). The syndrome known as “manganism” is caused by exposure to very high levels of manganese dusts or fumes and is characterized by a “Parkinson-like syndrome” including weakness, anorexia, muscle pain, apathy, slow speech, monotonous tone of voice, emotionless “mask-like” facial expression, and slow clumsy movement of the limbs. In general, these effects are irreversible. Some motor functions may already be affected following chronic exposure to levels of manganese $\leq 1 \text{ mg/m}^3$ (if the inhaled manganese is respirable), but individuals in these situations have not shown the overt, clinical symptoms of those exposed to much higher levels (Mergler et al., 1994; Roels et al., 1992).

By the oral route, manganese is often regarded as one of the least toxic elements, although there is some controversy as to whether the neurological effects observed with inhalation exposure also occur with oral exposure. Several case reports of oral exposure to high doses of manganese have described neurological impairment as an effect, but the quantitative and qualitative details of exposure necessary to establish direct causation are lacking. An individual who took large mineral supplements over several years displayed symptoms of manganism (Banta and Markesbery, 1977).

An epidemiological study was conducted in Greece to investigate the possible correlation between long-term (i.e., more than 10 years) manganese exposure from drinking water and neurological effects in elderly people (Kondakis et al., 1989). The levels of manganese in the drinking-water of 3 different geographical areas were 3.6-14.6 : g/L in the control area and 81-253 : g/L and 1800-2300 : g/L in the manganese-containing areas. The total population in

the three areas being studied range from 3200 to 4350 people. The study included only individuals over the age of fifty drawn from a random sample of 10% of all households. The number of subjects sampled were 62, 49, and 77 for control, low-, and high-exposed groups. The authors performed a neurological examination of the subjects (weakness/fatigue, gait disturbances, tremors, dystonia, etc.) and expressed the results as composite scores. They found no differences in the manganese content in the blood, but a statistically-significant difference in both the manganese content in the hair and composite neurological scores between the high-exposed area (concentrations 1800-2300 : g/L) and the control area, suggesting neurological impairment in the high exposed area. The investigators estimated a dietary intake of 5-6 mg/day (personal communication), but data were not provided. Because of the uncertainty in the amount of manganese in the diet, and possible exposure from other sources such as dust, and little information on nutritional status and other possible confounding variables, it is difficult to estimate the total exposure to manganese.

The incidence of motor neuron disease (MND) in a small Japanese town was positively correlated with a significantly increased manganese concentration in local rice and a low magnesium concentration in the drinking-water (Iwami et al., 1994). The study did not provide good estimates of overall exposure to manganese in either the control population or the population with MND; therefore, development of the disease could not be conclusively attributed to manganese exposure. The simultaneous exposure to manganese and the deficiency of other essential minerals was possibly the reason for the enhanced incidence of neurotoxicological symptoms found in this study in Japan and in another population in Guam (Florence and Stauber, 1989; Yoshida et al., 1988).

There was also some speculation on a link between mineral deficiency, enhanced oral manganese uptake and Mn-catalyzed denaturation of copper-free prion protein to the pathogenic prion protein (Brown et al., 2000), which might explain the enhanced occurrence of some prion diseases in certain world regions (Purdey, 2000).

Goldsmith et al. (1990) investigated a Parkinson's disease cluster within southern Israel in which the prevalence of the disease was increased among persons 50 to 59 years old, suggesting an early onset. Well water and soils in the region reportedly contained high levels of manganese, although no quantitative data were provided. In addition, the manganese-containing fungicide Maneb was commonly used in the area. Several factors limit the use of this study for evaluation of the human health effects of excess manganese exposure. Lack of environmental concentration data prevent reliable estimation of exposure rates. Potentially confounding factors include the high levels of aluminum, iron, and other metals in the soil and water, and the use of the herbicide paraquat in the area (ATSDR, 2000). Paraquat is structurally related to N-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP), which causes irreversible symptoms of parkinsonism in humans.

Contrary to the above studies, another long-term drinking-water study in a rural northern area of Germany (Vieregge et al., 1995) found no neurological effects following ingestion of increased manganese. No significant differences in neurological tests were found in older people (41 subjects older than 40 years with a mean age of 57.5) consuming well water containing at least 0.3 mg/L of manganese (0.3 to 2.16 mg/L of manganese) for 10 to 40 years. The control

group (74 subjects, mean age 56.9 years) was exposed to water containing less than 0.05 mg/L of manganese. Subjects of both groups were randomly selected and matched with respect to age, sex, nutritional habits, and drug intake. However, like the Kondakis et al. (1989) study, this study lacks exposure data from other routes and sources, and the manganese concentration range in the water was very broad.

Two other studies involving ingestion exposure to manganese reported no increases in adverse health effects. In one area of Japan, a manganese concentration of 0.75 mg/L in the drinking-water supply had no apparent adverse effects on the health of consumers (Suzuki, 1970). No signs of toxicity were observed in patients given 30 mg of manganese citrate (9 mg of manganese) per day for many months (Schroeder et al., 1966).

One epidemiological study has been identified which attempts to link potential overexposure to ingested manganese with neurotoxicity in children. Adverse neurological effects (decreased performance in school and in neurobehavioral examinations of the WHO core test battery) were reported in 11- to 13-year-old children who were exposed to excess manganese through ingestion of contaminated water and consumption of food made of wheat fertilized with sewage water (He et al., 1994; Zhang et al., 1995). The exposed and control groups were both from farming communities and were matched for age, sex, grade, family income level, and parental education level. The average manganese concentration of the drinking-water was 0.241 mg/L for the exposed area compared to the control level of 0.04 mg/L. However, the total exposure data, including manganese exposure from food, water and air, exposure duration, as well as other confounding factors and the nutritional status of the children were not well-characterized.

A recently published case study (Woolf et al., 2002) reported increased manganese levels in the hair and blood of a 10-year-old child exposed to increased manganese in drinking water. The child had been ingesting drinking water supplied by a well for 5 years prior to a clinic visit for evaluation of over-exposure to manganese. In addition, the family lived in a house near a toxic waste dump. An evaluation of the well water performed four months prior to the child's health assessment indicated that manganese and iron levels in the water were both elevated, with concentrations of 1.21 (reference level, 0.05 mg/L) and 15.7 mg/L, respectively. The child's whole blood and serum manganese levels were 3.82 : g/100 mL (reference normal, <1.4 : g/100 mL) and 0.90 : g/100 mL (reference normal, <0.265 : g/100 mL), respectively. The child's hair manganese level was 3,091 ppb of washed, acid-digested hair (reference normal, <260 ppb hair). Although the child's 16-year-old brother did not exhibit elevated blood manganese, he did have increased manganese in his hair. The 10-year-old did not exhibit any clinical effects of manganese over-exposure (cogwheeling, abnormally high muscle tone, fixed facies, etc.) and had good balance with closed eyes, although he did have trouble coordinating rapid alternating motor movements (this deficiency is consistent with the test performance of occupational workers chronically exposed to airborne manganese). Magnetic resonance imaging (MRI) of the child's brain did not indicate any hyperintense signaling of the globus pallidus, basal ganglia, mid-brain or pons, which would indicate manganese deposition in these areas of the brain. Selective deposition of manganese in the globus pallidus and basal ganglia has been shown to occur in children and adults with chronic manganese overexposure (Devenyi et al., 1994; Hauser et al., 1996). The absence of the signaling argues against manganese toxicity. Results from a battery of neuropsychologic tests on the child indicated that global cognition was unimpaired.

However, the child had difficulties in both visual and verbal memory, which the study authors considered consistent with a deficit in free retrieval skills. The family was counseled to use bottled water for drinking and cooking; one month after the initial test, the child's whole blood manganese level was reduced to 1.71 : g/100 mL (Woolf et al., 2002). It is difficult to determine the total exposure from this study.

Results from studies of an Aboriginal population in Groote Eylandt have been cited as additional evidence for a relationship between elevated manganese exposure, violent behavior, and adverse health effects. The soil on this Australian island is exceptionally high in manganese (40,000 to 50,000 ppm), and the fruits and vegetables grown in the region are reported to contain elevated concentrations of the element. High alcohol intake, anemia, and a diet deficient in zinc and several vitamins (Florence and Stauber, 1989) may contribute to increased uptake and retention of manganese. The proportion of arrests in this native population is the highest in Australia, and high incidences of stillbirths and congenital malformations, as well as a high occurrence of Parkinson-like neurobehavioral syndrome, have been observed (Cawte and Florence, 1989; Kilburn, 1987). Clinical symptoms consistent with manganese intoxication are present in about 1% of the inhabitants. Quantitative data on oral intake have not been reported, but elevated concentrations of manganese have been determined in the blood and hair of the Aborigines (Stauber et al., 1987). However, Stauber et al. (1987) did not find a correlation between hair levels of manganese and the severity of neurological symptoms in individuals. A study of the neurologic status of the Aborigines in Groote Eylandt identified two general syndromes. One syndrome is characterized by muscle atrophy and weakness, while the other is characterized by ataxia and oculomotor disturbances (Kilburn, 1987). Although an association of adverse health effects with elevated manganese exposure is suggested by these observations, the small population of Groote Eylandt and the difficulty in defining an appropriate control population have prevented the identification of statistically-significant trends (U.S. EPA, 1993).

Several of the studies above utilized hair analysis as a method for estimating exposure to manganese. ATSDR (2000) has outlined several potential limitations to the use of hair analysis. The normal cycle of hair growth and loss restricts its usefulness to a period of a few months following exposure. External contamination of hair by dye, bleaching agents, or other materials may result in values which are not representative of absorbed doses. Further, the affinity of manganese for pigmented tissue may result in variations of manganese concentration with hair color.

Kihira et al. (1990) have associated manganese with amyotrophic lateral sclerosis (ALS). Spinal cord samples from ALS patients were found to have higher manganese concentrations in the lateral fasciculus and anterior horn than in the posterior horn. ALS patients also exhibited a positive correlation between manganese and calcium spinal cord content, while controls exhibited a negative correlation. It was suggested that an imbalance between manganese and calcium in ALS patients plays a role in functional disability and neuronal death. This study needs to be interpreted with caution, however, because it is not conclusive that the high manganese concentrations in these patients preceded the onset of the disease.

Creutzfeldt-Jakob Disease (CJD) clusters in central Slovakia have occurred near areas of

high manganese in conjunction with low copper (Purdey, 2000). The level of manganese in natural uncultivated pasture in CJD-endemic areas was 210 ppm dry weight in comparison to CJD-free areas where the level was 85 ppm dry weight. The levels of manganese in pine needles and some specific crops were also measured and were approximately 1.5-16 times greater in the CJD-endemic regions (Purdey, 2000). It was suggested that manganese replaces copper in CNS prion proteins (PrP) causing a protease-resistant, misfolded PrP. Brown et al. (2000) determined that manganese can replace copper in recombinant PrP and reported that the PrP appears less stable and quickly converts to a misfolded form. Although the manganese-loaded PrP initially had a similar structure and activity as copper-loaded PrP, aging of the manganese-loaded PrP caused it to become proteinase-resistant and lose function.

Reproductive and Developmental Studies

Male workers afflicted with clinically identifiable symptoms of manganism also have loss of libido and impotence from occupational exposure to manganese for 1-21 years (Emara et al., 1971; Mena et al., 1967; Rodier, 1955; Schuler et al., 1957). Impaired fertility, as measured by fewer children/married couple, has been observed in male workers exposed for 1-19 years to manganese dust at levels that did not produce obvious manganism (0.97 mg/m^3 ; Lauwerys et al., 1985).

Three groups of men occupationally exposed to manganese for 1 or more years (63 miners or ore processors, 38 electric welders in mechanical fields, and 110 electric welders in shipbuilding) were reported to have increased semen liquification time and decreased sperm count and viability (Wu et al., 1996). Matched controls consisted of 99 men who were employed in the same occupation, but were not exposed to manganese or other reproductive toxins. Manganese levels, as well as those of a few other metals, were increased in the semen of the exposed group. Although this study suggests that manganese exposure may cause sperm toxicity, a stepwise regression analysis of the other metals present indicated that the higher nickel concentrations were also associated with lesser semen volume and a greater percentage of deformed sperm. This prevents any conclusive link between manganese and reproductive function.

By contrast, no significant differences in reproductive outcome were found between exposed men and matched controls in a reproductive epidemiology study involving 314 men in a manganese plant (Jiang et al., 1996). The geometric mean airborne manganese concentration was 0.145 mg/m^3 as MnO_2 . The incidences of sexual dysfunction were evaluated through researchers' questions and judged by the occurrence of two positive responses to three potential conditions: impotence, abnormal ejaculation (early ejaculation or non-ejaculation), and lack of sexual desire.

No information was found regarding reproductive effects in women following manganese exposure.

Studies are limited regarding developmental toxicity in humans following oral exposures to manganese. Kilburn (1987) reported an increased incidence in birth defects and stillbirths in a

small population of indigenous peoples in Groote Eylandt, Australia. Although the area was rich in manganese deposits and ingestion of excess amounts of the metal was suspected, the study

suffered from a lack of exposure data, small sample sizes, and no suitable control group. Further, inhalation exposure to manganese could not be ruled out.

Cancer and Mutagenicity Studies

Mutagenicity

The genotoxic potential of high manganese exposure in humans is not known (IPCS, 1999). Elias et al. (1989) found an increase in the incidence of chromosomal aberration in metal active gas welding workers who had been welding for 10-24 years. Occupational exposure to nickel, as well as manganese, was reported. Since nickel is known to cause chromosomal aberration via inhalation, the results could not be attributed solely to the influence of manganese.

Carcinogenicity

No studies are available on the potential carcinogenicity of high exposure to manganese in humans (ATSDR, 2000).

Variation In Human Sensitivity

Individuals that have an impaired excretion and increased retention would be sensitive to manganese toxicity. Reasons for such susceptibility are genetic make-up, developmental stage, age, health and nutritional status. First, individuals with decreased excretion or impaired liver function can be at risk from exposure to excess manganese because the liver is the main organ for excreting manganese. This group may include the elderly who may have declining organ function, the very young who may have immature and developing organs, and those with liver disease. For example, Devenyi et al. (1994) reported observable neurological signs associated with manganese toxicity in individuals with chronic liver disease. Hauser et al. (1996) reported changes in brain MRI scans in liver failure patients which were identical to those observed in cases of manganese intoxication. Second, individuals with increased retention of manganese may be more sensitive to manganese toxicity including those whose nutritional status causes increased uptake of manganese. For example, the very young are considered a potential sensitive population due to the increased retention of manganese in animals (Keen et al., 1986; Kostial et al., 1978; Rehnberg et al., 1980) and humans (Zlotkin and Buchanan, 1986). This increased retention leads to increased manganese in the tissue, especially in the brain (Kontur and Fechter, 1985, 1988; Kostial et al., 1978; Kristensson et al., 1986; Miller et al., 1975; Rehnberg et al., 1981). This is a concern because the nervous system is the primary target organ. Although some data suggest that infants are potentially more susceptible to the toxic effects of manganese, evidence indicates that individual susceptibility varies greatly. The Kawamura et al. (1941) study suggested that young children (age 1 to 6 years) may be less sensitive to manganese toxicity than adults or older people. Current information is not sufficient to quantitatively assess the susceptibility of the young compared to adults.

Although studies are mixed, the majority have also suggested that the elderly (50 years of age or over) are more susceptible to manganese neurotoxicity than the general population (Kawamura et al., 1941; Rodier, 1955; Tanaka and Lieben, 1969). Loss of neuronal cells due to

aging and/or accumulated damage from other environmental neurotoxicants, as well as less effective homeostatic control, may contribute to this increased susceptibility (Silbergeld, 1982).

5.2 Animal Studies

5.2.1 Short-term Exposure Studies

Lethality

Acute lethality of manganese in animals appears to vary depending on the chemical species and whether exposure is via gavage or dietary ingestion (ATSDR, 2000). Single-dose oral LD₅₀ values in adult rats exposed by gavage ranged from 331 mg Mn/kg-day (as manganese chloride; Kostial et al., 1989) to 1,082 mg Mn/kg-day (as manganese acetate; Smyth et al., 1969), while a 14-day exposure of rats to 1,300 mg Mn/kg-day (as manganese sulfate) in feed resulted in no deaths (NTP, 1993).

Manganese compounds administered by parenteral routes generally result in mortality at lower doses. For example, Larsen and Grant (1997) administered a single intravenous dose of 150, 200, 300, or 400 : mol/kg in saline to male mice (5/group). These doses correspond to 8.2, 11, 16, and 22 mg Mn/kg, respectively. These study authors reported an LD₅₀ value of 300 : mol/kg (16 mg Mn/kg). LD₅₀ values for the intraperitoneal route ranged from 14 to 64 mg Mn/kg.

Age may be a factor in susceptibility to acute manganese toxicity. Kostial et al. (1978) found that MnCl₂ produced the greatest oral toxicity in the youngest and oldest groups of exposed rats. Roth and Adleman (1975) proposed that the increased susceptibility of older rats may result from a decrease in adaptive responsiveness, which is characteristic of the aging process. Increased susceptibility of younger rats may reflect high intestinal absorption and body retention of manganese.

General Toxicity

In a 14-day oral exposure study, NTP (1993) administered diets containing 0, 3, 130, 6,250, 12,500, 25,000, or 50,000 ppm manganese sulfate monohydrate to F344 rats (5/sex/dose). All rats survived the exposure period. Statistically-significant differences in manganese-treated rats included reduced body weight gain (57% decrease) and final body weight (13% decrease) in the high-dose males when compared to the control group. Decreased leukocyte and neutrophil counts and reduced liver weight were observed in high-dose males and females. The high-dose groups also exhibited diarrhea during the second week of the study. Manganese concentrations in the livers of animals receiving the 50,000 ppm diet were more than twice those of the controls. The NOAEL and LOAEL values based on decreased weight gain (males) and hematological changes were approximately 650 and 1,300 mg Mn/kg-day, respectively.

NTP (1993) also administered diets containing 0, 3, 130, 6,250, 12,500, 25,000, or 50,000 ppm manganese sulfate monohydrate to B6C3F₁ mice (5/sex/dose) for 14 days. However, study animals were poorly randomized at the beginning of the study, and no effects clearly attributable to manganese exposure were identified.

Exon and Koller (1975) reported that rats administered as little as 6 mg Mn/kg-day as Mn_3O_4 in feed for 28 days gained only 44% as much weight as control rats over the duration of the study. Since no histopathological changes were observed in the exposed animals, the authors suggested that the decrease in body weight gain might have been due to manganese interference in metabolism of calcium, phosphorous, and iron.

Hepatic

Shukla et al. (1978) administered a dose of 16 mg $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$ /kg (4.4 mg Mn/kg) in drinking water (dose calculated by investigators) to rats for 30 days and evaluated the effect on hepatic enzyme activity. Treated rats revealed significantly decreased succinic dehydrogenase, alcohol dehydrogenase, and α -amylase activity when compared with controls. In contrast, manganese exposure resulted in significantly increased activities of monoamine oxidase (MAO), adenosine triphosphatase, arginase, glutamate pyruvate transaminase (alanine aminotransferase or ALT), ribonuclease, glucose-6-phosphatase, and β -amylase activity in the livers of treated rats.

Hietanen et al. (1981) studied the effect of manganese on hepatic and extrahepatic enzyme activities. Male Wistar rats were exposed to 0.5% Mn (as MnCl_2) in the drinking water for 1, 4, or 6 weeks. Assuming an average body weight of 0.35 kg and average water consumption of 0.045 L/day (U.S. EPA, 1986a), this corresponds to an exposure of 0.7 mg Mn/kg-day. Changes in the activity of several enzymes, including aryl hydrocarbon hydroxylase, ethoxycoumarin γ -deethylase, and epoxide hydrolase, were observed at 1 week but not at 6 weeks. Enzyme activities were increased in the liver, and decreased in the intestines and kidney.

Neurological

The central nervous system is the chief target of manganese toxicity. Oral doses ranging from 1 to 150 mg per kg of body weight per day produced a number of neurological effects in rats and mice, mainly involving alterations in neurotransmitter and enzyme levels in the brain. These changes were sometimes accompanied by clinical signs, such as changes in coordination and activity level (ATSDR, 2000).

Deskin et al. (1980) studied neurological alteration induced by manganese chloride in neonatal CD rats. Rats were intubated with 1, 10 or 20 mg Mn/kg-day from birth to 24 days old. Manganese administration (10 and 20 mg/kg-day) resulted in a significant elevation of manganese in the hypothalamic area and corpus striatum, but neurochemical alterations (a decrease in dopamine concentration and turnover) were observed only in the hypothalamic area. The highest dose also resulted in an increase in monoamine oxidase activity in the hypothalamus of treated rats. A subsequent study by Deskin et al. (1981) using the same protocol (but doses of 10, 15 or 20 mg/kg-day) reported a significant elevation in serotonin levels in the hypothalamus, but not the striatum, following exposure to 20 mg/kg-day.

Kontur and Fechter (1988) intubated neonatal Long-Evans rats daily with 0, 25 or 50 mg/kg-day manganese chloride ($\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$) for 14 or 21 days. The level of manganese in the brain was increased at both 14 and 21 days, but was greater at 14 days. However, monoamine and metabolite levels were not altered by manganese treatment in any brain region. The authors suggest that the different results from short-term studies reported by different laboratories may be because of species or strain differences, the dosing regimen or vehicle, the route of administration, or the time points chosen for testing.

Kimura et al. (1978) provided rats with diets supplemented with 564 ppm of manganese as MnCl_2 for 3 weeks. Assuming a food consumption factor of 5% (i.e., 5g diet per 100 g body weight per day), this corresponds to a daily dose of 28 mg Mn/kg-day. The study authors reported that brain serotonin levels were decreased in manganese-treated rats. Monoamine oxidase activity was unchanged, but l-amino-acid decarboxylase activity in the brain was decreased by manganese treatment. Histopathological analysis of the brain was not conducted. Blood serotonin levels were increased in treated rats, and this change was accompanied by decreased blood pressure.

5.2.2 Long-term Exposure Studies

General Toxicology

Chronic ingestion of 1-2 mg Mn/kg-day produced changes in appetite and reduction in hemoglobin synthesis in rabbits, pigs, and cattle (Hurley and Keen, 1987). Transient effects on biogenic amine levels and activities of dopamine β -hydroxylase and monoamine oxidase in rat brain have been noted with long-term exposures to manganese (Eriksson et al., 1987; Lai et al., 1984; Subhash and Padmashree, 1990). An increase in physical activity level and a transient increase in dopaminergic function were observed in rats given 40 mg Mn/kg-day for 65 weeks (Nachtman et al., 1986). Two-year oral exposures to extremely high doses (1800-2250 mg/kg-day as MnSO_4) in male and female mice resulted in hyperplasia, erosion, and inflammation of the forestomach; no effects were seen in rats (NTP, 1993).

Mitochondria-rich organs, such as the liver and pancreas, are hypothesized to be most affected by oral exposure to manganese because of the interaction of manganese with mitochondrial enzymes. Wassermann and Wassermann (1977) reported ultrastructural changes of the liver cells in rats exposed to 200 mg/L of manganese chloride in their drinking water for 10 weeks. Assuming water consumption of 0.05 L/day and an average body weight of 0.35 kg (U.S. EPA, 1986a), this level of exposure corresponds to an average daily dose of approximately 12 mg Mn/kg-day. Increased metabolic activity was inferred from an increased amount of rough endoplasmic reticulum, the occurrence of multiple rough endoplasmic cisternae and prominent Golgi apparatus, and large Golgi vesicles filled with osmiophilic particles in the biliary area of the liver cell. The authors attributed this apparent increase in metabolic activity to biochemical processes related to the nutritional requirement for manganese, and homeostatic processes triggered by increased exposure. They noted that other observed liver effects, including the presence of glycogenosomes in the biliary area, groups of collagen fibers in the Disse's spaces, and degenerative changes in some centrilobular liver cells, may either be direct toxic phenomena or secondary responses to the effect exerted by manganese on other target tissues. ATSDR (2000) evaluated these data and designated 12 mg Mn/kg-day as the NOAEL in

this study.

In a 13-week study, NTP (1993) administered diets containing manganese sulfate at 0, 1,600, 3,130, 6,250, 12,500, or 25,000 ppm ($\text{mg MnSO}_4 \cdot \text{H}_2\text{O}$ per kg diet) to F344 rats (10/sex/dose). The baseline concentration of manganese in the control diets was approximately 92 ppm. Mean daily intake of manganese sulfate monohydrate ranged from 98 mg/kg-day (32 mg Mn/kg-day) for the low-dose to 1,669 mg/kg-day (542 mg Mn/kg-day) for the high-dose males. For females, the range was 114 mg/kg-day (37 mg Mn/kg-day) for the low-dose group and 1,911 mg/kg-day (621 mg Mn/kg-day) for the high-dose group. No rats died during the study, and no clinical or histopathology findings were attributed to manganese exposure. Females receiving diets with $\geq 6,250$ ppm manganese sulfate experienced decreased body weight gain. Absolute and relative liver weights were decreased in males receiving diets with $\geq 1,600$ ppm, and in females in the highest dose group only. Hematological effects were also reported. All groups of exposed males exhibited a significantly increased neutrophil count. Lymphocyte counts were decreased in males receiving $\geq 6,250$ ppm in the diet and females in the three highest dose groups. The low dose of 1,600 ppm (about 32 mg Mn/kg-day) was identified as the LOAEL for this study, based on effects on liver weight and neutrophil counts in male rats.

In a concurrent 13-week study, NTP (1993) administered diets containing manganese sulfate (monohydrate) at 0, 3,130, 6,250, 12,500, 25,000, or 50,000 ppm to B6C3F₁ mice (10/sex/dose). The baseline concentration of manganese in the control diets was approximately 92 ppm. Mean daily intake of manganese sulfate monohydrate ranged from 328 mg/kg-day (107 mg Mn/kg-day) for the low-dose to 8,450 mg/kg-day (2,746 mg Mn/kg-day) for the high-dose group. No deaths were attributed to manganese exposure. Both male and female mice in the highest dose group exhibited significantly decreased body weight gain. The male mice in the highest dose group also had decreased relative and absolute liver weights. Both sexes at the highest dose exhibited decreased hematocrit and hemoglobin concentrations. The NTP report suggests that these findings may indicate microcytic anemia, which may have resulted from a sequestration or deficiency of iron. Males receiving $\geq 25,000$ ppm also exhibited significantly lower leukocyte counts, although this finding was of questionable relevance to manganese exposure. No clinical findings were attributed to manganese exposure. The LOAEL for this study was 3,130 ppm (107 mg Mn/kg-day), based on significantly decreased body weight gain in male mice.

Komura and Sakamoto (1991) investigated the effect of different forms of manganese on potential adverse effects following ingestion exposure to the element. Male mice (8/group) were exposed either to a control diet containing 130 mg Mn/kg, or a diet supplemented with an additional 2,000 mg Mn/kg as $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$, $\text{Mn}(\text{CH}_3\text{COO})_2 \cdot 4\text{H}_2\text{O}$, MnCO_3 , or MnO_2 . Assuming an average food consumption of 13% of body weight, the average daily dose from the control diet was approximately 17 mg Mn/kg-day, while the average daily dose from the manganese-enriched diet was 276 mg Mn/kg-day. The duration of treatment was 100 days. The mice were tested for spontaneous motor activity after 30 days. Blood and tissues were analyzed at the termination of the experiment. No significant difference in food intake among groups was seen. Body weight gain and red and white blood cell count was decreased in groups that received $\text{Mn}(\text{CH}_3\text{COO})_2 \cdot 4\text{H}_2\text{O}$ or $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$. Motor activity was reduced in the MnCO_3 group. Tissue manganese concentrations in groups receiving supplemental manganese were 2 to 3 times that of controls. A LOAEL of 276 mg Mn/kg-day was identified in this study based on

decreased weight gain and hematological effects.

Hepatic

Leung et al. (1982) administered 1,000, 10,000, or 20,000 mg $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$ /L in drinking water to female Wistar rats. Exposure was initiated at conception by administration of manganese-containing drinking water to the dams, and continued through age 60 days. The estimated doses were 38.9, 389, and 778 mg Mn/kg-day (U.S. EPA, 1993). Treated rats exhibited liver necrosis and ultrastructural alterations that resembled human cholestasis. A LOAEL of 38.9 mg Mn/kg-day was identified in this study based on hepatic necrosis.

Suzuki et al. (1975) administered 250, 500, or 1,000 mg of MnO_2 in saline to 4 kg monkeys (*Macaca mullata*, age not specified) by subcutaneous injection. Injections were given once a week for 9 weeks. Estimated time-averaged doses correspond to 5.6, 11, and 23 mg Mn/kg-day. At autopsy, manganese-treated monkeys had irregular arrangement of hepatic cords and lymphocytic infiltration.

Neurological

Neurotoxicity is a known effect of long-term exposure to inhaled manganese in humans and animals, but the potential for neurotoxicity resulting from oral exposure is less well characterized. The only report of neurobehavioral toxicity in primates from orally administered manganese is by Gupta et al. (1980). Muscular weakness and lower limb rigidity were observed in 4 male rhesus monkeys given oral doses of manganese chloride (25 mg $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$ /kg, 6.9 mg Mn/kg-day) for 18 months. Histologic analysis showed degenerated neurons in the substantia nigra of the exposed animals at autopsy. There were no biochemical data. This study is of limited use for risk assessment because only one dose level was evaluated.

Studies involving oral exposures of manganese in drinking water or by gavage in neonatal rodent pups have reported changes in brain neurochemistry but generally do not show significant adverse effects on neurological development (ATSDR, 2000). Dorman et al. (2000) reported on neurological changes in rat pups dosed for 21 days postnatally with 11 or 22 mg Mn/kg-day by mouth in drinking water. The high dose group had significant increases in brain striatal DA (dopamine) and DOPAC (dihydroxyphenylacetic acid) concentrations and exhibited significant increases in the startle response, in the absence of pathological lesions. Because manganese is an essential nutrient in developing infants, the potential adverse effects from manganese deficiency may be of greater concern than potential toxicity from over-exposure.

Chandra et al. (1979) evaluated the neurological effects of manganese in mice exposed from birth. Neonatal mice were initially exposed by nursing from dams given 5 mg/mL MnCl_2 in their drinking water. After weaning at 25 days, the mice received manganese in their drinking water. Average exposures to manganese were determined to be 0.030 mg Mn/day for 60 days, 0.036 mg Mn/day through the 90th day, 0.075 mg Mn/day through the 120th day and 0.090 mg Mn/day for the interval between 150 and 180 days. Assuming a body weight of 0.03 kg at adulthood, the average daily dose at the termination of the experiment was approximately 3 mg Mn/kg-day. Elevated levels of striatal dopamine, norepinephrine, and homovanillic acid were

observed at 60 and 90 days of age, with a concomitant increase in spontaneous locomotor activity. Exposure past 90 days did not influence motor activity. Chandra et al. (1979) proposed that the hyperactivity observed in these mice was an early behavioral effect of excess manganese exposure that resulted from elevated dopamine and norepinephrine levels. The study authors further suggested that the observed hyperactivity may be comparable to the psychomotor excitement observed in the early stages of human manganism.

Chandra and Shukla (1981) exposed male albino rats to 1,000 mg/L $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$ (436 mg Mn/L) in drinking water. Assuming water consumption of 0.049 L/day and an average adult body weight of 0.35 kg, this level of exposure corresponds to an average daily dose of 61 mg Mn/kg-day. Levels of catecholamines, homovanillic acid, manganese, and the activity of monoamine oxidase were determined in the corpus striatum at time intervals up to 360 days. The investigators found initial increases in dopamine, norepinephrine, and homovanillic acid levels. This initial increase was followed by a period of normal levels. After 300 days, a decrease in all levels was observed. These changes were not correlated with the tissue concentration of manganese. The authors suggested that the decreased locomotor activity observed during later periods of manganese exposure may be related to lowered dopamine and norepinephrine levels in the brain, and that this stage of chronic toxicity may correspond to the later neurologic phase of motor dyskinesia in humans. Ali et al. (1981) conducted concurrent behavioral studies, and found an initial increase in spontaneous locomotor activity followed by a decrease during later periods of manganese exposure.

Purdey (2000) examined an endemic of sheep scrapie (a form of transmissible spongiform encephalopathy) in North Central/Eastern Iceland. Purdey reported high (200 ppm dry weight) levels of manganese in the herbage of areas where the sheep had suffered from a high incidence of scrapie for decades. Areas that were scrapie free had a mean level of 80 ppm dry weight of manganese in the herbage. These data, along with the data on CJD in humans (Purdey, 2000; Brown et al., 2000), suggest a link between high manganese and low copper in the etiology of these degenerative neurologic diseases, but further data are needed to support the hypothesis.

Reproductive and Developmental Studies

Reproductive Effects

The results of several studies in rats and mice indicate that the ingestion of high dose of manganese can delay reproductive maturation in male animals (ATSDR, 2000). Testosterone levels were reduced in male rats given an oral dose of 13 mg Mn/kg-day for 100-224 days (Laskey et al., 1982), while delayed growth of the testes was observed in young rats ingesting 140 mg Mn/kg-day for 90 days (Gray and Laskey, 1980). These effects do not appear to be severe enough to affect male reproductive function (ATSDR, 2000). Several studies which found effects on male reproductive organs, however, did not assess reproductive performance (IPCS, 1999).

Laskey et al. (1982) found a slight decrease in pregnancy rate but no significant effect on litter size, ovulations, resorption, or fetal weight when male and female rats were exposed to 130 mg Mn/kg-day (as Mn_3O_4) in the diet for 90-100 days prior to breeding.

The results of most studies indicate that oral exposure to manganese does not result in reproductive toxicity in the female rodent (e.g., rats and mice) and rabbit (See also ATSDR, 2000), although increased postimplantation loss was observed in female rats in at least one study (Szakmáry et al., 1995).

Developmental Effects

Results from several developmental studies in rodents and rabbits are equivocal. Data from the majority of these studies indicate that manganese exposure during part or all of gestation results in increased manganese levels in the pups (Järvinen and Ahlström, 1975; Kontur and Fechter, 1988), but generally causes either no measurable effect (Grant et al., 1997), transient effects such as weight decreases and hyperactivity (Pappas et al., 1997), or reversible effects on skeletal and organ development (Szakmáry et al., 1995). Joardar and Sharma (1990) administered varying levels of MnSO_4 (10.25, 20.25, and 61.00 mg/100 g bw) and KMnO_4 (6.5, 13, and 36 mg/100 g bw) to mice by gavage over a 3-week period. Sperm head abnormalities and the percentage of abnormal sperm were significantly increased in all treated groups.

Cancer and Mutagenicity Studies

Mutagenicity

Laboratory evidence for the mutagenicity and genotoxicity of high dose manganese exposure is equivocal. Joardar and Sharma (1990) administered varying levels of MnSO_4 (10.25, 20.25, and 61.00 mg/100 g bw) and KMnO_4 (6.5, 13, and 36 mg/100 g bw) to mice over a 3-week period. The frequencies of chromosomal aberrations and micronuclei in bone marrow cells were significantly increased. Dikshith and Chandra (1978) administered repeat oral doses of 0.014 mg Mn/kg-day (as MnCl_2) to albino rats for 180 days with no significant chromosomal damage noted in either bone marrow or spermatogonial cells.

In vitro bacterial gene mutation tests have yielded both positive and negative results, while *in vitro* tests with fungi and mammalian cells have been predominantly positive. Manganese chloride produced an increased frequency of mutations in *Salmonella typhimurium* strain TA1537, but induced negative results in other strains; manganese sulfate was reported to be both positive and negative in separate studies in *Salmonella* strain TA97, but negative in other strains (IPCS, 1999). Positive results were obtained with various manganese compounds in *Phytobacterium fischeri* and *Escherichia coli*, as well as in *Saccharomyces cerevisiae* and hamster embryo cells (ATSDR, 2000). In spite of these results, the genotoxic potential of manganese in humans is not known (IPCS, 1999).

Carcinogenicity

No animal studies are available that have investigated the potential carcinogenicity of manganese following inhalation or dermal exposure (ATSDR, 2000). A 2-year oral study of manganese sulfate in rats and mice produced equivocal evidence of carcinogenicity (NTP, 1993). In rats fed manganese sulfate (30-331 mg Mn/kg-day in males, 26-270 mg Mn/kg day in females), no treatment-related increases in tumor incidence were reported. In mice fed manganese sulfate (63-722 mg Mn/kg-day in males, 77-905 mg Mn/kg-day in females), the incidence of follicular cell adenoma of the thyroid was increased slightly in high-dose animals compared to controls. These increases were not statistically significant, and the tumors were observed at the end of the study only. However, follicular cell adenoma of the thyroid appears with low frequency in historical control male mice of this strain. Thus, the significance of these results and their relevance to typical human oral exposure to manganese is questionable.

Stoner et al. (1976) tested manganese sulfate in a mouse lung adenoma screening bioassay. These investigators exposed 6- to 8-week-old Strain A/Strong mice of both sexes (10/sex) to 6, 15 or 30 mg MnSO₄/kg via intraperitoneal injection. Doses were administered three times a week for a total of 21 injections. The cumulative doses were 132, 330 and 660 mg MnSO₄/kg, corresponding to 42.9, 107.2 and 214.4 mg Mn/kg. Observation continued for 22 weeks after the dosing period, and the mice were sacrificed at 30 weeks. The percentage of mice with tumors was elevated at the highest dose level, but the difference was not significant when compared with the vehicle controls. An apparent increase in the average number of pulmonary adenomas per mouse was noted both at the middle and high doses, but the increase was significant only at the high dose (660 mg MnSO₄/kg; $p < 0.05$). Although the study results are suggestive of carcinogenic activity, they do not conclusively meet the positive-response criteria (increased tumor incidence and an observable dose-response relationship) for the interpretation of lung tumor data in this mouse strain (Shimkin and Stoner, 1975).

6.0 QUANTIFICATION OF TOXICOLOGICAL EFFECTS

Limitations of Using Rodent Data In Assessing Neurotoxicity of Manganese

There are considerable species differences between rodents and primates in nutritional requirements as well as neurotoxicity of manganese. Therefore, rodents are of limited value in assessing the neurobehavioral effects associated with extrapyramidal deficits (Chandra, 1983).

Manganese has a propensity for accumulation in the melanin pigment (Lyden et al., 1985) and there is a relative lack of neuromelanin in rodents. This may explain the fact that neurologic effects (e.g., tremor, gait disorders) seen in primates are often preceded or accompanied by psychologic symptoms (e.g., irritability, emotional lability) but are not apparent in rodents.

Contributing to the difficulties in interpreting the toxicologic data from exposure of rodents to manganese is the substantial difference in species' requirements for this dietary element. The estimated requirement for rats is 50 mg Mn/kg diet (Rogers, 1979). Assuming a

food consumption equivalent to 5% of body weight (U.S. EPA, 1986a), this corresponds to a requirement for about 2.5 mg Mn/kg body weight (bw)/day. In contrast, the adequate intake for men and women (including lactating women) is about 2.3 -2.6 mg Mn/day, or about 0.03 - 0.07 mg Mn/kg bw/day, assuming a reference body weight of 70 kg. The dietary requirement for manganese in humans, then, is about two orders of magnitude lower than for rodents, suggesting that data derived from rodent studies may not be appropriate for use in deriving quantitative estimates of manganese levels that might be expected to result in adverse effects in humans.

As discussed above, rodent studies are limited in their use as a database from which to extrapolate effects in humans from over-exposure to manganese, because rodents do not exhibit the same neurologic deficits that humans do following exposure to manganese. On the other hand, the optimal levels of oral exposure to manganese for humans have not been well defined. For example, the available epidemiological studies in drinking water are of limited use in quantitative assessment of manganese toxicity, because of a lack of total exposure data. Balance studies are also not useful because short and moderate-term manganese balance studies are found not to be proportional to manganese intakes (Greger, 1999). Therefore, the health advisories (acute and chronic) are based on human dietary studies (See Sections below).

Dose Response and Risk Characterization

Manganese is a ubiquitous element that is essential for normal physiologic functioning in all animal species. Several disease states in humans have been associated with both deficiencies and excess intakes of manganese. Thus any quantitative risk assessment for manganese must take into account aspects of both the essentiality and the toxicity of manganese. In humans, many data are available providing information about the range of essentiality for manganese. In addition, there are many reports of toxicity to humans exposed to manganese by inhalation; much less is known, however, about oral intakes resulting in toxicity. As discussed above, rodents do not provide a good experimental model for manganese toxicity, and only one limited study in primates by the oral route of exposure is available (Gupta et al., 1980). The following assessment, therefore, focuses more on what is known to be a safe oral intake of manganese for the general human population. Finally, it is important to emphasize that individual requirements for, as well as adverse reactions to, manganese may be highly variable. The reference dose is estimated to be an intake for the general population that is not associated with adverse health effects; this is not meant to imply that intakes above the reference dose are necessarily associated with toxicity. Some individuals may, in fact, consume a diet that contributes more than 10 mg Mn/day without any cause for concern.

Determination of Health Advisories

Health Advisories (HAs) are generally determined for one-day, ten-day and life time exposure if adequate data are available that identify a sensitive noncarcinogenic end point of toxicity. The HAs for noncarcinogenic toxicants are derived using the following formula:

$$HA = \frac{(\text{NOAEL or LOAEL}) \times (\text{BW})}{(\text{UF}) (\text{L/day})} = \text{mg/L} (\text{: g/L})$$

where:

NOAEL or LOAEL = No- or Lowest-Observed-Adverse-Effect Level (in mg/kg bw/day).

BW = assumed body weight of a child (10 kg) or an adult (70 kg).

UF = uncertainty factor (10, 100, 1,000 or 10,000) in accordance with EPA or NAS/ODW guidelines.

L/day = assumed daily water consumption of a child (1 L/day) or an adult (2 L/day).

One-day HA

No suitable information was found in the available literature for determining the One-day HA for manganese. The Ten-day HA for a child of 1 mg/L, calculated below is recommended for use as a conservative estimate for a 1-day exposure for both children and adults.

Ten-day HA

The adequate intake for a child 7 to 12 months old is 0.6 mg/day, and that from a 1 to 3-year-old is 1.2 mg/day (IOM, 2002). Taking the upper end of the adequate intake for a 10 kg child (up to 1 mg/day), and assuming the manganese comes from a maximum of 1 liter of formula per day, this would correspond to a manganese concentration of 1 mg/L. This 10-day HA for a child should also be protective of adults.

The Ten-day HA for a 10-kg child is calculated as follows:

$$1\text{- and }10\text{-day HA} = \frac{1 \text{ mg/day}}{1 \text{ L/day}} = 1 \text{ mg/L}$$

However, it is advised that for infants younger than 6 months, the lifetime HA of 0.3 mg/L be used even for an acute exposure of 10 days, because of the concerns for differences in manganese content in human milk and formula and the possibility of a higher absorption and lower excretion in young infants.

Lifetime Health Advisory

Lifetime health advisories are only developed for chemicals that are not likely to be carcinogenic to humans. The Lifetime HA represents that portion of an individual's total exposure that is attributed to drinking water and is considered protective of noncarcinogenic adverse health effects over a lifetime exposure. The Lifetime HA is derived in a three-step process. Step 1 determines the Reference Dose (RfD), formerly called the Acceptable Daily Intake (ADI). The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious health effects during a lifetime, and is derived from the NOAEL (or LOAEL), identified from a chronic (or subchronic) study, divided by an uncertainty factor(s). From the RfD, a Drinking Water Equivalent Level (DWEL) can be determined (Step 2). A DWEL is a medium-specific (i.e., drinking water) lifetime exposure level, assuming 100% exposure from that medium, at which adverse, noncarcinogenic health effects would not be expected to occur. The DWEL is derived from the multiplication of the RfD by the assumed body weight of an adult and divided by the assumed daily water consumption of an adult. The Lifetime HA in drinking water alone is determined in Step 3 by factoring in other sources of exposure, e.g., the relative source contribution (RSC). The RSC from drinking water is based on actual exposure data or, if data are not available, a value of 20% is assumed.

Step 1: Determination of Reference Dose (RfD)

Choice of Principal Study and Critical Effect

Manganese is an essential trace element that is required for normal physiologic function in humans and animals. Excess exposure to manganese, particularly via the inhalation route, is associated with neurotoxicological symptoms that resemble parkinsonism. Thus, derivation of the RfD must consider issues of both essentiality and toxicity.

The RfD is not based on rodent studies, because rodents do not exhibit the same neurologic deficits that humans do following exposure to manganese. For example, manganese at high doses induces Parkinson-like symptoms in humans and primates, but not in rodents. Because of the species difference in the response to manganese exposure, rodents are not good models for manganese toxicity studies. More details on these species differences can be seen in IRIS (U.S. EPA, 1997).

The oral toxicity data on which risk assessments may be based are quite limited in scope. It is recognized that the information available in humans is inherently more useful than data obtained from laboratory animals, especially non-primates. However, the toxicity data in humans following ingestion of large amount of manganese are not suitable for a quantitative assessment (For details, See Section 5.1.2 Long-term Exposure).

Dose-Response Assessment

Based on the dietary information described by WHO (1973), Schroeder et al. (1966), and NRC (1989), EPA estimated that an intake of 10 mg Mn/day (0.14 mg Mn/kg-day, assuming a body weight of 70 kg) in the diet is safe for a lifetime of exposure. This level of manganese represents

a NOAEL for chronic ingestion of manganese by humans. Application of a UF of 1 was used to derive the dietary RfD of 0.14 mg Mn/kg-day (U.S. EPA, 1997). The use of 1 as the UF is based on the following considerations. Manganese is an essential trace element for human health. The information used to derive the RfD was collected from many large human populations consuming normal diets over an extended period of time. The available data suggest that as long as physiological systems are not overwhelmed, humans exert effective homeostatic control over manganese so that body burden is kept relatively constant even when the concentration of manganese in the diet varies.

Application of Modifying Factor in Water

U.S. EPA (1997) has recommended the use of a modifying factor of 3 when assessing exposure to manganese from drinking water. Four reasons for this recommendation have been outlined:

- While toxicokinetic data suggest that there is no significant difference in absorption of manganese from food versus water, uptake of manganese from water appears to be greater in fasted individuals.
- The study by Kondakis et al. (1989) raises concern for possible adverse health effects associated with a lifetime consumption of drinking water containing 2 mg/L of manganese.
- Evidence exists that neonates absorb more manganese from the gastrointestinal tract, and excrete less of the absorbed manganese. Additional evidence suggests that absorbed manganese more easily crosses the blood-brain barrier in neonates. However, this evidence comes from animal studies; similar absorption studies in human neonates have not been performed, although Collipp et al. (1983) observed increased hair manganese levels in infants fed prepared formula compared with infants fed breast milk.
- Infant formula typically contains a much higher concentration of manganese than human or cows' milk. Powdered formula reconstituted with drinking water represents an additional source of manganese intake for a potentially sensitive population.

The potential impacts on children, when considered in conjunction with the likelihood that the most adverse effects of manganese (e.g., those seen in manganese miners or others with chronic overexposure to inhaled manganese) are likely to be irreversible and not manifested for many years after exposure, warrant caution until more definitive data are available (U.S. EPA, 1997). Recent data indicate, however, that in contrast to the symptoms of manganism, preclinical neurological effects of inhalation exposure of occupational workers to excess manganese are reversible (Roels et al., 1999). Similarly, symptoms of oral exposure to excess manganese in compromised individuals (e.g., individuals with liver disease who could not excrete manganese in the bile) were resolved when the exposure to excess manganese was decreased (Devenyi et al., 1994; Fell et al., 1996). These data indicate that the human body can recover from certain adverse effects of overexposure to manganese if the exposure is stopped

and the body can clear the excess. Significant uncertainty still exists, however, concerning at what level of manganese intake these preclinical neurological symptoms might occur.

The RfD for chronic exposure to manganese in drinking water is therefore calculated as follows:

$$\text{RfD} = \frac{10 \text{ mg/day}}{1 \times 70 \text{ kg}} = 0.14 \text{ mg/kg-day}$$

where:

10 mg/person-day = chronic no adverse effect level per person from dietary intake

1 = uncertainty factor

70 kg = assumed body weight of adult

Step 2: Determination of the Drinking Water Equivalent Level (DWEL)

$$\text{DWEL} = \frac{(0.14 \text{ mg/kg-day})(70 \text{ kg})}{3 (2 \text{ L/day})} = 1.6 \text{ mg/L (1600 : g/L)}$$

where:

0.14 mg/kg-day = RfD

70 kg = assumed body weight of adult

2 L/day = assumed water consumption by 70-kg adult

3 = modifying factor for assessing exposure to manganese from drinking water (mainly for bioavailability concerns)

Step 3: Determination of the Lifetime HA

The Lifetime HA = (1.6 mg/L)(20%) = 0.3 mg/L (rounded from 0.32 mg/L)

where

1.6 mg/L = DWEL

20% = relative source contribution for manganese in drinking water

Evaluation of Carcinogenic Potential

- Available data are equivocal regarding carcinogenic potential of manganese.
- Based on the Draft Guidelines for Carcinogen Risk Assessment (U.S. EPA, 2003b; 1999), there is inadequate information to assess the human carcinogenic potential for manganese.
- Based on 1986 Guidelines for Carcinogen Risk Assessment (U.S. EPA, 1986b) manganese has been classified in Group D: Not classified as to human carcinogenicity.

7.0 ANALYTIC METHODS AND TREATMENT TECHNOLOGY

Analytical Methods

Manganese can be measured by several well-documented analytical methods as shown in the Table 7-1.

Treatment Technology

The technologies include conventional treatment, ion exchange, reverse osmosis, lime softening, and chemical precipitation.

Conventional treatment usually includes pre-treatment steps of chemical coagulation, rapid mixing, and flocculation, followed by flocculation removal via sedimentation or flotation. After clarification, the water is then filtered. Common filter media include sand, and dual- and tri-media (e.g., silica sand, garnet sand, or anthracitic coal).

Ion exchange involves the selective removal of charged inorganic species from water using an ion-specific resin. The surface of the ion exchange resin contains charged functional groups that hold ionic species by electrostatic attraction. As water containing contaminant ions passes through a column of resin beds, charged ions on the resin surface are exchanged for the contaminant species in the water.

Reverse osmosis (RO) is similar to other membrane processes, such as ultrafiltration and nanofiltration, since water passes through a semi-permeable membrane. However, in the case of RO, the principle involved is not filtration. Instead, it involves the use of applied hydraulic pressure to oppose the osmotic pressure across a non-porous membrane, forcing the water from the concentrated solution side to the dilute solution side. The water does not travel through pores, but rather dissolves into the membrane, diffuses across, then dissolves out into the permeate. Most inorganic and many organic contaminants are rejected by the membrane and will be retained in the concentrate.

In the lime-softening process, the pH of the water being treated is raised sufficiently to precipitate calcium carbonate and, if necessary, magnesium hydroxide. Calcium and magnesium

ions in water cause hardness. After mixing, flocculation, sedimentation, and pH readjustment, the softened water is filtered.

Results of a preliminary technology assessment and review indicate that all of the above-mentioned techniques remove manganese from water. However, data indicate that chemical precipitation is the most effective option.

Table 7-1: Analytical Methods for Manganese

Method	Type	Method Detection Limit (µg/L)
EPA 200.7	Inductively Coupled Plasma Optical Emission Spectrometry (ICP)/Atomic Emission Spectrometry	1.0
SM 3120 B	ICP/Atomic Emission Spectrometry	Estimated Detection Limit (EDL) 2.0
EPA 200.8	ICP/Mass Spectrometry	0.02
SM 3111B	Atomic Absorption, direct aspiration	Instrument Detection Level (IDL) 10 Optimum conc. range 100-10,000
EPA 200.9	Stabilized Temperature Graphite Furnace AA Spectrometry	0.3
SM 3113 B	Atomic Absorption, Furnace	EDL 0.2 Optimum conc. range 1-30

8.0 OTHER CRITERIA, GUIDANCE AND STANDARDS

- There is no current Maximum Contaminant Level (MCL) for manganese.
- OSHA (1998) has established a maximum permissible air exposure limit for manganese fumes at no greater than 5 mg/m³ and elemental or inorganic manganese at no greater than 0.2 mg/m³, averaged over any 8-hour period in the workplace environment.

- The World Health Organization (WHO) has established a provisional guideline value for manganese of 0.5 mg/L. This guideline is provisional because there is some evidence of a potential hazard, but available information on health effects is limited. Concentrations of this substance at or below the health-based guideline value may affect appearance, taste, or odor of water.
- EPA recommends a concentration of manganese in drinking water not to exceed 0.05 mg/L (ppm). This recommendation is to avoid staining of clothing and fixtures and is believed to be more than adequate to protect human health.
- The Food and Drug Administration (FDA) also recommends 0.05 mg/L of manganese in bottled water.
- EPA has also established rules setting limits on the amount of manganese factories can discharge to the water.

9.0 REFERENCES

- Ali, M.M., G.S. Shukla, D.K. Saxena, et al. 1981. Behavioral dysfunctions and central neurotransmitters in manganese exposed rats. J. Environ. Biol. 2:29-39 (as cited in ATSDR, 2000).
- Andersen, M.E., J.M. Gearhart, and H.J. Clewell. 1999. Pharmacokinetic data needs to support risk assessment for inhaled and ingested manganese. NeuroToxicol. 20:161-171.
- ANSI/NSF. 2000. American National Standards Institute, NSF International. Drinking water treatment chemicals - Health effects. ANSI/NSF 60-2000. Ann Arbor, MI.
- ATSDR. 2000. *Toxicological Profile for Manganese*. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.
- Bales, C. W., J.H. Freeland-Graves, P.H. Lin, et al. 1987. Plasma uptake of manganese: Influence of dietary factors. In: Kies, C., ed., *Nutritional Bioavailability of Manganese*. Washington D.C.: American Chemical Society, pp. 112-122.
- Banta, R. G. and W .R. Markesbery. 1977. Elevated manganese levels associated with dementia and extrapyramidal signs. Neurology 27:213-216.
- Barceloux D.G. 1999. Manganese. Clin.Toxicol. 37:293-307.
- Bean E.L. 1974. Potable water-quality goals. J. Amer. Water Works Assoc. 66:221.
- Bell, J.G., C.L. Keen, and B. Lönnnerdal. 1989. Higher retention of manganese in suckling than in adult rats is not due to maturational differences in manganese uptake by rat intestine. J. Toxicol. Environ. Health 26:387-398.
- Bench, G., T.M. Carlsen, P.G. Grant, J.S. Wollett Jr., R.E. Martinelli, J.L. Lewis, K.K. Divine. 2001. Olfactory bulb uptake and determination of biotransfer factors in the California ground squirrel (*Spermophilus beecheyi*) exposed to manganese and cadmium in environmental habitats. Environ. Science Tech. 35:270- 7.
- Bleich, S., D. Degner, R. Sprung, A. Riegel, W. Poser, E. Ruther. 1999. Chronic manganism: Fourteen years follow-up. J. Neuropsych. Clin. Neurosci. 11: 117.
- Brenneman, K.A., B.A. Wong, M.A. Buccellato, E.R. Costa, E.A. Gross, and D.C. Dorman. 2000. Direct olfactory transport of inhaled manganese ($^{54}\text{MnCl}_2$) to the rat brain: Toxicokinetic investigations in a unilateral nasal occlusion model. Toxicol. App. Pharmacol. 169:238-248.
- Brown, D.R., F. Hafiz, L.L. Glassmith, B.S. Wong, I.M. Jones, C. Clive, and S.J. Haswell. 2000. Consequences of manganese replacement of copper for prion protein function and proteinase-resistance. EMBO J. 19:1180-6.

Canavan, M.M., S. Cobb, and C. Srinker. 1934. Chronic manganese poisoning. *Arch. Neurol. Psych.* 32:501-12.

Cawte, J., and M. T. Florence. 1989. A manganic milieu in North Australia: Ecological manganism: Ecology; diagnosis; individual susceptibility; synergism; therapy; prevention; advice for the community. *Int. J. Biosocial. Med. Res.* 11(1):43-56.

Chandra, S.V., G.S. Shukla and D.K. Saxena. 1979. Manganese-induced behavioral dysfunction and its neurochemical mechanism in growing mice. *J. Neurochem.* 33(6):1217-1221.

Chandra, S.V. and G.S. Shukla. 1981. Concentrations of striatal catecholamines in rats given manganese chloride through drinking water. *J. Neurochem.* 36(2):683-687.

Chandra 1983. Neurological consequences of manganese imbalance. In Dreosti IE, Smith RM (eds), *Neurobiology of the trace elements, 2: neurotoxicology and neuropharmacology*. Humana Press, Clifton, NJ, pp 167-96.

Collipp, P.J., S.Y. Chen, and S. Maitinsky. 1983. Manganese in infant formulas and learning disability. *Annals Nutr. Metabol.* 27:488-494.

Cook, D.G., S. Fahn, and K.A. Brait. 1974. Chronic manganese intoxication. *Archives of Neurology* 30:59-64.

Davidsson L., A. Cederblad, B. Lönnerdal, and B. Sandström. 1989a. Manganese absorption from human milk, cow's milk, and infant formulas in humans. *Amer. J. Dis. Children* 43(7):823-827.

Davidsson, L., A. Cederblad, B. Lönnerdal, and B. Sandström. 1989b. Manganese retention in man: A method for estimating manganese absorption in man. *Amer. J. Clin. Nutr.* 49:170-179.

Davis, C.D. and J.L. Greger. 1992. Longitudinal changes of manganese-dependent superoxide dismutase and other indexes of manganese and iron status in women. *Amer. J. Clin. Nutr.* 55:747-752.

Deskin, R., S.J. Bursian, and F.W. Edens. 1980. Neurochemical alterations induced by manganese chloride in neonatal rats. *NeuroToxicol.* 2:65-73.

Deskin, R., S.J. Bursian and F.W. Edens. 1981. The effect of chronic manganese administration on some neurochemical and physiological variables in neonatal rats. *Gen. Pharmacol.* 12(4):279-280.

Devenyi, A.G., T.F. Barron, and A.C. Mamourian. 1994. Dystonia, hyperintense basal ganglia, and high whole blood manganese levels in Alagille's syndrome. *Gastroenterol.* 106(4):1068-1071.

Dikshith, T.S. and S.V. Chandra. 1978. Cytological studies in albino rats after oral

administration of manganese chloride. Bull. Environ. Contam. Toxicol. 19(6):741-746.

Dorman, D.C., M.F. Struve, D. Vitarella, G.L. Byerly, J. Goetz, and R. Miller. 2000. Neurotoxicity of manganese chloride in neonatal and adult CD rats following subchronic (21-day) high-dose oral exposure. J. Applied Toxicol. 20: 179-187.

Dörner, K., E. Sievers, and S. Dziadzka. 1987. Manganese utilization in breast-fed and formula-fed infants. In: Goldman, A.A, S.A. Atkinson and L.A. Hanson, eds., Human Lactation. New York: Plenum Press. pp. 89-97.

Elias, Z., J.M. Mur, F. Pierre, et al. 1989. Chromosome aberrations in peripheral blood lymphocytes of welders and characterization of their exposure by biological samples analysis. J. Occup. Med. 31:477-483.

Emara, A.M., S.H. El-Ghawabi, O.I. Madkour, et al. 1971. Chronic manganese poisoning in the dry battery industry. Br. J. Ind. Med. 28:78-82 (as cited in ATSDR 2000).

Eriksson, H., S. Lenngren, and E. Heilbronn. 1987. Effect of long-term administration of manganese on biogenic amine levels in discrete striatal regions of rat brain. Arch. Toxicol. 59:426-431.

Ethyl Corporation. 1997. The case for an environmentally beneficial fuel additive. Baton Rouge, USA (as cited in Lynam, 1999).

Exon, J.H. and L.D. Koller. 1975. Effects of feeding manganese antiknock gasoline additive exhaust residues (Mn_3O_4) in rats. Bull. Environ. Contam. Toxicol. 14:370-373.

Fechter, L.D. 1999. Distribution of manganese in development. NeuroToxicol. 20:197-201.

Fell, J.M.E., A.P. Reynolds, N. Meadows, et al. 1996. Manganese toxicity in children receiving long-term parenteral nutrition. Lancet 347:1218-1221.

Finley, J.W. 1999. Manganese absorption and retention by young women is associated with serum ferritin concentration. Amer. J. Clin. Nutr. 70:37-43.

Florence, T.M. and J.L. Stauber. 1989. Manganese catalysis of dopamine oxidation. Science Total Environ. 78:233-240.

Freeland-Graves, J.H., C W. Bales, and F. Behmardi. 1987. Manganese requirements of humans. In: Kies, C., ed., Nutritional Bioavailability of Manganese. Washington, D.C.: American Chemical Society, pp. 90-104.

Freeland-Graves, J.H. and C. Llanes. 1994. Models to study manganese deficiency. In: Klimis-Tavantzis, D.J., ed., *Manganese in Health and Disease*. Boca Raton, FL: CRC Press, Inc., pp. 59-86.

Gianutsos, G., G.R. Morrow, J. B. Morris. 1997. Accumulation of manganese in rat brain

following intranasal administration. *Fund. Applied Toxicol.* 37:102-105.

Gianutsos, G., M.D. Seltzer, R. Saymeh, et al. 1985. Brain manganese accumulation following systemic administration of different forms. *Arch. Toxicol.* 57(4):272-275.

Gibbons, R.A., S.N. Dixon, K. Hallis, et al. 1976. Manganese metabolism in cows and goats. *Biochim. Biophys. Acta* 444:1-10.

Gibson, R.S. 1994. Content and bioavailability of trace elements in vegetarian diets. *American J. Clin. Nutr.* 59(suppl):1223S-1232S.

Goldsmith, J., Y. Herishanu, J. Abarbanel, et al. 1990. Clustering of Parkinson's disease points to environmental etiology. *Arch. Environ. Health* 45:88-94 (as cited in ATSDR, 2000).

Grant, D., W.F. Blazak, and G.L. Brown. 1997. The reproductive toxicology of intravenously administered MnDPDP in the rat and rabbit. *Acta Radiol.* 38 (4 Pt 2):759- 769.

Gray, L.E. and J.W. Laskey. 1980. Multivariate analysis of the effects of manganese on the reproductive physiology and behavior of the male house mouse. *J. Toxicol. Env. Health* 6:861-867.

Greger, J.L. 1998. Dietary standards for manganese: Overlap between nutritional and toxicological studies. *J. Nut.* 128:368S-371S.

Greger, J.L. 1999. Nutrition *versus* toxicology of manganese in humans: Evaluation of potential biomarkers. *NeuroToxicol.* 20:205-212.

Griffin, A.E. 1960. Significance and removal of manganese in water supplies. *J. Amer. Water Works Assoc.* 52:1326.

Gupta, S.K., R.C. Murthy, and S.V. Chandra. 1980. Neuromelanin in manganese-exposed primates. *Tox. Letters* 6: 17-20.

Hauser, R.A., T.A. Zesiewicz, C. Martinez, A.S. Rosemurgy, and C.W. Olanow. 1996. Blood manganese correlates with brain magnetic resonance imaging changes in patients with liver disease. *Can. J. Neurol. Sci.* 23:95-98.

He, P., D. Liu, G. Zhang, S. Maosen. 1994. [Effects of high-level manganese sewage irrigation on children's neurobehavior]. *Chung Hua Yu Fang I Hsueh Tsa Chih*, 28:216-218 (Chinese).

Henriksson, J. and H. Tjälve. 2000. Manganese taken up into the CNS via the olfactory pathway in rats affects astrocytes. *Toxicol. Sciences* 55:392-8.

Hietanen, E., J. Kilpio and H. Savolainen. 1981. Neurochemical and biotransformational enzyme responses to manganese exposure in rats. *Arch. Environ. Contam. Toxicol.* 10(3):339-345.

Holzgraefe, M., W. Poser, H. Kijewski, W. Beuche. 1986. Chronic enteral poisoning caused by potassium permanganate: A case report. J. Toxicol. Clin. Toxicol. 24:235-244 [erratum in: J. Toxicol. Clin. Toxicol. 24:462].

HSDB. 2001. Manganese compounds. Hazardous Substances Data Bank. Last revised: May 23, 2001. Available on the Internet at:
<http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~BAA.EaWOW:2>

Hurley, L.S., C.L. Keen, and D.L. Baly. 1984. Manganese deficiency and toxicity: effects on carbohydrate metabolism in the rat. NeuroToxicol. 5:97-104.

Hurley, L.S. and C.L. Keen. 1987. Manganese. In: Mertz W, ed. Trace Elements in Human and Animal Nutrition, Vol. 1. 5th ed. New York, NY, Academic Press, pp. 185-223.

Ingersoll, R.T., E.B. Montgomery Jr., and H.V. Aposhian. 1995. Central nervous system toxicity of manganese. I. Inhibition of spontaneous motor activity in rats after intrathecal administration of manganese chloride. Fund. Applied Toxicol. 27:106-113.

IOM. 2002. Institute of Medicine. Dietary Reference Intakes: Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Food and Nutrition Board, Institute of Medicine. Washington DC: National Academy Press. pp. 10-1 - 10-22.

IPCS. 1999. *Manganese and its Compounds*. Concise International Chemical Assessment Document 12, International Programme on Chemical Safety, World Health Organization. Available on the Internet at: <http://www.inchem.org/documents/cicads/cicads/cicad12.htm>.

Iwami, O., T. Watanabe, C.S. Moon, H. Nakatsuka and M. Ikeda. 1994. Motor neuron disease on the Kii Peninsula of Japan: Excess manganese intake from food coupled with low magnesium in drinking water as a risk factor. Science Total Environ. 149:121-135.

Järvinen, R. and A. Ahlström, 1975. Effect of the dietary manganese level on tissue manganese, iron, copper, and zinc concentrations in female rats and their fetuses. Med. Biol. 53:93-99.

Jiang, Y., J. Lu, P. Xie, et al. 1996. [Effects of manganese on the sexual function and reproductive outcome of male exposed workers]. Chi. J. Ind. Hyg. Occup. Dis. 14:271-273. (Chinese) (as cited in ATSDR 2000).

Joardar, M. and A. Sharma. 1990. Comparison of clastogenicity of inorganic Mn administered in cationic and anionic forms *in vivo*. Mutat. Res. 240(3):159-163.

Johnson, P.E., G.I. Lykken, and E.D. Korynta, 1991. Absorption and biological half-life in humans of intrinsic ⁵⁴Mn tracers from foods of plant origin. J.Nutr. 121:711-717.

Kato, M. 1963. Distribution and excretion of radiomanganese administered to the mouse. Q. J. Exp. Physiol. 48:355-369.

- Kawamura, C.L., H. Ikuta, S. Fukuzimi, R. Yamada, S. Tsubaki, T. Kodama, and S. Kurata. 1941. Intoxication by manganese in well water. *Kitasato Arch. Exp. Med.* 18:145-169.
- Keen, C.L., J.G. Bell, and B. Lönnnerdal. 1986. The effect of age on manganese uptake and retention from milk and infant formulas in rats. *J. Nutr.* 116:395-402.
- Keen, C.L., J.L. Ensunsa, M.S. Clegg. 2000. Manganese metabolism in animals and humans including the toxicity of manganese. *Met. Ions Biol. Syst.* 37:89-121.
- Keen, C.L., J.L. Ensunsa, M.H. Watson, D.L. Baly, S.M. Donovan, M.H. Monaco and M.S. Clegg. 1999. Nutritional Aspect of Manganese from Experimental Studies. *Nerotox.*, 20:213-226.
- Kies, C. 1994. Bioavailability of Manganese. Editor: Klimis-Tavantzis, DJ. *Manganese Health Dis.*, 39-58. CRC Press, Boca Raton
- Kihira, T., M. Mukoyama, K. Ando, et al. 1990. Determination of manganese concentrations in the spinal cords from amyotrophic lateral sclerosis patients by inductively coupled plasma emission spectroscopy. *J. Neurol. Sci.* 98:251-258 (as cited in ATSDR 2000).
- Kilburn, C.J. 1987. Manganese, malformation and motor disorders: Findings in a manganese exposed population. *NeuroToxicol.* 8(3):421-430.
- Kimura, M., N. Yagi and Y. Itokawa. 1978. Effect of subacute manganese feeding on serotonin metabolism in the rat. *J. Toxicol. Environ. Health* 4(5-6):701-707.
- Komura, J. and M. Sakamoto. 1991. Short-term oral administration of several manganese compounds in mice: physiological and behavioral alterations caused by different forms of manganese. *Bull. Environ. Contam. Toxicol.* 46(6):921-928.
- Kondakis, X.G., N. Makris, M. Leotsinidis, M. Prinou, and T. Papapetropoulos. 1989. Possible health effects of high manganese concentration in drinking water. *Arch. Environ. Health* 44: 175-178.
- Kontur, P.J. and L.D. Fechter. 1985. Brain manganese, catecholamine turnover, and the development of startle in rats prenatally exposed to manganese. *Teratol.* 32(1): 1-11
- Kontur, P.J. and L.D. Fechter. 1988. Brain regional manganese levels and monoamine metabolism in manganese-treated neonatal rats. *Neurotoxicol. Teratol.* 10:295-303.
- Kostial, K., M. Blanusa, T. Malijkovic, D. Kello, I. Rabar, and J.F. Stara. 1989. Effect of a metal mixture in diet on the toxicokinetics and toxicity of cadmium, mercury, and manganese in rats. *Tox. Ind. Health* 5:685-698.
- Kostial, K., D. Kello, S. Jugo, et al. 1978. Influence of age on metal metabolism and toxicity. *Environ. Health Perspect.* 25:81-86.

Kristensson, K., H. Eriksson, B. Lundh, et al. 1986. Effects of manganese chloride on the rat developing nervous system. *Acta Pharmacol. Toxicol.* (Copenh.) 59:345-348

Lai, J.C., T.K. Leung, and L. Lim. 1984. Differences in the neurotoxic effects of manganese during development and aging: Some observations on brain regional neurotransmitter and non-neurotransmitter metabolism in a developmental rat model of chronic manganese encephalopathy. *NeuroToxicol.* 5:37-47.

Larsen, L.E. and D. Grant. 1997. General toxicology of MnDPDP. *Acta Radiol.* 38 (4 Pt 2):770- 779.

Laskey, J.W., G.L. Rehnberg, J.F. Hein, and S.D. Carter. 1982. Effects of chronic manganese (Mn_3O_4) exposure on selected reproductive parameters in rats. *J. Toxicol. Environ. Health* 9:677-687.

Lauwerys, R., H. Roels, P. Genet, et al. 1985. Fertility of male workers exposed to mercury vapor or to manganese dust: A questionnaire study. *Am. J. Ind. Med.* 7:171-176 (as cited in ATSDR, 2000).

Leach, R.M. and E.D.Harris. 1997. Manganese. *Clinical Nutrition in Health and Disease*, 2 (Handbook of Nutritionally Essential Mineral Elements), 335-355.

Leahy, P.P., and T.H. Thompson. 1994. The National Water-Quality Assessment Program. U.S. Geological Survey Open-File Report 94-70. 4 pp. Available on the Internet at: <http://water.usgs.gov/nawqa/NAWQA.OFR94-70.html>. Last updated August 23,2000.

Leung, T.K., J.C. Lai and L. Lim. 1982. The effects of chronic manganese feeding on the activity of monoamine oxidase in various organs of the developing rat. *Comp. Biochem. Physiol.* 71C (2):223-228

Lönnerdal, B. 1994. Manganese nutrition of infants. In: Klimis-Tavantzis, D.J., ed., *Manganese in Health and Disease*. CRC Press, Boca Raton, FL, pp. 175-191.

Lönnerdal, B., C.L. Keen, J.G. Bell, and B. Sandström. 1987. Manganese uptake and retention: Experimental animal and human studies. In: Kies, C., ed., *Nutritional Bioavailability of Manganese*. American Chemical Society, Washington, D.C. pp. 9-20.

Lutz, T.A., A. Schroff, and E. Scharrer. 1993. Effect of calcium and sugars on intestinal manganese absorption. *Biol. Trace Elem. Res.* 39:221-227.

Lyden, A, B.S. Larsson, N.G. Linquist.1985. Melanin affinity of manganese. *Acta Pharmacol Toxicol* 55:133.

Lynam, D.R., J.W. Roos, G.D. Pfeifer, B.F. Fort, and T.G. Pullin. 1999. Environmental effects and exposures to manganese from use of methylcyclopentadienyl manganese tricarbonyl (MMT) in gasoline. *NeuroToxicol.* 20:145-150.

- Maynard, L.S. and G.C. Cotzias. 1955. The partition of manganese among organs and intracellular organelles of the rat. *J. Biol. Chem.* 214:489-495
- McDermott, S.D. and C. Kies. 1987. Manganese usage in humans as affected by use of calcium supplements. In: Kies, C., ed., *Nutritional Bioavailability of Manganese*. American Chemical Society, Washington, D.C. pp. 146-151.
- Mena, I. 1974. The role of manganese in human disease. *Annals Clin. and Lab. Science* 4:487-491.
- Mena, I., O. Marin, S. Fuenzalida, et al. 1967. Chronic manganese poisoning: Clinical picture and manganese turnover. *Neurology* 17:128-136.
- Mergler, D., G. Huel, R. Bowler, A. Iregren, S. Belanger, M. Baldwin, R. Tardif, A. Smargiassi, L. Martin. 1994. Nervous system dysfunction among workers with long-term exposure to manganese. *Environ. Res.* 64:151-180.
- Miller, S.T., G.C. Cotzias, and H.A. Evert. 1975. Control of tissue manganese: Initial absence and sudden emergence of excretion in the neonatal mouse. *Am. J. Physiol.* 229: 1080-1084.
- Moss, A.J., A.S. Levy, I. Kim, Y.K. Park. 1989. Use of vitamin and mineral supplements in the United States: current uses, types of products, and nutrients. *Advance Data, Vital and Health Statistics of the National Center for Health Statistics*. Hyattsville, MD: National Center for Health Statistics. No.174. Hyattsville, MD: National Center for Health Statistics (as cited in IOM, 2002).
- Nachtman, J.P., R.E. Tubben, and R.L. Commissaris. 1986. Behavioral effects of chronic manganese administration in rats: Locomotor activity studies. *Neuro. Toxicol. Teratol.* 8:711-715.
- NRC. 1989. Biologic markers in reproductive toxicology. National Academy of Sciences/National Research Council. Washington, DC: National Academy Press, 15-35.
- NTP. 1993. *Toxicology and Carcinogenesis Studies of Manganese (II) Sulfate Monohydrate (CAS No. 10034-96-5) in F344/N Rats and B6C3F₁ Mice (Feed Studies)*. NTP Tech. Rep. Ser. 428. National Toxicology Program, Research Triangle Park, NC.
- OSHA. 1998. Occupational Safety and Health Administration. Code of Federal Regulations 29 CFR 1910.1000, Table Z-1. Limits for air contaminants.
- Pappas, B.A., G. Zhang, C.M. Davidson, T. Crowder, G.A. Park, T. Fortin. 1997. Perinatal manganese exposure: behavioral, neurochemical, and histopathological effects in the rat. *Neurotoxicol. Teratol.* 19(1):17-25.
- Purdey, M. 2000. Ecosystems supporting clusters of sporadic TSEs demonstrate excesses of the radical-generating divalent cation manganese and deficiencies of antioxidant cofactors Cu, Se, Fe, Zn. Does a foreign cation substitution at prior protein's Cu domain initiate TSE? *Med.*

Hypoth. 54:273-306.

Rehnberg, G.L., J.F. Hein, S.D. Carter, et al. 1980. Chronic manganese oxide administration to preweanling rats: manganese accumulation and distribution. *J. Toxicol. Environ. Health* 6(1):217-226.

Rehnberg, G.L., J.F. Hein, S.D. Carter, et al. 1981. Chronic ingestion of Mn_3O_4 by young rats: tissue accumulation, distribution, and depletion. *J. Toxicol. Environ. Health* 7(2):263-272.

Rehnberg, G.L., J.F. Hein, S.D. Carter, et al. 1982. Chronic ingestion of Mn_3O_4 by rats: tissue accumulation and distribution of manganese in two generations. *J. Toxicol. Environ. Health* 9(2): 175-188.

Rehnberg, G.L., J.F. Hein, S.D. Carter, et al. 1985. Age-dependent changes in gastrointestinal transport and retention of particulate manganese oxide in the rat. *J Toxicol Environ Health* 16:887-899.

Rodier, J. 1955. Manganese poisoning in Moroccan miners. *Br. J. Ind. Med.* 12:21-35.

Roels, H.A., P. Ghyselen, J.P. Buchet, E. Ceulemans, and R.R. Lauwerys. 1992. Assessment of the permissible exposure level to manganese in workers exposed to manganese dioxide dust. *Br. J. of Ind. Med.* 49:25-34.

Roels, H.A., R. Meiers, M. Delos, I. Ortega, R. Lauwerys, J.P. Buchet, and D. Lison. 1997. Influence of the route of administration and the chemical form ($MnCl_2$, MnO_2) on the absorption and cerebral distribution of manganese in rats. *Arch. Toxicol.* 71:223-230.

Roels, H.A., M.I. Ortega Eslava, E. Ceulemans, A. Robert, and D. Lison. 1999. Prospective study on the reversibility of neurobehavioral effects in workers exposed to manganese dioxide. *NeuroToxicol.* 20:255-271.

Rogers, A.E. 1979. Nutrition. In Baker, H.J., J.R. Lindsey, S.H. Weisbroth (eds), *The laboratory rat, vol. 1: biology and diseases*. Academic Press, N.Y. pp 123-53.

Roth, G.S. and R.C. Adleman. 1975. Age-related changes in hormone binding by target cells and tissues: Possible role of altered adaptive responsiveness. *Exp. Gerontol.* 10:1-11.

Sandström, B., L. Davidsson, A. Cederblad, R. Eriksson, and B. Lönnerdal. 1986. Manganese absorption and metabolism in man. *Acta Pharmacol. Toxicol.* 59(Suppl 7):60-62.

Schroeder, H.A., J.J. Balassa, I.H. Tipton. 1966. Essential trace metals in man: Manganese. A study in homeostasis. *J. Chron. Dis.* 19:545-571.

Schuler, P., H. Oyanguren, V. Maturana, et al. 1957. Manganese poisoning: Environmental and medical study at a Chilean mine. *Ind. Med. Surg.* 26:167-173 (as cited in ATSDR 2000).

Schwartz, R., B.J. Apgar, and E.M. Wein. 1986. Apparent absorption and retention of Ca, Cu,

Mg, Mn, and Zn from a diet containing bran. *Amer. J. Clin. Nut.* 43:444-455.

Shacklette, H.T., and J.G. Boerngen. 1984. Element concentrations in soils and other surficial materials of the coterminous United States. USGS Paper 1270. Washington, DC: US Govern. Printing Office, p. 6.

Shimkin, M.B. and G.D. Stoner. 1975. Lung tumors in mice: Application to carcinogenicity bioassay. *Adv. Cancer Res.* 21:1-58.

Shukla, G.S., S. Singh and S.V. Chandra. 1978. The interaction between manganese and ethanol in rats. *Acta Pharmacol. Toxicol. (Copenh.)* 43(5):354-362.

Shukla, G.S. and S.V. Chandra. 1987. Concurrent exposure to lead, manganese, and cadmium and their distribution to various brain regions, liver, kidney, and testis of growing rats. *Arch. Environ. Contam. Toxicol.* 16(3):303-310.

Silbergeld, E.K. 1982. Current status of neurotoxicology, basic and applied. *Trends Neurosci.* 5:291-294.

Smyth, H.F., C.P. Carpenter, C.S. Weil, U.C. Pozzani, J.A. Striegel, and J.S. Nycum. 1969. Range-finding toxicity data: List VII. *AIHA J* 30:470-476.

Stauber, J.L., T.M. Florence and W.S. Webster. 1987. The use of scalp hair to monitor manganese in aborigines from Groote Eylandt. *NeuroToxicol.* 8(3):431-435.

Stoner, G.D., M.B. Shimkin, M.C. Toxell, T.L. Thompson, and L.S. Terry. 1976. Test for carcinogenicity of metallic compounds by pulmonary tumor response in strain A mice. *Cancer Res.* 36:1744-1747.

Subhash, M.N. and T.S. Padmashree. 1990. Regional distribution of dopamine β -hydroxylase and monoamine oxidase in the brains of rats exposed to manganese. *Food Chem. Tox.* 28:567-570.

Sumino, K., K. Hayakawa, T. Shibata, and S. Kitamura. 1975. Heavy metals in normal Japanese tissues. Amounts of 15 heavy metals in 30 subjects. *Arch. Environ. Health* 30:487-494.

Suzuki, Y. 1970. Environmental contamination by manganese. *Jap. J. Ind. Health* 12:529-533.

Suzuki, Y., T. Mouri, K. Nishiyama, et al. 1975. Study of subacute toxicity of manganese dioxide in monkeys. *Tokushima J. Exp. Med.* 22:5-10.

Szokmáry, E., G. Ungvary, A. Hudak, et al. 1995. Developmental effect of manganese in rat and rabbit. *Cent. Eur. J. Occup. Environ. Med.* 1:149-159.

Tanaka, S., and J. Lieben. 1969. Manganese poisoning and exposure in Pennsylvania. *Arch. Environ. Health.* 19:674-684.

- Ter Haar, G., M. Griffing, M. Brandt, D. Oberding, and M. Kapron. 1975. Methylcyclopentadienyl manganese tricarbonyl as an antiknock: Composition and fate of manganese exhaust products. *J Air Pollut. Control Assoc.* 25:858-860 (as cited in ATSDR, 2000).
- Thomson, A.B., D. Olatunbosun, L.S. Valverg. 1971. Interrelation of intestinal transport system for manganese and iron. *J. Lab. Clin. Med.* 78:642-655.
- Tipton, I.H., M.J. Cook. 1963. Trace elements in human tissue. Part II. Adult subjects from the United States. *Health Phys.* 9:103-145.
- Tjälve, H., J. Henriksson, J. Tallkvist, B.S. Larsson, N.G. Lindquist. 1996. Uptake of manganese and cadmium from the nasal mucosa into the central nervous system via olfactory pathways in rats. *Pharmacol. Toxicol.* 79:347-356.
- U.S. EPA. 1984. *Health Assessment Document for Manganese*. Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Cincinnati, OH (EPA-600/8-83-013F).
- U.S. EPA. 1986a. Reference Values for Risk Assessment. U.S. Environmental Protection Agency. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office. Cincinnati, OH.
- U.S. EPA. 1986b. Guidelines for Carcinogenic Risk Assessment. U.S. Environmental Protection Agency. Fed. Reg. 51(185):33992-34003.
- U.S. EPA. 1990. *Comments on the Use of Methylcyclopentadienyl Manganese Tricarbonyl in Unleaded Gasoline*. U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC.
- U.S. EPA. 1993. *Drinking Water Criteria Document for Manganese*. Final Draft. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment. ECAO-CIN-D008. Cincinnati, OH.
- U.S. EPA. 1994. *Drinking Water Criteria Document for Manganese*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. September, 1993. Updated: March, 1994.
- U.S. EPA. 1996a. *Exposure Factors Handbook. Vol. I-General Factors*. U.S. Environmental Protection Agency, Washington, DC (EPA/600/8-89/043).
- U.S. EPA. 1996b. Proposed Guidelines for Carcinogen Risk Assessment. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. EPA/600/P-92/003C
- U.S. EPA. 1997. *Manganese*. Integrated Risk Information System. (IRIS). U.S. Environmental Protection Agency. Last revised April 1, 1997. Available on the Internet at: <http://www.epa.gov/iris/subst/0373.htm>

U.S. EPA. 1999. Draft Revised Guidelines for Carcinogen Risk Assessment. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. NCEA-F-0644, July 1999. Available on line at: <http://www.epa.gov/NCEA/raf/cancer.htm>

U.S. EPA. 2001. *Contaminant Candidate List Preliminary Regulatory Determination Support Document for Manganese*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. November, 2001 (EPA 815-R-01-013).

U.S. EPA. 2003a. *Health Effects Support Document for Manganese*. U.S. Environmental Protection Agency, Office of Water. EPA. EPA-822-R-03-003. Washington, D.C.

U.S. EPA. 2003b. Final Draft Guidelines for Carcinogen Risk Assessment. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. Available on line at: <http://cfpub.epa.gov/ncea/cfm/>

USGS. 2001. USGS National Water Quality Assessment Data Warehouse. Available on the Internet at: <http://infotrek.er.usgs.gov/pls/nawqa/nawqa.home>. Last updated April 19, 2001.

Vieregge P., B. Heinzow, G. Korf, H.M. Teichert, P. Schleifenbaum, and H.U. Moseinger. 1995. Long term exposure to manganese in rural well water has no neurological effects. *Can. J. Neur. Science* 22:286-289.

Vitarella, D., B.A. Wong, O.R. Moss, and D.C. Dorman. 2000. Pharmacokinetics of inhaled manganese phosphate in male Sprague-Dawley rats following subacute (14-day) exposure. *Tox. Applied Pharm.* 3:279-285.

Wang, J.D., C.C. Chuang, Y.H. Hwang, J.R. Chiang, J.M. Lin, and J.S. Chen. 1989. Manganese induced parkinsonism: An outbreak due to unrepaired ventilation control system in a ferromanganese smelter. *Br. J. Ind. Med.* 46:856-859.

Wassermann, D. and M. Wassermann. 1977. The ultrastructure of the liver cell in subacute manganese administration. *Environ. Res.* 14(3):379-390 (as cited in U.S. EPA, 1993).

Wedler, F.C. 1994. Biochemical and nutritional role of manganese: An overview. In: Klimis-Tavantzis, D.J., ed., *Manganese in Health and Disease*. Boca Raton, FL: CRC Press, Inc., pp. 1-36 (as cited in ATSDR, 2000).

WHO. 1973. Trace Elements in Human Nutrition: Manganese. Technical Report Service, 532. World Health Organization, Geneva, Switzerland.

WHO. 1981. Environmental Health Criteria 17: Manganese. World Health Organization. Geneva, Switzerland (as cited in ATSDR, 2000).

WHO. 2002. Environmental Health Criteria 228: Principles and methods for the assessment of risk from essential trace elements. World Health Organization: Geneva, Switzerland.

Woolf, A., R. Wright, C. Amarasiriwardena, and D. Bellinger. 2002. A child with chronic

manganese exposure from drinking water. *Environ. Health Persp.* 110:613-616.

Wu W., Y. Zhang, F. Zhang, et al. 1996. [Studies on the semen quality in workers exposed to manganese and electric welding]. *Chin. J. Prev. Med.* 30:266-268 (Chinese).

Yoshida, S., Y. Yase, S. Iwata, Y. Mizumoto, K.M. Chen, and D.C. Gajdusek. 1988. Comparative trace-elemental study on amyotrophic lateral sclerosis (ALS) and Parkinsonism-dementia (PD) in the Kii peninsula of Japan and Guam. *Wakayama Med. Rep.* 30:41-53.

Zayed, J., C. Thibault, L. Gareau, et al. 1999. Airborne manganese particulates and methylcyclopentadienyl manganese tricarbonyl (MMT) at selected outdoor sites in Montreal. *NeuroToxicol.* 20(2-3):151-158.

Zhang, G., D. Liu, and P. He. 1995. [Effects of manganese on learning abilities in school children]. *Chung Hua Yu Fang I Hsueh Tsa Chih* 29:156-158 (Chinese).

Zheng W., D.F. Perry, D.L. Nelson, and H.V. Aposhian. 1991. Choroid plexus protects cerebrospinal fluid against toxic metals. *FASEB J.* 5:2188-2193.

Zlotkin, S.H. and B.E. Buchanan. 1986. Manganese intakes in intravenously fed infants: Dosages and toxicity studies. *Biol. Trace Elem. Res.* 9:271-279.

NORTH CAROLINA ADMINISTRATIVE CODE
TITLE 15
DEPARTMENT OF NATURAL RESOURCES
AND
COMMUNITY DEVELOPMENT
CHAPTER 2
ENVIRONMENTAL MANAGEMENT DIVISION
SUBCHAPTER 2L
CLASSIFICATIONS AND WATER QUALITY STANDARDS
APPLICABLE TO THE GROUNDWATERS
OF
NORTH CAROLINA
SECTION .0100 AND .0200



EFFECTIVE DATE - JUNE 10, 1979
ENVIRONMENTAL MANAGEMENT COMMISSION
RALEIGH, NORTH CAROLINA

TABLE OF CONTENTS

SUBCHAPTER 2L - GROUNDWATER CLASSIFICATION AND STANDARDS

SECTION .0100 - GENERAL CONSIDERATIONS

- .0101 INTRODUCTION
- .0102 DEFINITIONS
- .0103 GENERAL RULES
- .0104 ANALYTICAL PROCEDURES

SECTIONS .0200 - CLASSIFICATIONS AND WATER QUALITY STANDARDS APPLICABLE
TO GROUNDWATERS OF NORTH CAROLINA

- .0201 GROUNDWATER CLASSIFICATION
- .0202 GROUNDWATER QUALITY STANDARDS

SUBCHAPTER 2L - GROUNDWATER CLASSIFICATION
AND STANDARDS

SECTION .0100 - GENERAL CONSIDERATIONS

.0101 INTRODUCTION

(a) N.C. General Statute [43-214.] directs the Environmental Management Commission to develop and adopt, after proper study, a series of classifications and standards applicable to each classification, which will be appropriate for the purpose of classifying each of the waters of the state in such a way as to promote the policy and purposes of the act. Pursuant to this statute, this Regulation establishes a series of classifications and water quality standards applicable to the groundwaters of the state.

(b) Only in the very last few years has pollution been recognized as a major threat to the quality of the groundwaters of the state. The increasing incidence and potential for pollution results primarily from the change in the use of land from principally agricultural and silviculture activities to residential, commercial, and industrial activities. This change in land use has resulted in a large and continuing increase in the amount of wastes disposed on the land and in the number of other sources of pollution, such as landfills, waste disposal and processing facilities, chemical stockpiles, chemical and hydrocarbon spills and concentrations of septic tanks. Although the land in much of the state is capable of cycling many types of waste, unlimited and uncontrolled pollution sources will result in, not only pollution of the groundwaters, but eventual pollution of the surface waters as well. Poorly managed groundwater development is having a significant impact on the groundwater quality in some parts of the state.

(c) The regulations established in this Subchapter are intended to maintain and preserve the quality of groundwaters, prevent and abate pollution and contamination, protect public health, and permit management of groundwaters for best usage by the citizens of North Carolina.

History Note: Statutory Authority G.S. [43-214.]:
Eff. June 10, 1979.

.0102 DEFINITIONS

The definition of any word or phrase used in these regulations shall be the same as given in North Carolina General Statute [43-

213 except that the following words and phrases shall have the following meanings:

- (1) Deleterious substance means those substances which may cause the water to be exceedingly unpleasant to taste, or unsightly, but which are not toxic.
- (2) Fresh groundwaters are those groundwaters having a chloride concentration equal to or less than 250 milligrams per liter.
- (3) Groundwaters are those waters in the saturated zone of the water-bearing consolidated and unconsolidated formations.
- (4) Micrograms per liter (ug/l) gives the weight in micrograms of any constituent in one liter of solution.
- (5) Milligrams per liter (mg/l) is the weight in milligrams of any specific constituent or constituents in a liter of the solution.
- (6) Naturally occurring concentration means the concentration of chemical or biological substances or physical characteristics which exist naturally and which have not been changed by man's activities.
- (7) Natural quality means the physical, biological and chemical quality which occurs naturally and which has not been changed by man's activities.
- (8) Parts per million (ppm) and parts per billion (ppb) shall be construed to be equivalent to milligrams per liter and micrograms per liter, respectively.
- (9) Point of discharge is the point of initial contact of waste with the existing soil or rock materials.
- (10) Potable waters are those waters suitable for drinking, culinary and food processing purposes.
- (11) Saline groundwaters are those groundwaters having a chloride concentration of more than 250 mg/l.
- (12) The saturated zone is that part of the water-bearing consolidated and unconsolidated formations in which all the voids, large and small, are ideally filled with water under pressure greater than atmospheric. It does not include the capillary fringe.
- (13) Source of water supply for drinking, culinary use or food processing shall mean any groundwater source either public or private, the waters from which are used for human consumption, or are used in connection with the processing of milk, beverages, or food.
- (14) Toxic substances shall mean those substances which if ingested or assimilated into any organism either directly or indirectly will cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in such organisms of their offspring).

- (15) The unsaturated zone is the portion of the consolidated and unconsolidated formations between land surface and the water table. It includes the capillary fringe.
- (16) Water table is the surface of the saturated zone in the unconfined water-bearing formation or material at which the pressure is atmospheric.

History Note: Statutory Authority G.S. 143-214.1;
Eff. June 10, 1979.

.0103 GENERAL RULES

(a) The discharge of any wastes to the subsurface or groundwaters of the state by means of wells is prohibited [G.S. 143-214.2(b)].

(b) The maximum concentrations for toxic and deleterious substances shall not exceed the specified concentrations for each classification. Where not specified, the maximum concentrations for toxic substances in GA or GSA groundwaters shall not exceed the maximum recommended or established concentrations in the National Interim Primary Drinking Water Regulations. The maximum concentration for unspecified deleterious substances in GA and GSA groundwaters shall not exceed the maximum recommended or established concentration in the National Interim Primary Drinking Water Regulations or the naturally occurring concentration, as determined by the department, whichever is greater.

(c) Waters which, at the time of classification, contain toxic or deleterious substances in excess of the maximum allowable concentrations but for which it would be feasible to upgrade the quality by treatment to the standards established for classification, shall be designated restricted (RS).

(d) Any person subject to the provisions of General Statute 143-215.1 may apply to the Environmental Management Commission for a variance from the groundwater classification and quality standards established pursuant to these regulations and North Carolina General Statute 143-214.1. A variance may be granted by the commission pursuant to the requirements of North Carolina General Statute 143-215.3(e). The burden of proof in any public hearing or other proceeding pursuant to North Carolina General Statute 143-215.3(e) shall be upon the applicant for a variance.

History Note: Statutory Authority G.S. 143-214.1;
Eff. June 10, 1979.

.0104 ANALYTICAL PROCEDURES

Tests or analytical procedures to determine conformity or nonconformity with standards will, insofar as practicable and

applicable, be made in accordance with the methods given in the latest pertinent issue of the Federal Register (presently December 1, 1976) as submitted by the U.S. Environmental Protection Agency for water programs. Other analytical procedures shall conform to those found in the latest edition of either "Standard Methods for the Examination of Water and Wastewater" (published jointly by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation) or "Methods for Chemical Analysis of Water and Wastes" (prepared by the U.S. Environmental Protection Agency and available from the Office of Technology Transfer, Washington, D.C. 20460).

History Note: Statutory Authority G.S. 143-214.1;
Eff. June 10, 1979.

SECTION .0200 - CLASSIFICATIONS AND WATER QUALITY
STANDARDS APPLICABLE TO GROUNDWATERS
OF NORTH CAROLINA

.0201 GROUNDWATER CLASSIFICATIONS

The groundwater classification for separately identified groundwaters shall be those specified in the following series of classifications:

(1) class GA waters; usage and occurrence:

- (a) Best Usage of Waters. Source of water supply for drinking, culinary use, and food processing;
- (b) Conditions Related to Best Usage. This class is intended for those groundwaters in which chloride concentrations are equal to or less than 250 mg/l, considered safe for drinking, culinary use, and food processing without treatment, but which may require disinfection or other treatment when necessary to reduce naturally occurring concentrations in order to meet the National Interim Primary Drinking Water Regulations;
- (c) Occurrence. At depths greater than 20 feet below land surface and in the saturated zone above a depth of 20 feet where these waters are a principal source of potable water supply;

(2) class GSA waters; usage and occurrence:

- (a) Best Usage. Sources of water supply for potable mineral water, culinary use, food processing, and conversion to fresh waters;
- (b) Conditions Related to Best Usage. This class is intended for those groundwaters in which chloride concentrations are greater than 250 mg/l, and which are considered safe for potable mineral water, culinary use, and food processing without treatment but may require disinfection or other treatment when necessary to reduce naturally occurring concentrations in order to meet the National Interim Primary Drinking Water Regulations;
- (c) Occurrence. At depths greater than 20 feet below land surface and in the saturated zone above a depth of 20 feet where these waters are a principal source of potable water supply;

(3) class GB waters; usage and occurrence:

- (a) Best Usage. Source of recharge to surface waters and groundwaters occurring below a depth of 20 feet;
- (b) Conditions Related to Best Usage. Precipitation is the principal source of recharge to the saturated zone.

The water in the saturated zone above a depth of 20 feet is of drinking water quality in much of the state. However, the upper 20 feet of the earth's surface is generally very vulnerable to pollution from man's activities, and should be considered a cycling zone for removing most or all of the contaminants from the water by adsorption, absorption, filtration or other natural treatment processes. In recognition of this fact, this classification is intended for those fresh groundwaters occurring at depths less than 20 feet below land surface that are of suitable quality for recharge to the deeper aquifers and surface waters of the state;

- (c) Occurrence. In the saturated zone above a depth of 20 feet below land surface;
- (4) class GSB waters; usage and occurrence:
 - (a) Best Usage. Source of recharge to saline surface waters and saline groundwaters occurring below a depth of 20 feet;
 - (b) Conditions Related to Best Usage. Precipitation is the principal source of recharge to the saturated zone. The water in the saturated zone above a depth of 20 feet is considered safe for potable mineral water in much of the state. However, the upper 20 feet of the earth's surface is generally very vulnerable to pollution from man's activities and should be considered a cycling zone for removing most or all of the contaminants from the water by adsorption, absorption, filtration or other natural treatment processes. In recognition of this fact, this classification is intended for those saline groundwaters occurring at depths less than 20 feet below land surface that are of suitable quality for recharge to the deeper aquifers and surface waters of the state;
 - (c) Occurrence. In the saturated zone above a depth of 20 feet below land surface;
- (5) class GC waters; usage:
 - (a) Best Usage of Waters. Source of water supply for purposes other than human drinking, culinary use, or food processing;
 - (b) Conditions Related to Best Usage. This class includes those waters that do not meet the quality criteria requirements of waters having a higher classification and for which treatment to upgrade to a higher classification would technically or economically not be feasible, or not in the best interest of the public.

History Note: Statutory Authority G.S. 143-214.1;
Eff. June 10, 1979.

.0202 GROUNDWATER QUALITY STANDARDS

The water quality standards for separately identified groundwaters shall be those specified in the following series of standards:

(1) Class GA waters:

- (a) arsenic: not greater than 50 ug/l;
- (b) cadmium: not greater than 10 ug/l;
- (c) chloride: allowable increase not to exceed 50 percent of the naturally occurring chloride concentration or result in a concentration of more than 250 mg/l;
- (d) chromium: not greater than 50 ug/l;
- (e) coliform group total: not greater than 1.0/100 ml;
- (f) color: less than 5.0 units;
- (g) lead: not greater than 50 ug/l;
- (h) mercury: not greater than 2.0 ug/l;
- (i) nitrate (as N): not greater than 10 mg/l;
- (j) nitrite (as N): not greater than 1.0 mg/l;
- (k) oil and grease: free from taste or odor;
- (l) pesticides: shall not exceed maximum limits recommended or established by the National Interim Primary Drinking Water Regulations;
- (m) phenol: not greater than 1.0 ug/l;
- (n) phthalate esters: none in measurable quantities;
- (o) polychlorinated biphenyls: none in measurable quantities;
- (p) radioactive substances: shall not exceed maximum limits recommended or established by the National Interim Primary Drinking Water Regulations;
- (q) selenium: not greater than 10 ug/l;
- (r) silver: not greater than 50 ug/l;
- (s) total dissolved solids: allowable increase not to exceed 50 percent of the naturally occurring total dissolved solids concentration or result in a concentration of more than 1000 mg/l;

(2) Class GSA waters:

- (a) arsenic: not greater than 50 ug/l;
- (b) cadmium: not greater than 10 ug/l;
- (c) chloride: allowable increase not to exceed 100 percent of the naturally occurring chloride concentration;
- (d) chromium: not greater than 50 ug/l;
- (e) coliform group, total: not greater than 1.0 per 100 ml;
- (f) color: less than 5.0 units;
- (g) lead: not greater than 50 ug/l;

- (h) mercury: not greater than 2.0 ug/l;
 - (i) nitrate (as N): not greater than 10 mg/l;
 - (j) nitrite (as N): not greater than 1.0 mg/l;
 - (k) pesticides: shall not exceed maximum limits recommended or established by the National Interim Primary Drinking Water Regulations;
 - (l) phenol: not greater than 1.0 ug/l;
 - (m) phthalate esters: none in measurable quantities;
 - (n) polychlorinated biphenyls: none in measurable quantities;
 - (o) radioactive substances: shall not exceed maximum limits recommended or established by the National Interim Primary Drinking Water Regulations;
 - (p) selenium: not greater than 10 ug/l;
 - (q) silver: not greater than 50 ug/l;
- (3) Class GB Waters. All chemical, radioactive, biological, taste producing, odor producing, thermal, and other deleterious substances will be allowed only in such amounts, whether alone or in combination with other substances, as will not result in the contravention of established water quality standards;
- (4) Class GSB Waters. All chemical, radioactive, biological, taste producing, odor producing, thermal, and other deleterious substances will be allowed only in such amounts, whether alone or in combination with other substances, as will not result in the contravention of established water quality standards;
- (5) Class GC Waters. All chemical, radioactive, biological, taste producing, odor producing, thermal, and other deleterious substances shall not exceed the concentration existing at the time of classification.

History Note: Statutory Authority G.S. 143-214.1;
Eff. June 10, 1979.



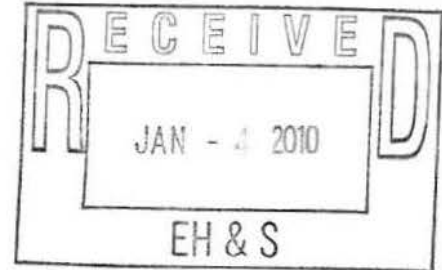
North Carolina Department of Environment and Natural Resources

Division of Water Quality
Coleen H. Sullins
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

December 18, 2009



Mr. Allen Stowe
Water Management
Duke Energy Corporation
EC 13K / PO Box 1006
Charlotte, NC 28201-1006

Dear Mr. Stowe:

Over the past several months, the Division of Water Quality (DWQ) has been reviewing the data and maps submitted by Duke Energy on April 30, 2009. Based on the review of the submitted data, specific recommendations and additional information requests on a site-by-site basis are attached. These attachments are formatted so that they can be sent to each individual site with the appropriate contact information for any follow up actions. All information requested is due no later than February 28, 2010.

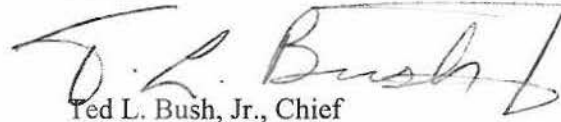
During this review period, there has been a clarification by the Attorney General's Office of how Corrective Action (15A NCAC 02L .0106) requirements apply to facilities permitted prior to December 30, 1983. It was determined that facilities exceeding groundwater standards, permitted under G.S. 143-215.1, and permitted prior to December 30, 1983, fall under 15A NCAC 02L .0106(c). This clarification gives Duke Energy the option to seek approval of a corrective action plan that does not require remediation to groundwater standards [15A NCAC 2L .0106 (k)] or may allow attenuation by natural processes [15A NCAC 2L .0106 (l)].

As a result of the Attorney General's clarification, DWQ is requesting that each facility place groundwater monitoring wells at the compliance boundary. Where appropriate, monitoring of groundwater discharges to surface water will be required. As permits are renewed, groundwater monitoring will be added to the updated permits, and similar parameters will be required to be monitored at each site.

In light of concerns brought up by your staff in past discussions, combining compliance boundaries for adjacent DWQ permitted activities will be allowed, as well as encouraged. We will also continue to work with other Divisions in DENR to determine options for combining compliance boundaries with adjacent non-DWQ permitted activities.

As this program progresses, we look forward to continue working with you. If you have any questions concerning the attached requests at any of your sites, please contact Debra Watts at (919) 715-6699 or Eric Smith at (919) 715-6196. Your prompt attention to these matters is appreciated.

Sincerely,



Ted L. Bush, Jr., Chief
Aquifer Protection Section

Attachments

cc: Coleen H. Sullins
Chuck Waklid
Jeff Poupart, NPDES
Andrew Pitner – Mooresville Regional Office APS
Sherry Knight – Winston-Salem Regional Office APS
Central Office Files



North Carolina Department of Environment and Natural Resources

Division of Water Quality

Coleen H. Sullins

Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

Attachment 1

Site Name: Allen Steam Station

County: Gaston County

Division of Water Quality Aquifer Protection Section Regional Office: Mooresville Regional Office (MRO)

Hydrogeology

- Based on the supplied maps, monitoring wells AB-4, AB-4D, AB-5, AB-6A, AB-6R, and AB-8 are located inside the Review/Compliance Boundaries. These wells are not suitable for determining compliance.
- Recommend a monitoring well be added near the southeast corner of the active ash basin at the Compliance Boundary. There appears to be a topographic draw that extends to the southeast away from the Active Ash Basin. This could be a conduit for groundwater to flow toward Lake Wylie from the Active Ash Basin.
- Based on a clarification of the 15A NCAC 02L rules, monitoring wells are now required to be located at the Compliance Boundary. The proposed locations of these wells must be shown on the requested maps. Construction of these monitoring wells may begin after approval from the MRO.
- Where constructing wells at the Compliance Boundary may not be feasible due to the proximity of surface water, groundwater seepage monitoring will be required. The proposed locations of these monitoring points must be shown on the requested maps. The MRO will approve the final locations of the monitoring points.
- Combining Compliance Boundaries around any adjacent Division of Water Quality (DWQ) permitted activities is acceptable as well as recommended.
- Compliance Boundaries must not cross your property boundaries.

Groundwater Sampling and Data

- Please make sure that you sample the monitoring wells for the following constituents during each sampling event:

Aluminum	Boron	Cobalt	Manganese	Potassium	Thallium
Antimony	Cadmium	Copper	Mercury	Selenium	TDS
Arsenic	Calcium	Iron	Nickel	Silver	Vanadium
Barium	Chloride	Lead	Nitrate	Sodium	Zinc
Beryllium	Chromium	Magnesium	pH (field)	Sulfate	

- The listed parameters are intended to monitor constituents from the coal ash; additional parameters may be necessary to address contributions to the ash ponds from any other waste sources.
- All of the requested groundwater sampling parameters should be instituted starting with the next sampling round after receiving this letter.
- Please send the groundwater sampling data in both electronic (Microsoft Excel) and hardcopy forms.
- Please report all metals in micrograms per liter ($\mu\text{g/L}$) with the exception of Copper and Zinc which should be reported in milligrams per liter (mg/L) in accordance with the 15A NCAC 02L standard changes effective 1/1/10.
- The Aquifer Protection Section (APS) may allow some groundwater sampling parameters to be deleted based on non-detects over several sampling rounds or historical data provided.

AQUIFER PROTECTION SECTION

1636 Mail Service Center, Raleigh, North Carolina 27699-1636

Location: 2728 Capital Boulevard, Raleigh, North Carolina 27604

Phone: 919-733-3221 \ FAX 1: 919-715-0588; FAX 2: 919-715-6048 \ Customer Service: 1-877-623-6748

Internet: www.ncwaterquality.org

An Equal Opportunity \ Affirmative Action Employer

One
North Carolina
Naturally

OFFICIAL COPY

Feb 18 2020

Additional Information Requested

- Please submit the following updates to the maps by February 28, 2010:
 - Locations of proposed monitoring wells and/or groundwater seepage monitoring points,
 - Locations of all on-site inactive ash ponds and ash storage areas not previously identified, and
 - Locations of all on-site active and inactive Division of Waste Management (DWM) permitted solid waste facilities along with their associated Compliance Boundaries and monitoring wells,
- For the updated maps: Submit one (1) electronic copy and two (2) hard copies to the DWQ APS Central Office, and one (1) electronic copy and two (2) hard copies to the DWQ APS Regional Office.
 - Updates to the map can be made on the same aerial photo base as in the previous submittal. Please include the elevation contours.
- Additional questions relating to previous submittal:
 - Monitoring wells AB-2 and AB-2D are located outside of the Compliance Boundary and are adjacent to a non-DWQ permitted ash storage area. What is their relevance to the NPDES permit?
 - Are the Structural Fill areas part of a DWQ permit?

Contacts

DWQ APS Central Office Mailing Address: 1636 Mail Service Center
Raleigh, North Carolina 27699-1636

DWQ APS Central Office Staff: Debra Watts
APS Groundwater Protection Unit Supervisor
debra.watts@ncdenr.gov
(919) 715-6699

Betty Wilcox
Environmental Chemist
betty.wilcox@ncdenr.gov
(919) 715-6169

Eric G. Smith, P.G.
Hydrogeologist
eric.g.smith@ncdenr.gov
(919) 715-6196

DWQ APS MRO Mailing Address: 610 East Center Avenue
Mooresville, North Carolina 28115

DWQ APS MRO Staff: Andrew Pitner
APS Supervisor
andrew.pitner@ncdenr.gov
(704) 663-1699



North Carolina Department of Environment and Natural Resources

Division of Water Quality
Coleen H. Sullins
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

OFFICIAL COPY

Attachment 2

Site Name: Buck Steam Station

County: Rowan County

Division of Water Quality Aquifer Protection Section Regional Office: Mooresville Regional Office (MRO)

Hydrogeology

- Based on the supplied maps, monitoring wells MW-1S, MW-1D, MW-3S, MW-3D, MW-4S, and MW-4D are at the edge of the waste boundary. These wells are not suitable for determining compliance.
- Recommend a monitoring well be added at the Compliance Boundary in a direct line northwest from the current location at the waste boundary toward the on-site water supply well. This will allow you to see if any contamination is migrating toward the water supply well.
- Recommend a monitoring well be added approximately 750 feet east of the large cylindrical structure at the Compliance Boundary. According to the topographic data, there is a draw that extends to the north in this area. This could be a conduit for groundwater to flow toward the Yadkin River from the Active Ash Basin.
- Recommend a monitoring well be added to the south of the Active Ash Basin Primary Cell at the Compliance Boundary. This well should be between the houses on Dukeville Road and the Active Ash Boundary to demonstrate that groundwater contamination is not migrating toward the residential houses.
- Recommend monitoring well(s) be added at the Compliance Boundary between the Active Ash Basins and the houses along Leonard Road.
- Based on a clarification of the 15A NCAC 02L rules, monitoring wells are now required to be located at the Compliance Boundary. The proposed locations of these wells must be shown on the requested maps. Construction of these monitoring wells may begin after approval from the MRO.
- Where constructing wells at the Compliance Boundary may not be feasible due to the proximity of surface water, groundwater seepage monitoring will be required. The proposed locations of these monitoring points must be shown on the requested maps. The MRO will approve the final locations of the monitoring points.
- Combining Compliance Boundaries around any adjacent Division of Water Quality (DWQ) permitted activities is acceptable as well as recommended.
- Compliance Boundaries must not cross your property boundaries.

Groundwater Sampling and Data

- Please make sure that you sample the monitoring wells for the following constituents during each sampling event:

Aluminum	Boron	Cobalt	Manganese	Potassium	Thallium
Antimony	Cadmium	Copper	Mercury	Selenium	TDS
Arsenic	Calcium	Iron	Nickel	Silver	Vanadium
Barium	Chloride	Lead	Nitrate	Sodium	Zinc
Beryllium	Chromium	Magnesium	pH (field)	Sulfate	

- The listed parameters are intended to monitor constituents from the coal ash; additional parameters may be necessary to address contributions to the ash ponds from any other waste sources.

AQUIFER PROTECTION SECTION

1636 Mail Service Center, Raleigh, North Carolina 27699-1636

Location: 2728 Capital Boulevard, Raleigh, North Carolina 27604

Phone: 919-733-3221 \ FAX 1: 919-715-0588; FAX 2: 919-715-6048 \ Customer Service: 1-877-623-6748

Internet: www.ncwaterquality.org

An Equal Opportunity \ Affirmative Action Employer

One
North Carolina
Naturally

Feb 18 2020

- All of the requested groundwater sampling parameters should be instituted starting with the next sampling round after receiving this letter.
- Please send the groundwater sampling data in both electronic (Microsoft Excel) and hardcopy forms.
- Please report all metals in micrograms per liter ($\mu\text{g/L}$) with the exception of Copper and Zinc which should be reported in milligrams per liter (mg/L) in accordance with the 15A NCAC 02L standard changes effective 1/1/10.
- The Aquifer Protection Section (APS) may allow some groundwater sampling parameters to be deleted based on non-detects over several sampling rounds or historical data provided.

Additional Information Requested

- Please submit the following updates to the maps by February 28, 2010:
 - Locations of proposed monitoring wells and/or groundwater seepage monitoring points,
 - Locations of all on-site inactive ash ponds and ash storage areas not previously identified, and
 - Locations of all on-site active and inactive Division of Waste Management (DWM) permitted solid waste facilities along with their associated Compliance Boundaries and monitoring wells,
- For the updated maps: Submit one (1) electronic copy and two (2) hard copies to the DWQ APS Central Office, and one (1) electronic copy and two (2) hard copies to the DWQ APS Regional Office.
 - Updates to the map can be made on the same aerial photo base as in the previous submittal. Please include the elevation contours.
- Additional questions relating to previous submittal:
 - Is the Site Water Well sampled and how often?
 - Portions of the property boundary extend into the Yadkin River. Is this the case?

Contacts

DWQ APS Central Office Mailing Address: 1636 Mail Service Center
Raleigh, North Carolina 27699-1636

DWQ APS Central Office Staff: Debra Watts
APS Groundwater Protection Unit Supervisor
debra.watts@ncdenr.gov
(919) 715-6699

Betty Wilcox
Environmental Chemist
betty.wilcox@ncdenr.gov
(919) 715-6169

Eric G. Smith, P.G.
Hydrogeologist
eric.g.smith@ncdenr.gov
(919) 715-6196

DWQ APS MRO Mailing Address: 610 East Center Avenue
 Mooresville, North Carolina 28115

DWQ APS MRO Staff: Andrew Pitner
APS Supervisor
andrew.pitner@ncdenr.gov
(704) 663-1699



North Carolina Department of Environment and Natural Resources

Division of Water Quality

Coleen H. Sullins

Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

Attachment 3

Site Name: Cliffside Steam Station

County: Cleveland County

Division of Water Quality Aquifer Protection Section Regional Office: Mooresville Regional Office (MRO)

Hydrogeology

- Based on the supplied data, you labeled monitoring wells CLMW-2 and MW-2D as the background wells; however, based on submitted water level data, these wells should be downgradient wells.
- CLMW-6 is not a suitable for a background well due to its location at the Waste Boundary. Recommend that a new background well be added elsewhere on the property.
- Based on the supplied maps, monitoring wells CLMW-1, CLMW-2S, MW-2D, CLMW-3S, CLMW-3D, CLMW-5S, MW-8S, MW-8D, MW-11S, and MW-11D are located within the waste boundary. These wells are not suitable for determining compliance.
- Based on a clarification of the 15A NCAC 02L rules, monitoring wells are now required to be located at the Compliance Boundary. The proposed locations of these wells must be shown on the requested maps. Construction of these monitoring wells may begin after approval from the MRO.
- Where constructing wells at the Compliance Boundary may not be feasible due to the proximity of surface water, groundwater seepage monitoring will be required. The proposed locations of these monitoring points must be shown on the requested maps. The MRO will approve the final locations of the monitoring points.
- Combining Compliance Boundaries around any adjacent Division of Water Quality (DWQ) permitted activities is acceptable as well as recommended.
- Compliance Boundaries must not cross your property boundaries.

Groundwater Sampling and Data

- Please make sure that you sample the monitoring wells for the following constituents during each sampling event:

Aluminum	Boron	Cobalt	Manganese	Potassium	Thallium
Antimony	Cadmium	Copper	Mercury	Selenium	TDS
Arsenic	Calcium	Iron	Nickel	Silver	Vanadium
Barium	Chloride	Lead	Nitrate	Sodium	Zinc
Beryllium	Chromium	Magnesium	pH (field)	Sulfate	

- The listed parameters are intended to monitor constituents from the coal ash; additional parameters may be necessary to address contributions to the ash ponds from any other waste sources.
- All of the requested groundwater sampling parameters should be instituted starting with the next sampling round after receiving this letter.
- Please send the groundwater sampling data in both electronic (Microsoft Excel) and hardcopy forms.
- Please report all metals in micrograms per liter ($\mu\text{g/L}$) with the exception of Copper and Zinc which should be reported in milligrams per liter (mg/L) in accordance with the 15A NCAC 02L standard changes effective 1/1/10.
- The Aquifer Protection Section (APS) may allow some groundwater sampling parameters to be deleted based on non-detects over several sampling rounds or historical data provided.

AQUIFER PROTECTION SECTION

1636 Mail Service Center, Raleigh, North Carolina 27699-1636

Location: 2728 Capital Boulevard, Raleigh, North Carolina 27604

Phone: 919-733-3221 \ FAX 1: 919-715-0588; FAX 2: 919-715-6048 \ Customer Service: 1-877-623-6748

Internet: www.ncwaterquality.org

An Equal Opportunity \ Affirmative Action Employer

One
North Carolina
Naturally

OFFICIAL COPY

Feb 18 2020

Additional Information Requested

- Please submit the following updates to the maps by February 28, 2010:
 - Locations of proposed monitoring wells and/or groundwater seepage monitoring points,
 - Locations of all on-site inactive ash ponds and ash storage areas not previously identified, and
 - Locations of all on-site active and inactive Division of Waste Management (DWM) permitted solid waste facilities along with their associated Compliance Boundaries and monitoring wells,
- For the updated maps: Submit one (1) electronic copy and two (2) hard copies to the DWQ APS Central Office, and one (1) electronic copy and two (2) hard copies to the DWQ APS Regional Office.
 - Updates to the map can be made on the same aerial photo base as in the previous submittal. Please include the elevation contours.
- Additional questions relating to previous submittal:
 - What is proposed or currently constructed on the barren areas shown on the submitted June 2007 aerial map?

Contacts

DWQ APS Central Office Mailing Address: 1636 Mail Service Center
Raleigh, North Carolina 27699-1636

DWQ APS Central Office Staff: Debra Watts
APS Groundwater Protection Unit Supervisor
debra.watts@ncdenr.gov
(919) 715-6699

Betty Wilcox
Environmental Chemist
betty.wilcox@ncdenr.gov
(919) 715-6169

Eric G. Smith, P.G.
Hydrogeologist
eric.g.smith@ncdenr.gov
(919) 715-6196

DWQ APS MRO Mailing Address: 610 East Center Avenue
Mooresville, North Carolina 28115

DWQ APS MRO Staff: Andrew Pitner
APS Supervisor
andrew.pitner@ncdenr.gov
(704) 663-1699



North Carolina Department of Environment and Natural Resources

Division of Water Quality
Coleen H. Sullins
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

Attachment 4

Site Name: Marshall Steam Station

County: Catawba County

Division of Water Quality Aquifer Protection Section Regional Office: Mooresville Regional Office (MRO)

Hydrogeology

- Based on the supplied maps, monitoring wells MW-7S, MW-7D, MW-8S, MW-8D, MW-9S, and MW-9D are located inside of the waste boundary. These wells are not suitable for determining compliance.
- Based on a clarification of the 15A NCAC 02L rules, monitoring wells are now required to be located at the Compliance Boundary. The proposed locations of these wells must be shown on the requested maps. Construction of these monitoring wells may begin after approval from the MRO.
- Where constructing wells at the Compliance Boundary may not be feasible due to the proximity of surface water, groundwater seepage monitoring will be required. The proposed locations of these monitoring points must be shown on the requested maps. The MRO will approve the final locations of the monitoring points.
- Combining Compliance Boundaries around any adjacent Division of Water Quality (DWQ) permitted activities is acceptable as well as recommended.
- Compliance Boundaries must not cross your property boundaries.

Groundwater Sampling and Data

- Please make sure that you sample the monitoring wells for the following constituents during each sampling event:

Aluminum	Boron	Cobalt	Manganese	Potassium	Thallium
Antimony	Cadmium	Copper	Mercury	Selenium	TDS
Arsenic	Calcium	Iron	Nickel	Silver	Vanadium
Barium	Chloride	Lead	Nitrate	Sodium	Zinc
Beryllium	Chromium	Magnesium	pH (field)	Sulfate	

- The listed parameters are intended to monitor constituents from the coal ash; additional parameters may be necessary to address contributions to the ash ponds from any other waste sources.
- All of the requested groundwater sampling parameters should be instituted starting with the next sampling round after receiving this letter.
- Please send the groundwater sampling data in both electronic (Microsoft Excel) and hardcopy forms.
- Please report all metals in micrograms per liter ($\mu\text{g/L}$) with the exception of Copper and Zinc which should be reported in milligrams per liter (mg/L) in accordance with the 15A NCAC 02L standard changes effective 1/1/10.
- The Aquifer Protection Section (APS) may allow some groundwater sampling parameters to be deleted based on non-detects over several sampling rounds or historical data provided.

Additional Information Requested

- Please submit the following updates to the maps by February 28, 2010:
 - Locations of proposed monitoring wells and/or groundwater seepage monitoring points,
 - Locations of all on-site inactive ash ponds and ash storage areas not previously identified, and

AQUIFER PROTECTION SECTION

1636 Mail Service Center, Raleigh, North Carolina 27699-1636

Location: 2728 Capital Boulevard, Raleigh, North Carolina 27604

Phone: 919-733-3221 | FAX 1: 919-715-0588, FAX 2: 919-715-6048 | Customer Service: 1-877-623-6748

Internet: www.ncwaterquality.org

An Equal Opportunity / Affirmative Action Employer

One
North Carolina
Naturally

OFFICIAL COPY

Feb 18 2020

- Locations of all on-site active and inactive Division of Waste Management (DWM) permitted solid waste facilities along with their associated Compliance Boundaries and monitoring wells,
- For the updated maps: Submit one (1) electronic copy and two (2) hard copies to the DWQ APS Central Office, and one (1) electronic copy and two (2) hard copies to the DWQ APS Regional Office.
 - Updates to the map can be made on the same aerial photo base as in the previous submittal. Please include the elevation contours.
- Additional questions relating to previous submittal:
 - On the supplied map, your Compliance Boundary extends around the Ash Landfill Permit 18-04 that is located just west of MW-6. This Ash Landfill is not under the NPDES permit. Is the Division of Waste Management in agreement with extending the Compliance Boundary around it?
 - The Waste Boundary crosses the property boundary near north boundary of active ash basin. Is this correct?
 - Are the Structural Fill areas part of a DWQ permit?
 - What are the rectangular-shaped structures near the middle of the Active Ash Basin that are not included in the waste boundary and what do they contain?

Contacts

DWQ APS Central Office Mailing Address: 1636 Mail Service Center
Raleigh, North Carolina 27699-1636

DWQ APS Central Office Staff: Debra Watts
APS Groundwater Protection Unit Supervisor
debra.watts@ncdenr.gov
(919) 715-6699

Betty Wilcox
Environmental Chemist
betty.wilcox@ncdenr.gov
(919) 715-6169

Eric G. Smith, P.G.
Hydrogeologist
eric.g.smith@ncdenr.gov
(919) 715-6196

DWQ APS MRO Mailing Address: 610 East Center Avenue
Mooresville, North Carolina 28115

DWQ APS MRO Staff: Andrew Pitner
APS Supervisor
andrew.pitner@ncdenr.gov
(704) 663-1699



North Carolina Department of Environment and Natural Resources

Division of Water Quality

Coleen H. Sullins
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

OFFICIAL COPY

Feb 18 2020

Attachment 5

Site Name: Riverbend Steam Station

County: Gaston County

Division of Water Quality Aquifer Protection Section Regional Office: Mooresville Regional Office (MRO)

Hydrogeology

- Based on the supplied maps, monitoring wells WM-1S, WM-1D, WM-2S, WM-2D, WM-3S, WM-3D, WM-4S, WM-4D, WM-5S, WM-5D, WM-6S, and WM-6D are between the waste boundaries and the review boundaries. These wells are not suitable for determining compliance.
- Based on a clarification of the 15A NCAC 02L rules, monitoring wells are now required to be located at the Compliance Boundary. The proposed locations of these wells must be shown on the requested maps. Construction of these monitoring wells may begin after approval from the MRO.
- Where constructing wells at the Compliance Boundary may not be feasible due to the proximity of surface water, groundwater seepage monitoring will be required. The proposed locations of these monitoring points must be shown on the requested maps. The MRO will approve the final locations of the monitoring points.
- Combining Compliance Boundaries around any adjacent Division of Water Quality (DWQ) permitted activities is acceptable as well as recommended.
- Compliance Boundaries must not cross your property boundaries.

Groundwater Sampling and Data

- Please make sure that you sample the monitoring wells for the following constituents during each sampling event:

Aluminum	Boron	Cobalt	Manganese	Potassium	Thallium
Antimony	Cadmium	Copper	Mercury	Selenium	TDS
Arsenic	Calcium	Iron	Nickel	Silver	Vanadium
Barium	Chloride	Lead	Nitrate	Sodium	Zinc
Beryllium	Chromium	Magnesium	pH (field)	Sulfate	

- The listed parameters are intended to monitor constituents from the coal ash; additional parameters may be necessary to address contributions to the ash ponds from any other waste sources.
- All of the requested groundwater sampling parameters should be instituted starting with the next sampling round after receiving this letter.
- Please send the groundwater sampling data in both electronic (Microsoft Excel) and hardcopy forms.
- Please report all metals in micrograms per liter ($\mu\text{g/L}$) with the exception of Copper and Zinc which should be reported in milligrams per liter (mg/L) in accordance with the 15A NCAC 02L standard changes effective 1/1/10.
- The Aquifer Protection Section (APS) may allow some groundwater sampling parameters to be deleted based on non-detects over several sampling rounds or historical data provided.

AQUIFER PROTECTION SECTION

1636 Mail Service Center, Raleigh, North Carolina 27699-1636

Location: 2728 Capital Boulevard, Raleigh, North Carolina 27604

Phone: 919-733-3221 \ FAX: 1: 919-715-0588; FAX 2: 919-715-6048 \ Customer Service: 1-877-623-6748

Internet: www.ncwaterquality.org

An Equal Opportunity \ Affirmative Action Employer

One
North Carolina
Naturally

Additional Information Requested

- Please submit the following updates to the maps by February 28, 2010:
 - Locations of proposed monitoring wells and/or groundwater seepage monitoring points,
 - Locations of all on-site inactive ash ponds and ash storage areas not previously identified, and
 - Locations of all on-site active and inactive Division of Waste Management (DWM) permitted solid waste facilities along with their associated Compliance Boundaries and monitoring wells,
- For the updated maps: Submit one (1) electronic copy and two (2) hard copies to the DWQ APS Central Office, and one (1) electronic copy and two (2) hard copies to the DWQ APS Regional Office.
 - Updates to the map can be made on the same aerial photo base as in the previous submittal. Please include the elevation contours.

Contacts

DWQ APS Central Office Mailing Address: 1636 Mail Service Center
Raleigh, North Carolina 27699-1636

DWQ APS Central Office Staff: Debra Watts
APS Groundwater Protection Unit Supervisor
debra.watts@ncdenr.gov
(919) 715-6699

Betty Wilcox
Environmental Chemist
betty.wilcox@ncdenr.gov
(919) 715-6169

Eric G. Smith, P.G.
Hydrogeologist
eric.g.smith@ncdenr.gov
(919) 715-6196

DWQ APS MRO Mailing Address: 610 East Center Avenue
Mooresville, North Carolina 28115

DWQ APS MRO Staff: Andrew Pitner
APS Supervisor
andrew.pitner@ncdenr.gov
(704) 663-1699



North Carolina Department of Environment and Natural Resources

Division of Water Quality

Coleen H. Sullins

Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

OFFICIAL COPY

Attachment 6

Site Name: Belews Creek Steam Station

County: Stokes County

Division of Water Quality Aquifer Protection Section Regional Office: Winston-Salem Regional Office (WSRO)

Hydrogeology

- Based on the supplied maps, monitoring wells MW-101S, MW-101D, MW-102S, and MW-102D are at the waste boundary. Based on their location, these wells are not suitable for determining compliance.
- Recommend a monitoring well be added directly west of monitoring well MW-104S on the western side of the Active Ash Basin at the Compliance/Property Boundary. There appears to be a topographic draw that extends southwest toward a pond. This could be a conduit for groundwater to flow toward the pond from the Active Ash Basin.
- MW-104S and MW-104D are not suitable background wells due to their location within the Compliance Boundary. Recommend that a new background well be added elsewhere on the property.
- Based on a clarification of the 15A NCAC 02L rules, monitoring wells are now required to be located at the Compliance Boundary. The proposed locations of these wells must be shown on the requested maps. Construction of these monitoring wells may begin after approval from the WSRO.
- Where constructing wells at the Compliance Boundary may not be feasible due to the proximity of surface water, groundwater seepage monitoring will be required. The proposed locations of these monitoring points must be shown on the requested maps. The WSRO will approve the final locations of the monitoring points.
- Combining Compliance Boundaries around any adjacent Division of Water Quality (DWQ) permitted activities is acceptable as well as recommended.
- Compliance Boundaries must not cross your property boundaries.

Groundwater Sampling and Data

- Please make sure that you sample the monitoring wells for the following constituents during each sampling event:

Aluminum	Boron	Cobalt	Manganese	Potassium	Thallium
Antimony	Cadmium	Copper	Mercury	Selenium	TDS
Arsenic	Calcium	Iron	Nickel	Silver	Vanadium
Barium	Chloride	Lead	Nitrate	Sodium	Zinc
Beryllium	Chromium	Magnesium	pH (field)	Sulfate	

- The listed parameters are intended to monitor constituents from the coal ash; additional parameters may be necessary to address contributions to the ash ponds from any other waste sources.
- All of the requested groundwater sampling parameters should be instituted starting with the next sampling round after receiving this letter.
- Please send the groundwater sampling data in both electronic (Microsoft Excel) and hardcopy forms.
- Please report all metals in micrograms per liter ($\mu\text{g/L}$) with the exception of Copper and Zinc which should be reported in milligrams per liter (mg/L) in accordance with the 15A NCAC 02L standard changes effective 1/1/10.
- The Aquifer Protection Section (APS) may allow some groundwater sampling parameters to be deleted based on non-detects over several sampling rounds or historical data provided.

AQUIFER PROTECTION SECTION

1636 Mail Service Center, Raleigh, North Carolina 27699-1636

Location: 2728 Capital Boulevard, Raleigh, North Carolina 27604

Phone: 919-733-3221 \ FAX 1: 919-715-0588; FAX 2: 919-715-6048 \ Customer Service: 1-877-623-6748

Internet: www.ncwaterquality.org

An Equal Opportunity \ Affirmative Action Employer

One
North Carolina
Naturally

Feb 18 2020

Additional Information Requested

- Please submit the following updates to the maps by February 28, 2010:
 - Locations of proposed monitoring wells and/or groundwater seepage monitoring points,
 - Locations of all on-site inactive ash ponds and ash storage areas not previously identified, and
 - Locations of all on-site active and inactive Division of Waste Management (DWM) permitted solid waste facilities along with their associated Compliance Boundaries and monitoring wells,
- For the updated maps: Submit one (1) electronic copy and two (2) hard copies to the DWQ APS Central Office, and one (1) electronic copy and two (2) hard copies to the DWQ APS Regional Office.
 - Updates to the map can be made on the same aerial photo base as in the previous submittal. Please include the elevation contours.
- Additional questions relating to previous submittal:
 - On the supplied maps, you show the Compliance Boundary for the Active Ash Basin being combined and extending around the Pine Hall Road Ash Landfill. This Ash Landfill is not under the NPDES permit. Is the Division of Waste Management in agreement with combining and extending the compliance boundaries? If not, make sure that the Compliance Boundary is the proper distance from the Active Ash Basin waste boundary only.
 - Based on other aerial photography, there appears to be several earthen structures which resemble ash ponds, structural fills, or landfills on your property southeast, south, and southwest of the steam plant along State Route 2042 which are not included on the supplied maps due to their scale. What are these structures?
 - Are the Structural Fill areas part of a DWQ permit?
 - What are the rectangular-shaped earthen structures located near the northern intersection of Duke Power Steam Plant Road and Pine Hall Road.

Contacts

DWQ APS Central Office Mailing Address: 1636 Mail Service Center
Raleigh, North Carolina 27699-1636

DWQ APS Central Office Staff: Debra Watts
APS Groundwater Protection Unit Supervisor
debra.watts@ncdenr.gov
(919) 715-6699

Betty Wilcox
Environmental Chemist
betty.wilcox@ncdenr.gov
(919) 715-6169

Eric G. Smith, P.G.
Hydrogeologist
eric.g.smith@ncdenr.gov
(919) 715-6196

DWQ APS WSRO Mailing Address: 585 Waughtown Street
Winston-Salem, North Carolina 27107

DWQ APS WSRO Staff: Sherri Knight
APS Supervisor
sherri.knight@ncdenr.gov
(336) 771-5000



North Carolina Department of Environment and Natural Resources

Division of Water Quality

Coleen H. Sullins

Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

OFFICIAL COPY

Feb 18 2020

Attachment 7

Site Name: Dan River Steam Station

County: Rockingham County

Division of Water Quality Aquifer Protection Section Regional Office: Winston-Salem Regional Office (WSRO)

Hydrogeology

- Based on the supplied data shallow monitoring well MW-12 has a water table above the screen.
- Based on the supplied maps, monitoring wells MW-9S, MW-9D, MW-10S, MW-10D, MW-11S, and MW-11D are located within the waste boundary. These wells are not suitable for determining compliance.
- Recommend that you extend your Review/Compliance Boundaries around the Ash Storage areas. This would make the MW-12 and MW-12D fall within the Compliance Boundary. Recommend that a new background well be added elsewhere on the property.
- Based on a clarification of the 15A NCAC 02L rules, monitoring wells are now required to be located at the Compliance Boundary. The proposed locations of these wells must be shown on the requested maps. Construction of these monitoring wells may begin after approval from the WSRO.
- Where constructing wells at the Compliance Boundary may not be feasible due to the proximity of surface water, groundwater seepage monitoring will be required. The proposed locations of these monitoring points must be shown on the requested maps. The WSRO will approve the final locations of the monitoring points.
- Combining Compliance Boundaries around any adjacent Division of Water Quality (DWQ) permitted activities is acceptable as well as recommended.
- Compliance Boundaries must not cross your property boundaries.

Groundwater Sampling and Data

- Please make sure that you sample the monitoring wells for the following constituents during each sampling event:

Aluminum	Boron	Cobalt	Manganese	Potassium	Thallium
Antimony	Cadmium	Copper	Mercury	Selenium	TDS
Arsenic	Calcium	Iron	Nickel	Silver	Vanadium
Barium	Chloride	Lead	Nitrate	Sodium	Zinc
Beryllium	Chromium	Magnesium	pH (field)	Sulfate	

- The listed parameters are intended to monitor constituents from the coal ash; additional parameters may be necessary to address contributions to the ash ponds from any other waste sources.
- All of the requested groundwater sampling parameters should be instituted starting with the next sampling round after receiving this letter.
- Please send the groundwater sampling data in both electronic (Microsoft Excel) and hardcopy forms.
- Please report all metals in micrograms per liter ($\mu\text{g/L}$) with the exception of Copper and Zinc which should be reported in milligrams per liter (mg/L) in accordance with the 15A NCAC 02L standard changes effective 1/1/10.
- The Aquifer Protection Section (APS) may allow some groundwater sampling parameters to be deleted based on non-detects over several sampling rounds or historical data provided.

AQUIFER PROTECTION SECTION

1636 Mail Service Center, Raleigh, North Carolina 27699-1636

Location: 2728 Capital Boulevard, Raleigh, North Carolina 27604

Phone: 919-733-3221 \ FAX 1: 919-715-0588; FAX 2: 919-715-6048 \ Customer Service: 1-877-623-6748

Internet: www.ncwaterquality.org

An Equal Opportunity \ Affirmative Action Employer

One
North Carolina
Naturally

Additional Information Requested

- Please submit the following updates to the maps by February 28, 2010:
 - Locations of proposed monitoring wells and/or groundwater seepage monitoring points,
 - Locations of all on-site inactive ash ponds and ash storage areas not previously identified, and
 - Locations of all on-site active and inactive Division of Waste Management (DWM) permitted solid waste facilities along with their associated Compliance Boundaries and monitoring wells,
- For the updated maps: Submit one (1) electronic copy and two (2) hard copies to the DWQ APS Central Office, and one (1) electronic copy and two (2) hard copies to the DWQ APS Regional Office.
 - Updates to the map can be made on the same aerial photo base as in the previous submittal. Please include the elevation contours.

Contacts

DWQ APS Central Office Mailing Address: 1636 Mail Service Center
Raleigh, North Carolina 27699-1636

DWQ APS Central Office Staff: Debra Watts
APS Groundwater Protection Unit Supervisor
debra.watts@ncdenr.gov
(919) 715-6699

Betty Wilcox
Environmental Chemist
betty.wilcox@ncdenr.gov
(919) 715-6169

Eric G. Smith, P.G.
Hydrogeologist
eric.g.smith@ncdenr.gov
(919) 715-6196

DWQ APS WSRO Mailing Address: 585 Waughtown Street
Winston-Salem, North Carolina 27107

DWQ APS WSRO Staff: Sherri Knight
APS Supervisor
sherri.knight@ncdenr.gov
(336) 771-5000



North Carolina Department of Environment and Natural Resources

Division of Water Quality
Coleen H. Sullins
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

June 17, 2011

MEMORANDUM

To: Aquifer Protection Section Staff
Interested Parties

From: Ted L. Bush, Chief
Aquifer Protection Section

Subject: Policy for Compliance Evaluation of Long-Term Permitted Facilities with No Prior Groundwater Monitoring Requirements

Adherence to state regulations is fundamental to the protection of the waters of the state and is mandated in permits issued by the Division of Water Quality (DWQ). Evaluating permit conformity can be challenging, and oftentimes regulatory staff will add permit conditions to a permit to help determine if a facility is in compliance with state requirements. When groundwater monitoring requirements are added to a permitted facility that has operated for some period of time, it may be necessary to place wells at or near the compliance boundary (defined by 15A NCAC 2L .0107), rather than the review boundary (defined by 15A NCAC 2L .0108). This is determined by considering, at minimum, the following factors:

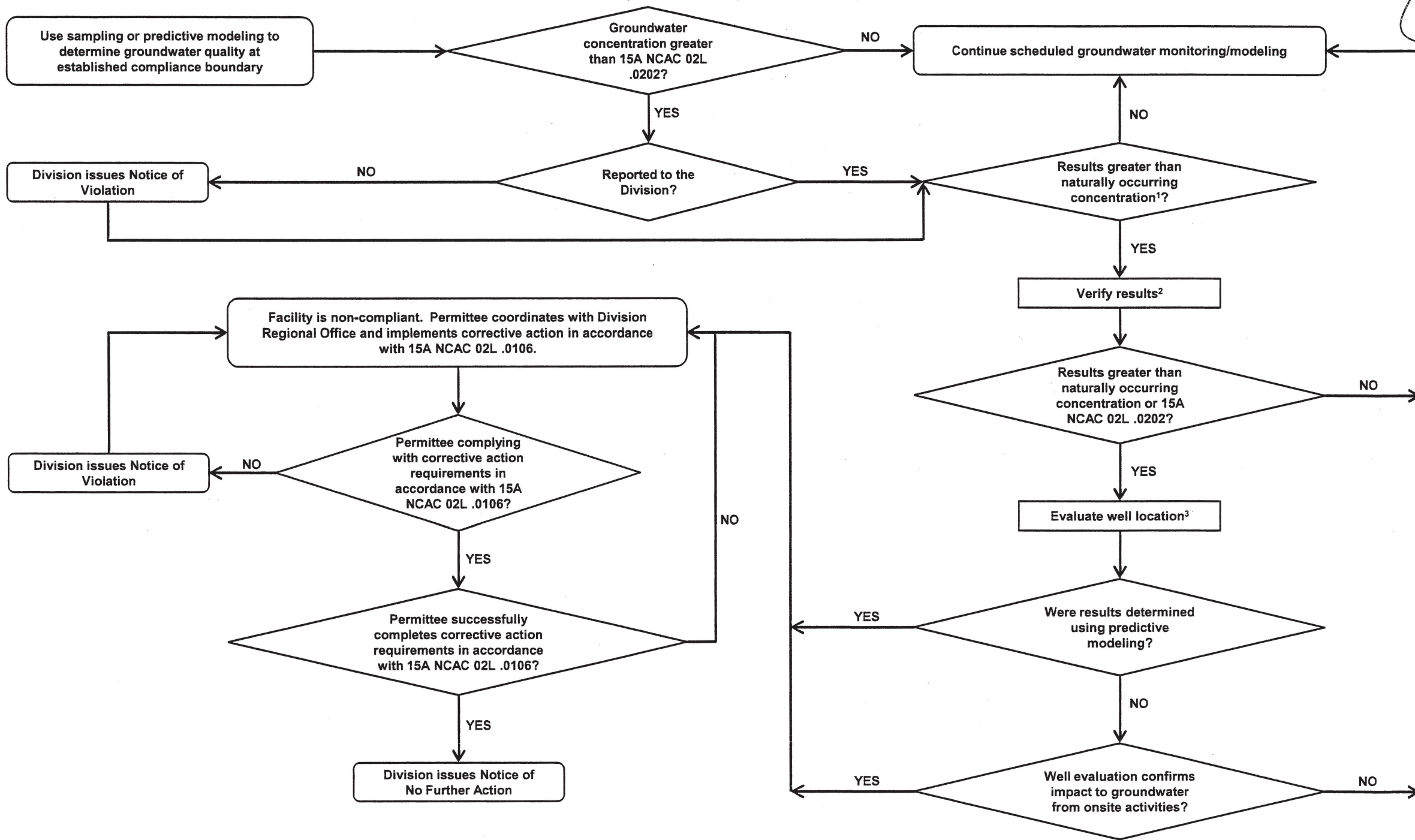
- 1) *Type of Permitted Activity.* Some permitted activities are more conducive to potential contamination than others. For instance, an unlined lagoon has a higher probability of contaminating the subsurface than a lined lagoon due to infiltration of the permitted waste into the underlying soil.
- 2) *Subsurface Geology.* Groundwater flow in the subsurface is controlled by the local geology. Some geological formations due to their structure and composition, such as unconsolidated sand or fractured bedrock, allow for greater groundwater flow rates. These formations have open pathways that can allow contaminants to easily migrate throughout the subsurface.
- 3) *Duration of Permitted Activity.* The longer a permitted activity takes place, the more opportunity there is for potential contamination to migrate away from the source. If the subsurface geology allows for greater groundwater flow, the amount of time it takes for potential contaminants to move away from the source is decreased. For the purpose of this document, a "Long-Term Permitted Facility" is a facility that has operated long enough that resulting contamination from the permitted source has a high probability of having reached or passed the compliance boundary.
- 4) *Location of the Review and Compliance Boundaries.* The distance of the review and compliance boundaries from the source is determined by rule. However, in some instances these boundaries can be closer to the source based on the location of the property boundaries.

Once the factors above have been considered and wells have been installed and sampled, the attached flowchart will be used to determine facility compliance. The flowchart outlines the steps to be taken to assess whether or not groundwater standards have been exceeded at the compliance boundary, and only apply to long-term permitted facilities as defined above. The flowchart is designed to apply to any DWQ permitted facility where groundwater monitoring requirements have recently been added to the permit.

If the permitted facility is determined to be in non-compliance after following the steps outlined on the attached flowchart, adherence to the corrective action requirements specified in 15A NCAC 2L .0106 will be required. However, as long as the permittee is cooperative with the Division in taking all necessary steps to bring the facility into compliance, a notice of violation may not be necessary. The overall determination of whether or not a notice of violation is necessary will largely be based on the overall compliance history of the facility and the potential for impacts to human health and the environment.

cc: Surface Water Protection (Matt Matthews)

Compliance Evaluation of Long-Term Permitted Facilities with No Prior Groundwater Monitoring Requirements
(Refer to Policy Dated 6/17/11)



¹Per 15A NCAC 2L .0202 (b)(3). Naturally occurring, site-specific concentration to be evaluated by permit holder and approved by DWQ.

²Verification may include re-sampling, further well development, consideration of other analytical methods, comparison to split-sample results, review of model parameters (if determined using predictive modeling), etc.

³Evaluation will include a review of an array of hydrogeologic, site-specific features, related well location and construction specifications, groundwater flow direction, compliance boundaries, other contaminant sources, etc.

6/17/11

OFFICIAL COPY

Feb 18 2020

**UTILITY INDUSTRY ACTION PLAN
FOR THE
MANAGEMENT OF COAL COMBUSTION
PRODUCTS**

Submitted to the
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Solid Waste
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

by the
UTILITY SOLID WASTE ACTIVITIES GROUP
701 Pennsylvania Avenue, NW
Washington, D.C. 20004-2696
202-508-5645

October 2006

Contents

I.	Introduction.....	1
II.	Overview And Schedule Of Implementation.....	4
III.	Groundwater Performance Standards For CCP Units.....	6
IV.	Groundwater Monitoring Program For CCP Units.....	6
V.	Restrictions On Placement Of CCPs In Sand And Gravel Pits	9
VI.	Dry Handling of Fly Ash.....	9

UTILITY INDUSTRY ACTION PLAN

I. Introduction

A. Background

The Utility Solid Waste Activities Group (“USWAG”)¹ is pleased to submit this Utility Industry Action Plan for the Management of Coal Combustion Products (the “Action Plan”). The Action Plan is an important component of the utility industry’s response to the Environmental Protection Agency’s (“EPA’s”) Resource Conservation Challenge, an initiative that calls for the industry to partner with the Agency to find innovative ways to prevent pollution and promote the beneficial use of residues from the combustion of coal in boilers used to generate electricity, commonly called “coal combustion products” or “CCPs”.² In response to the Resource Conservation Challenge, EPA and the industry also are jointly implementing the Coal Combustion Products Partnership (“C²P²”), a collaborative effort to reduce barriers and encourage increased beneficial use of CCPs.

CCPs are beneficially used in numerous applications, including, among others, as raw material in portland cement, for mine reclamation, as replacement for cement in concrete and grout, as mineral filler in asphaltic concrete, as aggregate for highway subgrades and road base material, as a component of flowable fill, and as structural fill.³

¹ USWAG is an association of the Edison Electric Institute (“EEI”), the American Public Power Association (“APPA”), the National Rural Electric Cooperative Association (“NRECA”) and approximately 80 electric utility operating companies located throughout the country. EEI is the principal national association of investor-owned electric power and light companies. APPA is the national association of publicly-owned electric utilities. NRECA is the national association of rural electric cooperatives. Together, USWAG members represent more than 85 percent of the total electric generating capacity of the United States and service more than 95 percent of the nation’s consumers of electricity and over 93 percent of the nation’s consumers of natural gas.

² For purposes of this Action Plan, CCPs are the materials generated from the combustion of coal subject to the Bevill Amendment study provision (RCRA § 8002(n), 42 U.S.C. § 6982(n)). In addition to materials generated solely from the combustion of coal, CCPs include “[f]ly ash, bottom ash, boiler slag, and flue gas emission control wastes from the combustion of coal by electric utility power plants, when such wastes are mixed with, codisposed, cotreated, or otherwise comanaged with other wastes generated in conjunction with the combustion of coal or other fossil fuels.” See EPA, REPORT TO CONGRESS, WASTES FROM THE COMBUSTION OF FOSSIL FUELS, Vol. 1, p. 1-2, Vol. 2, p. 1-1 (March 1999) (“1999 RTC”), quoting *Gearhart v. Reilly*, Civil No. 91-2345 (D.D.C. June 30, 1992) (Consent Decree). CCPs also include the residuals from the combustion of coal and other fuels and materials where coal makes up at least 50 percent of the mixture. See *id.*, Vol. 2, p. 3-9. This description of the scope of the Bevill exclusion (and hence the definition of “CCPs” in this Action Plan) was first contained in a 1981 interpretive letter from EPA to USWAG (Letter from G. Dietrich, EPA, to P. Emler, USWAG, dated Jan. 13, 1981, pp. 7-8) and was later clarified in EPA’s first Bevill determination. See 58 Fed. Reg. 42466, 42469 n.4 (Aug. 9, 1993).

³ See 1999 RTC, Vol. 2, pp. 3-36–3-37; 65 Fed. Reg. 32214, 32229 (May 22, 2000).

Currently, just over 40 percent of CCPs produced by electric power generating plants are used in such applications.⁴ The balance of CCPs must be managed in landfills and surface impoundments. The goal of C²P² is to increase the percentage of CCPs diverted to beneficial uses and thereby to decrease the volume of CCPs managed in landfills and surface impoundments.

The industry is committed to C²P² as a means of ultimately achieving complete resource conservation of CCPs. Until full beneficial use of CCPs is achieved, continued management of CCPs in an environmentally responsible manner will remain an essential component of electric power generation. The utility industry through USWAG developed this Action Plan to complement the goals of C²P² by ensuring that until complete resource conservation of CCPs is achieved, the remaining CCPs will be managed in a manner that protects human health and the environment.

This Action Plan details the industry's commitment to (1) adopt groundwater performance standards at facilities that manage CCPs, (2) implement a comprehensive monitoring program to measure conformance with the groundwater performance standards at CCP facilities, (3) ensure that no CCPs are placed in sand and gravel pits without appropriate engineering controls, and to (4) consider the option of using dry handling technology prior to constructing a new landfill or surface impoundment to manage fly ash on their property. These commitments are designed to address concerns previously raised by EPA regarding CCP management. The Action Plan does not supersede any federal, state, local or tribal law, regulation, or any existing permit, agreement or approval by an appropriate governmental agency. The following section briefly describes the process used to develop the Action Plan, followed by a presentation of the elements of the Plan.

B. The Development of the Utility Industry Action Plan

USWAG designed this Action Plan to address concerns raised by the EPA in the Agency's Regulatory Determination on Wastes from the Combustion of Fossil Fuels, 65 Fed. Reg. 32214 (May 22, 2000) (the "Regulatory Determination") and in subsequent communications with the industry. In the Regulatory Determination, EPA announced its decision that CCPs do not warrant regulation under RCRA Subtitle C, a decision that USWAG supported in comments filed with the Agency. USWAG Comments on the Regulatory Determination, Sept. 19, 2000 ("USWAG Comments"). The Regulatory Determination also announced EPA's intent to develop national standards under RCRA Subtitle D for CCPs disposed of in landfills and surface impoundments. 65 Fed. Reg. at 32230. In support of the proposed Subtitle D regulation of CCPs, EPA pointed to a group of "damages cases" involving CCP disposal sites at which, according to the Agency, environmental damage had either been proved or alleged in a manner that suggested that some CCP management practices may pose a risk to human health and the environment.

⁴ American Coal Ash Association, 2005 Coal Combustion Product (CCP) Production and Use Survey (Sept. 29, 2006).

Id. In addition, the Agency found that some CCP management units lacked groundwater monitoring. *Id.*

Following the Regulatory Determination, USWAG submitted comments that questioned the need for regulating CCPs under RCRA Subtitle D. *See, e.g.*, USWAG Comments at 4-6. In particular, USWAG noted that the damage cases relied on by EPA primarily involve outdated CCP management scenarios (*e.g.*, historic disposal in older uncontrolled sites) that do not provide an accurate representation of current industry practices. The cases relied on by EPA presented incomplete data sets, failed to take account for site specific conditions, and often focused on sites that either have been closed or whose management practices have been substantially changed since the incidents causing the alleged damage. Furthermore, in the few instances where the damage cases indicated significant problems with CCP management, EPA failed to recognize that the utilities involved had already acted responsibly to address the environmental issues. In short, USWAG believes that EPA has not, and indeed cannot, demonstrate that mandatory Subtitle D regulation of CCPs is necessary to protect human health and the environment. To the contrary, prescriptive Federal regulations would have the opposite effect of inhibiting environmentally protective, site-specific, and risk-based remedies currently available to states to address the small percentage of CCP management units posing environmental concerns. For these reasons, USWAG continues to oppose any prescriptive Federal regulation of CCPs. At the same time, USWAG reaffirms the utility industry's strong commitment to managing CCPs in a manner protective of human health and the environment.

As part of this commitment, USWAG has reached out to staff from EPA's Office of Solid Waste ("OSW") in an effort to understand and address the Agency's concerns relating to CCP management units. OSW staff invited USWAG to draft a plan to address the following Agency concerns: (1) the low percentage of existing CCP surface impoundments and landfills with groundwater monitoring programs; (2) the placement of CCPs in sand and gravel pits without appropriate engineering controls; and (3) the Agency's desire that the utility industry consider dry handling technology prior to constructing new landfills or surface impoundments to manage fly ash. USWAG members accept OSW's invitation and welcome the opportunity to work in partnership to reassure the public that the utility industry is managing CCPs in a manner protective of human health and the environment.

In response to this invitation, USWAG's Ash Management & Solid Waste Committee convened a panel of industry CCP technical experts to develop an action plan to address the concerns identified. This Utility Industry Action Plan is the result of USWAG's efforts. The Action Plan has the following four operative sections designed to address the concerns raised by OSW staff: Section III (Groundwater Performance Standards for CCP Units); Section IV (Groundwater Monitoring Program for CCP Units); Section V (Restrictions on Placement of CCPs in Sand and Gravel Pits); and Section VI (Dry Handling of Fly Ash). USWAG expects that technical work to implement Sections III, IV and V will be conducted by persons having professional qualifications to perform the tasks required by the Plan.

In developing comprehensive groundwater performance standards and groundwater monitoring program guidelines for facilities with CCP landfills and surface impoundments (Sections III and IV of the Action Plan), the industry panel relied on EPA's solid waste guidance and extant regulations. *See, e.g.*, EPA, GUIDE FOR INDUSTRIAL WASTE MANAGEMENT, EPA530-R-03-001 (Feb. 2003); Criteria for Classification of Solid Waste Disposal Facilities and Practices, 40 C.F.R. Part 257; and Criteria for Municipal Solid Waste Landfills, 40 C.F.R. Part 258. The groundwater monitoring program incorporates an implementation schedule modeled on EPA's municipal solid waste landfill regulations. *See* 40 C.F.R. § 258.50(c). The monitoring program also includes design and operating guidelines (*i.e.*, location and number of wells, sampling parameters and frequency of monitoring, recordkeeping) to detect a CCP-related exceedance of groundwater performance standards as defined in Section III. The plan also includes procedures for conducting assessment monitoring and directs participating owners or operators to coordinate corrective action when necessary with appropriate federal, state, tribal or local regulatory agencies (collectively "appropriate governmental agencies").

Section V of the Action Plan addresses the Agency's concerns over placement of CCPs in sand and gravel pits. Section V states that CCPs shall not be placed in sand and gravel pits without appropriate site-specific engineering and management controls.

Finally, Section VI of the Action Plan was developed to respond to the Agency's request for the industry to take steps to encourage the use of dry fly ash handling technology in place of wet sluicing of fly ash prior to constructing new landfills or surface impoundments used to manage fly ash on company property. Section VI of the Action Plan responds to EPA's request by prompting owners and operators of power plants to consider the option of using dry handling technology prior to constructing a new landfill or surface impoundment to manage fly ash on their property.

II. Overview and Schedule of Implementation

This Action Plan applies to owners and operators of electric power generating plants that generate and manage CCPs and that choose to adopt the Action Plan as part of their standard operating procedures ("participating owners or operators"). Participating owners or operators agree to (1) adopt the groundwater performance standards in Section III of the Plan at their facilities with surface impoundments and landfills that receive CCPs after agreeing to participate in the Plan⁵ ("CCP Units"),⁶ (2) implement the groundwater monitoring program in Section IV at their facilities with CCP Units, (3) comply with the restrictions on the placement of CCPs in sand and gravel pits in

⁵ *See, e.g.*, 40 C.F.R. § 258.1(c).

⁶ The term "CCP Unit" includes landfill and surface impoundment units whose primary function is to manage CCPs. The term does not include, for example, a wastewater treatment impoundment that only incidentally contains small quantities of CCPs in wastewater received by the unit after a participating owner or operator elects to participate in the Plan.

Section V, and (4) consider the option of using dry handling technology for fly ash prior to constructing a new landfill or surface impoundment to manage fly ash on their property in accordance with Section VI. This Action Plan is effective at a facility six months after the date on which a participating owner or operator notifies USWAG of its agreement to participate in the Plan with respect to that facility (the “Effective Date”).

Participating owners or operators agree to implement groundwater performance monitoring following a schedule patterned after that applicable to owners or operators of municipal solid waste landfills.⁷ Specifically, participating owners or operators of CCP Units located less than one mile upgradient from a groundwater well that is an active source of drinking water (“active drinking water well”) agree to comply with the provisions of Section III and IV within three years of agreeing to participate in this Plan. Furthermore, participating owners or operators of CCP Units located one mile or more but less than two miles upgradient from an active drinking water well agree to implement the provisions of Sections III and IV within four years of agreeing to participate in this Plan. Finally, participating owners or operators of CCP Units that are located two miles or more upgradient from an active drinking water well agree to implement the provisions of Section III and IV within five years of agreeing to participate in this Plan.

Notwithstanding the foregoing, and as substantially provided for existing municipal solid waste landfills, participating owners or operators of facilities with CCP Units can adopt an alternative schedule to implement Sections III and IV of this Action Plan so long as the alternative schedule addresses potential risks to human health and the environment by considering the following factors: (a) proximity of human and environmental receptors; (b) design of the CCP Unit; (c) age of the CCP Unit; (d) size of the CCP Unit; (e) resource value of the underlying aquifer, including (i) current and future uses, (ii) proximity and withdrawal rate of users, (iii) groundwater quality and quantity.⁸ Participating owners or operators will coordinate with the appropriate governmental agency in adopting an alternative schedule to implement Sections III and IV of this Action Plan.

After the Effective Date of this Action Plan, participating owners or operators, in accordance with Section V and VI, agree to adopt the restrictions on the placement of CCPs in sand and gravel pits and agree to consider the option of using dry handling technology prior to constructing a new landfill or surface impoundment to manage fly ash on their property. In accordance with the foregoing implementation schedule, USWAG and the participating owners or operators commit to execute this Action Plan in a manner protective of human health and the environment.

⁷ See 40 C.F.R. § 258.50(c).

⁸ See 40 C.F.R. § 258.50(d).

Nothing in this Action Plan supersedes any applicable federal, state, tribal or local laws and regulations, or any existing permit, agreement, or approval by an appropriate governmental agency.

III. Groundwater Performance Standards For CCP Units

Each CCP Unit is subject to a designated groundwater performance standard. The default groundwater performance standard for CCP-derived constituents in a designated drinking water source aquifer is the national primary drinking water maximum contaminant levels (“MCLs”) occurring at the lesser of 150 meters from the CCP Unit boundary or the property boundary as detected by sampling conducted in accordance with Section IV.⁹

Alternatively, as allowed in EPA’s regulations for solid waste disposal facilities, an owner or operator may adopt a groundwater quality performance standard for a CCP Unit approved by an appropriate governmental agency, provided the alternative considers factors such as (a) the hydrogeological characteristics of the facility and surrounding land including any natural attenuation and dilution characteristics of the aquifer, (b) the volume, physical and chemical characteristics of the leachate, (c) the quantity, quality, and direction of flow of groundwater underlying the facility, (d) the proximity and withdrawal rates of groundwater users, (e) the availability of alternative drinking water supplies, (f) the existing quality of the groundwater, including other sources of contamination and their cumulative impacts on the water, (g) public health, safety and welfare effects, and (h) whether the groundwater is currently used or reasonably expected to be used for drinking water.¹⁰ The default groundwater performance standard and any alternative groundwater performance standard adopted pursuant to this paragraph are collectively referred to herein as the “Groundwater Performance Standards.”

IV. Groundwater Monitoring Program For CCP Units

A. Applicability of Groundwater Monitoring Program

Participating owners or operators agree to implement a groundwater monitoring program that meets the guidelines set forth in this Section IV. The goal of the groundwater monitoring program is to yield groundwater samples that will, to the extent reasonably possible, (a) represent the quality of background groundwater unaffected by the CCP Unit, and (b) detect CCP-related exceedances of Groundwater Performance Standards.

⁹ See EPA, GUIDE FOR INDUSTRIAL WASTE MANAGEMENT, EPA530-R-03-001 (Feb. 2003) at 9-8.

¹⁰ See 40 C.F.R. § 258.40(d).

To meet the standards set forth in Section IV, participating owners or operators of facilities with CCP Units may either install and operate a separate groundwater monitoring system for each CCP Unit or, alternatively, a multi-CCP unit groundwater monitoring system. A multi-CCP Unit groundwater monitoring system used in lieu of an individual CCP Unit monitoring system must meet the requirements of Section IV and be as protective of human health and the environment as individual monitoring systems based on the following factors: (1) the number, spacing, and orientation of CCP Units; (2) the hydrogeologic setting; (3) the site history; (4) the engineering design of the CCP Units; and (5) the nature of the CCPs placed in the CCP Unit.¹¹ Any groundwater monitoring system that covers a CCP Unit and is conducted pursuant to a federal, state or tribal regulatory provision, permit, agreement or approval shall be deemed to conclusively meet the guidelines in Section IV of this Action Plan.

Additionally, the groundwater monitoring program guidelines in Section IV may be waived if participating owners or operators of a CCP Unit can demonstrate that there is no reasonable potential for migration of CCP-derived primary drinking water constituents from the CCP Unit to an aquifer designated as a drinking water source.¹² In accordance with EPA regulations, this demonstration must be based on (1) site specific field measurements, sampling, and analysis of physical, chemical and biological processes affecting constituent fate and transport, and (2) constituent fate and transport predictions that maximize constituent migration and consider impacts on human health and the environment.¹³ The demonstration shall be retained in the files of the participating owner or operator in accordance with established records retention policies and shall be made available to appropriate governmental agencies upon request.

B. Groundwater Monitoring Program

As set forth in EPA's GUIDE FOR INDUSTRIAL WASTE MANAGEMENT, EPA530-R-03-001 (Feb. 2003), participating owners or operators agree to install a monitoring system of at least three monitoring wells downgradient from a CCP Unit and at least one upgradient well to assess background water quality.¹⁴ The monitoring system may be modified based on site-specific conditions, if approved by the appropriate governmental agency. A determination of background quality of groundwater may include sampling at a location that is not hydraulically upgradient of the CCP Unit where (i) hydrological conditions do not allow the owner or operator to determine what well is hydraulically upgradient, or (ii) sampling at other locations will provide an indication of background

¹¹ See 40 C.F.R. § 258.51(b).

¹² See EPA, GUIDE FOR INDUSTRIAL WASTE MANAGEMENT at 9-14.

¹³ 40 C.F.R. §§ 257.21(b), 258.50(b).

¹⁴ See, e.g., EPA, GUIDE FOR INDUSTRIAL WASTE MANAGEMENT at 9-16, Table 3.

groundwater quality that is as representative or more representative than that provided by an upgradient well.¹⁵

Participating owners or operators agree to conduct semi-annual monitoring for CCP-related primary drinking water constituents (*i.e.*, constituents with MCLs) that are reasonably expected to migrate to the groundwater based on site-specific factors.¹⁶ Participating owners or operators agree to maintain records of sampling results generated by monitoring performed pursuant to this Section IV in accordance with established records retention policies.

Participating owners or operators agree to determine within a reasonable period of time after completing semi-annual sampling and analysis whether there has been a statistically significant increase over background levels for CCP-related constituents that exceed the Groundwater Performance Standards.¹⁷ If such an exceedance of a Groundwater Performance Standard is detected, the participating owner or operator agrees to take steps to determine whether the increase was caused by factors unrelated to the CCP Unit. Factors unrelated to the unit include, but are not limited to (i) constituent sources other than the CCP Unit being monitored, (ii) natural variations in groundwater quality, (iii) statistical errors, (iv) analytical errors, and (v) sampling errors.¹⁸ If the participating owner or operator determines that the increase was caused by a factor unrelated to the CCP Unit, no additional measures are necessary and the original groundwater monitoring program may be resumed.¹⁹ If factors unrelated to the CCP Unit have been ruled out, the participating owner or operator agrees to consult with the appropriate governmental agency to determine the type of assessment monitoring to conduct at the CCP Unit.²⁰

If assessment monitoring and analysis confirms a statistically significant CCP-derived increase over background that exceeds Groundwater Performance Standards for one or more constituents, then a participating owner or operator shall, within 90 days of such confirmation, consult with the appropriate governmental agency and begin to develop a risk-based management plan to address contamination.²¹

¹⁵ See 40 C.F.R. § 258.51(a).

¹⁶ See EPA, GUIDE FOR INDUSTRIAL WASTE MANAGEMENT at 9-13.

¹⁷ See 40 C.F.R. §§ 257.25(a), 258.55(a). For a description of appropriate methods for determining statistically significant increases over background, see 40 C.F.R. §§ 257.23(g), (h), 258.53(g), (h).

¹⁸ See EPA, GUIDE FOR INDUSTRIAL WASTE MANAGEMENT at 9-46.

¹⁹ *Id.*

²⁰ *Id.* at 9-46 to 9-47.

²¹ See, *e.g.*, 40 C.F.R. §§ 257.26(a), 258.56(a).

V. Restrictions On Placement Of CCPs In Sand And Gravel Pits

After the Effective Date of this Action Plan, participating owners or operators agree not to place or contract for the placement of CCPs into sand and gravel pits without appropriate site-specific engineering and management controls to protect groundwater. Appropriate site-specific engineering and management controls may include compaction, encapsulation, grading, capping, natural or synthetic barriers, or placement above seasonal high-groundwater table fluctuations.

VI. Dry Handling Of Fly Ash

After the Effective Date, participating owners or operators agree to consider the option of using dry handling technology for fly ash prior to constructing a new landfill or surface impoundment to manage fly ash on their property. Participating owners or operators that consider the option of dry handling technology in the construction of a new fly ash landfill or surface impoundment but decide not to proceed with the option agree to maintain records that indicate the basis for that determination in accordance with established records retention policies. Nothing in this section of the Action Plan shall be deemed to (1) supersede or add to the requirements of 40 C.F.R Part 423, where applicable, (2) affect the management of CCPs other than fly ash, or (3) prohibit the use of water to condition fly ash for management or to prepare fly ash for a beneficial use.



Duke Energy
526 South Church St.
Charlotte, NC 28202

Mailing Address:
EC13K / PO Box 1006
Charlotte, NC 28201-1006

August 4, 2011

State of North Carolina
Department of Environment and Natural Resources
Division of Water Quality
Information Processing Unit
1617 Mail Service Center
Raleigh, North Carolina 27699-1617

Subject: Duke Energy Carolinas LLC – Allen Steam Station
Groundwater Quality Monitoring – Compliance Report Form

Please find attached the completed Groundwater Compliance Report Form (GW-59CCR) for Allen Steam Station's Ash Basin (NPDES Permit #NC0004979).

Predictive modeling compliance calculations derived for monitoring wells AB-9S, AB-9D, AB-10S, and AB-10D will be included in the annual modeling report.

As required by the GW-59CCR form, parameters exceeding the generic standards published at 15A NCAC 02L.0202(g-h) have been bolded. However, per 15A NCAC 02L.0202(b), where naturally occurring substances exceed the generic standards, the appropriate 2L standard shall be the naturally occurring concentration as determined by the Director.

All values reported on the attached reports are dependent on the accuracy of approved analytical methods used to measure parameters.

Should you have questions regarding this report, please contact me at (704) 382-4309.

Sincerely,

Allen Stowe
Water Management

cc: Debra Watts

Attachments

RECEIVED
AUG 05 2011
Information Processing Unit

GROUNDWATER QUALITY MONITORING:
COMPLIANCE REPORT FORMMail original
and 1 copy
to:DEPARTMENT OF ENVIRONMENT & NATURAL RESOURCES
DIVISION OF WATER QUALITY INFORMATION PROCESSING UNIT
165 MAIL SERVICE CENTER, RALEIGH, NC 27662-1016 Phone: (919) 733-3122

FACILITY INFORMATION

Facility Name:
Permit Name (if different):
Facility Address:

Please Print Clearly or Type

Allen Steam Station
Duke Energy Carolinas, LLC
253 Plant Allen Road
(Street)Permit Type:
PERMIT Number:NPDES
NC0004979

Expiration Date:

5/31/2015

TYPE OF PERMITTED OPERATION BEING MONITORED

Ash Impoundment Groundwater

Contact Person:

Well Location/Site Name:

Allen Stowe
Allen Ash Basin
Telephone: 704-382-4309
No. of wells to be sampled: 13
(from Permit)

Monitoring Well Construction Information

		Well ID Number (From Permit)															
	Units	AB-1R	AB-4S	AB-4D	AB-11D	AB-12S	AB-12D	AB-13S	AB-13D	AB-14D	MW-	MW-	MW-	MW-	MW-	MW-	
Well Depth [ft below land surface]	ft	70.89	22.38	49.99	20.53	23.58	96.53	21.97	72.20	29.45							
Measuring Point (toc) [ft above land surface]	ft	2.29	2.52	2.19	2.68	2.05	2.04	2.74	2.65	2.44							
Well Diameter	in	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0							
Screen Top [ft below land surface]	ft	60.89	7.38	44.99	15.53	8.58	91.53	6.97	67.20	24.45							
Screen Bottom [ft below land surface]	ft	70.89	22.38	49.99	20.53	23.58	96.53	21.97	72.20	29.45							
Relative Measuring Point Elevation	ft	675.86	650.46	649.17	618.07	651.69	651.75	648.72	648.54	641.80							

Sampling Information and Field Analysis

CHECK IF DRY WELL AT TIME OF SAMPLING		<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY	<input type="checkbox"/> DRY
Sample Date	Units	AB-1R	AB-4S	AB-4D	AB-11D	AB-12S	AB-12D	AB-13S	AB-13D	AB-14D	MW-	MW-	MW-	MW-	MW-	MW-
7/7/2011		7/7/2011	7/7/2011	7/7/2011	7/7/2011	7/7/2011	7/7/2011	7/7/2011	7/7/2011	7/7/2011						
Water Level [ft below measuring pt.] (#2546)	ft	55.26	12.91	11.53	9.44	15.06	13.44	11.54	11.42	16.08						
Volume of Water pumped/bailed	gal	9.00	8.00	21.00	4.50	7.00	42.00	11.25	31.50	11.00						
Temperature (00010)	deg. C	17.4	17.4	17.8	17.0	15.2	16.31	18.59	17.7	16.9						
Odor (00085)		None	None	None	None	None	None	None	None	None						
Appearance		Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal						
Specific Cond - field (00094)	umhos/cm	155	120	110	105	25	139.30	75.00	158	170						
pH - field (00400)	5.5 - 8.5	SU	6.5	5.9	6.0	6.0	4.8	6.27	5.46	6.2	5.7					

Laboratory Information

Laboratory Name: Duke Energy Analytical Laboratory
 Sample Analysis Date: July 8 - 27, 2011
 Certification #: NC DENR # 248
 Samples for metals were collected unfiltered: ☒ Yes ☐ No
 and field acidified: ☒ Yes ☐ No

	15A-2L	Units	AB-1R	AB-4S	AB-4D	AB-11D	AB-12S	AB-12D	AB-13S	AB-13D	AB-14D	MW-	MW-	MW-	MW-	MW-	MW-
Sb - Antimony (01097)	1	ug/l	<1	<1	<1	<1	<1	<1	<1	<1	<1						
As - Arsenic (01002)	10	ug/l	<1	<1	<1	<1	<1	<1	<1	<1	<1						
Ba - Barium (01007)	700	ug/l	51	33	25	40	34	48.00	22.00	51	149						
B - Boron (01022)	700	ug/l	<50	<50	<50	<50	<50	<50	<50	<50	59						
Cd - Cadmium (01027)	2	ug/l	<1	<1	<1	<1	<1	<1	<1	<1	<1						
Cl - Chloride (00940)	250	mg/l	1.2	4.7	6.6	4.2	3.4	4.90	7.50	8.1	10						
Cr - Chromium (01034)	10	ug/l	<5	<5	<5	<5	<5	<5	<5	<5	<5						
Cu - Copper (01042)	1	mg/l	<0.005	<0.005	0.016	<0.005	<0.005	<0.005	<0.005	<0.005	0.169						
Fe - Iron (01045)	300	ug/l	81	114	<10	193	35	275.00	26.00	391	2780						
Pb - Lead (01051)	15	ug/l	<1	<1	<1	<1	<1	<1	<1	<1	<1						
Mn - Manganese (01055)	50	ug/l	30	6	<5	19	44	14.00	101.00	57	601						
Hg - Mercury (71900)	1	ug/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05						
Ni - Nickel (01067)	100	ug/l	<5	<5	7	<5	<5	<5	<5	<5	460						
Nitrate (NO ₃ -N) (00620)	10	mg/l	0.11	0.92	1.8	0.04	<0.023	1.60	1.80	2	3.3						
Se - Selenium (01147)	20	ug/l	<1	<1	<1	<1	<1	<1	<1	<1	<1						
SO ₄ Sulfate (00945)	250	mg/l	18	11	4.6	0.35	0.7	5.10	0.79	1.3	17						
Th - Thallium (01059)	0.2	ug/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2						
TDS Total Diss. Solids (70300)	500	mg/l	130	87	120	140	45	140.00	78.00	160	110						
Zn - Zinc (01092)	1	mg/l	<0.005	<0.005	0.019	<0.005	<0.005	<0.005	0.01	<0.005	0.011						
Al - Aluminum (01105)	NE	ug/l	NA	NA	NA	NA	NA	NA	NA	NA	NA						

BOLD values equal or exceed the corresponding 25 standard

I certify that, to the best of my knowledge and belief, the information submitted in this report is true, accurate, and complete, and that the laboratory analytical data was produced using approved methods of analysis by a DWQ-certified laboratory. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Brian R. Weisker / GM II - Regulated Fossil Stations

Permittee (or Authorized Agent) Name and Title - Please print or type

Signature of Permittee (or Authorized Agent)

8/1/2011
DateRECEIVED
AUG 05 2011
Information Processing Unit
DWQ-59CCR

Regulation 61-68

Water Classifications and Standards

Disclaimer

DHEC provides this copy of the regulation for the convenience of the public and makes every effort to ensure its accuracy. However, this is an unofficial version of the regulation. The regulation's most recent final publication in the *South Carolina State Register* presents the official, legal version of the regulation.

Statutory Authority:

S.C. Code Sections 48-1-10 et seq.

Regulation History as Published in State Register			
Date	Document Number	Volume	Issue
July 24, 1981	-	5	14
June 28, 1985	458	9	6
January 22, 1988	771	12	1
April 27, 1990	1039	14	5
April 26, 1991	1313	15	4
April 24, 1992	1385	16	4
May 28, 1993	1565	17	5, Part I
June 26, 1998	2218	22	6, Part 2
June 22, 2001	2572	25	6
June 25, 2004	2855	28	6
April 25, 2008	3161	32	4
February 24, 2012	4161	36	2
June 22, 2012	4212	36	6
June 27, 2014	4425	38	6

Table of Contents

SECTION A. PURPOSE AND SCOPE	1
SECTION B. DEFINITIONS	1
SECTION C. APPLICABILITY OF STANDARDS	7
SECTION D. ANTIDEGRADATION RULES	10
SECTION E. GENERAL RULES AND STANDARDS APPLICABLE TO ALL WATERS	12
SECTION F. NARRATIVE BIOLOGICAL CRITERIA	24
SECTION G. CLASS DESCRIPTIONS, DESIGNATIONS, AND SPECIFIC STANDARDS FOR SURFACE WATERS	25
Outstanding National Resource Waters	26
Outstanding Resource Waters	26
Trout Waters	27
Freshwaters	29
Shellfish Harvesting Waters	30
Class SA	31

	Class SB	32
SECTION H.	CLASS DESCRIPTIONS AND SPECIFIC STANDARDS FOR GROUND WATERS	33
	Class GA	34
	Class GB	34
	Class GC	35
SECTION I.	SEVERABILITY	35
APPENDIX.	WATER QUALITY NUMERIC CRITERIA FOR THE PROTECTION OF AQUATIC LIFE AND HUMAN HEALTH	36
	Priority Toxic Pollutants	36
	Non Priority Pollutants	45
	Organoleptic Effects	50
	Water Quality Criteria Additional Notes	52
	Attachment 1 – Conversion Factors for Dissolved Metals	54
	Attachment 2 – Parameters for Calculating Hardness-Dependent Criteria	55
	Attachment 3 – Calculation of Freshwater Ammonia Criterion	56

A.PURPOSE AND SCOPE.

1. These regulations, promulgated pursuant to authority in the S. C. Pollution Control Act, Section 48-1-10 et seq., 1976 Code of Laws, establish a system and rules for managing and protecting the quality of South Carolina's surface and ground water. They establish the State's official classified water uses for all waters of the State, establish general rules and specific numeric and narrative criteria for protecting classified and existing water uses, and establish procedures for classifying waters of the State. The water quality standards include the uses of the waters, the numeric and narrative criteria, and the antidegradation rules contained in this regulation.

a. The uses of the waters of the State are defined and described in Sections B, C, E, F, G, and H of this regulation.

b. Numeric criteria for aquatic life and human health are numeric values for specific parameters and pollutants or water quality levels which have been assigned for the protection of the existing and classified uses for each of the classifications in South Carolina and are listed in Section D, E, G, H, and the Appendix. Narrative criteria for aquatic life and human health are general goals and statements of attainable or attained conditions of biological integrity and water quality of the waterbody. These narrative criteria rely upon the use of standardized measures and data analyses to make qualitative determinations of the water quality and use attainment. The Department uses scientifically sound and, where applicable, EPA-approved methods in making these determinations. Narrative criteria are listed in Sections C, D, E, F, G, and H.

c. Antidegradation rules provide a minimum level of protection to all waters of the State and also include provisions and requirements necessary to determine when and if water quality degradation is allowed. Antidegradation rules are described in Section D of this regulation.

2. Waters which meet standards shall be maintained. Waters which do not meet standards shall be improved, wherever attainable, to achieve those standards. However, the Department cannot assure that classified waters shall at all times meet the numeric water quality standards for such uses.

3. Recognizing the technical and economic difficulty in restoring water quality, the Department shall emphasize a preventive approach in protecting waters of the State.

4. It is a goal of the Department to maintain and improve all surface waters to a level to provide for the survival and propagation of a balanced indigenous aquatic community of flora and fauna and to provide for recreation in and on the water. It is also a goal to provide, where appropriate and desirable, for drinking water after conventional treatment, shellfish harvesting, and industrial and agricultural uses.

5. It is a goal of the Department to maintain or restore ground water quality so it is suitable as a drinking water source without any treatment.

B.DEFINITIONS.

1. The definition of any word or phrase employed in this regulation shall be the same as given in the South Carolina Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976, hereafter referred to as the Act. Words or phrases which are not defined in the Act are defined as follows:

2. **7Q10** means the annual minimum seven day average flow rate that occurs with an average frequency of once in ten years as published or verified by the U. S. Geological Survey (USGS) or an estimate extrapolated from published or verified USGS data.

3. **30Q5** means the annual minimum thirty day average flow rate that occurs with an average frequency of once in five years as published or verified by the U. S. Geological Survey (USGS) or an estimate extrapolated from published or verified USGS data.
4. **Acute** means a stimulus severe enough to rapidly induce an effect; in aquatic toxicity tests, an effect observed in 96 hours or less typically is considered acute. When referring to aquatic toxicology or human health, an acute effect is not always measured in terms of lethality.
5. **Acute-to-chronic ratio** (ACR) means the ratio of the acute toxicity of an effluent or a toxicant to its chronic toxicity. It is used as a factor for estimating chronic toxicity on the basis of acute toxicity data, or for estimating acute toxicity on the basis of chronic toxicity data.
6. **Agricultural** means the use of water for stock watering, irrigation, and other farm purposes.
7. **Annual average flow** means the annual mean flow rate of a stream at a specific point as published or verified by the U. S. Geological Survey (USGS) or an estimated annual mean flow rate extrapolated from published or verified USGS data.
8. **Aquaculture** means a defined managed water area which uses discharges of pollutants into that designated area for the maintenance or production of harvestable freshwater, estuarine, or marine plants or animals.
9. **Aquatic farm** means the cultivation, production, or marketing of domestic aquatic organisms which are any fish, aquatic invertebrates, or aquatic plants that are spawned, produced, or marketed as a cultivated crop in the waters of the State.
10. **Aquatic toxicity test** mean laboratory experiments that measure the biological effect (e.g., growth, survival, and reproduction) of effluents or receiving waters on aquatic organisms.
11. **Aquifer** means a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of ground water to wells or springs.
12. **Balanced indigenous aquatic community** means a natural, diverse biotic community characterized by the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination by pollutant tolerant species.
13. **Best management practice** (BMP) means a practice or combination of practices that are the most effective, practical ways of controlling or abating pollution from widespread or localized sources.
14. **Bioaccumulation** means the process by which a compound is taken up and retained by an aquatic organism, both from water and through food.
15. **Bioavailability** means a measure of the physiochemical access that a toxicant has to the biological processes of an organism. The less the bioavailability of a toxicant, the less its toxic effect on an organism.
16. **Bioconcentration** means the process by which a compound is absorbed from water through gills or epithelial tissues and is concentrated in the body.
17. **Bioconcentration factor** (BCF) means the ratio of a substance's concentration in tissue versus its concentration in water, in situations where the food chain is not exposed or represents equilibrium partitioning between water and organisms.

18. **Biological assessment** means an evaluation of the biological condition of a waterbody using biological surveys and other direct measurements of resident biota in surface waters and sediments.

19. **Biological criteria**, also known as biocriteria, mean narrative expressions or numeric values of the biological characteristics of aquatic communities based on appropriate reference conditions. Biological criteria serve as an index of aquatic community health.

20. **Biological monitoring**, also known as biomonitoring, means a description of the living organisms in water quality surveillance used to indicate compliance with water quality standards or permit effluent limits and to document water quality trends. Methods of biological monitoring may include, but are not limited to, toxicity testing such as ambient toxicity testing, whole effluent toxicity testing, and ambient assessment of the resident biological community.

21. **Chlorophyll *a*** means a photosynthetic pigment present in all types of green plants. It is used as a measure of algal biomass and is an indicator of nutrient enrichment.

22. **Chronic** means a stimulus that lingers or continues for a relatively long period of time, often one-tenth of the life span or more. Chronic should be considered a relative term depending on the life span of an organism. The measurement of a chronic effect can be reduced growth, reduced reproduction, etc., in addition to lethality.

23. **Classified uses** means those uses specified in Section G for surface waters and Section H for ground waters, whether or not those uses are being attained.

24. **Concentrated aquatic animal production facility** means a hatchery, fish farm, or other facility related to aquatic animal production which is not located in waters of the State and is subject to a National Pollutant Discharge Elimination System (NPDES) permit.

25. **Conventional treatment as applying to potable water supplies** means treatment including at least flocculation, sedimentation, filtration, and disinfection.

26. **Criterion continuous concentration (CCC)** means the highest instream concentration of a toxicant or an effluent to which the organisms can be exposed to protect against chronic (long-term) effects. EPA derives chronic criteria from longer term (often greater than 28 days) tests that measure survival, growth, reproduction, and in some cases bioconcentration.

27. **Criterion maximum concentration (CMC)** means the highest instream concentration of a toxicant or an effluent to which the organisms can be exposed for a brief period of time without causing an acute effect. EPA derives acute criteria from 48 to 96 hour tests of lethality or immobilization.

28. **Daily average** means the average of all samples taken during any 24 hour period.

29. **Daily maximum** (for bacterial indicators only) means the highest arithmetic average of bacterial samples collected [for each of the bacterial indicator species (i.e., *E. coli*, enterococci, and /or fecal coliform)] in any 24 hour period during a calendar month.

30. **Deleterious substances** mean those substances which in sufficient concentrations or levels have a harmful effect on classified or existing water uses.

31. **Ecoregions** mean areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. The EPA has published a document that outlines the Level III ecoregions (please refer to U.S. Environmental Protection Agency. 1999. Level III ecoregions of the continental United States (revision of Omernik, 1987). Corvallis, Oregon, U.S. E.P.A.-National Health and Environmental Effects Research Laboratory, Map M-1.) The following are South Carolina Level III ecoregions: Blue Ridge Mountains, Piedmont, Southeastern Plains, and Middle Atlantic Coastal Plains.

32. **Ephemeral streams** mean streams that generally have defined natural watercourses that flow only in direct response to rainfall or snowmelt and in which discrete periods of flow persist no more than 29 consecutive days per event.

33. **Existing uses** means those uses actually being attained in or on the water, on or after November 28, 1975, regardless of the classified uses.

34. **Fishing** means the taking, harvesting, or catching of finfish or crustaceans for human consumption.

35. **Full pool elevation** means the maximum lake level attained before water releases over a fixed weir, spillway, or other discharge structure. In larger lakes and reservoirs, the full pool elevation is the maximum level established for management.

36. **Groundwater** means water below the land surface in a zone of saturation.

37. **Hydrograph controlled release (HCRs)** means the onsite storage or holding of treated wastewater or the use of an alternative discharge option contained in Section D.2.a. of this regulation, during specified critical streamflow conditions and then discharging the treated wastewater to the stream when streamflow is sufficient to assimilate the wastewater.

38. **Intermittent streams** means streams that generally have defined natural watercourses which do not flow year around, but flow beyond periods of rainfall or snowmelt.

39. **Lake** means any water of the State that is a freshwater pond, reservoir, impoundment, or similar body of water located wholly or partially within the State.

40. **LC50** means the concentration of a toxicant at which lethality occurs to 50 percent of the test organisms during a specified exposure time period.

41. **Mixing zone** means:

a. For surface waters, an area where a discharge undergoes initial dilution and is extended to cover the secondary mixing in the ambient waterbody. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented (except as defined within a Zone of initial dilution) and public health and welfare are not endangered.

b. For ground waters, a hydrogeologically controlled three-dimensional flow path in the subsurface which constitutes the pathway for waste constituents to migrate from a source.

42. **Monthly average** (for bacterial indicators only) means the calendar month (i.e., 28 days, 29 days, 30 days, or 31 days) geometric mean of all bacterial samples collected [for each of the bacterial indicator species (i.e., *E. coli*, enterococci, and/or fecal coliform)] during that calendar month.

43. **Natural conditions** mean those water quality conditions unaffected by anthropogenic sources of pollution.

44. **No discharge zone (NDZ)** means a waterbody (or a portion of a waterbody) so designated that no discharging Marine Sanitation Devices (MSDs) are allowed on vessels on waterbodies so designated. All vessels located on such designated waterbodies shall be equipped with MSDs which discharge to a holding tank which shall be pumped out at a designated pump-out location or shall discharge legally outside the boundary of the United States.

45. **No observed effect concentration (NOEC)** means the highest tested concentration of an effluent or a toxicant at which no adverse effects are observed on the aquatic test organisms at a specific time of observation and determined using hypothesis testing.

46. **Nutrients** mean an element or chemical essential to life including, but not limited to, nitrogen and phosphorus.

47. **Organoleptic** effects mean those sensory effects associated with taste and smell.

48. **Outstanding recreational or ecological resource waters** means waters which are of exceptional recreational or ecological importance or of unusual value. Such waters may include, but are not limited to: waters in national or state parks or wildlife refuges; waters supporting threatened or endangered species; waters under the National Wild and Scenic Rivers Act or South Carolina Scenic Rivers Act; waters known to be significant nursery areas for commercially important species or known to contain significant commercial or public shellfish resources; or waters used for or having significant value for scientific research and study.

49. **Practical quantitation limit (PQL)** means a concentration at which the entire analytical system must give a recognizable signal and acceptable calibration point. It is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard analyzed by a specific analytical procedure, assuming that all the method-specific sample weights volumes, and processing steps have been followed..

50. **Prohibited area** means an area adjacent to point source discharges or other sources of potential contamination in shellfish growing waters where the gathering of clams, mussels, or oysters is prohibited to protect public health.

51. **Primary contact recreation** means any activity with the intended purpose of direct water contact by the human body to the point of complete submergence, including but not limited to swimming, water skiing, and skin diving.

52. **Propagation** means the continuance of species through reproduction and growth in the natural environment, as opposed to the maintenance of species by artificial culture and stocking.

53. **Public water system** means any public or privately owned waterworks system which provides drinking water for human consumption, except those serving a single private residence or dwelling.

54. **Recharge area** means an area where an underground source of drinking water is poorly confined, is under water table conditions, and has a downward component of flow from the water table into the underground source of drinking water.

55. **Secondary contact recreation** means any activity occurring on or near the water which does not have an intended purpose of direct water contact by the human body to the point of complete submergence, including but not limited to fishing, boating, canoeing, and wading.

56. **Shellfish** mean bivalve mollusks, specifically clams, mussels, or oysters.

57. **Shellfish harvesting** means taking of bivalve mollusks, specifically clams, mussels, or oysters, for direct marketing or human consumption.

58. **Source for drinking water supply** means any source of surface water which is used for domestic consumption, or used in connection with the processing of milk, beverages, food or for other purposes which required finished water meeting regulations (40 CFR Part 141 and 40 CFR Part 143) established pursuant to the Safe Drinking Water Act (Public Law 93- 523, 95-190) applicable to public water systems.

59. **Tidal conditions** mean conditions determined by the Department as appropriate for tidally influenced waters of the State to be analogous to the 7Q10 or the annual average flow for flowing waters of the State.

60. **Tidal saltwaters** means those waters whose elevation is subject to changes due to oceanic tides and which have chloride ion content in excess of 250 milligrams per liter (mg/l) (salinity = 0.48 parts per thousand).

61. **Toxic wastes** means those wastes or combinations of wastes including disease-causing agents which, discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, may cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), physical deformations, or restrict or impair growth in such organisms or their offspring.

62. **Underground source of drinking water** (USDW) means an aquifer or its portion:

- a. Which supplies any public water system or individual residential well; or
- b. Which contains a sufficient quantity of ground water to supply a public water system or individual residential well; and,
 - (1) Currently supplies drinking water for human consumption; or
 - (2) Contains water with less than ten thousand milligrams per liter total dissolved solids.

63. **Variance** means a short-term exemption from meeting certain otherwise applicable water quality standards.

64. **Water table** means that level below the land surface at which all the voids are filled with water at a pressure equal to atmospheric.

65. **Weekly average** means the average of all samples taken during any consecutive seven day period.

66. **Whole effluent toxicity** (WET) means the aggregate toxic effect of an aqueous sample measured directly by an aquatic toxicity test.

67. **Zone of initial dilution (ZID)** means that minimal area of a mixing zone immediately surrounding the outfall where water quality criteria are not met, provided there is no acute toxicity to drifting organisms and public health and welfare are not endangered.

C.APPLICABILITY OF STANDARDS.

1. The water quality standards are applicable to both surface waters and ground waters.
2. Any exception specified in this regulation is to be applied exclusively to the situation for which it was incorporated and not as a general rule applicable to all situations or waters of the State.
3. Uses in all waters shall be protected, wherever attainable, regardless of flow and classification of waters.
4. Critical flows for determining permit effluent limitations and/or permit conditions or requirements, including permit development such as wasteload allocations or load allocations in TMDL's, will be calculated in accordance with the following:

a. Aquatic life numeric criteria.

(1) The applicable critical flow conditions for aquatic life criteria shall be defined as 7Q10 or tidal conditions as determined by the Department. The numeric criteria of this regulation are not applicable to waters of the State when the flow rate is less than 7Q10 except as prescribed below.

(2) The Department shall consider conditions that are comparable to or more stringent than 7Q10 where appropriate to protect classified and existing uses, such as below dams and in tidal situations. Only those situations where the use of 7Q10 flows are determined to be impracticable, inappropriate, or insufficiently protective of aquatic life uses shall be considered as a situation in which the Department may consider other flow conditions.

(3) NPDES Permit conditions shall be based on a critical condition analysis (e.g., critical flow, temperature or pH, or a combination of factors which would represent a critical conditions). Regarding ambient water temperature as a component of a critical condition analysis, the Department may consider less stringent limits during November through February based on a critical ambient water temperature during November through February.

b. Human health and organoleptic numeric criteria.

(1) The applicable critical flow conditions for human health shall be defined as annual average flow for carcinogens, 7Q10 (or 30Q5 if provided by the applicant) for noncarcinogens, or tidal conditions as determined by the Department. The applicable critical flow conditions for organoleptic criteria shall be defined as annual average flow or tidal conditions as determined by the Department. The numeric criteria of this regulation are not applicable to waters of the State when the flow rate is less than the annual average flow for carcinogens or 7Q10 (or 30Q5 if provided by the applicant) for noncarcinogens, except as prescribed below.

(2) The Department shall consider conditions that are comparable to or more stringent than annual average flow, 7Q10, or 30Q5 (if provided by the applicant) where appropriate to protect the classified and existing uses, such as below dams and in tidal situations. Only those situations where the use of annual average flow, or 7Q10, or 30Q5 (if provided by the applicant) are determined to be impracticable, inappropriate, or insufficiently protective of human health uses shall be considered as a situation in which the Department may consider other flow conditions.

c. As described below, the Department may also consider conditions other than 7Q10 for use with an HCR.

(1) After a complete antidegradation review in compliance with Section D.2., an HCR for oxygen-demanding substances may be permitted by the Department for the following situations:

i. If other flow-related effluent conditions are allowed by federal effluent guidelines as specified in 40 CFR Parts 400-499 (Chapter I, Subchapter N) and when used the numeric criteria shall not be exceeded and all water quality standards are maintained and protected;

ii. For industrial discharges, after application of advanced wastewater treatment, as determined by the Department, for the type of wastewater discharged;

iii. For other discharges, after application of advanced wastewater treatment which will be defined, for this purpose, at or below the following permit effluent limitations of BOD₅ = 10 mg/l, NH₃-N = 1 mg/l, and DO = 6 mg/l.

(2) In cases where an HCR may be allowed, the permit effluent limitations for toxics will not be variable and will be based on the critical flow conditions (chemical-specific or WET).

(3) In cases where an HCR may be allowed, new or proposed expansions of existing permits shall require instream biological assessments and existing permits may require instream biological assessments.

5. Intermittent streams and ephemeral streams shall be considered waters of the State. The water quality standards of the class of the stream to which intermittent and ephemeral streams are tributary shall apply, disregarding any site-specific numeric criteria for the named waterbody. This does not preclude the development of site-specific numeric criteria for intermittent and ephemeral streams.

6. The standards of adjacent waters must be maintained in basins excavated from high ground and constructed solely for berthing vessels. The standards of the adjacent waters must also be maintained with regard to impacts from created marina basins.

7. The existing and classified uses of downstream waters shall be maintained and protected and existing uses shall be protected regardless of the classification of the downstream waters. In tidally-influenced waters, the existing and classified uses of both upstream and downstream waters shall be maintained and protected and the existing uses shall be protected regardless of the classification of the upstream and downstream waters.

8. Where surface waters are not classified by name (unlisted) in R.61-69, Classified Waters, the water quality standards of the class of the stream to which they are tributary shall apply, disregarding any site specific numeric criteria for the named waterbody. In tidal areas where an unlisted tributary may affect or flows between two differently classified waterbodies, regardless of whether the location is upstream or downstream, the more stringent numeric criteria of the classified waters apply to the unlisted tributary, disregarding any site-specific numeric criteria for those waterbodies. This does not preclude the development of site-specific numeric criteria for unlisted tributaries.

9. Because of natural conditions some surface and ground waters may have characteristics outside the standards established by this regulation. Such natural conditions do not constitute a violation of the water quality standards; however, degradation of existing water quality is prohibited unless consistent with Section D.4. of this regulation.

10. A mixing zone for surface waters may be allowed by the Department. All water quality standards of the classification of the surface waters, including affected downstream waters, are applicable unless a mixing zone, setting forth certain conditions, is granted by the Department. When the Department grants a mixing zone, the mixing zone shall not be an area of waste treatment nor shall it interfere with or impair the existing uses of the waterbody. The size of the mixing zone shall be minimized, as determined by the Department, and shall be based upon applicable critical flow conditions. Since mixing zones are allocated impact zones where human health and aquatic life numeric criteria can be exceeded, the Department shall restrict their use. The following prohibitions and restrictions are established in order to support these important uses of the waters of the State.

a. In order to protect human health, mixing zones are not allowed when: they would endanger public health and welfare, the mixing zone would adversely affect shellfish harvesting, or the mixing zone would be for bacteria (e.g. fecal coliform).

b. In order to protect aquatic life, mixing zones are not allowed when: a pollutant, excluding temperature or thermal, in a discharge would attract biota; the mixing zone would result in undesirable aquatic organisms or a dominance of nuisance species outside of the mixing zone; there is a reasonable expectation that a discharge would adversely affect a federally-listed endangered or threatened aquatic species, its habitat, or a proposed or designated critical habitat; the mixing zone would not allow safe passage of aquatic organisms when passage would otherwise be unobstructed; or the mixing zone would not allow for the protection and propagation of a balanced indigenous aquatic community in and on the water body.

c. In order to protect both human health and aquatic life, mixing zones are not allowed when: a discharge would not be predicted to or does not produce adequate mixing at the point of discharge; or a discharge would be to a waterbody where multiple discharges interact if the combined mixing zone would impair the waterbody outside the mixing zone. The Department may prohibit or limit mixing zones in waters of the State that may be considered a significant estuarine nursery habitat for resident species.

d. The size of the mixing zone shall be kept to a minimum and may be determined on an individual project basis considering biological, chemical, engineering, hydrological, and physical factors.

11. Mixing zones for ground waters may be allowed by the Department. In order to ensure the maintenance and protection of the uses of the waters of the State and in compliance with Section D of this regulation, any mixing zone granted by the Department shall be determined on an individual basis by the Department as prescribed below.

a. The numeric standards for Class GB ground water, Section H.9., are applicable unless a mixing zone solely within the bounds of the property, setting forth certain conditions, is granted by the Department. Such a mixing zone shall be granted upon satisfactory demonstration to the Department that:

(1) Reasonable measures have been taken or binding commitments are made to minimize the addition of contaminants to ground water and/or control the migration of contaminants in ground water;

(2) The ground water in question is confined to a shallow geologic unit which has little or no potential of being an Underground Source of Drinking Water, and discharges or will discharge to surface waters without contravening the surface water standards set forth in this regulation;

(3) The contaminant(s) in question occurs within the bounds of the property, and there is minimum possibility for ground water withdrawals (present or future) to create drawdown such that contaminants would flow off-site; and

(4) The contaminants or combination of contaminants in question are not dangerously toxic, mobile, or persistent.

b. [Reserved].

12. Site-specific numeric criteria for surface waters may be established by the Department to replace the numeric criteria of Sections E, G, and the appendix of this regulation or to add new numeric criteria not contained in this regulation. Establishment of such numeric criteria shall be subject to public participation and administrative procedures for adopting regulations. In addition, such site-specific numeric criteria shall not apply to tributary or downstream waters unless specifically described in the water classification listing R.61-69, Classified Waters.

13. In classifying and adopting standards for the waters of the State, the Department considers:

a. The size, depth, surface area covered, volume, flow direction, rate of flow, stream gradient and temperature of the water;

b. The character of the district bordering such water and its suitability for the uses and with a view to conserving it and encouraging the most appropriate use of the lands bordering on such water for residential, agricultural, industrial, or recreational purposes;

c. The uses which have been made, are being made, may be made or are desired to be made of such waters for transportation, domestic, and industrial consumption, irrigation, swimming, fishing, fish culture, fire prevention, sewage disposal or other uses;

d. The present quality of such waters; and

e. Information, about the four items above, from government agencies, interested groups, and the public.

D.ANTIDEGRADATION RULES.

1. Existing water uses and the level of water quality necessary to protect these existing uses shall be maintained and protected regardless of the water classification and consistent with the policies below.

a. A new activity or expansion of an existing activity shall not be allowed in Class ONRW, Class ORW, or Shellfish Harvesting Waters if it would exclude, through establishment of a prohibited area, an existing shellfish harvesting or culture use. A new activity or expansion of an existing activity which will result in a prohibited area may be allowed in Class SA or Class SB waters when determined to be appropriate by the Department and would not remove or impair an existing use.

b. Existing uses and water quality necessary to protect these uses are presently affected or may be affected by instream modifications or water withdrawals. The stream flows necessary to protect classified and existing uses and the water quality supporting these uses shall be maintained consistent with riparian rights to reasonable use of water.

c. Existing or classified ground water uses and the conditions necessary to protect those uses shall be maintained and protected.

2. Where surface water quality exceeds levels necessary to support propagation of fish, shellfish, and wildlife, and recreation in and on the water, that quality shall be maintained and protected unless the

Department finds, after intergovernmental coordination and public participation, that allowing lower water quality is necessary to important economic or social development in the areas where the waters are located. In allowing such lower water quality, water quality adequate to fully protect existing and classified uses shall be maintained. The highest statutory and regulatory requirements for all new and existing point sources shall be achieved and all cost-effective and reasonable best management practices for nonpoint source control shall be achieved within the State's statutory authority and otherwise encouraged. In order to fulfill these goals, the Department shall consider (a) and (b) below when evaluating any proposed expansion or new discharge to waters of the State that will lower water quality to a measurable effect. This includes, but is not limited to, the new or increased loading of any pollutant or pollutant parameter in the effluent regardless of whether the discharge flow changes.

a. An alternatives analysis, conducted by the applicant, must demonstrate to the Department that none of the following applicable alternatives that would minimize or eliminate the lowering of water quality are economically and technologically reasonable:

- (1) Water recycle or reuse;
- (2) Use of other discharge locations;
- (3) Connection to other wastewater treatment facilities;
- (4) Use of land application;
- (5) Product or raw material substitution;
- (6) Any other treatment option or alternative.

b. After the alternatives analysis is completed, the Department shall evaluate whether a proposed discharge that will result in the lowering of water quality of a waterbody, and for which there are no economically or technologically reasonable alternatives, is necessary for important economic or social development. For this to be accomplished, several economic and social factors must be considered. If an evaluation of the economic and social factors reveals that affordable treatment options that, combined with any alternatives, would prevent the need for the lowering of water quality, the Department shall deny the request. Conformance of the proposed discharge with the applicable '208 Areawide Water Quality Management Plans may demonstrate importance to economic and social development as well as intergovernmental coordination and public participation. Activities requiring permits or certification by the Department shall provide for public participation through the Department's existing public notification processes. Economic and social factors to be considered may include the following:

- (1) Employment (increases, maintenance, or avoidance of reduction);
- (2) Increased industrial production;
- (3) Improved community tax base;
- (4) Improved housing; and/or
- (5) Correction of an environmental or public health problem.

3. The water quality of outstanding resource surface waters designated as Class ONRW or Class ORW shall be maintained and protected through application of the standards for these classifications as described in Section G.

4. Certain natural conditions may cause a depression of dissolved oxygen in surface waters while existing and classified uses are still maintained. The Department shall allow a dissolved oxygen depression in these naturally low dissolved oxygen waterbodies as prescribed below pursuant to the Act, Section 48-1-83, et seq., 1976 Code of Laws:

a. For purposes of section D of this regulation, the term “naturally low dissolved oxygen waterbody” is a waterbody that, between and including the months of March and October, has naturally low dissolved oxygen levels at some time and for which limits during those months shall be set based on a critical condition analysis. The term does not include the months of November through February unless low dissolved oxygen levels are known to exist during those months in the waterbody. For a naturally low dissolved oxygen waterbody, the quality of the surface waters shall not be cumulatively lowered more than 0.1 mg/l for dissolved oxygen from point sources and other activities; or

b. Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable water quality standard established for that waterbody, the minimum acceptable concentration is 90 percent of the natural condition. Under these circumstances, an anthropogenic dissolved oxygen depression greater than 0.1 mg/l shall not be allowed unless it is demonstrated that resident aquatic species shall not be adversely affected pursuant to Section 48-1-83. The Department may modify permit conditions to require appropriate instream biological monitoring.

c. The dissolved oxygen concentrations shall not be cumulatively lowered more than the deficit described above utilizing a daily average unless it can be demonstrated that resident aquatic species shall not be adversely affected by an alternate averaging period.

E. GENERAL RULES AND STANDARDS APPLICABLE TO ALL WATERS.

1. The General Assembly of South Carolina in the Act has declared the following policy: “It is declared to be the public policy of the State to maintain reasonable standards of purity of the air and water resources of the State, consistent with the public health, safety and welfare of its citizens, maximum employment, the industrial development of the State, the propagation and protection of terrestrial and marine fauna and flora, and the protection of physical property and other resources. It is further declared that to secure these purposes and the enforcement of the provisions of this Act, the Department of Health and Environmental Control shall have authority to abate, control and prevent pollution.”

2. The classes and standards described in Section G and H of this regulation implement the above State policy by protecting the waters of South Carolina. Consistent with the above policy, the Department adopts the following general standards in items 3-17 for all waters of South Carolina.

3. No waters of the State shall be used for the sole or principal purpose of transporting or treating wastes.

4. a. Any discharge into waters of the State must be permitted by the Department and receive a degree of treatment and/or control which shall produce an effluent which is consistent with the Act, the Clean Water Act (P.L. 92-500, 95-217, 97-117, 100-4), this regulation, and related regulations. No permit issued by the Department shall be interpreted as creating any vested right in any person. Additionally, any discharge into waters of the State containing sanitary wastes shall be effectively disinfected as necessary to meet the appropriate standards of this regulation. The Department may require best management practices (BMPs)

for control of stormwater runoff as part of the requirements of an NPDES permit, a State construction permit, or a State 401 Water Quality Certification.

b. When not specifically covered by permit reporting requirements, any unauthorized discharge into waters of the State which may cause or contribute to an excursion of a water quality standard must be reported by the responsible party to the Department orally within 24 hours of becoming aware of such conditions. Further, written notification must be provided to the Department (Bureau of Water) within five (5) days of becoming aware of such conditions and the written notice must include the following:

(1) A description of the discharge and cause;

(2) The duration of the discharge, including exact dates and times, and if not corrected, the time that the unauthorized discharge is expected to cease, and what steps are being taken to eliminate, minimize, and prevent recurrence of the discharge.

5. All ground waters and surface waters of the State shall at all times, regardless of flow, be free from:

a. Sewage, industrial waste, or other waste that will settle to form sludge deposits that are unsightly, putrescent, or odorous to such degree as to create a nuisance, or interfere with classified water uses or existing water uses;

b. Floating debris, oil, grease, scum, and other floating material attributable to sewage, industrial waste, or other waste in amounts sufficient to be unsightly to such a degree as to create a nuisance or interfere with classified water uses or existing water uses;

c. Sewage, industrial, or other waste which produce taste or odor or change the existing color or physical, chemical, or biological conditions in the receiving waters or aquifers to such a degree as to create a nuisance, or interfere with classified water uses (except classified uses within mixing zones as described in this regulation) or existing water uses; and,

d. High temperature, toxic, corrosive, or deleterious substances attributable to sewage, industrial waste, or other waste in concentrations or combinations which interfere with classified water uses (except classified uses within mixing zones as described in this regulation), existing water uses, or which are harmful to human, animal, plant or aquatic life.

6. Waters where classified uses are not being attained can be reclassified for protection of an attainable use and standards designated for that use where:

a. Natural conditions prevent the attainment of the use; or

b. Natural, ephemeral, intermittent, low flow conditions, or water levels prevent the attainment of the use; or

c. Human caused conditions or sources prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

d. Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or

e. Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, preclude attainment of aquatic life protection uses; or

f. Controls more stringent than those required by Sections 301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact.

7. Before the Department may grant a variance for any water of the State, there must be a demonstration that one of the following factors for reclassifying uses has been satisfied:

a. Natural conditions prevent the attainment of the use; or

b. Natural, ephemeral, intermittent, low flow conditions, or water levels prevent the attainment of the use; or

c. Human caused conditions or sources prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

d. Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or

e. Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, preclude attainment of aquatic life protection uses; or

f. Controls more stringent than those required by Sections 301(b) and 306 of the Clean Water Act would result in adverse social and economic impact, disproportionate to the benefits to the public health, safety or welfare as a result of maintaining the standard.

8. If the demonstration necessary under Section E.7 above has been satisfied, the Department may then grant a variance provided the following apply:

a. The variance is granted to an individual discharger for a specific pollutant(s) or parameter(s) and does not otherwise modify water quality standards; and

b. The variance identifies and justifies the criterion that shall apply during the existence of the variance; and

c. The variance is established as close to the underlying criterion as is possible and upon expiration of the variance, the underlying criterion shall become the effective water quality standard for the waterbody; and

d. The variance is reviewed every three years, at a minimum, and extended only where the conditions for granting the variance still apply; and

e. The variance does not exempt the discharger from compliance with any applicable technology or other water quality-based permit effluent limitations; and

f. The variance does not affect permit effluent limitations for other dischargers.

9. Prior to removing any uses or granting a variance, notice and an opportunity for a public hearing shall be provided.

10. Discharge of fill into waters of the State is not allowed unless the activity is consistent with Department regulations and will result in enhancement of classified uses with no significant degradation to the aquatic ecosystem or water quality.

11. In order to protect and maintain lakes and other waters of the State, consideration needs to be given to the control of nutrients reaching the waters of the State. Therefore, the Department shall control nutrients as prescribed below.

a. Discharges of nutrients from all sources, including point and nonpoint, to waters of the State shall be prohibited or limited if the discharge would result in or if the waters experience growths of microscopic or macroscopic vegetation such that the water quality standards would be violated or the existing or classified uses of the waters would be impaired. Loading of nutrients shall be addressed on an individual basis as necessary to ensure compliance with the narrative and numeric criteria.

b. Numeric nutrient criteria for lakes are based on an ecoregional approach which takes into account the geographic location of the lakes within the State and are listed below. These numeric criteria are applicable to lakes of 40 acres or more. Lakes of less than 40 acres will continue to be protected by the narrative criteria.

(1) For the Blue Ridge Mountains ecoregion of the State, total phosphorus shall not exceed 0.02 mg/l, chlorophyll a shall not exceed 10 ug/l, and total nitrogen shall not exceed 0.35 mg/l.

(2) For the Piedmont and Southeastern Plains ecoregions of the State, total phosphorus shall not exceed 0.06 mg/l, chlorophyll a shall not exceed 40 ug/l, and total nitrogen shall not exceed 1.50 mg/l.

(3) For the Middle Atlantic Coastal Plains ecoregion of the State, total phosphorus shall not exceed 0.09 mg/l, chlorophyll a shall not exceed 40 ug/l, and total nitrogen shall not exceed 1.50 mg/l.

c. In evaluating the effects of nutrients upon the quality of lakes and other waters of the State, the Department may consider, but not be limited to, such factors as the hydrology and morphometry of the waterbody, the existing and projected trophic state, characteristics of the loadings, and other control mechanisms in order to protect the existing and classified uses of the waters.

d. The Department shall take appropriate action, to include, but not limited to: establishing numeric effluent limitations in permits, establishing Total Maximum Daily Loads, establishing waste load allocations, and establishing load allocations for nutrients to ensure that the lakes attain and maintain the above narrative and numeric criteria and other applicable water quality standards.

e. The criteria specific to lakes shall be applicable to all portions of the lake. For this purpose, the Department shall define the applicable area to be that area covered when measured at full pool elevation.

12. a. The water temperature of all Freshwaters which are free flowing shall not be increased more than 5oF (2.8°C) above natural temperature conditions and shall not exceed a maximum of 90°F (32.2°C) as a result of the discharge of heated liquids unless a different site-specific temperature standard as provided for in C.12. has been established, a mixing zone as provided in C.10. has been established, or a Section 316(a) determination under the Federal Clean Water Act has been completed.

b. The weekly average water temperature of all Shellfish Harvesting, Class SA and Class SB waters shall not exceed 4°F (2.2°C) above natural conditions during the fall, winter or spring, and shall not exceed 1.5°F (0.8°C) above natural conditions during the summer as a result of the discharge of heated liquids unless a different site-specific temperature standard as provided for in C.12. has been established, a mixing zone as provided for in C.10 has been established, or a Section 316(a) determination under the Federal Clean Water Act has been completed.

c. The weekly average water temperature of all Freshwaters which are lakes shall not be increased more than 5°F (2.8°C) above natural conditions and shall not exceed 90°F (32.2°C) as a result of the discharge of heated liquids unless a different site-specific temperature standard as provided for in C.12. has been established, a mixing zone as provided in C.10. has been established, or a Section 316(a) determination under the Federal Clean Water Act has been completed.

13. Numeric criteria based on organoleptic data (prevention of undesirable taste and odor) are adopted herein. Those substances and their criteria are listed in the appendix. For those substances which have aquatic life and/or human health numeric criteria and organoleptic numeric criteria, the most stringent of the three shall be used for derivation of permit effluent limitations.

14. Numeric criteria for the protection and maintenance of all classes of surface waters are adopted herein and are listed in Sections E, G, and the appendix. Footnotes that further describe the application of these numeric criteria are included in the appendix.

a. Application of numeric criteria to protect aquatic life.

(1) The stated CMC value shall be used as an acute toxicity number for calculating permit effluent limitations.

(2) The stated CCC value shall be used as a chronic toxicity number for calculating permit effluent limitations.

(3) If metals concentrations for numeric criteria are hardness-dependent, the CMC and CCC concentrations shall be based on 25 milligrams/liter (mg/l) hardness (as expressed as CaCO₃) if the ambient hardness is less than 25 mg/l. Concentrations of hardness less than 400 mg/l maybe based on the actual mixed stream hardness if it is greater than 25 mg/l and less than 400 mg/l and 400 mg/l if the ambient hardness is greater than 400 mg/l.

(4) If separate numeric criteria are given for fresh and salt waters, they shall be applied as appropriate. In transitional tidal and estuarine areas, the Department shall apply the more stringent of the criteria to protect the existing and classified uses of the waters of the State.

(5) The Department shall review new or revised EPA criteria for adoption by South Carolina when published in final form.

(6) If the State develops site-specific criteria for any substances for which EPA has developed national criteria, the site-specific criteria shall supersede the national criteria.

b. Application of numeric criteria to protect human health.

(1) If separate numeric criteria are given for organism consumption, water and organism consumption (W/O), and drinking water Maximum Contaminant Levels (MCLs), they shall be applied as appropriate.

The most stringent of the criteria shall be applied to protect the existing and classified uses of the waters of the State.

(2) The Department shall review new or revised EPA criteria for adoption by South Carolina when published in final form by EPA.

(3) If the State develops site-specific criteria for any substances for which EPA has developed national criteria, the site-specific criteria shall supersede the national criteria.

(4) Adoption of EPA human health criteria does not preclude the Department from considering health effects of other pollutants or from considering new or revised EPA criteria when developing effluent permit conditions.

c. Application of criteria for the derivation of permit effluent limitations.

(1) Numeric criteria for substances listed in Sections E, G, and the appendix shall be used by the Department to derive NPDES permit effluent limitations at the applicable critical flow conditions as determined by the Department unless an exception is provided below.

(2) When the derived permit effluent limitation based on aquatic life numeric criteria is below the practical quantitation limit for a substance, the derived permit effluent limitation shall include an accompanying statement in the permit that the practical quantitation limit using approved analytical methods shall be considered as being in compliance with the limit. Appropriate biological monitoring requirements shall be incorporated into the permit to determine compliance with appropriate water quality standards. Additionally, if naturally occurring instream concentration for a substance is higher than the derived permit effluent limitation, the Department may establish permit effluent limitations at a level higher than the derived limit, but no higher than the natural background concentration. In such cases, the Department may require biological instream monitoring and/or WET testing.

(3) When the derived permit effluent limitation based on human health numeric criteria is below the practical quantitation limit for a substance, the derived permit effluent limitation shall include an accompanying statement in the permit that the practical quantitation limit using approved analytical methods shall be considered as being in compliance with the limit. Additionally, if naturally occurring instream concentration for a substance is higher than the derived permit effluent limitation, the Department may establish permit effluent limitations at a level higher than the derived limit, but no higher than the natural background concentration.

(4) NPDES permit effluent limitations for metals shall normally be expressed on the permits as total recoverable metals, but the Department may utilize a federally- approved methodology to predict the dissolved fraction, partitioning coefficient, or the bioavailable portion of metals in calculating these limits.

(5) Except as provided herein, where application of MCLs or W/O numeric criteria using annual average flow for carcinogens, 7Q10 (or 30Q5 if provided by the applicant) for noncarcinogens, or comparable tidal condition as determined by the Department results in permit effluent limitations more stringent than limitations derived from other applicable human health (organism consumption only), aquatic life, or organoleptic numeric values; MCLs or W/O shall be used in establishing permit effluent limitations for human health protection. The Department may, after Notice of Intent included in a notice of a proposed NPDES permit in accordance with Regulation 61-9.124.10, determine that drinking water MCLs or W/O shall not apply to discharges to those waterbodies where there is: no potential to affect an existing or proposed drinking water source and no state-approved source water protection area. For purposes of this section, a proposed drinking water source is one for which a complete permit application, including plans

and specifications for the intake, is on file with the Department at the time of consideration of an NPDES permit application. for a discharge that will affect or has the potential to affect the drinking water source.

(6) Except as provided herein, where the Department may determine that an NPDES permitted discharge will not cause, have reasonable potential to cause, or contribute to an exceedence of the numeric criterion for turbidity under the following conditions:

i. The facility withdraws its surface intake water containing turbidity from the same body of water into which the discharge is made;

ii. The facility does not significantly concentrate or contribute additional turbidity to the discharged water;

iii. The facility does not alter the turbidity through chemical or physical means that would cause adverse water quality impacts to occur.

(7) Site-specific permit effluent limitations and alternate criteria less stringent than those derived in accordance with the above requirements may be derived where it is demonstrated that such limits and criteria shall maintain the existing and classified uses, adequate opportunity for public participation in such derivation process has occurred, and the effluent shall not cause criteria for human health to be exceeded. Where a site- specific permit effluent limitation and alternate criterion has been derived, such derivation shall be subject to EPA review as appropriate. Also, at a minimum, opportunity for input in derivation of a site-specific permit effluent limitation and alternate criterion shall be provided via public notice in NPDES permit notices.

(8) In order to protect recreational uses in freshwaters (including FW, and all types of Trout Waters) of the State, NPDES permit effluent limitations shall be specified as indicated below:

i. Monthly Average (<i>E. coli</i>)	126 MPN per 100 ml
ii. Daily Maximum (<i>E. coli</i>)	349 MPN per 100 ml (see c(12) below)
iii. Shellfish protection	Class SFH requirements for fecal coliform (see c(11)i. and c(11)ii. below) may be specified (in addition to the limits above) for the protection of downstream waters (regardless of their individual classification) with shellfish uses.
iv. Municipal separate storm sewer systems	For municipal separate storm sewer systems (as described in R.61-9.122.26.a.) compliance with the bacterial standards shall be determined in accordance with c(13) below.
v. Protection of upstream and/or downstream waters	Permit limitations may include (in addition to the requirements listed in c(8)i. and c(8)ii. above) one or more bacterial limitations for fecal coliform, <i>E. coli</i> and/or enterococci to protect both uses in the specific receiving water body and also to protect any upstream and/or downstream uses that may be required. If more than one bacterial limit is required, the conditions associated with each section below shall apply independently regardless of the water classification at the point of discharge.

vi. Class ORW or ONRW protection	For Class ORW or ONRW waters, the bacterial requirements shall be those applicable to the classification of the waterbody immediately prior to reclassification to either ORW or ONRW, including consideration of natural conditions. See G.5 and G.7 for prohibitions.
----------------------------------	---

(9) In order to protect recreational uses in Class SA saltwaters of the State, NPDES permit effluent limitations shall be specified as indicated below:

i. Monthly Average (enterococci)	35 MPN per 100 ml
ii. Daily Maximum (enterococci)	104 MPN per 100 ml (see c(12) below)
iii. Shellfish protection	Class SFH requirements for fecal coliform (see c(11)i. and c(1)ii. below) may be specified (in addition to the limits above) for the protection of upstream and/or downstream waters (regardless of their individual classification) with shellfish uses.
iv. Municipal separate storm sewer systems	For municipal separate storm sewer systems (as described in R.61-9.122.26.a.) compliance with the bacterial standards shall be determined in accordance with c(13) below.
v. Protection of upstream and/or downstream waters	Permit limitations may include (in addition to the requirements listed in c(9)i. and c(9)ii. above) one or more bacterial limitations for fecal coliform, E. coli and /or enterococci to protect both uses in the specific receiving water body and also to protect any upstream or downstream uses that may be required. If more than one bacterial limit is required, the conditions associated with each section above or below shall apply independently regardless of the water classification at the point of discharge.
vi. Class ORW or ONRW protection	For Class ORW or ONRW waters, the bacterial requirements shall be those applicable to the classification of the waterbody immediately prior to reclassification to either ORW or ONRW, including consideration of natural conditions. See G.5 and G.7 for prohibitions.

(10) In order to protect recreational uses in Class SB saltwaters of the State, NPDES permit effluent limitations shall be specified as indicated below:

i. Monthly Average (enterococci)	35 MPN per 100 ml
----------------------------------	-------------------

ii. Daily Maximum (enterococci)	501 MPN per 100 ml (see c(12) below)
iii. Class SA recreational daily maximum and/or shellfish protection	Class SA daily maximum (see c(9)ii. above) recreational use requirements for enterococci and/or Class SFH requirements (see c(11)i. and c(11)ii. below) for fecal coliform may be specified (in addition to the limits above) for the protection of upstream and/or downstream waters (regardless of their individual classification).
iv. Municipal separate storm sewer systems	For municipal separate storm sewer systems (as described in R.61-9.122.26.a.) compliance with the bacterial standards shall be determined in accordance with c(13) below.
v. Protection of upstream and/or downstream waters	Permit limitations may include (in addition to the requirements listed in c(10)i. and c(10)ii. above) one or more bacterial limitations for fecal coliform, <i>E. coli</i> and/or enterococci to protect both uses in the specific receiving water body and also to protect any upstream or downstream uses that may be required. If more than one bacterial limit is required, the conditions associated with each section above or below shall apply independently regardless of the water classification at the point of discharge.
vi. Class ORW or ONRW protection	For Class ORW or ONRW waters, the bacterial requirements shall be those applicable

(11) In order to protect for the consumption of shellfish, for any discharge either directly or indirectly in Class SFH waters or in Class SA, Class SB, ORW or ONRW waters with existing and/or approved shellfish harvesting uses as described in Section C.7, including protection of shellfish upstream and/or downstream uses in all waters regardless of their classification, NPDES permit effluent limitations shall be specified as indicated below:

i. For protection of shellfish uses-Monthly Average (Fecal coliform)	14 MPN per 100 ml
ii. For protection of shellfish uses- Daily Maximum (Fecal coliform)	43 MPN per 100 ml (see c(12) below)
iii. For protection of recreational uses - Monthly Average (enterococci)	35 MPN per 100 ml

iv. For protection of recreational uses-Daily Maximum (enterococci)	104 MPN per 100 ml (see c(12) below)
v. Protection of upstream and/or downstream waters	Permit limitations may include (in addition to the requirements listed in c(11)i. through c(11)iv. above) one or more bacterial limitations for fecal coliform, <i>E. coli</i> and /or enterococci to protect both uses in the specific receiving water body and also to protect any upstream or downstream uses that may be required. If more than one bacterial limit is required, the conditions associated with each section above shall apply independently regardless of the water classification at the point of discharge.
vi. Municipal separate storm sewer systems	For municipal separate storm sewer systems (as described in R.61-9.122.26.a.) compliance with the bacterial standards shall be determined in accordance with c(13) below.

(12) Provided the permittee verifies in writing to the Department that conditions (12)i. through (12)iv. below have been met, the permittee would be in compliance with the daily maximum bacterial requirement. However, nothing in this regulation precludes the Department from taking action, depending on the individual circumstances to protect public health and/or the environment.

i. If the facility exceeds the permitted Daily Maximum bacterial limitation listed above (for *E. coli*, enterococci or fecal coliform) but two (2) additional samples collected within 48 hours of the original sample result do NOT exceed the required Daily Maximum limit; and

(A) For all waters not involving shellfish protection (regardless of the specific water classification), the individual bacterial sample result has not exceeded 800 MPN per 100ml, and for those waters involving shellfish protection, the individual bacterial sample result for fecal coliform has not exceeded 200 MPN per 100ml; and

(B) There is neither an existing Consent Order nor Administrative Order associated with the facilities operation of their disinfection system; and

(C) Either:

1. For facilities that routinely collect ten (10) bacterial samples per month (or 120 or more samples per calendar year), there were no more than four (4) total bacteria samples exceeding the daily maximum limit in the previous twelve (12 months); or

2. For facilities other than those listed in (C) 1. above (e.g. smaller facilities or those that do not routinely collect 10 samples or more per month), there was no more than one (1) bacterial sample exceeding the daily maximum limit in the previous twelve (12 months); and

ii. The permittee verifies that all disinfection equipment was fully functional, and the solids handling system was fully functional during that monitoring period; and

iii. Any additional bacterial sampling collected during the monthly monitoring period when the daily maximum exceedance occurred was reasonably distributed in time while maintaining representative sampling; and

iv. The permittee must provide sufficient laboratory data sensitivity (e.g., dilutions) to accurately represent the effluent bacterial concentration to utilize this procedure. Effluent bacterial results reported as greater than (>) do not meet this criteria, since the actual results are unknown.

(13) For waters of the State, where a permit has been issued pursuant to R.61-9.122.26 and R.61-9.122.34, the Department shall consider the permittee in compliance with the established bacterial (i.e., *E. coli*, enterococci, fecal coliform) criteria for recreational uses of the waterbody if the permittee is in compliance with their permit.

(14) TMDL(s), WLA(s), and LA(s) included in currently approved freshwater fecal coliform TMDL documents shall be converted to *E. coli* utilizing a translator equation established by the Department and shall be based upon existing targets included in approved freshwater fecal coliform bacteria TMDL documents.

(15) All effluent permit limitations which include WET shall require that the WET tests be conducted using *Ceriodaphnia dubia* (*C. dubia*), except as stated. If the salinity of a discharge to a saline waterbody is high enough to be toxic to *C. dubia*, *Mysidopsis bahia* (*M. bahia*) shall be used. If the hardness of a waterbody is low enough to be toxic to *C. dubia*, then *Daphnia ambigua* (*D. ambigua*) may be used. Low salinity discharges to saltwater may be tested using either *C. dubia* or *M. bahia* with salinity adjustment, as determined by the Department. The Department may consider an alternative species if it can be demonstrated that the proposed species meets the requirements of 40 CFR 136.4 and 5., as approved by EPA. EPA test methods (40 CFR 136) for acute and chronic toxicity testing with freshwater organisms or marine and estuarine organisms must be followed. The Department may consider an alternative method if it can be demonstrated that the proposed method meets the requirements of 40 CFR 136, and is approved by EPA.

d. Evaluation of ambient water quality.

(1) If the numeric criterion for toxic pollutants is lower than the analytical detection limit, the criterion is not considered violated if the ambient concentration is below the detection limit and the instream indigenous biological community is not adversely impacted.

(2) If the ambient concentration is higher than the numeric criterion for toxic pollutants, the criterion is not considered violated if biological monitoring has demonstrated that the instream indigenous biological community is not adversely impacted.

(3) In order to appropriately evaluate the ambient water quality for the bioavailability of the dissolved portion of hardness dependent metals, the Department may utilize a federally- approved methodology to predict the dissolved fraction or partitioning coefficient in determining compliance with water quality standards established in this regulation.

(4) The assessment of fecal coliform for purposes of evaluating the shellfish harvesting use for South Carolina's Shellfish Management Units is conducted in accordance with provisions of S.C. Regulation 61-47, Shellfish. R.61-47 also includes specific language describing the use of the allowable 10% exceedance value in the shellfish program.

(5) The assessment of enterococci for purposes of issuing swimming advisories for ocean beaches for recreational use will be based on the single sample maximum of 104/100 ml.

(6) The assessment of enterococci and *E. coli* for purposes of Section 303(d) listing determinations for recreational uses shall be based on the geometric mean with an allowable 10% exceedance, where sufficient data exists to calculate a geometric mean. In the absence of sufficient data to calculate a geometric mean, the assessment shall be based on the single sample maximum with an allowable 10% exceedance.

15. The Department may require biological or other monitoring in NPDES permits to further ascertain any bioaccumulative effects of pollutants. Such monitoring may include analyses of fish and shellfish, macroinvertebrates, macrophytes, and/or sediments in order to assess the accumulation of pollutants in tissues or sediments that:

a. May cause or have the potential to cause adverse impacts to the balanced indigenous aquatic community; and

b. May cause or have the potential to cause adverse impacts to human health and/or terrestrial flora and fauna.

16. The Department may consider other scientifically-defensible published data which are appropriate for use in developing permit limits and evaluating water quality for constituents for which EPA has not developed national criteria or South Carolina has no standards.

a. The Department shall apply a sensitivity factor to aquatic toxicity data unless, in the Department's judgment, the data represent a minimum of three appropriately sensitive species representing three taxonomic groups (plant, macroinvertebrate, and fish).

(1) If only an acute toxicity effect concentration for a number of species for a particular pollutant is given as an LC₅₀, the lowest concentration should be divided by an acute-to- chronic ratio (ACR) of 10 and a sensitivity factor of 3.3, for an acceptable instream concentration in order to protect against chronic toxicity effects.

(2) If a chronic toxicity effect concentration for a number of species for a particular pollutant is given as a no observed effect concentration (NOEC), the lowest concentration should be divided by a sensitivity factor of 3.3 in order to protect against chronic toxicity to the most sensitive species.

b. The Department must notify the permittee that other such data were used in developing permit limits and provide justification for their use.

17. Tests or analytical methods to determine compliance or non-compliance with standards shall be made in accordance with methods and procedures approved by the Department and the EPA. In making any tests or applying analytical methods to determine compliance or non-compliance with water quality standards, representative samples shall be collected in accordance with methods and procedures approved by the Department and the EPA. Consideration of representative sample methods shall include the following:

a. Surface water and ground water samples shall be collected so as to permit a realistic appraisal of quality and actual or potential damage to existing or classified water uses. For ground waters, consideration shall be given to, but shall not be limited to, depth to water table, flow direction, and velocity. For surface waters, time of day, flow, surface area, and depth shall be considered.

b. Biological assessment methods may be employed in appropriate situations to determine abnormal nutrient enrichment, trophic condition, LC₅₀, concentration of toxic substances, acceptable instream concentrations, or acceptable effluent concentrations for maintenance of a balanced indigenous aquatic community.

c. Temporal distribution of samples in tidally influenced waters shall cover the full range of tidal conditions.

d. Ambient toxicity tests used for screening purposes shall be conducted using *Ceriodaphnia dubia* (*C. dubia*), except as stated. If salinity of a waterbody is high enough to be toxic to *C. dubia*, *Mysidopsis bahia* (*M. bahia*) will be used. If the hardness of a waterbody is low enough to be toxic to *C. dubia*, then *Daphnia ambigua* (*D. ambigua*) may be used. The Department may consider an alternative species if it can be demonstrated that the proposed species meets the requirements of 40 CFR.136.4 and 5, as approved by EPA. EPA test methods (40 CFR Part 136) for acute and chronic toxicity testing with freshwater organisms or marine and estuarine organisms must be followed. The Department may consider an alternative method if it can be demonstrated that the proposed method meets the requirements of 40 CFR.136, and is approved by EPA.

18. For the protection of human health, methylmercury concentration in fish or shellfish shall not exceed 0.3 mg/kg in wet weight of edible tissue.

a. NPDES permit implementation for methylmercury will require mercury monitoring, assessment and minimization for discharges that meet the following conditions;

- (1) The receiving stream is impaired for methylmercury in fish or shellfish tissue, and;
- (2) The discharge or proposed discharge has consistently quantifiable levels of mercury.

b. The need for a total mercury effluent limit, for the protection of aquatic life and/or human health, pursuant to R.61-9.122.44(d), shall be based on a reasonable potential analysis of the discharge compared to the mercury standards for ambient waters.

19. The assessment of methylmercury in fish or shellfish for purposes of Section 303(d) listing determinations shall be based on the Department's Fish Consumption Advisories.

F.NARRATIVE BIOLOGICAL CRITERIA.

1. Narrative biological criteria are contained in this regulation and are described throughout the sections where applicable. The following are general statements regarding these narrative biological criteria.

a. Narrative biological criteria in Section A.4. describe the goals of the Department to maintain and improve all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora. These narrative criteria are determined by the Department based on the condition of the waters of the State by measurements of physical, chemical, and biological characteristics of the waters according to their classified uses.

b. Section C.10. describes narrative biological criteria relative to surface water mixing zones and specifies requirements necessary for the protection and propagation of a balanced indigenous aquatic community.

c. Narrative biological criteria shall be consistent with the objective of maintaining and improving all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora attainable in waters of the State; and in all cases shall protect against degradation of the highest existing or classified uses or biological conditions in compliance with the antidegradation rules contained in this regulation. Section D.1.a. describes narrative biological criteria relative to activities in Outstanding National Resource Waters, Outstanding Resource Waters and Shellfish Harvesting Waters.

d. In order to determine the biological quality of the waters of the State, it is necessary that the biological component be assessed by comparison to a reference condition(s) based upon similar hydrologic and watershed characteristics that represent the optimum natural condition for that system. Such reference condition(s) or reaches of waterbodies shall be those observed to support the greatest variety and abundance of aquatic life in the region as is expected to be or would be with a minimal amount of disturbance from anthropogenic sources. Impacts from urbanization and agriculture should be minimal and natural vegetation should dominate the land cover. There should also be an appropriate diversity of substrate. Reference condition(s) shall be determined by consistent sampling and reliable measures of selected indicative communities of flora and fauna as established by the Department and may be used in conjunction with acceptable physical, chemical, and microbial water quality measurements and records judged to be appropriate for this purpose. Narrative biological criteria relative to activities in all waters are described in Section E.

e. In the Class Descriptions, Designations, and Specific Standards for Surface Waters Section, all water use classifications protect for a balanced indigenous aquatic community of fauna and flora. In addition, Trout Natural and Trout Put, Grow, and Take classifications protect for reproducing trout populations and stocked trout populations, respectively.

2. [Reserved].

G. CLASS DESCRIPTIONS, DESIGNATIONS, AND SPECIFIC STANDARDS FOR SURFACE WATERS.

1. All surface waters of the State, except as discussed in Section C., shall be identified within one of the classes described below. The Department may determine in accordance with Section 312 of the Clean Water Act that for some waterbodies (or portions of waterbodies), the designation of No Discharge Zone (NDZ) for Marine Sanitation Devices (MSDs) shall be enacted with application of the existing classified standards of the waterbody. Those waters classified by name shall be listed in Regulation 61-69 along with the NDZ designation, if applicable.

2. Where a surface water body is tributary to waters of a higher class, the quality of the water in the tributary shall be protected to maintain the standards of the higher classified receiving water.

3. For items not listed in each class, criteria published pursuant to Sections 304(a) and 307(a) of the Federal Clean Water Act or other documents shall be used as guides to determine conditions which protect water uses. Many of these criteria are listed in the appendix to this regulation. For consideration of natural conditions, refer to Sections: C.9., D.4., E.12., E.14.c.(2), E.14.c.(3), F.4.d., G.4., G.6., and G.9. For the following numeric criteria for turbidity (with the exception of Outstanding National Resource Waters, Outstanding Resource Waters, Trout waters, and Shellfish Harvesting Waters), compliance with these turbidity criteria may be considered to be met as long as the waterbody supports a balanced indigenous aquatic community when land management activities employ Best Management Practices (BMPs). For consideration, BMPs must be in full compliance with all specifications governing the proper design,

installation, operation and maintenance of such BMPs and all applicable permit conditions and requirements must be met.

4. **Outstanding National Resource Waters (ONRW)** are freshwaters or saltwaters which constitute an outstanding national recreational or ecological resource.

Quality Standards for Outstanding National Resource Waters	
ITEMS	STANDARDS
a. Color, dissolved oxygen, fecal coliform enterococci, <i>E. coli</i> , pH, temperature, turbidity, and other parameters.	Water quality conditions shall be maintained and protected to the extent of the Department's statutory authority. Numeric and narrative criteria for Class ONRW shall be those applicable to the classification of the waterbody immediately prior to reclassification to Class ONRW, including consideration of natural conditions.

5. In order to maintain the existing quality of Class ONRW waters the following additional standards apply:

ITEMS	STANDARDS
a. Discharge from domestic, industrial, or agricultural waste treatment facilities; aquaculture; open water dredged spoil disposal.	None allowed.
b. Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, concentrated aquatic animal production facilities, and uncontaminated groundwater from mining.	None allowed.
c. Dumping or disposal of garbage, cinders, ashes, oils, sludge, or other refuse.	None allowed.
d. Activities or discharges from waste treatment facilities in waters upstream or tributary to ONRW waters.	Allowed if there shall be no measurable impact on the downstream ONRW consistent with antidegradation rules.

6. **Outstanding Resource Waters (ORW)** are freshwaters or saltwaters which constitute an outstanding recreational or ecological resource or those freshwaters suitable as a source for drinking water supply purposes with treatment levels specified by the Department.

Quality Standards for Outstanding Resource Waters	
ITEMS	STANDARDS
a. Color, dissolved oxygen, fecal coliform enterococci, <i>E. coli</i> , pH, temperature, turbidity, and other parameters.	Water quality conditions shall be maintained and protected to the extent of the Department's statutory authority. Numeric and narrative criteria for Class ORW shall be those applicable to the classification of the waterbody immediately prior to reclassification to Class ORW, including consideration of natural conditions.

7. In order to maintain the existing quality of Class ORW waters the following additional standards apply:

ITEMS	STANDARDS
a. Discharge from domestic, industrial, agricultural waste treatment facilities; aquaculture; open water dredged spoil disposal.	None allowed.
b. Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, concentrated aquatic animal production facilities, and uncontaminated groundwater from mining.	Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules.
c. Dumping or disposal of garbage, cinders, ashes, oils, sludge, or other refuse.	None allowed.
d. Activities or discharges from waste treatment facilities in waters upstream or tributary to ORW waters.	Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules.

8. **Trout Waters.** The State recognizes three types of trout waters: Natural; Put, Grow, and Take; and Put and Take.

a. **Natural (TN)** are freshwaters suitable for supporting reproducing trout populations and a cold water balanced indigenous aquatic community of fauna and flora. Also suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses.

b. **Put, Grow, and Take (TPGT)** are freshwaters suitable for supporting growth of stocked trout populations and a balanced indigenous aquatic community of fauna and flora. Also suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses.

c. **Put and Take (TPT)** are freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses. The standards of Freshwaters classification protect these uses.

9. The standards below protect the uses of Natural and Put, Grow, and Take trout waters.

Quality Standards for Trout Waters	
ITEMS	STANDARDS
a. Garbage, cinders, ashes, oils, sludge, or other refuse	None allowed.
b. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except those given in a. above.	None alone or in combination with other substances or wastes in sufficient amounts to be injurious to reproducing trout populations in natural waters or stocked populations in put, grow, and take waters or in any manner adversely affecting the taste, color, odor, or sanitary condition thereof or impairing the waters for any other best usage as determined for the specific waters which are assigned to this class.
c. Toxic pollutants listed in the appendix.	As prescribed in Section E of this regulation.
d. Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, concentrated aquatic animal production facilities, and uncontaminated groundwater from mining.	Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules.
e. Dissolved oxygen.	Not less than 6 mg/l.
f. <i>E. coli</i>	Not to exceed a geometric mean of 126/100 ml based on at least four samples collected from a given sampling site over a 30 day period, nor shall a single sample maximum exceed 349/100 ml.

g. pH.	Between 6.0 and 8.0.
h. Temperature.	Not to vary from levels existing under natural conditions, unless determined that some other temperature shall protect the classified uses.
i. Turbidity.	Not to exceed 10 Nephelometric Turbidity Units (NTUs) or 10% above natural conditions, provided uses are maintained.

10. **Freshwaters (FW)** are freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses.

Quality Standards for Freshwaters	
ITEMS	STANDARDS
a. Garbage, cinders, ashes, oils, sludge, or other refuse	None allowed.
b. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except those given in a. above.	None alone or in combination with other substances or wastes in sufficient amounts to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
c. Toxic pollutants listed in the appendix.	As prescribed in Section E of this regulation.
d. Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, concentrated aquatic animal production facilities, and uncontaminated groundwater from mining.	Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules.
e. Dissolved oxygen.	Daily average not less than 5.0 mg/l with a low of 4.0 mg/l.
f. <i>E. coli</i>	Not to exceed a geometric mean of 126/100 ml based on at least four samples collected from a given sampling site over a 30 day period, nor shall a single sample maximum exceed 349/100 ml.
g. pH.	Between 6.0 and 8.5.
h. Temperature.	As prescribed in E.12. of this regulation.

i. Turbidity. Except for Lakes.	Not to exceed 50 NTUs provided existing uses are maintained.
Lakes only.	Not to exceed 25 NTUs provided existing uses are maintained.

11. **Shellfish Harvesting Waters (SFH)** are tidal saltwaters protected for shellfish harvesting and uses listed in Class SA and Class SB. Suitable for primary and secondary contact recreation, crabbing, and fishing. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora.

Quality Standards for Shellfish Harvesting Waters	
ITEMS	STANDARDS
a. Garbage, cinders, ashes, oils, sludge, or other refuse	None allowed.
b. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except those given in a. above.	None alone or in combination with other substances or wastes in sufficient amounts to adversely affect the taste, color, odor, or sanitary condition of clams, mussels, or oysters for human consumption; or to impair the waters for any best usage as determined for the specific waters which are assigned to this class.
c. Toxic pollutants listed in the appendix.	As prescribed in Section E of this regulation.
d. Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, and concentrated aquatic animal production facilities.	Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules.
e. Dissolved oxygen.	Daily average not less than 5.0 mg/l with a low of 4 mg/l.
f. Fecal coliform.	Not to exceed an MPN fecal coliform geometric mean of 14/100 ml; nor shall the samples exceed an MPN of 43/100 ml.
g. Enterococci.	Not to exceed a geometric mean of 35/100 ml based on at least four samples collected from a given sampling site over a 30 day period; nor shall a single sample maximum exceed 104/100 ml. Additionally, for beach monitoring and notification activities for CWA Section 406 only, samples shall not exceed a single sample maximum of 104/100 ml.

h. pH.	Shall not vary more than 3/10 of a pH unit above or below that of effluent-free waters in the same geological area having a similar total alkalinity and temperature, but not lower than 6.5 or above 8.5.
i. Temperature.	As prescribed in E.12. of this regulation.
j. Turbidity.	Not to exceed 25 (NTUs) provided existing uses are maintained.

k. The Department may designate prohibited areas where shellfish harvesting for market purposes or human consumption shall not be allowed, consistent with the antidegradation rule, Section D.1.a. of this regulation.

12. Class SA are tidal saltwaters suitable for primary and secondary contact recreation, crabbing, and fishing, except harvesting of clams, mussels, or oysters for market purposes or human consumption and uses listed in Class SB. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora.

Quality Standards for Class SA Waters	
ITEMS	STANDARDS
a. Garbage, cinders, ashes, oils, sludge, or other refuse.	None allowed.
b. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except those given in a. above.	None alone or in combination with other substances or wastes in sufficient amounts to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
c. Toxic pollutants listed in the appendix.	As prescribed in Section E of this regulation.
d. Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, and concentrated aquatic animal production facilities.	Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules.
e. Dissolved oxygen.	Daily average not less than 5.0 mg/l with a low of 4.0 mg/l.

f. Enterococci.	Not to exceed a geometric mean of 35/100 ml based on at least four samples collected from a given sampling site over a 30 day period; nor shall a single sample maximum exceed 104/100 ml. Additionally, for beach monitoring and notification activities for CWA Section 406 only, samples shall not exceed a single sample maximum of 104/100 ml.
g. pH.	Shall not vary more than one-half of a pH unit above or below that of effluent-free waters in the same geological area having a similar total salinity, alkalinity and temperature, but not lower than 6.5 or above 8.5.
h. Temperature.	As prescribed in E.12. of this regulation.
i. Turbidity.	Not to exceed 25 NTUs provided existing uses are maintained.

j. The Department shall protect existing shellfish harvesting uses found in Class SA waters consistent with the antidegradation rule, Section D.1.a. of this regulation and shall establish permit limits in accordance with Section E.14.c(8), (9), (10), and (11) and Section G.11.f. of this regulation.

13. Class SB are tidal saltwaters suitable for primary and secondary contact recreation, crabbing, and fishing, except harvesting of clams, mussels, or oysters for market purposes or human consumption or human consumption. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora.

Quality Standards for Class SB Waters	
ITEMS	STANDARDS
a. Garbage, cinders, ashes, oils, sludge, or other refuse	None allowed.
b. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except those given in a. above.	None alone or in combination with other substances or wastes in sufficient amounts to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
c. Toxic pollutants listed in the appendix.	As prescribed in Section E of this regulation.
d. Stormwater, and other nonpoint source runoff, including that from agricultural uses, or permitted discharge from aquatic farms, and concentrated aquatic animal production facilities.	Allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with antidegradation rules.

e. Dissolved oxygen.	Not less than 4.0 mg/l.
f. Enterococci.	Not to exceed a geometric mean of 35/100 ml based on at least four samples collected from a given sampling site over a 30 day period; nor shall a single sample maximum exceed 501/100 ml. Additionally, for beach monitoring and notification activities for CWA Section 406 only, samples shall not exceed a single sample maximum of 501/100 ml.
g. pH.	Shall not vary more than one-half of a pH unit above or below that of effluent-free waters in the same geological area having a similar total salinity, alkalinity and temperature, but not lower than 6.5 or above 8.5.
h. Temperature.	As prescribed in E.12. of this regulation.
i. Turbidity.	Not to exceed 25 NTUs provided existing uses are maintained.

j. The Department shall protect existing shellfish harvesting uses found in Class SB waters consistent with the antidegradation rule, Section D.1.a. of this regulation and shall establish permit limits in accordance with Section E.14.c(8), (9), (10), and (11) and Section G.11.f. of this regulation.

H. CLASS DESCRIPTIONS AND SPECIFIC STANDARDS FOR GROUND WATERS.

1. All ground waters of the State, except within mixing zones, shall be identified within one of the classes described below.

2. It is the policy of the Department to maintain the quality of ground water consistent with the highest potential uses. Most South Carolina ground water is presently suitable for drinking water without treatment and the State relies heavily upon ground water for drinking water. For this reason, all South Carolina ground water is classified Class GB effective on June 28, 1985.

3. The Department recognizes that Class GB may not be suitable for some ground water. Class GA is established for exceptionally valuable ground water and Class GC is established for ground water with little potential as an underground source of drinking water.

4. In keeping with this policy the Department declares that effective June 28, 1985, all ground waters of the State shall be protected to a quality consistent with the use associated with the classes described herein. Further, the Department may require the owner or operator of a contaminated site to restore the ground water quality to a level that maintains and supports the existing and classified uses (except classified uses within mixing zones, as described in this regulation). For purposes of this section, the term operator means any person in control of, or having responsibility for, the operation of on-site activities or property and owner means a person or a previous person who has assumed legal ownership of a property through the provisions of a contract of sale or other legally binding transfer of ownership. The term owner also means any person who owned, operated, or otherwise controlled activities at such site before the title or control of which was conveyed to a unit of State or local government due to bankruptcy, foreclosure, tax delinquency, abandonment, or similar means. However, nothing in this section shall be construed to supersede specific statutory or regulatory provision that relieves owners or operators of certain contaminated sites from liability for restoration of groundwater, including, without limitation, S.C. Code '44-2-80 (b) and (c). The term does not include a unit of State or local government which acquired ownership or control involuntarily through bankruptcy, tax delinquency, abandonment, or other circumstances in which the government involuntarily acquires title by virtue of its function as sovereign. The exclusion provided under this

paragraph shall not apply to any State or local government which has caused or contributed to the release or threatened release of a contaminant from the site, and such a State or local government shall be subject to these provisions in the same manner and to the same extent, both procedurally and substantively, as any nongovernmental entity.

5. A ground water monitoring program approved by the Department may be required for any existing or proposed disposal system or other activities to determine the ground water quality affected by such systems or activities. Such monitoring program may be required through the Department's permitting and certification programs.

6. Those ground waters which are classified Class GA or Class GC after petition and proper administrative procedures other than Class GB shall be described by location and listed in Regulation 61-69.

7. Class GA are those ground waters that are highly vulnerable to contamination because of the hydrological characteristics of the areas under which they occur and that are also characterized by either of the following two factors:

a. Irreplaceable, in that no reasonable alternative source of drinking water is available to substantial populations; or

b. Ecologically vital, in that the ground water provides the base flow for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat.

8. The standards below protect these ground waters:

Quality Standards for Class GA Ground Waters	
ITEMS	STANDARDS
a. Treated wastes, toxic wastes, deleterious substances, or constituents thereof.	None allowed.

9. **Class GB.** All ground waters of the State, unless classified otherwise, which meet the definition of underground sources of drinking water (USDW) as defined in Section B.

Quality Standards for Class GB Ground Waters	
ITEMS	STANDARDS
a. Inorganic chemicals.	Maximum contaminated levels as set forth in R.61-58, State Primary Drinking Water Regulations.
b. Organic chemicals.	Maximum contaminated levels as set forth in R.61-58, State Primary Drinking Water Regulations.
c. Man-made radionuclides, priority pollutant volatile organic compounds, herbicides, polychlorinated biphenyls, and other synthetic organic compounds not specified above, treated wastes, thermal wastes,	Not to exceed concentrations or amounts such as to interfere with the use actual or intended, as determined by the Department.

colored wastes or other wastes of constituents thereof.	
---	--

10. **Class GC** are those ground waters not considered potential sources of drinking water and of limited beneficial use, i.e., ground waters that exceed a concentration of 10,000 mg/l total dissolved solids or are otherwise contaminated beyond levels that allow cleanup using methods reasonably employed in public water system treatment. These ground waters also must not migrate to Class GA or Class GB ground waters or have a discharge to surface water that could cause degradation.

Quality Standards for Class GC Ground Waters	
ITEMS	STANDARDS
a. Treated wastes, toxic wastes, deleterious substances, or constituents thereof.	None which interfere with any existing use of an underground source of drinking water.

I. SEVERABILITY.

Should any section, paragraph, or other part of this regulation be declared invalid for any reason, the remainder shall not be affected.

APPENDIX: WATER QUALITY NUMERIC CRITERIA FOR THE PROTECTION OF AQUATIC LIFE AND HUMAN HEALTH

This appendix contains three charts (priority pollutants, nonpriority pollutants, and organoleptic effects) of numeric criteria for the protection of human health and aquatic life. The appendix also contains three attachments which address hardness conversions and application of ammonia criteria. Footnotes specific to each chart follow the chart. General footnotes pertaining to all are at the end of the charts prior to the attachments. The numeric criteria developed and published by EPA are hereby incorporated into this regulation. Please refer to the text of the regulation for other general information and specifications in applying these numeric criteria.

PRIORITY TOXIC POLLUTANTS

Priority Pollutant		CAS Number	Freshwater Aquatic Life		Saltwater Aquatic Life		Human Health			FR Cite/ Source
			CMC (µg/L)	CCC (µg/L)	CMC (µg/L)	CCC (µg/L)	For Consumption of: Water & Organism (µg/L) Organism Only (µg/L) MCL (µg/L)			
1	Antimony	7440360					5.6 B, ee	640 B, ee	6 ee	65FR66443 SDWA
2	Arsenic	7440382	340 A, D, K	150 A, D, K	69 A, D, Y	36 A, D, Y	10 C	10 C	10 C	65FR31682 57FR60848 SDWA
3	Beryllium	7440417					J, ee	J, ee	4 ee	65FR31682 SDWA
4	Cadmium	7440439	0.53 D, E, K	0.10 D, E, K	43 D, Y	9.3 D, Y	J, ee	J, ee	5 ee	65FR31682 SDWA
5a	Chromium III	16065831	580 D, E, K	28 D, E, K			J, ee	J, ee	100 Total ee	EPA820/B-96-001 65FR31682 SDWA
5b	Chromium VI	18540299	16 D, K	11 D, K	1,100 D, Y	50 D, Y	J, ee	J, ee	100 Total ee	65FR31682 SDWA
6	Copper	7440508	3.8 D, E, K, Z, II	2.9 D, E, K, Z, II	5.8 D, Z, Y, cc	3.7 D, Z, Y, cc	1,300 T, ee			65FR31682
7	Lead	7439921	14 D, E, Y	0.54 D, E, Y	220 D, Y	8.5 D, Y				65FR31682
8	Mercury	7439976	1.6 D, K, dd	0.91 D, K, dd	2.1 D, bb, dd	1.1 D, bb, dd	0.050 B, ee	0.051 B, ee	2 ee	65FR31682 SDWA

9	Nickel	7440020	150 D, E, K	16 D, E, K	75 D, Y	8.3 D, Y	610 B, ee	4, 600 B, ee	65FR31682	
10	Selenium	7782492	L, Q, S	5.0 S	290 D, aa	71 D, aa	170 Z, ee	4,200 ee	50 ee	65FR31682 65FR66443 SDWA
11	Silver	7440224	0.37 D, E, G		2.3 D, G					65FR31682
12	Thallium	7440280					0.24	0.47	2 ee	68FR75510 SDWA
13	Zinc	7440666	37 D, E, K	37 D, E, K	95 D, Y	86 D, Y	7,400 T, ee	26,000 T, ee		65FR31682 65FR66443
14	Cyanide	57125	22 K, P	5.2 K, P	1 P, Y	1 P, Y	140 ee, jj	140 ee, jj	200 ee	EPA820/B-96-001 57FR60848 68FR75510 SDWA
15	Asbestos	1332214							7 million fibers/L I, ee	57FR60848
16	2, 3, 7, 8-TCDD (Dioxin)	1746016						0.046 ppq O, C	30ppq O, C	State Standard SDWA
17	Acrolein	107028	3	3			6 ee, nn	9 ee, nn		74FR27535 74FR46587
18	Acrylonitrile	107131					0.051 B, C	0.25 B, C		65FR66443
19	Benzene	71432					2.2 B, C	51 B, C	5 C	IRIS 01/19/00 65FR66443 SDWA
20	Bromate	15541454							10 C	SDWA
21	Bromoform	75252					4.3 B, C	140 B, C	80 Total THMs C	65FR66443 SDWA
22	Bromoacetic acid	79083							60 Total HAA5 C,mm	SDWA
23	Carbon Tetrachloride	56235					0.23 B, C	1.6 B, C	5 C	65FR66443 SDWA
24	Chlorite	67481							100	SDWA

25	Chlorobenzene	108907			130T, ee	1,600 T, ee	100 T, ee	68FR75510 SDWA
26	Chlorodibromomethane	124481			0.40 B, C	13 B, C	80 Total THMs C	65FR66443 SDWA
27	Chloroform	67663			5.7 B, C, hh	470 B, C, hh	80 Total THMs C	62FR42160 SDWA
28	Dibromoacetic acid	631641					60 Total HAA5 C, mm	SDWA
29	Dichloroacetic acid	79436					60 Total HAA5 C,mm	SDWA
30	Dichlorobromomethane	75274			0.55 B, C	17 B, C	80 Total THMs C	65FR66443 SDWA
31	1, 2-Dichloroethane	107062			0.38 B, C	37 B, C	5 C	65FR66443 SDWA
32	1, 1-Dichloroethylene	75354			330 ee	7,100 ee	7 C	68FR75510 SDWA
33	1, 2-Dichloropropane	78875			0.50 B, C	15 B, C	5 C	65FR66443 SDWA
34	1, 3-Dichloropropene	542756			0.34 ee	21 ee		68FR75510
35	Ethylbenzene	100414			530 ee	2,100 ee	700 ee	68FR75510 SDWA
36	Methyl Bromide	74839			47 B, ee	1,500 B, ee		65FR66443
37	Methylene Chloride	75092			4.6 B, C	590 B, C	5 C	65FR66443 SDWA
38	Monochloroacetic acid	79118					60 Total HAA5 C,mm	SDWA
39	1, 1, 2, 2-Tetrachloroethane	79345			0.17 B, C	4.0 B, C		65FR66443

40	Tetrachloroethylene	127184			0.69 C	3.3 C	5 C	65FR66443 SDWA		
41	Toluene	108883			1,300 ee	15,000 ee	1000 ee	68FR75510 SDWA		
42	1,2-Trans-Dichloroethylene	156605			140 ee	10,000 ee	100 ee	68FR75510 SDWA		
43	Trichloroacetic acid	79039			60 Total HAA5 C,mm			SDWA		
44	1, 1, 1-Trichloroethane	71556			J, ee	J, ee	200 ee	65FR31682 SDWA		
45	1, 1, 2-Trichloroethane	79005			0.59 B, C	16 B, C	5 C	65FR66443 SDWA		
46	Trichloroethylene	79016			2.5 C	30 C	5 C	65FR66443 SDWA		
47	Vinyl Chloride	75014			0.025 kk	2.4 kk	2 C	68FR75510 SDWA		
48	2-Chlorophenol	95578			81 B, T, ee	150 B, T, ee		65FR66443		
49	2, 4-Dichlorophenol	120832			77 B, T, ee	290 B, T, ee		65FR66443		
50	2, 4-Dimethylphenol	105679			380 B, T, ee	850 B, T, ee		65FR66443		
51	2-Methyl- 4, 6-Dinitrophenol	534521			13 ee	280 ee		65FR66443		
52	2, 4-Dinitrophenol	51285			69 B, ee	5,300 B, ee		65FR66443		
53	Pentachlorophenol	87865	19 F, K	15 F, K	13 Y	7.9 Y	0.27 B, C	3.0 B, C, H	1 C	65FR31682 65FR66443 SDWA
54	Phenol	108952			10,000 T, ee, nn	860,000 T, ee, nn		74FR27535 74FR46587		
55	2, 4, 6-Trichlorophenol	88062			1.4 B, C, T	2.4 B, C		65FR66443		

56	Acenaphthene	83329			670 B, T, ee	990 B, T, ee	65FR66443			
57	Anthracene	120127			8,300 B, ee	40,000 B, ee	65FR66443			
58	Benzidine	92875			0.000086 B, C	0.00020 B, C	65FR66443			
59	Benzo (a) Anthracene	56553			0.0038 B, C	0.018 B, C	65FR66443			
60	Benzo (a) Pyrene	50328			0.0038 B, C	0.018 B, C	0.2 C	65FR66443 SDWA		
61	Benzo (b) Fluoranthene	205992			0.0038 B, C	0.018 B, C		65FR66443		
62	Benzo (k) Fluoranthene	207089			0.0038 B, C	0.018 B, C		65FR66443		
63	Bis-2-Chloroethyl Ether	111444			0.030 B, C	0.53 B, C		65FR66443		
64	Bis-2-Chloroisopropyl Ether	108601			1,400 B, ee	65,000 B, ee		65FR66443		
65	Bi-s2-Ethylhexyl Phthalate (DEHP)	117817	v	v	v	v	1.2 B, C	2.2 B, C	6 C	65FR66443 SDWA
66	Butylbenzene Phthalate	85687	ii	ii	ii	ii	1,500 B, ee	1,900 B, ee		65FR66443
67	2-Chloronaphthalene	91587					1,000 B, ee	1,600 B, ee		65FR66443
68	Chrysene	218019					0.0038 B, C	0.018 B, C		65FR66443
69	Dibenzo(a,h)Anthracene	53703					0.0038 B, C	0.018 B, C		65FR66443

70	1, 2-Dichlorobenzene	95501			420 ee	1,300 ee	600 ee	68FR75510 SDWA
71	1, 3-Dichlorobenzene	541731			320 ee	960 ee		65FR66443
72	1, 4-Dichlorobenzene	106467			63 ee	190 ee	75 ee	68FR75510 SDWA
73	3, 3'-Dichlorobenzidine	91941			0.021 B, C	0.028 B, C		65FR66443
74	Diethyl Phthalate	84662	ii	ii	17,000 B, ee	44,000 B, ee		65FR66443
75	Dimethyl Phthalate	13113	ii	ii	270,000 B, ee	1,100,000 B, ee		64FR66443
76	Di-n-butyl Phthalate	84742	ii	ii	2,000 B, ee	4,500 B, ee		65FR66443
77	2, 4-Dinitrotoluene	121142			0.11 C	3.4 C		65FR66443
78	1, 2-Diphenylhydrazine	122667			0.036 B, C	0.20 B, C		65FR66443
79	Fluoranthene	206440			130 B, ee	140 B, ee		65FR66443
80	Fluorene	86737			1,100 B, ee	5,300 B, ee		65FR66443
81	Hexachlorobenzene	118741			0.00028 B, C	0.00029 B, C	1 C	65FR66443 SDWA
82	Hexachlorobutadiene	87683			0.44 B, C	18 B, C		65FR66443
83	Hexachlorocyclo- pentadiene	77474			40 T, ee	1100 T, ee	50 ee	68FR75510 SDWA
84	Hexachloroethane	67721			1.4 B, C	3.3 B, C		65FR66443
85	Indeno 1,2,3(cd) Pyrene	193395			0.0038 B, C	0.018 B, C		65FR66443

86	Isophorone	78591			35 B, C	960 B, C	65FR66443
87	Nitrobenzene	98953			17 B, ee	690 B, H, T, ee	65FR66443
88	N-Nitrosodimethylamine	62759			0.00069 B, C	3.0 B, C	65FR66443
89	N-Nitrosodi-n-Propylamine	621647			0.0050 B, C	0.51 B, C	65FR66443
90	N-Nitrosodiphenylamine	86306			3.3 B, C	6.0 B, C	65FR66443
91	Pyrene	129000			830 B, ee	4,000 B, ee	65FR66443
92	1, 2, 4-Trichlorobenzene	120821			35 ee	70 ee 70 ee	68FR75510 SDWA
93	Aldrin	309002	3.0 G, X	1.3 G, X	0.000049 B, C	0.000050 B, C	65FR31682 65FR66443
94	alpha-BHC	319846			0.0026 B, C	0.0049 B, C	65FR66443
95	beta-BHC	319857			0.0091 B, C	0.017 B, C	65FR66443
96	gamma-BHC (Lindane)	58899	0.95 K	0.16 G	0.98 ee	1.8 ee 0.2 C	65FR31682 68FR75510 SDWA
97	Chlordane	57749	2.4 G 0.0043 G, X	0.09 G 0.004 G, X	0.00080 B, C	0.00081 B, C 2 C	65FR31682 65FR66443 SDWA
98	4, 4'-DDT	50293	1.1 G, gg 0.001 G, X, gg	0.13 G, gg 0.001 G, X, gg	0.00022 B, C	0.00022 B, C	65FR31682 65FR66443
99	4, 4'-DDE	72559			0.00022 B, C	0.00022 B, C	65FR66443
100	4, 4'-DDD	72548			0.00031 B, C	0.00031 B, C	65FR66443

101	Dieldrin	60571	0.24 K	0.056 K, N	0.71 G	0.0019 G, X	0.000052 B, C	0.000054 B, C	65FR31682 65FR66443	
102	alpha-Endosulfan	959988	0.22 G, W	0.056 G, W	0.034 G, W	0.0087 G, W	62 B, ee	89 B, ee	65FR31682 65FR66443	
103	beta-Endosulfan	33213659	0.22 G, W	0.056 G, W	0.034 G, W	0.0087 G, W	62 B, ee	89 B, ee	65FR31682 65FR66443	
104	Endosulfan Sulfate	1031078					62 B, ee	89 B, ee	65FR31682 65FR66443	
105	Endrin	72208	0.086 K	0.036 K, N	0.037 G	0.0023 G, X	0.059 ee	0.060 ee	2 ee	68FR75510 SDWA
106	Endrin Aldehyde	7421934					0.29 B, ee	0.30 B, H, ee		65FR66443
107	Heptachlor	76448	0.52 G	0.0038 G, X	0.053 G	0.0036 G, X	0.000079 B, C	0.000079 B, C	0.4 C	65FR31682 65FR66443 SDWA
108	Heptachlor Epoxide	1024573	0.52 G, U	0.0038 G, U, X	0.053 G, U	0.0036 G, U, X	0.000039 B, C	0.000039B, C	0.2 C	65FR31682 65FR66443 SDWA
109	Polychlorinated Biphenyls PCBs	--		0.014 M, X		0.03 M, X	0.000064 B, C, M	0.000064 B, C, M	0.5 C	65FR31682 65FR66443 SDWA
110	Toxaphene	8001352	0.73	0.0002 X	0.21	0.0002 X	0.00028 B, C	0.00028 B, C	3 C	65FR31682 65FR66443 SDWA

Footnotes:

- A This water quality criterion was derived from data for arsenic (III), but is applied here to total arsenic, which might imply that arsenic (III) and arsenic (V) are equally toxic to aquatic life and that their toxicities are additive. In the arsenic criteria document (EPA 440/5-84-033, January 1985), Species Mean Acute Values are given for both arsenic (III) and arsenic (V) for five species and the ratios of the SMAVs for each species range from 0.6 to 1.7. Chronic values are available for both arsenic (III) and arsenic (V) for one species; for the fathead minnow, the chronic value for arsenic (V) is 0.29 times the chronic value for arsenic (III). No data are known to be available concerning whether the toxicities of the forms of arsenic to aquatic organisms are additive.
- B This criterion has been revised to reflect The Environmental Protection Agency's q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of May 17, 2002. The fish tissue bioconcentration factor (BCF) from the 1980 Ambient Water Quality Criteria document was retained in each case.
- C This criterion is based on carcinogenicity of 10^{-6} risk. As prescribed in Section E of this regulation, application of this criterion for permit effluent limitations requires the use annual average flow or comparable tidal condition as determined by the Department.
- D Freshwater and saltwater criteria for metals are expressed in terms of total recoverable metals. As allowed in Section E of this regulation, these criteria may be expressed as dissolved metal for the purposes of deriving permit effluent limitations. The dissolved metal water quality criteria value may be calculated by using these 304(a) aquatic life criteria expressed in terms of total recoverable metal, and multiplying it by a conversion factor (CF). The term "Conversion Factor" (CF) represents the conversion factor for

converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. (Conversion Factors for saltwater CCCs are not currently available. Conversion factors derived for saltwater CMCs have been used for both saltwater CMCs and CCCs). See “Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria”, October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water, available from the Water Resource center, USEPA, 401 M St., SW, mail code RC4100, Washington, DC 20460; and 40CFR§131.36(b)(1). Conversion Factors can be found in Attachment 1 – Conversion Factors for Dissolved Metals.

- E The freshwater criterion for this metal is expressed as a function of hardness (mg/L) in the water column. The value given here corresponds to a hardness of 25 mg/L as expressed as CaCO_3 . Criteria values for other hardness may be calculated from the following: $\text{CMC (dissolved)} = \exp\{m_A [\ln(\text{hardness})] + b_A\}$ (CF), or $\text{CCC (dissolved)} = \exp\{m_C [\ln(\text{hardness})] + b_C\}$ (CF) and the parameters specified in Attachment 2 – Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent. As noted in footnote D above, the values in this appendix are expressed as total recoverable, the criterion may be calculated from the following: $\text{CMC (total)} = \exp\{m_A [\ln(\text{hardness})] + b_A\}$, or $\text{CCC (total)} = \exp\{m_C [\ln(\text{hardness})] + b_C\}$.
- F Freshwater aquatic life values for pentachlorophenol are expressed as a function of pH, and are calculated as follows: $\text{CMC} = \exp(1.005(\text{pH}) - 4.869)$; $\text{CCC} = \exp(1.005(\text{pH}) - 5.134)$. Values displayed in table correspond to a pH of 7.8.
- G This criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endosulfan (EPA 440/5-80-046), Endrin (EPA 440/5-80-047), Heptachlor (440/5-80-052), Hexachlorocyclohexane (EPA 440/5-80-054), Silver (EPA 440/5-80-071). The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a “CMC” derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.
- H No criterion for protection of human health from consumption of aquatic organisms excluding water was presented in the 1980 criteria document or in the *1986 Quality Criteria for Water*. Nevertheless, sufficient information was presented in the 1980 document to allow the calculation of a criterion, even though the results of such a calculation were not shown in the document.
- I This criterion for asbestos is the Maximum Contaminant Level (MCL) developed under the Safe Drinking Water Act (SDWA) and the National Primary Drinking Water Regulation (NPDWR).
- J EPA has not calculated a 304(a) human health criterion for this contaminant. The criterion is the Maximum Contaminant Level developed under the Safe Drinking Water Act (SDWA) and the National Primary Drinking Water Regulation (NPDWR).
- K This criterion is based on a 304(a) aquatic life criterion that was issued in the *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water*, (EPA-820-B-96-001, September 1996). This value was derived using the GLI Guidelines (60FR15393-15399, March 23, 1995; 40CFR132 Appendix A); the difference between the 1985 Guidelines and the GLI Guidelines are explained on page iv of the 1995 Updates. None of the decisions concerning the derivation of this criterion were affected by any considerations that are specific to the Great Lakes.
- L The $\text{CMC} = 1 / [(f_1/\text{CMC}_1) + (f_2/\text{CMC}_2)]$ where f_1 and f_2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC_1 and CMC_2 are $185.9 \mu\text{g/l}$ and $12.82 \mu\text{g/l}$, respectively.
- M This criterion applies to total PCBs, (e.g., the sum of all congener or all isomer or homolog or Aroclor analyses.)
- N The derivation of the CCC for this pollutant did not consider exposure through the diet, which is probably important for aquatic life occupying upper trophic levels.
- O This state criterion is also based on a total fish consumption rate of 0.0175 kg/day .
- P This water quality criterion is expressed as μg free cyanide (as CN)/L.
- Q This value was announced (61FR58444-58449, November 14, 1996) as a proposed GLI 303 I aquatic life criterion
- S This water quality criterion for selenium is expressed in terms of total recoverable metal in the water column. It is scientifically acceptable to use the conversion factor (0.996 – CMC or 0.922 – CCC) that was used in the GLI to convert this to a value that is expressed in terms of dissolved metal.
- T The organoleptic effect criterion is more stringent than the value for priority toxic pollutants.
- U This value was derived from data for heptachlor and the criteria document provides insufficient data to estimate the relative toxicities of heptachlor and heptachlor epoxide.
- V There is a full set of aquatic life toxicity data that show that DEHP is not toxic to aquatic organisms at or below its solubility limit.
- W This value was derived from data for endosulfan and is most appropriately applied to the sum of alpha-endosulfan and beta-endosulfan.
- X This criterion is based on a 304(a) aquatic life criterion issued in 1980 or 1986, and was issued in one of the following documents: Aldrin/Dieldrin (EPA440/5-80-019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endrin (EPA 440/5-80-047), Heptachlor (EPA 440/5-80-052), Polychlorinated Biphenyls (EPA 440/5-80-068), Toxaphene (EPA 440/5-86-006). This CCC is based on the Final Residue value procedure in the 1985 Guidelines. Since the publication of the Great Lakes Aquatic Life Criteria Guidelines in 1995 (60FR15393-15399, March 23, 1995), the EPA no longer uses the Final Residue value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria.

- Y This water quality criterion is based on a 304(a) aquatic life criterion that was derived using the 1985 Guidelines (*Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, PB85-227049, January 1985) and was issued in one of the following criteria documents: Arsenic (EPA 440/5-84-033), Cadmium (EPA 440/5-84-032), Chromium (EPA 440/5-84-029), Copper (EPA 440/5-84-031), Cyanide (EPA 440/5-84-028), Lead (EPA 440/5-84-027), Nickel (EPA 440/5-86-004), Pentachlorophenol (EPA 440/5-86-009), Toxaphene, (EPA 440/5-86-006), Zinc (EPA 440/5-87-003).
- Z When the concentration of dissolved organic carbon is elevated, copper is substantially less toxic and use of Water-Effect Ratios might be appropriate.
- aa The selenium criteria document (EPA 440/5-87-006, September 1987) provides that if selenium is as toxic to saltwater fishes in the field as it is to freshwater fishes in the field, the status of the fish community should be monitored whenever the concentration of selenium exceeds 5.0 7g/L in salt water because the saltwater CCC does not take into account uptake via the food chain.
- bb This water quality criterion was derived on page 43 of the mercury criteria document (EPA 440/5-84-026, January 1985). The saltwater CCC of 0.025 ug/L given on page 23 of the criteria document is based on the Final Residue value procedure in the 1985 Guidelines. Since the publication of the Great Lakes Aquatic Life criteria Guidelines in 1995 (60FR15393-15399, March 23, 1995), the EPA no longer uses the Final Residue value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria.
- cc This water quality criterion was derived in *Ambient Water Quality Criteria Saltwater Copper Addendum* (Draft, April 14, 1995) and was promulgated in the Interim Final National Toxics Rule (60FR22228-22237, May 4, 1995).
- dd This water quality criterion was derived from data for inorganic mercury (II), but is applied here to total mercury. If a substantial portion of the mercury in the water column is methylmercury, this criterion will probably be under protective. In addition, even though inorganic mercury is converted to methylmercury and methylmercury bioaccumulates to a great extent, this criterion does not account for uptake via the food chain because sufficient data were not available when the criterion was derived.
- ee This criterion is a noncarcinogen. As prescribed in Section E of this regulation, application of this criterion for determining permit effluent limitations requires the use of 7Q10 or comparable tidal condition as determined by the Department.
- gg This criterion applies to DDT and its metabolites (i.e., the total concentration of DDT and its metabolites should not exceed this value).
- hh Although a new RfD is available in IRIS, the surface water criteria will not be revised until the National Primary Drinking Water Regulations: Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 DBPR) is completed, since public comment on the relative source contribution (RSC) for chloroform is anticipated.
- ii Although EPA has not published a completed criteria document for phthalate, it is EPA's understanding that sufficient data exist to allow calculation of aquatic life criteria.
- jj This recommended water quality criterion is expressed as total cyanide, even though the IRIS RfD the EPA used to derive the criterion is based on free cyanide. The multiple forms of cyanide that are present in ambient water have significant differences in toxicity due to their abilities to liberate the CN-moiety. Some complex cyanides require even more extreme conditions than refluxing with sulfuric acid to liberate the CN-moiety. Thus, these complex cyanides are expected to have little or no 'bioavailability' to humans. If a substantial fraction of the cyanide present in a water body is present in a complexed form (e.g., $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$), this criterion may be overly conservative.
- kk This recommended water quality criterion was derived using the cancer slope factor of 1.4 (Linear multi-stage model (LMS) exposure from birth).
- ll Freshwater copper criteria may be calculated utilizing the procedures identified in EPA-822-R-07-001.
- mm HAA5 means five haloacetic acids (monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, bromoacetic acid and dibromoacetic acid).
- nn This criterion has been revised to reflect the EPA's cancer slope factor (CSF) or reference dose (RfD), as contained in the Integrated Risk Information System (IRIS) as of (Final FR Notice June 10, 2009). The fish tissue bioconcentration factor (BCF) from the 1980 Ambient Water Quality Criteria document was retained in each case.

NON PRIORITY POLLUTANTS

Non Priority Pollutant		CAS Number	Freshwater Aquatic Life		Saltwater Aquatic Life		Human Health			FR Cite/Source
			CMC (µg/L)	CCC (µg/L)	CMC (µg/L)	CCC (µg/L)	For Consumption of:		MCL (µg/L)	
							Water Organism (µg/L)	& Organism Only (µg/L)		
1	Alachlor								2 M	SDWA

2	Ammonia	7664417	CRITERIA ARE pH AND TEMPERATURE DEPENDENT - SEE DOCUMENT FOR DETAILS C							EPA822-R99-014 EPA440/5-88-004
3	Aesthetic Qualities		NARRATIVE STATEMENT AND NUMERIC CRITERIA – SEE TEXT							Gold Book
4	Atrazine								3 M	SDWA
5	Bacteria		FOR PRIMARY CONTACT RECREATION AND SHELLFISH USES – SEE TEXT							Gold Book
6	Barium	7440393					1,000 A, L		2,000 L	Gold Book
7	Carbofuran	1563662							40 L	SDWA
8	Chlorine	7782505	19	11	13	7.5			G	Gold Book SDWA
9	Chlorophenoxy Herbicide 2, 4, 5, -TP	93721					10 A, L		50 L	Gold Book SDWA
10	Chlorophenoxy Herbicide 2, 4-D	94757					100 A, L		70 L	Gold Book SDWA
11	Chlorophyll <i>a</i>		NARRATIVE STATEMENT AND NUMERIC CRITERIA – SEE TEXT							State Standard
12	Chlorpyrifos	2921882	0.083 F	0.041 F	0.011 F	0.0056 F				Gold Book
13	Color		NARRATIVE STATEMENT – SEE TEXT							State Standard
14	Dalapon	75990							200 L	SDWA
15	Demeton	8065483		0.1 E		0.1 E				Gold Book
16	1,2-Dibromo-3-chloropropane (DBCP)	96128							0.2 M	SDWA
17	Di(2-ethylhexyl) adipate	103231							400 L	SDWA
18	Dinoseb	88857							7 L	SDWA

19	Dinitrophenols	25550587					69 L	5,300 L		65FR66443
20	Nonylphenol	1044051	28	6.6	7.0	1.7				71FR9337
21	Diquat	85007							20 L	SDWA
22	Endothall	145733							100 L	SDWA
23	Ether, Bis Chloromethyl	542881					0.00010 D, M	0.00029 D, M		65FR66443
24	Cis-1, 2-dichloroethylene	156592							70 L	SDWA
25	Ethylene dibromide								0.05 M	SDWA
26	Fluoride	7681494							4000 L	SDWA
27	Glyphosate	1071836							700 L	SDWA
28	Guthion	86500		0.01 E		0.01 E				Gold Book
29	Hexachlorocyclo-hexane- Technical	319868					0.0123 L	0.0414 L		Gold Book
30	Malathion	121755		0.1 E		0.1 E				Gold Book
31	Methoxychlor	72435		0.03 E		0.03 E	100 A, L		40 L	Gold Book SDWA
32	Mirex	2385855		0.001 E		0.001 E				Gold Book
33	Nitrates	14797558					10,000 L		10,000 L	SDWA Gold Book

34	Nitrites	14797650							1,000 L	SDWA
35	Nitrogen, Total		NARRATIVE STATEMENT AND NUMERIC CRITERIA - SEE TEXT							State Standard
36	Nitrosamines						0.0008 L	1.24 L		Gold Book
37	Nitrosodibutylamine, N	924163					0.0063 A, M	0.22 A, M		65FR66443
38	Nitrosodiethylamine, N	55185					0.0008 A, M	1.24 A, M		Gold Book
39	Nitrosopyrrolidine, N	930552					0.016 M	34 M		65FR66443
40	Oil and Grease		NARRATIVE STATEMENT – SEE TEXT							Gold Book
41	Oxamyl	23135220							200 L	SDWA
42	Oxygen, Dissolved	7782447	WARMWATER, COLDWATER, AND EXCEPTIONS FOR NATURAL CONDITIONS - SEE TEXT K							Gold Book State Standard
43	Diazinon	333415	0.17	0.17	0.82	0.82				71FR9336
44	Parathion	56382	0.065 H	0.013 H						Gold Book
45	Pentachlorobenzene	608935					1.4 E	1.5 E		65FR66443
46	pH		SEE TEXT I							Gold Book State Standard
47	Phosphorus, Total		NARRATIVE STATEMENT AND NUMERIC CRITERIA - SEE TEXT							State Standard
48	Picloram	1918021							500 L	SDWA
49	Salinity		NARRATIVE STATEMENT - SEE TEXT							Gold Book
50	Simazine	122349							4 L	SDWA

51	Solids,Suspended,and Turbidity		NARRATIVE STATEMENT AND NUMERIC CRITERIA - SEE TEXT							Gold Book State Standard
52	Styrene	100425							100 L	SDWA
53	Sulfide-Hydrogen Sulfide	7783064		2.0 E		2.0 E				Gold Book
54	Tainting Substances		NARRATIVE STATEMENT - SEE TEXT							Gold Book
55	Temperature		SPECIES DEPENDENT CRITERIA - SEE TEXT J							Red Book
56	1, 2, 4, 5-Tetrachlorobenzene	95943					0.97 D	1.1 D		65FR66443
57	Tributyltin (TBT)	688733	0.46	0.063	0.37	0.010				EPA 822-F-00-008
58	2, 4, 5-Trichlorophenol	95954					1,800 B, D	3,600 B, D		65FR66443
59	Xylenes, Total								10, 000 L	SDWA
60	Uranium								30	SDWA
61	Beta particles and photon emitters								4 Millirems/ yr	SDWA
62	Gross alpha particle activity								15 picocuries per liter (pCi/l)	SDWA
63	Radium 226 and Radium 228 (combined)								5 pCi/l	SDWA

Footnotes:

- A This human health criterion is the same as originally published in the Red Book which predates the 1980 methodology and did not utilize the fish ingestion BCF approach. This same criterion value is now published in the Gold Book.

- B The organoleptic effect criterion is more stringent than the value presented in the non priority pollutants table.
- C According to the procedures described in the *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, except possibly where a very sensitive species is important at a site, freshwater aquatic life should be protected if both conditions specified in Attachment 3 - Calculation of Freshwater Ammonia Criterion are satisfied.
- D This criterion has been revised to reflect The Environmental Protection Agency's q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of April 8, 1998. The fish tissue bioconcentration factor (BCF) used to derive the original criterion was retained in each case.
- E The derivation of this value is presented in the Red Book (EPA 440/9-76-023, July, 1976).
- F This value is based on a 304(a) aquatic life criterion that was derived using the 1985 Guidelines (*Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, PB85-227049, January 1985) and was issued in the following criteria document: Chloropyrifos (EPA 440/5-86-005).
- G A more stringent Maximum Residual Disinfection Level (MRDL) has been issued by EPA under the Safe Drinking Water Act. Refer to S.C. Regulation 61-58, *State Primary Drinking Water Regulations*.
- H This value is based on a 304(a) aquatic life criterion that was issued in the *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water* (EPA-820-B-96-001). This value was derived using the GLI Guidelines (60FR15393-15399, March 23, 1995; 40CFR132 Appendix A); the differences between the 1985 Guidelines and the GLI Guidelines are explained on page iv of the 1995 Updates. No decision concerning this criterion was affected by any considerations that are specific to the Great Lakes.
- I South Carolina has established some site-specific standards for pH. These site-specific standards are listed in S.C. Regulation 61-69, *Classified Waters*.
- J U.S. EPA, 1976, Quality Criteria for Water 1976.
- K South Carolina has established numeric criteria in Section G for waters of the State based on the protection of warmwater and coldwater species. For the exception to be used for waters of the State that do not meet the numeric criteria established for the waterbody due to natural conditions, South Carolina has specified the allowable deficit in Section D.4. and used the following document as a source. U.S. EPA, 1986, Ambient Water Quality Criteria for Dissolved Oxygen, EPA 440/5-86-003, National Technical Information Service, Springfield, VA. South Carolina has established some site-specific standards for DO. These site-specific standards are listed in S.C. Regulation 61-69, *Classified Waters*.
- L This criterion is a noncarcinogen. As prescribed in Section E of this regulation, application of this criterion for determining permit effluent limitations requires the use of 7Q10 or comparable tidal condition as determined by the Department
- M This criterion is based on an added carcinogenicity risk. As prescribed in Section E of this regulation, application of this criterion for permit effluent limitations requires the use annual average flow or comparable tidal condition as determined by the Department.

ORGANOLEPTIC EFFECTS

	Pollutant	CAS Number	Organoleptic Effect Criteria (µg/L)	FR Cite/Source
1	Acenaphthene	83329	20	Gold Book
2	Chlorobenzene	108907	20	Gold Book
3	3-Chlorophenol		0.1	Gold Book
4	4-Chlorophenol	106489	0.1	Gold Book
5	2, 3-Dichlorophenol		0.04	Gold Book

6	2, 5-Dichlorophenol		0.5	Gold Book
7	2, 6-Dichlorophenol		0.2	Gold Book
8	3, 4-Dichlorophenol		0.3	Gold Book
9	2, 4, 5-Trichlorophenol	95954	1	Gold Book
10	2, 4, 6-Trichlorophenol	88062	2	Gold Book
11	2, 3, 4, 6-Tetrachlorophenol		1	Gold Book
12	2-Methyl-4-Chlorophenol		1,800	Gold Book
13	3-Methyl-4-Chlorophenol	59507	3,000	Gold Book
14	3-Methyl-6-Chlorophenol		20	Gold Book
15	2-Chlorophenol	95578	0.1	Gold Book
16	Copper	7440508	1,000	Gold Book
17	2, 4-Dichlorophenol	120832	0.3	Gold Book
18	2, 4-Dimethylphenol	105679	400	Gold Book
19	Hexachlorocyclopentadiene	77474	1	Gold Book
20	Nitrobenzene	98953	30	Gold Book
21	Pentachlorophenol	87865	30	Gold Book
22	Phenol	108952	300	Gold Book
23	Zinc	7440666	5,000	45FR79341

Footnote:

These criteria are based on organoleptic (taste and odor) effects. Because of variations in chemical nomenclature systems, this listing of pollutants does not duplicate the listing in Appendix A of 40 CFR Part 423. Also listed are the Chemical Abstracts Service (CAS) registry numbers, which provide a unique identification for each chemical.

WATER QUALITY CRITERIA ADDITIONAL NOTES

1. Criteria Maximum Concentration and Criterion Continuous Concentration

The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The Criterion Continuous Concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The CMC and CCC are just two of the six parts of a aquatic life criterion; the other four parts are the acute averaging period, chronic averaging period, acute frequency of allowed exceedence, and chronic frequency of allowed exceedence.

2. Criteria for Priority Pollutants, Non Priority Pollutants and Organoleptic Effects

This appendix lists all priority toxic pollutants and some nonpriority toxic pollutants, and both human health effect and organoleptic effect criteria issued pursuant to CWA §304(a), the SDWA, and the NPDWR. Blank spaces indicate that EPA has no CWA §304(a) criteria recommendations. Because of variations in chemical nomenclature systems, this listing of toxic pollutants does not duplicate the listing in Appendix A of 40CFR Part 423.

3. Human Health Risk

The human health criteria for the priority and non priority pollutants are based on carcinogenicity of 10^{-6} risk.

4. Water Quality Criteria published pursuant to Section 304(a) or Section 303(c) of the CWA

Many of the values in the appendix were published in the California Toxics Rule. Although such values were published pursuant to Section 303(c) of the CWA, they represent the EPA's most recent calculation of water quality criteria.

5. Calculation of Dissolved Metals Criteria

The 304(a) criteria for metals are shown as total recoverable metals. As allowed in Section E of this regulation, these criteria may be expressed as dissolved metals. Dissolved metals criteria may be calculated in one of two ways (please refer to Attachments). For freshwater metals criteria that are hardness-dependent, the dissolved metal criteria may be calculated using a hardness of 25 mg/l as expressed as CaCO_3 . Saltwater and freshwater metals' criteria that are not hardness-dependent are calculated by multiplying the total recoverable criteria before rounding by the appropriate conversion factors. The final metals' criteria in the table are rounded to two significant figures. Information regarding the calculation of hardness dependent conversion factors are included in the footnotes.

6. Chemical Abstract Services Number

The Chemical Abstract Services number (CAS) for each pollutant is provided (where available).

7. Gold Book Reference

The Gold Book reference listed in the appendix refers to the May 1, 1986 EPA publication EPA 440/5-86-001.

8. Federal Register Reference

The FR listed in the appendix refers to the appropriate *Federal Register* listing, and source refers to the origin of the value. Many of the numeric values contained in this appendix have been modified, revised, or altered and therefore, the source as listed may not be the same as it appears in this table. Also, South Carolina may have selected to use a different value or may have promulgated a different value in its previous iterations of this regulation, so differences from these sources should be expected.

9. Maximum Contaminant Levels

The appendix includes Maximum Contaminant Levels (MCLs) developed under the Safe Drinking Water Act (SDWA) and the National Primary Drinking Water Regulation (NPDWR).

10. Organoleptic Effects

The appendix contains 304(a) criteria for pollutants with toxicity-based criteria as well as non-toxicity based criteria. The basis for the non-toxicity based criteria are organoleptic effects (e.g., taste and odor) which would make water and edible aquatic life unpalatable but not toxic to humans. The table includes criteria for organoleptic effects for 23 pollutants. Pollutants with organoleptic effect criteria more stringent than the criteria based on toxicity (e.g., included in both the priority and non-priority pollutant tables) are footnoted as such.

11. Category Criteria

In the 1980 criteria documents, certain water quality criteria were published for categories of pollutants rather than for individual pollutants within that category. Subsequently, in a series of separate actions, the EPA derived criteria for specific pollutants within a category. Therefore, in this appendix South Carolina is replacing criteria representing categories with individual pollutant criteria (e.g., 1, 3-dichlorobenzene, 1, 4-dichlorobenzene and 1, 2-dichlorobenzene).

12. Specific Chemical Calculations

A. Selenium

(1) Human Health

In the 1980 Selenium document, a criterion for the protection of human health from consumption of water and organisms was calculated based on a BCF of 6.0 l/kg and a maximum water-related contribution of 35 Φ g Se/day. Subsequently, the EPA Office of Health and Environmental Assessment issued an errata notice (February 23, 1982), revising the BCF for selenium to 4.8 L/kg. In 1988, EPA issued an addendum (ECAO-CIN-668) revising the human health criteria for selenium. Later in the final National Toxic Rule (NTR, 57 FR 60848), EPA withdrew previously published selenium human health criteria, pending EPA review of new epidemiological data.

This appendix includes human health criteria for selenium, calculated using a BCF of 4.8 L/kg along with the current IRIS RfD of 0.005 mg/kg/day. South Carolina included these water quality criteria in the appendix because the data necessary for calculating a criteria in accordance with EPA's 1980 human health methodology are available.

(2) Aquatic Life

This appendix contains aquatic life criteria for selenium that are the same as those published in the CTR. In the CTR, EPA proposed an acute criterion for selenium based on the criterion proposed for selenium in the Water Quality Guidance for the Great Lakes System (61FR584440). The GLI and CTR proposals take into account data showing that selenium's two prevalent oxidation state in water, selenite and selenate, present differing potentials for aquatic toxicity, as well as new data indication that various forms of selenium are additive. The new approach produces a different selenium acute criterion concentration, or CMC, depending upon the relative proportions of selenite, selenate, and other forms of selenium that are present. EPA is currently undertaking a reassessment of selenium, and expects the 304(a) criterion for selenium will be revised based on the final reassessment (63FR26186). However, until such time as revised water quality criteria for selenium are published by the EPA, the water quality criteria in this appendix are EPA's current 304(a) criteria.

B. Chromium (III)

The aquatic life water quality criteria for chromium (III) included in the appendix are based on the values presented in the document titled: *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water*.

C. PCBs

In this appendix, South Carolina is publishing aquatic life and human health criteria based on total PCBs rather than individual arochlors.

Attachment 1 - Conversion Factors for Dissolved Metals

Metal	Conversion Factor freshwater CMC	Conversion Factor freshwater CCC	Conversion Factor saltwater CMC	Conversion Factor saltwater CCC
Arsenic	1.000	1.000	1.000	1.000
Cadmium	$1.136672 - [(\ln \text{hardness})(0.041838)]$	$1.101672 - [(\ln \text{hardness})(0.041838)]$	0.994	0.994
Chromium III	0.316	0.860	--	--
Chromium VI	0.982	0.962	0.993	0.993
Copper	0.960	0.960	0.83	0.83
Lead	$1.46203 - [(\ln \text{hardness})(0.145712)]$	$1.46203 - [(\ln \text{hardness})(0.145712)]$	0.951	0.951
Mercury	0.85	0.85	0.85	0.85
Nickel	0.998	0.997	0.990	0.990
Selenium	--	--	0.998	0.998
Silver	0.85	--	0.85	--
Zinc	0.978	0.986	0.946	0.946

Attachment 2 - Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent

Chemical	m_A	b_A	m_C	b_C	Freshwater Conversion Factors (CF)	
					Acute	Chronic
Cadmium	1.0166	-3.924	0.7409	-4.719	$1.136672 - [\ln(\text{hardness})(0.041838)]$	$1.101672 - [\ln(\text{hardness})(0.041838)]$
Chromium III	0.8190	3.7256	0.8190	0.6848	0.316	0.860
Copper	0.9422	-1.700	0.8545	-1.702	0.960	0.960
Lead	1.273	-1.460	1.273	-4.705	$1.46203 - [\ln(\text{hardness})(0.145712)]$	$1.46203 - [\ln(\text{hardness})(0.145712)]$
Nickel	0.8460	2.255	0.8460	0.0584	0.998	0.997
Silver	1.72	-6.52	--	--	0.85	--
Zinc	0.8473	0.884	0.8473	0.884	0.978	0.986

Attachment 3 - Calculation of Freshwater Ammonia Criterion

1. The one-hour average concentration of total ammonia nitrogen (in mg N/L) does not exceed, more than once every three years on the average, the CMC calculated using the following equation:

$$CMC = \frac{0.275}{1+10^{7.204-pH}} + \frac{39.0}{1+10^{pH-7.204}}$$

In situations where salmonids are absent, the CMC may be calculated using the following equation:

$$CMC = \frac{0.411}{1+10^{7.204-pH}} + \frac{58.4}{1+10^{pH-7.204}}$$

2. The thirty-day average concentration of total ammonia nitrogen (in mg N/L) does not exceed, more than once every three years on the average, the CCC calculated using the following equations:

When fish early life stages (ELS) are present:

$$CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}} \right) \times \min(2.85, 1.45 \times 10^{0.028 \times (25-T)})$$

When fish early life stages are absent:

$$CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}} \right) \times 1.45 \times 10^{0.028 \times (25-\max(T,7))}$$

and the highest four-day average within the 30-day period does not exceed 2.5 times the CCC.

In the absence of information substantiating that ELS are absent, the ELS present equation will be used

Keywords:
Groundwater
Coal ash
Waste codisposal
Solid wastes
Leaching
Attenuation

EPRI
Electric Power
Research Institute

EPRI LIBRARY

Comanagement of Coal Combustion By-Products and Low-Volume Wastes: A Southeastern Site

EPRI LIBRARY

Prepared by
Radian Corporation
GeoTrans, Inc.
and
Battelle PNL

OFFICIAL COPY

Feb 18 2020

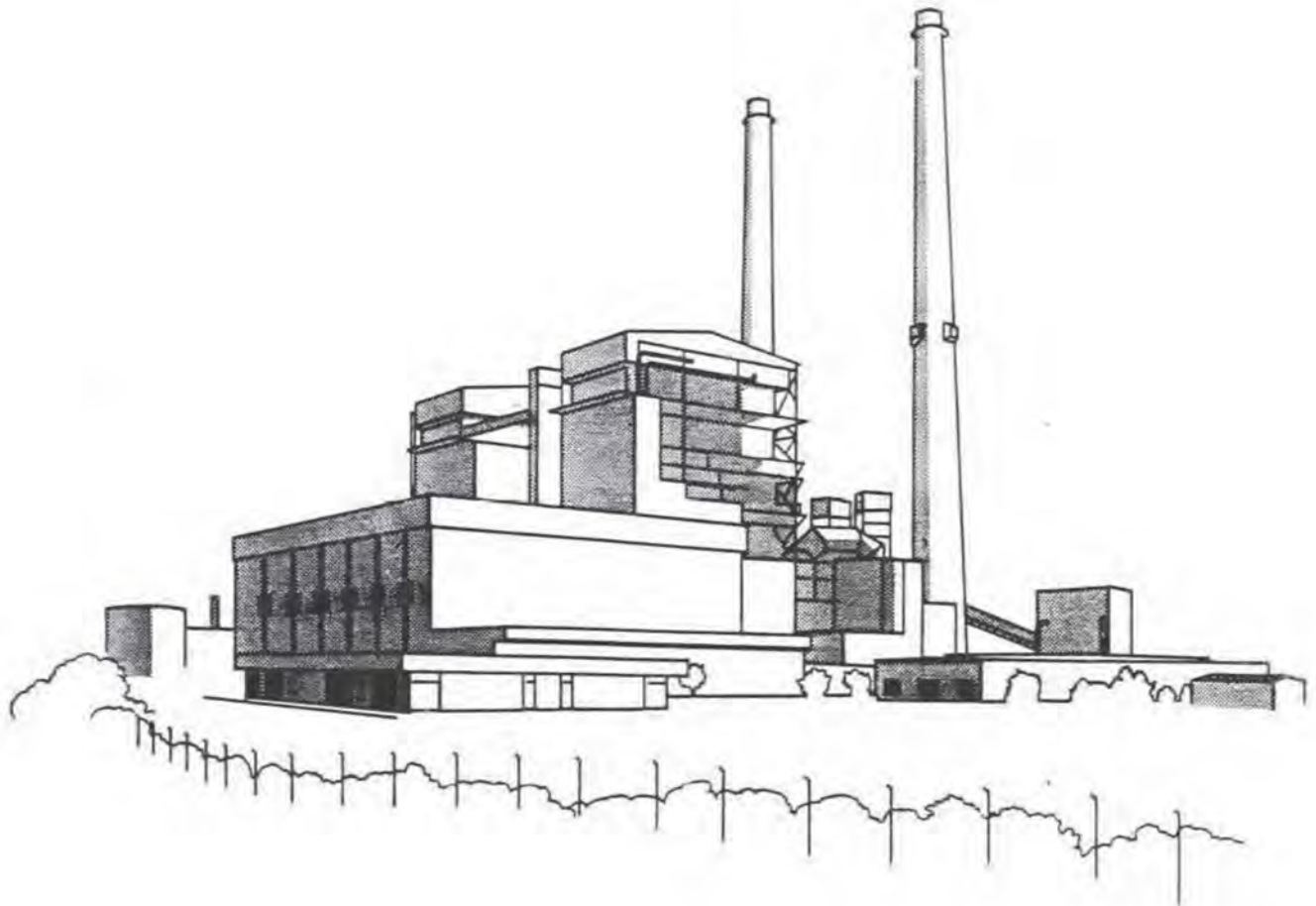


Page 1 of 386 pages
filed in the docket
on 2/18/2020. ktm

Solid Waste

Report to Congress

Wastes from the Combustion of Coal by Electric Utility Power Plants



OFFICIAL COPY

Feb 18 2020

Characterization of Field Leachates at Coal Combustion Product Management Sites

Arsenic, Selenium, Chromium, and Mercury Speciation

Technical Report

OFFICIAL COPY

Feb 18 2020

Human and Ecological Risk Assessment of Coal Combustion Wastes

Draft

Prepared for:

U.S. Environmental Protection Agency
Office of Solid Waste
Research Triangle Park, NC 27709

Prepared by:

RTI
P.O. Box 12194
Research Triangle Park, NC 27709

August 6, 2007





99991111

I/A

Hart Exhibit 24
Docket No. E-7. Sub

I/A

Duke Energy File Header

Project: 3412



008-019

Box #: 008

File #: 019



Document Efficiency
At Work.SM



99991111

OFFICIAL COPY

Feb 18 2020

INVESTIGATIONS OF COAL ASH DISPOSAL
AND
ITS IMPACT UPON GROUNDWATER

DUKE POWER COMPANY

D. P. Roche
A. Gnilka
J. E. Harwood

December 1984

Investigations of Duke Power Coal Ash Disposal and Its Impact Upon Groundwater

Executive Summary

Beginning in 1978, field and laboratory investigations of the composition of coal ash leachate and its behavior in the disposal environment were conducted by Duke Power and outside contractors. Leach tests, using EPA and ASTM protocols, were conducted on dry fly ash and bottom ash from the Allen, Belews Creek, and Marshall plants, as well as on ponded ash from all ash storage basins. All results found the concentrations of toxic metals in the ash to be non-hazardous according to the EPA criterion. Groundwater monitoring, in 13 test wells installed by Duke Power around a retired and active ash basin, found over a four-year period that drinking water quality was maintained in the wells down-gradient of the sites after groundwater stabilization had occurred following well installation. Additional groundwater monitoring and soil testing from the same sites, done by an EPA contractor, also found the downgradient groundwater to be drinking water quality and suggested the high ion exchange capacity of the soil lining the ash basin to be the mechanism preventing migration of soluble metals from the ash basin. These field and laboratory studies confirm that wet disposal of coal ash by Duke Power has no significant impact on groundwater.

Investigations of Duke Power Coal Ash Disposal
and Its Impact Upon Groundwater

Introduction

In 1983, the burning of 14,800,000 tons of bituminous coal at Duke Power's eight fossil stations produced 1,213,000 tons of fly ash and 409,000 tons of bottom ash. Except for 68,500 tons of fly ash (in cement and filler applications) and 51,000 tons of bottom ash (lightweight aggregate) sold that year for reuse, all of the coal ash was disposed of by sluicing to storage ponds ranging in size from 14 to 500 acres surface area. The ponds have NPDES permits for discharge of the supernatant water to receiving waters via an overflow tower. While permit effluent limitations have historically been complied with for the pond discharges to surface waters, the question of any leaching of ash constituents to groundwaters was raised in 1978 in light of the increased scrutiny by regulatory agencies. Since that time Duke Power has conducted groundwater monitoring and leachate testing to resolve this issue.

Because Duke's two largest fossil stations, Marshall and Belews Creek, are beginning conversion in 1984 from sluicing and ponding of fly ash to dry collection in silos and landfilling, the question of fly ash leachate will be less relevant to Duke as over 60% of the fly ash produced by the Company will be handled dry, compacted, and landfilled. This disposal method will greatly reduce any leaching of fly ash. However, prior to this change in disposal method, the lack of adverse effects of ash leachate even in the pond environment

had been demonstrated. This report provides the results of ash leaching tests for all Duke fossil stations, and extensive and intensive groundwater monitoring at Plant Allen, conducted by Duke and by outside consultants.

Ash Leachate Analyses

The Environmental Protection Agency Extraction Procedure (May 19, 1980 Federal Register) calls for addition of distilled water equal to 16 times the weight of the solid (100 gms.), pH adjustment to 5.0 ± 0.2 using 0.5 N acetic acid, and agitation for 24 hours. The sample is then filtered through a .45 micron membrane and the filtrate is diluted to 20 times the initial weight of the solid (2000 ml. for 100 gms.). The leachate is then preserved by acidification to pH 1.4 to 2.0 using nitric acid and is analyzed for eight toxic metals: arsenic, selenium, barium, cadmium, chromium, lead, mercury, and silver.

The American Society for Testing and Materials (ASTM, Committee D-34) has recommended a shaker method for extraction of solid waste for leachate analysis. The method calls for a 4:1 liquid/solid ratio and a 350 gm. solid sample, rather than the 16:1 ratio and 100 gm. sample required by EPA. The sample is shaken using a shaker table for 48 hours, with no pH adjustment. The sample is filtered and preserved as described above, but the filtrate is not diluted.

Both the Extraction Procedure (EP) and ASTM method have been used to simulate leachate from Duke fly and bottom ash, both in the dry and ponded state. These results have been compared to the EPA toxicity criterion limits for a solid waste under the Resource Conservation and Recovery Act (RCRA), which are:

<u>Element</u>	<u>Concentration (ppb)</u>
Arsenic	5,000
Selenium	1,000
Barium	100,000
Cadmium	1,000
Chromium	5,000
Lead	5,000
Mercury	200
Silver	5,000

Initially (in 1980), Duke Power analyzed samples of ponded ash (mostly bottom ash combined with some fly ash) by the EP procedure for all ash ponds. The results are shown in Table 1.

In the same time period, leach tests of dry fly and bottom ash at Belews Creek were conducted by consulting laboratories for the companies marketing the ash for reuse. Southeast Laboratories used the EP procedure to obtain the following results (in ppb) for bottom ash:

Table 1. Extraction Procedure Analysis of Poned Ash from Duke Power Ash Basins.
Samples collected in 1980.

All concentrations are in parts per billion.

	<u>Allen</u>	<u>Belews</u>	<u>Buck</u>		<u>Cliffside</u>	<u>Dan River</u>		<u>Lee</u>	<u>Marshall</u>	<u>Riverbend</u>	
			<u>Cell 1</u>	<u>Cell 2</u>		<u>Cell 1</u>	<u>Cell 2</u>			<u>Cell 1</u>	<u>Cell 2</u>
Arsenic	51	31	35	35	36	33	73	22	31	82	75
Barium	1200	1,100	2400	2200	1900	1300	2100	<1000	1100	1100	1300
Cadmium	<25	30	<25	<25	<25	<25	<25	<25	<25	<25	<25
Chromium	10	70	50	50	60	30	80	100	70	20	60
Lead	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500
Mercury	0.11	0.11	0.2	0.18	0.44	2.2	0.17	2	<0.1	<0.1	<0.1
Selenium	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6
Silver	150	50	110	90	30	70	60	100	70	30	40

Arsenic	1.4
Barium	50
Cadmium	5
Chromium	20
Lead	10
Mercury	0.5
Selenium	0.8
Silver	10

The Georgia Institute of Technology also analyzed Belews Creek bottom ash for radionuclides and found 2.4 pCi/g Radium-226, which is well below the proposed EPA limit of 5 pCi/g.

Raba-Kistner Consultants performed both the EP and ASTM leach tests on Belews Creek fly ash. The results are shown in Table 2.

Also in 1980, as part of an ash pond investigation conducted by EPA (the A. D. Little, Inc., study) at Plant Allen, samples of dry ash from Units 1 and 3 were analyzed utilizing the EP. The results are shown in Table 3, along with a Ra-226 activity of 4.3 (Unit 1) and 4.2 (Unit 3) pCi/g.

Plant Allen fly ash, bottom ash, and coal were also tested in 1982 in a U. S. Department of Energy study by Versar, Inc. Samples were processed according to both the EP and ASTM methods. Duke split samples with Versar and did its own EP and ASTM leach tests for comparison. The DOE test results are shown in Table 4, and Duke's are given in Table 5.

Table 2. BELEWS CREEK

FLY ASH LEACHATE (ppb)

	<u>ASTM</u>	<u>EPA EP</u>	<u>EPA Limits</u>
pH	3.7	4.0	
Arsenic	500	<5	5,000
Barium	Not Determined	<500	100,000
Cadmium	100	<100	1,000
Chromium	115	<100	5,000
Cobalt	100	<100	
Copper	2050	600	
Iron	2000	300	
Lead	<1000	<1000	5,000
Manganese	200	100	
Mercury	Not Determined	<2	200
Nickel	300	200	
Selenium	50	<10	1,000
Silver	Not Determined	<100	5,000
Zinc	1050	300	

Source: Raba-Kistner Consultants

Table 3. Extraction Procedure Results for Plant Allen Fly Ash

RESULTS FROM INITIAL SAMPLE ANALYSESSAMPLE INFORMATION

Utility Name: Duke Power
Plant Name: Plant Allen
Plant Location: Gaston, N.C.
Type of Sample: Fly Ash
Sampling Location: Unit 1, ESP
Date Sampled: July 16, 1980

RESULTS

Basis: These results are from analyses performed by Arthur D. Little, Inc. on grab samples obtained during the first visit to the site. The limitation on the confidence levels for both sampling and analyses are noted in the accompanying cover letter.

Concentrations of Elements Measured in EPA Extraction Procedure (Ref: Fed. Register, Vol. 45, (May 19, 1980), pp. 33127-33131)

Element Concentration (microgram/L extract)

Arsenic 98 ± 20
Barium (mg/L) 0.51 ± 0.16
Cadmium 16 ± 3
Chromium < 8
Lead < 1
Mercury < 2
Selenium 52 ± 7
Silver < 2

Activities of Radioisotopes Measured In Solid Samples Ref: Fed. Register, Vol. 43, Dec. 18, 1978, pp. 59022-3; see cover letter for experimental details)

<u>Isotope</u>	<u>Specific Activity</u> (picocurie/gram)
Radium-226	4.3 ± 0.3

Table 3. (cont'd)

RESULTS FROM INITIAL SAMPLE ANALYSESSAMPLE INFORMATION

Utility Name: Duke Power
Plant Name: Plant Allen
Plant Location: Gaston, N.C.
Type of Sample: Fly Ash
Sampling Location: Unit 3
Date Sampled: July 16, 1980

RESULTS

Basis: These results are from analyses performed by Arthur D. Little, Inc. on grab samples obtained during the first visit to the site. The limitation on the confidence levels for both sampling and analyses are noted in the accompanying cover letter.

Concentrations of Elements Measured in EPA Extraction Procedure (Ref: Fed. Register, Vol. 45, (May 19, 1980) pp. 33127-33131)

Element Construction (microgram/L extract)

Arsenic 63 ± 10
Barium (mg/L) 0.36 ± 0.16
Cadmium 5 ± 3
Chromium < 8
Lead < 1
Mercury < 2
Selenium 8 ± 2
Silver < 2

Activities of Radioisotopes Measured In Solid Samples Ref: Fed. Register, Vol. 43, Dec. 18, 1978 pp. 59022-3; see cover letter for experimental details)

<u>Isotope</u>	<u>Specific Activity (picocurie/gram)</u>
Radium-226	4.2 ± 0.4

Table 4. Extraction Procedure and ASTM Leach Test Results (ppb) for Plant Allen

Coal, Fly Ash, and Bottom Ash - Department of Energy Study

<u>Sample</u>	<u>Arsenic</u>	<u>Barium</u>	<u>Cadmium</u>	<u>Chromium</u>	<u>Lead</u>	<u>Mercury</u>	<u>Selenium</u>	<u>Silver</u>
Coal								
EP	<10	270	<0.5	1.1	1.6	<.05	33	<.05
ASTM	41	310	<0.5	1.0	4.3	<.05	<10	.8
Fly Ash- Unit 2								
EP	460	230	<0.5	1.1	1.6	.19	150	<.05
ASTM	100	330	1.1	90	6.5	.53	94	1.3
Fly Ash- Unit 5								
EP	310	210	1.7	<1.0	3.7	<.05	19	<.05
ASTM	180	480	1.2	90	6.5	<.05	40	.42
Bottom Ash- Unit 5								
EP	12	660	<0.5	<1.0	<1.0	<.05	10	<.05
ASTM	10	260	1.4	<1.0	<1.0	<.05	10	<.05

Table 5. ALLEN LEACHATE STUDY - Duke Power Results

Sample Description	Arsenic		Barium*		Cadmium		Chromium	
	ppb	mg/g	ppb	mg/g	ppb	mg/g	ppb	mg/g
Flyash, unit #2								
EPA #1	269.3	4.08×10^{-3}	219.83	3.33×10^{-3}	3.96	6.00×10^{-5}	4.97	7.54×10^{-5}
EPA #2	274.1	4.28×10^{-3}	228.43	3.56×10^{-3}	3.41	5.32×10^{-5}	7.61	1.19×10^{-4}
ASTM #1	72.74	2.68×10^{-4}	266.03	9.80×10^{-4}	7.76	2.86×10^{-5}	119.08	4.39×10^{-4}
ASTM #2	91.9	3.33×10^{-4}	211.13	7.65×10^{-4}	1.36	4.93×10^{-6}	126.02	4.57×10^{-4}
Flyash, unit #5								
EPA #1	417.9	6.62×10^{-3}	268.93	4.26×10^{-3}	5.95	9.43×10^{-5}	16.63	2.64×10^{-4}
EPA #2	441.9	6.89×10^{-3}	433.93	6.77×10^{-3}	6.49	1.01×10^{-4}	14.41	2.25×10^{-4}
ASTM #1	254.9	9.05×10^{-4}	332.53	1.18×10^{-3}	0.45	1.60×10^{-6}	85.77	3.04×10^{-4}
ASTM #2	202.2	8.17×10^{-4}	300.93	1.07×10^{-3}	1.21	4.29×10^{-6}	80.22	2.85×10^{-4}
Bottom ash, unit #5								
EPA	<2.0	$<3.07 \times 10^{-5}$	46.37	7.10×10^{-4}	<0.20	$<3.07 \times 10^{-6}$	<0.50	$<7.68 \times 10^{-6}$
ASTM	5.84	1.92×10^{-5}	98.33	3.24×10^{-4}	0.36	1.18×10^{-6}	<0.50	$<1.64 \times 10^{-6}$
Coal								
EPA #1	<2.0	$<3.12 \times 10^{-5}$	40.53	6.33×10^{-4}	0.20	3.12×10^{-6}	0.53	8.28×10^{-6}
EPA #2	<2.0	$<3.18 \times 10^{-5}$	46.23	7.36×10^{-4}	0.29	4.61×10^{-6}	<0.50	$<7.95 \times 10^{-6}$
ASTM #1	<2.0	$<7.52 \times 10^{-6}$	141.73	5.33×10^{-4}	0.72	2.71×10^{-6}	<0.50	$<1.88 \times 10^{-6}$
ASTM #2	<2.0	$<7.65 \times 10^{-6}$	170.93	6.54×10^{-4}	0.97	3.71×10^{-6}	0.67	2.56×10^{-6}

*Corrected for filter blank.

Table 5. ALLEN LEACHATE STUDY (CONT'D)

Sample Description	Lead		Mercury		Silver		Selenium	
	ppb	mg/g	ppb	mg/g	ppb	mg/g	ppb	mg/g
Flyash, unit #2								
EPA #1	<1.0	$<1.52 \times 10^{-5}$	<0.1	$<1.52 \times 10^{-6}$	0.51	7.73×10^{-6}	68.74	1.04×10^{-3}
EPA #2	<1.0	$<1.56 \times 10^{-5}$	<0.1	$<1.56 \times 10^{-6}$	0.11	1.72×10^{-6}	69.12	1.08×10^{-3}
ASTM #1	<1.0	$<3.68 \times 10^{-6}$	<0.1	$<3.68 \times 10^{-7}$	1.48	5.45×10^{-6}	426.60	1.57×10^{-3}
ASTM #2	<1.0	$<3.63 \times 10^{-6}$	<0.1	$<3.63 \times 10^{-7}$	0.62	2.25×10^{-6}	445.30	1.61×10^{-3}
Flyash, unit #5								
EPA #1	<1.0	$<1.58 \times 10^{-5}$	<0.1	$<1.58 \times 10^{-6}$	0.56	8.88×10^{-6}	<5.0	$<7.92 \times 10^{-5}$
EPA #2	<1.0	$<1.56 \times 10^{-5}$	<0.1	$<1.56 \times 10^{-6}$	0.28	4.37×10^{-6}	<5.0	$<7.80 \times 10^{-5}$
ASTM #1	<1.0	$<3.55 \times 10^{-6}$	<0.1	$<3.55 \times 10^{-7}$	0.45	1.60×10^{-6}	13.60	4.83×10^{-5}
ASTM #2	<1.0	$<3.55 \times 10^{-6}$	<0.1	$<3.55 \times 10^{-7}$	0.39	1.38×10^{-6}	13.97	4.96×10^{-5}
Bottom ash, unit #5								
EPA	<1.0	$<1.54 \times 10^{-5}$	<0.1	$<1.54 \times 10^{-6}$	0.68	1.04×10^{-5}	<5.0	$<7.68 \times 10^{-5}$
ASTM	<1.0	$<3.29 \times 10^{-6}$	<0.1	$<3.29 \times 10^{-6}$	1.19	3.92×10^{-6}	11.74	3.86×10^{-5}
Coal								
EPA #1	<1.0	$<1.56 \times 10^{-5}$	<0.1	$<1.56 \times 10^{-6}$	0.11	1.72×10^{-6}	8.01	1.25×10^{-4}
EPA #2	<1.0	$<1.59 \times 10^{-5}$	<0.1	$<1.59 \times 10^{-6}$	0.45	7.16×10^{-6}	6.90	1.10×10^{-4}
ASTM #1	<1.0	$<3.76 \times 10^{-6}$	<0.1	$<3.76 \times 10^{-7}$	0.11	4.14×10^{-7}	26.27	9.88×10^{-5}
ASTM #2	<1.0	$<3.83 \times 10^{-6}$	<0.1	$<3.83 \times 10^{-7}$	0.22	8.42×10^{-7}	26.27	1.01×10^{-4}

In 1983, Duke Power tested dry fly ash and bottom ash from Plant Marshall by the EP method (Table 6).

Table 6. Location: Marshall Steam Station Date: 9/23 & 29/83
 Flyash and Bottom Ash
 Toxicity Leach (Extraction Procedure)

Location Description

	(Concentration)							
	Arsenic µg/l	Barium mg/l	Cadmium mg/l	Chromium mg/l	Lead mg/l	Mercury µg/l	Selenium µg/l	Silver mg/l
Flyash 1-A 09-23-83	82	0.26	<0.014	<0.02	<0.14	<0.1	166	<0.012
Flyash 1-B 09-23-83	89	0.16	<0.014	<0.02	<0.14	<0.1	166	0.017
Bottom Ash 2-A 09-29-83	118	0.062	<0.014	0.18	<0.14	<0.1	3.8	0.017
Bottom Ash 2-B 09-29-83	75	0.074	<0.014	<0.02	<0.14	<0.1	4.1	0.014

Duke Power Groundwater Monitoring

A monitoring program more extensive than that required by RCRA has been in progress at the Allen Steam Station since 1978. This in-house program was designed to evaluate the performance of Duke's ash basins, and their effect on groundwater movement and water quality. Additional Information: Duke's Ash Basin Equivalency Demonstration, EPA's Fossil-Fired Exemption (Dietrich Letter), EPRI Report - Codisposal of Liquid and Solid Wastes from a Typical Coal-Fired Generating Unit.

The objectives of this monitoring program were:

1. Provide data for documenting the condition/quality of groundwater at the ash basin site;
2. Predict and assess the effects of ash basin leachates on the physical and chemical quality of adjacent groundwater;
3. Determine the projected length of time that a typical ash basin substrate can retain leachates; and
4. Predict/calculate the life expectancy of an ash basin with respect to ion exchange capabilities of underlying soils.

Results of this study will be used to:

1. Have groundwater quality data from our service area which may be quite different from the limited studies EPA will use for formulating regional/national groundwater quality standards for industrial waste ponds (i.e., ash basins, resin basins);
2. Participate at the state or regional level in the development of groundwater quality standards and resulting legislation; and
3. Address any future groundwater legislation by means of a strong technical data base such as was done with the Ash Basin Equivalency Demonstration.

Ash Basin History

Allen station is a five-unit, 1140 MW coal-fired steam plant located on Lake Wylie in North Carolina. Mill tailings, bottom ash, and fly ash derived from the processing and burning of coal are pumped via ash slurry lines to a series of ash basins. Development of the ash disposal site (Figure 1) began with area A, which first received fly ash from the plant in the late 1950s.

Area B contains ash that was dredged from area A in the early 1970s. In 1972-73, it was covered with 30-60 cm of earth fill and planted with a ground cover. Currently, ash sluiced from the plant is pumped directly to the ash basin designated as area C. The series of dikes around this area were completed in 1973 and the basin has been operational since then.

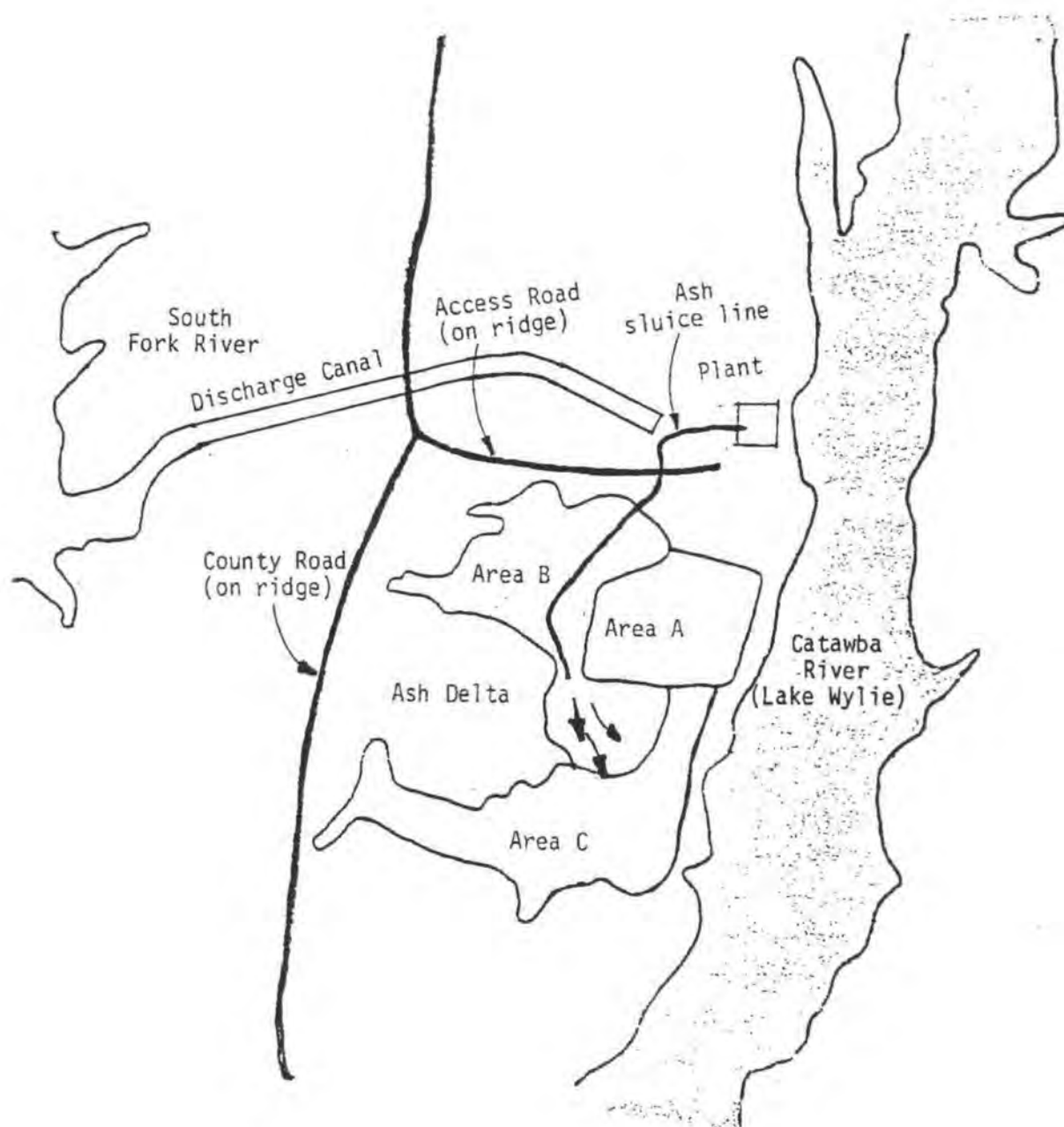


FIG. 1 - ALLEN ASH DISPOSAL SITE

These three areas typify the ash storage extremes that may exist around a steam station during the typical cycle of ash basin utilization and reclamation: stored ash generated in the plant's early days; dredge material less than 10 years old with limited reclamation; and currently generated ash. Note that the prevailing direction of movement of the groundwater is toward the river, as indicated by topographic relief in the plant vicinity (Figure 2). The series of ash basins are placed so that groundwater infiltration into the deeper aquifer is negligible, if not totally precluded. Additional Information: Allen Revegetation Study.

Well Construction

a. Layout-Physical Location/Site

Wells were located on the site based on an examination of available geological/historical/groundwater information. Field surveys were then conducted to select final well locations based on: 1) accessibility by drill rigs, 2) accessibility by well monitoring personnel, 3) placement in area which will not be disturbed by routine plant activities, 4) placement in areas not affected by future modifications of basin, 5) avoidance of unsuitable physical features, i.e., culverts, rock fill, avoid excessive clearing. The final well locations are indicated on Figure 2. Additional Information: Groundwater Monitoring Program.

b. Boring Logs

Extensive records were maintained to document all aspects of the actual well emplacement. Information included in the boring logs includes: date, well number, field, depths for sampling, soil field classification, general drilling procedures. Additional Information: See field logs of boring logs, Personal Communication: Jocassee Soils Lab; Construction personnel, DE Geologist, DE Civil Soils Engineers, Bowser-Morner, Law Engineering, Haley and Aldrich.

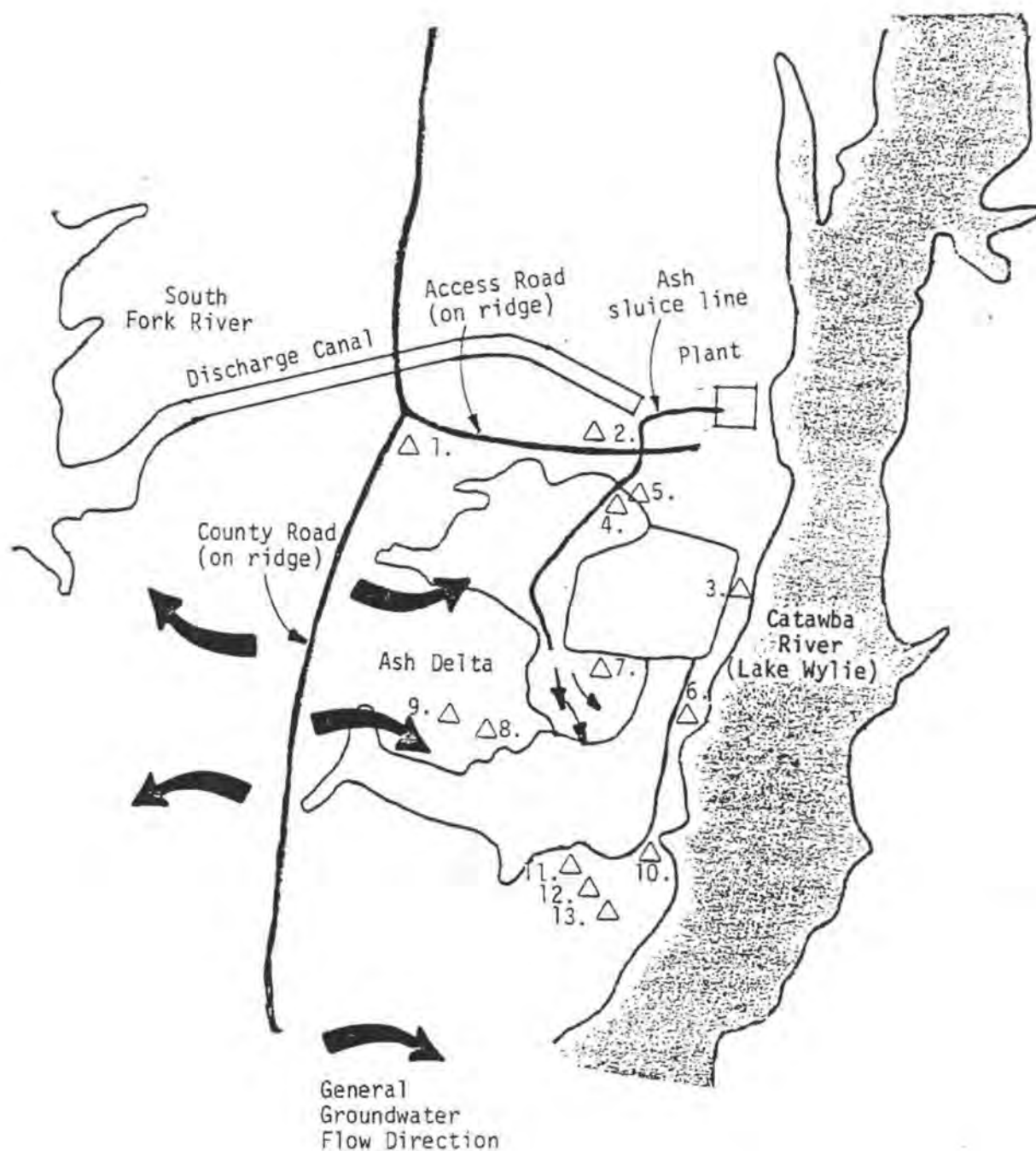


FIG. 2. - SAMPLING WELL LOCATIONS AT PLANT ALLEN

c. Soil Analyses

Soil analyses were conducted by the Jocassee Soils Laboratory. Additional Information: Results from Soils Lab are contained in separate appendix and include soil particle size analysis, grain size distribution, moisture, calculated permeabilities and soil descriptions. Results were discussed with Soil Lab personnel, Civil Engineering personnel, DE geologist, Haley and Aldrich, Weston, Inc., EPRI.

Well Design

a. Air Lift Sampler

The gas lift sampler (Figure 3) consists of two plastic tubes. The smaller tube (1/4 in. OD) supplies pressurized nitrogen from a regulated source to the discharge hole at the bottom of the gas line; the larger one (3/4 inc. OD) returns a gas-water mixture to the surface.

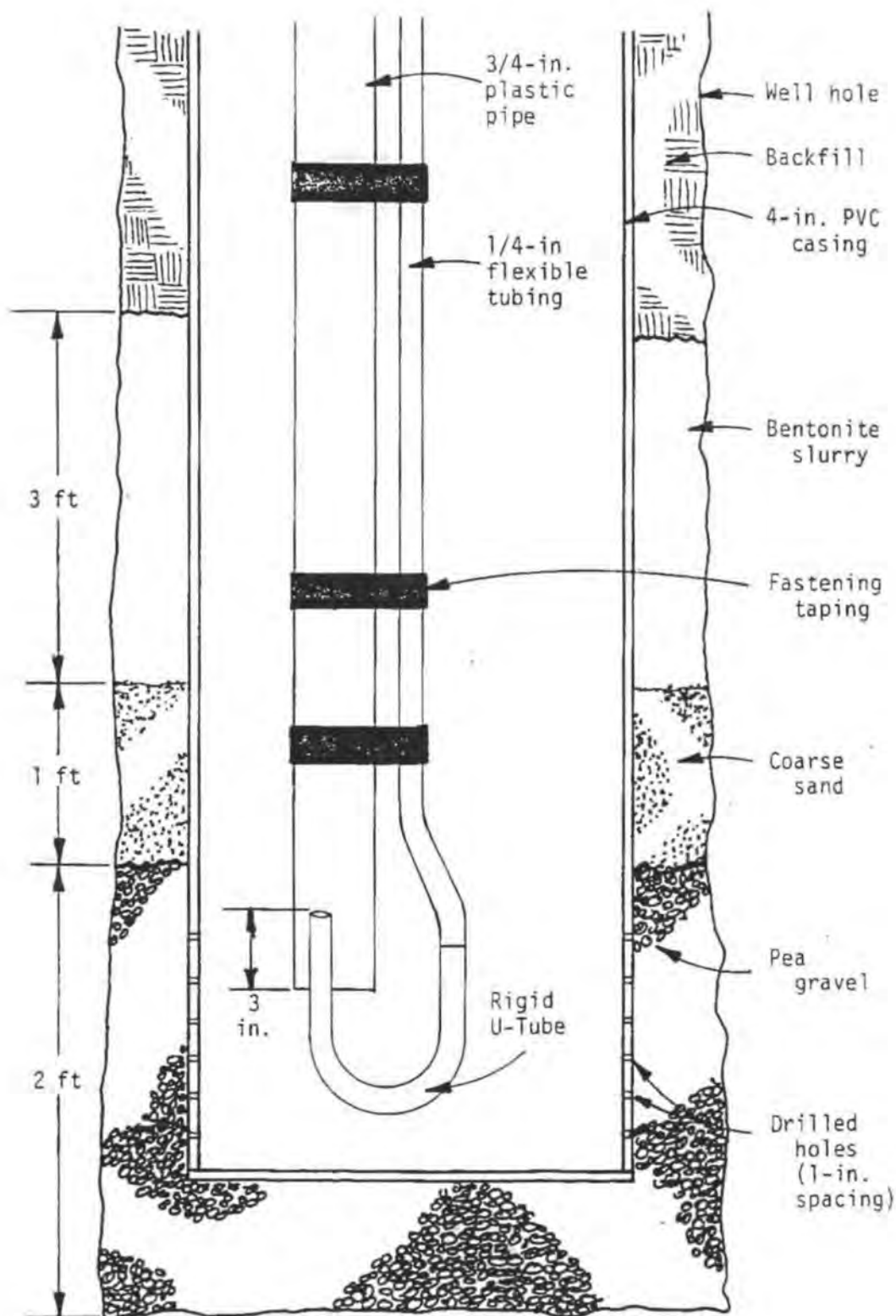


Figure 3. Schematic Diagram of gaslift sampler.

This assembly, constructed of PVC material, is inserted into a 4 inch PVC casing. The nitrogen feed line is connected to the inflow fixture and the gas is permitted to flow at a rate that produces the optimal water flow at the discharge tube. Samples are taken directly from the discharge tube opening.

b. Function of Wells

Table 7 lists the wells, general information and its function - control or monitoring. Additional information: Well installation log; surveyors log, site layout, soil boring data, general soils information, discussions with DE geologists, Civil Engineering personnel, Soils Laboratory personnel.

c. General Well Construction

All wettable surfaces of the well and associated piping and tubing were made of plastic to minimize potential metal contamination. Further details of well construction are contained in the air lift sampler description.

Sampling Procedure

a. Well Stabilization

Well installation was completed by February, 1978, and the wells were pumped using nitrogen on a weekly basis through April, 1978. This procedure ensured that drilling-related disturbances in the soil strata

Table 7. Function, location, and
design details of wells.*

Well Depth,

No. ft. Function and specifications

- | | | |
|----|----|---|
| 1 | 66 | Control (to provide hydrological and chemical background data) |
| 2 | 52 | Control (same as well 1) |
| 3 | 32 | Monitoring; river side of old ash-basin dike, below perched-water table
(nearest depth for ample groundwater volume) |
| 5 | 47 | Monitoring; finished to about 30 ft. below well 4 |
| 6 | 30 | Monitoring; river side of new ash-basin dike, below perched-water table |
| 7 | 43 | Monitoring; on peninsula in new ash basin, finished below perched-
water table |
| 8 | 50 | Control; northwest corner of new basin, finished below perched-water
table |
| 9 | 50 | Control; farther west than well 8, below perched-water table |
| 10 | 20 | Monitoring; river side of dike of new ash-basin discharge |
| 11 | 46 | Monitoring; river side of south dike of new basin, sufficiently below
table for ample groundwater sample |
| 12 | 43 | Monitoring; south and 30 ft. downgradient of well 11 |
| 13 | 40 | Monitoring; south and 30 ft. downgradient of well 12 |

*Well #4 discontinued because of rerouting of ash discharge
resulted in permanent lowering of water table.

had stabilized and that all water used during drill operations had been removed from the wells and surrounding soils. Conductivity measurements and spot sampling conducted during this period indicated that the wells had stabilized and a full-scale monthly sampling program was initiated.

b. Sampling Protocol

Wells were allowed to recharge prior to sampling (two-day survey) which eliminated any minor contamination from surface water infiltration, and ensured removal of waters that might be affected by different oxidation/reduction regimes as a result of exposure to the atmosphere. When these waters were removed, a more representative groundwater sample would be taken.

Although sampling initially consisted of monthly analyses, so little change was detected that quarterly sampling was deemed adequate. It should be noted, however, that in shallow wells - less than 3 m - the temperature was observed to change seasonally, even though the major chemical parameters showed no discernible trend. The procedure required that each well be pumped/sampled on two consecutive days. The wells were pumped to the lowest level possible on the first day, allowed to recharge for 24 hours, and then re-sampled. Temperature, pH, conductivity, and water level were measured in the field. Additional information: Groundwater Monitoring Program.

Analytical Procedure

a. Trace Metals

Composite samples were collected for laboratory analysis for the following: arsenic, cadmium, chromium, manganese, sodium, nickel, and zinc. The samples were put on ice and then brought to the lab where they were passed through a 0.45 μ filter (soluble fraction), transferred to acid washed glass bottles, and then acidified to a pH of approximately 2.0 with nitric acid. The maximum time between sample collection and completion of sample preservation was four hours.

The routine sample analysis consisted of calcium, chloride, magnesium, nitrate, potassium, sodium, sulfate, arsenic, cadmium, chromium, copper, iron, manganese, mercury, selenium and arsenic. Additional information: Sample study design, raw data sheets, various summaries in files.

b. Field Measurements

Sampling procedure for the field was as follows:

- 1) The depth to water in a monitoring well was measured using a volt-meter with calibrated coax cable and the value recorded on data sheets.

- 2) The 3/4 inch PVC tubing permanently mounted inside the 4 inch PVC casing was adjusted to a desirable pumping depth and this depth was recorded on field data sheets.
- 3) Pumping was started and the conductivity (μ mhos/cm²) of the discharge water was monitored by a specific conductance bridge. The values for specific conductance at selected pumping times were recorded on a well pumping data sheet.
- 4) When conductivity reached a constant value, the temperature and pH of the discharge water were measured and values recorded on data sheets.
- 5) All field instruments were calibrated in the laboratory.

Summary of Analytical Results

The presence of leachate in the test wells was determined by comparing the concentration of substances present with those in the control wells and with the dissolved constituents in the old and new ash basins. Conductivities above 100 μ mhos and calcium concentrations exceeding 8 mg/l were taken to indicate the presence of leachate. On this basis, wells 3, 4, and 11 were judged to be situated in the leachate plume.

For the first two years of data analyzed, the highest conductivity recorded for the control wells was 98 μ mhos. By comparison, the lowest conductivity for the test wells in the plume was 180 μ mhos. Average calcium concentration

measured in the control wells was 2.62 mg/l, whereas the average for test wells 3, 4, and 11 was 54.5 mg/l. The elevated calcium levels were probably associated with the leading edge of the plume.

With the possible exception of test well 12, none of the other test wells appeared to be in the leachate plume. As shown in Figure 4, wells 11, 12 and 13 were situated on a hill sloping down to the river. Although well 11 is definitely situated in the plume, as mentioned, well 13 is not, because none of the parameters measured there exceeded those at the control wells. Well 12 is questionable, however, with average magnesium concentrations (2 mg/l) intermediate between those wells 11 and 13.

The concentration of trace elements in the control and test wells for the entire study is provided in Table 8, giving the single highest and lowest values recorded. For comparison, the table includes Interim Primary Drinking Water Standards.

As noted, minimum concentrations are generally near or at the detection limit of the instrumentation. In all cases, the minimum concentrations were less than the Interim Drinking Water Standards. Maximum values were observed during the early portion of the sampling period when water quality within the well was still influenced by the drilling process. Well No. 4 located at the ash/clay interface became dry during the last 2 years of the study because of

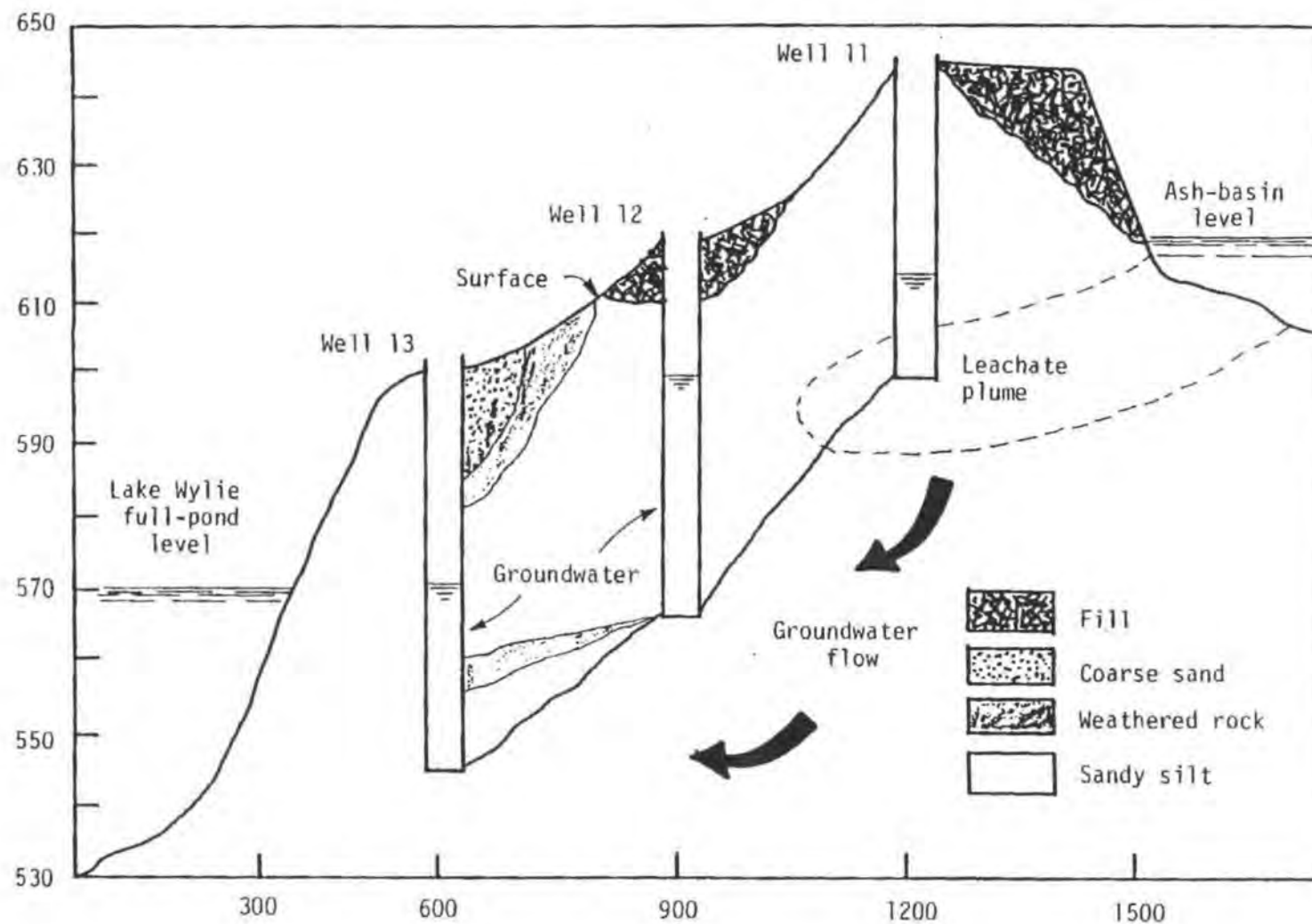


Figure 4. Horizontal movement of leachate plume is tracked over long term using calcium and conductivity data at wells 11, 12, and 13, placed downgrade from basin and each other

Table 8. Maximum - Minimum Concentrations (ppb) measured during groundwater sampling during 1979 - 1982 at Allen Steam Station.

Well No.	As Min - Max	Cd Min - Max	Se Min - Max	Cr Min - Max	Cu Min - Max	Ni Min - Max	Zn Min - Max
1	1.2 - <2.0	<0.2 - 0.3	<5.0 - 6.0	<0.5 - <20.0	<1.0 - <20.0	<5.0 - <20.0	1.2 - <20.0
2	2.0 - 6.5	0.7 - 1.1	<5.0 - 12.0	<0.5 - 90.0	1.8 - <10.0	<5.0 - 20.0	10.0 - 36.0
3	<2.0 - 9.2	<0.2 - 8.5	<5.0 - 8.5	<0.5 - 10.0	<10.0 - 30.0	<5.0 - 10.0	<1.0 - 70.0
4	8.8 - 112.5	<0.2 - 7.0	<5.0 - 19.5	<0.5 - 10.0	<1.0 - <10.0	<5.0 - 40.0	<1.0 - 80.0
5	<2.0 - 8.0	<0.2 - 7.0	<5.0 - 5.8	<0.5 - 20.0	<1.0 - <10.0	40 - 68.0	48 - 50
6	<2.0 - 2.0	<0.2 - 2.0	** - <5.0	0.7 - 10	<1.0 - <10.0	<5.0 - 20.0	4.1 - 20.0
7	<2.0 - 4.5	<0.2 - 3.5	<5.0 - 5.5	<0.5 - 10	<1.0 - <10.0	<5.0 - 10.0	11.0 - 20.0
8	<2.0 - 5.6	<0.2 - 15.0	** - <5.0	<0.5 - 20	<1.0 - <10.0	<5.0 - 10.0	1.7 - 20.0
9	1.3 - <2.0	<0.1 - *	** - <5.0	<0.5 - <20	<1.0 - <20.0	<5.0 - <20.0	<1.0 - <20.0
10	<2.0 - 6.8	7.6 - 19.0	<5.0 - 12.0	<0.5 - <20	<1.0 - <10.0	<5.0 - <10.0	8.0 - 20.0
11	<2.0 - 6.9	<0.2 - 7.7	<5.0 - 12.0	1.9 - 20	1.2 - 20.0	<5.0 - 20.0	6.6 - 90.0
12	<2.0 - 3.4	<0.2 - 7.0	<5.0 - 8.5	<0.5 - 20	<1.0 - <10.0	<5.0 - 10.0	11.0 - 30.0
13	<2.0 - 5.1	<0.2 - 2.8	<5.0 - 11.5	1.6 - 50	2.1 - 10.0	<5.0 - <10.0	2.2 - 30.0
EPA ¹	50	10	10	50	1000	NC ²	5000

¹- EPA Interim Primary Drinking Water Standards

²- No criterion

* - One sample only

** - Detection limit changed from <1.0 to <5.0

rerouting of ash sluice lines in the area. Consequently, these data reflect the quality of interstitial water in the ash pond rather than the actual groundwaters.

Environmental Protection Agency Contract No. 68-02-3167:
Characterization and Environmental Monitoring of Full Scale
Utility Waste Disposal Sites

Prime Contractor: Arthur D. Little, Inc.

Geotechnical Subcontractor: Bowser-Morner Testing Laboratories, Inc.

Chemical Analysis Subcontractor: TRW, Inc.

The purpose of this program was to obtain information to enable promulgation of federal regulations under RCRA for the storage, treatment, and disposal of coal ash and flue gas desulfurization sludge.

The study involved geohydrologic and ground water quality investigations at six utility waste sites. Soil borings were performed to take split spoon and Shelby tube samples and to install test wells. Flush joint, steel casing (4 inch ID) borings, using wash-boring techniques, were employed. Soil samples were obtained at 5 ft. intervals, with the split-spoon sampler used to determine Standard Penetration. Wells consisted of 2 in. ID, Schedule 80 PVC pipe with slotted well points surrounded to 5 ft. above the point with Ottawa sand. The casings were backfilled with sand, cement grouted at ground surface, and completed with a 3 ft. stand pipe with vented locking cap. Samples of dry fly ash were also taken for leachate analysis.

The Plant Allen site was selected as being representative of the Piedmont region and the combined ponding of fly and bottom ash. The site was also selected to investigate Duke Power's practice of treating boiler cleaning waste in the ash basin.

The geology of the Allen site was found to consist primarily of residual (silty clay with low organic content) soils with some very localized alluvial deposits from former surface drainage areas. The original groundwater table was located at a maximum depth of 33 ft. Groundwater flow was found to be $5 \times 10^5 \text{ m}^3/\text{yr}$. The A. D. Little subcontractors decided upon 12 test wells to characterize the retired and active ash basins, in locations similar to those selected by Design Engineering for the Duke study. Two background wells (3-4 and 3-4A) were located upgradient from DP well #8, and seven downgradient wells were installed. Well 3-5 was placed near DP #11, Wells 3-6A and B near DP #10, Well 3-7 further upriver, Well 3-9 and 3-8A near DP #6 and Well 3-8 upriver and downgradient of the dike separating the retired and active basins. Well 3-1 was located within the retired pond and Wells 3-2 and 3-3 were placed in the active pond. Well 3-2 sampled the water in the ash at the bottom of the pond. In addition, the toe drains of the active pond dike were designated 3-10, 3-11, and 3-12, and the pond NPDES discharge was designated 3-13. The sampling locations are shown in Figure 5. All wells were flushed after installation and were subsequently sampled by peristaltic pump. Groundwater sampling occurred in February and March 1981 and in July 1982. Samples of boiler cleaning waste were taken during the cleaning of Allen #4 in November 1981.

Groundwater samples were analyzed by Inductively Coupled Argon Plasma emission spectroscopy, except for analysis of arsenic and selenium by hydride evolution atomic absorption and analysis of sulfate (and five other anions) by ion chromatography. Data for some selected parameters are shown in Table 9

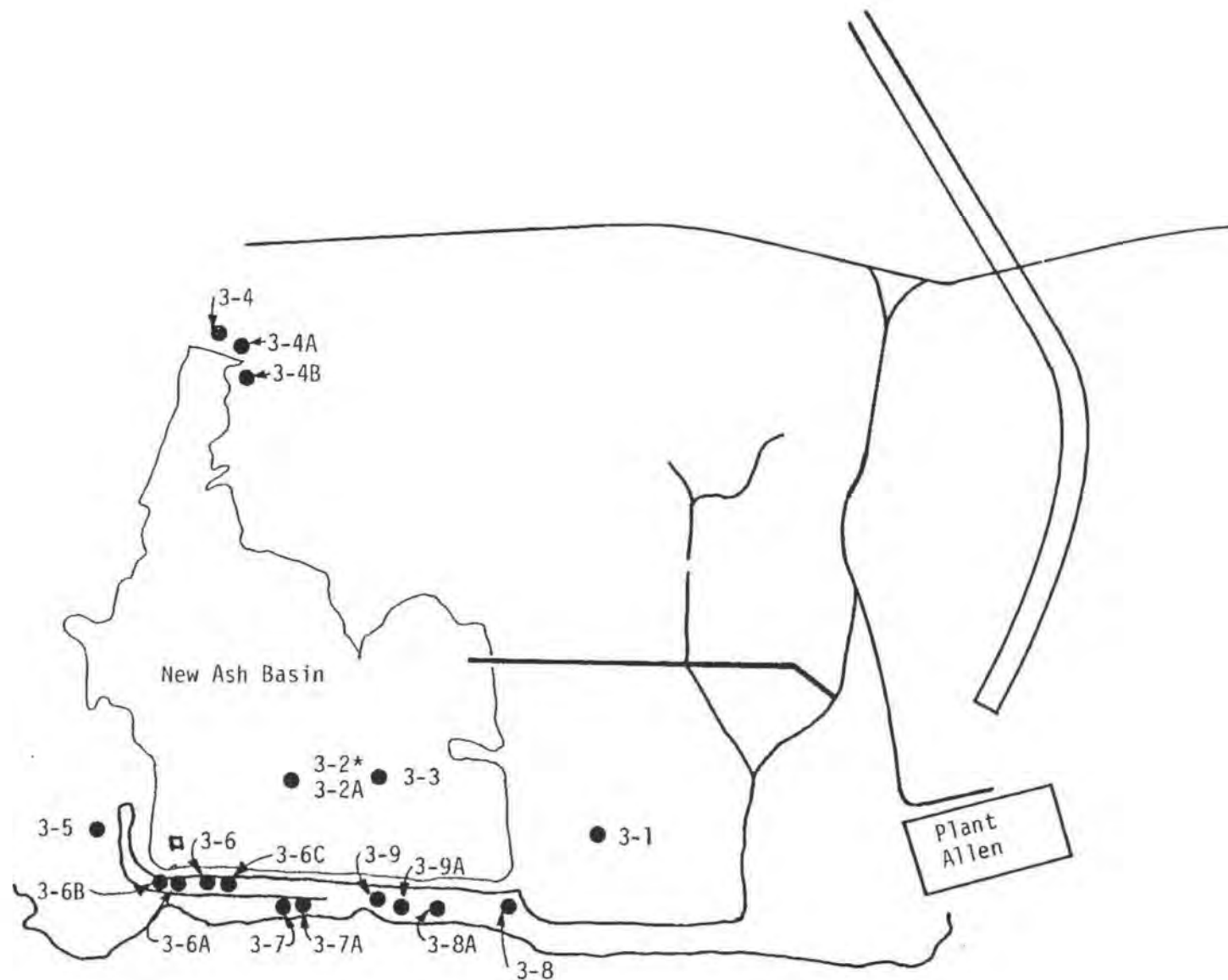


Figure 5. EPA/ADL Groundwater Monitoring Wells In-Place at Plant Allen as of June 30, 1982.

*3-2 - Depth at ash/clay interface
 3-2A - Well point within the ash.

Table 9. Selected Groundwater Data for Plant Allen Sampling Location

DATE	<u>February 1981</u>		<u>March 1981</u>				<u>July 1982</u>			
Location	<u>3-2</u>	<u>3-9</u>	<u>3-2</u>	<u>8</u>	<u>3-9</u>	<u>6</u>	<u>3-2</u>	<u>8</u>	<u>3-9</u>	<u>6</u>
As (ppb)	1550	NA	2425	<2	<0.2	<2	318	<5	<0.1	NS (Inaccessible)
Se (ppb)	3	NA	<2	<5	<.26	<5	6.6	<5	<0.1	NS (Inaccessible)
Cu (ppm)	<.008	<.008	<.005	2.2	<.005	<1	<.008	<1	<.008	NS (Inaccessible)
Mg (ppb)	10.5	7.9	11.7	1.2	8.7	1.2	6	1.15	7.1	NS (Inaccessible)
SO ₄ (ppm)	320	<4	320	NA	<4	NA	169	NA	4	NS (Inaccessible)

NS = Not Sampled
 NA = Not Analyzed

for Wells 3-2 (worst case high concentrations) and 3-9 (downgradient of active pond) with some data from Duke wells 8 (background) and 6 for comparison. The parameters shown are arsenic and selenium (primary drinking water standards), magnesium (indicator of ion exchange capacity), and copper and sulfate (secondary drinking water standards). The difference in the concentration of arsenic and sulfate between that found within the active pond and in the downgradient well is noteworthy. The arsenic concentrations detected in the interstitial waters of the ash-soil interface at the bottom of the active pond (well 3-2) were much higher than the leachable arsenic found in dry fly ash from Allen Unit 1 (98 ppb) and Unit 3 (63 ppb), yet no arsenic was detected in well 3-9 downgradient of the active pond.

Soil attenuation is suggested by A. D. Little as the mechanism preventing migration of arsenic from the ponds. This was demonstrated by lab experiments in which interstitial water from well 3-2 (fortified with cadmium, chromium, copper, lead, and selenium) was used as a test leachate to be combined in 50-ml aliquots with .05, .5, 5, and 25 gms. of soil from the borings for 3-2. The slurries were shaken for 24 hrs., filtered through a .45 um filter, and aliquots were either preserved with nitric acid for ICAP or cooled for ion chromatography. Analyses were performed both on solutions and on digested solids.

Statistically significant decreases in concentration between starting solutions and equilibrated solutions were considered to be the quantity adsorbed by the soil. The starting solution concentrations of arsenic and selenium were 512 and 125 ppb, respectively. The alluvial soil used from the bottom of well 3-2 was 69% sand, 28% clay, 8% silt, with 0.08% total organic

carbon and 4940 ppm manganese. The pH of the leachate/soil mixtures was 8.97 for the .05 gms. solution, 8.58 for .5 gms., 6.99 for 5 gms., and 6.5 for the 25 gms. solution.

The equilibrated final solutions contained as much as 360 ppb arsenic and 113 ppb selenium for the smallest amount of soil but as little as <0.2 ppb arsenic and 0.2 ppb selenium for the 25 gm. soil sample, indicating the soil's high adsorptive capacity, the highest of any site studied by A. D. Little. The high manganese content of the soil is suggested as the explanation for its ability to adsorb arsenic and selenium.

The soil from 3-2, the groundwater from the downgradient wells, and the pond toe drains and discharge water did not have concentrations of copper, nickel, and zinc above background, confirming that the high concentrations of these metals added to the pond during a boiler cleaning are precipitated and confined within the pond.

Duke Power Company
Legal Department
422 South Church Street
Charlotte, NC 28242-0001
(704) 382-8121



DUKE POWER

February 13, 1997

(704)382-8137 Fax

STEVE C. GRIFFITH, JR.
ELLEN T. RUFF
W. EDWARD POE, JR.
WILLIAM LARRY PORTER
PETER C. BUCK
JOHN E. LANSCH
WILLIAM J. BOWMAN, JR.
ALBERT V. CARR, JR.
ROBERT M. BISANAR
EDWARD M. MARSH, JR.
RONALD V. SHEARIN
W. WALLACE GREGORY, JR.
JEFFERSON D. GRIFFITH, III
JEFFREY M. TREPEL
PAUL R. NEWTON
MICHAEL LIU
ROBERT T. LUCAS III
KAROL P. MACK
GARRY S. RICE
LISA F. VAUGHN
CHRISTIN JARVIS
MARY LYNNE GRIEG
SALLY G. Helweg
LEISL N. MUST

Certified Mail - Return Receipt Requested

Thomas Quinn, Esquire
Mendes & Mount
750 - 7th Avenue
New York, NY 10019

Re: Insured: Duke Power Company
Sites/Claims: Asbestos-Related Bodily Injury and Various Property
Damage (See Attachment)

Dear Mr. Quinn:

Duke Power Company ("Duke") is writing to provide you with notice of certain claims and/or circumstances that may give rise to certain claims for coverage. Our records reflect that notice is to be provided to Mendes & Mount for at least the following policies:

Capacity Managers International	128811	(12/31/76 - 12/31/77)
First State Insurance Company	127720	(10/23/73 - 12/31/76)
Lexington Insurance Company	128394	(12/31/75 - 12/31/76)
Lexington Insurance Company	128832	(12/31/76 - 12/31/77)
North Star Reinsurance Corp.	127721	(10/23/73 - 12/31/75)
North Star Reinsurance Corp.	128393	(12/31/75 - 12/31/76)
Northbrook Insurance Company	127719	(10/23/73 - 12/31/75)
Northbrook Insurance Company	128395	(12/31/75 - 12/31/76).

The information contained herein is confidential. We are providing it to you with the understanding that you will keep it confidential pursuant to your obligations under the policies of insurance sold to Duke.

I. ASBESTOS-RELATED BODILY INJURY CLAIMS

After the North Carolina Supreme Court decision, Woodson v. Rowland, which permitted injured workers to pursue a civil action against their employer notwithstanding coverage under the Workers Compensation Act, approximately 379 claimants asserted claims against Duke for asbestos-related injuries caused

Thomas Quinn, Esquire
February 13, 1997
Page 2

** per DEC*
Not confidential
~~CONFIDENTIAL~~

by exposure to asbestos during their employment. To date, Duke has paid out approximately \$79 million to resolve these claims. Recently, approximately 169 additional claimants have asserted claims against Duke for asbestos-related bodily injuries. The total demand of these unsettled claims exceeds \$50 million.

II. ENVIRONMENTAL PROPERTY DAMAGE CLAIMS

A. Manufactured Gas Plant Sites

1. Burlington, North Carolina MGP Site

The Burlington MGP site operated as a gas works between approximately 1929 and 1950. Duke has conducted a preliminary site environmental assessment, including several soil borings, and collected samples around the area of the former MGP structures. The site assessment demonstrates that contaminants are present in the soil. The Burlington MGP is included in the Memorandum of Understanding ("MOU") entered into with North Carolina Department of Environment, Health and Natural Resources ("NCDEHNR").

2. Charlotte, North Carolina MGP Site

The Charlotte MGP operated from approximately 1900 until sometime in the 1950s. Contaminants associated with MGP operations have been found in the soil and ground water. Duke conducted a Phase II site investigation in August through October 1991. The site investigation results showed extensive soil contamination. In February 1996, Duke sampled ground water monitoring wells and found levels of several contaminants that exceeded ground water cleanup criteria. The Charlotte MGP is included in the MOU entered into with the NCDEHNR. To date, Duke has spent approximately \$249,483 on investigation and remediation activity for this site.

3. Greensboro/Duke Parcel, North Carolina MGP Site

A gas plant was operated on the Greensboro/Duke parcel MGP site between approximately 1911 and 1952. Duke has conducted Phase I and II site investigations, which demonstrate extensive soil and ground water contamination. The Greensboro/Duke Portion MGP is included in the MOU entered into with the NCDEHNR. Duke has signed an Administrative Order on Consent ("AOC") with NCDEHNR for this site, requiring a remedial implementation plan and remedial investigation report. To date, the NCDEHNR has not signed this AOC. Duke has spent approximately \$184,414 to date on investigation and remediation activity for this site.

OFFICIAL COPY
Feb 18 2020

~~CONFIDENTIAL~~

4. Greensboro/Jefferson-Pilot Parcel, North Carolina MGP Site

A MGP operated on this site from approximately 1883-1910. To date, no sampling or soil, ground water, surface water, or sediment has been conducted at this site.

5. High Point, North Carolina MGP Site

A MGP was operated on the High Point site between approximately 1913 and 1948. The NCDEHNR conducted a preliminary assessment of the site and recommended that a site inspection be conducted at the site. A tar-like substance has been observed in onsite soil. The High Point MGP is included in the MOU entered into with the NCDEHNR. To date, no sampling or soil, ground water, surface water, or sediment has been conducted at this site.

6. Salisbury, North Carolina MGP Site

The Salisbury MGP operated from at least 1887 to the mid 1950s. The Salisbury MGP is included in the MOU entered into with the NCDEHNR. To date, no sampling or soil, ground water, surface water, or sediment has been conducted at this site.

7. Winston-Salem, North Carolina MGP Site

The Winston-Salem MGP site contained an operational gas works between approximately 1901 and 1952. Camel City Cleaners and Piedmont Natural Gas currently own portions of the site where the original MGP was located. Camel City Cleaners and Duke have reached a private agreement that Duke will be responsible only for the cleanup of contamination attributable to MGP operations. The Winston-Salem MGP is included in the MOU entered into with the NCDEHNR. To date, Duke has spent approximately \$62,438 on investigation and remediation activity for this site.

8. Greenville, Bramlette Street, South Carolina MGP Site

A gas works was operated on the Greenville, Bramlette Street site from approximately 1917 to 1952. An investigation was conducted in 1995 at an adjacent property owned by a third-party, the Vaughn landfill. In 1996, a Phase II investigation was conducted which included the former MGP site. These investigations demonstrate that contaminants associated with the operation of a

MGP are present in soil and ground water. To date, Duke has not made any payments for investigation and remediation activity for this site.

9. Greenville, E. Broad Street, South Carolina MGP Site

A gas works was operated on the Greenville, E. Broad Street site from approximately 1875 to 1951. In 1991, the South Carolina Department of Health and Environmental Control required Duke to perform a Phase II site assessment to determine the horizontal and vertical extent of contamination. In March 1993, Duke conducted an amendment to the Phase II site assessment and installed additional monitoring wells. In June 1994, Duke agreed to work with the Electric Power Research Institute to collaborate on investigation of the site in an effort to minimize damages. Remediation on the site began in July 1995. To date, Duke has excavated approximately 10,000 cubic yards of soil from the site. Duke has spent approximately \$1,395,855 to date on investigation and remediation activity for this site.

10. Spartanburg, South Carolina MGP Site

A gas works operated on this site from approximately 1889 to 1952. To date, no sampling of soil, ground water, surface water, or sediment has been conducted at this site. However, geotechnical borings undertaken in preparation for site development have been conducted on the site in the past. Soil saturated with tar has been observed during these activities.

B. Coal-Fired Power Plants

Duke conducts coal-fired power generation activities at seven plants in North Carolina (Allen, Belews Creek, Buck, Cliffside, Dan River, Marshall, and Riverbend) and one plant in South Carolina (Lee). The coal combustion process generates at least four residuals: fly ash, bottom ash, boiler slag, and boiler blowdown. These solid wastes contain various contaminants. The residual coal ash is produced in large quantities and is managed in ash management areas. At some power plants, Duke sluices ash residual with water to ash basins or dredge ponds where the ash was allowed to settle. At others, Duke manages dry ash in landfills or disposal areas.

1. Allen Coal-Fired Power Plant, North Carolina

The Allen power plant operated as a coal-burning power plant from 1957 and has a total capacity of 1,125,000 kilowatts. The plant is in a rural area approximately 7 miles south of Belmont, North Carolina. The Allen power plant

has five electric generating units. Ground water sampling at this site show the presence of contaminants above the applicable state cleanup criteria.

2. Belews Creek Coal-Fired Power Plant, North Carolina

The Belews Creek power plant, which began operating in 1974, has a total capacity of over 2.2 million kilowatts. The plant is located in a rural area 8 miles southeast of Walnut Cove, North Carolina. Belews has two electric generating units. The NCDEHNR required the installation and regular sampling of monitoring wells at this site in accordance with the facility's solid waste permit for its fly ash landfill. Testing from these wells show the presence of contaminants in the ground water above the applicable state cleanup criteria.

3. Buck Coal-Fired Power Plant, North Carolina

The Buck plant began its operations in 1926 and has a combined capacity of 364,000 kilowatts. The plant is located approximately 5 miles east of Spencer, North Carolina in a primarily rural area. The Buck plant has four electric generating units. No investigations or cleanup have been conducted at this site to date.

4. Cliffside Coal-Fired Power Plant, North Carolina

The Cliffside power plant began operating in 1940 and is capable of producing 760,000 kilowatts of power. The plant is located in a rural area 3 miles south of Cliffside, North Carolina. The Cliffside power plant has five electric generating units. No investigation has been conducted at this site to date.

5. Dan River Coal-Fired Power Plant, North Carolina

The Dan River power plant began operations in 1949 and is capable of producing 272,000 kilowatts of power. The Dan River power plant has three electric generating units. The plant is located southeast of Eden, North Carolina in a rural area. The NCDEHNR has required ground water monitoring. Sampling of ground water at the site demonstrates the presence of contaminants above the applicable state cleanup criteria.

6. Marshall Coal-Fired Power Plant, North Carolina

The Marshall power plant began operation in 1965 and is capable of producing over 2 million kilowatts of power. The plant is located in Terrell, North Carolina in a rural area. The Marshall power plant has four electric generating

units. Sampling of ground water at this site demonstrates the presence of contaminants above the applicable state cleanup criteria.

7. Riverbend Coal-Fired Power Plant, North Carolina

The Riverbend Power plant began operation in 1929 and provides 454,000 kilowatts of power. The plant is located in a rural area 6 miles north of Mt. Holly, North Carolina. The Riverbend plant has four electric generating units. No investigation has been conducted at this site to date.

8. Lee Coal-Fired Power Plant, South Carolina

The Lee power plant began operation in 1951 and generates a total of 388,000 kilowatts of power. The plant is located in a rural area approximately 6 miles southeast of Pelzer, South Carolina. The Lee plant has three electric generating units. Sampling of ground water at this site demonstrates the presence of contaminants above the applicable state cleanup criteria.

C. Hydroelectric Facilities

Duke owns and operates 25 active hydroelectric ("hydro") plants or pump storage facilities. Upstream industrial discharges in the Catawba River may have resulted in the deposition and accumulation of contaminants in dammed areas at least two of these plants: the Fishing Creek Hydro facility and the Wylie Hydro facility.

1. Fishing Creek Hydro Facility

The Fishing Creek Hydro is located on the Catawba River in Chester and Lancaster Counties, South Carolina. The Fishing Creek dam was constructed in 1916. The dam has created a 2,580-acre reservoir. Bowater, Inc. ("Bowater") operates a pulp and paper mill which is located approximately 8 miles upstream (north) of the Fishing Creek dam. Bowater operated a chlorine-bleaching system for at least 40 years, presumably unregulated for much of this period. Bowater discharges treated wastewater into the Catawba River.

2. Wylie Hydro Facility

The Wylie Hydro is located on the Catawba River in York County, South Carolina just south of the North Carolina border. Wylie Dam was constructed in 1924, damming the Catawba River and creating a large reservoir (Lake Wylie), which has a surface area of approximately 12,450 acres. Sandoz Chemical

Thomas Quinn, Esquire
February 13, 1997
Page 7

CONFIDENTIAL

Corporation ("Sandoz") operates a large chemical manufacturing plant approximately 20 miles upstream (north) of the Wylie Dam. Sandoz has operated at this location for approximately 40 years. Sandoz manufactures dyes, organic chemicals, and herbicides. Sandoz discharges a large volume of wastewater into the Catawba River.

D. Substations

Duke owns and operates approximately 2,000 transmission and distribution substations located along its electrical transmission lines. Substation equipment sometimes overheats or experiences power surges that sporadically cause equipment to fail. Expansion or bulging of electrical equipment during failure can lead to rupture and release of PCB-contaminated insulating fluid. Releases of PCBs from failed capacitors have been identified as the primary source of contamination at substations.

E. Oak Hill Superfund Site

Duke has been named a PRP on the Oak Hill PCB Superfund site located in Lenoir, North Carolina. This site apparently operated as a scrap facility from approximately 1952 to 1972. EPA has remediated the site at a cost of \$2.17 million, and demands that amount from Duke and the other PRP. Negotiations with the EPA are ongoing.

Please let us know as soon as possible if you believe that these policies sold to Duke do not provide defense and/or indemnity for the claims identified above.

Very truly yours,



Jeff D. Griffith III

JDGiii/lst
Attachment

ATTACHMENT

SITES WITH POTENTIAL ENVIRONMENTAL LIABILITIES

- A. Manufactured Gas Plant Sites
 - 1. Burlington, NC
 - 2. Charlotte, NC
 - 3. Greensboro/Duke Parcel, NC
 - 4. Greensboro/Jefferson-Pilot Parcel, NC
 - 5. High Point, NC
 - 6. Greenville, SC/ Bramlette St. MGP
 - 7. Greenville, SC/ E. Broad St. MGP
 - 8. Salisbury, NC
 - 9. Spartanburg, SC
 - 10. Winston-Salem, NC

- B. Fossil Power Plants
 - 1. Allen, NC
 - 2. Belews Creek, NC
 - 3. Buck, NC
 - 4. Cliffside, NC
 - 5. Dan River, NC
 - 6. Lee, SC
 - 7. Marshall, NC
 - 8. Riverbend, NC

- C. Hydro Electric Power Plants
 - 1. Fishing Creek Hydro
 - 2. Wylie Hydro

- D. Substations

Approximately 2,000 active substations.

- E. Oak Hill Superfund Site

* Per DEC, this is
NOT Confidential.
(Vol. 14 pg. 250)
ktm

Hart Exhibit 26 I/A
Part 1 of 2
Docket No. E-7, Sub 1214

Page 1 of 208 pages filed
in the docket on
2/18/2020. ktm

Coal Combustion Products

Ten Year Plan

Confidential

Coal Combustion Product (CCP) Issues Document August 18, 2003

Summary

- Created in response to changing state/federal CCP regulations and increased awareness of the environmental impacts associated with the disposal/reuse of certain CCPs, especially gypsum and fly ash.
- Objective – This document seeks to identify the issues relevant to current Duke CCP management practices and to develop recommendations aimed at evaluating the risks and benefits associated with these practices.
- The CCP Issues Document is viewed as the initial step of the CCP management evaluation process.
- Implementation of proposed recommendations, in light of federal and state regulatory trends, is warranted.

CCP Issues Document - Content

- Current Generic Disposal/Reuse Practices and Associated Risks
- CCP Facility Matrix (Facility Specific) - Coal Combustion, Pollution Controls, CCP Disposal Practices, and Environmental Impacts
- Recommendations –Identify Issues and Potential Implications

Management Considerations

Benefits

- Relationships with state and federal regulators will likely be improved.
- Long term risks and liability will be reduced.
- Potential problems will be identified.
- A clear stance on CCP management will allow for more effective long term strategic planning for EHS and Ash Management moving forward.

Risks

- Most of the proposed recommendations will result in increased capital and O&M expenditures.
- These recommendations, if implemented, will be largely irreversible in nature.
- EPA will likely require ground water monitoring for all surface impoundments within the next 5 years
- Unknown impacts to ash due to addition of air pollution abatement equipment.

Recommendations

- Develop and execute ground water monitoring plan for all on-site (active and retired) ash management units. Implement in 2004.
 - Should impacts be noted, work with state agencies to develop a consistent and measured approach to address any issues.
- Concentrate research efforts on ash benefaction and reuse options that immobilize regulated constituents (e.g., ash reburn, flime, Pos-o-Tec).
- Continue to actively cultivate markets (e.g., NC DOT) to establish viable reuse outlets (i.e., encapsulated, immobilized uses) for CCPs.
- Better partner with industry stakeholders (i.e., other Carolina utilities, USWAG, EPRI, EEI) on regulatory and research initiatives.
- When feasible, utilize existing or active ash management units rather than procure new property for future ash placement.

Hart Exhibit 28
Docket No. E-7, Sub 1214

From: Jimmie A Stowe Jr <JASTowe@dukeenergy.com>
Sent: Friday, August 13, 2004 9:53 AM
To: Ruhe, Mike; Mathis, Tony R; Ervine, Tim; Burrell, Donna L; Mark S Hays; Everett, George T; Leap, Tom Y Jr; Starcher, Michael S; Newell, Jeff W; Larry S Harper
Cc: Miller, William M; Scruggs, Don
Subject: Groundwater Well Installation at Allen Steam Station

Bill Miller, Don Scruggs and Allen Stowe met with Bill Goforth of the NC DENR DWQ Groundwater Section on August 12, 2004 to discuss the placement and installation of monitoring wells around the Allen ash basin. Allen Stowe explained the 2000 Bevill Determination and ongoing discussions with the utility industry and EPA regarding groundwater monitoring for unlined surface impoundments. Allen Stowe also stated Duke Power's intent to be proactive on this issue and to initiate groundwater monitoring at its unlined surface impoundments before any agreement between the utility industry and EPA was accepted. Mr. Goforth was informed that monitoring wells would be installed at Allen and Marshall Steam Station(s) this year. The other seven NC fossil sites would have monitoring wells installed in 2005-2006.

After a brief review of site maps by Bill Miller and Don Scruggs, a tour of the ash basin and the surrounding areas was given. Mr. Goforth stated that the pre-existing wells on the dike adjacent to the Catawba River could be investigated for use (with minor modifications). Mr. Goforth concurred with the location and the proposed depths (well pair - one shallow, one deep) for the background and the two monitoring wells located closest to locations where the ash basin is located near residences. Mr. Goforth requested that two additional monitoring wells be sited between the western side of the ash basin and the housing development. NC DENR and Gaston County officials will be contacted to ascertain additional permit requirements. A modification to the existing NPDES permit may also be necessitated. These wells will be installed the week of September 20, 2004. Hopefully, the groundwater monitoring wells at MSS will also be installed during this week.

Overall, the meeting atmosphere was very cordial and productive. If additional information is required, please contact me. Thanks

Allen Stowe
phone: (704) 382-4309
fax: (704) 382-9840
e-mail: jastow@duke-energy.com

Duke Energy – Regulated Generation Carolina's Region

Monthly Technical Manager's Meeting

Coal Combustion Products Update

June 27, 2007



DRAFT [REDACTED]

1

DUKE_SUTTON_00009028

OFFICIAL COPY

Feb 19 2020

Duke Energy – Regulated Generation Carolina's Region

OFFICIAL COPY

Feb 19 2020

Table of Contents:

- Overview of Environmental Management Program for Coal Combustion Products
- Coal Combustion Products 10-Year Plan Station Updates

Duke Energy – Regulated Generation Carolina's Region

Environmental Management Program for Coal Combustion Products

DRAFT

3

DUKE_SUTTON_00009030

Why develop this policy?

- ☐ Ash management decisions are becoming more complex
 - varying regulations (waste and water),
 - multiple states
 - multiple facilities
- ☐ Risks are becoming more apparent:
 - Regulatory compliance risk
 - Environmental impact risk
 - Public perception risk
- ☐ Maintain a uniform risk profile
- ☐ Ensure long term operational flexibility

What has changed?

- ☐ Recent ash sampling has revealed that CCP leaching chemistry is “worse” than previously assumed.
- ☐ Changing CCP chemistry with plant modifications (FGD, SCR, SNCR, Trona)
- ☐ Evolving industry knowledge on ash chemistry
- ☐ Changing regulatory requirements (As, Hg)
- ☐ Lessons learned from the merger

CCP Management Options

1. Use as a Raw Material
2. Agricultural Applications
3. Landfills
4. Engineered Fills
5. Surface Impoundments

Use as a Raw Material & Agricultural Applications

☐ Management Program

- No significant limitations on use other than those imposed by regulations
- Environmental review required for new applications

☐ Implications

- No change

Landfills

☐ Management Program

- Use of best available technology to ensure operational flexibility.
- Encourage use of landfills as primary disposal option.

☐ Implications

- Construction of new/expanded landfills may be required at some stations.
- Limit reliance on re-use options or engineered fills as long-term disposal strategy.

Engineered Fills

☐ Management Program

- Projects must have a beneficial end use.
- Environmental evaluation and approval required for new projects.
- New fills must utilize construction practices to minimize adverse impacts.

☐ Implications

- Restrictions on engineered fills may result in fewer approvable fills requiring more landfill capacity.
- Implementation of effective infiltration cap for new fills and fills under construction.

Disposal in Surface Impoundments

☐ Management Program

- Implement groundwater monitoring programs.
- Prohibit most “dry stacking” outside of ash basin boundary.
- Require use of best available liner/cap technology for new or expanded facilities and closure.

Disposal in Surface Impoundments

□ Implications

- More stringent requirements for impoundments may drive the decision to convert to dry handling.
- Installation of engineered liners for new or expanded ponds.
- Installation of engineered caps or application of “clean closure” practices for pond closures.
- Need to pursue landfill capacity at many stations for disposal of ash removed from the basins.

Duke Energy – Regulated Generation Carolina's Region

Coal Combustion Products 10-Year Plan Station Updates

DRAFT [REDACTED]

12

[REDACTED] DUKE_SUTTON_00009039

Duke Energy – Regulated Generation Carolina's Region

- Station Coal Parameters
- Riverbend Steam Station (Complete Update)
 - 2006-2007 Project
 - 2010-2011 Project Planning
- Allen Steam Station
- Belews Creek Steam Station
- Buck Steam Station
- Cliffside Steam Station
- Dan River Steam Station
- Lee Steam Station
- Marshall Steam Station

Station Coal Parameters (FPMG March 2007)

Station	Coal Parameter	2008	2009	2010	2011	2012
Allen	HHV (Btu / lb)	11,400	11,225	11,225	11,225	11,255
	Ash Content (%)	18.40	17.15	17.15	17.15	17.15
	Sulfur (lbs SO ₂ /mmBtu)	1.83	1.73	1.73	1.73	1.73
Belews Crk	HHV (Btu / lb)	12,250	12,250	12,250	12,250	12,250
	Ash Content (%)	12.50	12.50	12.50	12.50	12.50
	Sulfur (lbs SO ₂ /mmBtu)	1.60	1.60	1.60	1.60	1.60
Buck	HHV (Btu / lb)	11,500	11,575	11,575	11,575	11,575
	Ash Content (%)	17.50	14.00	14.00	14.00	14.00
	Sulfur (lbs SO ₂ /mmBtu)	1.79	1.60	1.60	1.60	1.60
Cliffside 1-4	HHV (Btu / lb)	12,250	12,250	12,250	---	---
	Ash Content (%)	12.50	12.50	12.50	---	---
	Sulfur (lbs SO ₂ /mmBtu)	1.60	1.60	1.60	---	---
Cliffside 5	HHV (Btu / lb)	12,075	12,075	12,075	11,932	11,932
	Ash Content (%)	13.90	13.90	13.90	13.98	13.98
	Sulfur (lbs SO ₂ /mmBtu)	1.65	1.65	1.65	3.73	3.73

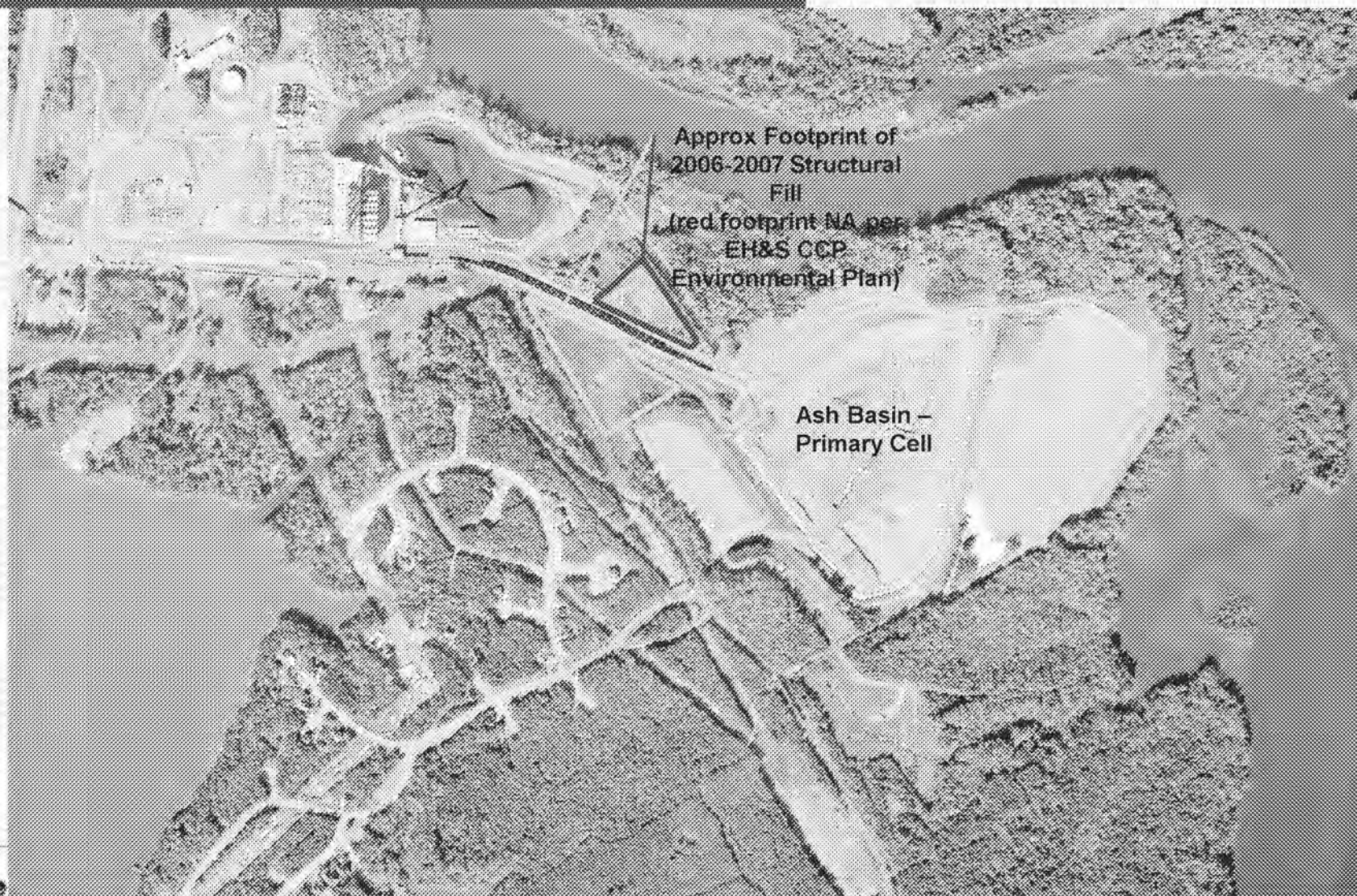
Station Coal Parameters (FPMG March 2007)

Station	Coal Parameter	2008	2009	2010	2011	2012
Dan River	HHV (Btu / lb)	12,000	12,000	12,000	12,000	12,000
	Ash Content (%)	13.00	13.00	13.00	13.00	13.00
	Sulfur (lbs SO ₂ /mmBtu)	1.60	1.60	1.60	1.60	1.60
Lee	HHV (Btu / lb)	12,000	12,000	12,000	12,000	12,000
	Ash Content (%)	13.00	13.00	13.00	13.00	13.00
	Sulfur (lbs SO ₂ /mmBtu)	1.60	1.60	1.60	1.60	1.60
Marshall	HHV (Btu / lb)	12,350	12,350	12,375	12,375	12,375
	Ash Content (%)	12.10	12.10	11.90	11.90	11.90
	Sulfur (lbs SO ₂ /mmBtu)	2.39	2.39	2.52	2.52	2.52
Riverbend	HHV (Btu / lb)	11,850	11,570	11,570	11,570	11,570
	Ash Content (%)	14.35	12.35	12.35	12.35	12.35
	Sulfur (lbs SO ₂ /mmBtu)	1.66	1.50	1.50	1.50	1.50

Coal Combustion Products 10-Year Plan Update

Riverbend Steam Station

Aerial Photo November 2005

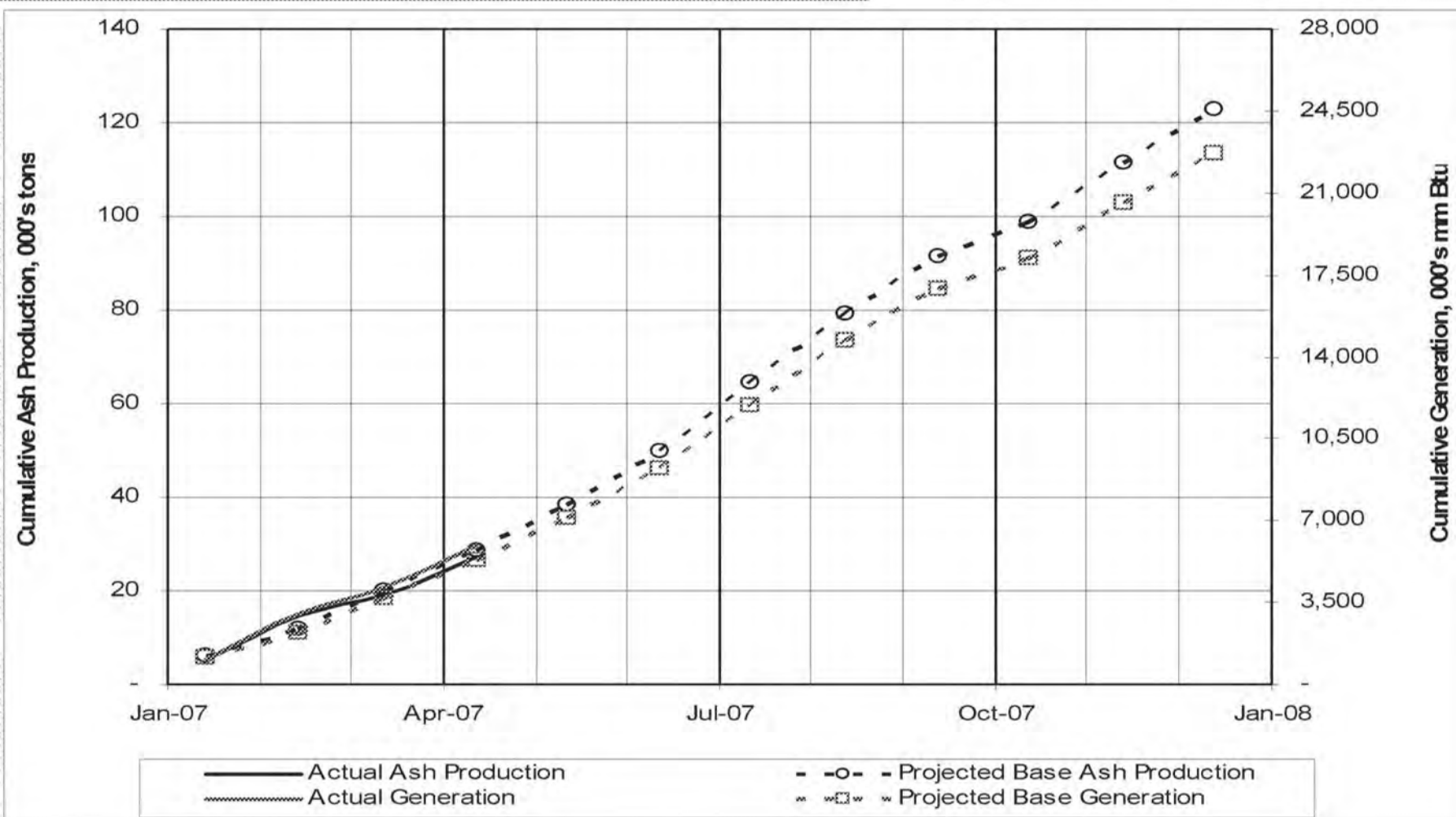


CCP 10-Year Plan Update – Riverbend Station

2007 YTD Results

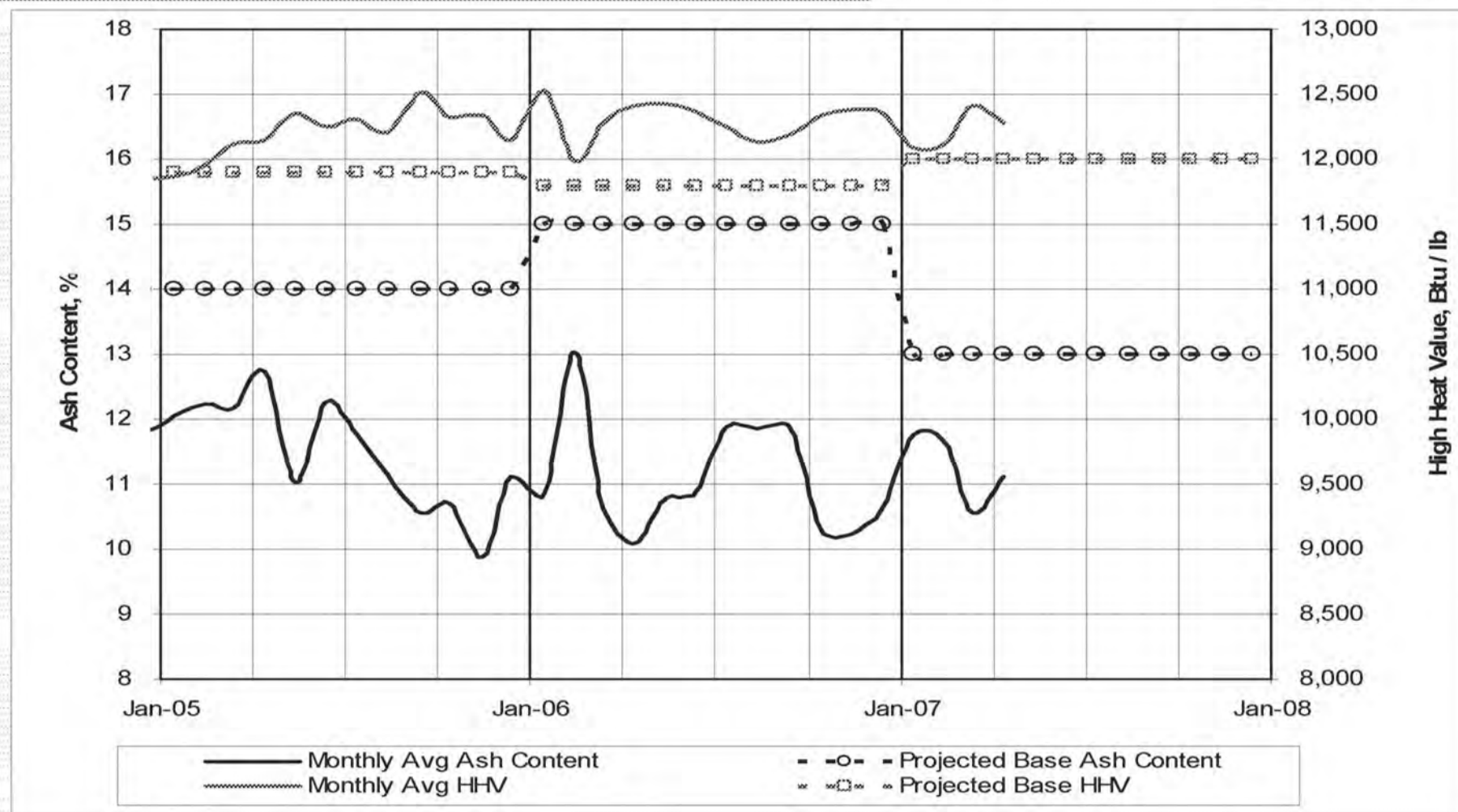
OFFICIAL COPY

Feb 19 2020



CCP 10-Year Plan Update – Riverbend Station

2005 – 2007 Coal Quality



Riverbend 2006-2007 Ash Basin Project

- General Contractor: Ash Basics Construction Co.
- Target Ash Removal Quantity: 600,000 cubic yards
- Total Project Budget: \$2.49 Million
- Project Schedule: Nov 2006 through Dec 2007
- Within budget and schedule
- Unique Project Features
 - ☐ Installation of Visual Barrier Fence
 - Issue: Dusting
 - ☐ Discharge Tower Stoplog Upgrade
 - In progress
 - ☐ Cinder Pit Drainage Changes
 - In progress
 - ☐ Improvements to Gravel Roads
 - ☐ Re-shape top of fill for synthetic cap: 50K cy
 - Issues: Slope drains, funding and timing.

Riverbend 2010-2011 Project Planning

- New Wording Revises Ash Reuse Permit Stating "No Residual Solids in Critical Watershed Zone"
- Must go Off-site with Landfill
- Lincoln CT Site = Favored Option
- Adjacent Land Purchase Offers = Favored Option
- Other Potential Options Being Investigated:
 - ☐ Off-site to Charlotte Airport at 2M Cubic Yards
 - ☐ Off-site to Highway Projects
 - ☐ Land Purchases Near Marshall
 - ☐ Ash to Marshall
- Rezoning / Site Characterization / Permitting
- Maximizing Volume on Current Fill Project to support landfill permitting timeline

DRAFT [REDACTED]

20

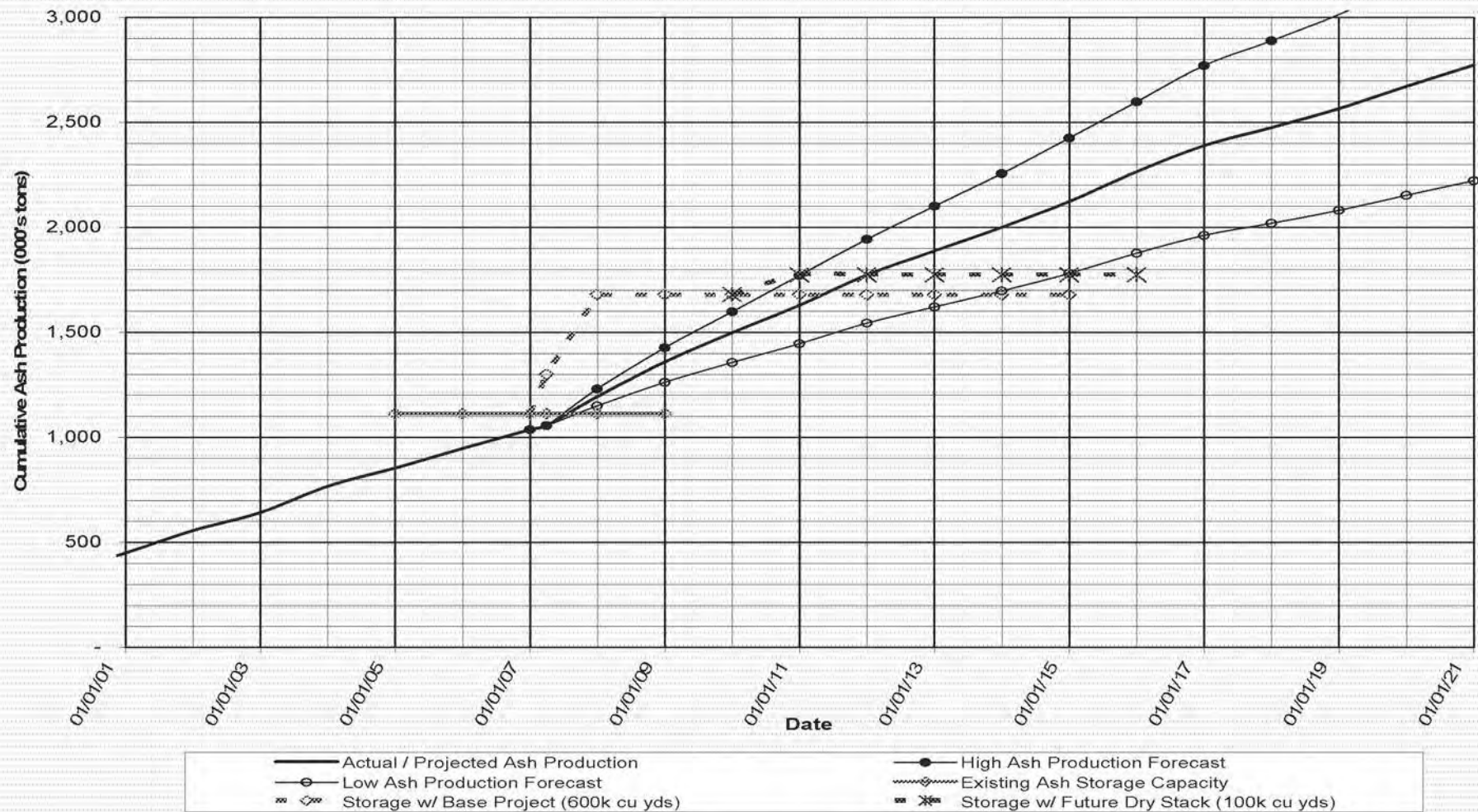
CCP 10-Year Plan Update – Riverbend Station

Ash Production and Ash Basin Storage Capacity Projections

Date	Fuel Consumption (000's mmBtu)			Coal High Heat Value (Btu's / lb)			Coal Ash Content (Percent)			Coal Consumption (000's tons)			Annual Ash Production (000's tons)			
	Low	Base	High	Low	Base	High	Low	Base	High	Low	Base	High	Actual	Low	Base	High
01/01/93													37.0	37.0	37.0	37.0
12/31/93													36.0	36.0	36.0	36.0
12/31/94													27.5	27.5	27.5	27.5
12/31/95													66.4	66.4	66.4	66.4
12/31/96													61.4	61.4	61.4	61.4
12/31/97													62.6	62.6	62.6	62.6
12/31/98													61.3	61.3	61.3	61.3
12/31/99													97.3	97.3	97.3	97.3
12/31/00													106.8	106.8	106.8	106.8
12/31/01													85.7	85.7	85.7	85.7
12/31/02													125.9	125.9	125.9	125.9
12/31/03													86.7	86.7	86.7	86.7
12/31/04		16,719			11,991			12.4			697.2		92.4	92.4	92.4	92.4
12/31/05		19,568			12,226			11.5			800.2		90.1	90.1	90.1	90.1
12/31/06		19,972			12,325			11.1			812.6		19.3	19.3	19.3	19.3
03/31/07		4,133			12,194			11.4			169.4					
12/31/07	19,067	25,423	29,220	12,500	12,005	11,405	12.4	13.0	13.7	762.7	1,058.9	1,281.0	94.2	137.7	174.9	174.9
12/31/08	20,470	27,293	29,220	12,443	11,850	11,258	13.6	14.4	15.1	822.6	1,151.6	1,297.8	112.1	165.3	195.5	195.5
12/31/09	19,591	26,122	29,220	12,149	11,570	10,992	11.7	12.4	13.0	806.3	1,128.9	1,329.2	94.6	139.4	172.4	172.4
12/31/10	18,422	24,563	29,220	12,149	11,570	10,992	11.7	12.4	13.0	758.2	1,061.5	1,329.2	89.0	131.1	172.4	172.4
12/31/11	20,311	27,062	29,220	12,149	11,570	10,992	11.7	12.4	13.0	836.0	1,170.3	1,329.2	98.1	144.5	172.4	172.4
12/31/12	16,054	21,405	26,757	12,149	11,570	10,992	11.7	12.4	13.0	660.7	925.0	1,217.2	77.5	114.2	157.8	157.8
12/31/13	15,751	21,001	26,251	12,149	11,570	10,992	11.7	12.4	13.0	648.3	907.6	1,194.2	76.1	112.1	154.9	154.9
12/31/14	17,222	22,963	28,703	12,149	11,570	10,992	11.7	12.4	13.0	708.8	992.3	1,305.7	83.2	122.6	169.3	169.3
12/31/15	19,942	26,589	29,220	12,149	11,570	10,992	11.7	12.4	13.0	820.7	1,149.0	1,329.2	96.3	141.9	172.4	172.4
12/31/16	17,511	23,348	29,186	12,149	11,570	10,992	11.7	12.4	13.0	720.7	1,009.0	1,327.6	84.6	124.6	172.2	172.2
12/31/17	12,089	16,118	20,148	12,149	11,570	10,992	11.7	12.4	13.0	497.5	696.6	916.5	58.4	86.0	118.9	118.9
12/31/18	12,696	16,928	21,160	12,149	11,570	10,992	11.7	12.4	13.0	522.5	731.5	962.6	61.3	90.3	124.8	124.8
12/31/19	14,846	19,794	24,743	12,149	11,570	10,992	11.7	12.4	13.0	611.0	855.4	1,125.5	71.7	105.6	146.0	146.0
12/31/20	14,254	19,006	23,757	12,149	11,570	10,992	11.7	12.4	13.0	586.7	821.3	1,080.7	68.8	101.4	140.1	140.1

	Data corresponding to Low Ash Production. Based on cumulative effects of: 75% of generation, 105% of HHV (not to exceed 12,500 Btu/lb), and 95% of coal ash content)
	Data corresponding to Base Ash Production per Mar 2007 PROSYM Projections
	Data corresponding to High Ash Production. Based on cumulative effects of: 125% of generation (not to exceed 70% capacity factor), 95% of coal HHV, and 105% of coal ash content)
	Historical Data corresponding to Actual Ash Production
	Generation and Coal Quality Projections linked to other Excel worksheets contained in this Excel workbook.

CCP 10-Year Plan Update – Riverbend Station Ash Production and Ash Basin Storage Capacity Projections



DRAFT

22

CCP 10-Year Plan Update – Riverbend Station Planning and Budgeting Overview

OFFICIAL COPY

Feb 19 2020

Estimated Costs (Year 2007 Dollars)																											
Item No.	Description	Capital, Risk, or O&M	Units	Year No. →		1		2		3		4		5		6		7		8		9		10		11	
				Year →	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Cost	Cost	Cost	Cost	Cost	Cost	Cost	Cost	Cost	Cost	Cost	Cost
1.0	Ash Basin																										
1.1	Ash Basin Survey	O&M	EA	\$ 15,000	\$ -	1	\$ 15,000	-	\$ -	1	\$ 15,000	-	\$ -	-	\$ -	1	15,000	\$ -	\$ -	1	15,000	\$ -	\$ -	1	\$ 15,000	-	\$ -
2.0	2006 - 2007 Ash Basin Cleanout Project (In Progress)																										
2.1	Engineering / Permit / Bid / Award	O&M	EA	100,000	0.500	50,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2.2	Site Preparation	O&M	acres	50,000	15	750,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2.3	Excavate, Haul and Place Ash	O&M	fill cu yds	3.00	520,000	1,560,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2.4	Synthetic Cap - Engineering / Permitting / Bid / Award	C	EA	100,000	-	1	100,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2.5	Synthetic Cap - Construction & Installation	C	acres	150,000	-	-	-	15	2,250,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2.6	Periodic Maintenance & Repairs	O&M	EA	50,000	-	-	-	-	-	1	50,000	-	-	-	1	50,000	-	1	50,000	-	-	-	-	1	50,000	-	
3.0	Future Dry Ash Stack																										
3.1	Engineering / Permit / Bid / Award	O&M	EA	100,000	-	-	-	1	100,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3.2	Site Preparation	O&M	acres	50,000	-	-	-	-	-	6	300,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3.3	Excavate, Haul and Place Ash	O&M	fill cu yds	3.00	-	-	-	-	-	100,000	300,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3.4	Synthetic Cap - Engineering / Permitting / Bid / Award	C	EA	100,000	-	-	-	-	-	1	100,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3.5	Synthetic Cap - Construction & Installation	C	acres	150,000	-	-	-	-	-	-	-	6	900,000	-	-	-	-	-	-	-	-	-	-	-	-	-	
3.6	Associated Ash Costs, Periodic Maintenance & Repairs	O&M	EA	25,000	-	-	-	-	-	-	-	-	-	1	25,000	-	1	25,000	-	-	-	-	1	25,000	-	-	
4.0	Future Off-Site Ash Landfill																										
4.1	Engineering / Permit / Bid / Award	O&M	LS	1,000,000	-	-	-	0.25	250,000	0.50	500,000	0.25	250,000	-	-	-	-	-	-	-	-	-	-	-	-	-	
4.2	Land Purchase	C	acres	160,000	-	-	-	50	8,000,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
4.3	Site Preparation	O&M	acres	150,000	-	-	-	-	-	8	1,200,000	8	1,200,000	-	-	-	-	-	8	1,200,000	8	1,200,000	-	-	-	-	
4.4	Single Synthetic Liner - Construction & Installation	C	acres	410,000	-	-	-	-	-	8	3,200,000	8	3,200,000	-	-	-	-	8	3,200,000	8	3,200,000	-	-	-	-	-	
4.5	Excavate, Haul and Place Ash	O&M	tons	5.00	-	-	-	-	-	-	500,000	2,500,000	-	-	-	-	-	-	-	500,000	2,500,000	-	-	-	-	-	
4.6	Synthetic Cap - Engineering / Permitting / Bid / Award	C	EA	100,000	-	-	-	-	-	-	1	100,000	-	-	-	-	-	-	-	1	100,000	-	-	-	-	-	
4.7	Synthetic Cap - Construction & Installation	C	acres	150,000	-	-	-	-	-	-	-	-	15	2,250,000	-	-	-	-	-	-	-	-	15	2,250,000	-	-	
4.8	Associated Ash Costs, Periodic Maintenance & Repairs	O&M	EA	50,000	-	-	-	-	-	-	-	-	-	-	1	50,000	-	-	1	50,000	-	-	-	1	50,000	-	
5.0	OR-Ash Disposal to Future Marshall CCP Landfill																										
5.1	Excavate & Load Ash	Risk	tons	4.00	-	-	-	-	-	100,000	400,000	500,000	2,000,000	-	-	-	-	-	-	500,000	2,000,000	-	-	-	-	-	
5.2	Haul and Place Ash at Future Marshall CCP Landfill	Risk	tons	7.00	-	-	-	-	-	100,000	700,000	500,000	3,500,000	-	-	-	-	-	-	500,000	3,500,000	-	-	-	-	-	
Annual O&M:				\$ 2,360,000		\$ 15,000		\$ 350,000		\$ 2,350,000		\$ 3,965,000		\$ 75,000		\$ 50,000		\$ 1,290,000		\$ 3,750,000		\$ 75,000		\$ 65,000			
Annual Capital:				\$ -		\$ 100,000		\$ 10,250,000		\$ 3,380,000		\$ 4,280,000		\$ 2,250,000		\$ -		\$ 3,280,000		\$ 3,380,000		\$ 2,250,000		\$ -			
Annual Risk:				\$ -		\$ -		\$ -		\$ 1,100,000		\$ 5,500,000		\$ -		\$ -		\$ -		\$ 5,500,000		\$ -		\$ -			

DRAFT

Coal Combustion Products 10-Year Plan Update

Allen Steam Station

Aerial Photo April 2006



3.02 Allen Station - April 2006

CCP 10-Year Plan Update – Allen Station

- ☐ Dry ash conversion capital in 2007 and 2008; begin operation 1/2009.
- ☐ Fill within ash basin until 1/2009; on-site interim structural fill available.
- ☐ Retired ash basin capital in 2008 and 2009 – status?
- ☐ Synthetic cap Fills 1B and 2B in 2009 and 2010.
- ☐ Synthetic cap Fill 4B in 2011.

DRAFT [REDACTED]

25

CCP 10-Year Plan Update – Allen Station

- ☐ Fly ash beneficiation starting 7/2010; paid for by ash marketer from revenues.
- ☐ Airport structural fill project is dead.
- ☐ Mine backhaul project is alive; capital in 2008.

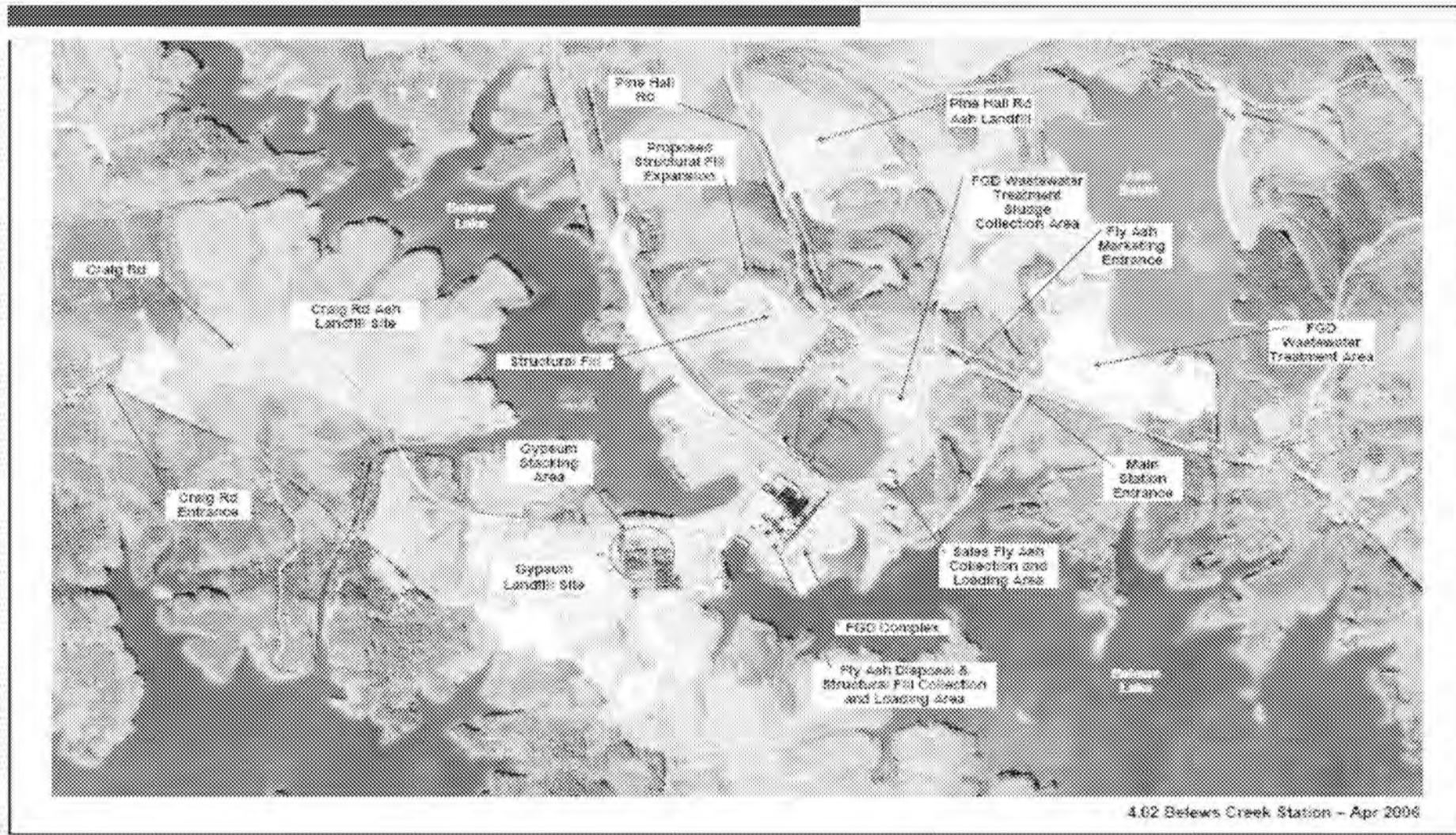
DRAFT [REDACTED]

26

Coal Combustion Products 10-Year Plan Update

Belews Creek Steam Station

Aerial Photo April 2006



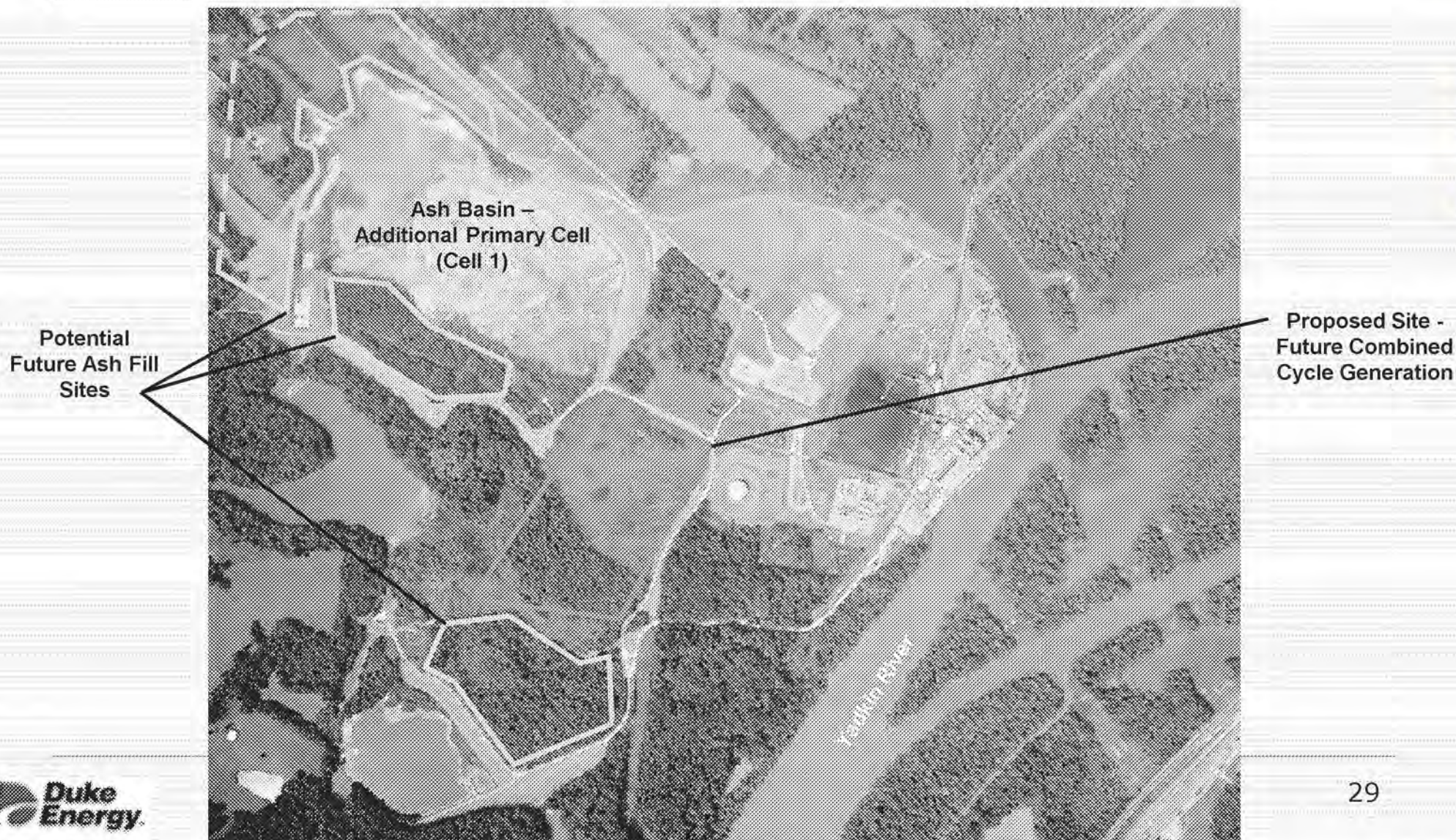
CCP 10-Year Plan Update–Belews Creek Station

- ☐ Pine Hall Road landfill synthetic cap to be installed in 2007/2008.
- ☐ Capital for synthetic cap on current ash structural fill in 2008, but will depend on when actually complete the fill and begin using Craig Road.
- ☐ Capital for synthetic cap on ash structural fill expansion area in 2009 not necessary.

Coal Combustion Products 10-Year Plan Update

Buck Steam Station

Aerial Photo June 2005



CCP 10-Year Plan Update - Buck Station

- ☐ 2007 YTD Results
- ☐ 2005 – 2007 Coal Quality
- ☐ Aerial Photograph
- ☐ Ash Production and Ash Basin Storage Capacity Projections – Chart
- ☐ Ash Production and Ash Basin Storage Capacity Projections – Data
- ☐ Planning and Budgeting Overview

Buck 2009-2010 Project Planning

- On site landfill on brownfield retired pond option
- On-site structural fill with post-beneficial use
- Off-site structural fill to 1-85 widening project
- On-site Pond Expansion = Favored Option
 - Soil to CT Project
 - Soil to 1-85 Project
 - Soil stockpile on-site
 - Blue Herron rookery
 - Permitting
 - Timing
- Preliminary Siting Study in 2007

DRAFT [REDACTED]

31

Coal Combustion Products 10-Year Plan Update

Cliffside Steam Station

Aerial Photo June 2005



7.02 Cliffside Station -- June 2005

CCP 10-Year Plan Update – Cliffside Station

- ☐ Continue monitoring of the pH and solids in ash pond to maximize storage volume until new landfill is completed.
- ☐ Using consultant to mitigate through an incidental take permit from the FWS the “dwarf-flowered heartleaf” (*Hexastylis naniflora*).
- ☐ Continue to stack ash within the ash pond to improve performance.

Coal Combustion Products 10-Year Plan Update

Dan River Steam Station

Aerial Photo November 2003

Potential
Future Ash Fill
Site

Approx
Footprint of
2007 Ash
Fill

Ash Basin – Primary Cell

CCP 10 Year Plan Update - Dan River Station

- ☐ 2007 YTD Results
- ☐ 2005 – 2007 Coal Quality
- ☐ Aerial Photograph
- ☐ 2006-2007 Ash Project
- ☐ Ash Production and Ash Basin Storage Capacity Projections – Chart
- ☐ Ash Production and Ash Basin Storage Capacity Projections – Data
- ☐ Planning and Budgeting Overview

Dan River 2007 Ash Excavation & Fill Project

- General Contractor: Taylor & Murphy Construction Co.
 - Subcontracted to Trans-Ash
- Target Ash Removal Quantity: 300,000 cubic yards
- Total Project Budget: \$2.02 Million
- Project Schedule: Nov 2006 through Oct 2007
- Within Budget and Schedule
- Unique Project Features
 - Installation of Chemical Injection System to minimize discharge of Total Suspended Solids

Dan River 2010-2011 Project Planning

- On-site Landfill on Brownfield Dry Ash Stacks
- On-site Structural Fill with Post-Beneficial Use on Dry Ash Stacks
- On-site Dry Ash Stacks
- Off-site Land Purchase
- Preliminary Siting Study in 2008

DRAFT [REDACTED]

37

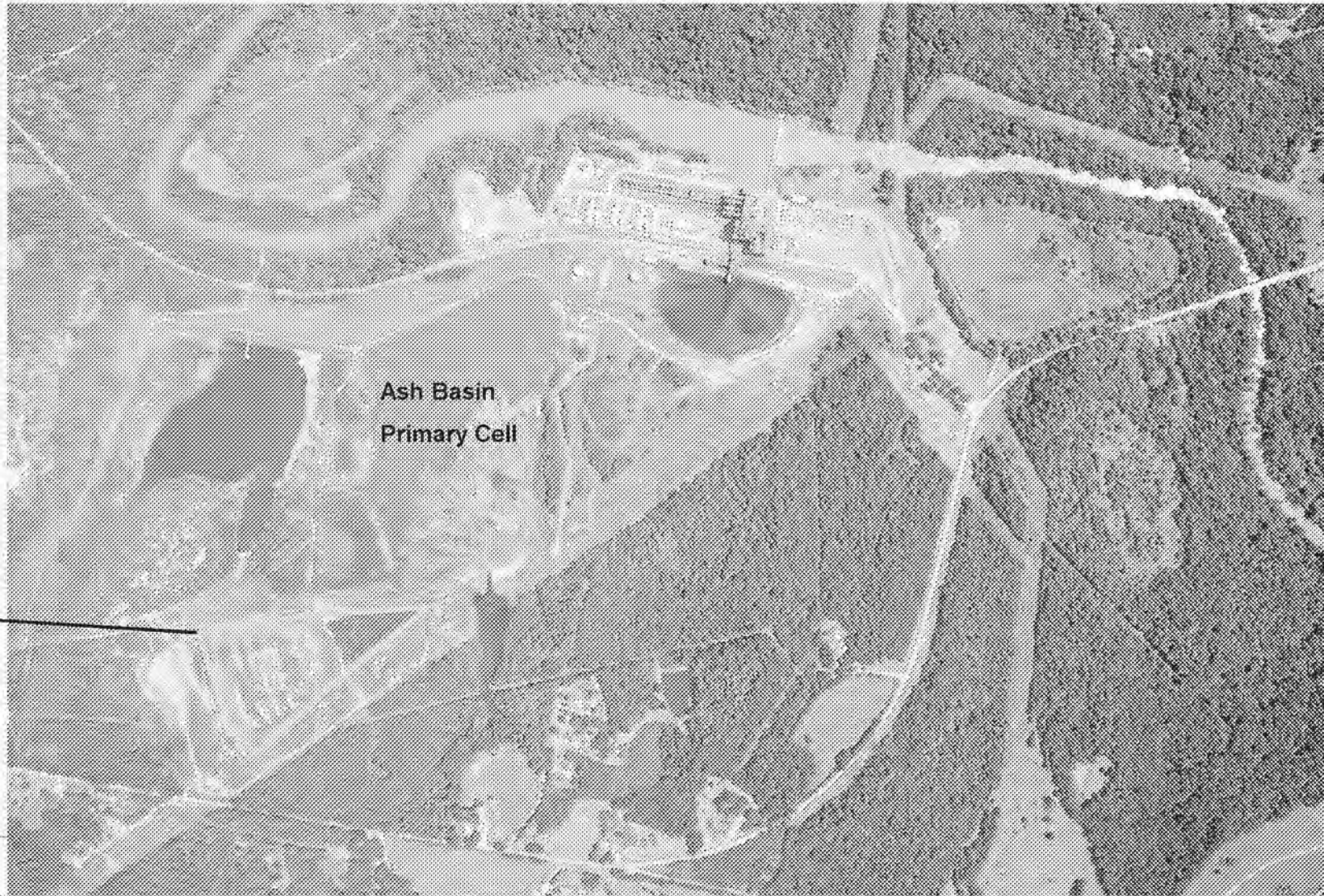
Coal Combustion Products 10-Year Plan Update

Lee Steam Station

Aerial Photo June 2005

OFFICIAL COPY

Feb 19 2020



Ash Basin
Primary Cell

Approx
Footprint of
2006-2007
Structural Fill



CCP 10 Year Plan Update – Lee Station

- ☐ 2007 YTD Results
- ☐ 2005 – 2007 Coal Quality
- ☐ Aerial Photograph
- ☐ 2006-2007 Ash Project
- ☐ Ash Production and Ash Basin Storage Capacity Projections – Chart
- ☐ Ash Production and Ash Basin Storage Capacity Projections – Data
- ☐ Planning and Budgeting Overview

Lee 2006-2007 Ash Basin Cleanout Project

- General Contractor: Taylor & Murphy Construction Co.
- Target Ash Removal Quantity: 300,000 cubic yards
- Total Project Budget: \$2.60 Million
- Project Schedule: Sep 2006 through Sep 2007
- Within budget and schedule
- Unique Project Features
 - ☐ Extension of Ash Sluice Piping
 - Issue: Mis-specified pipe by Trigon = \$80K
 - ☐ SCDHEC has specified minimum permeability criteria for Soil Cover
 - Issue: Installed Cap soil permeability marginally high due to dry weather.
 - Issue: Synthetic cap may be required in 2007-2008 = High Risk.
 - ☐ Fill Fence
 - ☐ Gravel pond roads

Lee 2010-2011 Ash Project Planning

- Off-site Synthetically Lined Landfills
 - Anderson Regional Landfill
 - Twin Chimneys
- On-site Greenfield at Nature Preserve = Favored Option
- On-site Brownfield at Retired Pond = Favored Option
- On-site Green/Brownfield Across Cannon Bottom Road
- Preliminary Siting Study by S&ME Complete
- Hydrogeologic Site Characterization Study by SCS Consultants in 2007+

DRAFT [REDACTED]

41

Coal Combustion Products 10-Year Plan Update

Marshall Steam Station

Aerial Photo April 2006



14.02 Marshall Station - April 2006

CCP 10-Year Plan Update – Marshall Station

- ☐ Capital for synthetic cap on structural fill Phase 1 in 2011.
- ☐ Capital for on-site lined landfill in 2010.
- ☐ Fly ash beneficiation capital in 2008/2009; starts 1/2009.
- ☐ Capital for purchasing land off-site?

Duke Energy – Regulated Generation Carolina's Region

OFFICIAL COPY

Feb 19 2020

Questions?



DRAFT

44

DUKE_SUTTON_00009071

2008 Coal Combustion Products Ten Year Plan

Carolinas & Regulated Midwest Stations

Carolinas & Regulated Midwest Operations

